ln = 2072
ID = 332966

Republika Slovenija
MINISTRSTVO ZA ZNANOST IN TEHNOLOGIJO
61000 Ljubljana, Slovenska 50

Telefon: (061) 13 11 107
Telefax: (061) 13 24 140

ZAKLJUČNO POROČILO

O REZULTATIH OPRAVLJENEGA ZNANSTVENO-RAZISKOVALNEGA DELA NA PODROČJU APLIKATIVNEGA RAZISKOVANJA

Naslov projekta: ***Onesnaževanje zraka, padavin, tal in vodnih virov v Šaleški dolini pred pričetkom obratovanja odžvepljevalne naprave v TEŠ***

Izvajalci: ***Institut "Jožef Stefan", Jamova 39, 61111 Ljubljana***
Gozdarski inštitut Slovenije, Večna pot 2, 61000 Ljubljana
BF Oddelek za agronomijo, Jamnikarjeva 101, 61000 Ljubljana
ERICo Velenje, Koroška 64, 63320 Velenje

Sofinancerji: ***Republika Slovenija, Ministrstvo za okolje in prostor, Župančičeva 6, 61000 Ljubljana***
Termoelektrarna Šoštanj, Lole Ribarja 18, 63325 Šoštanj
Rudnik lignita Velenje, Partizanska 78, 63320 Velenje

Odgovorni nosilec: dr. Borut Smodiš

Številka pogodbe: S2-6255-94

Datum: Januar 1995

ZAKLJUČNO POROČILO ZA LETO 1995

I. Cilji projekta:

1. V celoti so bili doseženi cilji projekta, ki so obsegali naslednja področja:

- *izokinetični odvzem trdnih suspendiranih delcev z njihovo porazdelitvijo po aerodinamskih premerih na izviru emisije (dimnik TEŠ) pred pričetkom obratovanja odžveplevalne naprave in njihova večelementna analiza,*
- *kontinuirno zbiranje in analiza trdnih suspendiranih delcev v zraku na dveh postajah Ekološkega Informacijskega Sistema TEŠ,*
- *zbiranje in analiza celokupnega depozita na istih postajah, v obdobju enega leta,*
- *zgoščen popis propadanja gozdov na območju GG Nazarje in Slovenj Gradec,*
- *Ugotavljanje vpliva polutantov na gozdni ekosistem na osnovi raziskav, opravljenih na profilu: Smrekovec - Zavodnje - Veliki vrh - Graška gora - Slovenjgraško sedlo.*

2. Cilji projekta se med raziskavo niso spremenili.

II. Poročilo o realizaciji predloženega programa dela

Projekt je nastal z združitvijo predlaganih projektov z naslovoma: "Raziskava onesnaženosti okolja v Šaleški dolini pred pričetkom obratovanja odžveplevalne naprave v Termoelektrarni Šoštanj" in "Raziskava stanja gozdnega ekosistema na vplivnem območju Termoelektrarne Šoštanj pred obratovanjem odžveplevalne naprave v Termoelektrarni Šoštanj". Glede na močno zmanjšan obseg financiranja projekta s strani MZT (od predlaganih 8286 ur letno na 2300 ur letno in proporcionalno znižan delež sofinanciranja), je bil obseg dela pri novem (združenem) projektu temu ustrezno spremenjen. To pa pomeni, da vsi cilji, kot so bili zastavljeni v predlogih samostojnih projektov, niso doseženi.

Vsebinsko raziskovalno poročilo je v prilogi.

III. Izkoriščanje dobljenih rezultatov:

1. Rezultati projekta so potencialno pomembni za naslednja področja:

a-b) Projekt je bil aplikativne narave. Spoznanja s širšega področja bioindikacije onesnaženosti okolja, predvsem gozdnih ekosistemov smo preiskusili v naših razmerah.

c) Izpopolnitev oziroma razširitev metodološkega instrumentarija. Vpeljani in preizkušeni so bili mednarodno primerljivi načini vzorčenja emisije pepela z dimnimi plini in suspendiranih trdnih delcev v zraku (aerosolov), padavin, tal in biološkega materiala ter preverjena zanesljivost ustreznih analitskih metod za ugotavljanje onesnaženosti z *mikroelementi, kakor tudi biometrične metode za ugotavljanje prizadetosti kopenskih ekosistemov in za ugotavljanje škodljivih vplivov na okolje in ljudi.*

d) Razvoj svojega temeljnega raziskovanja. Rezultati raziskav prispevajo k boljšemu poznavanju vpliva različnih polutantov na ekosisteme. Na tej osnovi smo poskušali ugotoviti emisijsko območje TEŠ in ugotoviti mehanizme, ki vodijo v propadanje gozdov zaradi vplivov onesnaženega zraka. Raziskovalni rezultati, izhajajoči iz projekta, so tema več doktorskih in magistrskih del.

f) Razvoj aplikativnega raziskovanja. TEŠ je eden največjih nadzorovanih onesnaževalcev zraka v Sloveniji, ki vpliva na okoliški kopenski ekosistem. Kljub izboljšanju tehnologije bo v naslednjih letih potrebno podrobneje spremljati nadaljnje vplive dimnih plinov in pepela v njih na okolico, pri čemer bodo rezultati tega projekta predstavljali referenco tako glede na zatečeno stanje kot tudi glede na metodološki instrumentarij za proučevanje polutantov in njihov vpliv na ekosisteme. Izsledki raziskave bodo neposredno osnova za postavitev in dločitev obratovalnega monitoringa TEŠ po izgraditvi in namestitvi čistiinih naprav. Rezultati te raziskave bodo pomembna referenčna baza za druge tovrstne raziskave v Sloveniji, ki že potekajo ali pa so v planu. Zaradi velikega števila interdisciplinarnih raziskav, povezanih v tem projektu bo raziskovalna ploskev v Zavodnjah s postavljeno infrastrukturo služila kot ena izmed raziskovalnih ploskev integralnega monitoringa ekosistemov v Sloveniji, kot primer onesnaženega gozdnega ekosistema na občutljivih tleh.

2. *S katerimi* ***razvojnimi cilji*** *Slovenije korelirajo rezultati vašega raziskovalnega projekta ?*

d) Napredek gospodarske infrastrukture:
   - Smotrna raba energije;

e) Varstvo okolja:
   - Preprečevanje onesnaženosti,
   - Oblikovanje in odstranjevanje onesnaženosti okolja;

f) Preprečevanje in zdravljenje bolezni;

j) Splošno širjenje znanja:
   - Napredek znanosti;

3. *Kateri so* ***neposredni rezultati*** *vašega projekta glede na zgoraj označen potencialni pomen in razvojne cilje ?*

Neposredni rezultat je ocena stanja okolja kot posledice onesnaževanja TEŠ. Poglobljeno je poznavanje stanja v ekosistemu in kroženje posameznih polutantov v njem. S tem je podana osnova za nadaljnja raziskovanja onesnaženosti okolja na tem geografskem področju. Predlagana je metodologija tovrstnih raziskav. Ker so bili izmerjeni kvantitativni podatki, jih bodo lahko uporabili načrtovalci ukrepov za sanacijo onesnaženega okolja in izboljšanja tehnologije, rezultati pa so uporabni tudi za epidemiološke študije v zdravstvu. Nadalje so *neposredni rezultati našega projekta osnove za izdelavo obratovalnega monitoringa TEŠ. Izsledki te raziskave bodo dobra referenčna osnova za podobne raziskave drugod v Sloveniji, predvsem za ugotavljanje vplivov različnih onesnaževalcev in drugih stresorjev na gozdne ekosisteme. V tem projektu pridobljeni rezultati in izsledki številnih drugih raziskav, opravljenih v gozdnih ekosistemih tega območja bodo osnova za postavitev ploskve integralnega monitoringa gozdnih ekosistemov.*

4. *Kakšni so lahko **dolgoročni rezultati** vašega raziskovalnega projekta glede na zgoraj označen potencialni pomen in razvojne cilje ?*

Dolgoročni rezultati projekta so predvsem v tem, da smo posneli tako imenovano niičelno stanje okolja, pred začetkom obratovanj odžveplevalnih naprav na TEŠ. S tem bomo v prihodnosti lahko spremljali izboljševanje stanja v gozdnih ekositemih ob ponavljanju istih analiz. Posredno bomo lahko ovrednotili tudi smoternost investicije vrazžveplevalne naprave glede na stanje okolja. Raziskave okolja v Šaleški dolini pred, med in po pričetku obratovanja razžveplevalnih čistilnih naprav v TEŠ bodo pokazale dejanski prispevek TEŠ k onesnaženosti lokalnega okolja. Rezultati raziskave nakazujejo nadaljnji prioritetni vrstni red ukrepov za izboljšanje stanja v urbanem in ruralnem okolju. So tudi koristna osnova pri pojasnjevanju vzrokov za propadanje gozdov ter za ustrezen pristop k gosodarjenju z gozdovi na emisijsko ogroženih območjih. Novi raziskovalci, ki so se izobraževali in formirali v okviru dela na projektu, so sedaj usposobljeni za samostojno delo pri temeljnem in aplikativnem raziskovanju na področju proučevanja vplivov velikih energetskih objektov na okolje.

5. *Kako boste **izkoristili** dosežena znanstvena spoznanja.*

Tovrstnih podatkov v našem prostoru doslej ni bilo. Dobljeni rezultati so osnova za obratovalni monitoring TEŠ. Z nadaljnjim spremljanjem stanja onesnaženosti in ekosistema v celoti bomo lahko ugotavljali dejanske spremembe v okolju ob dograjevanju razžveplevalnih naprav na posameznih blokih TEŠ. Poleg osnov za obratovalni monitoring bomo analize opravljene na emisijskem območju TEŠ primerjali s podobnimi analizami na drugih območjih, kjer potekajo naše raziskave, konkretno na območju Triglavskega narodnega parka. S tem bomo veliko lažje interpretirali določene analizirane parametre v drugem okolju, na podobnih objektih, isti analizni in vzorčevalni tehniki.

6. *Kakšna je verjetnost, da bodo vaša znanstvena spoznanja deležna tudi največjega **odziva** ?*

   a) *V domačih znanstvenih krogih:*
   Na vplivnem območju TEŠ smo že v preteklih letih opravili veliko različnih interdisciplinarnih raziskav. Zaradi velikega pomena, ki ga ima onesnaženje na gozdne ekosisteme smo tako naprimer zastavili večje število raziskav, ki so se ukvarjale s

propadanjem gozdov. Del tega projekta je smiselno nadaljevanje temeljnega raziskovalnega projekta "Ohranjanje in varovanje gozdov", v katerem smo zastavili tri osnovne modelne raziskave gozdnih ekosistemov v povezavi z vplivi izpuhov TEŠ in sicer:

-preučevanje vplivov na gozdna tla in motnje v mineralni prehrani

- preučevanje vplivov na mikorizo in s tem vplivi na mineralno prehrano in hormonsko regulacijo

- preučevanje vplivov na biokemične in fiziološke pokazatelje stresa v listih in iglicah

Omenjene in druge raziskave so vključevale številne diplomske, magistrske in doktorske naloge na področju gozdarstva, biologije, kemije in varstva okolja.

b) V mednarodnih znanstvenih krogih:

V poglavju IV so našteta mednarodna sodelovanja, kar nedvomno potrjuje odzivnost v mednarodnem merilu. Ker je okolje TEŠ zanimiv delovni poligon za različne raziskave, so se nekateri tuji dodiplomski in podiplomski študentje tudi neposredno vključevali v delo.

c) Pri uporabnikih:

TEŠ vključuje dobljene podatke in ugotovitve v svoj informacijski sistem in v poročila.

7. *Kdo že izraža* ***interes*** *po vaših znanstvenih spoznanjih ?*

   Spoznanja dobljena v tem projektu poleg finanserjev (ministrstva - MOP, MKGP in MZT -, TEŠ, Premogovnik Velenje) zanimajo lokalne skupnosti v Šaleškem bazenu in Mislinjski dolini, območne enote Zavoda za gozdove Republike Slovenije in nekatere kroge v Republiki Avstriji (gozdarje, okoljevarstvenike, univerze).

8. *Število diplomantov, magistrov in doktorjev, ki so zaključili študij z vključenostjo v raziskovalni projekt ?*

   diplome:

   a) v Sloveniji : 2 opravljeni, 1 v teku;

   b) v Avstriji : 1 opravljena, 1 v izdelavi;

   magisteriji:

   - 1 opravljen, 2 v pripravi;

   doktorati:

   - 3 opravljeni, 2 v pripravi.

IV. Sodelovanje z inozemskimi partnerji:

1. ***Število in oblika*** *formalnega raziskovalnega sodelovanja s tujimi raziskovalnimi inštitucijami.*

   - *TEMPUS JEP 4667 "Bioindication of forest site pollution. Development of methodology and training".*

- *IAEA 7261 "Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques"*
- *PECO CHGE-CT93-0037 "Access to the neutron irradiation devices and to laboratories for NAA and radiochemistry at the HMI Berlin for research in life sciences, earth science and material development".*
- *Copernicus ERB-CIPA-CT94-0218 "An impulse to exploit NAA as a manageable and competitive analytical tool in industry and environmental sanitation in Hungary, the Czech Republic and Slovenia".*
- *Internationales Büro des Forschungszentrums Jülich, 1F1A2A "Development, Validation and Application of NAA and Speciation Methods in Biological Materials".*
- *NIST 95-356 "Improvements in NAA procedures for the certification of reference materials".*

Poleg teh formalnih sodelovanj v mednarodnih projektih sodeluje skupina še pri večjem številu bilateralnih projektov in neformalno z več univerzami in raziskovalnimi inštituti v tujini.

2. *Kakšni so **rezultati** tovrstnega sodelovanja ?*
   Rezultati tovrstnega sodelovanja so delo na skupnih raziskovalnih projektih, izmenjava raziskovalcev in znanstvenih spoznanj ter skupne publikacije.

V. Bibliografija in drugi raziskovalni rezultati:

Bibliografija je podana za vsakega raziskovalca na projektu posebej. S križcem so označena dela, ki so relevantna za projekt. V rekapitulaciji in v dokazilih so navedena samo dela, ki se nanašajo na projekt.

Institut Jožef Stefan
Direktor

Odgovorni nosilec

doc. Dr. Danilo Zavrtanik

dr. Borut Smodiš

VSEBINSKO RAZISKOVALNO POROČILO

Vsebinski del projekta sestavljajo naslednja poročila:

I. ***Raziskava emisij elementov z dimnimi plini TEŠ in njihove koncentracije na Velikem vrhu in v Zavodnjah***

II. ***Raziskava onesnaženosti suhega in mokrega depozita v Šaleški dolini pred pričetkom obratovanja odžveplevalne naprave v Termoelektrarni Šoštanj***

III. ***Ugotavljanje vpliva polutantov na gozdni ekosistem:***

1. ***Popis poškodovanosti gozdov***
2. ***Raziskave prehranskih razmer za smreko in bukev v vplivnem območju TEŠ***
3. ***Proučevanje onesnaženosti gozdnih tal v imisijskem območju TEŠ s parno primerjalnimi raziskovalnimi objekti***
4. ***Raziskave mikorize***
5. ***Ugotavljanje stresa na osnovi analize zaščitnih substanc in reparaturnih mehanizmov v listih/iglicah gozdnega drevja in analize epifitskih lišajev***

Za vsakega od naštetih poglavij so predstavljeni: raziskovalna hipoteza, metodološko-teoretičen opis raziskovanja in rezultati, ugotovitve ter zaključki novih spoznanj.

Ključni deskriptorji: ***aerosoli / efekti / emisije / gozdna vegetacija / gozdni ekosistemi / onesnaževanje / padavine / suspendirani delci / termoelektrarna / težke kovine / tla / vode / zrak /***

I. RAZISKAVA EMISIJ ELEMENTOV Z DIMNIMI PLINI TEŠ IN NJIHOVE KONCENTRACIJE NA VELIKEM VRHU IN V ZAVODNJAH

IJS-Delovno Poročilo
IJS-DP-7341
Izdaja 1: januar 1996

RAZISKAVA EMISIJ ELEMENTOV Z DIMNIMI PLINI TEŠ IN NJIHOVE KONCENTRACIJE NA VELIKEM VRHU IN V ZAVODNJAH

B. Smodiš, L. Benedik, M. Bole, A. R. Byrne, J. Flis, I. Gros, R. Jaćimović, M. Križman, T. Lenart, J. Novak, B. Stropnik, M. Videmšek

Ljubljana, Januar 1996

Univerza v Ljubljani
Institut "Jožef Stefan", Ljubljana, Slovenija

Univerza v Ljubljani
Institut "Jožef Stefan", Ljubljana, Slovenija

Naročniki:	RS, Ministrstvo za znanost in tehnologijo RS, Ministrstvo za okolje in prostor Termoelektrarna Šoštanj Rudnik lignita Velenje
Izvajalca:	Institut "Jožef Stefan", Odsek za kemijo okolja, Ljubljana ERICo Velenje, Institut za ekološke raziskave Velenje
Pogodba štev.:	S2-6255-94
Nosilec naloge:	dr. Borut Smodiš
Naslov poročila:	Raziskava emisij elementov z dimnimi plini TEŠ in njihove koncentracije na Velikem vrhu in v Zavodnjah
Avtorji poročila:	dr. L. Benedik, M. Bole, dipl. inž., dr. A. R. Byrne, J. Flis, dipl. biol., I. Gros, R. Jaćimović, dipl. inž., mag. M. Križman, T. Lenart, J. Novak, dr. Borut Smodiš, B. Stropnik, M. Videmšek
Štev. delovnega poročila:	IJS-DP-7341
Štev. prijave v arhivu:	
Kopije:	naročniki (4 x) IJS knjižnica (1 x) QA arhiv odseka (1 x) nosilec naloge (1 x)

Komisija za pregled:

predsednik:	dr. M. Dermelj	
član:	dr. B. Smodiš	
član:	dr. B. Stropnik	

Ljubljana, januar 1996

RAZISKAVA EMISIJE ELEMENTOV Z DIMNIMI PLINI "TEŠ" IN NJIHOVE KONCENTRACIJE NA VELIKEM VRHU IN V ZAVODNJAH

dr. Boris Stropnik,

dr. Borut Smodiš,

dr. Anthony R. Byrne

dr. Ljudmila Benedik

mag. Milko Križman

Radojko Jaćimović, dipl. ing. fiz.

Mojca Bole, dipl. ing. kem. teh.

Jelka Flis, dipl. biol.

Jože Novak, kem. teh.

Marko Videmšek, gozd. teh.

Tatjana Lenart, kem. teh.

Igor Gros, študent rač.

IZVLEČEK

V poročilu je raziskana koncentracija elementov v trdnih suspendiranih delcih v dimnih plinih v dimniku Termoelektrarne Šoštanj (TEŠ), ki je edini avtomatsko nadzorovani onesnaževalec v Šaleški dolini. Prikazan je izvleček rezultatov enoletnih meritev koncentracij elementov v aerosolih na dveh mestih v vplivnem področju TEŠ za leto 1994. Uporabili smo vzorčevalnik, ki ločeno zbira inhalabilne in respirabilne aerosole. Vzorce smo analizirali z EDXRF, z izotopi za vzbujanje vzorcev. Analize smo opravili z EDXRF k_0-INNA in ETAAS. Rezultate smo predstavili na slikah in v preglednicah in sicer kot letne povprečne vrednost, dobljene rezultate smo primerjali z mejnimi dopustnimi vrednostmi, ki veljajo v Republiki Sloveniji in s priporočenimi po WHO. Izračunali smo emisijo elementov z dimnimi plini pri kurjenju premoga v TEŠ.

Koncentracije aerosolov in elementov v aerosolih v zraku, ki ga dihajo ljudje so nižje kot v ZDA v urbanih okoljih in tudi nižje od koncentracij, ki jih dovoljuje veljavna zakonodaja oz. jih priporoča WHO.

Vsebina

1 Uvod

V atmosfero prehaja ogromna količina anorganskih in organskih snovi v obliki trdnih, tekočih ali plinastih onesnaževalcev, v atmosferi pa pride do katalizirane kondenzacije plinastih komponent in adsorpcije na trdnih delcih. Na površini delcev se odvijajo katalizirane in fotokemijsko inducirane kemijske reakcije. Več kot 50 % vseh onesnaževalcev v zraku je v obliki trdnih delcev. Antropogeni elementi Cu, Zn, As, Se, Cd, Sb in I pa prihajajo v jezera in morja predvsem po zraku [1].

Največ suspendiranih delcev v zraku je, glede na premer, manjših od 10 μm. Znotraj tega je koncentracija bimodalna; večja je koncentracija aerosolov s premerom med 0,1 do 1 μm in med 3 in 10 μm. Delci v zraku, ki imajo premer večji od 2 μm, izvirajo iz naravnih materialov in so alkalni, manjši od 2 μm pa po navadi izvirajo iz človekove dejavnosti (sulfatni aerosol) in so kisli [2] [3].

Na zdravje ljudi najbolj vplivajo majhni suspendirani delci v vdihanem zraku - aerosoli [4] [5]. Človek potrebuje za dihanje okoli 20 000 litrov zraka na dan, to pomeni, da glede na težo vdihanega zraka in zaužite hrane uporabi 15 do 20-krat več zraka. Tako lahko onesnaženi zrak ogroža zdravje ljudi [6].

V Šaleški dolini je dodaten vir primarnih aerosolov pepel v izpustu dimnih plinov TEŠ. Emisija žveplovega dioksida pri ugodnih meteoroloških pogojih povečuje vsebnost sekundarnih aerosolov. Pri usmerjenem gibanju zraka (v izrednih vremenskih razmerah) iz dimnika na tla dobimo neposreden vpliv slabo razredčenih dimnih plinov na del bližnje okolice [8].

1.1 Opis Termoelektrarne Šoštanj

Termoelektrarna Šoštanj ima štiri proizvodne enote s skupno instalirano močjo 745 MW. V letu 1994 je porabila okoli 3,5 milijona t lignita, od tega je ostalo okoli 665 400 t pepela. Pepel, ki ga izločijo elektrostatski filtri iz dimnih plinov, transportirajo hidravlično po cevovodu na odlagališče ob Velenjskem jezeru. V atmosfero je bilo leta 1994 z dimnimi plini spuščeno 4 917 t pepela [7]. Ta se v atmosferi razredči, vpliva na spremembe v atmosferi in se prenaša na tla s padavinami.

Elementno sestavo pepela v dimniku med obratovanjem termoelektrarn so v svetu raziskovali že v začetku sedemdesetih let. V večini študij je bila elementna sestava analizirana glede na velikost delcev. Analiziran je bil pepel pred in za elektrostatskimi filtri oziroma v dimniku. V večini primerov so pri vzorčenju uporabili kaskadne impaktorje, kar pomeni, da so bili delci že pri vzorčenju razdeljni na skupine, ki so se razlikovale po aerodinamskih premerih [9] [10] [11] [12].

V tem delu smo analizirali elementno sestavo pepela v dimnih plinih za elektrostatskimi filtri, razdeljenega v osem frakcij po aerodinamskih premerih z izokinetičnim vzorčenjem v dimniku.

1.2 Mesta vzorčenja aerosolov

Za izvedbo načrtovanega programa nadzora koncentracij aeroslov in koncentracij elementov v aerosolih v okolici TEŠ smo izbrali 2 značilni mesti, ki so glede na meteorološke pogoje različni in sta bili predvidena za ugotavljanje vpliva TEŠ na okolico že v predhodnih obdobjih. To sta bili Veliki vrh in Zavodnje.

1.3 Čas in metode vzorčenja aerosolov

Vsak vzorec aerosolov predstavlja poprečno koncentracijo za dneve, ko je bil izpostavljen. To je 3 do 14 dni, poprečno en teden, kar je bilo pogojeno s pretokom zraka skozi filter.

Vzorčevanje smo izvedli s preverjenim vzorčevalnikom domače izdelave, ki zbira suspendirane delce v zraku z aerodinamskim premerom manjšim od 15 μm. V vzorčevalniku se aerosoli na posebni šobi razdelijo na dve frakciji - respirabilne in inhalabilne aerosole. Mejni aerodinamski premer pri katerem se aerosoli ločujejo je 2,5 μm. Frakciji se nato zbirata ločeno na dveh polikarbonatnih membranskih filtrih, ki so primerne za več različnih analiznih tehnik [13].

1.3.1 Prednosti izbranega vzorčenja aerosolov

Z izbrano metodo vzorčenja sem zajel tiste trdne onesnaževalce v zraku, ki [25]:

- izpolnjujejo zahteve veljavne zakonodaje in priporočil WHO,
- predstavljajo največji masni delež suspendiranih delcev in zajemajo vse trdne onesnaževalce zraka,
- vključujejo onesnaževanje zraka z dimnimi plini iz termoelektrarn,
- vsebujejo elemente v sledovih, ki neposredno vplivajo na zdravje ljudi,
- se adsorbirajo na vegetacijo in posredno preko hrane in krme vplivajo na zdravje živali in ljudi,
- spreminjajo barvo atmosfere,
- vključujejo kondenzacijska jedra za onesnaževalce v zraku,
- imajo zelo veliko specifično površino in pri ugodnih pogojih adsorbirajo onesnaževalce v zraku,
- katalizirajo procese pretvorbe plinastih komponent v trdne delce.

1.4 Vzorčenje in analize pepela v dimnih plinih TEŠ

Pepel v dimnih plinih smo vzorčevali izokinetično na izstopu iz posameznih polj elektrostatskih filtrov na Bloku 5 in v dimniku Bloka 4 na višini okoli 50 m nad tlemi, kjer so nameščene merilne naprave za avtomatski nadzor emisije CO_2, SO_2, NO_x in prahu

Koncentracije elementov v dimnih plinih so bile določene v štirih reprezentativnih skupinah vzorcev od skupaj odvzetih devetih.

1. vzorec z Bloka 5 je bil odvzet na izstopu iz elektrofiltra, polje A, odvzet 1994-10-18 med 13 uro 40 minut in 14 uro, koncentracija kisika v suhih dimnih plinih 8,2, količina suhih dimnih plinov za vzorec 0,769 m^3. V točki vzorčenja, zajeto z

vzorčevalnikom, je bila koncentracija pepela 56,4 mg/m^3. Povprečna koncentracija pepela v suhih dimnih plinih v času vzorčenja pri normalnih pogojih in vsebnosti kisika 7 % je bila 244 mg/m^3.

2. vzorec z Bloka 5 je bil odvzet na izstopu iz elektrofiltra, polje B, odvzet 1994-10-19 med 9 uro 10 minut in 9 uro 30 minut, koncentracija kisika v suhih dimnih plinih 8,0, količina suhih dimnih plinov za vzorec 0,714 m^3. V točki vzorčenja, zajeto z vzorčevalnikom, je bila koncentracija pepela 103,6 mg/m^3. Povprečna koncentracija pepela v suhih dimnih plinih v času vzorčenja pri normalnih pogojih in vsebnosti kisika 7 % je bila 327 mg/m^3.

1. vzorec z Bloka 4 je bil odvzet v dimniku 50 m nad tlemi, vzporedno z avtomatskimi merilnimi napravami, odvzet 1994-10-20 med 14 uro 35 minut in 15 uro 10 minut. V točki vzorčenja, zajeto z vzorčevalnikom, je bila koncentracija pepela 53,8 mg/m^3.

2. vzorec z Bloka 4 je bil odvzet v dimniku 50 m nad tlemi, vzporedno z avtomatskimi merilnimi napravami, odvzet 1994-10-21 med 8 uro 30 minut in 9 uro 00 minut. V točki vzorčenja, zajeto z vzorčevalnikom, je bila koncentracija pepela 33,2 mg/m^3.

V izračunu povprečne koncentracije elementov v prostorninskem metru dimnih plinov med vzorčenjem smo upoštevali povprečno koncentracijo pepela v suhih dimnih plinih pri normalnih pogojih in vsebnosti kisika 7 %.

Med izokinetičnim zajetjem so dimni plini potovali skozi posebno vzorčevalno napravo - kaskadni impaktor ANDERSEN STACK SAMPLER MARK II (Multi-stage, multi-jet particle size analyzer) z osmimi stopnjami na katerih se med vzorčenjem ujamejo različno veliki delci glede na njihov aerodinamski premer. Z upoštevanjem temperature in pretoka dimnih plinov ter gostote delcev (pepela) v dimnih plinih smo določili mejni aerodinamski premer delcev na posameznih stopnjah.

Pri vzorčevanju na Bloku 5 je bil aerodinamski premer delcev na stopnji 0 večji od 6,7 μm, na stopnji 1 med 6,7 in 4,2 μm, na st. 2 med 4,2 in 2,8 μm, na st. 3 med 2,8 in 2,9 μm, na st. 4 med 1,9 in 1,3 μm. na st. 5 med 1,3 in 0,6 μm, na st. 6

med 0,6 in 0,38 μm, na st. 7 med 0,38 in 0,23 μm, na st. 8 so bili delci manjši od 0,23 μm.

Pri vzorčevanju na Bloku 4 je bil aerodinamski premer delcev na stopnji 0 večji od 10 μm, na stopnji 1 med 10 in 6 μm, na st. 2 med 6 in 4,2 μm, na st. 3 med 4,2 in 2,9 μm, na st. 4 med 2,9 in 1,8 μm. na st. 5 med 1,8 in 1,0 μm, na st. 6 med 1,0 in 0,56 μm, na st. 7 med 0,56 in 0,38 μm, na st. 8 so bili delci manjši od 0,38 μm.

Impaktor smo za odvzem vzrocev po končanem vzorčenju odnesli v laboratorij, kjer smo pepel s pozameznih stopenj ločeno zbrali na Nuclepore filtre in jih označili.

2 ANALIZE

Opravil smo gravimetrične in kemijske analize.

2.1 Gravimetrične analize

Maso aerosolov smo določali s tehtanjem filtrov pred vzorčenjem in po njem na tehtnici Mettler AE 163, z natančnostjo 10 μg (Mettler instruments AG, Switzerland). Vsak filter sem pred tehtanjem razelektril na Nuclepore odstranjevalcu statičnega naboja (β sevalec).

Na enak način smo določili maso posmaeznih frakcij pepela iz dimnih plinov zajetega na posameznih stopnjah vzorčevalnika. To je s tehtanjem filtrov pred in po dodatku pepela iz ene od stopenj vzorčevalnika.

2.2 Kemijske analize aerosolov

Za analize vzorcev aerosolov smo uporabili EDXRF. Pred končno odločitvijo o izbiri glavne analizne metode smo preveril primernost EDXRF z analizo aerosolov na filtrih iz krožne analize IAEA [14] [15].

2.2.1 Eksperimentalna oprema in meritve

Za vzbujanje fluorescence v vzorcu smo uporabljal radioaktivne vire, izdelane v obročasti obliki, ki omogočajo izredno efektivno vzbujanje vzorca.

Pri delu smo uporabljali naslednje radioaktivne vire:

- ^{109}Cd (aktivnost okoli 0,7 GBq) razpada z zajetjem "K" elektrona in oddaja v glavnem Ag karakteristične žarke K-serije s poprečno energijo 22 keV. Razpolovni čas vira je 460 dni in ga lahko uporabljamo 3 do 5 let. Vir je praktično monokromatičen, kar je izredna prednost pri rentgenski fluorescenčni analizi, saj zagotavlja razmeroma majhno ozadje zaradi sipanja primarnega žarkovja na vzorcu. S tem virom lahko dobro vzbujamo atome (globalno) oziroma elektrone elementov od K do Tc v K-seriji in seveda težje elemente od Ba pa do U v L-seriji.

- ^{55}Fe (aktivnost približno 0,7 GBq) tudi razpada z zajetjem K elektrona, nastane jedro ^{55}Mn, ki potem oddaja karakteristične žarke K serije s poprečno energijo 6 keV. Vir ima razpolovni čas 2,7 let in je tudi praktično monokromatičen. Uporablja se predvsem za vzbujanje rentgenske fluorescence v lahkih elementih, in sicer od Na pa tja do Cr v K seriji. Tudi ta vir je mogoče uporabljati vsaj 5 let za razmeroma občutljivo vzbujanje atomov pri fluorescenčni analizi.

Za analizo rentgenskih spektrov smo pri delu uporabljal računalniški program AXIL. Kratica programa, pomeni analizo rentgenskega spektra s ponavljajočo se nelinearno metodo najmanjših kvadratov; program prilagaja merjenemu spektru teoretično izračunan spekter, ki kot spektralne črte uporablja Gaussove krivulje, kot ozadje pa linearne ali eksponentne polinome.

Ponovljivost in pravilnost kvantitativne analize smo preverili z nasledjimi materiali:

- NIST SRM 3087, Metals on filter media (Cr, Fe, Mg, Ni, Pb, Se, Zn).

- BCR CRM No. 128, Fly Ash Artificial Filter

- National Institute of Occupational Health, Sweden, Reference Material for Measurement of Elements in Filter Media, Series A-1

Zanesljivost EDXRF smo preverili z:

- IAEA krožno analizo
- k_o-INAA
- ETAAS za Ca in Pb na izbranih vzorcih aerosolov

2.3 Kemijske analize pepela v dimnih plinih

Za analizo vzorcev pepela iz dimnih plinov smo kot najbolj primerno uporabili večelementno k_o-instrumentalno nevtronsko aktivacijsko analizo (k_o-INAA) [14] [16] [17] [18] [19], za elementa Ni, Pb in Cd pa še elektrotermalno atomsko absorpcijsko spektroskopijo (ETAAS).

2.4 Obdelava podatkov za interpretacijo

2.4.1 Koncentracija aerosolov

Razlika v teži filtrov po vzorčenju in pred njim, deljena s količino prečrpanega zraka, je pokazala, kakšna je masna koncentracija posameznih frakcij aerosolov v zraku, poprečno za čas vzorčenja. Pri tem je upoštevana razdelitev zraka v separatorju. Podatki so bili vnešeni za obdelavo na osebnem računalniku.

2.4.2 Koncentracija elementov v zraku

Rezultate meritev spektrov na obeh sistemih ED XRF smo sproti shranjevali v treh kopijah. Posneti spektri so bili prenešeni v program AXIL.

Najprej smo analizirali spektre kvalitativno in nato kvantitativno z uporabo podatkov o pretokih zraka, premeru filtra in netto teži aerosolov s posebej prirejenim programom "AXIL KAVO". Poprečna brutto poraba časa - vzpostavitev, umerjanje, preverjanje, ponavljanje, izpad meritev - je bila pet ur za vsak vzorec. Pri tem smo upoštevali večkratno ponavljanje meritev zaradi preverjanja sistema.

2.4.3 Emisija elementov z dimnimi plini iz TEŠ

Povprečne koncentracije določenih elementov v pepelu iz dimnih plinov smo z uporabo podatkov o celoletni masi emitiranega pepela preračunali na celoletno emisijo elementov.

3 REZULTATI IN RAZPRAVA

3.1 Vzorci aerosolov iz okolice TEŠ

Rezultati analiz vzorcev so pokazali, da so izmerjene koncentracije elementov S, K, Ca, Ti, Fe. Cu, Zn, Pb in Br nekajkrat višje od izračunane meje detekcije za EDXRF. Koncentracije S, K, Ca, Ti, Fe, Cu, Zn, Pb in Br v vzorcih iz okolice TEŠ so bile višje od tistih iz poročila IAEA. Elementi Si, V, Cr, Mn, Ni in Zr pa so bili na meji detekcije EDXRF, kar pomeni, da so rezultati za del vzorcev manj zanesljivi. Podrobnejša opredelitev meje detekcije za vsak vzorec je odvisna od količine prečrpanega zraka skozi filter. Zaradi tega veljajo navedeni zaključki le splošno.

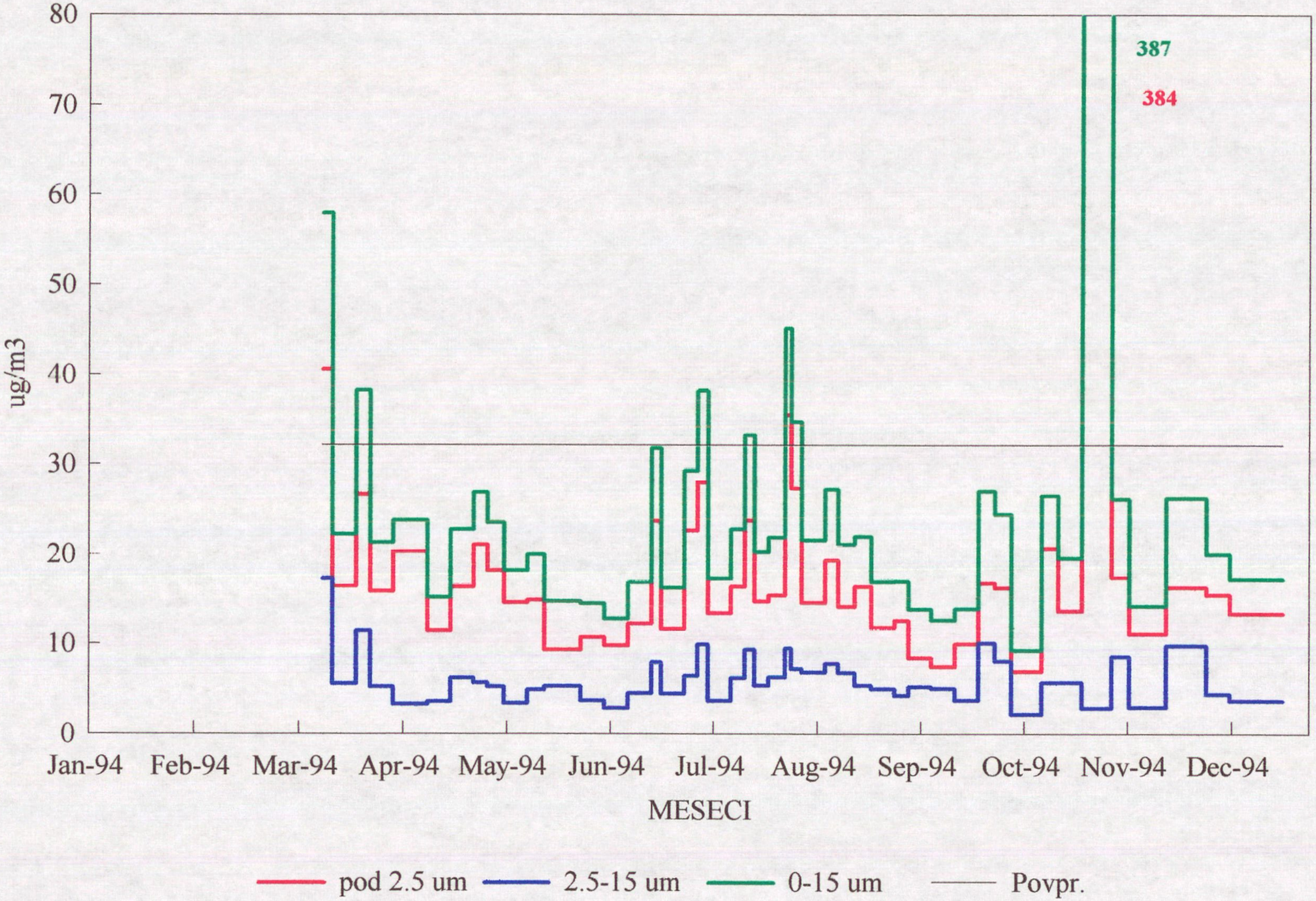
3.2 Koncentracije aerosolov v Zavodnjah in na Velikem vrhu

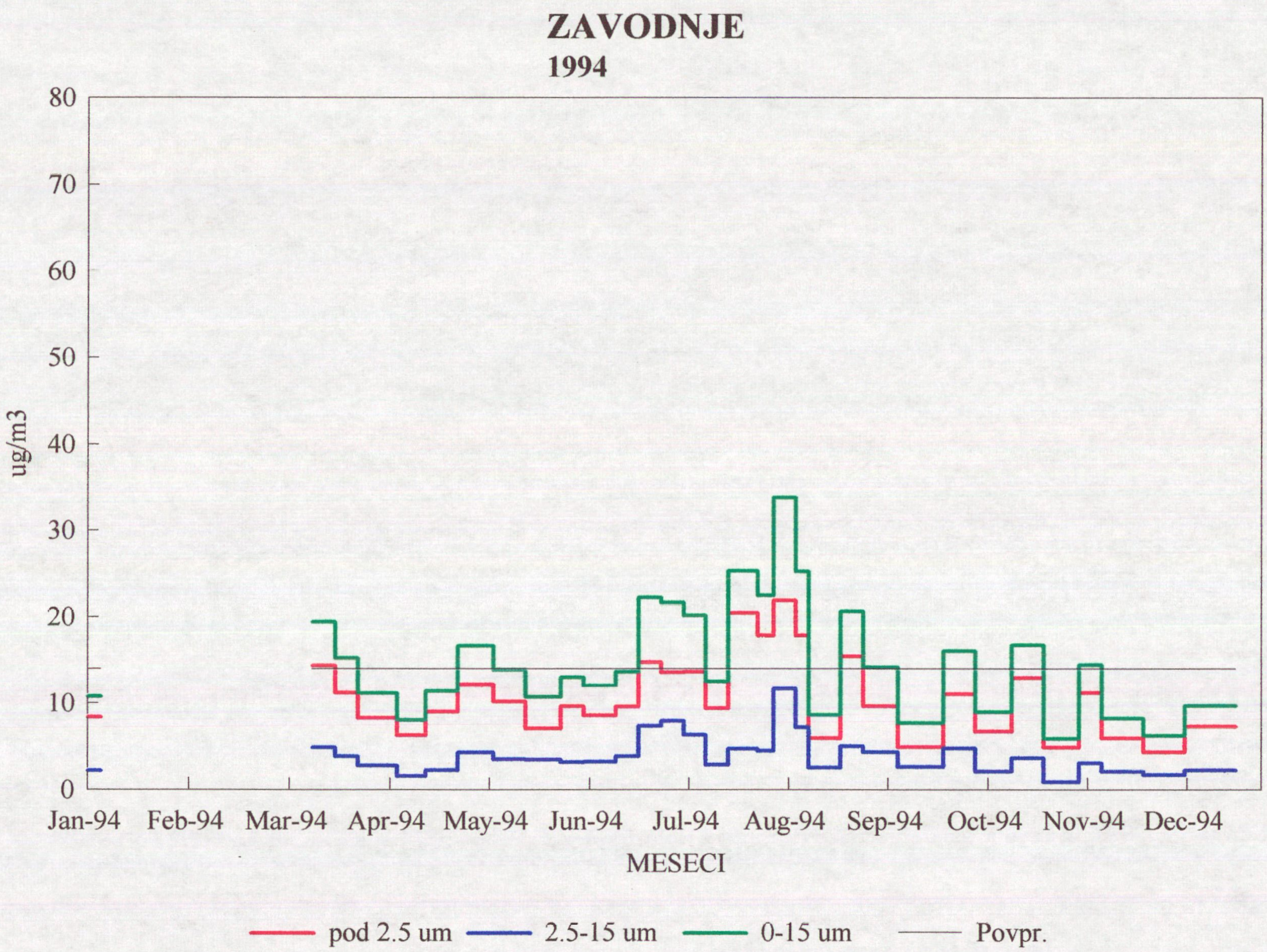
Visoke koncentracije aerosolov so prvo merilo onesnaženosti zraka. Na področju ugotavljanja onesnaženosti zraka s trdnimi delci je najbolj razširjeno ter avtomatizirano merjenje masnih koncentracij aerosolov v zraku.

Masne koncentracije in dinamika spreminjanja respirabilnih in inhalabilnih aerosolov so prikazane s slikami na straneh 10 in 11. Slika označena z naslovom Lokovica je avtomatska postaja na Velikem vrhu (domačini to področje imenujejo tudi Lokovica). Sprememba oznake je zaradi kratice uporabljene v banki podatkov. Na slikah so posebej prikazane povprečne masne koncentracije inhalabilnih in respirabilnih aerosolov ter skupna koncentracija obeh frakcij v obdobju vzorčenja (nekaj dni - vodoravne črtice na slikah). Poprečna letna koncentracija aerosolov je označena z vodoravno črto čez celo sliko in je predmet primerjave z mejnimi koncentracijami po veljavni zakonodaji [20]. Mesti vzorčenja sta imeli različno povprečno letno koncentracijo aerosolov v zraku. V Zavodnjah je bila 14 $\mu g/m^3$, na Velikem vrhu pa je bila 32 $\mu g/m^3$. Veliki vrh je bil sodeč po koncentracijah aerosolov za faktor 2 bolj obremenjen. Dovoljena masna koncentracija po slovenski zakonodaji ni prekoračena. Prav tako ne presega priporočil Svetovne zdravstvene organizacije [21].

Poprečne koncentracije aerosolov v Šaleški dolini so nižje od izmerjenih v ZDA v urbanih okoljih. Tako lahko ocenimo, da ima TEŠ z izpustom primarnih aerosolov manjši vpliv na svojo okolico, kot ga imajo razpršeni antropogeni viri v urbaniziranem okolju ZDA. Zelo majhen vpliv TEŠ na koncentracije aerosolov v okolici lahko gotovo pripišemo dobremu učinku čistilnih naprav - elektrostatskih filtrov.

LOKOVICA
1994




ZAVODNJE
1994
80
70
60
50
40
30
20
10
0
ug/m3
Jan-94
Feb-94
Mar-94
Apr-94
May-94
Jun-94
Jul-94
Aug-94
Sep-94
Oct-94
Nov-94
Dec-94
MESECI
pod 2.5 um
2.5-15 um
0-15 um
Povpr.

3.3 Koncentracije elementov v zraku

Koncentracije elementov v inhalabilnih in respirabilnih vzorcih zraka so se med letom spreminjale in so bile različne glede na mesti vzorčenja. Spremembe v respirabilnih in ihalabilnih aerosolih so v istem obdobju vzorčenja na različnih mestih podobne. Pri inhalabilnih so razlike večje, kot pri respirabilnih aerosolih. Elementi v sekundarnih aerosolih so bolj enakomerno porazdeljeni po vseh vzorčevalnih mestih, ker potrebujejo ustrezne pogoje za svoj nastanek. Eden od pogojev je tudi čas, kar je pomembno za sekundarne aerosole, ki izvirajo iz TEŠ. Pot zraka oziroma dimnih plinov je različna glede na meteorološke pogoje. V tedenskih povprečnih koncentracijah je opaziti večji vpliv TEŠ na povečanje žvepla v respirabilnih aerosolih.

Najpomembnejša je interpretacija rezultatov na način, ki je primerljiv z veljavno zakonodajo v Sloveniji in s priporočili WHO [21]. Zato moramo poznati povprečne letne koncentracije elementov v aerosolih v zraku.

Poprečne letne koncentracije elementov v respirabilni in inhalabilni frakciji (ločeno) za leto 1994 so prikazane v tabeli na strani 13. V tretjem in petem stolpcu tabele je odstotek rezultatov, ki so upoštevani pri izračunu poprečnih vrednosti v drugem in četrtem stolpcu istih tabel. Prikazani so podatki, kot smo jih dobil pri analizah EDXRF brez upoštevanja napak, ki so bile ugotovljene pri preverjanju zanesljivosti EDXRF.

Na straneh 14 in 15 so na slikah spremembe koncentracij žvepla v teku vzorčenja.

Na straneh 16 in 17 so podane koncentracije cinka tekom leta za obe mesti.

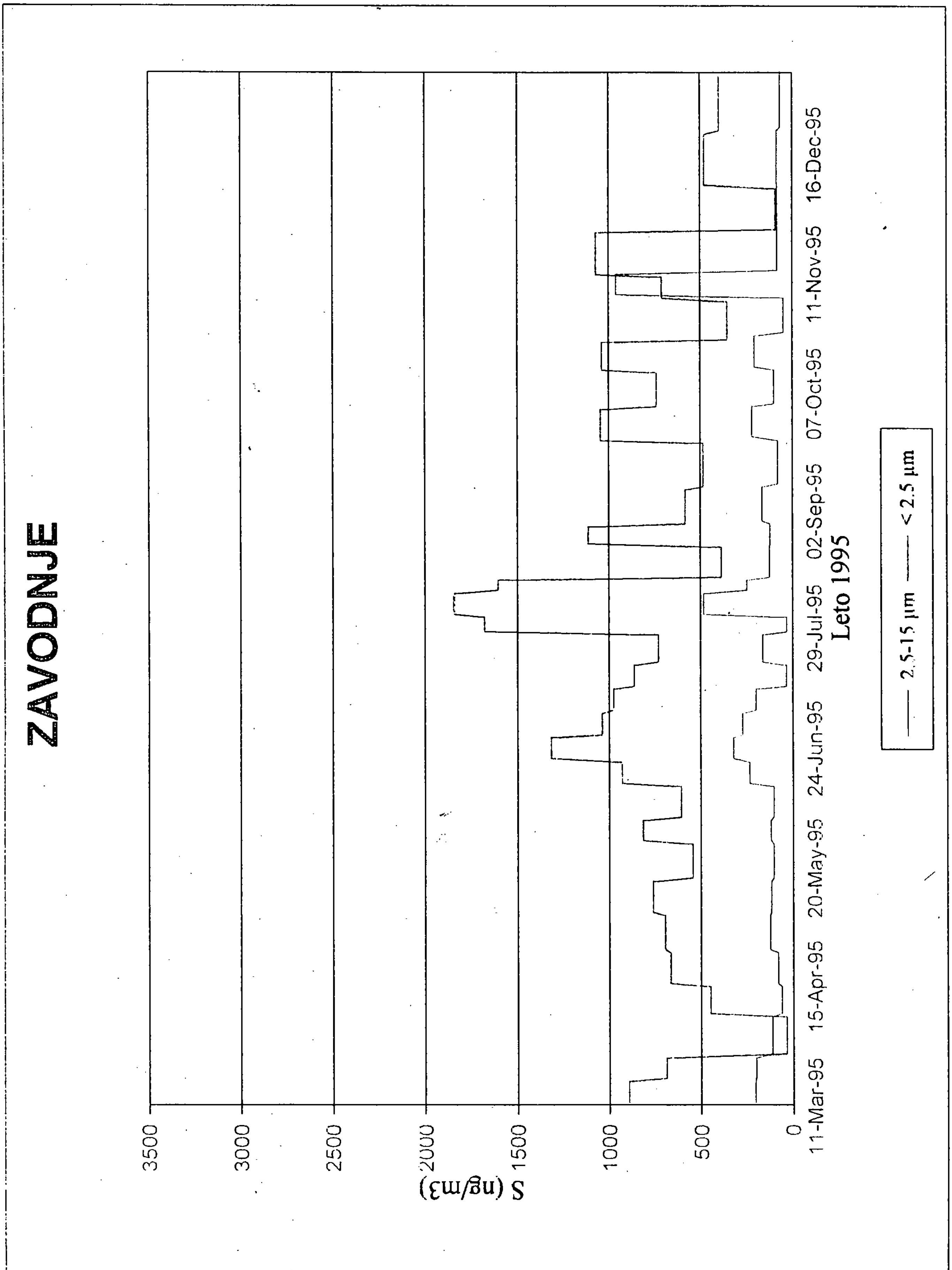
Na straneh 18 in 19 so slike o koncentracijah svinca in

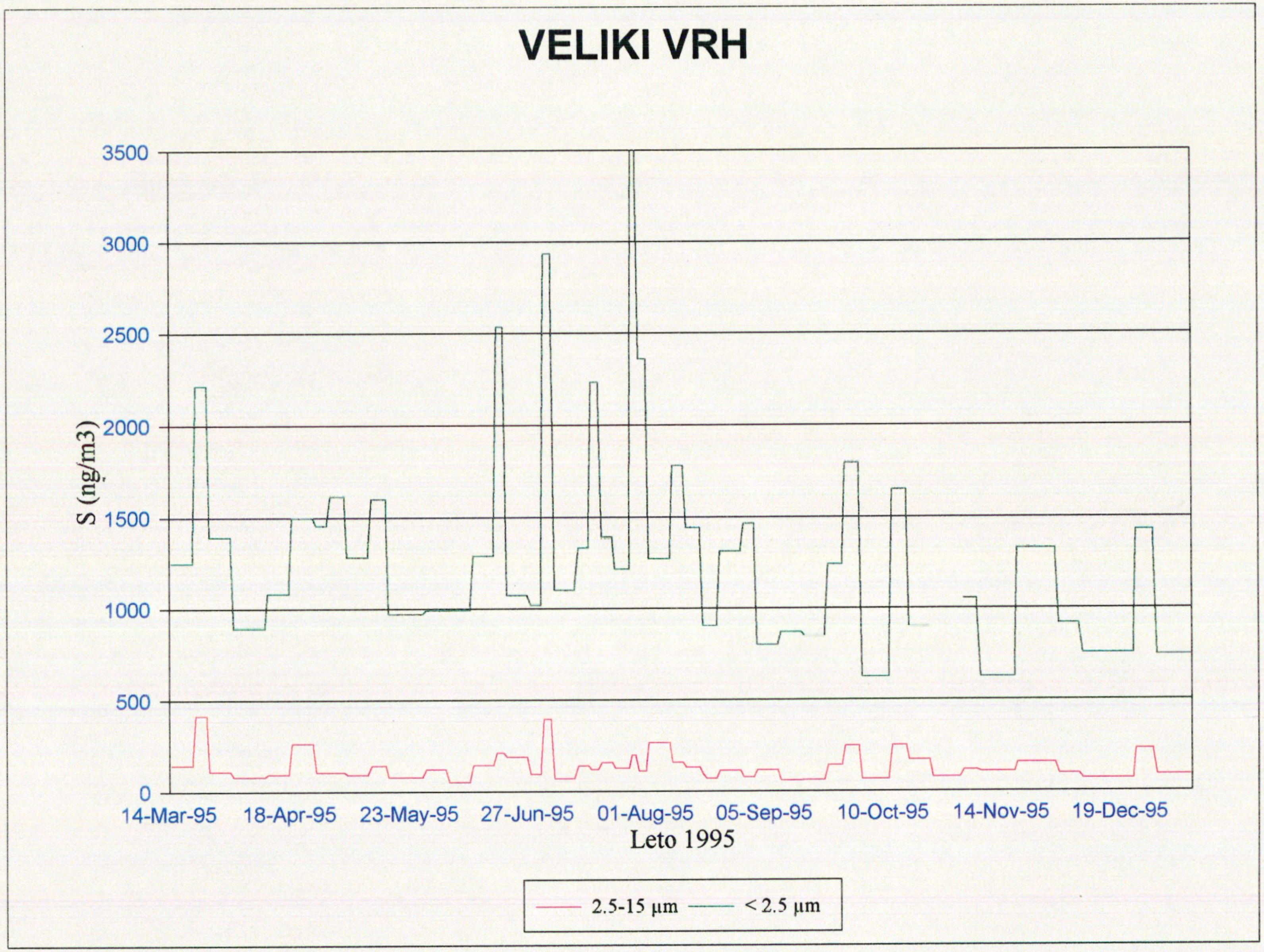
na straneh 20 in 21 koncentracije titana.

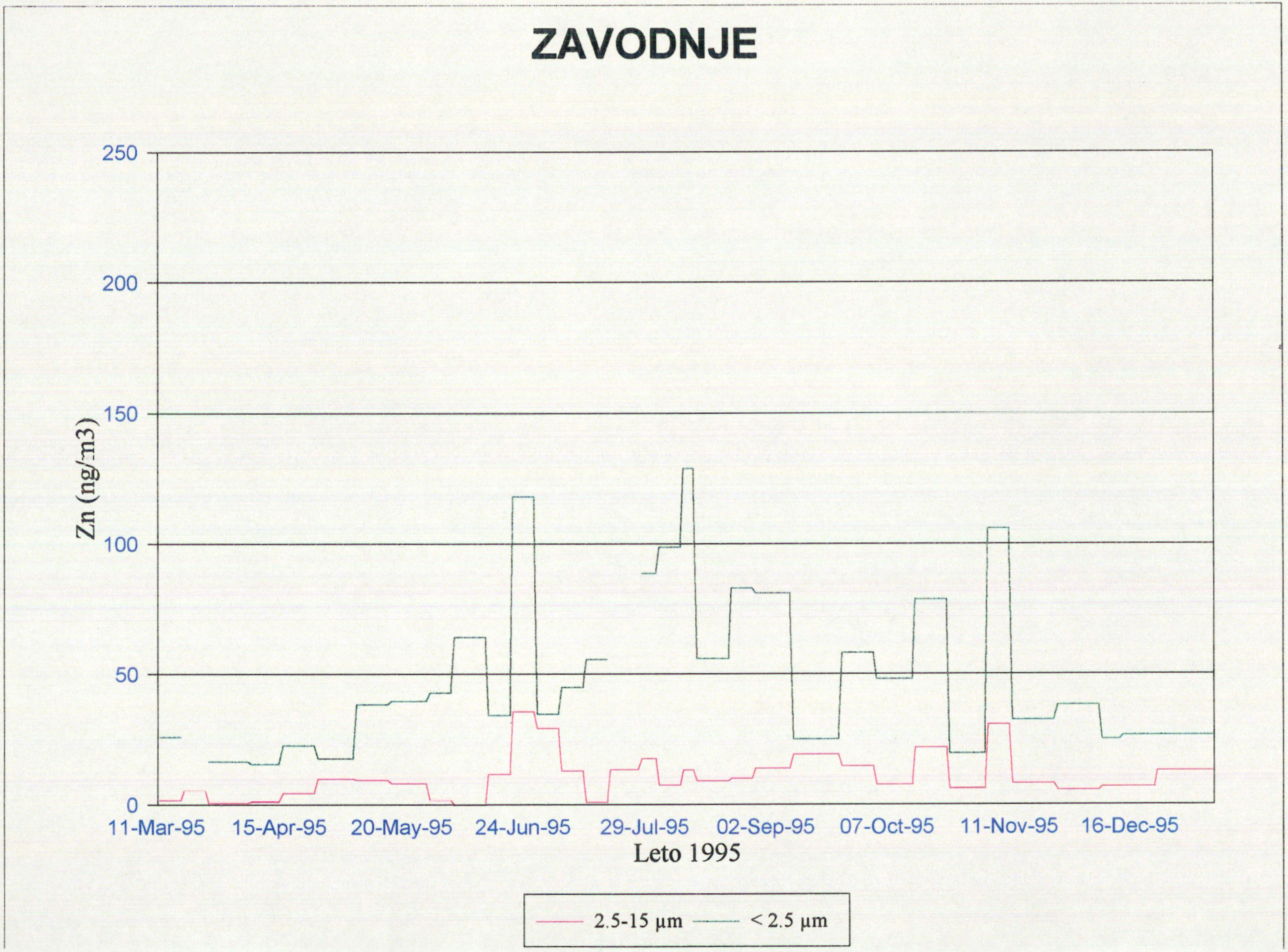
Povprečne koncentracije elementov v aerosolih.

ele.	Zavodnje respira. (ng/m3)	%	Vel. Vrh respira. (ng/m3)	%	Zavodnje inhalab. (ng/m3)	%	Vel. Vrh inhalab. (ng/m3)	%
Al	**65**	13	**53**	4	**0.3**	3	*	
Si	**45**	78	**63**	34	**53**	72	**57**	79
S	**803**	100	**1334**	100	**174**	100	**146**	100
K	**30**	69	**49**	89	**15**	94	**16**	96
Ca	**31**	100	**26**	91	**104**	100	**75**	100
V	*		*		*		*	
Ti	**2**	91	**3**	68	**4**	100	**8**	100
Cr	**116**	56	**256**	72	**6**	34	**17**	38
Mn	**95**	6	**218**	4	**11**	22	**11**	6
Fe	**255**	97	**461**	100	**109**	100	**187**	100
Ni	**39**	78	**78**	70	**2**	19	**8**	15
Cu	**41**	31	**74**	36	**3**	47	**8**	30
Zn	**34**	75	**79**	79	**7**	75	**11**	89
Pb	**52**	94	**99**	94	**11**	100	**9**	83
Sr	**15**	41	**37**	43	**3**	44	**7**	53
Zr	**15**	50	**30**	40	**3**	38	**6**	34

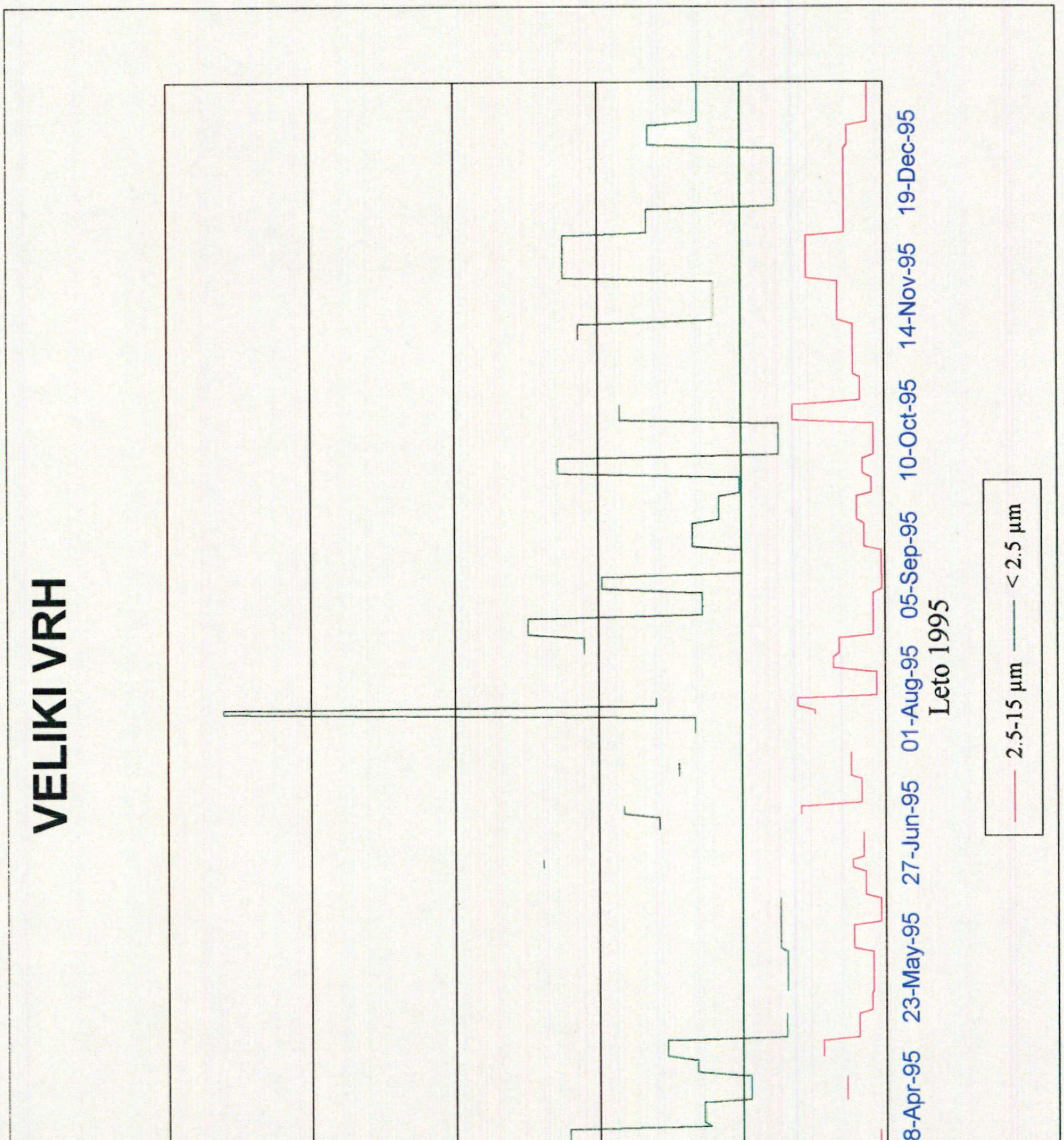
* pod mejo detekcije

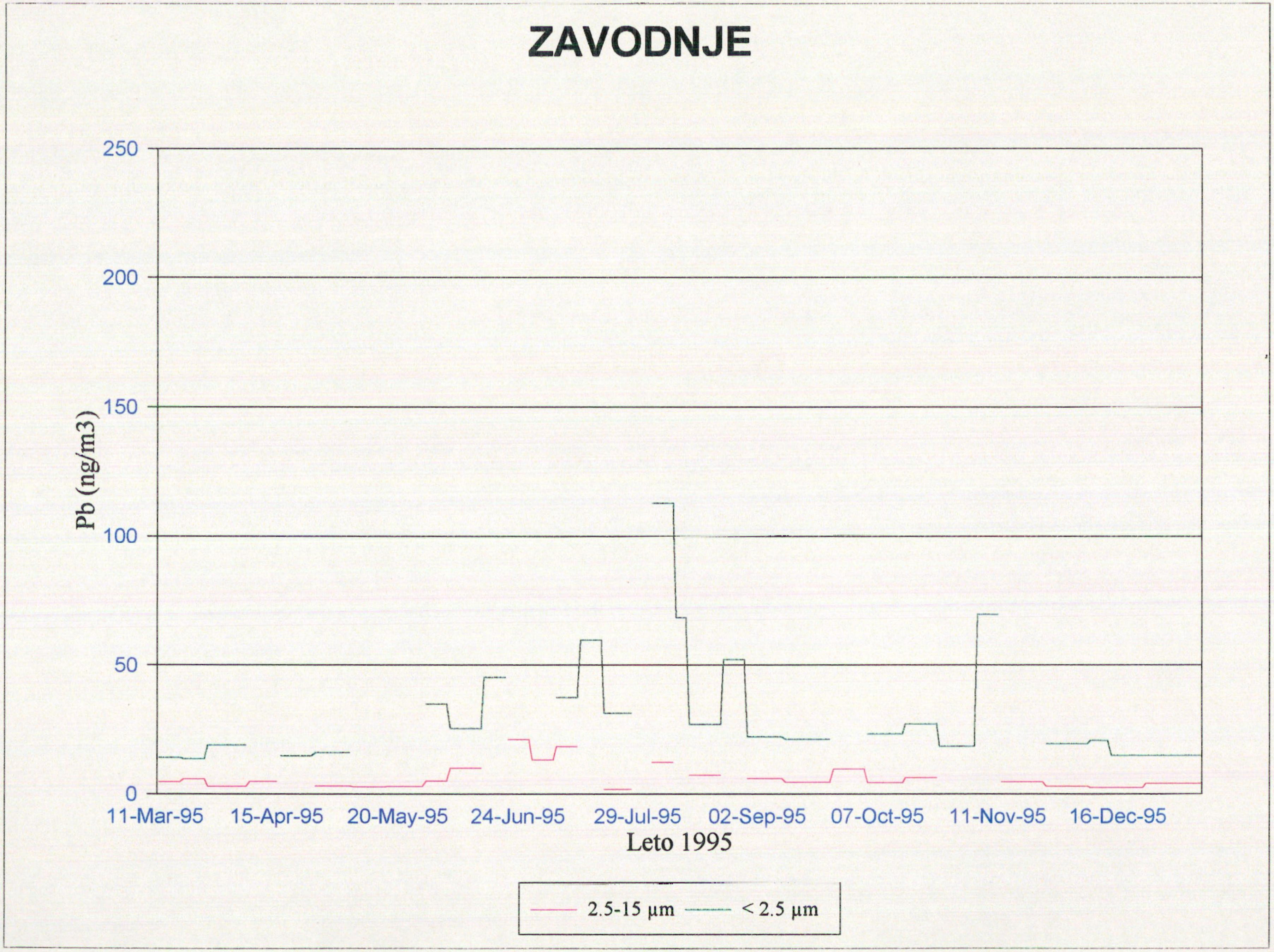

ZAVODNJE
S (ng/m3)
3500
3000
2500
2000
1500
1000
500
0
11-Mar-95
15-Apr-95
20-May-95
24-Jun-95
29-Jul-95
02-Sep-95
07-Oct-95
11-Nov-95
16-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm

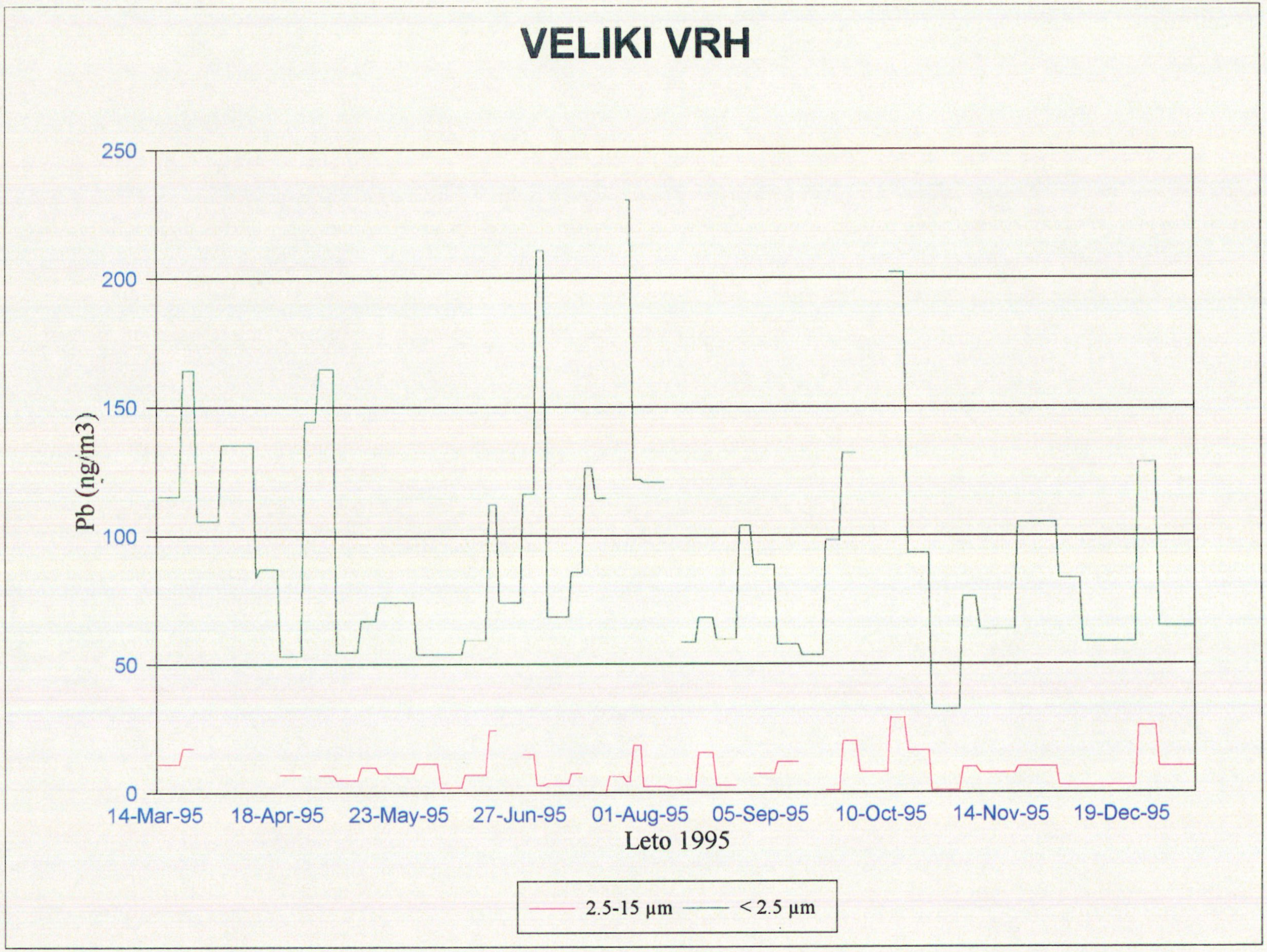

VELIKI VRH
S (ng/m3)
3500
3000
2500
2000
1500
1000
500
0
14-Mar-95
18-Apr-95
23-May-95
27-Jun-95
01-Aug-95
05-Sep-95
10-Oct-95
14-Nov-95
19-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm



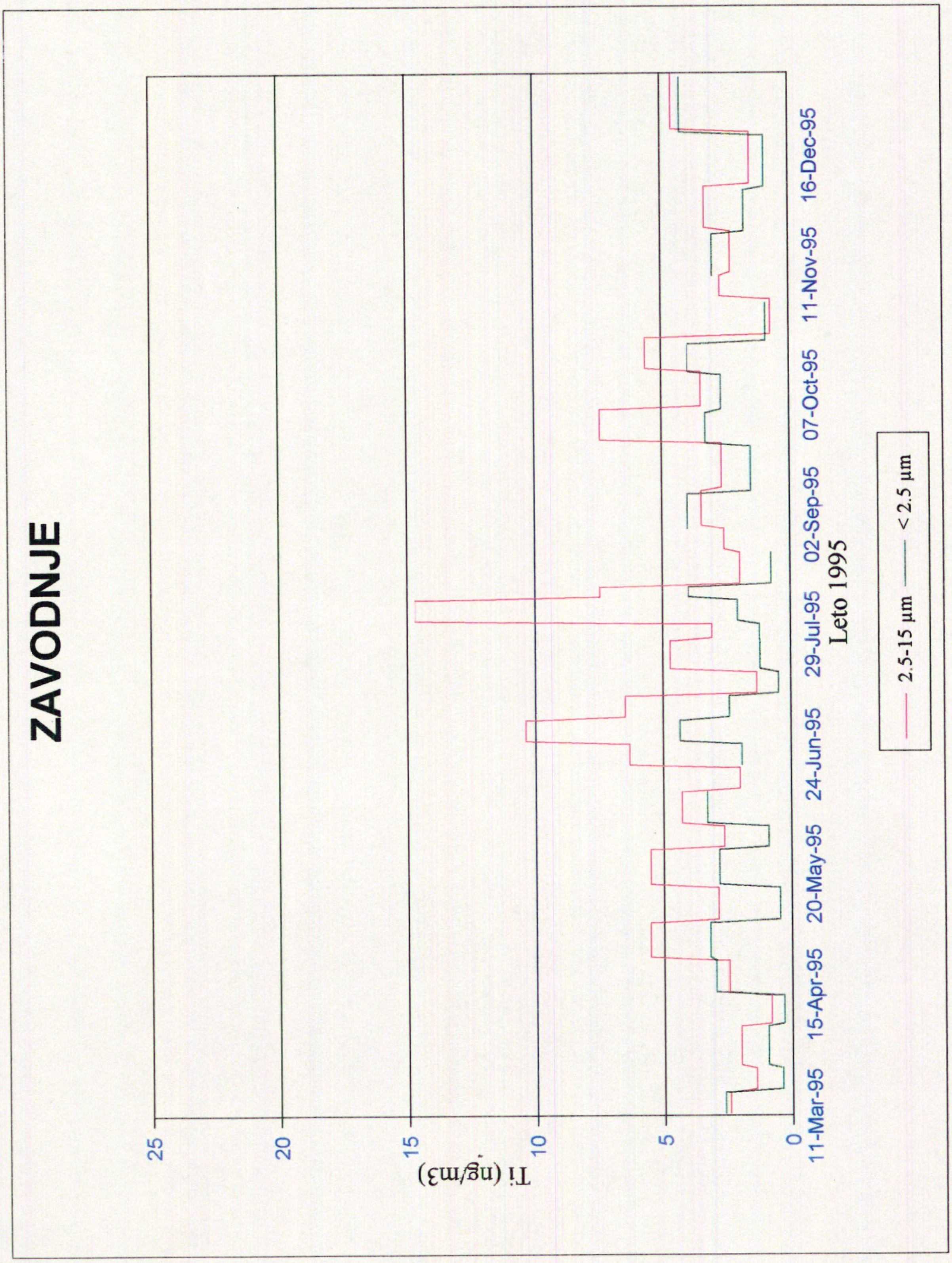
ZAVODNJE
Zn (ng/m3)
250
200
150
100
50
0
11-Mar-95
15-Apr-95
20-May-95
24-Jun-95
29-Jul-95
02-Sep-95
07-Oct-95
11-Nov-95
16-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm

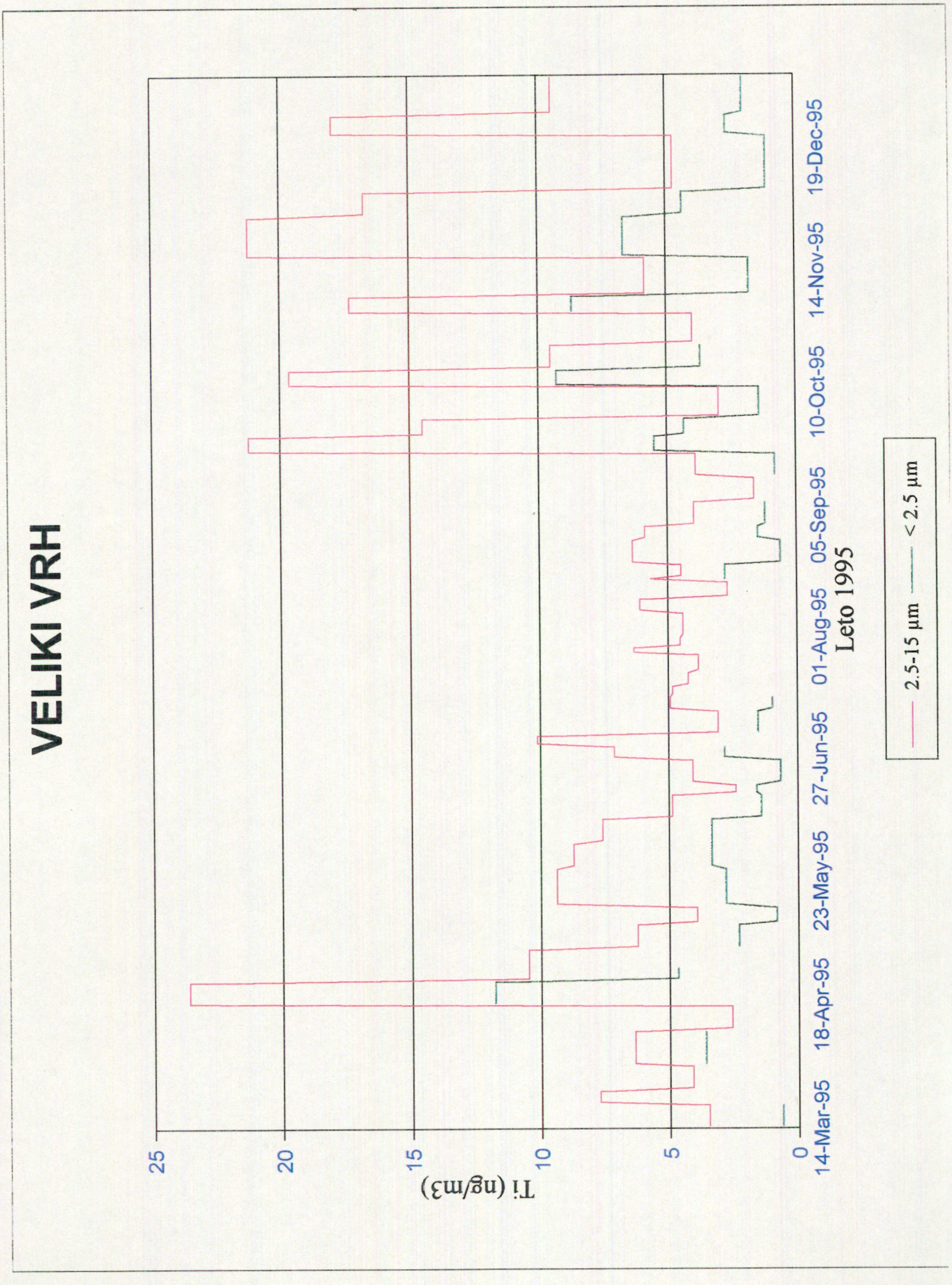

VELIKI VRH
Zn (ng/m3)
250
200
150
100
50
0
14-Mar-95
18-Apr-95
23-May-95
27-Jun-95
01-Aug-95
05-Sep-95
10-Oct-95
14-Nov-95
19-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm


ZAVODNJE
Pb (ng/m3)
250
200
150
100
50
0
11-Mar-95
15-Apr-95
20-May-95
24-Jun-95
29-Jul-95
02-Sep-95
07-Oct-95
11-Nov-95
16-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm



VELIKI VRH
Pb (ng/m3)
250
200
150
100
50
0
14-Mar-95
18-Apr-95
23-May-95
27-Jun-95
01-Aug-95
05-Sep-95
10-Oct-95
14-Nov-95
19-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm


ZAVODNJE
Ti (ng/m3)
25
20
15
10
5
0
11-Mar-95
15-Apr-95
20-May-95
24-Jun-95
29-Jul-95
02-Sep-95
07-Oct-95
11-Nov-95
16-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm


VELIKI VRH
Ti (ng/m3)
0
5
10
15
20
25
14-Mar-95
18-Apr-95
23-May-95
27-Jun-95
01-Aug-95
05-Sep-95
10-Oct-95
14-Nov-95
19-Dec-95
Leto 1995
2.5-15 µm
< 2.5 µm

3.4 Primerjava iz merjenih koncentracij elementov s priporočili WHO

Zdravniki oz. Svetovna zdravstvena organizacija, ki so pristojni za ocenjevanje vpliva onesnaženega zraka na zdravje ljudi, menijo, da vsaka, tudi komaj opazno povišana koncentracija škodljivih snovi v zraku škoduje zdravju ljudi.

Vir [21] pa je na osnovi zanesljivo ugotovljenih vplivov škodljivih snovi v okolju postavil mejne priporočene koncentracije škodljivih snovi. Mejne vrednosti so postavljene na osnovi primerov iz prakse, poleg tega pa so tudi ocenjene s faktorjem tveganja, dobljenim z raziskavami (izkušnje) v bolj obremenjenih okoljih. Za oceno ogroženosti ljudi v okolici TEŠ smo izmerjene vrednosti v tem delu primerjal z vrednostmi, ki so veljavne v naši zakonodaji, in s priporočili WHO. Naša zakonodaja kot nevarne navaja štiri elemente, priporočila WHO pa 8 elementov.

Tabela 1: Mejne in priporočene koncentracije potencialno nevarnih elementov v zraku (WHO)

Element	Koncentracija	Čas izpostav.	Faktor tveganja	Opombe
As	1 μg m^{-3}	-	3×10^{-3}	rakotvoren
Cd	1 μg m^{-3}	1 leto	$1{,}8 \times 10^{-3}$	
	0,20 μg m^{-3}	1 leto	-	varnostni faktor 10
Cr	1 μg m^{-3}	več let	4×10^{-2}	rakotvoren
Pb	0,5-1 μg m^{-3}	1 leto	-	varnostni faktor 2
Mn	1 μg m^{-3}	1 leto	-	-
Hg	1 μg m^{-3}	1 leto	-	-
Ni	1 μg m^{-3}	1 leto	4×10^{-4}	rakotvoren
V	1 μg m^{-3}	24 ur	-	-

Veljavna zakonodaja v Sloveniji [20] predpisuje mejne koncentracije Pb (1 μg/m^3), Cd (0,02 μg/m^3), Mn (1 μg/m^3) za naravno zunanje okolje kot mejne vrednosti za letno poprečje in kot 24 urno koncentracijo V (1 $\mu g/m^3$) [20].

Glavni zaključki iz ugotovljenih koncentracij preko leta so:

- Koncentracija žvepla je 10-krat višja v respirabilnih aeroslih v primerjavi z inhalabilnimi. V inhalabilnih aerosolih, aerodinamski premer med 2,5 in 15 μm, je žveplo v podobnih koncentracijah na obeh mestih. V respirabilnih aerosolih, aerodinamski premer manjši od 2,5 μm, je bilo žveplo na Velikem vrhu povišano za faktor 1,6. Razmerje med koncentracijo žvepla v respirabilni in inhalabilni frakciji je podobno koncentracijam v urbanem okolju v razvitem svetu. Nastanek sekundarnih aerosolov (sulfatni aerosol) iz SO_2, ki izvira iz TEŠ, ni dovolj hiter, da bi v prizemni plasti zraka opazili bistveno spremenjeno koncentracijo S v aerosolih v zraku. Poleti, ko pod vplivom sončnega sevanja proces transformacije poteka hitreje, je gibanje zraka bolj intenzivno. Pozimi, ko je atmosfera stabilnejša (inverzije), je proces transformacije v sulfatni aerosol počasen. Zato sklepam, da gre za vpliv globalnega onesnaženja atmosfere, ki mu na Velikem vrhu prispeva TEŠ.

- Koncentracija cinka je nizka v Zavodnjah. Na Velikem vrhu je višja za faktor 2 v respirabilnih aerosolih. V inhalabilnih aerosolih je podobna. Povečano koncentracijo lahko pripišemo lokalnemu viru, ki je v tem primeru zelo verjetno TEŠ.

- Nižja koncentracij svinca je v Zavodnjah. Na Velikem vrhu, kjer je tudi zelo malo prometa in gre v obeh primerih predvsem za transport onesnaževalcev na velike razdalje, je koncetracija svinca višja za faktor 2 v respirabilnih aerosolih. Sklepam, da je to prispevek TEŠ.

- Podobno povečanje v respirabilnih aerosolih je opazno tudi za krom, mangan, železo, kar lahko pripisujemo TEŠ in prevladujočim smerem gibanja zraka.

- Titan se pojavlja v višji koncentraciji v inhalabilnih aerosolih in to na Velikem vrhu. V inhalabilnih aerosolih na Velikem vrhu je višja koncentracija kroma, železa, niklja, bakra, cinka, svinca, stroncija in cirkonija.

3.5 EMISIJA ELEMENTOV Z DIMNIMI PLINI "TEŠ"

Pri kurjenju premoga v termoelektrarnah na mleti premog potujejo elementi iz premoga od mlinov skozi kurišče do izpusta dimnih plinov v atmosfero. Koncentracije elementov v pepelu so odvisne od temperature v kurišču, zadrževalnega časa za pepel v področju izgorevanja in od učinka delovanja elektrostatskih filtrov za izločanje pepela iz dimnih plinov. Višje temperature in daljši zadrževalni čas pepela povečajo izparevanje bolj hlapnih komponent iz kurjenega premoga oziroma pepela. V velikih kuriščih z izgorevanjem premoga v lebdeči plasti (temperatura v kurišču okoli 1 973 K, zadrževalni čas 1 - 2 h) se najmanši delci pepela bolj obogatijo z uparjenimi elementi in del teh najmanjših delcev potuje skozi filtre v dimnik. V kuriščih, kjer zmleti premogov prah hitro zgori v toku dimnih plinov (temperatura v kurišču okoli 1 625 K, zadrževalni čas 2 - 5 s), je obogatitev delcev z uparjenimi komponentami manjša [25].

V TEŠ zmleti premog zgori v toku dimnih plinov, zadrževalni čas pa je zelo kratek (kurišče v kotlu BABCOCK). Med segrevanjem in izgorevanjem premoga se poveča koncentracija uparjenih komponent v dimnih plinih.

Do dimnika se dimni plini ohlajajo v izmenjevalcu toplotne energije, ki ogreva vstopni zrak, ki gre v kurišče pomešan s premogovim prahom. Pred vstopom v elektrostatske filtre in nato v dimnik so dimni pliniohlajeni do 450 K. Pri ohlajanju dimnih plinov prihaja do procesa adsorbcije uparjenih komponent na trdnih delcih - pepelu. Količina adsorbirane komponente je odvisna od specifične površine delcev, ki je največja pri najmanjših delcih. Tako so manjši delci, ki uhajajo mimo filtrov, obogateni od večjih delcev pepela, ki jih izločijo filtri. Koncentracije elementov za vsako od stopenj vzorčevalnika so podane v za Blok 5, polje A, v tabeli na strani 25; za Blok 5, polje B, v tabeli na strani 26; za Blok 4, dimnik, prvi vzorec, v tabeli na strani 27, za Blok 4, dimnik, drugi vzorec, v tabeli na strani 28. V tabelah so določena polja označena z znakom, ki pomeni, da so bili rezultati pod mejo detekcije ali pa, da vzorci niso bili analizirani.

Koncentracije elementov po aerodinamskih premerih delcev v dimnih plinih za BLOK 5, polje A.
(Koncentracije so v mg/kg)

Element	STOPNJE								
	0	1	2	3	4	5	6	7	8
Al	92736	95636	91039	98924	92544	82030	89847	89647	40314
As	204	200	212	219	231	214	239	282	142
Au	0.13	0.16	0.14	0.066	0.031	0.20	0.035	0.19	1.57
Ba	615	599	525	535	468	373	452	538	*
Ca	70590	66150	63110	75060	53910	41420	43230	46750	*
Cd	2.94	0.22	2.64	2.49	3.62	3.78	5.48	4.68	*
Ce	89.5	86.2	81.9	89.5	89.4	74.7	85.6	92.8	*
Cl	188	206	463	*	*	*	*	*	19844
Co	*	0.18	*	9.93	17.3	15.9	16.2	*	*
Cr	*	664	*	107	186	167	144	*	7228
Cs	16.1	16.9	16.8	17.3	16.1	14.3	16.4	16.6	7.77
Dy	5.69	5.91	5.26	5.22	4.74	4.00	4.34	5.21	*
Eu	*	*	*	1.79	*	1.13	*	*	*
Fe	74270	77050	71640	76460	84920	73658	68600	60870	88980
Ga	55.1	56.8	61.2	58.8	64.6	65.5	91.3	109	*
Hf	3.00	3.09	2.70	2.85	2.40	1.87	2.13	1.93	*
Hg	*	*	*	*	*	*	*	*	*
I	*	*	*	*	18.18	*	*	*	*
In	*	0.22	0.18	0.26	0.28	0.22	0.29	*	*
K	21426	21456	21800	21789	24130	21565	25210	22585	15190
La	36.8	34.6	33.6	35.7	39.2	32.6	39.3	39.6	*
Mg	57420	64480	60170	66820	58620	57310	57570	53690	32770
Mn	996	1011	837	941	772	636	689	778	1346
Mo	49.7	162	147	144	149	135	155	168	1201
Na	11212	11610	11890	12093	13393	12114	13925	13313	8961
Nd	38.5	36.6	43.32	43.05	39.9	34.4	36.4	22.4	*
Ni	121	59.6	22.9	30.3	43.6	40.3	30.0	*	*
Pb	71.3	66.9	24.7	32.0	31.3	23.9	28.4	*	*
Rb	165	186	182	181	175	161	182	170	*
Sb	21.9	19.7	17.8	20.3	18.3	14.3	14.9	17.7	27.2
Sc	17.5	17.7	16.5	18.3	17.6	14.2	15.4	15.9	7.19
Se	38.4	22.8	20.9	12.2	9.19	8.98	12.5	41.5	47.6
Sm	5.85	5.84	5.20	5.58	5.62	4.53	5.45	5.70	2.85
Sn	*	*	*	*	*	*	*	*	*
Sr	320	433	413	407	365	298	446	751	*
Ta	*	1.15	1.05	0.99	0.97	0.73	0.81		*
Tb	1.18	0.91	0.81	0.81	0.67	0.60	0.78	0.66	*
Th	13.2	13.8	12.7	14.1	12.4	10.5	11.9	12.5	*
Ti	*	*	3132	6009	3999	3974	4600	*	*
Tm	*	1.31	*	1.11	1.14	*	*	*	*
U	23.7	24.3	24.7	27.2	23.4	20.5	26.6	29.7	*
V	217	220	246	259	251	248	346	437	189
W	21.7	14.7	8.54	8.86	9.17	9.81	12.0	11.0	*
Yb	2.91	3.04	2.76	3.01	2.43	1.96	2.16	2.41	*
Zn	1432	1269	1132	1102	1134	1016	1149	1209	1679
Zr	*	*	*	381	301	282	307	*	*

* - pod mejo detekcije

Koncentracije elementov po aerodinamskih premerih delcev v dimnih plinih za BLOK 5, polje B.
(Koncentracije so v mg/kg)

Ele-ment	STOPNJE								
	0	1	2	3	4	5	6	7	8
Al	107034	107133	104209	106389	102237	101155	99585	98502	31694
As	236	205	206	241	263	265	274	266	90.3
Au	0.51	0.11	0.13	0.037	0.024	0.027	0.034	1.76	1.46
Ba	712	544	523	492	498	476	510	565	1345
Ca	52310	49490	42660	40640	35990	30100	31970	37680	*
Cd	5.43	1.72	2.29	3.05	3.51	8.56	12.37	16.19	*
Ce	99.4	92.0	92.3	94.1	95.0	90.8	101	95.5	*
Cl	*	*	*	*	*	*	*	*	25865
Co	*	4.26	2.72	17.0	19.3	19.0	18.7	*	57.4
Cr	*	405	212	213	232	232	220	*	14638
Cs	19.4	18.1	17.7	18.6	19.5	18.5	19.7	18.1	*
Dy	6.02	4.92	5.33	5.01	4.28	3.90	3.76	4.75	*
Eu	*	*	*	1.71	1.63	1.62	2.06	*	*
Fe	83784	74290	70260	77099	89560	85228	73367	61557	89130
Ga	64.7	55.3	54.9	61.8	71.4	80.9	97.6	84.1	*
Hf	2.83	2.98	2.66	2.78	2.56	2.48	2.52	2.57	*
Hg	2.316	*	*	*	*	*	*	*	*
I	*	*	*	*	*	*	*	*	139.7
In	*	0.16	*	0.31	0.32	0.35	0.35	*	*
K	28004	24298	24402	26212	28094	26904	29160	24780	7324
La	45.6	40.5	38.8	41.6	44.3	42.1	47.1	43.6	*
Mg	75410	62930	66150	64910	58330	60001	61770	65480	23130
Mn	996	971	928	882	743	681	680	675	1248
Mo	169	140	177	152	163	160	175	165	1021
Na	11203	9784	9639	10092	11055	10954	11744	10117	4141
Nd	53.1	39.4	60.0	43.7	44.5	42.6	47.2	47.5	*
Ni	50.1	21.5	68.3	39.1	34.9	n.a.	n.a.	n.a.	n.a.
Pb	152	23.9	63.6	33.3	31.8	n.a.	n.a.	n.a.	n.a.
Rb	204	193	185	194	207	198	213	188	*
Sb	16.1	14.2	15.2	15.3	14.8	13.4	13.5	15.0	22.2
Sc	19.9	19.0	18.9	18.6	17.8	15.7	16.1	15.1	4.58
Se	36.9	30.7	29.2	15.6	14.8	15.6	17.3	69.7	118
Sm	6.70	5.91	5.92	6.27	6.23	5.99	6.42	5.95	2.28
Sn	*	*	*	*	*	*	*	*	*
Sr	*	333	374	332	361	363	379	370	*
Ta	1.23	1.13	0.83	0.94	0.97	0.90	0.85	1.05	*
Tb	0.86	0.93	0.98	0.80	0.73	0.65	0.67	0.94	*
Th	14.2	13.4	13.5	13.8	13.6	12.7	14.0	13.4	4.90
Ti	4950	*	*	4316	4310	3371	4384	*	*
Tm	1.67	*	*	0.46	0.55	1.17	*	*	*
U	25.8	23.9	25.0	25.0	25.6	24.2	27.6	27.6	*
V	248	217	221	249	250	268	308	325	125
W	13.6	9.23	7.37	8.40	9.60	8.72	12.5	9.74	29.5
Yb	3.18	2.62	2.60	2.64	2.49	2.19	2.28	2.33	
Zn	2221	1741	1749	1943	2146	2097	2162	2009	1533
Zr	*	*	*	363	315	339	386	*	*

* - pod mejo detekcije
n.a. - ni analizirano

Koncentracije elementov po aerodinamskih premerih delcev v dimnih plinih za BLOK 4, dimnik, prvi vzorec.
(Koncentracije so v mg/kg)

Element	STOPNJA								
	0	1	2	3	4	5	6	7	8
Al	58506	54924	77387	105859	98226	96271	89189	98565	71430
As	135	124	149	189	187	183	173	210	154
Au	1.07	1.55	1.19	0.26	0.20	0.23	0.12	4.68	2.98
Ba	931	505	718	696	494	406	458	582	411
Ca	*	39970	67040	47380	33730	30630	33350	45950	*
Cd	*	7.56	n.a.	11.6	n.a.	n.a.	n.a.	n.a.	n.a.
Ce	71.3	53.3	78.7	93.1	86.7	81.5	90.3	105	92.9
Cl	10202	5748	2170	*	*	*	*	*	4834
Co	*	*	*	7.78	15.3	16.0	14.8	*	*
Cr	*	*	*	243	158	153	136	*	*
Cs	11.2	9.86	12.3	16.8	16.8	16.6	17.4	19.2	21.8
Dy	4.28	4.90	5.01	5.84	5.16	4.65	4.16	5.07	2.73
Eu	*	*	*	*	1.65	1.43	*	1.61	*
Fe	60570	56290	64890	78100	79607	79840	68650	65400	82070
Ga	*	*	38.8	48.4	56.5	57.0	63.5	75.3	80.5
Hf	*	2.58	2.65	2.52	2.16	1.91	2.13	2.34	*
Hg	455	20.4	112	2.43	1.18	0.94	1.53	2.87	*
I	*	*	*	*	*	*	*	*	*
In	*	*	*	0.21	0.23	0.33	0.29	0.27	*
K	15920	14810	19356	24242	25445	25556	25522	26610	20240
La	27.4	20.3	33.3	39.9	39.8	39.2	39.7	44.2	28.2
Mg	46600	40260	55710	71190	63530	63560	58490	62400	43300
Mn	686	559	863	869	725	662	600	702	838
Mo	178	449	182	143	121	113	126	150	159
Na	7851	7219	10382	10440	10761	10787	10682	11108	9853
Nd	*	*	*	41.0	36.7	39.2	42.6	44.6	*
Ni	*	934	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pb	*	186	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rb	*	98.5	111	178	184	180	190	196	197
Sb	*	10.3	13.3	14.1	12.9	12.0	11.0	14.2	15.4
Sc	10.9	10.9	14.8	18.6	17.4	15.8	15.0	16.8	16.6
Se	155	184	170	27.5	13.0	13.7	16.2	38.0	96.6
Sm	3.38	3.29	4.39	5.81	5.41	5.09	5.14	5.56	4.42
Sn	*	*	*	*	*	*	*	*	*
Sr	*	*	*	370	321	286	352	533	*
Ta	*	*	*	1.20	0.92	0.81	0.78	1.00	*
Tb	*	*	*	0.79	0.72	0.63	0.62	0.85	*
Th	5.30	7.89	10.2	12.9	12.1	11.5	12.2	14.0	10.4
Ti	5510	*	5159	6250	4379	5198	3748	*	6610
Tm	*	*	*	*	*	0.52	0.75	*	*
U	*	14.1	17.2	20.8	19.9	18.8	20.3	23.4	18.5
V	175	111	182	240	231	258	249	342	239
W	10.8	20.5	5.70	8.27	8.25	8.05	7.22	7.20	*
Yb	*	*	2.26	2.55	2.43	1.99	2.15	2.49	*
Zn	1679	1626	1158	1197	1202	1159	1212	1391	1719
Zr	*	*	*	*	397	251	279	*	*

* - pod mejo detekcije
n.a. - ni analizirano

Koncentracije elementov po aerodinamskih premerih delcev v dimnih plinih za BLOK 4, dimnik, drugi vzorec.
(Koncentracije so v mg/kg)

Element	STOPNJA								
	0	1	2	3	4	5	6	7	8
Al	64299	88697	88285	107647	85539	103225	102544	94882	73526
As	184	222	167	213	174	255	252	273	213
Au	7.24	0.57	2.37	0.98	0.28	0.29	0.24	1.59	4.70
Ba	*	546	646	496	355	491	423	506	*
Ca	*	69030	62840	44940	29740	33720	44860	47160	63900
Cd	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ce	35.20	83.85	76.09	88.79	65.84	91.97	99.41	103	95.13
Cl	7812	1658	1974	*	*	*	*	713	4633
Co	*	*	*	*	8.21	17.5	15.7	*	*
Cr	10809	*	*	*	53.6	164	106	*	*
Cs	9.40	15.9	14.7	17.9	12.9	18.3	19.0	19.2	16.6
Dy	*	5.45	5.07	5.54	3.72	4.24	4.54	5.50	4.12
Eu	*	*	*	1.75	1.23	1.51	1.04	*	*
Fe	139900	78830	63250	73690	60388	87690	76860	64940	73630
Ga	*	26.4	34.1	51.9	42.1	63.3	69.0	81.0	65.8
Hf	*	2.00	2.38	2.50	1.81	2.42	2.54	2.38	*
Hg	*	4.54	7.88	1.99		0.62	0.77	2.54	*
I	*	*	*	*	*	*	*	*	*
In	*	*	*	0.21	0.23	0.32	0.30	0.30	*
K	18780	22875	18595	22916	18008	27041	28295	26992	25210
La	*	33.04	31.77	40.79	29.84	43.35	44.81	44.09	34.60
Mg	44810	63440	58940	65020	51440	61730	70810	63550	47190
Mn	1683	898	859	927	624	695	658	670	620
Mo	437	188	139	123	102	147	156	160	238
Na	10047	12131	8926	11026	8534	12928	13541	12703	11121
Nd	*	68.0	*	44.7	30.1	44.5	47.6	36.6	*
Ni	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Pb	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rb	*	168	156	180	140	198	213	209	235
Sb	46.4	19.4	11.5	13.1	10.3	13.6	14.1	15.2	16.0
Sc	10.7	17.0	15.9	18.6	13.0	17.1	17.0	16.9	16.8
Se	280	84.8	193	39.5	15.6	21.0	25.5	49.0	91.4
Sm	4.00	4.71	5.51	6.10	4.30	6.04	5.66	5.40	4.73
Sn	*	*	*	*	*	*	114	*	*
Sr	*	*	*	350	270	380	424	517	*
Ta	*	*	*	0.93	0.68	0.90	0.98	1.27	*
Tb	*	0.93	*	0.99	0.55	0.71	0.75	0.81	*
Th	12.1	11.8	11.2	13.5	9.50	13.1	13.8	14.4	13.5
Ti	6404	6860	4590	*	3361	4505	4777	3802	5110
Tm	*	*	*	0.63	0.44	0.62	0.74	*	*
U	16.5	26.4	20.3	22.8	16.0	22.8	25.9	28.6	18.3
V	199	239	187	237	197	250	286	339	235
W	37.3	8.88	5.14	8.04	5.53	8.21	8.17	9.76	*
Yb	*	2.32	2.81	2.66	1.78	2.47	2.31	2.48	3.49
Zn	2349	1360	1343	1252	978	1414	1520	1543	1618
Zr	*	*	*	*	264	347	193	*	*

* - pod mejo detekcije
n.a. - ni analizirano

Poprečno koncentracijo elementov za pepel v dimniku smo izračunali kot vsoto prispevkov posameznih frakcij glede na maso posamezne frakcije po posameznem vzorčevanju (4 vzorčenja). Koncentracije, ki so bile pod mejo detekcije analizne metode nismo upoštevali. Tako smo s seštevanjem prispevka vsebnosti elementov posameznih frakcij pepela v dimnih plinih dobili najvišjo koncentracijo v dimnih plinih (označeno z nagnjeno pisavo). Pomeni, da je bila dejanska koncentracija manjša od izračunane. Podatki so v tabeli na strani 30.

Povprečni koncentraciji elementov v dimnih plinih za Blok 5 v času vzorčenja so izračunane za izstop iz elektrostatskih filtrov, polje A in polje B (skupno dva vzorca). Povrečni koncentraciji za Blok 4 so izračunane za dva vzorca odvzeta iz dimnika Bloka 4.

Iz povprečij vseh štirih vzorcev je izračunana povprečna emisija elementov s pepelom v dimnih plinih TEŠ, brez upoštevanja razlik masi emitiranih delcev skozi posamezne dimnike. Emisijo elementov s pepelom v dimnih plinih za eno leto smo izračunali z upoštevanjem skupne letne mase emitiranega pepela iz TEŠ [7] izmerjeno z avtomatskimi meritvami. Rezultati so v tabeli na strani 30, na desni v zadnjem stolpcu. Vsebnost hlapnih komponent elementov v dimnih plinih ni upoštevana.

Za primerjavo z veljavnimi predpisi smo koncentracije elementov v pepelu iz dimnih plinov na izstopu iz elektrostatskih filtrov oz. dimnikov preračunali na koncentracije v enem prostorninskem metru dimnih plinov. Za masno koncentracijo pepela v dimnih plinih smo upoštevali povprečno koncentracijo pepela na Bloku 5 v času odvzema vzorcev, ki je znašala 285 mg/m^3 pri normalnih pogojih in 7 % vsebnosti kisika v dimnih plinih. Rezultati so v tabeli na strani 31. V isti tabeli so na desni podane predpisane vrednosti. Vidimo, da koncentracije elementov v dimnih plinih ne dosegajo predpisanih najvišjih koncentracij, ki veljajo za Termoelektrarno Šoštanj.

Povprečna koncentracija elementov v vzorcih in emisija iz TEŠ v letu 1994.
(Koncentracije so v mg/kg)

Element	Blok 5		Blok 4		Povprečne konc. (mg/kg)	Emisija (kg/leto)
	Polje A (mg/kg)	Polje B (mg/kg)	Vz. 1 (mg/kg)	Vz. 2 (mg/kg)		
Al	88505	102085	95268	98265	96031	472183
As	224	259	182	231	224	1102
Au	0.11	0.06	0.35	0.45	0.24	1
Ba	*443*	498	476	*443*	*465*	*2287*
Ca	*49325*	*34798*	*34375*	*38302*	*39200*	*192747*
Cd	*3.96*	*6.76*	*11.47*	*	*7.40*	*36*
Ce	*82.9*	*94.6*	87.0	87.6	*88.0*	*433*
Cl	*668*	*25865*	*672*	*1634*	*7210*	*35450*
Co	*15.3*	*18.0*	*14.7*	*14.3*	*15.6*	*77*
Cr	*188*	*257*	*158*	*154*	*189*	*929*
Cs	*15.7*	*19.0*	16.9	17.2	*17.2*	*84*
Dy	*4.48*	*4.24*	4.75	*4.38*	*4.46*	*22*
Eu	*1.25*	*1.73*	*1.53*	*1.32*	*1.46*	*7*
Fe	75393	82305	75767	76012	77369	380425
Ga	*70.5*	*77.1*	*58.6*	*58.8*	*66.3*	*326*
Hf	*2.21*	*2.58*	*2.11*	*2.31*	*2.30*	*11*
Hg	*	*2.32*	*3.11*	*1.10*	*2.18*	*11*
I	*18.2*	*140*	*	*	*78.9*	*388*
In	*0.25*	*0.33*	*0.28*	*0.29*	*0.29*	*1*
K	23033	27380	25339	24754	25126	123546
La	*36.2*	*43.5*	39.6	*40.1*	*39.8*	*196*
Mg	58657	60977	62521	62025	61045	300158
Mn	729	746	681	693	712	3502
Mo	145	164	124	139	143	704
Na	12806	10916	10709	11837	11567	56874
Nd	*37.1*	*44.6*	*39.9*	*42.0*	*40.9*	*201*
Ni	*39.1*	*37.3*	*934*	*	*337*	*1655*
Pb	*29.3*	*35.2*	*186*	*	*83.4*	*410*
Rb	*172*	*202*	*184*	*187*	*186*	*916*
Sb	16.3	14.2	*12.2*	13.2	*14.0*	*69*
Sc	15.8	17.0	16.21	16.2	16.3	80
Se	11.6	17.5	18.12	27.5	18.7	92
Sm	5.17	6.17	5.25	5.47	5.51	27
Sn	*	*	*	*114*	*114*	*561*
Sr	*369*	*360*	*330*	*369*	*357*	*1754*
Ta	*0.83*	*19.0*	*0.87*	*0.89*	*5.40*	*27*
Tb	*0.70*	*0.72*	*0.67*	*0.71*	*0.70*	*3*
Th	*11.8*	13.4	12.0	12.5	*12.4*	*61*
Ti	*4270*	*4027*	*4662*	*4317*	*4319*	*21237*
Tm	*1.14*	*0.79*	*0.63*	*0.61*	*0.79*	*4*
U	*23.5*	*25.4*	*19.8*	22.3	*22.8*	*112*
V	272	266	249	249	259	1273
W	*10.4*	9.69	*7.89*	*7.69*	*8.91*	*44*
Yb	*2.27*	*2.39*	*2.21*	2.28	*2.29*	*11*
Zn	1101	2082	1200	1335	1429	7028
Zr	*302*	*345*	*303*	*274*	*306*	*1504*

* - pod mejo detekcije
nnn - ocenjena vrednost

Koncentracije elementov v prostorninskem metru dimnih plinov pri normalnih pogojih in vsebnosti pepela 285 mg/m^3.
(Koncentracije so v mg/m^3)

Element	Blok 5		Blok 4		Povprečne konc. (mg/m3)	Mejne konc. (mg/m3)
	Polje A (mg/m3)	Polje B (mg/m3)	Vz. 1 (mg/m3)	Vz. 2 (mg/m3)		
Al	3.28E+01	4.09E+01	3.82E+01	3.85E+01	3.76E+01	
As	8.31E-02	1.04E-01	7.31E-02	9.03E-02	8.76E-02	1.50E+00
Au	4.11E-05	2.56E-05	1.42E-04	1.76E-04	9.62E-05	
Ba	*1.64E-01*	2.00E-01	1.91E-01	*1.74E-01*	*1.82E-01*	
Ca	*1.83E+01*	*1.39E+01*	*1.38E+01*	*1.50E+01*	*1.53E+01*	
Cd	*1.47E-03*	*2.71E-03*	*4.60E-03*	*	*2.19E-03*	1.50E+00
Ce	*3.07E-02*	*3.79E-02*	3.49E-02	3.43E-02	*3.44E-02*	
Cl	*2.47E-01*	*1.04E+01*	*2.70E-01*	*6.40E-01*	*2.88E+00*	
Co	*5.68E-03*	*7.23E-03*	*5.91E-03*	*5.62E-03*	*6.11E-03*	1.50E+00
Cr	*6.95E-02*	*1.03E-01*	*6.33E-02*	*6.02E-02*	*7.40E-02*	1.50E+00
Cs	*5.80E-03*	*7.61E-03*	6.80E-03	6.71E-03	*6.73E-03*	
Dy	*1.66E-03*	*1.70E-03*	1.91E-03	*1.72E-03*	*1.75E-03*	
Eu	*4.62E-04*	*6.92E-04*	*6.15E-04*	*5.17E-04*	*5.71E-04*	
Fe	2.79E+01	3.30E+01	3.04E+01	2.98E+01	3.03E+01	
Ga	*2.61E-02*	*3.09E-02*	*2.35E-02*	*2.30E-02*	*2.59E-02*	
Hf	*8.19E-04*	*1.03E-03*	*8.47E-04*	*9.03E-04*	*9.00E-04*	
Hg	*	*9.28E-04*	*1.25E-03*	*4.31E-04*	*6.52E-04*	
I	*6.74E-03*	*5.60E-02*	*	*	*1.57E-02*	
In	*9.45E-05*	*1.32E-04*	*1.13E-04*	*1.14E-04*	*1.13E-04*	
K	8.54E+00	1.10E+01	1.02E+01	9.69E+00	9.84E+00	
La	*1.34E-02*	*1.74E-02*	1.59E-02	*1.57E-02*	*1.56E-02*	
Mg	2.17E+01	2.44E+01	2.51E+01	2.43E+01	2.39E+01	
Mn	2.70E-01	2.99E-01	2.73E-01	2.71E-01	2.78E-01	
Mo	5.39E-02	6.57E-02	4.99E-02	5.45E-02	5.60E-02	
Na	4.75E+00	4.37E+00	4.30E+00	4.63E+00	4.51E+00	
Nd	*1.38E-02*	*1.79E-02*	*1.60E-02*	*1.64E-02*	*1.60E-02*	
Ni	*1.45E-02*	*1.49E-02*	*3.75E-01*	*	*1.01E-01*	1.50E+00
Pb	*1.09E-02*	*1.41E-02*	*7.45E-02*	*	*2.49E-02*	1.50E+00
Rb	*6.39E-02*	*8.10E-02*	*7.37E-02*	*7.31E-02*	*7.29E-02*	
Sb	6.05E-03	5.70E-03	*4.89E-03*	5.16E-03	*5.45E-03*	
Sc	5.86E-03	6.80E-03	6.51E-03	6.35E-03	6.38E-03	
Se	4.31E-03	6.99E-03	7.27E-03	1.08E-02	7.33E-03	
Sm	1.92E-03	2.47E-03	2.11E-03	2.14E-03	2.16E-03	
Sn	*	*	*	*4.46E-02*	*1.12E-02*	
Sr	*1.37E-01*	*1.44E-01*	*1.32E-01*	*1.44E-01*	*1.39E-01*	
Ta	*3.09E-04*	*7.61E-03*	*3.49E-04*	*3.47E-04*	*2.15E-03*	
Tb	*2.58E-04*	*2.88E-04*	*2.69E-04*	*2.79E-04*	*2.74E-04*	
Th	*4.36E-03*	5.37E-03	4.83E-03	4.88E-03	*4.86E-03*	
Ti	*1.58E+00*	*1.61E+00*	*1.87E+00*	*1.69E+00*	*1.69E+00*	
Tm	*4.24E-04*	*3.17E-04*	*2.52E-04*	*2.40E-04*	*3.08E-04*	
U	*8.70E-03*	*1.02E-02*	*7.96E-03*	8.72E-03	*8.89E-03*	
V	1.01E-01	1.06E-01	9.99E-02	9.74E-02	1.01E-01	
W	*3.84E-03*	3.88E-03	*3.17E-03*	*3.01E-03*	*3.47E-03*	
Yb	*8.43E-04*	*9.57E-04*	*8.89E-04*	8.94E-04	*8.96E-04*	
Zn	4.08E-01	8.34E-01	4.82E-01	5.23E-01	5.62E-01	
Zr	*1.12E-01*	*1.38E-01*	*1.22E-01*	*1.07E-01*	*1.20E-01*	

* - pod mejo detekcije
nnn - ocenjena vrednost
Mejne koncentracije - Uradni list Republike Slovenije št. 73/1994

3.6 Primerjava rezultatov

V letu 1993, je bila emisija določena z enim vzorčenjem. Sedaj, ko imamo štiri nove vzorce se lahko emisija elementov skozi dimnik bolj zanesljivo oceni. Z posnetek stanja pred obratovanjem naprave za razžveplanje dimnih plinov je smiselno upoštevati podatke o izmerjeni emisiji leta 1993 in 1994, ker se dopolnjujejo.

V letu 1993 je po TEŠ skozi vse dimnike skupno izpustila v okolico (ocena na osnovi enega vzorca), kot pepel v dimniku okoli 874 kg As, 4 650 kg Pb, 59 kg Cd, (Cr ni bil pravilno določen), 315 kg Co, (Ni ni bil določen).

V letu 1994 je TEŠ skozi vse dimnike skupno izpustila v okolico (ocena na osnovi enega vzorca), kot pepel v dimniku okoli 1 100 kg As, 410 kg Pb, 36 kg Cd, 929 kg Cr, 77 kg Co in 1 660 kg Ni.

Razlike med oceno iz leta 1993 in 1994 so pri svincu, kromu in kobaltu. Zaradi ponovljivosti rezultatov pri vzorcih iz leta 1994 je ocena emisije elementov z dimnimi plini za leto 1994 veliko bolj zanesljiva.

Geokemijska masna bilanca nakazuje relativno veliko emisijo Hg v atmosfero iz termoelektrarn na fosilna goriva [22]. TEŠ letno emitira z dimnimi plini okoli 0,6 t Hg. V dimnih plinih je okoli 95 % od vsega Hg, kar je primerljivo z rezultati raziskav v svetu. Za primerjavo v našem okolju sem vzel rudnik in proizvodnjo Hg v Idriji (sedaj v zapiranju), kjer je bila ugotovljena letna emisija okoli 20 kg na dan ali 7 t na leto.

Eden od pomembnih elementov v pepelu je tudi uran in njegovi potomci - radionuklidi ^{226}Ra, ^{210}Pb in ^{210}Po, kot je razvidno iz Tabel. EFP vsebuje okoli 360 Bq kg^{-1} (okoli 30 mg kg^{-1}) ^{238}U in prav tako ^{226}Ra, kar pomeni, da je relativno velik vir radona in izlužljivega ^{226}Ra. Zaradi tega sta odlagališče pepela in emisija pepela skozi dimnike pomembna tudi z radiološkega vidika. Iz Tabele je razvidno, da sta ^{238}U in ^{226}Ra podobno razporejena v vzorcih premoga in pepela in da je z analizo vzorca pepela dobljena koncentracija zelo blizu 340 Bq kg^{-1}, ki je bila prej že večkrat izmerjena v vzorcih iz odlagališča pepela TEŠ [23]. V zadnjem poročilu UNSCEAR [24], v katerem ugotavljajo, da termoelektrarne na premog emitirajo radioaktivne snovi v okolje, so v dimniku faktorji obogatitve za neuparjene radionuklide ^{238}U in njegove razpadno vrsto (^{238}U, ^{226}Ra) med 3 in 5 za ^{210}Pb in ^{210}Po. Glede na realativino visoko začetno vsebnost ^{238}U in ^{226}Ra v premogu in pepelu iz TEŠ pričakujem tudi relativno veliko emisijo ^{210}Pb in ^{210}Po skozi dimnik (v programu raziskav).

4 SKLEPI

Uporabljene tehnike vzorčenja aerosolov v okolici TEŠ so bile primerljive z tehnikami, ki jih uporabljajo v svetu. Mesta opazovanja imisijskih koncentracij aerosolov, Zavodnje in Veliki vrh, so enaka, kot jih zajema obstoječi avtomatski ekološki nadzorni sistem.

Za ugotavljanje neposrednega vpliva TEŠ na koncentracije elementov v zraku njene okolice smo izvedli izokinetično vzorčenje delcev v dimnih plinih s kaskadnim impaktorjem MARK II, postavljenem v samem dimniku za Blok 4 in na izstopu iz elektrostatskih filtrov Bloka 5. Pepel, ki ga elektrarna spušča v atmosfero, smo glede na aerodinamski premer delcev razdelili na devet stopenj.

Z večelementno analizno tehniko k_o-INAA (46 elementov) smo analizirali vsako frakcijo pepela iz dimnih plinov posebej. Kadmij, svinec in nikelj smo določili z ETAAS.

Kot večelementno, nedestruktivno analizno tehniko za aerosole smo izbrali EDXRF z izotopi za vzbujanje vzorcev in s programom AXIL za kvalitativno in kvantitavino analizo spektrov. Metoda je dovolj občutljiva glede na izbrano metodologijo vzorčenja in zahteve veljavne zakonodaje ter priporočene mejne koncentracije WHO. Metoda EDXRF je pri koncentracijah elementov v zraku okolice TEŠ in pri uporabi izvedenega vzorčenja najbolj zanesljiva za določitev S, K, Ca, Ti, V, Cu in Pb. Zanesljivost rezultatov, dobljenih z EDXRF, smo preverili z analizo ustreznih referenčnih materialov, BCR, NIST in s krožno analizo IAEA.

Pomembna prednost uporabe EDXRF pred k_o-INAA za analize aerosolov v okolici TEŠ je dovolj dobra zanesljivost za S in Pb. Določanje S pa je tudi velika prednost pred uporabo AAS za aerosole v okolici termoelektrarn, ki izpuščajo v zrak znatne količine SO_2 in pri raziskavah o onesnaženosti zraka, kjer so podatki o S pomembni.

Primerjava rezultatov kaže, da je okolje v Šaleški dolini manj onesnaženo kot urbano okolje v razvitih državah, kjer izvajajo podobne raziskave že vrsto let. Masne koncentracije aeroslov niso bile presežene. Na Velikem vrhu je bila koncentracija aeroslov za faktor 2 višja od tiste v Zavodnjah.

Z upoštevanjem podatkov o izpustu pepela v atmosfero preko dimnikov smo izračunali - ocenili celoletne količine izpuščenih elementov v atmosfero. Rezultati so primerljivi s podatki iz raziskav v svetu. Najmanjši delci pepela v dimnih plinih so bili najbolj obogateni z zdravju škodljivimi elementi, Cr, Zn, As, Cd, Mo, Co, Se in Pb. Radioaktivna elementa U in Th se koncentrirata v pepelu, ne glede na velikost delcev. Glede na relativno visoko povečano naravno koncentracijo ^{238}U in ^{226}Ra v premogu ocenjujem, da je povečana tudi emisija ^{210}Pb in ^{210}Po skozi dimnik.

Največje dovoljene koncentracije elementov As, Pb, Cd, Cr, Co in Ni v dimnih plinih niso bile presežene.

Veljavna zakonodaja v naši državi [20] predpisuje največje dopustne letne poprečne koncentracije trdnih delcev, kadmija, svinca, mangana in vanadija v zraku. Izmerjeni podatki, preračunani na letne poprečne vrednosti, so pokazali, da v letu 1994 zrak, ki ga ljudje dihajo v okolici TEŠ, ni bil prekomerno onesnažen glede na veljavno zakonodajo [20]. Koncentracije elementov v zraku, so bile nekajkrat nižje od največjih dovoljenih. Za vanadij je bilo upoštevano letno povprečje. Zaradi poznavanja emisje ostalih elementov iz TEŠ je praktično nemogoče, da bi lahko v 24 urah zabeležili preseganje 24-urne mejene vrednosti.

Sklepam, da zaradi koncentracij aerosolov in koncentracij potencialno nevarnih kemijskih elementov v okolici TEŠ ni pričakovati opaznih negativnih vplivov na zdravje ljudi. Izvzeti so ljudje z obolenji dihalnih organov.

Naprava za razžveplanje dimnih plinov vpliva pozitivno na emisijo elementov z dimnimi plini. Emisija je zmanjšana zaradi izboljšanega delovanja elektrostatskih filtrov in pranja dimnih plinov v procesu razžveplanja, ko se temperatura plinov zniža. Po pričakovanjih je sprememba tako lahko zelo opazna, kar je poleg žveplovega dioksida za okolico TEŠ zelo pomembno.

Potrebna je potrditev oz. preverjanje rezultatov o emisiji iz dimnikov TEŠ. V ta namen je nujno večkrat ponoviti vzorčenje v dimnikih iz dveh največjih enot (Blok 4 in Blok 5) TEŠ tako, da bodo zajeti različni režimi obratovanja. Še posebej pomembno je ugotoviti razlike med Bloka 4 pred in po obratovanju razžveplevalne naprave.

Za identifikacijo virov in raziskavo neposrednega vpliva dimnih plinov in drugih onesnaževalcev na ožje omejeno področje v vplivnem območju TEŠ bi morali uvesti zelo kratek vzorčevalni čas in uporabiti bolj občutljive analizne tehnike v kombinaciji z registracijo smeri in hitrosti vetra. Najboljši pogoji za tovrstne meritve so na obstoječih postajah (Šoštanj), kjer so na voljo podatki o smeri in hitrosti vetra, kar je običajno pri usmerjenem opazovanju glede na veter. Po razpoložljivih podatkih pa bi bilo smiselno začetek in konec vzorčenja zraka, ki prihaja iz smeri dimnika, vezati na izmerjeno koncentracijo SO_2 v obstoječih avtomatskih merilnih postajah.

5 Viri

[1] Tuncel g. *Black sea aerosols* IAEA Co-ordinated Research Programme on the Use of Nuclear Related Techniques in the Study of Environmental Pollution Asociated with Solid Wastes, IAEA, Vienna, (1991)

[2] Mamane Y. and Noll K. E. *Characterization of Large Particles at a Rural Site in the Eastern United States: Mass Distribution and Individual Particle Analysis,* Atmos. Environ., Vol. 19, No. 4, pp. 611-622 (1985)

[3] Nriagu J. O. and Davidson C. I. *Toxic Metals in the Atmosphere,* John Wiley & Sons Inc. (1986)

[4] Lipman M., Yates D. B. and Albert R. E., *Deposition, retention and clearance of inhaled particles.* British J. Ind. Med., Vol. 37, 337-362 (1980)

[5] Stahlhofen W., Gebhard J. and Heyder J., *Experimental determination of the regional deposition of aerosol particles in the human respiratory tract* Am. Ind. Hyg. Ass. J., Vol 41, 6/80, (1980).

[6] Arthur C. S. *Air Pollution,* Third Edition, Vol. VIII (1986)

[7] Dejanovič B. et al., *Letno poročilo za leto 1994*, Bilten (1995)

[8] Hrček D. in sodelavci, *Onesnaženost zraka v Sloveniji april 1991 - marec 1992*, MVO RS, Hidrometeorološki zavod Republike Slovenije (1992)

[9] Maenhaut W., Kauppinen E. I., Lind T. M., *Study of size-fractionated coal combustion aerosols using instrumental neutron activation analysis* J. of Radioan. Nucl. Chem., Articles 167/2, 259-269, (1993)

[10] Kauppinen E. I., Pakkanen T. A., *Coal combustion aerosols: a field study* Environ. Sci. Technol, 24/12, 1819-1824 (1990)

[11] Jervis R. E. and Pringle T. G. *Aerosol Characterization and Apportionment Using Cascade Impactors and Activation Analysis,* J. Radioanal. Nucl. Chem., Articles Vol. 123 321-332 (1988)

[12] Kim D. S., Hopke P. K., Casuccio G. S., Lee R. J., Miller S. E., Sverdrup G. M. and Garber R. W. *Comparison of Particles Taken From the* ESP *and Plume of a Coal - Fired Power Plant with Background Aerosol Particles,* Atmos. Environ., Vol. 23, No. 1, pp. 81 - 84 (1989)

[13] Hanson H. C., Nyman S. *Microcomputer - Controlled Two Size Fractionating Aerosol Sampler for Outdoor Environments,* Environ. Sci. Technol., Vol. 19, No. 11 (1985)

[14] Stropnik B., Byrne A. R., Smodiš B. *Air Pollution Monitoring by EDXRF in the Šalek Valley: Part 1*, Acta Chim. Slove., Vol. 40/4 (1993)

[15] Stropnik B., Byrne A. R., Smodiš B., Jaćimović R. *Air Pollution Monitoring in the Šalek Valley, Part 2: Elemental Composition of Size-Fractionated Lignite Coal-Combustion Particles During Šoštanj TPP Operation* , Acta Chim. Slove., Vol. 41/1 (1994)

[16] Smodiš B., *Reactor Neutron Activation Analysis Using k_o-Standardization Method. Part I: Theory and Experimental Considerations* Vestnik Slov. Kem. Druš. 39/4, 503-519 (1992)

[17] Smodiš B. *Študij in razvoj k_o -Standardizacijske metode za nevtronsko aktivacijsko analizo bioloških in ekoloških vzorcev*, Univerza v Ljubljani, FNT kemija in kemijska tehnologija, Disertacija, Ljubljana (1991)

[18] Smodiš B., Stropnik B. *Use of Nuclear-Related Analytical Techniques in Studies of Trace and Minor Elements in Air Pollution* Analyst (1994), V tisku.

[19] Stropnik B., Smodiš B., Jaćimović R., Stegnar P., IAEA Co-ordinated Research Programme on the Use of Nuclear Related Techniques in the Study of Environmental Pollution Asociated with Solid Wastes, IAEA, Vienna, (1991)

[20] Uradni list RS, št. 73/94. *Uredba o mejnih, opozorilnih in kritičnih imisijskih vrednostih snovi v zraku*, (1994)

[21] Air Quality Guidelines for Europe, *WHO regional publications, European series*; No. 23, ISBN 92-890-1114-9, WHO, Copenhagen (1987)

[22] Nriagu J. O., *Natural versus anthropogenic emissions of trace metals to the atmosphere, in Control and Fate of Atmospheric Trace Metals*, Pacyna J. M. and Ottar B., Eds., Elsevier, Amsterdam (1989)

[23] Stegnar P., Stropnik B., Jedovnicky M., Křižman M., Ribarič - Lasnik C., Mljač L., Flis J., *Končno poročilo "Ocena emisije škodljivih snovi iz bodočega odlagališča pepela in odžveplevalnih produktov na okolico in imisijske koncentracije škodljivih snovi v okolici odlagališča "*, Institut "Jožef Stefan" Ljubljana - DP 6593 (1992)

[24] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1988 Report, United Nations, New York, 1988, (1990)

[25] Stropnik B., *Analiza aerosolov in njihov vpliv v okolici Termoelektrarne Šoštanj*, Univerza v Ljubljani, FNT, Disertacija, (1994)

6 Zahvala

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II. RAZISKAVA ONESNAŽENOSTI SUHEGA IN MOKREGA DEPOZITA V ŠALEŠKI DOLINI PRED PRIČETKOM OBRATOVANJA OdŽVEPLEVALNE NAPRAVE V TERMOELEKTRARNI ŠOŠTANJ

RAZISKAVA ONESNAŽENOSTI SUHEGA IN MOKREGA DEPOZITA V ŠALEŠKI DOLINI PRED PRIČETKOM OBRATOVANJA ODŽVEPLEVALNE NAPRAVE V TERMOELEKTRARNI ŠOŠTANJ

mag. Marta SVETINA, dipl. ing. geol.

VSEBINA

1. NAMEN IN CILJ RAZISKAV

Glavni namen raziskav je, s široko zastavljenim monitoringom okolja oceniti stanje v ekosistemu in napovedati njegove spremembe glede na vpliv zračnega onesnaženja.

V ekološkem smislu je bil namen raziskave ločiti naravne ekološke variacije od antropogenih vplivov na ekosistem kot posledice delovanja zračnih onesnaževalcev.

Cilji naloge pa so:

- Ugotoviti stanje ekosistema in razložiti spremembe v njem glede na vpliv TEŠ in s tem izoblikovati znanstveno podlago za bodočo kontrolo (monitoring) vpliva polutantov na okolje.
- Primerjati dobljeno stanje z že obstoječimi podatki iz svetovne literature.
- S pomočjo meritev na referenčni točki posebej identificirati onesnaževalce, ki so posledica daljinskega transporta.

2. PODROBEN OPIS ZNANSTVENIH METOD

Glede na podobne raziskave v svetu [1,2] in na mednarodna navodila za integralni monitoring okolja [3] smo se odločili za vzorčevanje suhega in mokrega depozita skupaj.

Vzorčevali smo na dveh imisijsko najbolj obremenjenih lokacijah v Velenjski občini (Zavodnje in Veliki vrh) in na referenčni lokaciji v Podvolovljeku. Lokacija Veliki vrh je v bližini TEŠ, le 2m zračne razdalje, lokacija Zavodnje 8 km in primerjalna lokacija Podvolovljek 35 km zračne razdalje od elektrarne. Na teh lokacijah stojijo tudi postaje Analitično nadzornega alarmnega sistema (ANAS), kjer se opravljajo še druge ekološke meritve.

Vzorce suhega in mokrega depozita smo lovili v posebne vzorčevalnike, izdelane po mednarodnih hidrometeoroloških merilih [4]. Vzorec prestreže lijak v posebno vzorčevalno posodo. Zbiralna posoda je shranjena v posebej za to izdelanem termostetiranem ohišju. Vzorce padavin smo pobirali enkrat mesečno, od junija 1992 do konca leta 1994.

S k_0-bazično metodo nevtronske aktivacijske analize (INAA) smo v vzorcih filtrata, filtrov in tal določili približno 45 elementov.

Vzorci so bili obsevani skupaj s kosom Au-Al (0,1 % Au) žice in Zr folijo, ki sta služila kot komparator in monitor spektra nevtronov [5]. Vzorci so bili obsevani do dvajset ur v vrtiljaku reaktorja TRIGA Mark II Instituta "Jožef Stefan" v Podgorici. Meritve induciranih aktivnosti so bile opravljene na polprevodniških germanijevih detektorjih. Vsak vzorec je bil izmerjen dvakrat: prvič tri dni po obsevanju eno uro in drugič po sedmih dneh 20-25 ur. Na ta način lahko določimo, odvisno od vrste vzorca, približno 30-40 elementov. Za določitev elementov, katerih radionuklidi nastali po (n, gama) reakciji imajo relativno kratek razpolovni čas (Al, Cl, Dy, I, In, Mn, Mg, V in Ti), so bili vzorci obsevani samo 2-5 minut. Takoj po končanem obsevanju je bil vsak vzorec merjen po 60 in 300 sekund, po eni uri 1200 sekund in po dveh urah 3600 sekund. Posamezni spektri gama so bili po končani meritvi preneseni z večkanalnega analizatorja Canberra Series 90 na osebni računalnik in obdelani s programom ROMOS. Detajlnejši opis metode je v disertaciji Smodiša [6].

Meje zaznavnosti INAA za posamezne vrste vzorcev so prikazane v preglednici 1.

Zanesljivost rezultatov, dobljenih s k_0- standardizacijsko metodo nevtronske aktivacijske analize na Odseku za jedrsko kemijo Instituta "Jožef Stefan", smo preverili z analizo referenčnih materialov podobne sestave kot vzorci. Dobljeni rezultati so predstavljeni za vzorce vod v preglednici 2.

Preglednica I. Meje zaznavnosti INAA (TRIGA mark II reaktor IJS, = 2 x 10^{12} n/cm^{2}s).

Element	*Vzorec vode* [µg/l]	*Neraztopljeni delci* [µg/g]	*Vzorec tal* [µg/g]
Ag	0.3	0.4	---
Al	4	---	---
As	0.2	0.4	---
Au	---	0.0005	0.0006
Ba	11	5	5
Br	0.3	0.7	---
Ca	570	180	180
Ce	0.2	0.1	0.1
Cl	20	---	---
Co	0.03	0.05	0.03
Cr	0.5	0.1	0.02
Cs	0.08	0.06	0.04
Dy	0.05	---	---
Eu	---	0.1	0.05
Fe	50	74	17
Ga	---	1.4	4
Hf	---	0.03	0.03
Hg	0.2	0.09	---
K	40	123	460
La	0.1	0.3	0.04
Mg	130	---	---
Mn	0.07	---	---
Mo	---	0.2	0.3
Na	0.7	1.6	5
Nd	0.05	1.3	1.3
Rb	1.6	0.8	0.7
Re	---	---	0.01
Sb	0.05	0.07	0.03
Sc	0.006	0.005	0.004
Se	---	0.2	---
Sm	0.01	0.04	0.05
Sn	---	---	3
Sr	18	14	12
Ta	---	0.03	0.01
Tb	---	0.03	0.02
Th	---	0.02	0.02
Tm	---	0.04	0.03
U	0.1	0.04	0.1
V	0.3	---	---
W	---	---	0.7
Yb	---	0.02	0.03
Zn	2.6	1.4	1
Zr	---	20	14

Preglednica 2. Koncentracije elementov v standardu NIST SRM 1643c "Trace Elements in Water"; n - število vzorcev, LoD - spodnja meja zaznavnosti.

Element	Enota	n	Ugotovljeno:	Certificirano:
Ag	μg/l	9	2.44 ± 0.36	2.21 ± 0.3
Al	μg/l	2	124 ± 8	114.6 ± 5.1
As	μg/l	9	88.6 ± 3.3	82.1 ± 1.2
Ba	μg/l	11	53.9 ± 7.6	49.6 ± 3.1
Be	μg/l	---	< *LoD*	23.2 ± 2.2
Br	μg/l	6	4.53 ± 0.62	---
Ca	mg/l	9	38.2 ± 1.09	36.8 ± 1.4
Cd	μg/l	8	14.4 ± 1.9	12.2 ± 1.0
Cl	mg/l	3	4.49 ± 0.05	---
Co	μg/l	9	24.4 ± 4.4	23.5 ± 0.8
Cr	μg/l	9	20.9 ± 0.6	19.0 ± 0.6
Fe	μg/l	8	124 ± 28	106.9 ± 3.0
Hg	μg/l	5	0.51 ± 0.13	---
K	mg/l	10	2.43 ± 0.16	2.30
Mg	mg/l	3	10.0 ± 0.4	9.45 ± 0.27
Mn	μg/l	3	35.0 ± 0.5	35.1 ± 2.2
Mo	μg/l	10	104 ± 5	104.3 ± 1.9
Na	mg/l	9	12.4 ± 0.2	12.19 ± 0.36
Ni	μg/l	---	< *LoD*	606.0 ± 7.3
Pb	μg/l	---	< *LoD*	353.0 ± 0.9
Rb	μg/l	10	12.1 ± 1.4	11.4 ± 0.2
Sb	μg/l	6	0.223 ± 0.049	---
Se	μg/l	10	14.2 ± 0.5	12.7 ±0.7
Sm	μg/l	7	0.0275 ± 0.0057	---
Sr	μg/l	11	278 ± 14	264.0 ± 2.6
Ta	μg/l	2	0.061 ± 0.017	0.079
Tb	μg/l	2	0.066 ± 0.001	---
Tm	μg/l	4	0.012 ± 0.004	---
U	μg/l	2	0.139 ± 0.028	---
V	μg/l	3	31.1 ± 3.1	31.4 ± 2.8
Zn	μg/l	8	83.9 ± 2.5	73.9 ± 0.9

3. UGOTOVITVE

3.1. Rezultati

V preglednicah 3, 4 in 5 so predstavljene povprečne letne koncentracije elementov v padavinah na Velikem vrhu, ki je v neposredni bližini TEŠ, v Zavodnjah, ki so prav tako v vplivnem območju TEŠ (7 km zračne razdalje), in na primerjalni lokaciji Podvolovljek.

Letne povprečne vrednosti za leto 1992/93 so dobljene kot aritmetična sredina mesečnih koncentracij. Standardni odmik od povprečnih vrednosti je precejšen, kar je posledica spremenljivih meteoroloških pogojev in majhnega števila vzorcev. V nekaterih primerih odstopanja niso navedena, ker smo analizirali le en vzorec.

Za leto 1994 smo zaradi zmanjšanja finančnih sredstev za raziskave mesečne vzorce sproti zamrzovali, nato pa smo iz njih naredili skupni letni vzorec za vsako lokacijo posebej in ga analizirali. Na ta način smo naredili le eno analizo vsakega vzorca, v tabeli je navedena kot plus-minus vrednost napaka meritve.

V preglednicah so za posamezne elemente navedene tudi tipične koncentracije v padavinah na neurbanih področjih. Za mnogo elementov teh vrednosti nismo uspeli dobiti. Vrednosti smo povzeli iz podobnih študij v Nemčiji [1,7], v Kanadi Š8], na Bermudskih otokih [9] in drugje po svetu [10].

Preglednica 3. Povprečne letne koncentracije elementov v padavinah, določene z INAA, na lokacijah Zavodnje, Veliki vrh in Podvolovljek; LoD - spodnja meja zaznavnosti.

Lokacija	Leto	Ca [mg/l]	K [mg/l]	Mg [mg/l]	Cl [mg/l]	Na [mg/l]
Veliki vrh	1992/93	4.8 ± 2.6	0.754 ± 0.73	1.83	0.618	0.99 ± 0.76
	1994	1.1 ± 0.3	0.091 ± 0.017	0.432 ± 0.03	0.303 ± 0.033	0.15 ± 0.02
Zavodnje	1992/93	2.44 ± 0.93	0.644 ± 0.22	0.668	0.455	0.35 ± 0.19
	1994	---	0.148 ± 0.025	---	---	0.188 ± 0.002
Podvolovljek	1992/93	4.9 ± 3.5	2.5 ± 2.7	1.92	1.16	0.81 ± 0.95
	1994	1.37 ± 0.3	0.455 ± 0.03	0.392 ± 0.025	0.627 ± 0.023	0.315 ± 0.002
Podatki iz literature		0.20 - 4.54	0.41	0.12 - 1.87	0.09 - 1.6	0.07 - 0.76

Lokacija	Leto	Al [mg/l]	Fe [mg/l]	Mn [μg/l]	Zn [μg/l]	Ba [μg/l]
Veliki vrh	1992/93	0.12 ± 0.08	0.92 ± 0.35	40.5	85 ± 87	31.8 ± 19.1
	1994	0.399 ± 0.004	0.32 ± 0.043	8.29 ± 0.2	19.1 ± 2.4	< LoD
Zavodnje	1992/93	0.084 ± 0.057	0.50 ± 0.43	17.1	51 ± 12	15.5 ± 4.7
	1994	---	---	---	20.4 ± 1.9	< LoD
Podvolovljek	1992/93	0.033 ± 0.015	0.46 ± 0.19	12.9	78.9 ± 34.1	25.0 ± 21.3
	1994	0.237 ± 0.04	0.256 ± 0.035	9.8 ± 0.2	20.8 ± 2.0	< LoD
Podatki iz literature		0.044 - 0.081	0.03 - 0.2	3 - 41	18 - 54	2 - 12

Lokacija	Leto	Cu [μg/l]	Br [μg/l]	Rb [μg/l]	Pb [μg/l]	Mo [μg/l]
Veliki vrh	1992/93	25.2 ± 14.3	13.4 ± 18.7	6.2 ± 2.6	9.84 ± 6.92	3.5 ± 3.2
	1994	< LoD	9.0 ± 0.1	< LoD	---	< LoD
Zavodnje	1992/93	18.5 ± 3.7	5.2 ± 1.9	3.1 ± 1.1	11.3 ± 6.8	0.83 ± 0.37
	1994	< LoD	8.86 ± 0.2	< LoD	---	< LoD
Podvolovljek	1992/93	17.6 ± 11.5	13.4 ± 24.6	9.0 ± 5.9	7.98 ± 2.06	6.4 ± 8.2
	1994	< LoD	9.82 ± 0.15	< LoD	---	< LoD
Podatki iz literature		1.8 - 22.0	6 - 9	---	5 - 28	7

Preglednica 4. Povprečne letne koncentracije elementov v padavinah, določene z INAA, na lokacijah Zavodnje, Veliki vrh in Podvolovljek; LoD - spodnja meja zaznavnosti.

Lokacija	Leto	Co [μg/l]	V [μg/l]	Cr [μg/l]	Zr [μg/l]	Sr [μg/l]
Veliki vrh	1992/93	2.61 ± 0.56	7.33	3.56 ± 1.10	2.0 ± 1.1	1.03 ± 0.78
	1994	< LoD	1.66 ± 0.09	1.52 ± 1.21	< LoD	< LoD
Zavodnje	1992/93	0.060 ± 0.046	2.36	2.15 ± 0.65	2.0 ± 1.1	0.78 ± 0.86
	1994	< LoD	---	0.83 ± 0.59	< LoD	< LoD
Podvolovljek	1992/93	4.3 ± 4.2	2.2	2.6 ± 1.1	2.18 ± 1.69	1.06 ± 0.95
	1994	< LoD	0.95 ± 0.067	0.736 ± 0.465	< LoD	< LoD
Podatki iz literature		0.01 - 0.56	0.1 - 1.2	0.07 - 0.70	---	---

Lokacija	Leto	As [μg/l]	Se [μg/l]	Cd [μg/l]	Ce [μg/l]	La [μg/l]
Veliki vrh	1992/93	3.6 ± 2.5	1.26 ± 1.20	16.2 ± 25.3	1.39 ± 0.64	0.69 ± 0.15
	1994	0.754 ± 0.044	< LoD	---	< LoD	0.222 ± 0.043
Zavodnje	1992/93	1.16 ± 0.67	0.55 ± 0.19	0.46 ± 0.15	0.62 ± 0.25	0.36 ± 0.11
	1994	0.391 ± 0.054	< LoD	---	< LoD	< LoD
Podvolovljek	1992/93	0.953 ± 0.460	0.542 ± 0.083	0.48 ± 0.24	0.82 ± 0.37	0.54 ± 0.26
	1994	0.284 ± 0.04	< LoD	---	0.428 ± 0.21	0.2 ± 0.04
Podatki iz literature		0.29	---	0.3 - 2.1	---	---

Lokacija	Leto	Hg [μg/l]	Sb [μg/l]	Hf [μg/l]	Re [μg/l]	Nd [μg/l]
Veliki vrh	1992/93	0.31 ± 0.23	0.46 ± 0.28	0.046 ± 0.030	0.074 ± 0.05	0.22 ± 0.14
	1994	< LoD	0.091 ± 0.014	< LoD	< LoD	< LoD
Zavodnje	1992/93	0.31 ± 0.18	0.252 ± 0.076	0.032 ± 0.032	0.003 ± 0.004	0.158 ± 0.147
	1994	< LoD	0.0158 ± 0.025	< LoD	< LoD	< LoD
Podvolovljek	1992/93	0.36 ± 0.51	0.34 ± 0.23	0.044 ± 0.048	0.197	0.23 ± 0.18
	1994	< LoD	0.125 ± 0.015	< LoD	< LoD	< LoD
Podatki iz literature		0.04	0.3	---	---	---

Preglednica 5. Povprečne letne koncentracije elementov v padavinah, določene z INAA, na lokacijah Zavodnje, Veliki vrh in Podvolovljek; LoD - spodnja meja zaznavnosti.

Lokacija	Leto	Au [μg/l]	Ga [μg/l]	U [μg/l]	Dy [μg/l]	Tm [μg/l]
Veliki vrh	1992/93	0.025 ± 0.070	1.73 ± 0.65	1.2 ± 1.7	0.15	0.252± 0.03
	1994	< LoD	< LoD	0.11 ± 0.021	< LoD	< LoD
Zavodnje	1992/93	0.002 ± 0.001	0.184 ± 0.142	0.148 ± 0.030	< LoD	0.071 ± 0.006
	1994	< LoD	< LoD	< LoD	< LoD	< LoD
Podvolovljek	1992/93	0.001 ± 0.001	0.25 ± 0.13	0.142 ± 0.043	0.114	0.099 ± 0.042
	1994	0.0015 ± 0.0006	< LoD	0.138 ± 0.024	< LoD	< LoD
Podatki iz literature		---	---	---	---	---

Lokacija	Leto	Cs [μg/l]	Ag [μg/l]	Th [μg/l]	Sm [μg/l]	Yb [μg/l]
Veliki vrh	1992/93	0.26 ± 0.21	0.072 ± 0.063	0.41 ± 0.39	0.22 ± 0.33	0.191 ± 0.178
	1994	< LoD	< LoD	< LoD	0.031 ± 0.004	< LoD
Zavodnje	1992/93	0.154 ± 0.055	0.025 ± 0.024	0.11 ± 0.09	0.062 ± 0.031	0.034 ± 0.015
	1994	< LoD	< LoD	< LoD	0.018 ± 0.002	< LoD
Podvolovljek	1992/93	0.132 ± 0.068	0.030 ± 0.035	0.125 ± 0.095	0.062 ± 0.027	0.052 ± 0.019
	1994	< LoD	< LoD	< LoD	0.039 ± 0.0048	< LoD
Podatki iz literature		---	---	---	---	---

Lokacija	Leto	W [μg/l]	Tb [μg/l]	Sc [μg/l]	Sn [μg/l]	Ta [μg/l]
Veliki vrh	1992/93	0.045 ± 0.028	0.093 ± 0.067	0.39 ± 0.44	< LoD	0.013 ± 0.010
	1994	< LoD	< LoD	0.04 ± 0.006	< LoD	< LoD
Zavodnje	1992/93	0.034 ± 0.033	0.034 ± 0.003	0.14 ± 0.13	0.0024	0.009 ± 0.009
	1994	< LoD	< LoD	0.038 ± 0.0037	< LoD	< LoD
Podvolovljek	1992/93	0.039 ± 0.026	0.038 ± 0.004	0.12 ± 0.11	0.0058	0.010 ± 0.009
	1994	< LoD	< LoD	0.041 ± 0.005	< LoD	< LoD
Podatki iz literature		---	---	---	---	---

3.2. Diskusija

S padavinami se iz ozračja odstranjujejo snovi, ki jih človek spušča v zrak. Z dežjem padejo te snovi na tla in onesnažujejo tla, vodo in rastline. S kemijsko analizo padavin lahko dobimo zelo dobro sliko onesnaženosti atmosfere in njenega vpliva na tla. Kemijska sestava dežja je odvisna od atmosferskih in klimatskih pogojev, ki se spreminjajo iz kraja v kraj in iz leta v leto, zato se temu ustrezno spreminja tudi sestava padavin [11].

Izgorevanje premoga v termoelektrarnah je eden izmed glavnih virov elementov v sledovih v atmosferi. Iz dimnikov termoelektrarn izvira večji del Be, Co, Hg, Mo, Sb in Se v ozračju, poleg teh elementov pa predstavljajo termoelektrarne tudi precejšen vir As, Cr, Cu, Mn, Ni, Pb, V, Zn in Zr v zraku [12].

Okoli leta 1970 so na Aljaski v padavinah odkrili nepričakovano visoke koncentracije Pb, V, Mn, Cd, Ni in drugih elementov, ki so produkti človekove aktivnosti [12]. Ugotovili so, da se visoke koncentracije antropogenih elementov v oddaljenih pokrajinah pojavljajo občasno in kažejo močna sezonska nihanja. Prav zato so pojav teh polutantov na Aljaski pripisali daljinskemu zračnemu prenosu. V Skandinaviji so opravili vrsto obširnih raziskav, s katerimi so določili polutante, ki se prenašajo z daljinskim zračnim prenosom. Ugotovili so, da padavine iz zračnih mas, ki pridejo iz Evrope, vsebujejo desetkrat več elementov v sledovih v primerjavi s padavinami, ki pridejo s področja severnega Atlantika [12]. Poleg meteoroloških pogojev je pomemben faktor, ki vpliva na prenos elementov z zrakom, tudi hitrost usedanja. Najpočasneje se useda selen, približno enako počasi še arzen, svinec in cink, nato sledita vanadij in krom; največji razpon hitrosti usedanja imata baker in nikelj, ki se lahko usedata zelo počasi ali pa tudi precej hitro [12]. Zanimivo je, da se večina elementov usede z mokrim in ne s suhim depozitom; tudi temu je vzrok daljinski zračni prenos. Cawse [13] je ugotovil, da moker depozit lahko prispeva 80 do 100 % od skupnnega useda svinca, cinka, bakra in kobalta ter 60 do 80 % za nikelj, arzen, antimon, krom in selen. Visoke koncentracije antropogenih elementov v padavinah so ponavadi združene s povečano koncentracijo sulfatnega iona, posebno na delcih pod 1.0 μm premera [12].

Zanimivo je, da so v padavinah na primerjalni lokaciji v Podvolovljeku višje koncentracije makroelementov (kalcija, kalija, magnezija in natrija) kot v Šaleški dolini. To lahko pripišemo predvsem prahu, ki ga dviga veter iz okoliških neporaslih hribov.

Iz rezultatov je razvidno, da so v padavinah na Velikem vrhu koncentracije elementov v sledovih najvišje.

Če primerjamo koncentracije elementov v padavinah s tipičnimi koncentracijami elementov v padavinah na neurbanih področjih v svetu, lahko ugotovimo:

- v padavinah na Velikem vrhu so povečane koncentracije Al, Fe, Cu, Cd in Sb.
- v padavinah na vseh lokacijah so povečane koncentracije As, Ba, Br, Co, Cr, Hg, V, in Zn.

Ker je lokacija Veliki vrh le 2 km zračne razdalje od TEŠ, lahko povišane koncentracije aluminija in železa v padavinah na Velikem vrhu razložimo kot posledico usedanja večjih delcev, v katerih sta ta dva elementa (>2 μm premera).

Ker veljajo termoelektrarne za glavni antropogeni vir živega srebra, kobalta in antimona, ne preseneča povečana koncentracija teh elementov v padavinah.

Povečano koncentracijo bakra in kadmija v padavinah v bližini TEŠ (na Velikem vrhu) lahko pripišemo precej veliki hitrosti usedanja teh elementov, ki po Pacynu [12] znaša do 1.5 cm/s.

Arzen, brom in živo srebro prihajajo iz dimnika v atmosfero pretežno kot plini, kjer se adsorbirajo na zelo majhne delce in zato lahko potujejo z zračnimi masami zelo daleč [14]. To je verjetno vzrok za njihovo povišano koncentracijo v padavinah na vseh treh lokacijah.

Elementi cink, vanadij in krom imajo zelo nizko hitrost usedanja (okoli 0.4 cm/s), zato veljajo za polutante, ki se z zračnimi masami prenašajo na daljše razdalje [12]. Zato so njihove koncentracije približno enako povečane na vseh treh lokacijah.

Elementna analiza padavin kaže na povečane koncentracije v padavinah v neposredni bližini Termoelektrarne Šoštanj. Lokalni polutanti v padavinah, ki se usedajo na tla v neposredni bližini vira, so arzen, železo, kadmij, baker in antimon. V padavinah so ne glede na oddaljenost od Termoelektrarne Šoštanj povečane koncentracije arzena, barija, broma, kobalta, kroma, živega srebra, vanadija in cinka. Ti elementi torej potujejo z daljinskim zračnim prenosom.

4. LITERATURA

[1] Brechtel, H.M. 1989, Bulk precipitation deposition of inorganic chemicals in forest areas and its influence on water quality in the Federal Republic of Germany.- IASH Publ. No. 179, 221-228, Baltimore.

[2] Brechtel, H.M. 1991, Acidic precipitation deposition of air pollutants and its influences on the chemical quality of forest spring water in the Hessian highlands.- Mitteilungsblatt des Hydrographischen Dienstes in Österreich, Nr. 65/66, 178 p.p., Wein.

[3] Kleemola, S. & Söderman, G. 1993, Manual for integrated monitoring - Programme Phase 1993-1996.- Environmental Report 5, 38 p.p., Helsinki.

[4] World Meteorology Organisation, 1976, Sampling and analysis of precipitation.- In: Operations handbook for measurement of background atmospheric pollution, 22-52, Washington.

[5] Jeran, Z., Smodiš, B. & Jećimović, R. 1993, Multielemental analysis of transplanted lichens (Hypogymnia physodes, L. Nyl.) by instrumental neutron activation analysis.- Acta Chimica Slovenica 40/4, 289-299, Ljubljana.

[6] Smodiš, B. 1991, Študij in razvoj ko-standardizacijske metode za nevtronsko aktivacijsko analizo bioloških in ekoloških vzorcev.- 102-125, Ljubljana. (Disertacija. Fakulteta za naravoslovje in tehnologijo, Oddelek za kemijo in kemijsko tehnologijo.)

[7] Brechtel, H.M. 1989, Monitoring wet deposition in forest - Quantitative and qualitative aspects.- Air Pollution Report Series, Report No 21, 39-63, Brussels.

[8] Landsberger, S., Vermette, S.J. & Drake, J.J. 1987, Sulfur, Halogens, and Heavy Metals in Urban Summer Rainfall.- ACS Symposium Series 349, 215-218, Boston.

[9] Barrie, L A. & Schemenauer, R.S. 1989, Wet deposition of heavy metals.- In; Control and Fate of Atmospheric Trace Metals, NATO ASI Series, Series C: Mathematical and Physical Sciences - Vol. 268, 203-231, Boston.

[10] Kabata-Pendias, A. & Pendias, H. 1986, Trace elements in soils and plants.- CRC Press, Inc., 1-256, Boca Raton, Florida.

[11] Howells, G. 1989, Acid rain and acid waters.- Ellis Horwood Series in Environmental Science, 30 p.p., London.

[12] Pacyna, J.M. 1989, Source-Receptor Relationships for Atmospheric Trace Elements in Europe.- In: Acidic Precipitation, Volume 3: Sources, Deposition and Canopy Interactions, Springer-Verlag, 49-71, New York.

[13] Cawse, P.A. 1980, Inorganic Pollution and Agriculture.- Ministry of Agriculture, Fisheries and Food, 326 p.p., London.

[14] Norton, S.A., Dillan, P.J., Evans, R.D., Mierle, G. & Kahl, J.S. 1989, The History of Atmospheric Deposition of Cd, Hg, and Pb in North America.- In: Acidic Precipitation, Volume 3: Sources, Deposition and Conopy Interactions, Springer-Verlag, 73-101, New York.

III. UGOTAVLJANJE VPLIVA NA GOZDNI EKOSISTEM:

1. *POPIS POŠKODOVANOSTI GOZDOV*

2. *RAZISKAVE PREHRANSKIH RAZMER ZA SMREKO IN BUKEV V VPLIVNEM OBMOČJU TEŠ*

3. *PROUČEVANJE ONESNAŽENOSTI GOZDNIH TAL V IMISIJSKEM OBMOČJU TEŠ S PARNO PRIMERJALNIMI RAZISKOVALNIMI OBLEKTI*

4. *RAZISKAVE MIKORIZE*

5. *UGOTAVLJANJE STRESA NA OSNOVI ANALIZE ZAŠČITNIH SUBSTANC IN REPARATURNIH MEHANIZMOV V LISTIH/IGLICAH GOZDNEGA DREVJA IN ANALIZE EPIFITSKIH LIŠAJEV*

Projekt: **ONESNAŽENJE ZRAKA, PADAVIN IN VODNIH VIROV V ŠALEŠKI DOLINI**

Podprojekt: **a) Zgoščen popis propadanja gozdov na območju GGO Nazarje in Slovenj Gradec**
b) Pedološke raziskave

Sodelavci podprojekta:
mag. Dušan Jurc, dipl. biol., vodja na GIS
Nevenka Bogataj, dipl. inž. gozd., MR (do 1. 12. 1995)
Lado Eleršek, dipl. inž. gozd.
Polona Kalan, dipl. inž. kem., MR (do 1. 12. 1995)
dr. Hojka Kraigher, dipl. biol., dipl. inž. gozd., MR (do 1. 6.1994
mag. Primož Simončič, dipl. inž. les., MR (do 1. 6. 1995)
Ivan Smole, dipl. inž. gozd.
mag. Igor Smolej, dipl. inž. gozd.
dr. Marjan Zupančič, dipl. inž. gozd.

II. Poročilo o realizaciji predloženega programa dela:

Osnovno izhodišče raziskave je temeljilo na s številnimi raziskavami dokazano škodljivo učinkovanje onesnaženega zraka na gozdni ekosistem, vendar v obravnavanem območju do začetka raziskave nismo razpolagali s podatki o količinskem vnosu polutantov ter njihovimi učinki na tla in vegetacijo. Z ozirom na visoke koncentracije polutantov v zraku smo imeli namen ugotoviti spremembe v tleh in jih hkrati primerjati s količinami polutantov v rastlinah. Želeli smo ugotoviti razlike med močno onesnaženimi predeli in bolj čistimi, ne le v okviru kemijsko merljivih parametrov ampak tudi na nivoju odziva rastlin (bioindikatorjev - rastlin in gliv). Poleg tega smo imeli namen pridobiti podatke ne le za stanje v vplivnem območju TEŠ ampak tudi za predele, ki bi jih v Sloveniji lahko obravnavali kot malo obremenjene z onesnaženim zrakom (Pokljuka).
Delovna hipoteza, ki smo jo z načrtovano raziskavo želeli preveriti je bila: Onesnaženi zrak, katerega vir je TEŠ, povzroča merljive poškodbe vegetacije (bioindikatorjev - drevja), merljive spremembe kemijskih lastnosti tal (kar bi pokazala parna primerjava med bolj in manj onesnaženimi predeli) in spremembe v talni mikoflori (predvsem izginjanje mikoriznih gliv).
Delo sodelavcev GIS je v celotnem trajanju projekta potekalo v tesnem sodelovanju z delom na Agronomskem oddelku BF.
Delo prikazujemo po tematskih enotah:
1) Popis poškodovanost gozdov (Dušan Jurc)
2) Raziskave prehranskih razmer za smreko in bukev v vplivnem območju TEŠ (Primož Simončič)
3) Proučevanje onesnaženosti gozdnih tal v imisijskem območju TEŠ s parno primerjalnimi raziskovalnimi objekti (Mihej Urbančič)
4) Raziskave mikorize (Hojka Kraigher)

1. POPIS POŠKODOVANOSTI GOZDOV

1) Popis poškodovanost gozdov

Metode dela

Za ugotavljanje poškodb drevja smo uporabili metodo popisa poškodb gozdov, ki je predpisana v okviru Mednarodnega programa sodelovanja Ugotavljanje in monitoring vplivov onesnaženega zraka na gozd UN/ECE Konvencije o daljinskem transpotu onesnaženega zraka preko mej (UN/ECE CLRTAP) (opisana je v: Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. 3rd ed. 1994, 177 str.)

Popis je bil opravljen dvakrat: leta 1993 in leta 1995 (prvič posebej za potrebe tega raziskovalnega projekta, ker v Sloveniji nismo izvedli popisa na 4X4km mreži, drugič pa v okviru rednega štiriletnega rednega popisa poškodb gozdov v Sloveniji). Popis je bil opravljen na mreži popisnih ploskev na 4X4 km mreži v Gozdnogospodarskih območjih Nazarje in Slovenj Gradec.

Rezultati

Na preglednici 1 in 2 so prikazani rezultati popisa poškodovanosti gozdov v letu 1993 in 1995, na sliki 1 pa primerjava poškodovanost obeh popisov.

Preglednica 1:

STOPNJE POŠKODOVANOSTI DREVES ZA OE NAZARJE IN SLOVENJ GRADEC V LETU 1993

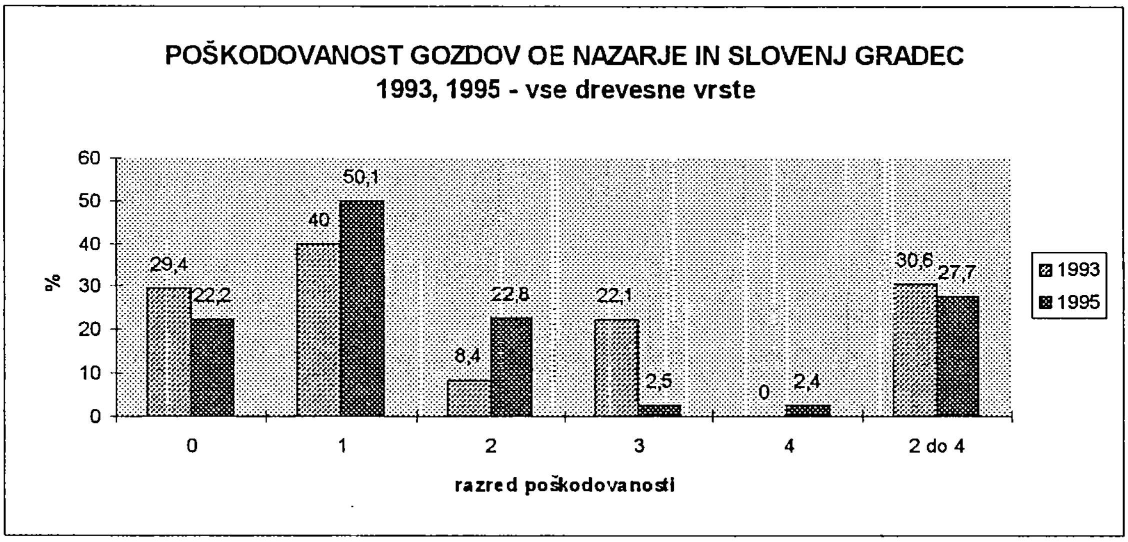
	0		1		2		3		4		2 - 4		1- 4		0 - 4	
Drevesna vrsta	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
smreka	207	17.6	549	46.6	111	9.4	310	26.3	0	0	421	35.8	970	82.4	1177	100
jelka	4	4.9	17	20.7	19	23.2	42	51.2	0	0	61	74.4	78	95.1	82	100
bor	11	15.9	37	53.6	7	10.1	14	20.3	0	0	21	30.4	58	84.1	69	100
o. igl.	16	59.3	11	40.7	0	0	0	0	0	0	0	0	11	40.7	27	100
bukev	164	74.9	48	21.9	4	1.8	3	1.4	0	0	7	3.2	55	25.1	219	100
hrast	9	40.9	9	40.9	1	4.5	3	13.6	0	0	4	18.2	13	59.1	22	100
o. list.	92	82.1	12	10.7	2	1.8	6	5.4	0	0	8	7.1	20	17.9	112	100
iglavci	238	17.6	614	45.3	137	10.1	366	27	0	0	503	37.1	1117	82.4	1355	100
listavci	265	75.1	69	19.5	7	2	12	3.4	0	0	19	5.4	88	24.9	353	100
skupaj	503	29.4	683	40,0	144	8.4	378	22.1	0	0	522	30.6	1205	70.6	1708	100

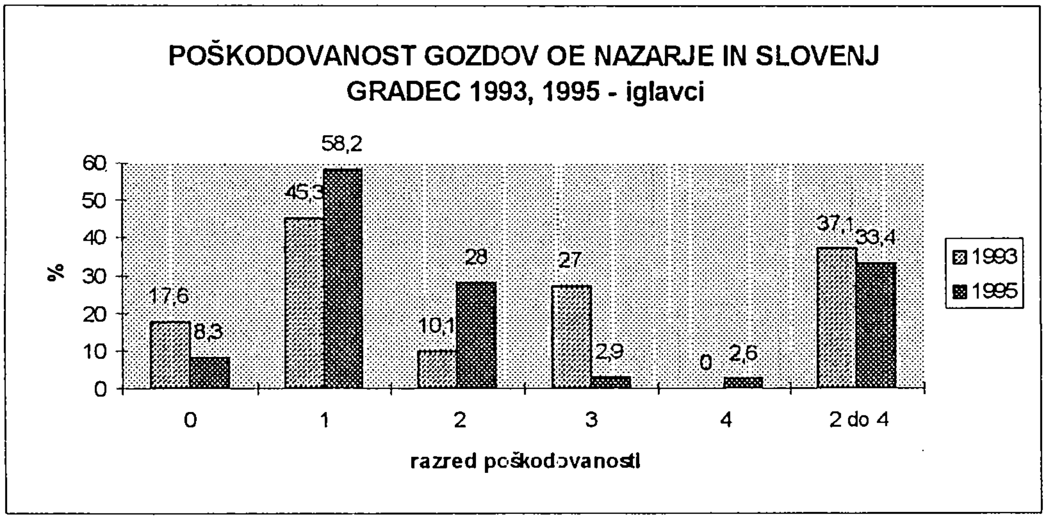
Preglednica 2:

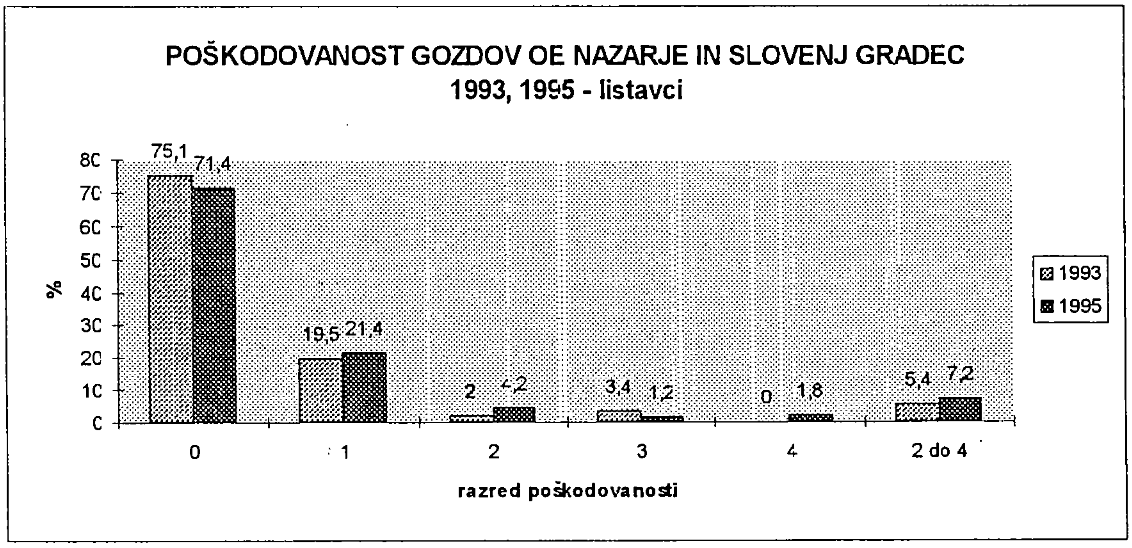
STOPNJE POŠKODOVANOSTI DREVES ZA OE NAZARJE IN SLOVENJ GRADEC V LETU 1995

	0		1		2		3		4		2 - 4		1- 4		0 - 4	
Drevesna vrsta	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
smreka	72	7,3	620	62,5	254	25,6	22	2,2	24	2,4	300	30,2	920	92,7	992	100
jelka	0	0	18	22,7	48	60,8	10	12,7	3	3,8	61	77,2	79	100	79	100
bor	14	16,3	41	47,7	26	30,2	2	2,3	3	3,5	31	36,1	45	52,3	86	100
o. igl.	12	52,2	8	34,8	2	8,6			1	4,4	3	13,0	11	47,8	23	100
bukev	136	67,7	49	24,3	10	5,0	3	1,5	3	1,5	16	8,0	65	32,3	201	100
hrast	5	45,5	6	54,5							0	0	6	54,5	11	100
o. list.	96	80,0	16	13,4	4	3,3	1	0,8	3	2,5	8	6,7	24	20,0	120	100
iglavci	98	8,3	687	58,2	330	28,0	34	2,9	31	2,6	395	33.4	1082	91,7	1180	100
listavci	237	71,4	71	21,4	14	4,2	4	1,2	6	1,8	24	7,2	93	28,0	332	100
skupaj	335	22,2	758	50,1	344	22,8	38	2,5	37	2,4	419	27,7	1177	77,8	1512	100

Slika 1: Primerjava poškodovanosti gozdov iz popisov leta 1993 in 1994:







V letu 1993 je bil popis opravljen na 63. ploskvah (na vsaki ploskvi je popisanih 24 dreves), leta 1995 na 71. ploskvah. Iglavci so v vzorcu udeleženi v skoraj 80%, kar kaže na veliko spremenjenost naravnih mešanih gozdov na tem območju. Najpomembnejši pokazatelj celokupne spremembe poškodovanosti vseh drevesnih vrst je aglomeracija razredov poškodovanosti 2-4 (nedvoumno poškodovana drevesa, osutost 25%-99%), ki se je od leta 1993 do leta 1995 zmanjšala za 3% (od 30,6% na 27,7%). Sprememba poškodovanosti ni velika in ne moremo ocenjevati, da gre za dolgoročni trend izboljševanja stanja gozdov. Izjemno zanimivi pa so rezultati poškodovanosti po posameznih razredih poškodovanosti. Opazimo lahko, da je prišlo do velikih premikov med posameznimi razredi: izredno se je v letu 1995 zmanjšalo število dreves v razredu poškodovanosti 3 (od 22,1% na 2,5%), povečalo pa se je število dreves v razredu poškodovanost 2 (od 8,4% na 22,8%). Celotno spremembo je povzročila izključno sprememba stanja iglavcev. Do večjih premikov je prišlo tudi med razredoma 0 (nepoškodovana drevesa) in 1 (rahlo poškodovana drevesa, osutost do 25%), saj se je število nepoškodovanih dreves zmanjšalo za 7% (od 29, 4% na 22,2%) število rahlo poškodovanih pa povečalo za 10% (od 40% na 50,1%). Doslej pri popisih poškodovanosti gozdov nismo zabeležili tako velikih premikov med razredi poškodovanosti v tako kratkem razdobju. Ali je ta rezultat že posledica reduciranih emisij TEŠ (ne le zaradi pričetka obratovanja razžveplevalne naprave, ampak tudi zaradi zmanjševanja obratovanja pri previsokem onesnaženju zraka) ne moremo z gotovostjo potrditi, je pa mogoče. Verjetno so k temu rezultatu prispevale tudi ugodne vremenske razmere za vegetacijo v letu 1995, ko pred popisom poškodovanosti ni bilo ekstremnih, stresnih vremenskih razmer (niti neobičajen zimski mraz, niti suša) in relativno neugodne razmere za vegetacijo v letu 1993. Zmanjšanje števila popolnoma nepoškodovanih dreves je mogoče prav tako razlagati izredno nezanesljivo. Morda gre za zakasnele učinke akumuliranega onesnaženja tal, kar nakazujejo ostale raziskave tega projekta.
Na sliki 2 prikazujemo prostorsko razporeditev poškodovanosti v letu 1995 na območju raziskave. (naslednja stran)

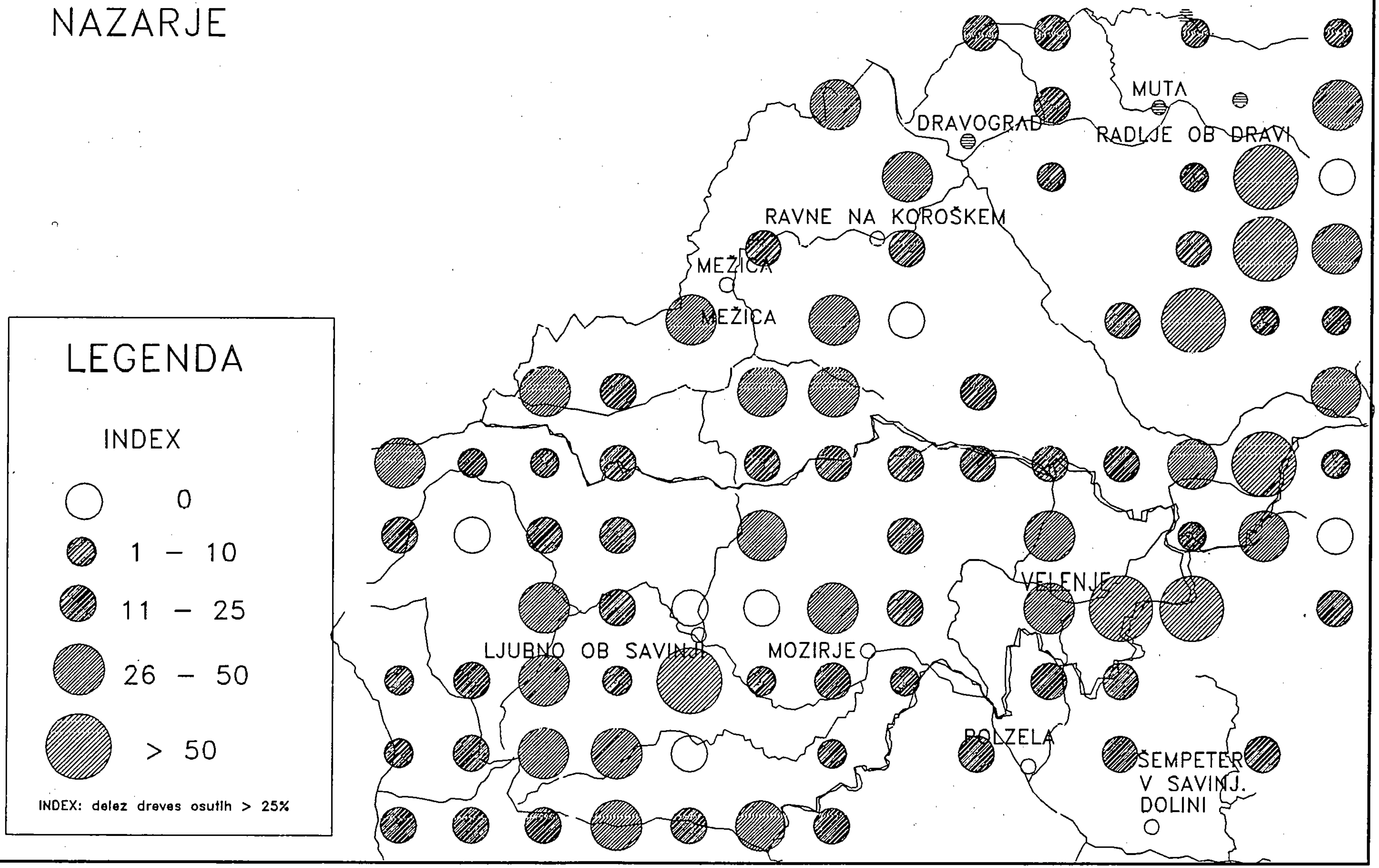
Opazimo lahko, da poškodovanost gozdov ni enostavno odvisna od oddaljenosti od največjega vira onesnaževanja zraka. Odvisna je ne le od izpostavljenost direktnemu vplivu onesnaženosti zraka in naravnim stresnim dejavnikom, ampak tudi od kakovosti rastišča in od "spremenjenosti" sestave gozda (od velikosti odmika od stabilnega naravnega gozda).

Zaključek

Popis poškodovanosti gozdov v letih 1993 in 1995 je nepričakovano zasledil izredno velike skoke med deleži dreves v posameznih razredih poškodovanosti. Ali ti skoki pomenijo tudi dolgoročni trend izboljšav zdravstvenega stanja gozdov na vplivnem območju TEŠ bodo pokazali popisi poškodovanost v naslednjih letih.

POPIS PROPADANJA 95

SLOVENJ GRADEC
NAZARJE



2. RAZISKAVE PREHRANSKIH RAZMER ZA SMREKO IN BUKEV V VPLIVNEM OBMOČJU TEŠ

2) Raziskave prehranskih razmer za smreko in bukev v vplivnem območju TE Šoštanj

Namen in cilj raziskave:

Na osnovi naloge "Raziskave mineralne prehrane za smreko na distričnih rjavih tleh na tonalitu v vplivnem območju TE Šoštanj" (SIMONČIČ 1992) ter že opravljeno in tekoče raziskovalno delo številnih raziskovalcev o vplivu TE Šoštanj na tla in vegetacijo, smo na GIS želeli oceniti vpliv odpadnih plinov iz TE Šoštanj na gozdna tla in prehranske razmere za smreko ter bukev.

V Sloveniji v preteklosti nismo posvečali dovolj pozornosti raziskavam vsebnostim in preskrbljenosti gozdnega drevja z mineralnimi hranili. Tako je bilo doslej izvedenih le nekaj foliarnih analiz v zvezi s proučevanjem prehranskih razmer sadik gozdnega drevja v gozdnih drevesnicah in nekaj študij mineralne sestave smrekovih iglic v odraslih sestojih (KALAN, 1980, KRAIGHER, 1991).

Različni abiotski in biotski dejavniki (geološko - petrografske, podnebne razmere, biološka aktivnost tal, itn) in antropogeni dejavniki (gospodarjenje z gozdom, imisije onesnaženega zraka) vplivajo na motnje glede preskrbljenosti gozdnega drevja s hranili. Med možnimi vzroki poškodb gozdnega drevja so različne fiziološke motnje, nezadostne in neharmonične prehranske razmere ter spremembe v kroženju snovi v gozdu.

Cilji naloge raziskave mineralne prehrane v vplivnem območju TE Šoštanj so:

- proučevati letni hod hranil (predvsem žveplo) za smreko v bolj (Prednji vrh pri Zavodnjah) in manj onesnaženem okolju (Pokljuka),
- spremljati prehranske razmere za smreko in bukev na poskusnih objektih v vplivnem območju TE Šoštanj (Prednji vrh) in na drugih ploskvah (stalne raziskovalne ploskve) ter ugotoviti morebitne povezave s talnimi lastnostmi, mokrim depozitom,itn.,
- spremljati vnos kislega depozita na raziskovalni ploskvi na Prednjem vrhu ter ugotavljati razlike v sestavi kapljevine pod krošnjami razliznih drevesnih vrst (bukev - smreka) in na prostem (ob imisijski merilni postaji Zavodnje).

Opis dela

V letu 1995 smo končali z delom terenskih raziskav na Prednjem vrhu (onesnaženo okolje - TE Šoštanj), na Osankarici (manj onesnaženo okolje) in na Pokljuki (čisto okolje):

- vzorčenje talnih vzorcev na Prednjem vrhu (smrekova ploskev) in na Osankarici (smreka, manj onesnaženo okolje), vzorčenje je bilo izvedeno 1989 in 1994 leta,
- vzorčenje smrekovih iglic za spremljanje **letnega hoda** (Prednji vrh ⇔ Pokljuka) ter vzorčenje listja in iglic za ugotavljanje **prehranskih razmer** v bolj in manj onesnaženem okolju (Prednji vrh ⇔ Osankarica ⇔ Pokljuka),
- vzorčenje sestojnih padavin (kapljevine in debelne odcedne vode) ter padavin na prostem.

METODE DELA

Tla smo vzorčili 1989 in 1994 leta kvantitativno s pomočjo kvadrata (25 cm x 25 cm) z lesenim okvirjem (Ol, Of,h sloj) in z valjastim svedrom (sloje 0-5 cm, 5 cm - 10 cm in 10 cm - 20 cm). V tleh smo po pripravi vzorcev določili pH (H_2O), pH ($CaCl_2$) vrednosti, celokupni C, N, S, P, K, Ca, Mg, izmenljive ione (Ca^{2+}, Mg^{2+}, K^+, Al^{3+}, Fe^{2+}, Mn^{2+}, H^+).
Iglice smrek in listje smo vzorčili po metodologiji vzorčenja smrekovih in borovih na 16 km x 16 km bioindikacijski mreži Slovenije (KALAN 1990) in po mednarodni metodologiji, ki jo priporoča strokovna skupina za mineralno prehrano (Foliar Analysis Expert Pannel ICP - Forests). V obdobju rasti smo foliarne vzorce nabirali vsakih štirinajst dni, v jeseni in pozimi pa na štiri tedne. Vzorce vod (padavinski vzorci in vzorci talne raztopine) pa smo vzorčili vsakih štirinajst dni od maja 1994 do junija 1995. Padavine smo zbirali po "throughfall" metodi, ki je opisana, tako kot tudi metoda vzorčenja talne raztopine, v navodilh za izvedbo monitoringa depozita na raziskovalnih ploskvah ICP-ECE in ECE-IM projektov (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests 1994).
Smrekove iglice in listje bukve smo v laboratoriju GIS posušili, zmleli in homogenizirali. V vseh vzorcih smo v letu 1995 določili določili celokupno vsebnost žvepla z elementno analizo, v vzorcih enoletnih smrekovih poganjkov pa še dušik po Kjeldahl-ovi metodi in makroelemente (P, K, Ca in Mg) po kislinskem razkroju vzorcev z mešanico HNO_3 in $HClO_4$ v razmerju 5:1.
V padavinskih vzorcih in vzorcih talne raztopine smo določili pH vrednost, elektroprevodnost (Ep), vsebnost sulfatnih, nitratnih in kloridnih ionov (ionska kromatografija), bazične katione K^+ s plamenskim fotometrom ter Mg^{2+} in Ca^{2+} z AAS spektrometrom, Al^{3+} pa smo določevali le v talni raztopini z AAS spektrometrom.

REZULTATI

Gozdna tla
Na preglednici 1 in 2 so prikazane lastnosti talnih vzorcev iz Prednjega vrha (smreka) in Osankarice (smreka), ki smo jih vzorčili v letu 1989, analizirali pa leta 1995. Na obeh objektih so distrična rajava tla na tonalitu. Kemijski rezultati so podani kot povprečne vrednosti za pet podploskev iz vsakega raziskovalnega objekta (n = 5).

kraj	sloj (cm)	pH H_2O	pH $CaCl_2$	C g/kg	N g/kg	C/N	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg
Prednji vrh 1989	Ol	4.0	3.6	509	16.0	31.8	627	676	4023	392	1630
	Of	3.7	3.2	446	15.8	28.2	598	540	3523	1045	1680
	0-5	4.0	3.6	174	6.9	25.2	429	1069	2181	5831	1010
	5-10	4.4	4.0	82	4.4	18.6	371	1169	2667	7804	770
	10-20	4.8	4.3	54	3.2	16.9	373	1250	3148	8612	800
Prednji vrh 1994	Ol	4.0	3.5	469			1365	650	6154	389	938
	Of,h	3.6	3.0	434	13.0	33.5	2061	177	3495	526	1842
	0-5	3.9	3.5	179	6.5	26.9	1780	1109	2200	6494	1062
	5-10	4.7	4.4	74	3.5	20.9	1428	1105	2181	8755	638
	10-20	4.6	4.3	54	2.2	24.1	1276	1080	3144	9657	644

Preglednica 1 : Kemijske lastnosti (pH vrednosti v vodni raztopini in raztopini $CaCl_2$, skupne vsebnosti C, N, P, K, Ca, Mg in S ter računsko C/N) slojev tal s 25 cm x 25 cm ploskev s Prednjega vrha (povprečne vrednosti, n = 5) vzorčenih leta 1989 in 1994.

kraj	sloj (cm)	pH H_2O	pH $CaCl_2$	C g/kg	N g/kg	C/N	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg
Osankarica 1989	**Ol**	4.0	3.6	522	16.2	32.2	533	792	3329	213	1290
	Of	3.6	3.1	380	12.9	29.5	615	796	2272	520	1350
	0-5	3.7	3.1	158	7.6	20.8	393	531	506	771	780
	5-10	3.8	3.2	92	5.7	16.1	324	553	963	633	550
	10-20	4.2	3.6	72	4.2	17.1	300	495	386	1056	440
Osankarica 1994	**Ol**	4.2	3.8	455	11.0	43.0	1851	779	3993	491	1234
	Of,h	3.8	3.3	297	12.6	23.6	2235	765	2036	880	1413
	0-5	3.8	3.3	130	6.5	20.3	1655	502	865	862	756
	5-10	4.2	3.5	79	3.9	20.7	1093	517	962	1043	624
	10-20	4.1	3.9	69	3.2	21.9	923	503	1046	1404	558

Preglednica 2 : Kemijske lastnosti (pH vrednosti v vodni raztopini in raztopini $CaCl_2$, skupne vsebnosti C, N, P,K, Ca, Mg, S in računsko C/N) slojev tal s 25 cm x 25 cm ploskev na Osankarici (povprečne vrednosti, n = 5) vzorčenih leta 1994 in 1995.

Na preglednicah 1 in 2 vidimo, da ni večjih razlike med analiznimi rezultati posameznih slojev tal na Prednjem vrhu glede na leto vzorčenja. Opazne razlike so predvsem v vsebnosti skupnega kalcija in žvepla v opadu (Ol) ter skupnega foforja (višje vsebnosti v vzorcih iz l. 1994). Na Osankarici pa so razlike glede vsebnosti ogljika (nižje vsebnosti so v vzorcih tal iz 1994 l.), C/N razmerja (v letu 1994 so višja razmerja), vsebnosti skupnega fosforja (tudi višje vsebnosti v letu 1994) in vsebnosti kalcija ter magnezija v opadu (večje vrednosti v letu 1994).

Mineralna prehrana

Analizni rezultati vsebnosti skupnega žvepla v eno in dvoletnih iglicah (preglednica 3) so pokazali razlike v obremenjenosti ploskev z emisijami žvepla in s tem smiselnost njihove postavitve (Prednji vrh v vplivnem območju TE Šoštanj, Osankarica, Pokljuka).

mesto vzorčenja	nad. viš. (m)	vsebnost žvepla (%)			
		vzorčenje 1989 l.		vzorčenje 1994 l.	
		dvoletne ig. 1988	enoletne ig. 1989	dvoletne ig. 1993	enoletne ig. 1994
Zavodnje-Prednji vrh	830	2.93	2.14	2.55	2.39
Osankarica - kont. pl.	1200	1.39	1.22	0.98	0.99
16kmx16kmBIM*		1.32	1.21	/	/
Pokljuka - kont .pl.	1200	/	/	1.06	0.78

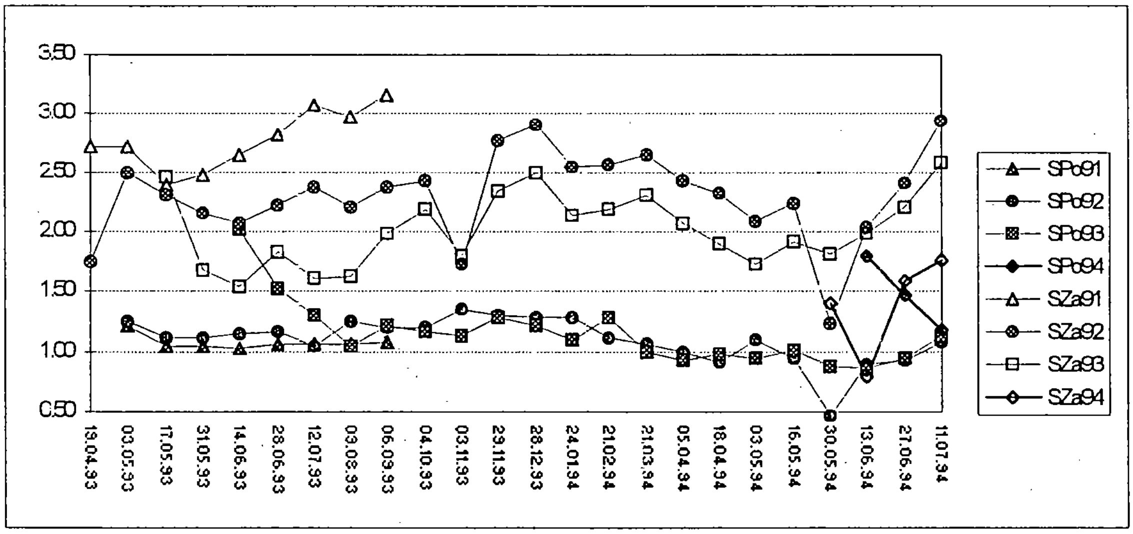
* BIM - bioindikacijska mreža Slovenije, povprečje

Preglednica 3: Vsebnosti skupnega žvepla (%) v eno in dvoletnih iglicah smrek vzorčenih 1989l. in 1994l.

Ploskev na Prednjem vrhu se nahaja v območju povečane emisije, v katerem lahko pričakujemo poškodbe drevja zaradi žvepla. Ploskvi na Pokljuki in na Osankarici pa sta je manj obremenjeni, vsebnosti so občasno nekoliko povečane in višje od naravne vsebnosti žvepla v smrekovih iglicah.

Na sliki 1, kjer so prikazani letni hodi vsebnosti žvepla v eno, dvo in triletnih (krajše obdobje) smrekovih iglicah na Pokljuki (ploskev v bližini barja Šijc) in na Prednjem vrhu (april 1993 - julij 1994), se vidijo tako razlike v vsebnostih žvepla med vzorci dveh z žveplom različno obremenjenih okolij, kot tudi sezonski vpliv - vpliv zime (večje imisije) na akumulacijo žvepla v iglicah smrek na Prednjem vrhu. Med rezultati letnega hoda vsebnosti žvepla v iglicah smrek na Pokljuki ni večjih razlik med eno in dvoletnimi iglicami (slika 1), medtem ko so na Prednjem vrhu te razlike opazne. V obremenjenem okolju je ta razlika celo leto več ali manj stalna. V maju (Prednji vrh) in juniju (Pokljuka), ko poteka intezivna rast mladih iglic, se visoka začetna koncentracija žvepla v iglicah hitro zniža (podobno kot tudi vsebnosti dušika), nato pa se v z žveplovim dioksidom obremenjenem okolju (Prednji vrh) povečuje vse do mirovanja vegetacije v jeseni.

Vsebnost skupnega žvepla (S_t) v eno, dvo in triletnih smrekovih iglicah (mg/g suhe snovi)



čas vzorčenja

Slika 1: Letni hod vsebnosti žvepla v približno dvajset let starih smrekah na Pokljuki (S_{Po91}, S_{Po92}, S_{Po93} and S_{Po94}) in na Prednjem vrhu (S_{Za91}, S_{Za92}, S_{Za93} and S_{Za94}), maj 1993 - julij 1994.

Padavine

Na preglednici 4 pa so prikazane vrednosti letnega vnosa žvepla (v obliki sulfata) in dušika (v obliki nitrata) na Prednjem vrhu (ploskev v gozdu) in na ploskvi na prostem. Zaradi primerjave so dodani še rezultati meritev vnosa sulfatnih in nitratnih ionov v sestojnih padavinah in v padavinah na prostem na Bavarskem (KENNEL 1994).

kraj	mesto vzorčenja	NO_3 - N kg/ha leto	SO_4 - S kg/ha leto
Prednji vrh	na prostem	3.2	13.0
	sestoj - smreka	7.1	32.7
	sestoj - bukev	5.2	20.1
Fichtelgebirge	na prostem	5 - 7	11 - 15
	sestoj - smreka	10 - 13	43 - 60
Bayerischer w.	na prostem	5 - 9	10 - 20
	sestoj - smreka	7 - 16	24 - 41
	sestoj - bukev	6 - 9	11 - 19

Preglednica 4: Vnos žvepla v sulfatni obliki in dušika v nitratni na raziskovalnih ploskvah na Prednjem (maj 1994 - junij 1995) vrhu in na Bavarskem (1988 - 1992l., KENNEL 1994).

Na preglednici 2 se jasno se razloči razlika glede vsebnosti nitratnih in sulfatnih ionov v sestavi kapljevine (padavine pod krošnjami smrek oz. bukev) in padavin vzorčenih na prostem tako na Prednjem vrhu kot tudi v literaturnih vrednostih iz Bavarske. Na sestavo sestojnih padavin vpliva vrsta vegetacije, pod katero vzorčimo padavine. Iz preglednice se vidi, da so razlike med depozitom žvepla in dušika (nitratna oblika) večje v primeru vzorčenja pod smrekovimi krošnjami kot pod bukovimi krošnjami.
Na osnovi zbranih meritev in literaturnih podatkov vidimo, da deluje smreka kot nekakšni "zračni" filter. Krošnje smrek, bukev prestrežejo poleg mokrega depozita (dež, sneg) tudi del suhega depozita (delci, plini, aerosoli). Del prestreženih padavin se v krošnji zadrži in izhlapeva v ozračje. Drug del padavin pa se steka po iglicah in kapa na tla pa steče po deblu do tal. Sestava padavin se spremeni na poti od vrha krošenj do gozdnih tal.
Kritične obremenitve za žveplo se gibljejo med nekaj kilogrami do trideset in več kilogramov žvepla na hektar na leto in so odvisne od padavin, vegetacije, nagiba terena, ekspozicije, teksture, drenaže in globine gozdnih tal, sposobnost tal da veže sulfatne ione in da sprošča bazične katione (KOMLENOVIĆ 1989). Na Prednjem vrhu smo za obdobje od maja 1994 do junija 1995 ugotovili, da je bil vnos žvepla v sulfatni obliki na smrekovi ploskvi višji od 30 kg žvepla na ha, kar že presega zgoraj omenjene kritične vrednosti za gozd. Takšni vnosi pa že lahko povzročijo spremembe kemizma gozdnih tal.

Viri

1. Anon., 1994. Manual on methods and criteria for harmonised sampling, assessment, monitoring and analysis of the effects of air pollution on forest. PCC WEST, BFH, Hamburg, PCCe East, Jiloviste-Smady, 177 s.
2. Kalan, J., 1980. Foliarna vsebnost hranil smreke na nekaterih najbolj razširjenih rastiščih v Sloveniji na različnih geološko-petrografskih podlagah. Ljubljana, IGLG, 38 s.
3. Kalan, J., 1990. Obremenjenost gozdov z žveplom leta 1989. Univerza E. Kardelja v Ljubljani, BF, Zbornik gozdarstva in lesarstva 36, s. 183--198.
4. Kennel, M., 1994. Stoffeintraege in Waldgebiete Bayerns. AFZ, vol. 49, no. 2, s. 69 - 72.
5. Komlenović, N., Gračan J., 1989. Kritične vrijednosti opterečenja sumporom i dušikom. Šum.list, 6-8, s. 363 - 371.
6. Kraigher, H., 1991. Mineralna prehrana mikoriznih smrek na Pohorju. Magistrsko delo, Biotehniška fakulteta, Oddelek za biologijo, Ljubljana 1991, 126 s.
7. Simončič, P. 1992. Razmere mineralne prehrane za smreko na distričnih rjavih tleh na tonalitu v vplivnem območju TE Šoštanj. Magistrsko delo. Ljubljana, Biotehniška fakulteta, Oddelek za agronomijo, 134 s.

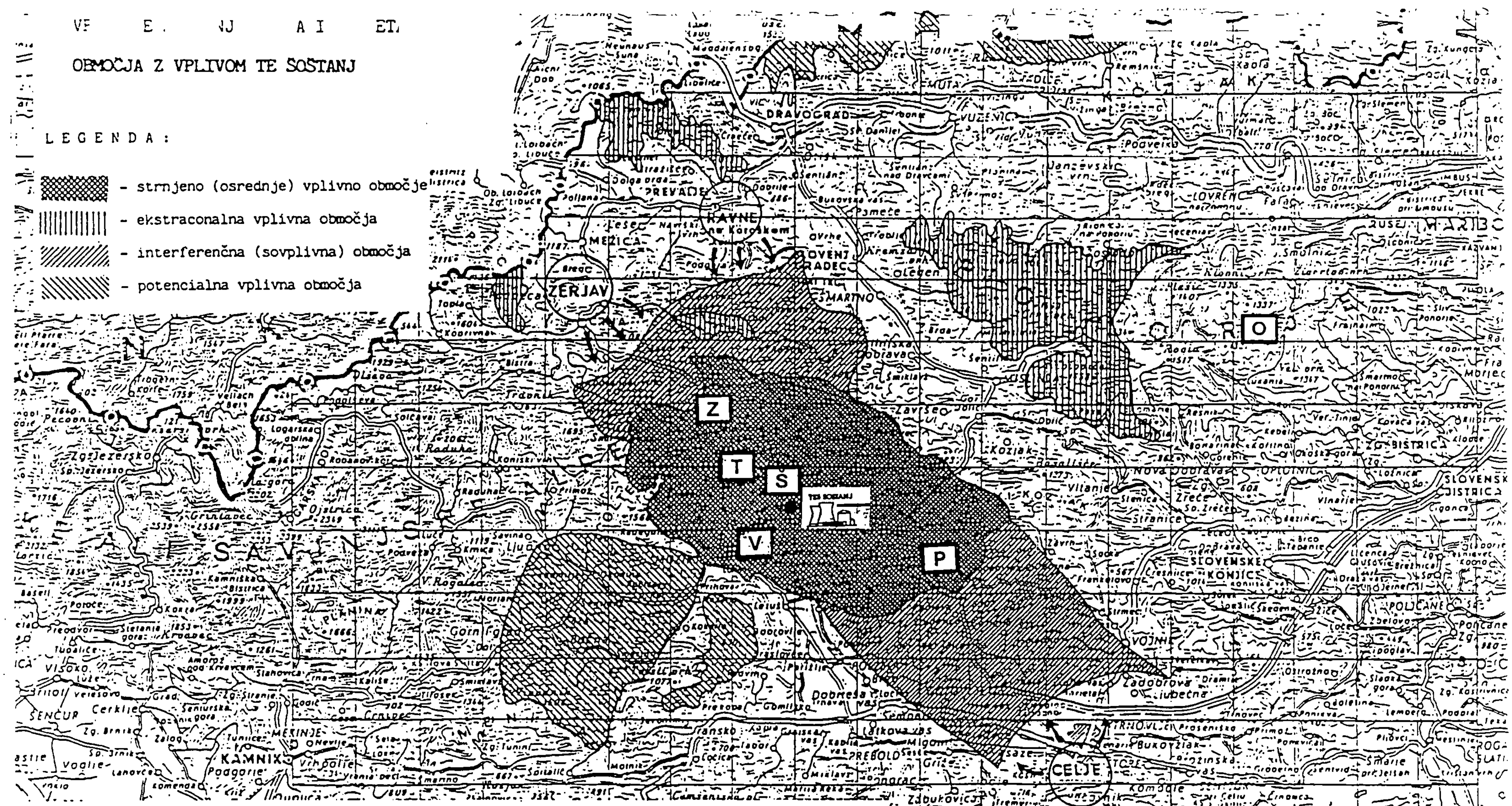
3. *PROUČEVANJE ONESNAŽENOSTI GOZDNIH TAL V IMISIJSKEM OBMOČJU TEŠ S PARNO PRIMERJALNIMI RAZISKOVALNIMI OBLEKTI*

3) Proučevanje onesnaženosti gozdnih tal v imisijskem območju šoštanjske termoelektrarne s parno-primerjalnimi raziskovalnimi objekti

1 UVOD

Termoelektrarna Šoštanj spada med največje onesnaževalce okolja v Sloveniji. Tako je npr. leta 1990 oddala v zrak 92964 ton žveplovega dvokisa, 12389 t dušikovih oksidov in 5731 t prašnih delcev (po viru RAJH-ALATIČ Z. in sod., 1991). Odpadni plini iz njenih dimnikov škodljivo vplivajo tudi na gozdove v njenem imisijskem območju in mestoma povzročajo njihovo propadanje. Škodljivi vplivi žveplovega dioksida in drugih onesnaževalcev zraka na rastlinstvo v vplivnem območju TE Šoštanj so že razmeroma dobro poznani (BATIČ F. in sod., 1994; DRUŠKOVIČ B., 1990; FERLIN F., 1990; KALAN J. in sod., 1989; KOLAR I., 1989; KRAIGHER H., 1990; RIBARIČ-LASNIK C., 1991; SMOLE I. in sod., 1995; idr.). Čedalje več je tudi študij, ki obravnavajo vplive odložin iz zaradi TEŠ onesnaženega zraka na gozdna tla (SIMONČIČ P., 1992; SVETINA-GROS M., 1994, idr.) ter raziskav onesnaženosti zraka, padavin, voda, radiološke meritve ipd..
Na gozdarskem inštitutu smo prvo pilotsko raziskavo vplivov škodljivih snovi iz zraka na gozdna tla in rastlinstvo na osnovi primerjanja lastnosti objektov s podobnimi rastiščnimi razmerami a z različno onesnaženostjo gozdov zastavili leta 1988 z večjim številom raziskovalnih ploskev na različnih koncih Slovenije (KALAN J., 1989; SMOLE I., 1990; URBANČIČ M., 1989 in 1992). Na osnovi the izkušenj so bili leta 1990 v imisijskem območju TEŠ (v gozdovih, ki poraščajo rastišča na rečnih usedlinah, na andezitskem tufu in na tonalitute kamnine so med najbolj razširjenimi na območju Šaleške doline) osnovani trije pari stalnih raziskovalnih objektov za nadzor stanja gozdov, za spremljanje dogajanj v njih in še posebej za ugotavljanje imisijskih vplivov TE Šoštanj na gozdna tla in rastlinstvo. Na njih proučujemo tudi stanje tal in zasledujemo morebitne spremembe v talnih lastnostih s ciljem, da ugotovimo učinke odložin žvepla in drugih odpadnih snovi iz onesnaženega zraka na gozdna tla in posledice teh vplivov na stanje, stabilnost in razvoj gozdnih ekosistemov.
V tem prispevku prikazujemo način izbora raziskovalnih objektov, metode pedoloških raziskav in važnejše izsledke o talnih lastnostih in onesnaženosti tal na teh treh parih objektov.

Slika 1: Nahajališča parno-primerjalnih raziskovalnih objektov (naslednja stran)



Slika 1: **Nahajališča parno-primerjalnih raziskovalnih objektov**
(Karta vplivnih območij je povzeta po KALAN in sod., 1989)

☐ lokacija raziskovalnega objekta

Nazivi raziskovalnih objektov:

Š - Široko
V - Veliki vrh
Z - Prednji vrh pri Zavodnjah
T - Topolšica
P - Pirešica
O - Osankarica

2 RAZISKOVALNI OBJEKTI IN METODE DELA

2.1 Opis nahajališč raziskovalnih objektov

Na stalnih raziskovalnih objektih se navadno proučuje vplive onesnaževalcev na tla tako, da se na istem mestu ugotavlja spremembe talnih lastnostih v določenih časovnih presledkih, n.pr. na vsakih 5 let. V obravnavanem primeru pa je zaenkrat uporabljena metoda parnih primerjav.

Leta 1990 smo pod vodstvom pedologa Janka Kalana v osrednjem imisijskem vplivnem območju termoelektrarne Šoštanj, ki ga imenujemo tudi Šaleško imisijsko območje, izbrali 5 stalnih raziskovalnih objektov, enega pa smo poiskali vzhodno od tega območja, na visokogorski planoti Pohorja. Objekte smo izbirali na gozdnih rastiščih, ki so med najbolj razširjenimi v Šaleškem imisijskem območju in sicer tako, da sta si bila po dva raziskovalna objekta različna v stopnji onesnaženosti, v ostalih ekoloških razmerah pa čimbolj podobna. Pričakovali smo, da bomo s primerjanjem talnih razmer med objektoma v paru dobili željene podatke o spremembah, ki jih v tleh povzročajo odložine iz onesnaženega zraka ter o učinkih teh sprememb na stanje obravnavanih gozdov. Kako močno so objekti onesnaženi, smo sklepali na osnovi njihovega položaja v prostoru glede na TEŠ, iz ocene poškodovanosti drevja zaradi imisij po ECE-metodi, iz stanja lišajev ter vsebnosti skupnega žvepla v vzorcih smrekovih iglic, ki so bile na objektih odvzete za foliarne analize (FERLIN F., 1990; KALAN J. in sod., 1989; KOLAR I., 1989; KRAIGHER H., 1990; RIBARIČ-LASNIK C., 1991; SMOLE I., 1990 idr.). Rastišča gozdnih združb je na osnovi svojih popisov vegetacije opredelil fitocenolog Ivan Smole.

Dva objekta sta bila izbrana na rastiščih gozdne združbe jelke z viličastim mahom (*Bazzanio Abietetum* WRABER (1953) 1958), v kmečkih gozdovih smreke s pretežno posamezno primesjo gradna, domačega kostanja, rdečega bora, jelke in bukve, v kateri prevladuje skupinskoprebiralno gospodarjenje. Sestoji poraščajo pobočne psevdogleje, ki so se razvili na pliokvartarnih fluviativnih sedimentih iz ilovice, peščene gline in glinastega proda. Objekt na Širokem pri Lajšah je dvainpol kilometra oddaljen od TEŠ, leži severno od termoelektrarne in je po naših ugotovitvah bolj izpostavljen njenimi imisijskim vplivom od primerjalnega objekta pri Topolšici, ki je po zračni črti od TEŠ v smeri severseverozahod oddaljen štiriinpol kilometra.

Drugi par primerjalnih objektov je bil osnovan v raznodobnih kmečkih gozdovih na rastiščih kisloljubnega gozda bukve, belkaste bekice in hrastov (*Querco-Luzulo-Fagetum* MARINČEK, ZUPANČIČ 1979), ki poraščajo rankerje, distrična rjava tla in sprana tla na andezitnih tufih, tufitih in vulkanskih brečah. Objekt na Velikem vrhu je triinpol kilometra (v smeri jugjugozahod) oddaljen od TEŠ, leži v mešanem kmečkem gozdu bukve, kostanja, gradna, rdečega bora in smreke. Je pod močnim vplivom njenih emisij. Blizu objekta je ANAS (Analitični Nadzorni Alarmni Sistem) postaja, ki meri onesnaženost zraka in druge meteorološke pojave. Objekt nad Pirešico leži približno 10 km vzhodno od TEŠ, na samem robu imisijskega območja, v malo onesnaženem, raznodobnem mešanem sestoju gradna, rdečega bora, bukve in kostanja, v katerem se je tudi steljarilo.

Peti objekt je postavljen v kmečki raznodobni bukov gozd s primesjo smreke, rdečega bora in macesna, ki leži na Prednjem vrhu pri Zavodnjah, blizu druge ANAS postaje, severozahodno od TEŠ. Čeprav je od termoelektrarne oddaljen približno 8 km (po zračni črti), je objekt močno izpostavljen njenim imisijskim vplivom. Ta gorski kisloljubni bukov gozd z belkasto bekico (Luzulo albidae-Fagetum s. lat.) porašča distrična rjava tla na tonalitu.

Šesti stalni raziskovalni objekt smo osnovali na Pohorju blizu Osankarice. Leži približno 30 km severovzhodno od TEŠ, izven njenega osrednjega vplivnega imisijskega območja. Osnovan je v enodobnem smrekovem debeljaku s posamezno primesjo bukve, jelke in gorskega javorja.

Sestoj porašča distrična rjava tla na tonalitu. Potencialna gozdna združba tega zasmrečenega rastišča je uvrščena v obubožano obliko visokogorskega pohorskega bukovega gozda (*Savensi-Fegetum, geogr. var. pohoricum* KOŠIR 1965, *forma depauperata*).

Raziskovalni objekti so bili osnovani na položnem terenu, kjer razvoj tal ni bil moten ali prekinjen zaradi erozijskih procesov, vlak, poti, starih kopišč, ognjišč, izvalov ter podobnih vplivov in na mestih, ki so bili rastiščno in sestojno ustrezno homogeni na površini, veliki najmanj en hektar .Važnejše rastiščne značilnosti, ki so bile ugotovljene na objektih ob fitocenoloških popisih in opisih reprezentančnih talnih profilov, so prikazane v Preglednici 1.

2.2 Opis terenskih in laboratorijskih del

V letu 1990 smo izvedli tudi prva terenska pedološka dela. Na vsakem izbranem raziskovalnem objektu smo izkopali po en reprezentančni talni profil, ki prikazuje tla, značilna za tisto rastišče, ga opisali in iz njegovih genetskih horizontov in podhorizontov odvzeli talne vzorce. V bližini talnega profila smo iz treh kvadratnih ploskev, vsaka je bila velika 25 cm x 25 cm, odvzeli kvantitativne vzorce tal iz sledečih plasti: opada (O_l), fermentacijske plasti (O_f), organskega podhorizonta z že humificirano organsko snovjo (O_h) ter iz sledečih globin tal: 0-5 cm, 5-10 cm, 10-20 cm, tako da za te plasti poznamo prostorninsko maso tal, kar nam je omogočilo izvesti kvantitativne laboratorijske analize tal. Tako nabrani vzorci tal so bili analizirani po standardnih metodah (opisane so v SIMONČIČ P. 1992, URBANČIČ M. 1989 in 1992 ter v drugih naših pedoloških prispevkih) v pedoloških laboratorijih gozdarskih inštitutov v Ljubljani (IGLG oz. sedaj GIS) in na Dunaju (FBVA), deloma pa so arhivirani za bodoče primerjalne in dopolnilne analize. Vzorcem so bile določene sledeče lastnosti: tekstura; reakcija (pH v $CaCl_2$); količina organskega ogljika (C) in skupnega dušika (N); ogljik-dušikovo razmerje (C/N); rastlinam lahko dostopen kalij (K_2O), fosfor (P_2O_5) in magnezij (Mg); izmenljivi kovinski bazični kationi (K^+, Ca^{++}, Mg^{++}, Na^+); izmenljiv vodik (H^+); vsota izmenljivih baz (SB), kationska izmenjalna kapaciteta (KIK), stopnja nasičenosti z bazami (V).
Kvantitativnim vzorcem, odvzetim iz plasti z vnaprej določenimi globinami so bile poleg teh parametrov na FBVA (Forstlichen Bundesversuhsanstalt, Dunaj) določene z atomsko absorbcijsko spektrofotometrijo (ekstrakcija z zlatotopko) celokupne vsebnosti sledečih težkih kovin: kroma (Cr), bakra (Cu), železa (Fe), mangana (Mn), niklja (Ni), svinca (Pb) in cinka (Zn). Na gozdarskem inštitutu so bile tem vzorcem z aparaturo Sulmhomat 12-ADG (suhi sežig) določene še količine skupnega žvepla.

Preglednica 1: Ekološke značilnosti raziskovalnih objektov

Ime objekta: *Name of the plot:*	**Topolšica**	**Široko**	**Veliki vrh**	**Pirešica**	**Prednji vrh pri Zavodnjah**	**Osankarica**
Matična podlaga: *Parent material:*	Rečne usedline (ilovica, peščena glina, glinast prod) iz pliokvartarja *Alluvial deposits*	Rečne usedline iz pliokvartarja *Alluvial deposits*	Andezitni tufi, tufiti, vulkanske breče (smrekovške plasti) iz oligocena *Andesitic tuff*	Andezitni tufi iz oligocena *Andesitic tuff*	Karavanški tonalit *Tonalit of Karavanke*	Pohorski tonalit *Tonalit of Pohorje*
Talni tip: *Type of the soil:*	Pobočni psevdoglej *Slope Pseudogley*	Pobočni psevdoglej *Slope Pseudogley*	Distrični kambisol *Dystric Cambisol*	Pobočni psevdoglej *Slope Pseudogley*	Distrični kambisol *Dystric Cambisol*	Distrični kambisol *Dystric Cambisol*
Rastišče gozdne združbe: *Site of the forest association:*	*Bazzanio-Abietetum* (WRABER (1953)1958), *typicum*	*Bazzanio-Abietetum, sphagnetosum* (ZORN 1965)	*Querco-Luzulo-Fagetum* (MARINČEK et ZUPANČIČ 1979)	*Querco-Luzulo-Fagetum*	*Luzulo albidae-Fagetum* (LOHM.et TX.1954), *s.lat.*	*Savensi-Fagetum depauperata* (KOŠIR 1965 *mscr)*
Nadmor. višina: *Altitude:*	440 m	410 m	480 m	420 m	825 m	1250 m
Nagib terena: *Slope gradient:*	10°	15°	15°	15°	15-20°	3-5°
Ekspozicija: *Exposure of site:*	N	N	NW	NE	SW	N
Ocena one-snaženosti gozda: *Pollution:*	Srednje onesnažen gozd *Medium polluted forest*	Močno onesnažen gozd *Strongly polluted forest*	Močno onesnažen gozd *Strongly polluted forest*	Malo onesnažen gozd *Little polluted forest*	Močno onesnažen gozd *Strongly polluted forest*	Malo onesnažen gozd *Little polluted forest*

3 IZIDI TALNIH PREISKAV IN UGOTOVITVE RAZISKAVE

3.1 Značilnosti tal reprezentančnih profilov

Na objektu Topolšica so se na pliokvartarnih rečnih usedlinah iz peščene gline in glinastega proda razvila zelo globoka tla. Prevladuje globok, distrični, počni psevdoglej s precej debelim organskim hoizontom. Tudi na objektu Široko so na pliokvartarnih sedimentih nastala zelo globoka tla. Tu prevladuje srednje globok (ker se psevdoglejni g horizont pojavlja v globini pod 45 cm), distrični, pobočni psevdoglej z razmeroma tankim organskim horizontom.
Psevdoglejna tla reprezentančnega profila Široko imajo v primerjavi s tlemi profila Topolšica tanjši organski horizont, so močneje oglejena, v g horizontu vsebujejo več gline, so manj kisla (za okoli 1/2 stopnje vsebnosti pH ($CaCl_2$)), vsebujejo nekoliko več skupnega dušika (N), imajo manjšo kationsko izmenjalno kapaciteto. V zgornjem delu so manj zasičene z izmenljivimi bazami, v spodnjem g- horizontu pa bolj.
Na objektu Veliki vrh so se na andezitskih tufih in tufitih razvila zelo globoka tla. Prevladuje podtip ilimeriziranega distričnega kambisola. Tudi na objektu Pirešica so na enaki kamnini nastala zelo globoka tla. Tu prevladuje srednje globok, distrični, pobočni psevdoglej.
V primerjavi s tlemi iz velikovrškega reprezentančnega profila so tla profila iz Pirešic bolj kisla, vsebujejo nekoliko več organske snovi in skupnega dušika, imajo ožja ogljik-dušikova (C/N) razmerja, z rastlinam dostopnim kalijem so bolje preskrbljena, imajo pa nižje stopnje nasičenosti z izmenljivimi bazami. Pri njih je illimerizacija slabše izražena, imajo bolj glinasto teksturo in slabšo propustnost za vodo. Za razliko od velikovškega profila so srednje močno psevdooglejena.
Na objektu Prednji vrh pri Zavodnjah in na objektu Osankarica na Pohorju prevladujejo globoka, tipična, distrična rjava tla na tonalitu. Distrični kambisol, predstavljen z zavodenjskim reprezentančnim profilom, ima zelo podobne lastnosti kot tla pohorskega profila. Vzorci pohorskih tal iz primerljivih globin praviloma vsebujejo manj organske snovi, so bolje preskrbljeni z dostopnim fosforjem in magnezijem in imajo nižje stopnje nasičenosti z izmenljivimi bazami od zavodenjskih.

Rezultati laboratorijskih analiz kvalitativnih talnih vzorcev iz genetskih (pod)horizontov reprezentančnih profilov so prikazani v preglednicah 2, 3 in 4.

3.2 Lastnosti kvantitativnih vzorcev

Kvantitativnim vzorcem, odvzetim iz ploskev, velikih po 25 cm x 25 cm, so bili določeni isti parametri kot talnim vzorcem iz profilov, poleg tega pa s kislinskim razklopom in AAS še celokupne vsebnosti nekaterih elementov, ki so za rastline in druge talne organizme pomembni kot hranila ali (in) nevarni kot možni zastrupljevalci. Zanimivejši izidi laboratorijskih analiz kvantitativnih vzorcev so prikazani v preglednicah 5 in 6.
Na vseh objektih so imeli kvantitativni vzorci iz vnaprej določenih plasti v primerjavi s talnimi vzorci iz ustreznih (ekstrapoliranih) globin reprezentančnega profila dovolj podobne lastnosti in zato v tem prispevku niso podrobneje prikazani.

Preglednica 2: Kemične lastnosti vzorcev iz reprezentančnih talnih profilov

Kraj Location	**Horizont** Horizon	**Globina** Depth (cm)	**pH** **($CaCl_2$)**	**Org.snov** Humus g/kg	**C/N**	**Skupni N** Total N g/kg	**Dostopni** **P_2O_5** mg/kg	Available **K_2O** mg/kg	**Dost./Avail** **Mg** mg/kg
Topolšica	Ol	7-6	-	-	-	-	-	-	-
	Of	6-3	3,18	672	42	9,4	130	600	130
	Oh	3-0	3,02	567	36	9,2	60	380	60
	Ah1	0-1	3,37	133	24	3,2	sledovi	120	sl
	Ah2	1-12	3,63	41	22	1,1	sl	100	sl
	(B)v	12-44	3,65	17	17	0,6	sl	100	sl
	(B)v/g	44-53	3,86	12	14	0,5	sl	80	0
	g1	63-80	3,82	9	17	0,3	sl	80	0
	g2	80-100	3,88	7	20	0,2	sl	80	0
	g3	100+120	4,02	5	15	0,2	sl	40	0
Široko	Ol	5-4	-	-	-	-	-	-	-
	Of	4-1	4,11	521	20	17,8	10	230	sl
	Oh	1-0	4,45	552	27	11,7	130	850	130
	Ah1	0-4	3,94	175	24	4,3	20	200	sl
	Ah2	4-11	4,03	43	17	1,5	20	100	sl
	(B)v1	11-25	4,11	22	16	0,8	sl	80	sl
	(B)v2	25-45	4,09	14	13	0,6	sl	60	sl
	g1	45-60	4,10	10	12	0,5	sl	50	0
	g2	60-80	4,16	10	12	0,5	sl	50	0
	g3	80-100	4,22	10	12	0,5	sl	70	0
	g4	100+120	4,25	9	10	0,5	sl	80	0
Veliki vrh	Ol	7-5	-	-	-	-	-	-	-
	Of	5-2	4,49	586	32	10,5	90	780	90
	Oh	2-0	4,06	396	37	6,3	sl	300	0
	Ah	0-10	4,22	78	35	1,3	sl	130	0
	E	10-26	4,26	28	27	0,6	sl	100	0
	(B)v/E	26-41	4,20	14	20	0,4	sl	70	0
	(B)v/Bt	41-61	4,15	9	13	0,4	sl	70	0
	(B)v1	61-80	4,24	7	13	0,3	sl	70	0
	(B)v2	80-100	4,35	7	20	0,2	sl	60	0
	(B)v3	100+120	4,36	7	20	0,2	sl	60	0
Pirešica	Ol	7-4	-	-	-	-	-	-	-
	Of	4-3	4,46	741	33	13.2	180	970	180
	Oh	3-0	3,16	483	22	12,5	130	880	130
	Ah	0-6	3,21	169	31	3.2	sl	340	sl
	E	6-16	3,83	40	23	1.0	sl	130	sl
	(B)v/Bt	16-47	3,91	21	24	0.5	sl	100	sl
	g1	47-60	3,61	16	13	0.7	sl	200	0
	g2	60-80	3,84	12	14	0,5	sl	250	0
	g3	80-100	3,84	10	12	0,5	sl	280	0
	g4	100-120	3,85	9	10	0,5	sl	290	0
Prednji v. pri Zavodnjah	Ol	2-1	-	-	-	-	-	-	-
	Of	1-0	3,93	655	26	14,8	90	410	sl
	Ah	0-5	3,29	466	29	9,3	50	230	sl
	Ah/(B)v	5-10	3,94	195	22	5,3	sl	110	sl
	(B)v	10-21	3,91	112	22	3.0	sl	50	0
	(B)v/C1	21-40	3,84	66	21	1,8	sl	40	0
	(B)v/C2	40-60	4,28	43	21	1.2	sl	30	0
	C/(B)v1	64-80	4,77	29	19	0,9	sl	30	0
	C/(B)V2	80-100	5,24	28	23	0,7	sl	30	0
	C/(B)v3	100-116	5,36	24	23	0,6	sl	30	0
Osankarica	Ol	3-1	-	-	-	-	-	-	-
	Of/Oh	1-0	4,77	552	24	13,1	130	400	sl
	Ah	0-5	3,66	207	16	7,6	40	140	sl
	Ah(B)v	5-15	3,88	112	18	3,7	10	50	sl
	(B)v1	15-37	4,66	66	21	1,8	10	40	10
	(B)v2	37-64	4,51	34	25	0,8	10	30	10
	C/(B)v1	64-80	4,28	17	17	0,6	20	30	20
	C/(B)v2	80-100	4,04	14	16	0,5	20	30	20
	C(B)	100-112	-	-	-	-	-	-	-

Preglednica 3: Izmenljive sposobnosti tal (v mmol IE/kg tal) reprezentančnih profilov

Kraj Location	Horizont Horizon	Ca++	Mg++	K+	Na+	SB	H+	KIK	V %
Topolšica	Ah1	14,7	9,3	2,6	0,9	27,5			
	Ah2	7,3	9,2	1,3	0,4	18,2	195	213,2	8,5
	(B)v	6,6	4,5	2,0	0,4	13,5	165	178,5	7,6
	(B)v/g	7,3	2,5	1,8	0,4	12,0	145	157,0	7,6
	g1	3,8	4,1	1,5	2,2	11,6	160	171,6	6,8
	g2	2,8	1,9	2,3	2,2	9,2	175	184,2	5,0
	g3	2,1	0,5	3,8	3,5	9,9	175	184,9	5,4
Široko	Ah1	9,7	4,2	5,1	0,4	19,4			
	Ah2	3,5	1,3	2,0	1,3	8,1	170	178,1	4,5
	(B)v1	2,2	0,9	1,8	0,4	5,3	145	150,3	3,5
	(B)v2	2,3	0,8	1,0	0,4	4,5	135	139,5	3,2
	g1	7,3	4,1	1,0	1,3	13,7	135	148,7	9,2
	g2	11,4	14,6	1,0	1,7	28,7	155	183,7	15,6
	g3	10,1	6,2	1,8	1,7	19,8	145	164,8	12,0
	g4	3,3	6,2	1,8	1,7	13,0	140	153,0	8,5
Veliki vrh	Ah	3,4	2,4	3,8	0,4	10,0	175	185,0	5,4
	E	11,3	2,4	2,8	0,8	17,3	150	167,3	10,3
	(B)v/E	11,1	2,9	2,3	1,7	18,0	135	153,0	11,8
	(B)v/Bt	7,4	2,1	1,8	1,7	13,0	125	138,0	9,4
	(B)v1	16,7	5,3	2,6	2,2	26,8	120	146,8	18,3
	(B)v2	30,8	23,1	3,1	2,6	59,6	100	159,6	37,3
	(B)v3	43,8	28,8	3,6	3,5	79,7	115	194,7	40,9
Pirešica	Ah	7,3	4,1	7,9	1,7	21,0			
	E	1,1	1,0	3,3	0,9	6,3	145	151,3	4,2
	(B)v/Bt	1,2	1,4	3,1	0,4	6,1	120	126,1	4,8
	g1	2,7	13,8	5,4	0,4	22,3	130	152,3	14,6
	g2	4,8	27,5	6,9	0,4	39,6	155	194,6	20,3
	g3	6,1	30,9	7,4	0,4	44,8	155	199,8	22,4
	g4	9,6	38,7	7,7	0,4	56,4	150	206,4	27,3
Zavodnje	Ah/(B)v	8,8	1,5	2,8	1,7	14,8	260	274,8	5,4
	(B)v	2,2	0,9	1,3	1,3	5,7	200	205,7	2,8
	(B)v/C1	3,1	0,8	0,8	1,7	6,4	185	191,4	3,3
	(B)v/C2	6,1	1,7	1,0	4,8	13,6	165	178,6	7,6
	C/(B)v1	7,9	2,1	0,8	2,2	13,0	155	168,0	7,7
	C/(B)V2	10,2	3,0	1,0	2,2	16,4	145	161,4	10,2
	C(B)v3	15,1	3,7	1,0	2,2	22,0			
Osankarica	Ah	6,0	2,8	0,3	0,4	9,5	285	294,5	3,2
	Ah(B)v	1,0	0,7	2,0	0,9	4,6	240	244,6	1,9
	(B)v1	0,7	0,3	0,3	0,4	1,7	195	196,7	0,9
	(B)v2	0,5	0,1	0,3	1,3	2,2	145	147,2	1,5

Preglednica 4: Tekstura tal reprezentančnih profilov

Kraj Location	Horizont Horizon	Pesek Sand %	Grob melj Coarse silt %	Drober melj Fine silt %	Glina Clay %	Teksturni razred Texture class
Topolšica	Ah2	34,0	33,8	18,0	14,2	meljasta ilovica *Silty loam*
	(B)v	25,8	41,2	22,0	10,2	meljasta ilovica *Silty loam*
	(B)v/g	45,8	12,0	12,0	30,2	glinasta ilovica *Clay loam*
	g1	25,0	15,8	35,5	23,7	meljasta ilovica *Silty loam*
	g2	26,1	12,7	33,5	27,7	meljasta ilovica *Silty loam*
	g3	16,3	23,8	29,7	30,2	meljastoglinasta ilovica *Silty clay loam*
Široko	Ah2	26,3	23,5	27,9	22,3	meljasta ilovica *Silty loam*
	(B)v1	21,1	20,3	34,6	24,0	meljasta ilovica *Silty loam*
	(B)v2	26,8	14,9	33,9	24,4	ilovica *Loam*
	g1	17,9	13,2	33,8	35,1	meljastoglinasta ilovica *Silty clay loam*
	g2	23,1	9,3	27,5	40,1	glinasta ilovica *Clay loam*
	g3	26,0	10,5	19,5	44,0	glina *Clay*
	g4	27,3	12,4	17,3	43,0	glina *Clay*
Veliki vrh	Ah	72,3	17,8	5,2	4,7	peščena ilovica *Sandy loam*
	E	48,4	11,2	24,4	16,0	ilovica *Loam*
	(B)v/E	46,2	11,7	28,0	14,1	ilovica *Loam*
	(B)v/Bt	36,6	19,9	23,2	20,3	ilovica *Loam*
	(B)v1	40,7	17,4	21,4	20,5	ilovica *Loam*
	(B)v2	40,6	14,2	22,4	22,0	ilovica *Loam*
	(B)v3	45,1	15,1	19,8	20,0	ilovica *Loam*
Pirešica	E	11,0	18,8	42,3	27,9	meljastoglinasta ilovica *Silty clay loam*
	(B)v/Bt	12,3	18,4	38,4	30,9	meljastoglinasta ilovica *Silty clay loam*
	g1	14,7	17,4	35,6	32,3	meljastoglinasta ilovica *Silty clay loam*
	g2	7,3	9,7	28,9	54,1	glina *Clay*
	g3	10,3	0,5	32,1	57,1	glina *Clay*
	g4	2,7	6,9	31,5	58,9	glina *Clay*
Prednji v. pri Zavodnjah	(B)v/C1	68,7	11,3	11,4	8,6	peščena ilovica *Sandy loam*
	(B)v/C2	68,5	10,9	14,5	6,1	peščena ilovica *Sandy loam*
	C/(B)v1	66,6	12,8	12,8	7,8	peščena ilovica *Sandy loam*
	C/(B)V2	84,5	6,3	8,0	1,2	ilovnat pesek *Loamy sand*
	C(B)v3	68,4	14,2	12,6	4,8	peščena ilovica *Sandy loam*
Osankarica	(B)v1	62,5	9,5	8,2	19,8	peščena ilovica *Sandy loam*
	(B)v2	63,4	12,6	15,8	8,2	peščena ilovica *Sandy loam*

Preglednica 5: Analizni podatki kvantitativnih vzorcev o reakcijah (pH vrednostih), količinah organske snovi (v g/kg tal in v kg/ha površine), vsebnostih celokupnega dušika, razmerjih med organskim ogljikom in celokupnim dušikom, vsebnostih celokupnega žvepla in razmerjih med organskim ogljikom in celokupnim žveplom. Prikazana so poprečja treh podvzorcev, nabranih na površinah 25 cm x 25 cm.

Kraj	Plast	Globina	pH	Org. snov	Org. snov	N	C/N	S	C/S
Location	Layer	Depth	(CaCl2)	Org. matter	Org. matter			mg/kg tal	
		cm		g/kg	kg/ha	kg/ha		mg/kg of soil	
Topolšica	Ol		3,27	891	2170	24	52	1290	393
	Of		3.30	724	19375	308	37	1510	245
	M5	0-5	3,28	195	30873	808	22	640	127
	M10	5-10	3,63	64	24698	813	18	430	75
	M20	10-20	3,93	31	30109	1068	16	400	36
Široko	Ol		3,63	781	4111	87	27	1090	416
	Of		4,17	707	17074	353	28	1970	208
	M5	0-5	4.47	348	48518	1198	23	1280	158
	M10	5-10	4.10	98	30598	809	22	540	106
	M20	10-20	3.60	40	34643	1047	19	440	52
V. vrh	Ol		4,53	914	10417	121	50	1220	434
	Of		4,49	650	7775	141	32	1540	245
	M5	0-5	3,82	128	38053	805	27	470	157
	M10	5-10	3,85	71	28095	517	32	330	124
	M20	10-20	3.98	45	35673	717	29	310	84
Pirešica	Ol		4,10	798	4919	81	35	1150	403
	Of	0-5	3.73	609	5866	130	26	1420	249
	M5	5-10	3.37	150	39562	923	25	540	161
	M10	10-20	3.70	67	34163	763	26	360	108
	M20		3,90	38	35858	852	24	300	73
Prednji v. pri	Ol		3,76	845	4574	68	39	1760	278
Zavodnjah	Of/Oh		3,94	776	21751	353	36	1880	239
	M5	0-5	3,60	466	66898	1337	29	1200	225
	M10	5-10	3,70	221	58114	1396	24	750	171
	M20	10-20	3,93	148	76629	1705	26	560	154
Osankarica	Ol		4,58	914	6295	76	48	1040	510
	Of/Oh		4,69	586	17155	351	28	1400	243
	M5	0-5	4.44	205	54844	1791	18	890	134
	M10	5-10	3,32	117	36204	1205	17	560	121
	M20	10-20	3,69	86	52439	1643	18	360	139

Preglednica 6: Vsebnosti težkih kovin (kobalta, kroma, bakra, niklja, svinca, cinka, v mg/kg tal) v kvantitativnih vzorcih.

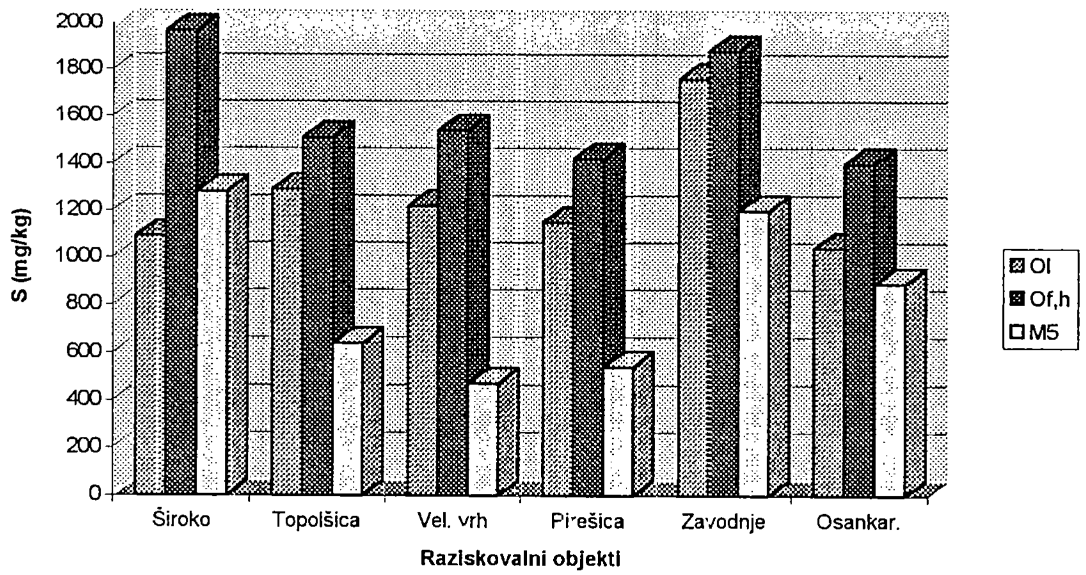
Kraj	Plast	Co	Cr	Cu	Ni	Pb	Zn
Location	*Layer*						
Topolšica	Ol	2	3	9	5	63	44
	Of	4	8	11	10	144	56
	M5	10	18	10	13	107	62
	M10	19	20	9	15	36	66
	M20	20	21	9	15	20	77
Široko	Ol	2	3	8	4	42	53
	Of	4	12	15	13	136	80
	M5	9	23	16	19	137	62
	M10	14	35	15	24	47	66
	M20	24	37	18	28	42	84
Veliki vrh	Ol	6	4	12	4	36	70
	Of	8	17	18	18	150	118
	M5	11	8	10	9	84	79
	M10	7	6	8	11	40	76
	M20	11	6	8	11	36	76
Pirešica	Ol	6	3	10	7	33	67
	Of	7	9	12	8	76	87
	M5	12	16	8	12	64	46
	M10	13	21	6	16	44	45
	M20	11	21	7	20	29	51
Prednji vrh pri	Ol	3	3	12	4	56	68
Zavodnjah	Of/Oh	4	9	12	9	221	89
	M5	9	10	9	8	149	77
	M10	17	11	8	10	63	79
	M20	16	12	8	13	59	76
Osankarica	Ol	2	2	9	4	31	61
	Of/Oh	8	10	12	1	95	51
	M5	5	10	8	10	76	36
	M10	7	11	6	10	56	32
	M20	10	12	6	3	44	42

Preglednica 7: **Interpretacijske koncentracije težkih kovin v tleh (izražene v mg/kg tal)**

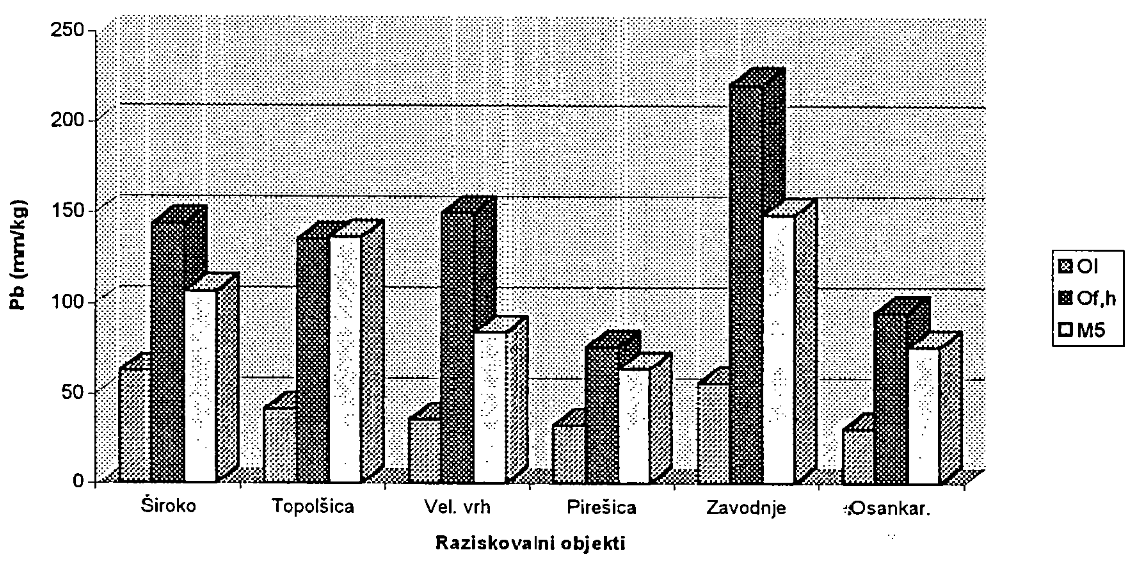
Kovina	Normalna vsebnost (BLUM el at. 1989)	Literaturna (pogosta) (KLOKE 1980)	Verjetno onesnažena tla (ÖNORM)	Mejne vrednosti še dopustne onesnaženosti (Ur.l. SRS 1990)
Kobalt (Co)	1-40	1-10	20	50
Krom (Cr)	2-50	2-50	50	100
Baker (Cu)	2-40	1-20	50	100
Nikelj (Ni)	5-50	2-50	40	60
Svinec (Pb)	2-20	0.1-20	50	100
Cink (Zn)	10-80	3-50	150	300

Ob parnih primerjavah izsledkov laboratorijskih analiz poprečnih kvantitativnih talnih vzorcev iz objektov (Široko:Topolščica, Veliki vrh:Pirešica, Prednji vrh pri Zavodnjah:Osankarica) ugotavljamo, da so imela tla iz objektov z večjo onesnaženostjo gozda v organskih horizontih praviloma večje koncentracije skupnega žvepla od tal objektov v manj onesnaženih gozdovih. Enaka ugotovitev velja tudi za vsebnosti celokupnega svinca v gornjih plasteh tal. Večina analiziranih talnih vzorcev je vsebovala nenormalno veliko svinca (nad 20 mg Pb na kg tal). Na štirih objektih (Široko,Topolščica, Veliki vrh, Prednji vrh pri Zavodnjah) pa so bila tla v zgornjih plasteh mestoma onesnažena s svincem preko mejne vrednosti še dopustne onesnaženosti (100 mg Pb na kg tal), ki jo navaja slovenski Uradni list iz leta 1990.
Količine ostalih težkih kovin (celokupnega kobalta, kroma, bakra, niklja, cinka), določene v talnih vzorcih, so se gibale v okvirih normalnih vsebnosti ali vsaj pod mejami, ki veljajo po avstrijskih predpisih (ÖNORM) za verjetno onesnaženost.

Slika 2: Poprečne vsebnosti celokupnega žvepla (v mg/kg tal) v organskih podhorizontih (Ol, Of,h) in talnih plasteh iz globine 0 do 5cm (M5) na raziskovalnih objektih



Slika 3: Poprečne vsebnosti celokupnega svinca (v gm/kg tal) v organskih podhorizontih (Ol, Of,h) in talnih plasteh iz globine 0 do 5cm (M5) na raziskovalnih objektih



4 POVZETEK

Gozdarski inštitut izvaja tudi posebne in interdisciplinarne raziskave propadanja gozdov in vplivov onesnaženega zraka na slovenske gozdove. V sklopu teh raziskav celotnega gozdnega prostora so uvrščena tudi proučevanja vplivov imisij termoelektrarne Šoštanj (TEŠ) na gozdove. V ta namen so bili leta 1990 v imisijskem območju TEŠ (v gozdovih, ki poraščajo rastišča na rečnih usedlinah, na andezitskem tufu in na tonalitu) osnovani trije pari stalnih raziskovalnih objektov za nadzor stanja gozdov, za spremljanje dogajanj v njih in še posebej za ugotavljanje imisijskih vplivov TE Šoštanj na gozdna tla in rastlinstvo. Objekta v paru se razlikujeta v imisijski obremenjenosti gozda, v ostalih ekoloških dejavnikih sta si podobna.

Na vsakem raziskovalnem objektu so bili odvzeti iz genetskih (pod)horizontov reprezentativnega profila kvalitativni talni vzorci, iz vnaprej določenih plasti treh ploskev velikosti 25cmx25cm (do globine 20cm) pa kvantitatinvni vzorci tal. Kvalitativnim vzorcem so bile z laboratorijskimi analizami določene onovne lastnosti (tekstura, reakcija, vsebnosti celokupnega dušika, ogljika, humusa, rastlinam dostopnih glavnih hranil, izmenjalne sposobnosti tal). Kvantitativnim talnim vzorcem pa so bili poleg teh parametrov določene še vsebnosti celokupnega žvepla in težkih kovin (Co, Cr, Cu, Ni, Pb, Zn).

Ob parnem primerjanju izidov pedoloških laboratorijskih preiskav se je izkazalo, da so vzorci iz gornjih plasti tal objektov iz bolj onesnaženih gozdov praviloma vsebovali več celokupnega žvepla in svinca od primerljivih vzorcev tal objektov iz z odložinami iz zraka manj obremenjenih območij. Na štirih objektih pa so bila tla v zgornjih plasteh mestoma onesnažena s svincem preko mejne vrednosti še dopustne onesnaženosti (100 mg Pb na kg tal).

5 VIRI

BATIČ, F./ JURC, D./ KALAN, J./ KOVAČ, M./ KRALJ, T./ MIKULIČ, V., 1993. Impact of Pollution Gasses from Thermal Power Plant in špštanj, Slovenija, on Forest Environment: A Brief Expertisa on Cause-consequence Relationship in Forest Decline Studies Carried out on Slovenian Forestry Institute. Gozdarski inštitut Slovenije, Ljubljana, e-423, 36 s.

DRUŠKOVIČ, B., 1990. Ocena poškodovanosti rastlinskega genetskega materiala v šaleški dolini z obrobjem. Raziskovalna naloga. Inštitut za biologijo Univerze v Ljubljani.

FERLIN, F., 1990. Vpliv onesnaževanja ozračja na rastno obnašanje in rastno zmogljivost odraslih smrekovih sestojev. Magistrsko delo. Ljubljana, Univerza Edvarda Kardelja v Ljubljani, Biotehniška fakulteta, VTOZD za gozdarstvo, 142 s.

KALAN, J., 1989. Pedološka proučevanja. Poročilo o raziskovalnem delu v letu 1989. Inštitut za gozdno in lesno gospodarstvo, Ljubljana

KALAN, J/ BATIČ, F./ HRČEK, D./ KRALJ, A./ SMOLE, I./ŠOLAR, M., 1989. Vpliv termoelektrarne Šoštanj na tla in vegetacijo. 1. faza. Inštitut za gozdno in lesno gospodarstvo, Ljubljana, p-225, 57 s.

KRAIGHER, H., 1990. Raziskave mikorize pri smreki v različno onesnaženih okoljih. Raziskovalna naloga. Inštitut za gozdno in lesno gospodarstvo, Ljubljana. 56 s.; Ref. 60

KOLAR, I., 1989. Umiranje smreke v gozdovih Šaleške doline. Magistrsko delo. Ljubljana, Univerza Edvarda Kardelja v Ljubljani, Biotehniška fakulteta, VTOZD za gozdarstvo.

LEŠNJAK, M./ HRČEK, D./ BATIČ, F./ ŠOLAR, M./ KOLAR, I./ FERLIN, F., 1989. Air pollution and damage on vegetation near TE Šoštanj thermal power plant in Slovenija, 8th World Clean Air Congress, Haag

RAJH-ALATIČ, Z./ ŠUŠTERŠIČ, A., 1991. Onesnaževanje zraka iz TEŠ, letno poročilo. Elektroinštitut Milan Vidmar, oddelek za elektrarne, Ljubljana

RIBARIČ-LASNIK, C., 1991. Ekofiziološke lastnosti smreke (Picea abies l. KARSTEN) na vplivnem območju termoelektrarne Šoštanj. Magistrsko delo. Ljubljana, Univerza v Ljubljani, Biotehniška fakulteta, VTOZD za biologijo

SIMONČIČ, P., 1992. Razmere mineralne prehrane za smreko na distričnih rjavih tleh na tonalitu v vplivnem območju termoelektrarne Šoštanj. Magistrsko delo. Ljubljana, Univerza v Ljubljani, Biotehniška fakulteta, oddelek za agronomijo, 134 s.
SMOLE, I./ KUTNAR, L., 1995. Spremembe gozdne vegetacije kot posledica učinkovanja onesnaženega zraka. Zbornik gozdarstva in lesarstva, 47. Ljubljana, s. 171-180
SMOLE, I., 1990. Spremembe gozdne vegetacije kot posledica učinkovanja onesnaženega zraka. Fazno poročilo raziskovalne naloge (p-243). Inštitut za gozdno in lesno gospodarstvo, Ljubljana. 23 str.; Ref. 11
SVETINA-GROS, M., 1994. Vpliv padavin na tla in vodne izvire na območju termoelektrarne Šoštanj. Magistrsko delo. Ljubljana, Univerza v Ljubljani, FNT, oddelek za geologijo, 102 s.
ŠKORIĆ, A./ FILIPOVSKI, G./ ĆIRIĆ, M., 1985. Klasifikacija zemljišta Jugoslavije. Akademija nauka I umjetnosti BiH, Sarajevo
URBANČIČ, M.,1989. Lastnosti gozdnih tal na tonalitu in andezitskem tufu v imisijskem območju termoelektrarne Šoštanj. Ekspertiza, (p-233). Inštitut za gozdno in lesno gospodarstvo, Ljubljana. 82 str.; Ref. 44
URBANČIČ, M., 1992. Uvajanje monitoringa gozdnih tal na stalnih raziskovalnih objektih v Sloveniji. Gozdarski vestnik, Vol. 50, št. 5-6. Ljubljana. Str. 258-266; Ref. 5
URADNI LIST SR SLOVENIJE, št.6, 1990. Uredba o ugotavljanju onesnaženosti kmetijskih zemljišč in gozda. Ljubljana, s. 355-357

4. RAZISKAVE MIKORIZE

4) Raziskave mikorize:

V okviru projekta je bil zaključena doktorska disertacija, katere povzetek podajamo:

KRAIGHER, Hojka, 1994:CITOKININI IN TIPI EKTOMIKORIZE PRI SADIKAH SMREKE (*Picea abies* (L.) Karst.) KOT KAZALCI ONESNAŽENOSTI GOZDNIH RASTIŠČ. Doktorska disertacija, Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, 156s., 13 tabel, 37 slik, 3 priloge, 299 referenc.

Vsebina naloge zajema študij citokininov in tipov ektomikorize pri sadikah smreke kot kazalcev onesnaženosti gozdnih rastišč. Na kratko je opisanih dvajset morfotipov ektomikorize v vzorcih tal z dveh različno onesnaženih gozdnih raziskovalnih ploskev v imisijski coni Termoelektrarne Šoštanj. Ploskev v Zavodnjah je predstavljala močno onesnaženo rastišče, ploskev v Mislinji pa relativno neonesnaženo. Dva tipa ektomikorize, *Lactarius lignyotus x Picea abies* in *Hydnum rufescens x Picea abies*, sta natančno opisana z anatomskimi in molekularnimi metodami. *Hydnum rufescens x Picea abies* je predlagan za kazalca neonesnaženih rastišč, *Paxillus involutus x Picea abies* pa za kazalca onesnaženih gozdnih rastišč v Sloveniji. Z metodami HPLC-RIA (visokotlačna tekočinska kromatografija-radioimunološki test) in HPLC-ELISA (encimsko-vezan imunološki test) so bili v filtratih rastnih medijev ektomikorizne glive *Laccaria bicolor* zabeleženi citokinini izopenteniladenin-tipa (izopenteniladenozin (iPA), izopenteniladenin (iP) in izopenteniladenozin-5-monofosfat (iPMP)), v filtratih glive *Thelephora terrestris* pa citokinini iP, iPA, iPMP, zeatin (Z) in zeatin ribozid (ZR). iPA in iP sta bila identificirana tudi z metodo GC-MS (plinska kromatografija - masna spektrometrija). V iglicah semenk smreke sta bila zabeležena citokonina iPMP in iPA. Posamezne vrste in sevi gliv so različno vplivali na vsebnost citokininov inokuliranih semenk smreke. Torej lahko spremembe v vrstni sestavi in abundanci tipov ektomikorize pod vplivi onesnaževanja vpliva na spremenjeno hormonalno ravnovesje višje rastline. V iglicah dvotedenskih semenk smreke, vzgojenih na talnem substratu iz Zavodenj ali iz Mislinje v kontroliranih pogojih, je bilo zabeleženo povišanje vsebnosti iP-tipa citokininov v iglicah smrek, ki so rastle na substratih iz Zavodenj. Vsebnosti citokininov v iglicah smrek, ki so rastle na nesterilnih substratih, so bile 2 do 3-krat višje kot v iglicah semenk smrek, vzgojenih na steriliziranih substratih. Možna razlaga je, da lahko onesnaženje tal vpliva na presnovo in rast korenin, ki se odraža v manjšem transportu asimilatov v korenine, zato prihaja do akumulacije iP-tipa citokininov v iglicah. Predlagana je možnost uporabe modela s semenkami smreke kot 'testnimi organizmi' za bioindikacijo onesnaženosti gozdnih tal. Za možnost kvantificiranja vsebnosti hormonov za bioindikacijo bi bilo potrebno testni model preizkusiti na nizu različno onesnaženih talnih substratov.

5. UGOTAVLJANJE STRESA NA OSNOVI ANALIZE ZAŠČITNIH SUBSTANC IN REPARATURNIH MEHANIZMOV V LISTIH/IGLICAH GOZDNEGA DREVJA IN ANALIZE EPIFITSKIH LIŠAJEV

UGOTAVLJANJE VPLIVA POLUTANTOV NA GOZDNI EKOSISTEM NA OSNOVI RAZISKAV, OPRAVLJENIH NA PROFILU: SMREKOVC-ZAVODNJE-VELIKI VRH-GRAŠKA GORA-SLOVENJEGRAŠKO SEDLO

UGOTAVLJANJE STRESA NA OSNOVI ANALIZE ZAŠČITNIH SUBSTANC IN REPARATURNIH MEHANIZMOV V LISTIH/IGLICAH GOZDNEGA DREVJA IN ANALIZE EPIFITSKIH LIŠAJEV

Raziskovalna skupina: Prof. dr. Franc BATIČ, BF, Odd. za agronomijo
Mag. Cvetka RIBARIČ-LASNIK, ERICO, Velenje
Mag. Tomaž SINKOVIČ, BF, Odd. za agronomijo
Samar AL-SAYEGH-PETKOVŠEK, ERICO, Velenje
Julija VRBOVŠEK, ERICO, Velenje

1. Uvod

Termoelektrarna Šoštanj je največji onesnaževalec zraka v Sloveniji. Izpušni plini njenih dimnikov škodljivo vplivajo na okoliške gozdove in druge ekosisteme in so eden izmed glavnih povzročitelj propadanja gozdov v okolici. Med nečistočami v izpušnih plinih prevladuje žveplov dioksid, katerega škodljivi vplivi na razne vrste vegetacij so dobro poznani. Z namenom ugotoviti obseg in stopnjo ogroženosti gozdnega ekosistema v vplivnem območju TE Šoštanj, smo izvedli naslednje meritve in opazovanja:

- Zgoščen popis propadanja gozdov na zgoščeni 8 x 8 km mreži na območju GG Slovenj Gradec in na 4 x 4 km mreži na ožjem vplivnem območju GG Nazarje v l. 1993 in ponovitev popisa v l. 1995

V okviru popisa propadanja gozdov je bila ocenjena tudi epifitska lišajska vegetacija in izračunan indeks čistoče zraka na mestih popisa kot rezultat opazovanja prisotnosti, številčnosti in pokrovnosti epifitskih lišajev.

Za ugotavljanje vzrokov propadanja gozdnega drevja, predvsem smreke, so bile na profilih Smrekovc-Veliki vrh, Veliki vrh - Brneško sedlo na Pohorju- Kobansko in Vič pri Dravogradu-Goriški vrh (Košenjak) v jeseni 1994 pobrane iglice za foliarne analize. Na profilih Smrekovc-Veliki vrh in Veliki vrh- Brneško (Slovenjegraško)sedlo se iglice za iste namene vzorčijo redno

že nekaj let v okviru magisterske in doktorske naloge mlade raziskovalke mag. Cvetke-Ribarič-Lasnik, iz ERICO, Velenje.V iglicah je bila analizirana vsebnost makrohranil (N, P, S, P, K, Ca), fotosintetskih pigmentov, tiolov, askorbinske kisline in aktivnosti encima peroksidaze. Vsebnost žvepla kaže predvsem onesnaženje z žveplovimi spojinami, medtemko ostali parametri dopuščajo tudi sklepanje na vpliv fotoiksidantov in splošnih stresnih situacij (suša, mraz, napadi gliv, insektov). Ob upoštevanju pedoloških analiz in stanja mikorize je mogoče sklepati na procese, ki potekajo zaradi vpliva polutantov v tleh in rastlinah.
Poleg analize biokemičnih pokazateljev stresa, ki nastaja v gozdnem drevju zaradi onesnaženja zraka, je bila na istih mestih, kot je bil narej popis propadanja gozdov in kjer so bili analizirani vzorci tal in iglic, je bila na vseh mestih analizirana še epifitska lišajska vegetacija, ki je dober indikator onesnaženja zraka z žveplovimi spojinami. Ta v veliko večji meri odraža le onesnaženje zraka in manj druge stresne dejavnike, ki vplivajo na uspevanje gozdov. Na izbranih ploskvah, domnevno čistih in bolj onesnaženih, je bila analizirana tudi mikoriza kot bioindikator stanja gozdnih tal. Kot kazalec eventuelnih vplivov onesnaženja na razmnoževanje gozdnega drevja, je bila na istih mestih kot so bile odvzete iglice za biokemične analize analizirana še kalivost semena smreke.
Pri izboru metod in načina vzorčenja je bila osnova delovna hipoteza, po kateri izpušni plini iz termoelektrarne Šoštanj vnašajo v gozdne ekosisteme snovi, ki neposredno vplivajo na gozdno drevje (analize iglic, analize lišajske vegetacije) ali pa so njihovi vplivi posredni preko sprememb v gozdnih tleh (spremembe v mineralni prehrani, mikorizi) ali preko povezav z drugimi okoljskimi parametri (klima, biotski agensi) vplivajo na destabilizacijo gozdnih ekosistemov (popisi propadanja gozdov).

2. Analiza biokemijskih parametrov v iglicah smreke (*Picea abies* /L./ Karst.)

Navadna smreka je bila izbrana kot glavna analizirana drevesna vrsta glede na zgoraj omenjeno hipotezo iz več razlogov:

1. Na celotnem emisijskem območju TEŠ je smreka v obstoječi gozdni vegetaciji glavna drevesna vrsta. Ne vzdrži kritika enega izmed recenzetov osnovnega predloga projekta naše raziskovalne skupine, da je izbira smreke napačna, ker smreka ni klimatozonalna drevesna drevesna vrsta na večjem delu analiziranih rastišč. Tega dejstva smo se dobro zavedali, vendar je bilo iz vidika izbora primerne drevesne vrste na celotnem obravnavanem območju nemogoče najti drugo drevesno vrsto na primerljivih rastiščih, s tem mislimo predvsem bukev (*Fagus sylvatica* L.) in hraste (*Quercus petraea* /Matusch./Leibl., *Q. robur* L.).
2. Kot vednozelena drevesna vrsta je smreka izredno primerna za tovrstna raziskovanja. Kopičenje polutantov in spremembe v fizioloških procesih in biokemični zgradbi kot odziv na delovanje zračnih onesnaževalcev po posredni in neposredni poti dopuščajo analizo stanja v času. V povezavi s primerno izbranimi vzorčnimi mesti glede na rastiščne dejavnike, stopnjo onesnaženja in stanje gozdnih sestojev so podane osnove za vzročno-posledično analizo dogajanj v gozdnem ekosistemu v veliko večji meri kot pri listavcih, katerih listi so na drevju

le eno rastno sezono.

3. Zaradi primerljivosti naših raziskav s podobnimi v tujini, predvsem s tistimi v sosednjem alpskem svetu, je izbor smreke tudi upravičen, saj je bilo na njej narejenih večina podobnih raziskav. Vzorčenje jelke (*Abies alba* Mill.) in borov (*Pinus sylvestris* L., *Pinus nigra* Arn., etc.) ni bilo mogoče, ker se na vplivnem področju TEŠ ne pojavljajo enakomerno, ali pa jih sploh ni, in tako ni izpolnjen eden izmed osnovnih pogojev za uvedbo določene rastlinske vrste kot bioindikatorja onesnaženosti ozračja.
4. Na onesnaženje zraka z žveplovimi spojinami, kar je slučaj pri izpuhih TEŠ, je smreka dokazano bolj občutljiv indikator kot druge, na vplivnem območju TEŠ prisotne gozdne drevesne vrste. Ne glede na to, da na celotnem vplivnem območju ni klimatozonalno drevo, smo prepričani, da bo tudi v bodoče, ob upoštevanju sonaravnega gospodarjenja z gozdovi še vedno med najvažnješimi gradniki gozdnih sestojev na obravnavanem območju.

Pri vzorčenju iglic smreke za analizo stresa in mineralne prehrane smo se zgledovali po izkušnjah raziskovalnih skupin v Avstriji, Nemčiji in Češki in po priporočilih IUFRO. Vzorčenje za analizo pigmentov in drugih biokemičnih pokazateljev stresa je potekalo v obdobju od konca avgusta do srede septembra. To je čas, ko se rast iglic in njihova diferenciacija ustavita, in se obdobje prilagajanja na zimske razmere še ni pričelo. Da je to obdobje najprimernejše za vzorčenje za tovrstne raziskave so na osnovi večletnih izkušenj ugotovili številni raziskovalci v nam bližnjem alpskem prostoru. Mi smo metodo vzorčenja iglic na terenu, njihove priprave in obdelave v laboratoriju kot tudi analitične postopke v veliki meri privzeli od skupine prof. D. Grilla, z Inštituta za fiziologijo rastlin Karl-Francove Univerze v Gradcu /Avstrija/, ki se že vrsto let ukvarja s to problematiko v Avstriji in ki je vsklajena s priporočili IUFRO.

Izbor vzorčnih mest v zgoraj omenjenih profilih (Sl.1) je bil opravljen glede na rezultate popisa propadanja gozdov, glede na meritve polutantov v zraku in klimatološke študije, z ozirom na rastiščne dejavnike in način gospodarjenje z gozdovi. Način vzorčenja in potek postopkov pri obdelavi in shranjevanju vzorcev za različne analize je shematično prikazan na Sl.2.

Fotosintetske pigmente (klorofile: klorofil a, klorofil b, karotene: karoten, karoten in ksantofile: lutein, zeaksantin, violaksantin, neoksantin in anteraksantin) smo analizirali z visokoločljivostno tekočinsko kromatografijo (HPLC) po metodi, ki jo je opisal Pfeifhofer (1989).

Vsebnost askorbinske kisline smo določili enako po HPLC metodi, opisani po Bui-Nguyen (1980) in Wimanbasiri-Wills (1983). Vodotopne tiole in aktivnost encima peroksidaze smo določali spektrofotometrično, tiole po metodi, ki sta jo opisala Grill & Esterbauer (1973), aktivnost peroksidaze po metodi, ki sta jo uvedla Keller & Schwager (1971).

Fotosintetske pigmente smo analizirali v štirih letnikih iglic. Služili so nam kot splošni pokazatelj vitalnosti smreke na rastišču, tako njihova absolutna koncentracija kot časovni potek naraščanja oz. upadanja koncentracije. Glede na rezultate drugih avtorjev je bila osnovna predpostavka, da imajo drevesa v čistem neonesnaženem okolju večjo koncentracijo vseh pigmentov in da koncentracija pigmentov narašča s starostjo iglic do tretjega oz. četrtega leta. Glede na okoljske dejavnike, ki vplivajo na koncentracijo pigmentov in razmerje med njimi, je bila osnovna predpostavka, da koncentracija klorofilo z nadmorsko višino normalno upada in se vzporedno veča koncentracija karotenoidov, pri čemer se z nadmorsko višino manjša koncentracija karotenov napram ksantofilom. To je v povezavi s prilagoditvijo na svetlobni režim rastišča in je posledica delovanja fotooksidantov. Analiza fotosintetskih pigmentov dopušča do neke mere tudi ločevanje vpliva kislih onesnaževalcev zraka (SO_2, HF), ki prizadanejo predvsem klorofile od vpliva fotooksidantov (O_3, PAN, drugi organski oksidanti), ki vplivajo predvsem na razmerje med klorofili in karotenoidi in na spremembo v sestavi karotenoidov.

Vodotopni tioli in askorbinska kislina so splošne stresne snovi v vseh celicah. V rastlinski celici delujejo kot antioksidanti.Njihova koncentracija se v normalnih razmerah, ko ni zračnega onesnaženja, veča z nadmorsko višino rastišča, hkrati z večanjem celokupnega stresa (večja intenziteta sevanja in predvsem UV sevanja, tvorba fotooksidantov, suša, mraz, veter). Pri onesnaževanju ozračja z žveplovim dioksidom pa koncentracija askorbinske kisline v iglicah smreke pri daljšem in močnejšem onesnaževanju upade, medtemko koncentracija tiolov naraste. Aktivnost encima peroksidaze velja za najbolj splošnega, nespecifičnega kazalca stresa, tudi vplivov onesnaženega zraka.

Vzporedno z analizami biokemičnih parametrov smrekovih iglic je potekala še analiza kalitve semen smreke z istih rastišč. S tem smo hoteli ugotoviti vpliv onesnaženja iz TEŠ na sposobnost razmnoževanja te drevesne vrste.

Naštete izhodišča so bila osnova za izbor analiziranih parametrov v iglicah smreke. Ob podatkih o mineralni prehranjenosti drevja, stanju gozdnih tal, analizi mikorize in epifitov, in upoštevaje, kadar so na voljo, meritve onesnaževalcev in podnebnih dejavnikov, bi lahko razložili rezultate popisa propadanja gozdov na določenem rastišču in posrednodoločili tudi emisijsko območje TEŠ.

V poročilu predstavljamo rezultate analiz zgoraj omenjenih parametrov iz vzorčenja v letu 1993, združeno za profila Smrekovc-Zavodnje- Veliki vrh in Veliki Vrh- Graška gora- Kope- Brneško sedlo na Pohorju. Za l. 1994 podajamo le rezultate analize fotosintetskih pigmentov posebej za v uvodu omenjene tri profile. Za lažjo interpretacijo podatkov analize fotosintetskih pigmentov, askorbinske kisline in drugih parametrov je predstavljna še analiza žvepla v iglicah za profil Smrekovc- Veliki vrh-Pohorje za leto 1993 (Sl.3) in za nekatera izbrana vzorčna mesta širšega emisijskega območja TEŠ še za l. 1994 (Sl. 4). Kot je razvidno iz obeh prikazov so močno onesnažena mesta, z veliko akumulacijo žvepla v iglicah v bližini TEŠ, to so vzorčna mesta Veliki vrh in Zavodnje (postaja ANAS, gozdni rob; Prendji vrh, cca 2 km zračne linije, v sestoju). Vsa bolj oddaljena vzorčna mesta, ki so hkrati tudi na večjih nadmorskih višinah so manj onesnažena, vendar je vsebnost žvepla tudi na teh mestih povišana. Iz prikazov je še razvidno, da vsebnost žvepla iz leta v leto precej niha, kar ni odvisno le od stopnje onesnaženosti zraka ampak tudi od drugih okoljskih parametrov v dotični rastni sezoni in in od tega pogojenega fiziološkega stanja smreke ob vzorčenju iglic. Za profil Košenjak in Kobansko vzorci še niso analizirani. Vzorčna mesta z največjo vsebnostjo žvepla imajo praviloma tudi najmanjšo vsebnost fotosintetskih pigmentov, moten starostni potek pigmentov in porušeno razmerje med njimi. Zmanjša se vsebnost karotenov in poveča vsebnost ksantofilov. Rezultati analiz fotosintetskih pigmentov v iglicah smreke, vzorčenih na profilih Smrekovc-Veliki vrh in Veliki vrh-Pohorje v jeseni l. 1993 so prikazani na slikah 5-7. Vsebnosti vseh pigmentov (Sl.5) kor vsota klorofilov (Sl.6) in vsota vseh karotenoidov (Sl.7) se ujemajo. Najbolj onesnažena mesta, ki so bližje TEŠ, ali pa so zaradi klimatskih prilik (inverzije, smer vetra v povezavi z lego rastišča) bolj na udaru izpušnih plinov imajo manjšo vsebnost pigmentov. Izstopajo prevsem vzorčna mesta Zavodnje, Veliki vrh, Lajše in Graška gora (vsi pigmenti, Sl. 5), ki imajo poleg majhne vsebnosti pigmentov še izrazito moten starostni potek koncentracij. Vsebnosti začno upadati ponekod že v drugem letu, ali pa je stagnacija vrednosti na nivoju triletnih iglic, oziroma znaten upad v štiriletnih iglicah.. Do neke mere izkazujeta podobno obnašanje pigmentov (celokupnih (Sl.5) in klorofilov; Sl. 6) tudi vzorčni mesti Kope in Brneško sedlo, ki sta očitno v določenih vremenskih situacijah izpostavljeni vplivom visokih koncentracij onesnaževalcev iz TEŠ. Vzorčni mesti Kramarice in Smrekovec, ki sta na zavetrni strani, in nad inverzijsko plastjo, izkazujeta večje koncentracije pigmentov in normalen starostni potek rasti koncentracij.Koncentracije klorofilov so večje v iglicah smrek z večjih nadmorskih višin, kar je v nasprotju z normalnimi trendi in kaže na močno onesnaženje zraka s kislimi odložinami (žveplov dioksid !) v dolini.Vsebnosti celokupnih karotenoidov (Sl.7) odražajo splošni oksidacijski stres. Zato njihova vsebnost bolj upada s starostjo iglic na večjih nadmorskih višinah, kjer je več fotooksidantov, čeprav je njihova absolutna vsebnost na teh mestih večja zaradi prilagoditve na to okolje. Vendar ne gre prezreti dejstva, da tudi žveplov dioksid deluje kot oksidant, zato tudi upad karotenoidov na najbolj onesnaženih mestih.

Vsebnost askorbinske kisline kot splošnega antioksidanta je z izjemo vzorčnih mest Kramarice in Smrekovec na vseh ostalih zelo majhna (Sl.8). To se je ujema z ugotovitvami avstrijskih in nemških raziskav. V njih so ugotovili, da vsebujejo iglice smrek, ki so rastle v z žveplovim dioksidom zelo onesnaženem zraku vedno majhno vsebnost askorbinske kisline. Vsebnost tega antioksidanta v iglicah smreke, ki rastejo v čistem okolju narašča z nadmorsko višino, podobno kot vsebnost vodotopnih tiolov. To potrjujejo tudi naši rezultati (Sl. 8 in Sl. 9), pri čemer naj bo se do določenih stopenj onesnaženja vsebnost tiolov povečevala tudi z naraščanjem žveplovega dioksida v zraku. Z ozirom na te ugotovitve tujih raziskovalcev so naši rezultati pogosto kontradiktorni in težko razložljivi. Tudi aktivnost encima peroksidaze (Sl. 10) se na večini močno onesnaženih mest močno poveča v enoletnih iglicah, kar lahko povezujemo z akumulacijo vpliva žveplovih spojin in drugih polutantov iz TEŠ, vendar smo pogosto na najbolj onesnaženih mestih izmerili tudi najnižje vrednosti aktivnosti peroksidaze, n.p. vzorčno mesto Zavodnje. Ali gre v tem primeru za prekoračeno obrambno sposobnost iglic in za začetek propada je težko zaključiti, vendar je takšna razlaga logična. Da bi ugotovili širše emisijsko območje TEŠ smo v letu 1994 vzorčili smrekove iglice ponovno na izbranih mestih profilov Smrekovec- Veliki vrh in Veliki vrh-Pohorje (Sl.11) in na še bolj proti severu-vzhodu oddaljenem profilu Košenjak pri Dravogradu (Sl.12) in na profilu Pohorje - Kobansko (Sl. 13). Rezultati analiz vseh fotosintetskih pigmentov so podobni kot v prejšnjih letih. Iz Sl. 11 je razvidno, da so najmanjše vsebnosti pigmentov v iglicah iz močno onesnaženih rastišč, ki so so v bližini TEŠ, ali sicer pod direktnim vplivom onesnaženega zraka. Izstopata predvsem vzorčni mesti Zavodnje in Veliki vrh. Analiza fotosintetskih barvil iglic vzorčenih na štirih mestih na profilu Košenjaka ob avstrijski meji kaže (Sl. 12), da se pojavljajo motnje na celem profil, a najbolj tik nad dolino Drave in na višini okrog 1000m. V tem pasu smo opazili tudi znatno poslabšanje lišajske obrasti in rezultati kažejo na vpliv TEŠ, še posebej ob anticiklonskih vremenskih prilikah, ko so izpušni plini ujeti v plast pod subsidenčno inverzijo. Podobno stanje nakazuje tudi profil Pohorje-Kobansko, na katerem so severna pobočja Pohorja v nižjih legah (vzorčni mesti Sv. Primož in Plužnikar) manj prizadeta kot bolj izpostavljeni vrhovi Kobanskega (Sl. 13). Tudi ti rezultati se ujemajo s kartiranji epifitske lišajske flore in vegetacije. Primerjava rezultatov analize vsebnosti fotosintetskih pigmentov, tiolov, askorbinske kisline in aktivnosti encima peroksidaze z analizami vsebnosti celokupnega žvepla pokaže, da so izhodišča naše delovne hipoteze potrjena. Metode se smiselno dopolnjujejo. Analiza vsebnosti žvepla v iglicah kaže predvsem akumulacijo žveplovih spojin v iglicah na določenem rastišču, ne moremo pa na osnovi teh podatkov še sklepati o stresu, ki mu je izpostavljeno gozdno drevje. Vsebnost posameznih fotosintetskih pigmentov, njihove vsote in razmerja dobro odražajo splošno vitalnost in s tem stopnjo prizadetosti. Vsaj v določeni meri lahko sklepamo na vpliv kislih polutantov in delež fotooksidantov. Vsebnost askorbinske kisline in tiolov kaže stopnjo reakcijske,oz. obrambne sposobnost in s tem tudi ogroženosti, povzročene od "naravnega stresa" na večjih nadmorskih višinah,oziroma od žveplovih spojin na onesnaženih mestih. V kombinaciji z analizami tal, epifitske lišajske vegetacije in stanja mikorize lahko z naštetimi biokemičnimi analizami interpretiramo stanje gozdov na določenem rastišču in dokaj dobro ocenimo delež vpliva iz TEŠ. Če bi uporabili še specifične indikatorje suše (ABA, etilen, nekatere amino kisline, poliamini) in z njo často povezanega temperaturnega stresa, bi delež motenj, ki jih povzroče onesnaževalci še bolj natančno opredelili. Kot že rečeno nam dodeljena sredstva v projektu tega niso dovoljevala in velik del predstavljenih rezultatov izvira iz drugih virov finansiranja.

Analiza kalivosti semena smreke, nabranega v širšem in ožjem emisijskem območju je pokazala, da onesnaženje znižuje kalivost, vendar je le ta v večji negativni korelaciji z nadmorsko višino rastišča kot s stopnjo onesnaženosti zraka na njem.(Sl. 14).

3. Analiza epifitske lišajske vegetacije

Epifitsko lišajsko vegetacijo smo v širšem emisijskem območju TEŠ uporabili kot indikator onesnaženosti zraka z žveplovimi spojinami. Na osnovi številnih opazovanj in laboratorijskih poskusov je dokazano, da epifitski lišaji izredno dobro odražajo delovanje onesnaženega zraka. V onesnaženem zraku propadejo prej kot večina višjih rastlin. Vzrok je v njihovi zgradbi in načinu aktivnosti. So steljčnice, brez tkiv in sposobnosti uravnavanja izmenjave plinov. To pomeni, da so zraku, tudi onesnaženemu stalno izpostavljeni. Aktivni so vedno, če je le dovolj vlage. Ker vsebnosti vode ne morejo uravnavati, saj so poikilohidri organizmi, so aktivni predvsem takrat ko je dovolj vlažno, torej tudi pozimi, ko je zrak zelo onesnažen. Kot epifiti so se prilagodili na sprejem snovi iz zraka, torej tudi onesnaževalcev. So simbiontski organizmi, v katerih po masi celičja prevladujejo heterotrofne glive nad avtotrofnimi algami. V onesnaženem okolju se to krhko ravnovesje hitro poruši. Zaradi vseh naštetih razlogov so epifitski lišaji izredno dobri kazalci kvalitete zraka, tako v urbanem kot v naravnem okolju. S svojo prisotnostjo, vrstno sestavo, pokrovnostjo in pogostnostjo vrst in tipov steljk izredno dobro odražajo predvsem tako imenovano "klasično onesnaženje zraka", tj. onesnaženje z industrijskimi in drugimi izpuhi, v katerih prevladujejo kisli onesnaževalci kor sta žveplov dioksid in flourovodik. Manj kot akutne, trenutne visoke koncentracije odraža stanje epifitske lišajske vegetacije dolgotrajno celokupno onesnaženje. Po številnih tujih raziskavah, pa tudi po opazovanjih v Sloveniji lahko trdimo, da stanje epifitske lišajske vegetacije dobro odraža povprečno onesnaženost zraka v zimski sezoni, ko so razmere najbolj drastične. Zaradi vsega naštetega jih uporabljamo kot splošne kazalce kvalitete zraka, še posebej tam, kjer ni meritev zračnih onesnaževalcev. Pri preučevanju vplivov onesnaženega zraka na ekosisteme je spremljanje stanja lišajev pomembno še iz razloga, da so lišaji relativno neodvisni od dogajanj v tleh, da nanje ne vplivajo v toliki meri kot na višje rastline biotski agensi in da so temperaturno relativno indiferentni. Iz vseh naštetih razlogov smo pri analizi stanja gozdnih ekosistemov v vplivnem območju TEŠ vključili tudi opazovanje stanja lišajev. V ta namen smo uporabili dve metodi. Prvo smo uporabili pri popisu propadanja gozdov, v keterem smo na izbrani skupini šestih dreves popisali obrast gozdnega drevja z lišaji po metodi, ki jo stalno uporabljamo pri popisu propadanja gozdov že od leta 1985. Druga metoda je bila vrstno kartiranje v širšem območju TEŠ, ki temelji na vrstnem kartiranju lišajev na izbranih mestih. Prva metoda je enostavna, hitro in lahko izvedljiva in da vpogled v splošno stanje zraka na širšem območju. Pri drugi metodi gre za popis vrst v odvisnosti od stopnje onesnaženja, kjer pa je potrebno v veliko večji meri upoštevati rastiščne dejavnike (podlago-drevo, podnebne dejavnike, starost podlage, itd.). Metoda je veliko bolj natančna, a časovno zelo zahtevna. Kot že omenjeno smo prvo metodo kartiranja izvedli ob vsakokratnem popisu propadanja gozdov, medtemko smo z drugo kartirali sistematično izbrana območja. Najprej ožje emisijsko območje, Šaleški bazen, nato širše, domnevno emisijsko območje, Uršljo goro, Pohorje, kjer so in nam še izdatno pomagajo sodelavci iz Univerze v Gradcu /Avstrija/ preko diplomskih nalog njihovih in naših študentov.

a) Popisi lišajev ob popisih propadanja gozdov

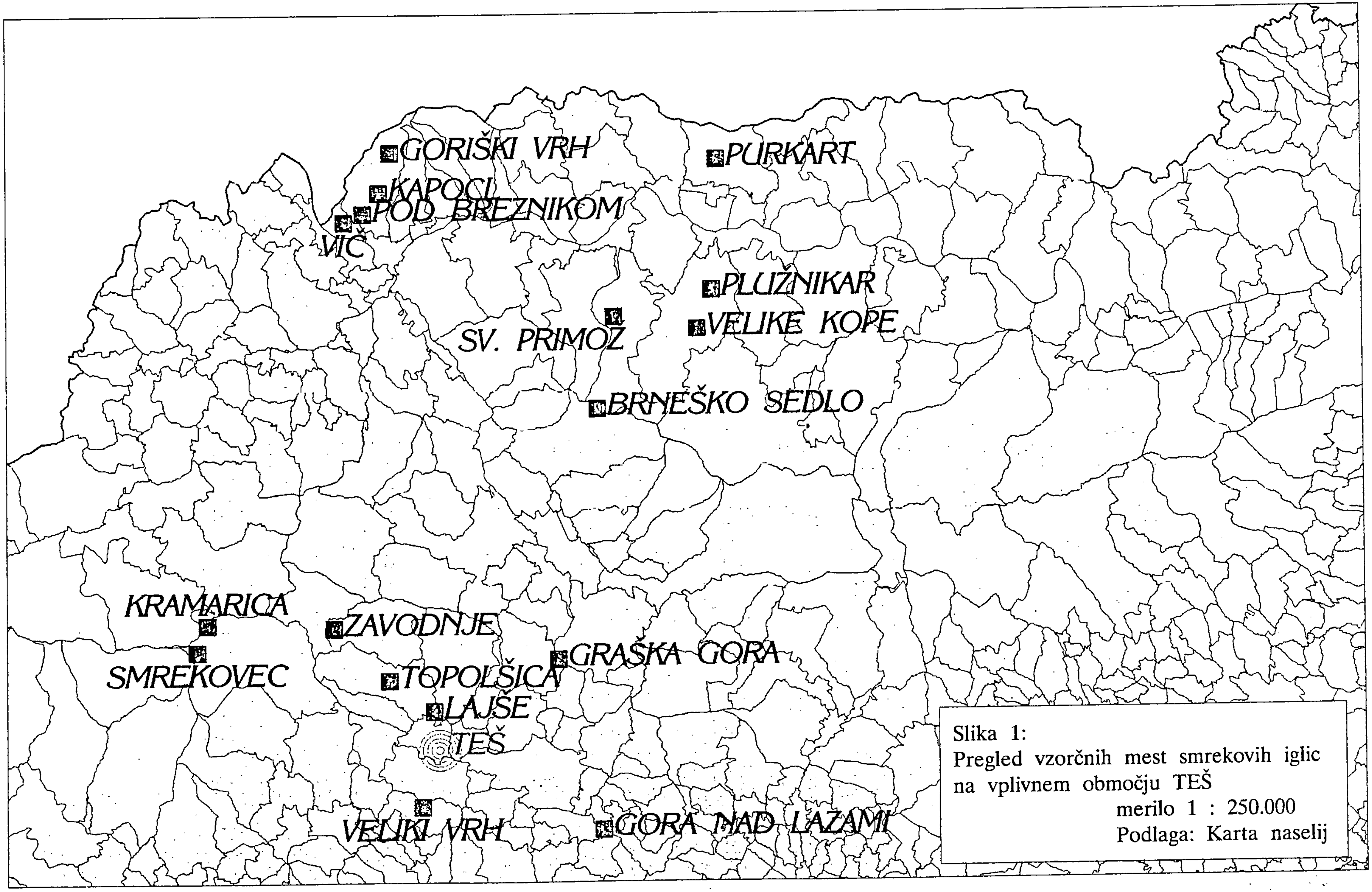
Analiza stanja epifitske lišajske vegetacije, ki odraža predvsem kvaliteto zraka kaže, da je zrak v ožjem šaleškem bazenu zelo močno onesnažen, saj je epifitska lišajska vegetacija na smreki in bukvi skoraj popolnoma uničena. Močno je razširjena skorjasta vrsta *Scoliciosporum chlorococcum* , ki povsod indicira onesnaženje z žveplovim dioksidom, oziroma eutrofikacijo. Vrednosti indeksa atmosferske čistoče, izračunanega na osnovi stanja lišajev so v večini v četrtem razredu in naraščajo v smeri proti zahodu. Tudi na območju GG Slovenj Gradec so še vrednosti indeksa dokaj nizke, prevladuje 3 razred, kar pomeni že delno onesnažen zraka.

Rezultati kartiranja epifitske lišajske vegetacije ob popisih propadanja gozdov l. 1993 in 1995 so prikazani na Sl. 15 (1993) in Sl. 16 (1995). Vsako popisno mesto je na karti območja opredeljeno z indeksi atmosferske čistoče, ki so izračunani posebej za vsako ocenjeno drevo. Vrednosti indeksa so izražene v razredih. Razred 1 pomeni bujno lišajsko obrast in čist zrak, razred 4 pa onesnaženo ozračje in revno lišajsko vegetacijo.. Vrednost 0 pomeni, da na opazovanem drevesu ni epifitskih lišajev in da je zrak zelo močno onesnažen.. Glede na razrede IAP je za vsako popisno mesto izračuna odstotek poškodovanosti lišajev. Večji kot je odstotek poškodovanosti lišajev, bolj je onesnažen zrak. Iz pregledne karte je razvidno, da je na večini popisnih mest propadanja gozdov zrak že tako močno onesnažen. da je uničeno več kot 59% lišajske obrasti. Bolj čista mesta so omejena na zatišne lege (Dolič, severna pobočja Pohorja, vrh Košenjaka, zatišne doline v zgornji Mežiški dolini, vrh Smrekovca. Na vseh ostalih mestih je lišajska obrast revna, kar jasno odraža vpliv onesnaženja iz TEŠ, kot to potrjujejo tudi druge raziskave (kartiranja vrst, analize biokemičnih indikatorjev vplivov onesnaženja v iglicah smreke, analiza celokupnega žvepla). Vrednosti IAP kažejo, podobno kot tudi ostali analizirani parametri. jasen vpliv meteoroloških dejavnikov (smer vetra, pojav inverzij) na uspevanje lišajev in s tem na stopnjo onesnaženosti ozračja. Primerjava stanja med letoma 1993 in 1995 kaže rahlo izboljšanje stanja, saj so se na precejšnem številu popisnih mest vrednosti IAP povišale, oz. se je zmanjšalodstotek poškodovanosti celotne ploskve. Na ombmočju območne enote Slovenj Gradec je opravil popis isti popisovalec, ki že vrsto let sodeluje pri popisu propadanja gozdov. V tem primeru v večji meri odpade "subjektivna napaka" popisovalca in izboljšanje stanja lišajev sovpada z manjšimi imisijami, kar nakazuje delno tudi vsebnost žvepla v iglicah in do do neke meri tudi izboljšanje stanja gozdov. Mesta v okolici neposrdni okolici TEŠ izpadejo še vedno zelo onesnažena, pravtako tudi emisijam iz TEŠ bolj izpostavljena mesta v širšem emisijske območju, kjer so pomemben dejavnik tudi vremenske prilike. Za podrobnejšo preverbo stanja bo potrebno ponovno vrstno kartiranje lišajev, v katerem bomo lahko dokazali povečanje pogostnosti in izboljšanje stanja pasameznih različno občutljivih vrst. Zaradi tega bi bilo tudi to opazovanje smiselno vključiti v obratovalni minitorin, saj epifitski lišaji dosti boljše reagirajo le na kvaliteto zraka in manj na druge dejavnike okolja.

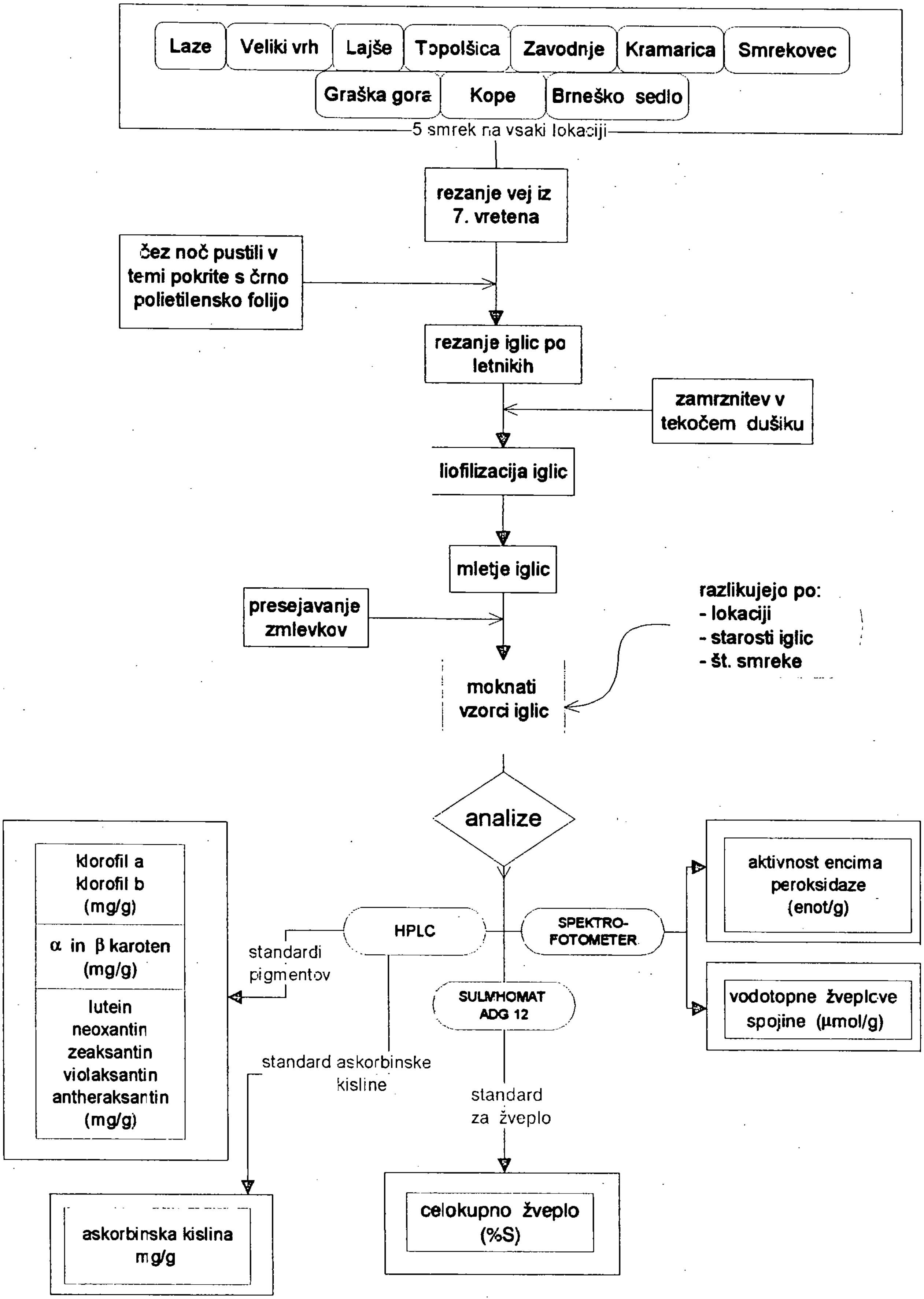
b) Kartiranje lišajev na osnovi kartiranja lišajskih vrst

Vrstna kartiranja lišajev, izvedena v o ožjem emisijskem območju, t.j. v Šaleškem bazenu, kažejo podobno stanje kot analize vsebnostu žvepla v iglicah smreke. Stanje je najslabše na Velikem vrhu in okolici in na pobočjih v širši okolici Zavodenj. Na bukvi, belem gabru in na iglavcih je normalna vrstna sestava epifitskih lišajev povsem uničena. V večini primerov drevje , ponekod celo iglice! popolnoma preraščajo zelene kokalne alge in na onesnaženje odporna vrsta lišaja s skorjasto steljko *Scoliciosporum chlorococcum* Na dniščih debel teh drevesnih vrst in na deblih dreves, ki bolj nevtralizirajo vplive kislih odložin iz zraka (javorji, lipe, jeseni, topoli, vrbe, sadno drevje) pa se pojavljajo na ožjem emisijskem območju tudi močno poškodovane steljke lišajskih vrst, ki so ostanek za ta drevesa značilne lišajske flore. To so predvsem vrste iz rodov *Hypogymnia, Parmelia, Physcia, Lecanora, Lecidea, Pertusaria in Candelariella*. Vendar se tudi med temi pojavljajo le na onesnaženje zraka najbolj odporne vrste (*Hypogymnia physodes, Parmelia sulcata, P. saxatilis, P. glabratula, Physicia ascendens, Lecanora expalens, L. symicta, L. conizaeoides, Lecidea elaeochroma, Pertusaria amara, Candelariella reflexa*), ki se večkrat in v boljšem stanju pojavljajo na dniščih debel ali na zavetrni strani debel, oziroma na zgornji strani debelejših vej v krošnji. Z oddaljevanjem od TEŠ se veča vrstna pestrost kot pogostnost in pokrovnost posameznih

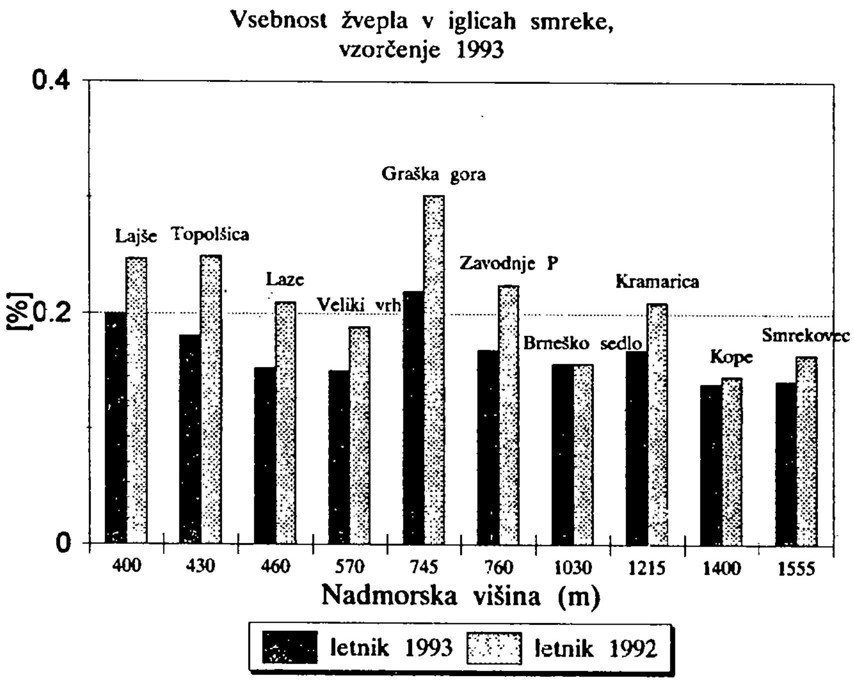
vrst. V tem območju, ki sega vse do Slemena, Kramaric, Paškega Kozjaka, celotno območje proti Polzeli in Dobrni je opazno tudi prevladovanje ene same vrste, pogosto često masovno, kar je pravtako znak onesnaženja. To stanje smo opazili tudi na izpostavljenih legah Pohorja (Tolsti vrh, pobočja pod Črnim vrhom, Črni vrh, Kope in pobočja pod Kopami) in celo večji del pobočja Košenjaka pri Dravogradu, od doline do približno 1000m nadmorske višine. V nekaterih zatišnih legah in ponekod na starejšem drevju z mineralno bogato podlago se pojavljajo tako imenovani "refugiji", to so nahajališča občutljivejših vrst, ketrih steljke so redno močno poškodovane. Takšna področja so nekatere soteske na območju Belih Vod, področje Dobrne, Doliča, Mislinjskega grabna. Žal, razen na profilih za vzorčenje smrekovih iglic, zaradi zmanjšanja obsega projekta podrobnejše kartiranje v okviru tega projekta ni bilo mogoče. Zato pri komentarju uporabljamo tudi izsledke nekaterih starejših opazovanj,opravljenih v okviru drugih projektov gozdarskega inštituta. Kot že omenjeno, smo v sodelovanju z Univerzo v Gradcu kartirali širše področje severne strani zahodnega Pohorja in Uršlje gore. Ti dve področji smo se odločili podrobneje kartirati, da bi ugotovili daljinski transport izpuhov iz TEŠ, na Pohorju pa imamo možnost primerjave s stanjem pred cca 100 leti, ko je na tem področju, predvsem okrog Ribnice na Pohorju, popisoval lišaje avstrijski botanik Kernstock, katerega herbarij in dela imajo v Gradcu. Ti popisi še niso v celoti končani in so zaenkrat še neobjavljeni. Ugotovili smo, da so nekatera področja Pohorja, predvsem severna in zatišne lege (Pesek, predeli okrog Šumika) še relativno čista, medtemko so proti jugu in zahodu izpostavljene lege kot tudi višji vrhovi že močno prizadeti. Pri kartiranju Uršlje gore smo na severni strani naleteli na boljše stanje kot smo pričakovali, vendar je vpliv TEŠ na epifitske lišaje jasen in močno izražen. Opazili pa smo izboljšanje povezano z sanacijo emisij iz Raven na Koroškem.Da bi dobili popolno sliko o širjenju onesnaževalcev iz TEŠ na osnovi kartiranja lišajev bi bilo potrebno še podrobno kartiranje naslednjih območij: Smrekovc-Golte-Sleme- Javorje; Gora Oljka z okolico;
Paški Kozjak, Stenica in morda še Konjiška gora (primerjava svernih in južnih pobočij). Dosedanja kartiranja na Lopatniku, Paškem Kozjaku, pa tudi na Boču so namreč pokazala, da obstaja nad 800 m nadmorske višine "brisan pas", ko ob ciklonskih vremenskih razmerah odnašajo vetrovi izpušne pline iz TEŠ daleč na vzhod in pride do zlitja vplivov s celjskim emisijskim bazenom.



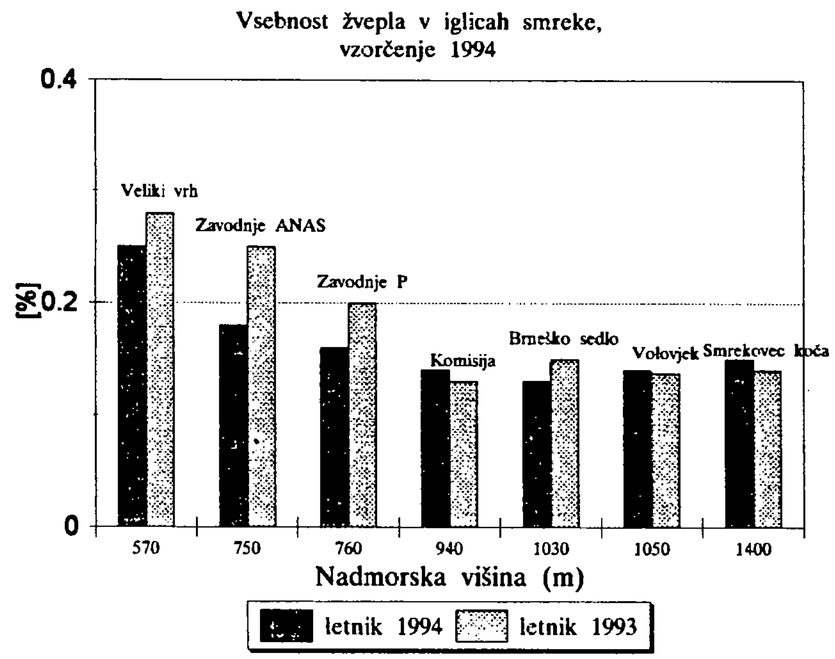
Slika 1:
Pregled vzorčnih mest smrekovih iglic na vplivnem območju TEŠ
merilo 1 : 250.000
Podlaga: Karta naselij



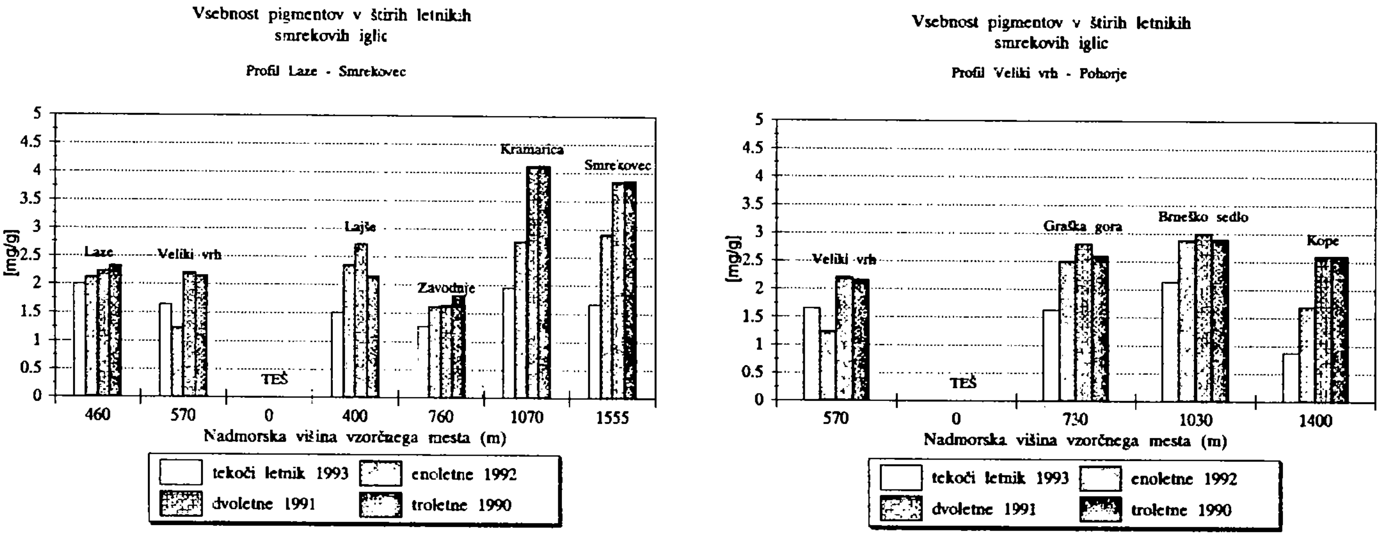
SLIKA 2: Pregled postopkov raziskovalnih metod.



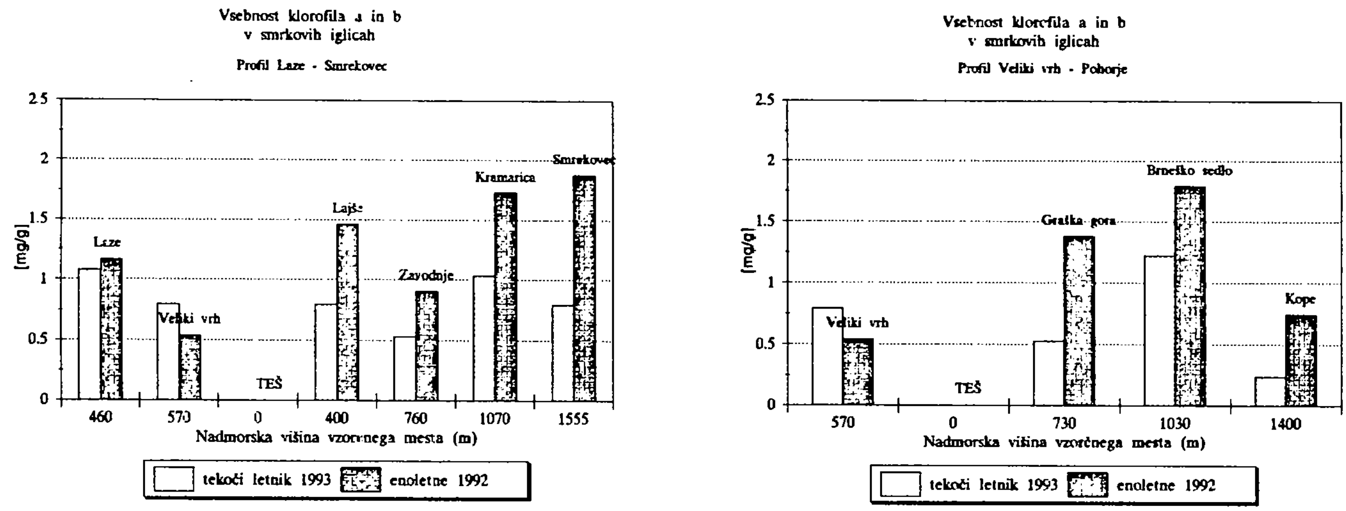
Slika 3: Celokupna vsebnost žvepla v dveh letnikih iglic smreke, vzorčenih na profilih Smrekovec - Veliki vrh in Veliki vrh - Pohorje, jeseni 1993.



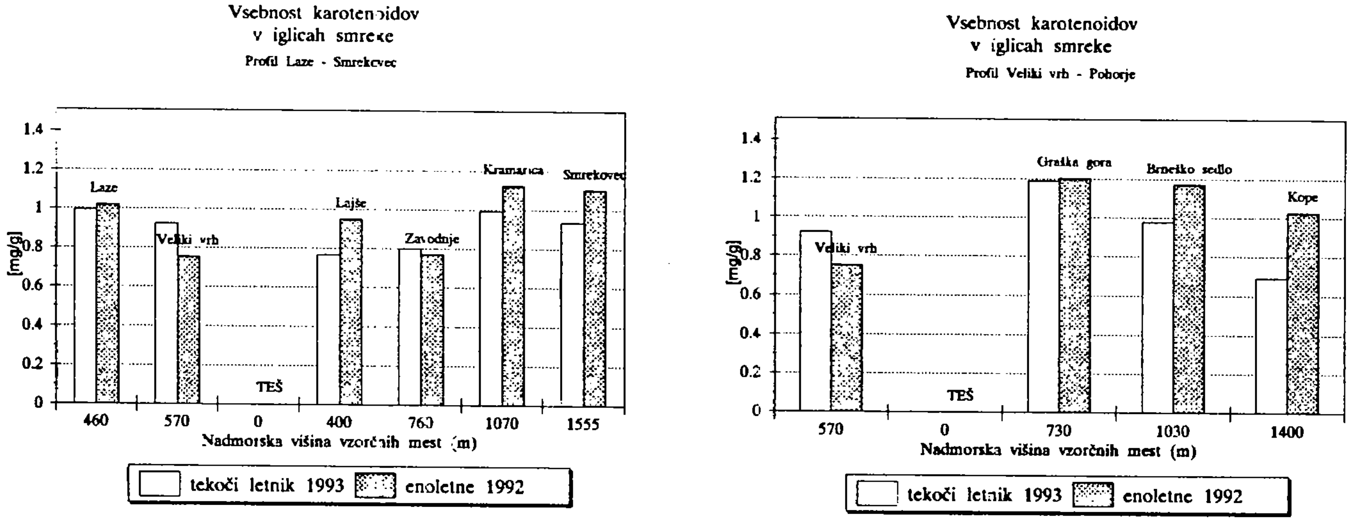
Slika 4: Celokupna vsebnost žvepla v dveh letnikih iglic smreke, vzorčenih na ožjem in širšem imisijskem območju TEŠ, jeseni 1994.



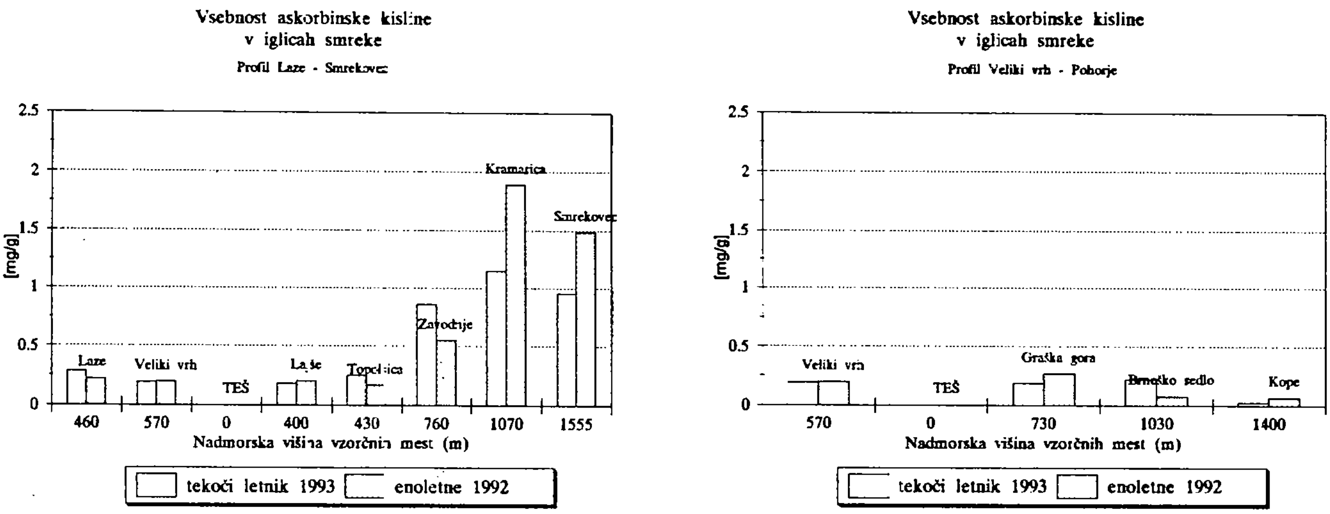
Slika 5: Vsebnost fotosinteznih pigmentov v štirih zaporednih letnikih smrekovih iglic, vzorčenih na profilih Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



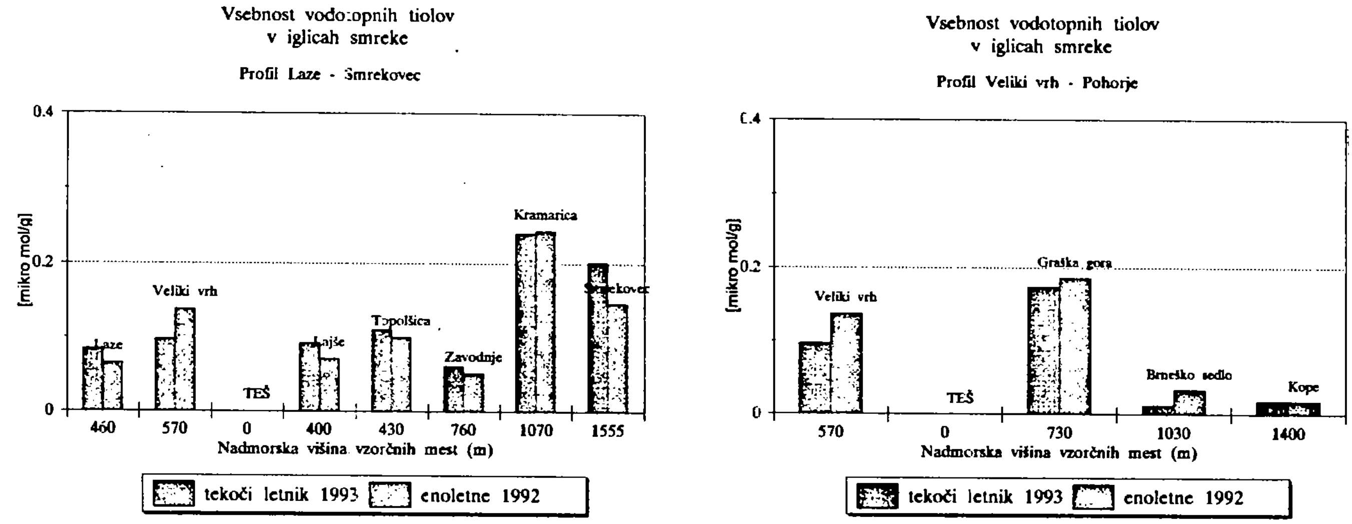
Slika 6: Vsebnost klorofila a in b v dveh letnikih smrekovih iglic, vzorčenih na profilih Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



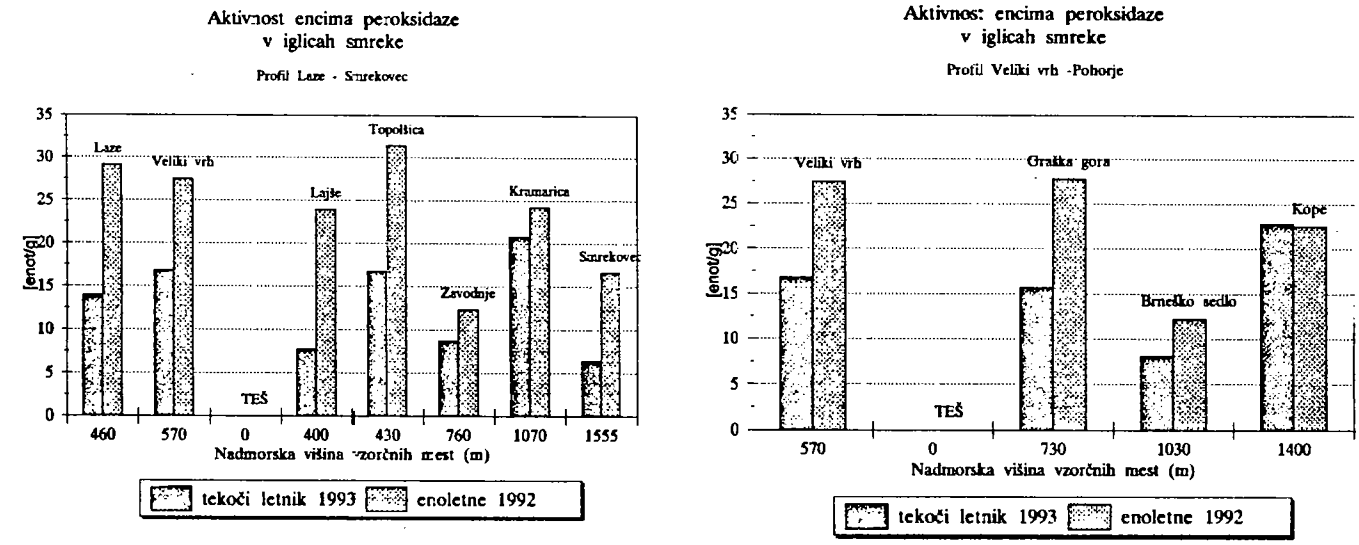
Slika 7: Vsebnost karotenoidov v dveh letnikih smrekovih iglic, vzorčenih na profilu Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



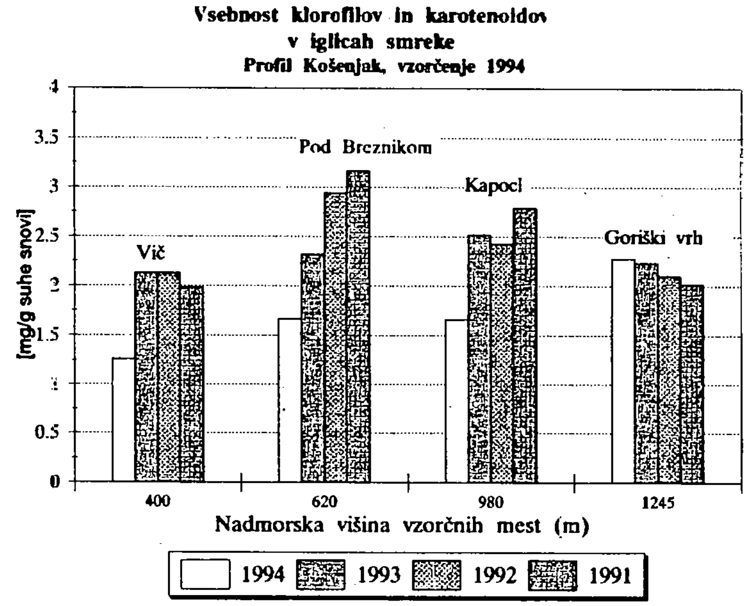
lika 8: Vsebnost askorbinske kisline v dveh letnikih smrekovih iglic, vzorčenih na profilu Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



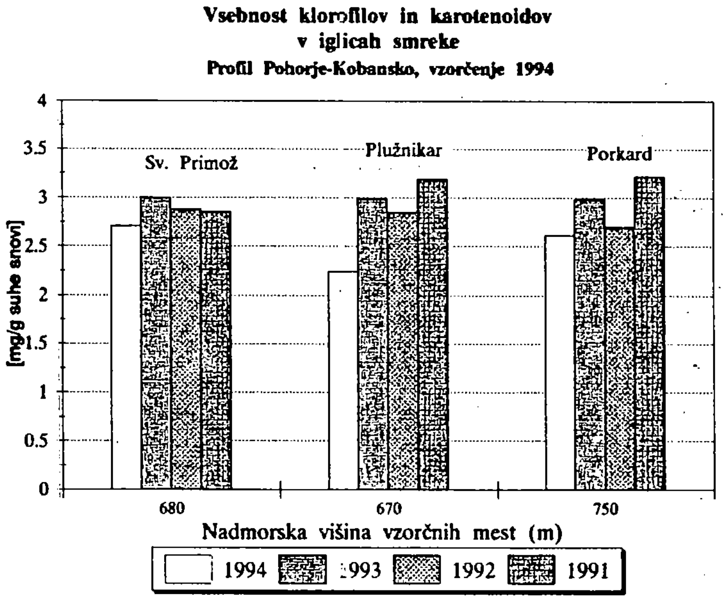
Slika 9: Vsebnost vodotopnih tiolov v dveh letnikih smrekovih iglic, vzorčenih na profilu Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



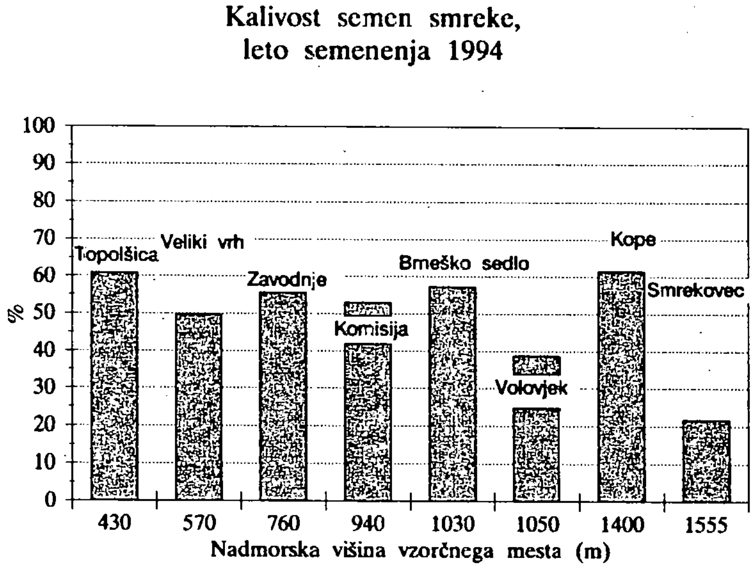
Slika 10: Aktivnost encima peroksidaze v dveh letnikih smrekovih iglic, vzorčenih na profilu Laze - Smrekovec in Veliki vrh - Pohorje, jeseni 1993.



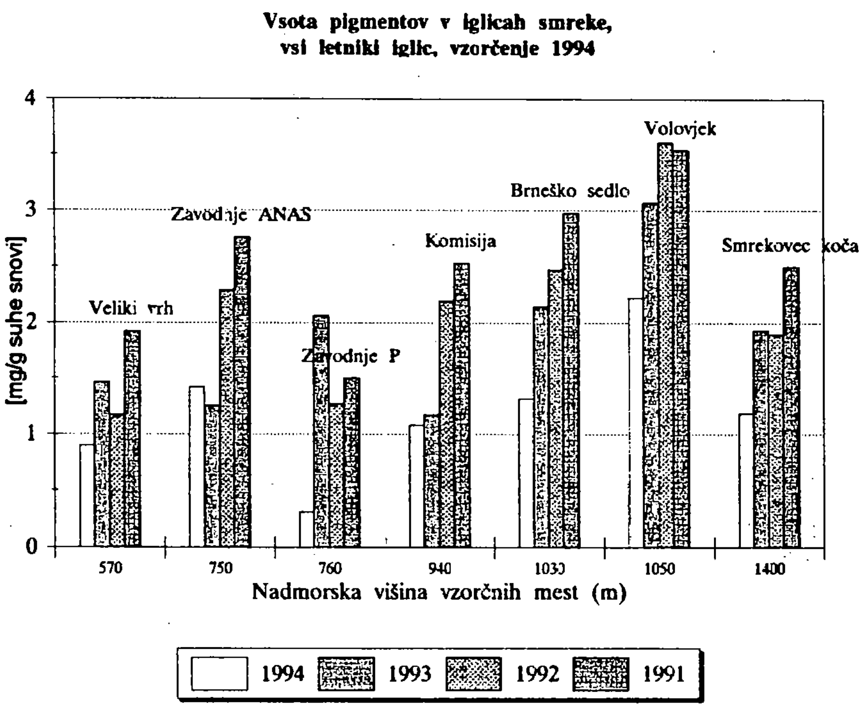
Slika 12: Celokupna vsebnost fotosinteznih pigmentov v štirih letnikih igli vzorčenih na profilih Košenjak pri Dravogradu, leta 1994.



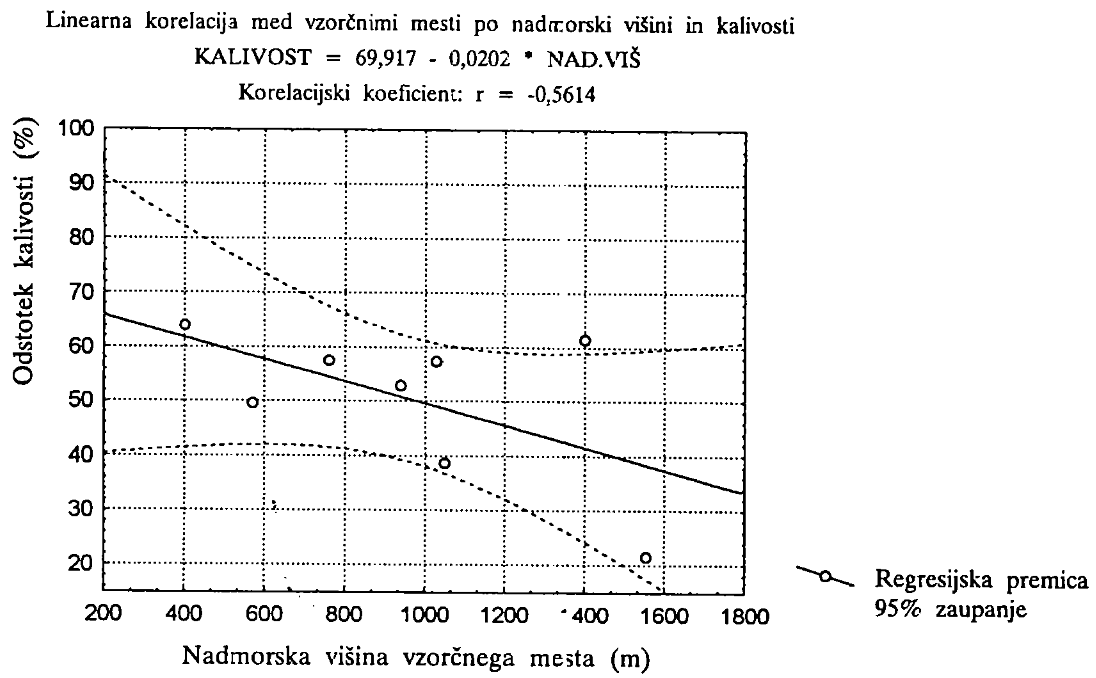
Slika 13: Celokupna vsebnost fotosinteznih pigmentov v štirih letnikih igli vzorčenih na profilih Pohorje-Kobansko, leta 1994.



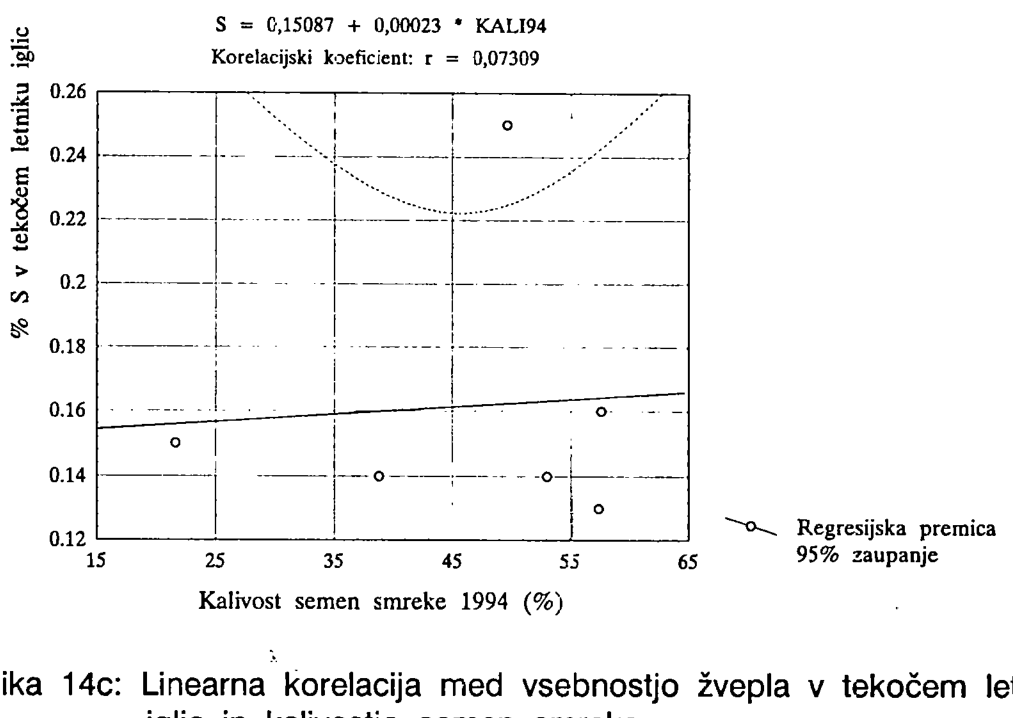
Slika 14a: Kalivost semen smreke na širšem in ožjem imisijskem območju TEŠ, obrod 1994.



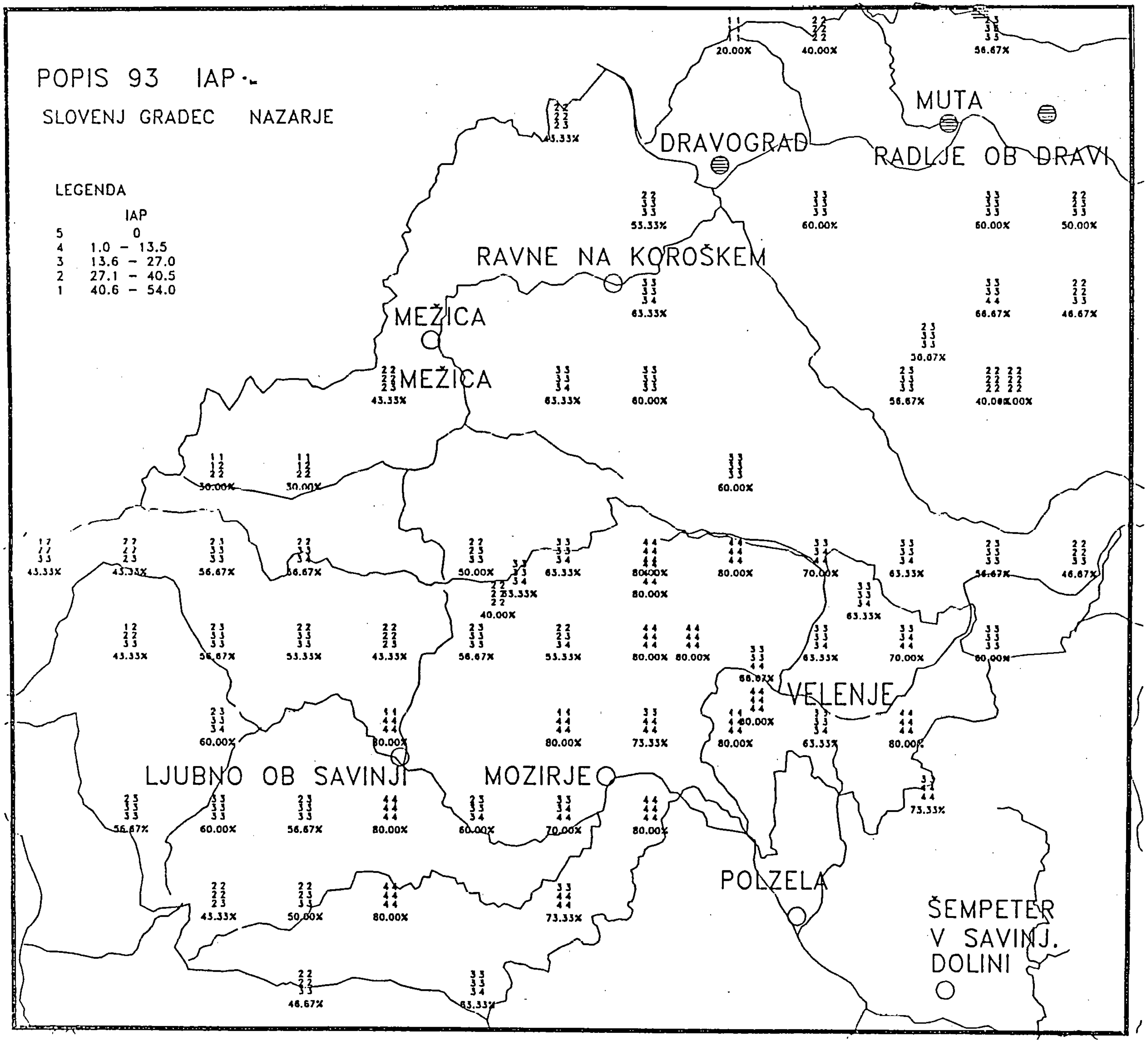
Slika 11: Vsebnost vseh fotosinteznih pigmentov v štirih letnikih iglic smreke, vzorčenih na širšem in ožjem imisijskem območju TEŠ, leta 1994.



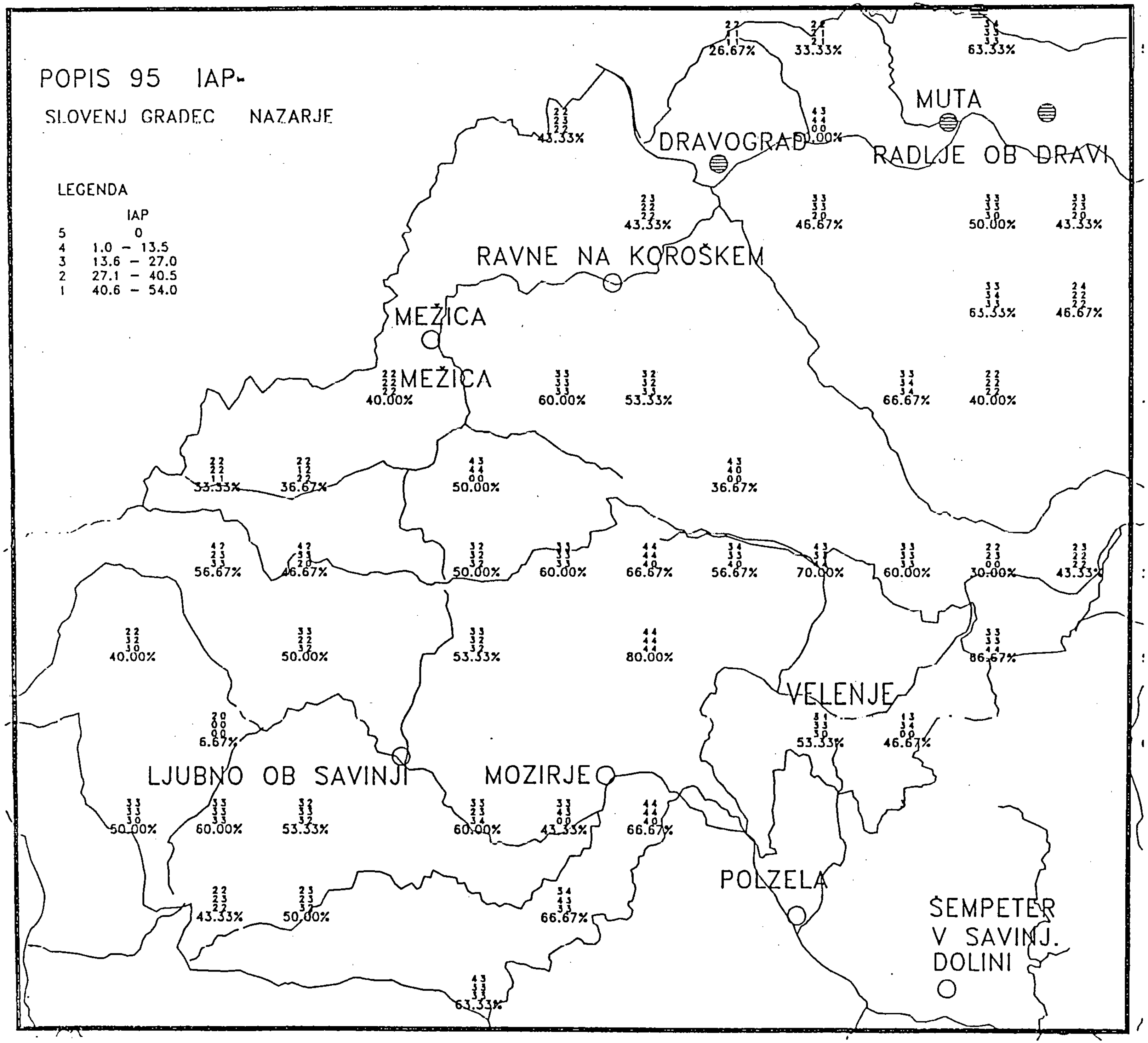
Slika 14b: Linearna korelacija med kalivostjo semen in nadmorsko višino vzorčnih mest.



Slika 14c: Linearna korelacija med vsebnostjo žvepla v tekočem letniku iglic in kalivostjo semen smreke.


POPIS 93 IAP
SLOVENJ GRADEC NAZARJE
LEGENDA
IAP
5 0
4 1.0 - 13.5
3 13.6 - 27.0
2 27.1 - 40.5
1 40.6 - 54.0
MUTA
DRAVOGRAD
RADLJE OB DRAVI
RAVNE NA KOROŠKEM
MEŽICA
MEŽICA
VELENJE
LJUBNO OB SAVINJI
MOZIRJE
POLZELA
ŠEMPETER V SAVINJ. DOLINI

Slika 15


POPIS 95 IAP
SLOVENJ GRADEC NAZARJE
LEGENDA
IAP
5 0
4 1.0 – 13.5
3 13.6 – 27.0
2 27.1 – 40.5
1 40.6 – 54.0
MUTA
DRAVOGRAD
RADLJE OB DRAVI
RAVNE NA KOROŠKEM
MEŽICA
MEŽICA
VELENJE
LJUBNO OB SAVINJI
MOZIRJE
POLZELA
ŠEMPETER V SAVINJ. DOLINI

Slika 16

Z A K L J U Č N O   P O R O Č I L O

O REZULTATIH OPRAVLJENEGA ZNANSTVENO-RAZISKOVALNEGA DELA NA PODROČJU APLIKATIVNEGA RAZISKOVANJA

Naslov projekta: Onesnaževanje zraka, padavin, tal in vodnih virov v Šaleški dolini pred pričetkom obratovanja odžvepljevalne naprave v TEŠ

II. DEL: BIBLIOGRAFIJA IN DOKAZILA

Odgovorni nosilec: dr. Borut Smodiš

Številka pogodbe: S2-6255-94

Datum: Januar 1995

BIBLIOGRAFIJA: Prof.dr. Franc BATIČ
Obdobje: 1994/95

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

Batič, F. & Kralj, A. 1995. Bioindikacija onesnaženosti ozračja v gozdovih z epifitskimi lišaji. Zbornik gozdarstva in lesarstva, 47:5-56.

Batič, F., Sinkovič, T. & Javornik, B. 1995. Morphological and genetic variability of *Quercus robur* L. populations in Slovenia. Zbornik gozdarstva in lesarstva 46:75-96.

Batič, F., Klemenčič, S., Jenčič-Medvešek, M., Macarol, B., Strniša, A., Ribarič-Lasnik, C. & Vidergar-Gorjup, N. 1995. Bioindikacija ozona v troposferi z občutljivim kultivarjem tobaka *Nicotiana tobacum* L. Bel W3. Zbornik gozdarstva in lesarstva 47: 131-144.

Jeran, Z., Byrne, A.R. & **Batič, F.** 1995. Transplanted epiphytic lichens as biomonitors of air-contamination by natural radionuclides around the Žirovski vrh uranium mine, Slovenia. Lichenologist 27 (5): 375-385.

Batič F., Grill, D., Kalan, P. & Ribarič-Lasnik, C. 1995. Impact of Emission Gases from Thermal Power Plant in Šoštanj on Biochemical Parameters of Norway Spruce Needles (*Picea abies* (L.) Karst). Acta Pharm. 45:191-197.

Al Sayegh-Petkovšek S., Kraigher, H., **Batič, F.**, Gogala, N. & Agerer, R. 1995. Mycorrhizal Potential of Two Forest Reasrch plots in Zavodnje and in Mislinja. Acta Pharm. 45:333-336.

Božič, G. & **Batič, F.**, 1995: Measurements of some physiological parameters as productivity indicators of poplar clones : *P. trichocarpa Torr. et Gray, P. deltoides Marsh. cv. "Lux", P. x euramericana (Dode) Gunier cv. regenerata, P. x euramericana (Dode) Gunier cv. "Panonia"*. Acta Pharm. 45:387-390.

Grube, M., **Batič, F.** & Mayrhofer, H. 1995. Contribution to the lichen flora of Slovenia I. The Snežnik Area. Hercogia 11, 189-196.

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci

Grill, D., **Batič**, F. & Tausz, M. 1996. Bioindication in forest decline studies: concepts and practice. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995: 1-6.

Batič, F. & Mayrhofer, H. 1995. Bioindication of air pollution by epiphytic lichens in forest decline studies in Slovenia. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:139-145.

1.07 Objavljeno vabljeno predavanje na strokovni konferenci

Batič F., 1994. Bioindikacija onesnaženosti zraka in njen pomen pri vzpostavitvi integralnega monitoringa.V: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. 3. - 30. 3. 1994, 12 s. 1-10. Izdal: Zavod za tehnično izobraževanje Ljubljana, 1994.

1.08 Objavljeno predavanje na znanstveni konferenci

Batič, F., Sinkovič, T. & Javornik, B. 1994. Evaluation of pedunculate oak (*Quercus robur* L.) populations in Slovenia. Proc. of IPBA, Rogla, December, 5-7, 1994:251-265.

Jeran, Z., Jaćimović, R., Smodiš, B. & **Batič, F.** 1995. The use of lichens in atmospheric trace element deposition studies in Slovenia. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:147-152.

Kraigher, H., **Batič**, F. & Agerer, R. 1995. Mycobioindication of forest site pollution. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:195-200.

Rogl, S., Javornik, B., Sinkovič, T. & **Batič, F.** 1995. Characterization of oak (*Quercus* L.) seed proteins by electrophoresis. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:227-232.

Sinkovič, T., **Batič**, F. & Javornik, B. 1995. Fluorescence *in situ* hybridization - a tool for detecting interspecies hybrids in plants. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:233-242.

Kraigher, H., **Batič**, F. & Urbančič, M. 1995. The Forest Research Plot on Pokljuka. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:333-335.

1.09 Objavljeno predavanje na strokovni konferenci

Jeran, Z., Jačimović, R., Lupšina-Miklavčič, V., Smodiš, B. & **Batič, F.** 1994. Ugotavljanje onasnaženosti zraka s kovinami in radionuklidi z uporabo biomonitorjev - lišajev. V: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. 3. - 30. 3. 1994, 19 s. 1-13. Izdal: Zavod za tehnično izobraževanje Ljubljana, 1994.

Batič, F., 1994. Onesnaženost ozračja in kopenski ekosistemi: I. proučevanja onesnaženosti ozračja s kartiranjem epifitskih lišajev. V: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. 3. - 30. 3. 1994, 32 - 36. Izdal: Zavod za tehnično izobraževanje Ljubljana, 1994.

Batič, F., Klemenčič, S., Jenčič-Medvešek, M., Macarol, B., Strniša, A., Ribarič-Lasnik, C. & Vidergar-Gorjup, N. 1994. Bioindikacija ozona v troposferi z občutljivim kultivarjem tobaka *Nicotiana tobacum* L. Bel W3. V: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. 3. - 30. 3. 1994, 37 - 50. Izdal: Zavod za tehnično izobraževanje Ljubljana, 1994.

Ribarič Lasnik, C., **Batič, F.** & Grill, D. 1994. Vpliv onesnaženega zraka na biokemijsko zgradbo smrekovih iglic na vplivnem območju termoelektrarne Šoštanj. V: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. - 30. 3. 1994, 51 - 54. Izdal: Zavod za tehnično izobraževanje Ljubljana, 1994.

1.12 Objavljeni povzetek predavanja na znanstveni konferenci

Jeran, Z., Byrne, A.R. & **Batič, F.** 1995. Gamaspektrometrična analiza nekaterih naravnih in umetnih radionuklidov v lišajih. 9. simpozij "Spektroskopija v teoriji in praksi", Bled, 10-13 april 1995. Zbornik povzetkov: 99.

Batič, F & Kruhar-Lorger, B. 1995. Primerjava epifitske lišajske flore in vegetacije na smreki, jelki in bukvi v treh različnih gozdnih sestojih. Simpozij " Flora in vegetacija Slovenije", Ljubljana, 21-23- april 1995. Zbornik povzetkov referatov: 8.

Batič, F., Mavsar, R. & Sinkovič, T. 1995. Morfološka variabilnost populacij doba (*Quercus robur* L.) v Sloveniji. Simpozij " Flora in vegetacija Slovenije", Ljubljana, 21-23- april 1995. Zbornik povzetkov referatov: 9.

Ribarič-Lasnik, C., **Batič, F.**, Virant-Klun, I. & Grill, D., 1994. Determination of multiple stress in Norway spruce from two forest sites in Slovenia by biochemical analysis of needles. "Air pollution and multiple stress", 16 th International meeting for specialists in air pollution effects on forest ecosistems, September 7-9. 1994, Fredericton, New Bruinswick, Canada, Abstracts: 61.

Jeran, Z., **Batič, F.**, Jaćimović, J. & Smodiš, B. 1994. Epiphytic lichens in air pollution studies of heavy metals in Slovenia. Second International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, September 20.23, 1994, Budapest, Hungary. Abstracts: 114.

Al-Sayegh-Petkovšek, S., Kraigher, H., **Batič, F.**, Gogala, N. & Agerer, R. 1994. Ectomycorrhizal potencial of two soil substrates- A pot experiment: Mycorrhizas in integrated systems. Fourth European Symposium on Mycorrhizas, Granada, 11-14 July 1994, Abstracts: 64.

Batič, F., Kalan, P., Kralj, T., Kraigher, H., Gomišček, B., Simončič, P., Sinkovič, T. & Šolar, M. 1995. Bioindication of air pollution and natural stresses on forests of Triglav National Park in Slovenia. 8th International Bioindicators Symposium, 22-28 May 1995, Česke Budejovice, Czech Republic, Abstracts p. 5.

Jeran, Z., Jaćimović, R., Smodiš, B., **Batič, F.** & Wolterbeek, H. Th. 1995. Atmospheric heavy metal pollution in Slovenia derived from results for epiphytic lichens. 6th International Hans Wolfgang Nürnberg Memorial Symposium on Metal Compounds in Environment and Life. 9-12 May 1995, Jülich, Germany. Book of Abstracts

Kraigher, H., **Batič, F.** & Agerer, R. 1995. the Diversity of types of ectomycorrhizae on Norway spruce on two forest research plots in Slovenia. Proceedings of International Biodiversity seminar ECCO XIV. Meeting, June 30-July 4, 1995, Gozd Martuljek, Slovenia, p. 107.

1.14. Objavljen poster ali povzetek posterja na znanstveni konferenci

Kraigher, H., **Batič, F.** & Agerer, R. 1994. Types of ectomycorrhizae on Norway spruce from two differently polluted forest research plots in Slovenia. "Air pollution and multiple stress", 16 th International meeting for specialists in air pollution effects on forest ecosistems, September 7-9. 1994, Fredericton, New Bruinswick, Canada, Abstracts: 32

Jeran, Z., **Batič, F.** & Jaćimović, R. 1995. Passive biomonitoring with epiphytic lichens for assessing trace element air pollution in Slovenia. 8th International Bioindicators Symposium, 22-28 May 1995, Česke Budejovice, Czech Republic, Abstracts p. 46.

Batič, F., Javornik, B., Mavsar, R. & Sinkovič, T. 1995. New methods in evaluation of oaks (*Quercus* L.) in Slovenia. IUFRO XX World Congress, 6-12 August, 1995, Tampere, Finland. Poster Abstracts, 126. p. 73.

Batič, F. & Kralj, T. 1996. Epiphytic lichen vegetation as a biomonitoring system in forest decline studies in Slovenia. International workshop "Exceedances of critical loads and levels ", Vienna, November 22-24, 1995, Abstracts:4.

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.01 Znanstvena monografija

Hojka Kraigher, **Franc Batič**, David Hanke, Reinhard Agerer and Dieter Grill (eds.) 1995. Proceedings of the International Colloquium on Bioindications of Forest Site Pollution: Development of Methodology and Training BIOFOSP, TEMPUS M-JEP 04667, August 22-31, 1995, 336p. Issued by Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana and Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia.

Hočevar, S, **Batič, F.**, Piskernik, M. & Martinčič, A. 1995. Glive v pragozdovih Slovenije. III. Dinarski gorski pragozdovi na Kočevskem in v Trnovskem gozdu. Strokovna in znanstvena dela 118. Gozdarski inštitut Slovenije in Oddelk za gozdarstvo Biotehnične fakultete Univerze v Ljubljani (še v tisku)

2.02 Strokovna monografija

Marko Kovač, Primož Simončič, Nevenka Bogataj, **Franc Batič**, Dušan Jurc, Milan Hočevar 1995. Monitoring propadanja gozdov in gozdnih ekosistemov - priročnik za terensko snemanje podatkov. Izdal in založil Gozdarski inštitut Slovenije, Večna pot 2, Ljubljana. 64 s.

2.05 Ostalo učno gradivo

Sinkovič, T., **Batič, F.** & Šuštar F. 1994. Seznam pomembnejših rastlin in navodila za računanje krmne vrednosti travne ruše. Za študente študija kmetijstva, smre agronomija in smer zootehnika. Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, Ljubljana, 47 s.

2.11 Poročilo o znanstveno-raziskovalni nalogi

Batič, F. 1995. Zaključno poročilo. Ohranjanje in varovanje gozdov (J4-0261-404-94). Gozdarski inštitut Slovenije, Ljubljana, 12 str.

Batič, F. 1994. Fazno poročilo. Taksonomske, citološke in izoencimske raziskave vrst hrastov (*Quercus* L.) in pojavljanje taksonov v naravnih sestojih v Sloveniji (L4-5497-486-94).

2.12 Poročilo o razvojno-raziskovalni nalogi

Gomišček, S., Gomišček, B., **Batič, F.**, Kraigher, H. & Brancelj, T. 1995 Fazno poročilo 1994. Onesnaženost zraka v Triglavskem narodnem parku in njen vpliv na gozd in vode- Atmosfera in narodni park. (L2-6241-486-16/94), Fakulteta za kemijo in kemijsko tehnologijo, Ljubljana, 47 str.

Batič, F., Kraigher, H., Smodiš, B., Stropnik, B. 1995. Fazno poročilo. Onesnaženost zraka, padavin, tal in vodnih virov v Šaleški dolini pred pričetkom obratovanja odžveplevalne naprave v Termoelektrarni Šoštanj (L2-6255--0486-94), Inštitut Jožef Stefan, Ljubljana, 5 s.

3. Izvedena in druga (v knjižnicah) nedostopna dela

3.07 Recenzije raziskovalnih nalog

Batič, F. 1995: Recenzija projekta aplikativnega raziskovanja (L4-7402-0404-95; Raziskave gozdnih tal in rizosfere ter njihov vpliv na nekatere fiziološke parametre gozdnega drevja v izbranih ekosistemih, sestojnih tipih in razvojnih stadijih gozda. Ministrstvo za znanost in tehnologijo Republike Slovenije.

Batič, F. 1995: Recenzija predloga slovensko-ameriškega raziskovalnega projekta (The establishment of a molecular marker laboratory). Ministrstvo za znanost in tehnologijo Republike Slovenije.

3.06 Elaborat, predštudija, študija

Jurc, M., **Batič, F.**, Jurc, D., Kraigher, H.,Sirk, I. & Kralj, T. 1994. Mikoteka in herbarij Gozdarskega inštituta Slovenije. Elaborat. Gozdarski inštiti Slovenije, Ljubljana, s. 32

Batič, F. & Smole , I. 1994. Katalog višjih rastlin herbarija Gozdarskega inštituta Slovenije. Poročilo. Gozdarski inštitut Slovenije.

Batič, F., Jurc, M., Koch, M., Kralj, T., Kruhar, B. & Grube, M. 1994. Katalog lišajev mikoteke in herbarija Gozdarskega inštituta Slovenije. Poročilo, Gozdarski inštitut Slovenije, 220 s.

3.07.1 Recenzije knjig (učbenikov)

Ravnik, V. 1993. Splošna botanika za študente živilske tehnologije. Skripta. Samozaložba, Ljubljana.

Dermastia, M. 1995. Botanika. Skripta. Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.

3.13 Organizacija znanstvenih in strokovnih sestankov

International Colloquium on Bioindications of Forest Site Pollution: Development of Methodology and Training BIOFOSP, TEMPUS M-JEP 04667, August 22-31, 1995, 336p. Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana and Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia; član programskega in organizacijskega odbora.

Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled 28. - 30. 3. 1994, Zavod za tehnično izobraževanje Ljubljana, 1994; član programskega odbora

3.14. Predavanje-gostovanje na tuji univerzi

4. SEKUNDARNO AVTORSTVO
4.1. Uredništvo

Gozdarski vestnik; član

Hojka Kraigher, **Franc Batič**, David Hanke, Reinhard Agerer and Dieter Grill (eds.) 1995. Proceedings of the International Colloquium on Bioindications of Forest Site Pollution: Development of Methodology and Training BIOFOSP, TEMPUS M-JEP 04667, August 22-31, 1995, 336p. Issued by Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana and Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia.

4.2 Mentorstvo

4.2.1 Mentorstvo pri diplomskih nalogah

Leben-Fon, N. 1994. Spremembe anatomske zgradbe smrekovih iglic (Picea abies /L./ Kars.) zaradi vplivov onesnaženega zraka. Diplomska naloga, Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.

Kruhar, B. 1994. Pregled epifitske lišajske flore na nekaterih bioindikacijskih točkah v odvisnosti od od podlage. Diplomska naloga, Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.

Podgornik, H. 1995. Primerjava med neto fotosintezo lostov in pridelkom nekaterih sort jablan (Malus domestica Borkh,) v odvisnosti od sistemov sajenja. Diplomska naloga, Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

Strniša, A. 1995. Vpliv emisij na gozdove v Zasavju. Diplomska naloga, Oddelek za gozdarstvo, Biotehniška fakulteta, Univerza v Ljubljani

4.2.2 Mentorstvo pri magisterijih

Belec, Z. 1992. Vrednotenje metode popisa propadanja gozdov na nekaterih rastiščih mariborskega gozdnogospodarskega območja, Magistrsko delo. Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

Simončič, P. 1992. Razmere mineralne prehrane za smreko na distričnih rjavih tleh na tonalitu v vplivnem območju Termoelektrarne Šoštanj. Magistersko delo. Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

4.2.3 Mentorstvo/somentorstvo pri doktoratih

Virant-Klun, I. 1993. Odpornost koruze (*Zea mays* L.) kultivarjev "Dea" in "Carla" na pomankanje vode. Doktorska disertacija. Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.

Kraigher, H. 1994. Citokinini in tipi ektomikorize pri sadikah smreke (*Picea abies* /L./ Karst.) kot kazalci onesnaženosti gozdnih rastišč. Doktorska disertacija, Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

4.2.4 Recenzije magisterija in doktorata
4.2.4.1. Magisteriji

Ribarič-Lasnik, C. 1991. Ekofiziološke lastnosti smreke (*Picea abies* /L./ Karsten) na vplivnem območju Termoelektrarne Šoštanj. Magistersko delo. Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.
Silan, D. 1992. Stomatarna difuzijska prevodnost trsta (*Phragmites australis* (Cav.)Trin.ex Steudel) na Cerkniškem jezeru. Magistrsko delo. Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.
Munda, A. 1992. Rod štorovke *Armillaria* (Fr.:Fr.) Staude. Vrstna sestava in razširjenost v Sloveniji

ter poskusi križanja. Magistersko delo. Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

Oven, P. 1993. Anatomija skorje in njen odziv na mehanska poškodovanja pri zdravih in prizadetih jelkah (*Abies alba* Mill.). Magistersko delo. Oddelek za lesarstvo., Biotehniška fakulteta, Univerza v Ljubljani.

Stopar, M. 1993. Vpliv zastajanja asimilatov na rast, rodnost in prehrano jablane (*Malus domestica* Borkh.). Magistersko delo. Oddelek za agronomijo, Bictehniška fakulteta, Univerza v Ljubljani.

Hudina, M. 1995. Identifikacija kultivarjev pri hruški (*Pyrus communis* L.) glede na variabilnost izoencimov v različnih tkivih. Magistersko delo. Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

Kump, B. 1995. Izvrednotenje genetske variabilnosti populacij in kultivarjev ajde (*Fagopyrum esculentum* Moench.) z uporabo DNA markerjev. Magistersko delo. Oddelek za agronomijo, Biotehniška fakulteta, Univerza v Ljubljani.

Brus, R. 1995. Vpliv onesnaževanja ozračja na genetsko strukturo bukovih populacij v Sloveniji. Magistrsko delo. Oddelek za gozdarstvo, Biotehniška fakulteta, Univerza v Ljubljani.

4.2.4.2 Doktorati

Jeran, Z. 1995. Epifitski lišaji- biološki indikatorji onesnažrnosti zraka s kovinami in radionuklidi. Doktorska disertacija. Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani.

Prof. dr. Franc BATIČ

ارد ۱۹۰۱

Dr. Ljudmila Benedik

BIBLIOGRAFIJA

1. ČLANKI IN SESTAVKI

1.01. Izvirni znanstveni članek

1. **L. Benedik**, A. R. Byrne: *Determination of uranium and thorium at ultra trace levels by RNAA*, Acta Chimica Slovenica, 41, 1-14 (1994).
2. **L. Benedik**, A. R. Byrne: *Simultaneous determination of trace uranium and thorium by radiochemical neutron activation analysis*, J. Radioanal. Nucl. Chem. Articles, 189, 325-331 (1995).
3. M. Križman, A. R. Byrne, **L. Benedik**: *Distribution of ^{230}Th in milling wastes from the Žirovski vrh Uranium Mine (Slovenia), and its radioecological implications*, J. Environ. Radioactivity, 26, 223-235 (1995).
4. A. R. Byrn, **L. Benedik**: *Urinary excretion of uranium and dietary intake*, Health Phys., 68, 732-733 (1995).

1.08. Objavljeno predavanje na znanstveni konferenci

1. B. Smodiš, **L. Benedik**, A. R. Byrne, M. Dermelj, A. Fajgelj, I. Falnoga, R. Jaćimović, Z. Jeran, P. Stegnar, V. Stibilj, B. Stropnik, Z. Šlejkovec: *Status of NAA in Slovenia: Achievements and applications*, 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-20 - 2-23.
2. M. Dermelj, **L. Benedik**, A. R. Byrne, R. Jaćimović, B. Smodiš, V. Stibilj, Z. Šlejkovec: *A review of analytical activities at "Jožef Stefan" Institute in the field of trace element determination in food articles using NAA*, FAO Meeting on Food Composition Activities in Eastern Europe, Modra, Slovaška, 1995, Zbornik referatov str. 91-95.

1.12. Objavljeni povzetek predavanja na znanstveni konferenci

1. M. Dermelj, V. Stibilj, A. R. Byrne, **L. Benedik**, Z. Šlejkovec, R. Jaćimović, B. Smodiš: *Neutron activation analysis of essential and toxic trace elements in food articles*, 1st Symposium on Food and 2nd Conference on Practical Application of European Legislation on Foodstuffs, Bled, 1995, Zbornik povzetkov str. 158.

1.14. Objavljeni poster ali povzetek posterja na znanstveni konferenci

1. **L. Benedik**, A. R. Byrne: *Determination of uranium and thorium by radiochemical neutron activation analysis*, Annual Meeting of the NSS '94, Rogaška Slatina, 1994, Zbornik referatov str. 359-367.

2. *MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA*

2.08. *Doktorska disertacija*

Ljudmila Benedik: *Razvoj postopkov za določanje sledov urana in torija z radikemično nevtronsko aktivacijsko analizo*, Disertacija, 1994.

2.13. *Elaborat, predštudija, študija*

1. D. Abramič, K. Al-Sabti, I. Arčon, M. Bele, **L. Benedik**, A. Blinc, R. Blinc, B. Borštnik, M. Brecl, M. Budnar, N. Bukovec, P. Bukovec, A. Cvelbar, I. Čadež, M. Čopič, U. Delalut, A. Demšar, F. Dimc, M. Dobršek, M. Drab, I. Falnoga, M. Fele-Baureman, R. Gabrovšek, L. Golič, J. Grdadolnik, M. Hribar, A. Jamnik, H. Janžekovič, A. Jesih, V. Kaučič, I. Kobal, S. Kobe, A. Kodre, M. Kosec, M. Kovač, M. Krajnc, S. Kralj, P. Kump, V. Kveder, G. Lahajnar, K. Lutar, T. Malavašič, B. Malič, T. Marčac-Grahek, V. Marinković, T. Meden, S. Milićev, I. Miloševi, M. Mozetič, A. Muehleisen, B. Navinšek, M. Nečemer, B. Orel, P. Panjan, A. Paulin, S. Pejovnik, P. Pelicon, M. Petrič, S. Petriček, M. Pleško, B. Praček, A. Prodan, N. Ramšak, M. Remškar, B. Saje, A. Sever-Škapin, J. Slunečko, B. Smodiš, S. Spruk, P. Šegedin, Ž. Šmit, M. Štuhec, J. Štupar, E. Tratar-Pirc, I. Turel, B. Udovic, V. Vlachy, F. Vodopivec, N. Zabukovec-Logar, B. Zalar, D. Zavrtanik, A. Zidanšek, B. Žemva, M. Žitnik: *A multipurpose x-ray beamline at ELETTRA : the scientific case and the conceptual design*, IJS, DP-7083 (1994).
4. M. Križman, **L. Benedik**: *Poročilo o vplivih rudnika urana Žirovski vrh na okolje. Obstoječe stanje (1993-94) pred pričetkom izvajanja del trajnega prenehanja izkoriščanja uranove rude in preprečevanja posledic rudarjenja RUŽV*, IJS DP-7172 (1995).
5. B. Smodiš, **L. Benedik**, M. Križman: *Ugotavljanje obremenjenosti tal z naravnimi in umetnimi radionuklidi*, IJS DP-7314 (1995).

BIBLIOGRAFIJA 1994 , 1995:

Ime in Priimek: BOGATAJ Nevenka

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

- BOGATAJ, N. 1995. Oak decline assessment in the year 1993. In: Oak decline in Slovenia, Endbericht uber die Arbeiten 1994, Ljubljana, Wien, GIS, Institut fur Waldoekologie BOKU; p.85-88
- BOGATAJ, N. , 1995 : Poročilo o propadanju gozdov za leto 1995, GV 9, s.342-350

1.05 Poljudni članek

- GORŠIN, A., BOGATAJ, N., KUTNAR, L., MATIJAŠIČ, M., KRČ, J., PAPEŽ, J., BINCHENDE, I. 1994: S poti po Norveški, GV 2, s. 104-112

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci
1.07 Objavljeno vabljeno predavanje na strokovni konferenci

1.08 Objavljeno predavanje na znanstveni konferenci

- BOGATAJ, N. 1995. Some aspects of interpretation of forest trees defoliation data. V: Bioindication of forest site pollution: development of methodology and training. Proceedings of the international colloquium (Tempus M-JEP 04667). Slovenian forestry institute and Agronomy dept., Biotechnical faculty, University of Ljubljana, Ljubljana, s. 287-92.

1.09 Objavljeno predavanje na strokovni konferenci

- JURC, D., BOGATAJ, N., 1994: Preučevanje propadanja gozdov in sprememb v ekosistemih v Sloveniji, v: Varstvo zraka, stanje in ukrepi za izboljšanje stanja v Sloveniji, 8 s. 10/1-10/3, Zavod za tehnično izobraževanje, Ljubljana
- BOGATAJ, N., SIMONČIČ, P., 1994: Vpliv imisijskih poškodb na vodno funkcijo gozda, zbornik referatov na seminarju "Gozd in voda", 215-226, Oddelek za gozdarstvo BF, Univerza Ljubljana

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci
1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci

1.12 Objavljeni povzetek predavanja na znanstveni konferenci
1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci
1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi
1.17 Poglavje ali samostojni sestavek v strokovni knjigi

1.18 Sestavek v enciklopediji

1.19 Objavljena recenzija, prikaz knjige, kritika

- BOGATAJ, N., 1994 : Ob mrtvici reke Mure, GV 5-6, S 286-287

1.20 Predgovor, spremna beseda

1.21 Polemika, diskusijski prispevek

1.22 Objavljeni intervju

1.23 Umetniški sestavki (notni zapisi, pesmi, novele...)

1.25 Drugi članki ali sestavki

- BOGATAJ, N., 1994: 10. redni letni sestanek predstavnikov držav podpisnic programa ICP Forests, GV 4, s 230-231.
- BOGATAJ, N., 1995: 11. redno letno srečanje predstavnikov držav, ki sodelujejo v programu UN/ECE ICP Forests, GV 4, s. 215-217

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.01 Znanstvena monografija

2.02 Strokovna monografija

2.03 Univerzitetni učbrnik

2.04 Drugi učbeniko z recenzijo (srednje in nižješolski...)

2.05 Ostalo učno gradivo (zapiski predavanj, zbirka vaj...)

2.06 Priročniki, slovarji, leksikoni

2.07 Bibliografija

2.08 Doktorska disertacija

2.09 Magistrsko delo

2.10 Specialistično delo

2.11 Poročilo o znanstveno - raziskovalni nalogi

2.12 Poročilo o razvojno - raziskovalni nalogi

2.13 Elaborat, predštudija, študija

- ŠUBIC, A./ SMOLEJ, I./ BOGATAJ, N./ KOVAČ, M./ HOČEVAR, M./ JURC, D./ KOBLER, A./ KRALJ, A. 1995. Poročilo o propadanju gozdov 1995 in integralni monitoring gozdnih ekosistemov. Poster in gradivo: "Festival znanosti 1995". Ljubljana.
- BOGATAJ, N., 1994 Forest condition in Europe, Results of the 1993 Survey, EC-UN/ECE Brussels, Geneve, p. 78, Annexes II-1-3;
- BOGATAJ, N. , 1995. Slovenia. V: Forest condition in Europe, Results of the 1994 Survey. Report, UN/ECE, Forests 1s., Brussels, Geneve, p. 78, Annexes
- BOGATAJ, N. 1994. Poročilo o poškodovanosti gozdov za leto 1993. Predavanja o mednarodnem raziskovalnem programu učinka onesnaženega zraka na gozdove. GIS, Ljubljana, 7. april 1994
- BOGATAJ, N. 1994. Searching for the connection between landscape ecology and forest decline, Mednarodna delavnica "Metode krajinskoekološke analize", Planinsko polje, 13.-16. september.
- BOGATAJ, N., 1995: Ogroženost gozdov, poglavje za Poročilo o stanju okolja, MVO, 10 s.

2.14 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

2.15 Posnetek glasbenega dela

2.16 Umetniška dela

2.17 Katalog razstave

2.20 Druge monografije

3. IZVEDENA IN DRUGA (V KNJIŽNICAH) NEDOSTOPNA DELA

3.01 Patentna prijava

3.02 Patent

3.03 Tehniška izboljšava (nova tehnologija)

3.04 Programska oprema

3.05 Poročilo o raziskovalni ali razvojni nalogi

3.06 Elaborat, predštudija študija

3.07 Izvedeniško mnenje, arbitražna odločba, recenzija

3.08 Poročilo o meritvah, preizkusih ipd.

3.09 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

3.10 Umetniške stvaritve in poustvaritve

3.11 Radijski in TV prispevki

3.12 Razstave

3.13 Organiziranje znanstvenih in strokovnih sestankov

3.14 Predavanja - gostovanja na tuji univerzi

3.20 Druga dela

4. SEKUNDARNO AVTORSTVO (se upošteva pri izpisu)

4.1 Uredništvo

4.2 Mentorstvo

4.3 Prevod

4.4 Ilustracije

4.5 Drugo

- GIS 1994. Seminar za popisovalce propadanja gozdov 1994. Ljubljana, 3 dni.

- GIS 1995. Seminar za popisovalce propadanja gozdov 1995. Ljubljana, 3 dni.
- GIS 1995. Propadanje gozdov in monitoring gozdnih ekosistemov. Priročnik za terensko snemanje podatkov. Ljubljana, GIS, 78 s.
- GIS 1995. Poročilo o propadanju gozdov 1995. Gradivo za novinarsko konferenco v okviru "Festivala znanosti 1995". Ljubljana, GIS in ZGS, 6 s.
- GIS 1995: Monitoring gozdnih ekosistemov in propadanja gozdov, priročnik za terensko snemanje podatkov, Gozdarski inštitut Slovenije.
- Priprava gradiva za razstave, 1995: GIS, Festival znanosti, zainteresirane posameznike.

Mojca Bole

Bibliografija in drugi raziskovalni rezultati:

1. ČLANKI IN SESTAVKI

1.05 Poljudni članek

Šterbenk E., Beričnik Vrbovšek J., Bole M., Rošer Drev A., Ramšak R., (1995). ŠALEŠKA UGREZNINSKA JEZERA - JEZERA, KI JIH NE BI BILO, ČE NE BI BILO PREMOGOVNIKA. Delo, 13. september 1995. Znanstvena priloga.

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

Ramšak R., Rejic M., Rošer Drev A., Bole M. (1992). CHARACTERISTICS OF THE VALENJE LAKE IN THE ŠALEK VALLEY WICH HAS BEEN PRODUCED BY ASH DRIFTING AWAY FROM THE THERMO POWER PLANT ŠOŠTANJ. Enviromental Contamination - 5th International Conference. Morges, Switzerland.

Rošer Drev A., Bole M., Rejic M., Ramšak R., (1994). THE QUALITATIVE STATE OF THE RIVER PAKA IN THE ŠALEK VALLEY - BIOLOGICAL AND CHEMICAL ANALYSIS. Environmental Contamination 6th International Conference. Delpni, Greece.

Svetina M., Bole M, (1995). DOLOČANJE SULFATA V VZORCIH PADAVIN. Zbornik 9. mednarodnega simpozija Spektroskopija v teoriji in praksi, Bled. 10. - 13. april 1995.

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

3. IZVEDBENA IN DRUGA NEDOSTOPNA DELA

3.05 Poročilo o raziskovalni ali razvojni nalogi

Bole M., Rošer Drev A. (1994). VODOTOKI ŠALEŠKE DOLINE. Poročilo za leto 1993. ERICo Velenje, Zavod za ekološke raziskave. Marec, 1994.

Rošer Drev A., Bole M., (1995). PROGRAM IZBOLJŠANJA KAKOVOSTI POVRŠINSKIH VODA V ŠALEŠKI DOLINI - PAKA IN PRITOKI. Poročilo za leto 1994. ERICo Velenje, Zavod za ekološke raziskave. Marec, 1995.

Stropnik B., Bole M., Mljač L., (1995) VPLIV ODPADNEGA EMAJLA V PODZEMNIH

PROSTORIH RUDNIKA LIGNITA VELENJE NA OKOLJE, ERICo Velenje, Zavod za ekološke raziskave, september 1995

3.06 Elaborat, predštudija, študija

Stropnik B., Rošer Drev A., Ramšak R., Bole M. (1992).STROKOVNO MNENJE NA PREDLOG ODLOKA O UREDITVENEM NAČRTU JEZERO, ERICo Velenje, Zavod za ekološke raziskave. Februar, 1992.

Stropnik B., Mljač L., Svetina Gros M., Ramšak R., Bole M., Čuhalev I., Rejic M., Smodiš B., Rajh Alatič Z., Jeran Z., Križman M., Ja}imovi} R. (1993). OCENA EKOLOŠKE PRIMERNOSTI PROSTORA ZA REKREACIJO NA OBMOČJU VELENJSKEGA JEZERA. ERICo Velenje, Zavod za ekološke raziskave Velenje. December, 1993.

Ramšak R., Rošer Drev A., Bole M. (1994). STROKOVNO MNENJE NA VLOGO GLIN POHIŠTVA d.o.o. (Nazarje 32) ZA IZPUST FEKALNIH IN TEHNOLOŠKIH ODPADNIH VODA NA BIOLOŠKO ČISTILNO NAPRAVO V MOZIRJU. ERICo Velenje. Marec, 1994.

Stropnik B., Mljač L., Kugonič N., Rošer Drev A., Ramšak R., Šterbenk E., Bole M., Svetina Gros M., Planinšek T., Zupan M., Čuhalev I., Alatič Z., Šušteršič A:, Jenko B., Smodiš B., Križman M., Al Sabti K., Jeran Z., (1994). EKOLOŠKI MONITORING ODLAGALIŠČA PEPELA, ŽLINDRE IN PRODUKTOV ODŽVEPLANJA (EKO-MON), Projekt, ERICo Velenje, Zavod za ekološke raziskave, Velenje. Maj, 1994.

Stropnik B., Ribarič Lasnik C., Mljač L., Kugonič N., Svetina M., Rošer Drev A., Ramšak R., Bole M., Flis J., Al Sayegh Petkovšek S., Šterbenk E., Beričnik J., (1995). SINTEZNA ŠTUDIJA, ERICo Velenje, Velenje.

3.08 Poročilo o meritvah, preiskusih

Bole M., Rošer Drev A. (1991). POROČILO O ONESNAŽENJU REKE PAKE Z ODPADNO VODO, KI PRITEČE IZ JAME RLV V PRELOGAH. ERICo Velenje, Zavod za ekološke raziskave. Maj, 1991.

Bole M. (1993). POROČILO O OPRAVLJENIH ANALIZAH REKE PAKE IN ODPADNE VODE V SKLOPU AKCIJE REŠEVANJA OB RAZLITJU NEVARNIH SNOVI NA RLV NOP. ERICo Velenje, Zavod za ekološke raziskave. Oktober, 1993.

Rošer Drev A., Bole M., Ramšak R. (1993). ANALIZA VODE NA KANALIZACIJSKEM KANALU ZA BODOČI DOTOK NA ČISTILNO NAPRAVO GABERKE. ERICo Velenje, Zavod za ekološke raziskave Velenje. April, 1993.

Bole M., Rošer Drev A., Ramšak R., Flis J., Stropnik B.(1993). ANALIZA GOŠČE IZ ČISTILNE NAPRAVE BIO DISK MOZIRJE. ERICo Velenje, Zavod za ekološke raziskave. Oktober, 1993.

Rošer Drev A., Bole M. (1991-1994). POROČILO OPORAVLJENIH PREISKAVAH OSUŠENIH USEDLIN IZ USEDALNIKOV BLATA, PREISKAVAH VODE IN RAZPRŠENE BIOLOŠKE RUŠE IZ CENTRALNE ČISTILNE NAPRAVE ŠALEŠKE DOLINE. Polletna in letna poročila. ERICo Velenje, Zavod za ekološke raziskave Velenje. 1991-1994.

Beričnik - Vrbovšek J., Bole M., Ramšak R., Rošer Drev A., (1994). VPLIV ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA ODPLAVA PEPELA, ERICo Velenje, Zavod za ekološke raziskave, polletno poročilo. Februar, 1994.

Beričnik - Vrbovšek J., Bole M., Ramšak R., Rošer Drev A.,(1994.) VPLIV ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA ODPLAVA PEPELA, ERICo Velenje, Zavod za ekološke raziskave, letno poročilo. Marec, 1994.

Bole M., Rošer Drev A., Ramšak R., (1994). ANALIZA GOŠČE IZ ČISTILNE NAPRAVE BIO DISK MOZIRJE. ERICo Velenje, Zavod za ekološke raziskave. December, 1994.

Štrbenk E., Bole M., Ramšak R.(1995) POROČILO O OPRAVLJENI INTERVENCIJI DNE, 14. FEBRUARJA 1995 (IZLITJE OLJA V PAKO) ERICo Velenje, Zavod za ekološke raziskave Velenje, 1995

Rošer Drev A., Bole M. (1995). POROČILO O OPRAVLJENIH PREISKAVAH VODE IZ CENTRALNE ČISTILNE NAPRAVE ŠALEŠKE DOLINE. ERICo Velenje, Zavod za ekološke raziskave Velenje. 1995.

Rošer Drev A., Bole M. (1995). POROČILO O OPRAVLJENIH PREISKAVAH OSUŠENIH USEDLIN IZ USEDALNIKOV BLATA, PREISKAVAH VODE IN RAZPRŠENE BIOLOŠKE RUŠE IZ CENTRALNE ČISTILNE NAPRAVE ŠALEŠKE DOLINE. Polletno poročilo. ERICo Velenje, Zavod za ekološke raziskave Velenje. 1995

Bole M., Rošer Drev A.,(1995), ANALIZE ODPADNIH VODA RLV NA IZTOKIH V

PAKO. Preliminarno poročilo, ERICo Velenje, Zavod za ekološke raziskave, oktober 1995

3.14 Predavanje

Šterbenk E., Drev-Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina Gros M., Ramšak R., Beričnik-Vrbovšek J. (1994). VARUJMO IN OHRANIMO ŠALEŠKO DOLINO, Zbornik, Občinska zveza prijateljev mladine Velenje, ERICo Velenje.

Šterbenk E., Drev-Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina M., Ramšak R., Beričnik-Vrbovšek J. (1995). VARUJMO IN OHRANIMO ŠALEŠKO DOLINO, Zbornik, Občinska zveza prijateljev mladine Velenje, ERICo Velenje.

3. 20 Druga dela

Bole M. (1991). ČIŠČENJE ODPADNE JAMSKE VODE RLV. Diplomska naloga. Univerza v Ljubljani, fakulteta za naravoslovje in tehnologijo, VTO za kemijo in kemijsko tehnologijo. Ljubljana.

Bole M., (1992). VPLIV TRANSPORTA PEPELA IN PRODUKTOV ODŽVEPLJANJA TEŠ NA POVRŠINSKE VODE. Pripravniška naloga, ERICo Velenje, Zavod za ekološke raziskave, Velenje. Januar, 1992

Bole M., Flis J., Šterbenk E. (1994). POROČILO O OGLEDU ČISTILNIH NAPRAV, KANALIZACIJ TER O ZBIRANJU IN RAVNANJU Z ODPADKI V ALPSKEM SVETU BAVARSKE IN NA TIROLSKEM. ERICo Velenje, Zavod za ekološke raziskave Velenje. Maj, 1994.

Štrbenk E., Beričnik - Vrbovšek J., Bole M., Rošer Drev A., Ramšak R.(1994) MONITORING UGREZNINSKIH JEZER NA OBMOČJU SREDNJEGA POREČJA PAKE. Tipkopis. ERICo Velenje, Zavod za ekološke raziskave Velenje, 1994

Rošer Drev A., Bole M. (1995). OGLED BIOLOŠKE ČISTILNE NAPRAVE SIERRE - TIP ČISTILNE NAPRAVE S PRITRJENO BIOLOŠKO RUŠO - BIOPUR SISTEM, Poročilo o službenem potovanju, ERICo Velenje, Zavod za ekološke raziskave, september 1995

4. SEKUNDARNO AVTORSTVO

4.2 Mentorstvo

Svetina Gros M., Bole M., Hočevar N., Steinbacher T., (1993). DUŠIK IN OGLJIK V TLEH NA PODROČJU OBČINE VELENJE. Raziskovalna naloga, Mladi raziskovalci za razvoj občine Velenje, ERICo Velenje. Maj, 1993.

Ramšak R., Bole M., (1994). FIZIKALNOKEMIJSKE IN BIOLOŠKE ANALIZE JEZER V ŠALEŠKI DOLINI, SUM 94, Raziskovalni tabor Škale, Poročilo o delu biološko kemijske skupine, Velenje. Avgust, 1994.

Bole M., OCENA KAKOVOSTI VIROV PITNE VODE V BELIH VODAH, Skupina kemija okolja, Delovno poročilo 7. raziskovalnega tabora Bele Vode 95,avgust 1995, ERICo Velenje

Dr. Anthony R. Byrne

BIBLIOGRAFIJA

1. ČLANKI IN SESTAVKI

1.01. Izvirni znanstveni članek

1. V. Stibilj. M. Dermelj, **A. R. Byrne**, T. Šimenc, J. M. Stekar: *Determination of trace amounts of selenium in poultry feedstuffs by gas chromatography,* J. Chromatog., A 668, 449-453 (1994).
2. L. Benedik, **A. R. Byrne**: *Determination of uranium and thorium at ultra trace levels by RNAA*, Acta Chimica Slovenica, 41, 1-14 (1994).
3. X B. Stropnik, **A. R. Byrne,** B. Smodiš, R. Jaćimović: *Air pollution monitoring by ED XRF in the Šalek Valley: Part 2: Elemental Composition of size-fractionated lignite coal-combustion particles during Šoštanj TPP operation,* Acta Chimica Slovenica, 41, 65-82 (1994).
4. Z. Šlejkovec, **A.R. Byrne,** M. Dermelj: *Determination of organoarsenic compounds in urine and blood after seafood consumption and exposure to inorganic arsenic,* Acta Chimica Slovenica, 41, 83-96 (1994).
5. V. Stibilj, M. Dermelj, **A. R. Byrne**: *^{81m}Se tracer for determination of the chemical yield in radiochemical NAA of selenium,* J. Radioanal. Nucl. Chem., 182, 317-322 (1994).
6. V. Stibilj, M. Dermelj, M. Franko, **A.R. Byrne**: *Spectrophotometric determination of the chemical yield in Radiochemical NAA of selenium,* Anal. Sciences, 10, 789-793 (1994).
7. **A. R. Byrne**, M. Dermelj: *Comprehensive RNAA of Cd, Co, Ni and Cu using ^{109}Cd, ^{57}Co and reactor-produced ^{67}Cu as radioisotopic yield monitors,* Biol. Trace Element Res., 43-45, 87-94 (1994).
8. **A. R. Byrne**: *Some improvements in the quality of NAA procedures and the reliability of the results,* Biol. Trace Element Res., 43-45, 529-537 (1994).
9. X L. Benedik, **A. R. Byrne**: *Simultaneous determination of trace uranium and thorium by radiochemical neutron activation analysis,* J. Radioanal. Nucl. Chem. Articles, 189, 325-331 (1995).
10. A. Fajgelj, **A. R. Byrne**: *Determination of lead with cadmium and thallium by NAA in environmental samples,* J. Radioanal. Nucl. Chem. Articles, 189, 333-343 (1995).
11. M. Križman, **A. R. Byrne,** L. Benedik: *Distribution of ^{230}Th in milling wastes from the Žirovski vrh Uranium Mine (Slovenia), and its radioecological implications,* J. Environ. Radioactivity, 26, 223-235 (1995).
12. **A. R. Byrne**, L. Benedik: *Urinary excretion of uranium and dietary intake,* Health Phys., 68, 732-733 (1995).
13. **A. R. Byrne,** Z. Šlejkovec, T. Stjive, L. Fay, W. Gössler, J. Gailer, K. Irgolič: *Arsenobetaine and other arsenic species in mushrooms,* Appl. Organometallic Chem., 9, 305-313 (1995).
14. **A. R. Byrne,** M. Škreblin, I. Falnoga, K. Al-Sabti, P. Stegnar, M. Horvat: *Mercury and Selenium: perspectives from Idrija,* Acta Chimica Slovenica, 42(2), 175-198 (1995).

15. S. F. Stone, F. W. Backhous, **A. R. Byrne**, S. Gangadharan, M. Horvat, K. Kratzer, R, M. Parr, J. D. Schladot, R. Zeisler, *Production of hair intercomparison metarials for use in population monitoring programmes for mercury and methyl mercury exposure,* Fres. J. Anal. Chem., 352, 184-187 (1995).

X 16. Z. Jeran, **A. R. Byrne**, F. Batič: *Transplanted epiphytic lichens as biomonitors of air pollution by natural radionuclides around the uranium mine at Žirovski vrh (Slovenia),* Lichenologist, 27 (5) 375-385, 1995.

1.04. Strokovni članek

1. **A. R. Byrne**: *Mercury in the Environment and Human Exposure Studies,* Quark, 1995, str. 82-84.

1.06. Objavljeno vabljeno predavanje na znanstveni konferenci

1. **A. R. Byrne**, M. Škreblin, I. Falnoga, K. Al-Sabti, M. Horvat: *Mercury and selenium: perspectives from Idrija,* International Symp. "Status Quo of Dental Amalgam", European Academy, Otzenhausen, Nemčija, 1994.
2. M. Dermelj, **A. R. Byrne**: *Simultaneous radiochemical neutron activation analysis of uranium, iodine and mercury in biological and environmental samples,* 9th Int. Conf. Modern Trends in Activation Analysis (MTAA-9), Seoul, Korea, Sept. 1995, p. 101, 1995.

1.08. Objavljeno predavanje na znanstveni konferenci

1. B. Smodiš, L. Benedik, **A. R. Byrne**, M. Dermelj, A. Fajgelj, I. Falnoga, R. Jaćimović, Z. Jeran, P. Stegnar, V. Stibilj, B. Stropnik, Z. Šlejkovec: *Status of NAA in Slovenia: Achievements and applications,* 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-20 - 2-23.
2. M. Dermelj, L. Benedik, **A. R. Byrne**, R. Jaćimović, B. Smodiš, V. Stibilj, Z. Šlejkovec: *A review of analytical activities at "Jožef Stefan" Institute in the field of trace element determination in food articles using NAA,* FAO Meeting on Food Composition Activities in Eastern Europe, Modra, Slovaška, 1995, Zbornik referatov str. 91-95.

1.12. Objavljeni povzetek predavanja na znanstveni konferenci

1. M. Dermelj, V. Stibilj, **A. R. Byrne**, L. Benedik, Z. Šlejkovec, R. Jaćimović, B. Smodiš: *Neutron activation analysis of essential and toxic trace elements in food articles,* 1st Symposium on Food and 2nd Conference on Practical Application of European Legislation on Foodstuffs, Bled, 1995, Zbornik povzetkov str. 158.

1.14. Objavljeni poster ali povzetek posterja na znanstveni konferenci

1. B. Smodiš, Z. Šlejkovec, **A. R. Byrne**, M. Rossbach: *Speciation of arsenic and mercury in mussels from the German Environmental Specimen Bank,* 13. International Symposyum "Chemistry of the Mediterranean", Rovinj 1994, Zbornik referatov (1994) str. 75-77.
2. L. Benedik, **A. R. Byrne**: *Determination of uranium and thorium by radiochemical*

neutron activation analysis, Annual Meeting of the NSS '94, Rogaška Slatina, 1994, Zbornik referatov str. 359-367.

3. S. F. Stone, F. W. Backhaus, **A. R. Byrne**, S. Gangadharan, M. Horvat, K. Kratzer, R. M. Parr, J. SChladot, R. Zeisler: *Production of hair intercomparison materials for use in population monitoring programmes for mercury and methylmercury exposure,* 6th Int. Conf. on Biological and Environmental Reference Materials, Hawai 1993.
4. V. Stibilj, M. Dermelj, **A. R. Byrne,** M. Franko: *Comparison of spectrophotometric and ^{81m}Se radiotracer recovery determination in RNAA of selenium in biological materials,* International Conference on Analytical Quality Control and Reference Materials: Life Sciences, Rome 1994, Abstracts (1994), str. 79.
5. V. Stibilj, M. Dermelj, **A. R. Byrne**: *Improvement of radiochemical neutron activation determination of Se in biological samples: spectrophotometric yield measurement following $Mg(NO_3)_2$ ashing,* 9. simpozij "Spektroskopija v teoriji in praksi", Bled 1995, Zbornik povzetkov (1995), str. 95.
6. Z. Jeran, **A. R. Byrne**, F. Batič: *Gamma spectrometry of some natural and artificial radionuclides in lichens as air pollution monitors,* 9. simpozij "Spektroskopija v teoriji in praksi", Bled 1995, Zbornik povzetkov (1995), str. 99.
7. Z. Šlejkovec, **A. R. Byrne**, B. Smodiš, M. Rossbach: *Preliminary studies on arsenic species in some environmental samples,* 6th Int. Symposium on Metal Compounds in Environment and Life, Jüllich, Nemčija, Maj 1995, str. 138.
8. M. Dermelj, V. Stibilj, **A. R. Byrne**, L. Benedik, Z. Šlejkovec, R. Jaćimović, B. Smodiš: *Applicability of neutron activation analysis (NAA) in quantitative determination of some essential and toxic trace elements in food articles,* 8th Conference on Food Chemistry (Euro Food Chem VIII) - Current Status and Future Trends in Analytical Food Chemistry, Vienna, 1995, str. 738.
9. J. Vaupotič, M. Šikovec, **A. R. Byrne**, I. Kobal, *High radon level schools in Slovenia,* Int. Symposium on the Natural Radiation Environ (NRE VI), Montreal 1995, str. 267.
10. M. B. A. Vasconcellos, M. Saiki, G. Paletti, M. G. M. Catherino, D. Baruzzi, D. A. Rodrigues, J. Cuten, **A. R. Byrne**, *Environmental exposure to mercury and methylmercury of Brazilian Indian population groups,* 4th Int. Congress of Int. Society fot Trace Element Research in Humans (ISTERH-4), Taormina, Sicily, 1995, str. 126.
11. D. Arnold, R. Bojanowski, Y. Bourlat, **A. R. Byrne**, M. T. Crespo, P. de Felice, S. M. Jerome, M. Korun, M. Maquoni, F. M. E. Perkin, M. W. Wakerley, *Characterization of an intertidal sediment from the Cumbrian coast,* ICRM Conference on Low Level Measurement Techniques, Seville, Spain, 1995, str. 26.
12. M. Dermelj, **A. R. Byrne**, V. Stibilj, *Radiochemical neutron activation analysis of trace iodine in environmental (non-biological) samples,* 1st Mediterranean Basin Conf on Anal. Chemistry, Cordoba, Spain 1995, P5-18.

2. *MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA*

2.13. Elaborat, predštudija, študija

1. **A. R. Byrne**, M. Horvat, N. Prosenc, J. Smerke: *Analytical Quality Control in Studies of Environmental Exposure to Mercury*, IJS DP-7138 (1994).
4. **A. R. Byrne**, M. Dermelj, B. Smodiš, Z, Šlejkovec, V. Stibilj, R. Jaćimović: *Improvements in neutron activation analysis procedures for the certification of reference materials,* IJS DP- 7302 (1995).

4. *SEKUNDARNO AVTORSTVO*

4.2. Mentorstvo

1. Doktorsko delo Ljudmile Benedik: *Razvoj postopkov za določanje sledov urana in torija z radikemično nevtronsko aktivacijsko analizo*, 1994.
2. Doktorsko delo Zdenke Šlejkovec: *Separacija arzenovih zvrsti v bioloških vzorcih in njihova določitev z nevtronsko aktivacijsko analizo,* 1994.
3. Doktorsko delo Borisa Stropnika: *Analiza aerosolov in njihov vpliv v okolici termoelektrarne Šoštanj,* 1994.
4. Doktorsko delo Janje Vavpotič: *Koncentracija radona in njegovih razpadnih produktov v bivalnem okolju ter modelni izračun doz,* 1995
5. Diplomsko delo Andreja Bibiča: *Sledenje privzema cinka pri enakonožcih (Isopoda, Crustacea) z uporabo radioaktivnega izotopa* ^{65}Zn, 1995.

Radojko Jaćimović

BIBLIOGRAFIJA

1. ČLANKI IN SESTAVKI

1.01. Izvirni znanstveni članek

1. B. Stropnik, A. R. Byrne, B. Smodiš, **R. Jaćimović**: *Air pollution monitoring in the Šalek valley, Part 2: Elemental composition of size-fractionated lignite coal-combustion particles during Šoštanj TPP operation*, Acta Chim. Slovenica 41/1/ 65 (1994).
2. B. Smodiš, M. Dermelj, **R. Jaćimović**: *Determination of trace elements in tobacco using different techniques of neutron activation analysis*, J. Radioanal. Nucl. Chem., Articles, 190/1/ 3 (1995).

1.08. Objavljeno predavanje na znanstveni konferenci

1. B. Smodiš, R. **Jaćimović**: *Estimating errors in the experimental determination of neutron fluence spectra*, 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-31 - 2-35.
2. B. Smodiš, L. Benedik, A. R. Byrne, M. Dermelj, A. Fajgelj, I. Falnoga, **R. Jaćimović**, Z. Jeran, P. Stegnar, V. Stibilj, B. Stropnik, Z. Šlejkovec: *Status of NAA in Slovenia: Achievements and applications*, 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-20 - 2-23.
3. Z. Jeran, **R. Jaćimović**, V. Lupšina-Miklavčič, B. Smodiš, F. Batič: *Ugotavljanje onesnaženosti zraka s kovinami in radionuklidi z uporabo biomonitorjev - lišajev*, Varstvo zraka, stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled, 1994, (1994), Zbornik referatov str. 19/1-19/13.
4. B. Smodiš, **R. Jaćimović**, Z. Jeran, B. Stropnik, V. Miklavčič, P. Stegnar: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, Applied Research on Air Pollution Using Nuclear-Related Analytical Techniques, Vienna, 1994, Report on First Research Co-ordination Meeting, NAHRES-19, IAEA, (1994), Zbornik referatov str. 173-180.
5. Z. Jeran, F. Batič, **R. Jaćimović**, B. Smodiš: *Epiphytic lichens in air pollution studies of heavy metals in Slovenia*. Proc. Second International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Budapest, 20.-23.9.1994, (izšlo 1995), str. 212-214.
6. M. Dermelj, L Benedik, A. R. Byrne, **R. Jaćimović**, B. Smodiš, V. Stibilj, Z. Šlejkovec: *A Review of analytical activities at "Jožef Stefan" Institute in the field of trace element determination in food articles*

using *NAA*, FAO Meeting on Food Composition Activities in Eastern Europe, Modra, Slovak Republik 1995, str. 91-95.

7. Z. Jeran, **R. Jaćimović**, B. Smodiš, F. Batič: *The use of lichens in atmospheric trace element deposition studies in Slovenia*, BIOFOSP, Ljubljana, August, 22.-31. 1995, str. 147-152.

8. M. Svetina-Gros, B. Smodiš, Z. Jeran, **R. Jaćimović**: *Trace elements in the precipitation of Šalek valley, Slovenia*, 2nd International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Budapest, 20.-23.9.1994, (izšlo 1995), str. 876-878.

9. D. Brajnik, S. Korpar, **R. Jaćimović**, G. Medin, M. Starič, A. Stanovnik: *Određivanje aktivnosti ^{90}Sr mjerenjem Čerenkovog zračenja u aerogelu*, 9. Kongres fizičara Jugoslavije, Maj 29.-31. 1995., Petrovac na moru, Zbornik radova, str. 493-497.

10. B. Smodiš, **R. Jaćimović**, B. Stropnik, M. Svetina Gros: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, Report on the Second Research Co-ordination Meeting, Menai, Australia, 27-31 March 1995, str. 15-1 - 15-10.

1.12. Objavljeni povzetek predavanja na znanstveni konferenci

1. M. Dermelj, V. Stibilj, A.R. Byrne, L. Benedik, Z. Šlejkovec, **R. Jaćimović**, B. Smodiš: *Neutron activation analysis of essential and toxic trace elements in food articles*, 1st Symposium on Food and 2nd Conference on Practical Application of European Legislation on Foodstuffs, Bled, 23-25 Maj 1995, Zbornik referatov, str. 158.

2. B. Smodiš, L. Benedik, A. R. Byrne, M. Dermelj, **R. Jaćimović**, Z. Jeran, V. Stibilj, Z. Šlejkovec: *Status of neutron activation analysis in Slovenia: achievements and applications*, 13th European TRIGA Users Conference, Bled, 1994, Abstracts, (1994).

1.14. Objavljeni poster ali povzetek posterja na znanstveni konferenci

1. Z. Jeran, **R. Jaćimović**, B. Smodiš, F. Batič, H. Wolterbeek: *Atmospheric heavy metal pollution in Slovenia derived from results for epiphytic lichens*, 6th International Hans Wolfgang Nuerneberg Memorial Symposium on Metal Compunds in Environment and Life, Jülich, Germany, 9-12 May 1995, Book of abstracts, (1995), str.73.

2. M. Svetina, B. Smodiš, Z. Jeran, **R. Jaćimović**: *Mikroelementi v vodnem krogotoku Šaleške doline*, 9. simpozij spektroskopija v teoriji in praksi, Bled, 10-13. april, 1995, Knjiga povzetkov, (1995), str. 101.

3. Z. Jeran, **R. Jaćimović**, F. Batič, A. Prosenc: *Natural and artifical radionuclides in lichnes as air pollution monitors*. Book of Abstracts: Symposium on Radiation protection in neighbouring countries in Central Europe - 1995, Portorož, Sept. 4 - 8, 1995, p. 99.

4. Z. Jeran, F. Batič, **R. Jaćimović**: *Passive biomonitoring with epiphytic lichens for assessing trace element air pollution in Slovenia*. Abstract: 8th International Bioindicators Symposium 1995, (ed. J. Boháč, J. Třiska, R.

Tichý), 22-28 May 1995, Česke Budějovice, Czech Republic, p. 46.

5. B. Smodiš, **R. Jaćimović**, F. De Corte: *Evaluation of the accuracy and precision of neutron fluence rate characterisation for use in NAA*. International Workshop on Neutron Research and Applications, Budimpešta, marec 1994, (1994)

6. **R. Jaćimović**, A. Trkov, B. Smodiš: *Nuclear constants for activation analysis of some nuclides and comparisons with experimentally measured values*, 2nd Regional Meeting: Nuclear Energy in Central Europe, Portorož, 1995, Abstracts, (1995), str. 17.

7. B. Smodiš, M. Dermelj, **R. Jaćimović**, B. Stropnik: *Ugotavljanje stanja onesnaženosti sedimentov v vodah Šaleške doline z uporabo instrumentalne nevtronske aktivacijske analize*. Zbornik povzetkov: 9. simpozij spektroskopija v teoriji in praksi, Bled, 10.-13. april, 1995, (1995), str. 98.

8. M. Dermelj, V. Stibilj, A.R. Byrne, L. Benedik, Z. Šlejkovec, **R. Jaćimović**, B. Smodiš: *Applicability of neutron activation analysis (NAA) in quantitative determination of some essential and toxic trace elements in food articles*, 8th Conference on Food Chemistry (Euro Food Chem VIII) - Current Status and Future Trends in Analytical Food Chemistry, Sept. 18.-20., 1995, Vienna, Austria, str. 738.

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.11. Poročilo o znanstveno-raziskovalni nalogi

1. Zaključno poročilo o opravljenem delu na znanstveno-raziskovalni nalogi **J2-2240**: *Uporaba lišajev kot bioloških indikatorjev pri študiju onesnaževanja zraka v Sloveniji s težkimi kovinami, toksičnimi elementi in radionuklidi* (1994).

2.13. Elaborat, predštudija, študija

1. B. Smodiš, R. **Jaćimović**, B. Stropnik, M. Svetina Gros: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, IJS DP-7181 (1995).
2. **R. Jaćimović**, B. Smodiš: *Homogeneity testing of IRMM Al-Co alloy samples for certification analysis*, IJS DP-7186 (1995).
3. A. R. Byrne, M. Dermelj, B. Smodiš, Z. Šlejkovec, V. Stibilj, **R. Jaćimović**: *Improvements in neutron activation analysis procedures for the certification of reference materials*, IJS DP-7302 (1995).
4. B. Smodiš, **R. Jaćimović**: *An impulse to exploit NAA as a manageable and competitive analytical tool in industry and environmental sanitation in Hungary, The Czech Republic and Slovenia, 2nd Progress Report*, IJS DP-7303 (1995).

BIBLIOGRAFIJA 1994 , 1995:

Mag. Dušan Jurc, dipl. biol.

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

- JURC, M./ JURC, D. 1995. Endophytic fungi in the needles of healty-looking Austrian pine (*Pinus nigra* Arn.). Acta Pharmaceutica, 2, suppl. I/95, Zagreb, s. 341-345.

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

1.05 Poljudni članek

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci
1.07 Objavljeno vabljeno predavanje na strokovni konferenci

1.08 Objavljeno predavanje na znanstveni konferenci

- JURC, M. / JURC, D. / GOGALA, N. / SIMONČIČ, P. 1995. Endophytes of Austrian pine needles as indicators of pollution. In: Proceedings of the BIOFOSP (Eds. Kraigher H. *et al*), 22.-31.08.1995, GIS in Odd. za agronomijo BF, Ljubljana, s. 165 - 172.

1.09 Objavljeno predavanje na strokovni konferenci

- JURC, D., BOGATAJ, N., 1994: Proučevanje propadanja gozdov in sprememb v ekosistemih v Sloveniji. V: Zbornik referatov: Varstvo zraka - stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled, 28.-30.3.1994, ZTI, Ljubljana, 8 str.

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci
1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci

1.12 Objavljeni povzetek predavanja na znanstveni konferenci
1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

- JURC, M., JURC, D., GOGALA, N., SIEBER, T.N., 1995. Fungal Endophytes in the Needles of Austrian pine (*Pinus nigra* Arn.) in Slovenia. IUFRO XX World Congress, 6-12 Avgust 1995, Tampere, Finland, Poster Abstracts, s. 76-77.

1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi
1.17 Poglavje ali samostojni sestavek v strokovni knjigi

- ŠOLAR, M. JURC, D., DRUŠKOVIČ, B., 1994: Kako ohraniti gozdove. V Okolje v Sloveniji, zbornik, Tehniška založba Slovenije, Ljubljana, s. 466-474

1.18 Sestavek v enciklopediji

1.19 Objavljena recenzija, prikaz knjige, kritika

1.20 Predgovor, spremna beseda

1.21 Polemika, diskusijski prispevek

1.22 Objavljeni intervju

1.23 Umetniški sestavki (notni zapisi, pesmi, novele...)

1.25 Drugi članki ali sestavki

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.01 Znanstvena monografija

2.02 Strokovna monografija

2.03 Univerzitetni učbrnik

2.04 Drugi učbeniko z recenzijo (srednje in nižješolski...)

2.05 Ostalo učno gradivo (zapiski predavanj, zbirka vaj...)

2.06 Priročniki, slovarji, leksikoni

- KOVAČ, M., SIMONČIČ, P., BOGATAJ, N. BATIČ, F., JURC, D., HOČEVAR, M. 1995: Monitoring gozdnih ekosistemov in propadanja gozdov, priročnik za terensko snemanje podatkov, Gozdarski inštitut Slovenije. 64 str.

2.07 Bibliografija

2.08 Doktorska disertacija

2.09 Magistrsko delo

2.10 Specialistično delo

2.11 Poročilo o znanstveno - raziskovalni nalogi

2.12 Poročilo o razvojno - raziskovalni nalogi

2.13 Elaborat, predštudija, študija

- JURC, D., KRALJ, T., 1993: Inventory of forest decline 1987 and the emission area of Šoštanj power - plant. V poročilu za Svetovno banko: Impact of polluted gasses from thermal power-plant Šoštanj, Slovenia, on forest environment: a brief expertise on cause - consequence relationship in forest decline studies carried out in the Institute for forest and wood economy. IGLG, Ljubljana, s. 25-27.
- JURC, D., 1993: Public opinion and forest dieback in Slovenia. V poročilu za Svetovno banko: Impact of polluted gasses from thermal power-plant Šoštanj, Slovenia, on forest environment: a brief expertise on cause - consequence relationship in forest decline studies carried out in the Institute for forest and wood economy. IGLG, Ljubljana, s. 25-27.
- ŽGAJNAR, L., JURC, D., KRALJ, T., MEDVED, M., MIKULIČ, V., 1994: Stanje in perspektive oskrbe s kostanjevim lesom iz domačih virov v tovarni "Tanin" Sevnica. Gis, Ljubljana, 34 str. (elaborat).
- JURC, M., BATIČ, F., JURC, D., KRAIGHER, H., SIRK, I., KRALJ, T., 1994. Mikoteka in herbarij Gozdarskega inštituta Slovenije. GIS, Ljubljana, 150 str.
- JURC, M., JURC, D., MUNDA, A., TORTIĆ, M., HOČEVAR, S., PILTAVER, A., 1994: Katalog gliv Mikoteke in herbarija Gozdarskega inštituta Slovenije,GIS Ljubljana, 181 str.

- MUNDA, A./ JURC, M./ JURC, D./ PILTAVER, A./ TORTIČ, M./ HOČEVAR, S./ KRAIGHER, H./ BEAUHEN, L./ DIMINIČ, D. 1995. Katalog Mikoteke in herbarija Gozdarskega inštituta Slovenije, GIS, Ljubljana, 100 s.

2.14 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

2.15 Posnetek glazbenega dela

2.16 Umetniška dela

2.17 Katalog razstave

2.20 Druge monografije

3. IZVEDENA IN DRUGA (V KNJIŽNICAH) NEDOSTOPNA DELA

3.01 Patentna prijava

3.02 Patent

3.03 Tehniška izboljšava (nova tehnologija)

3.04 Programska oprema

3.05 Poročilo o raziskovalni ali razvojni nalogi

3.06 Elaborat, predštudija študija

3.07 Izvedeniško mnenje, arbitražna odločba, recenzija

- JURC, D., 1994: Poškodbe navadnih gabrov (Carpinus betulus L.) na Žalah. GIS, Ljubljana, 4 str.
- JURC, D. 1995. Poškodbe duglazije v revirju Svetina, KE Celje. Ekspertiza, GIS, Ljubljana, 1 str.
- JURC, D. 1995. Bolezen lovorikovca, ognjenega trna in pušpana. Ekspertiza. GIS, Ljubljana, 3 str.
- JURC, D. / JURC, M. 1995. Poškodbe črnega bora (*Pinus nigra* Arn.) na Črnem Kalu. Ekspertiza, GIS, Ljubljana, 3 str.
- JURC, D./ JURC, M./ JAKŠA, J. 1995. Bukov rak v GGE Brezova reber. Ekspertiza, GIS,Ljubljana, 3 str.
- JURC, D./ MUNDA, A. / JURC, M. 1995. Zdravstveno stanje sadik v gozdnih drevesnicah v Sloveniji.Poročilo, GIS.
- JURC, D./ PAVLIN, R. 1995. Sušenje črnega bora pri blejskem gradu. Ekspertiza, GIS, Ljubljana, 3 str.
- JURC, D./ TITOVŠEK, J. 1995. Sušenje zelenega bora. Ekspertiza, GIS, Ljubljana, 4 str.

3.08 Poročilo o meritvah, preizkusih ipd.

3.09 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

3.10 Umetniške stvaritve in poustvaritve

3.11 Radijski in TV prispevki

3.12 Razstave

3.13 Organiziranje znanstvenih in strokovnih sestankov

3.14 Predavanja - gostovanja na tuji univerzi

3.20 Druga dela

- JURC, M., JURC, D., 1995. Research on *Cenangium ferruginosum* Fr. on Austrian pine (*Pinus nigra* Arn.) in Slovenia. Referat predstavljen na IUFRO S2.06-00 Pathology, Hyytiälä Forestry Field Station, Finland, 4-6 Avgust 1995, 8 str.
- JURC, D. 1995. Hipovirulenca kostanjevega raka. Posvetovanje o pravem kostanju, Zavod za , gozdove Slovenije, Sevnica, 12. 10. 1995
- JURC, D. 1995. Kako rešiti pravi kostanj? Predavanje za Društvo za varstvo rastlin, Kmetijski inštitut Slovenije, Ljubljana, 5. 6. 1995

4. SEKUNDARNO AVTORSTVO (se upošteva pri izpisu)

4.1 Uredništvo

4.2 Mentorstvo

4.3 Prevod

4.4 Ilustracije

4.5 Drugo

BIBLIOGRAFIJA 1994 , 1995:

Ime in Priimek : Polona KALAN

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

KALAN, J., KALAN, P., SIMONČIČ, P. 1995. Bioindikacija onesnaženosti gozdov z žveplom na osnovi vsebnosti žvepla v asimilacijskoi delih gozdnega drevja. Zbornik gozdarstva in lesarstva, 47, s. 85-116

KALAN, J., KALAN, P., SIMONČIČ, P. 1995. Proučevanje gozdnih tal na stalnih raziskovalnih ploskvah. Zbornik gozdarstva in lesarstva, s. 57-84

BATIČ, F., GRILL, D., KALAN, P., RIBARIČ - LASNIK, C. 1995: Impact of emission gases from the thermal power plantn in Šoštanj on the biochemical structure of Norway spruce needles (*Picea abies* /L./Karst.). Acta Pharmaceutica, 45. p. 191 - 197

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

1.05 Poljudni članek

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci

1.07 Objavljeno vabljeno predavanje na strokovni konferenci

1.08 Objavljeno predavanje na znanstveni konferenci

KALAN, P., HUDNIK, V., SIMONČIČ, P. 1995 Evaluation of forest soil sampling methodology, Proceedings of BIOFOSP, Ljubljana p. 135 - 138.

SIMONČIČ, P., KALAN, P. 1995 Comparison of the anual cycle of sulphur content in spruce needles from heavily polluted and less polluted areas, Proceedings of BIOFOSP, Ljubljana p. 131 - 134.

1.09 Objavljeno predavanje na strokovni konferenci

KALAN P., KALAN, J. 1994. Integrirano merjenje imisije žveplovega dioksida. Zbornik s posvetovanja Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji. Bled, 28. - 30. 3. 1994 ZTI - Zavod za tehnično izobraževanje Ljubljana. s. 15 - 18.

ROBEK, R., KUTNAR, L., KALAN, P. 1994. Varovanje vodne vloge gozdov pri transportu lesa. Zbornik: XVI. Gozdarski študijski dnevi. Biotehniška fakulteta, Oddelek za gozdarstvo, Ljubljana, s. 203 - 214.

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci
1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci

1.12 Objavljeni povzetek predavanja na znanstveni konferenci

KALAN, P., HUDNIK, V., SIMONČIČ, P. 1995 Evaluation of forest soil sampling methodology after determination of some elements by AAS. In: Spestroscopy in theory and Practice, 9th Symposium, Bled 11. - 13. 04. 1995 s. 40.

1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

KALAN P., KALAN, J. 1994. Integrirano merjenje imisije žveplovega dioksida. Posvetovanje: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji. Bled, 28. - 30. 3. 1994

1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi
1.17 Poglavje ali samostojni sestavek v strokovni knjigi

1.18 Sestavek v enciklopediji

1.19 Objavljena recenzija, prikaz knjige, kritika

1.20 Predgovor, spremna beseda

1.21 Polemika, diskusijski prispevek

1.22 Objavljeni intervju

1.23 Umetniški sestavki (notni zapisi, pesmi, novele...)

1.25 Drugi članki ali sestavki

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.01 Znanstvena monografija

2.02 Strokovna monografija

2.03 Univerzitetni učbrnik

2.04 Drugi učbeniko z recenzijo (srednje in nižješolski...)

2.05 Ostalo učno gradivo (zapiski predavanj, zbirka vaj...)

2.06 Priročniki, slovarji, leksikoni

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2.08 Doktorska disertacija

2.09 Magistrsko delo

2.10 Specialistično delo

2.11 Poročilo o znanstveno - raziskovalni nalogi

2.12 Poročilo o razvojno - raziskovalni nalogi

2.13 Elaborat, predštudija, študija

2.14 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

2.15 Posnetek glazbenega dela

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2.20 Druge monografije

3. IZVEDENA IN DRUGA (V KNJIŽNICAH) NEDOSTOPNA DELA

3.01 Patentna prijava

3.02 Patent

3.03 Tehniška izboljšava (nova tehnologija)

3.04 Programska oprema

3.05 Poročilo o raziskovalni ali razvojni nalogi

3.06 Elaborat, predštudija študija

3.07 Izvedeniško mnenje, arbitražna odločba, recenzija

3.08 Poročilo o meritvah, preizkusih ipd.

3.09 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

3.10 Umetniške stvaritve in poustvaritve

3.11 Radijski in TV prispevki

3.12 Razstave

3.13 Organiziranje znanstvenih in strokovnih sestankov

3.14 Predavanja - gostovanja na tuji univerzi

3.20 Druga dela

4. SEKUNDARNO AVTORSTVO (se upošteva pri izpisu)

4.1 Uredništvo

4.2 Mentorstvo

4.3 Prevod

4.4 Ilustracije

4.5 Drugo

BIBLIOGRAFIJA 1994 , 1995:

Ime in Priimek HOSTA KRAIGHER

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

- Kraigher H, Hanke DE (1995) Cytokinins in Norway Spruce Seedlings, grown on different Soil Substrates. Acta Pharmaceutica 45 (No.2, suppl. I) 325-328. (za delež avtorstva (90%) glej prilogo)
- Al Sayegh - Petkovšek S, Kraigher H, Batič F, Gogala N, Agerer R (1995) Mycorrhizal Potential of two Forest Research Plots in Zavodnje and in Mislinja. Acta Pharmaceutica, 45 (No.2, suppl. I) 333-338. (delež avtorstva je ca 10%)
- Kraigher H, Agerer R, Javornik B (1995) Ectomycorrhizae of *Lactarius lignyotus* on Norway spruce, characterized by anatomical and molecular tools. Mycorrhiza 5 175-180. (za delež avtorstva (50%) glej prilogo)

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

1.05 Poljudni članek

-

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci

- Kraigher H (1994) Molecular ecology in forestry: Taxonomy of ectomycorrhizae by anatomical characteristics and molecular markers. In: Proc. of IPBA (Eds. B.Javornik, B.Bohanec, I.Kreft), Rogla, December, 5. - 7., 1994: 189 - 200

1.07 Objavljeno vabljeno predavanje na strokovni konferenci

- Kraigher, H. (1995) Mikoriza nekaterih drevesnih in grmovnih vrst v Sloveniji. V: Prezrte drevesne vrste. XVII. gozdarski študijski dnevi (Ed. M. Kotar), Dolenjske Toplice, 9.-10.11.1995: 127-138.

1.08 Objavljeno predavanje na znanstveni konferenci

- Kraigher, H., Batič, F., Agerer, R. (1995) The diversity of types of ectomycorrhizae on Norway spruce on two forest research plots in Slovenia. Proceedings of International Biodiversity seminar ECCO XIV. Meeting, June 30-July 4, 1995, Gozd Martuljek, Slovenia, p. 107-108
- Kraigher, H, Hanke, DE (1995) Cytokinins in Norway spruce seedlings as tester organisms of forest soil pollution. In: Proceedings of the BIOFOSP (Eds. Kraigher H *et al*), 22.-31.08.1995, GIS in Odd. za agronomijo BF, Ljubljana, 195-200.
- Kraigher, H, Batič, F, Agerer, R (1995) Mycobioindication of forest site pollution. In: Proceedings of the BIOFOSP (Eds. Kraigher H *et al*), 22.-31.08.1995, GIS in Odd. za agronomijo BF, Ljubljana, 95-100.
- Kraigher, H, Batič, F, Urbančič, M (1995) The Forest Research Plot on Pokljuka. In: Proceedings of the BIOFOSP (Eds. Kraigher H *et al*), 22.-31.08.1995, GIS in Odd. za agronomijo BF, Ljubljana, 333-334.

1.09 Objavljeno predavanje na strokovni konferenci

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci

1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci

1.12 Objavljeni povzetek predavanja na znanstveni konferenci

1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

- Al Sayegh - Petkovšek, S., Kraigher, H., Batič, F., Gogala, N., Agerer, R. (1994) Ectomycorrhizal potential of two forest soil substrates - a pot experiment. In: Mycorrhizas in integrated systems - From genes to plant development, 4 ESM. Abstracts. Granada, 11.-14.07.1994.
- Kraigher, H., Batič, F., Agerer, R. (1994) Bioindication of pollution by types of ectomycorrhizae on Norway spruce from two differently polluted forest research plots in Slovenia. In: Air pollution and multiple stresses, 16th International meeting for specialists in air pollution effects on forest ecosystems, Abstracts. Fredericton, New Brunswick, Canada, 7.-9.09.1994.
- Kraigher, H. (1995) Identifikacija tipov ektomikorize po anatomskih karakteristikah in z molekularnimi metodami. V: Flora in vegetacija Slovenije 1995, Zbornik povzetkov referatov, Ljubljana, 21.-23.04.1995, Odd. za biol. BF in Društvo biologov Slovenije, s. 16.
- Batič, F., Kalan, P., Kralj, T., Kraigher, H., Gomišček, B., Simončič, P., Sinkovič, T., Šolar, M. (1995) Bioindication of Air Pollution and Natural Stresses on Forests of Triglav National Park in Slovenia.8th International Bioindicators Symposium, 22-28 May 1995, Česke Budejovice, Czech Republic, Abstracts p. 5.

1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi

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1.19 Objavljena recenzija, prikaz knjige, kritika

1.20 Predgovor, spremna beseda

- Kraigher, H.: Preface. In: Proceedings of the BIOFOSP (Eds. Kraigher H *et al*), 22.-31.08.1995, GIS in Odd. za agronomijo BF, Ljubljana, 2pp.

1.21 Polemika, diskusijski prispevek

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2.06 Priročniki, slovarji, leksikoni

2.07 Bibliografija

2.08 Doktorska disertacija

- Kraigher, H. (1994) Citokinini in tipi ektomikorize pri sadikah smreke (*Picea abies* (L.) Karst.) kot kazalci onesnaženosti gozdnih rastišč. Doktorska disertacija, Oddelek za agronomijo, Biotehniška Fakulteta, Univerza v Ljubljani, 156 s.

2.09 Magistrsko delo

2.10 Specialistično delo

2.11 Poročilo o znanstveno - raziskovalni nalogi

2.12 Poročilo o razvojno - raziskovalni nalogi

2.13 Elaborat, predštudija, študija

- Jurc, M., Batič, F., Jurc, D., Kraigher, H., Sirk, I., Kralj, T. (1994) Mikoteka in herbarij Gozdarskega inštituta Slovenije.- Elaborat, GIS, Ljubljana, 150 pp.
- Jurc, M., Kraigher, H., Munda, A. (1994) Katalog živih glivnih kultur mikoteke in herbarija Gozdarskega inštituta Slovenie.- Poročilo, GIS, Ljubljana, 72 pp.

2.14 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

2.15 Posnetek glazbenega dela

2.16 Umetniška dela

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3.02 Patent

3.03 Tehniška izboljšava (nova tehnologija)

3.04 Programska oprema

3.05 Poročilo o raziskovalni ali razvojni nalogi

- Gomišček, S., Gomišček, B., Batič, F., Kraigher, H. & Brancelj, T. (1995) Fazno poročilo 1994. Onesnaženost zraka v Triglavskem narodnem parku in njen vpliv na gozd in vode- Atmosfera in narodni park. (L2-6241-486-16/94), Fak. za kemijo in kemijsko tehnologijo, Ljubljana, 47 str.

3.06 Elaborat, predštudija, študija

3.07 Izvedeniško mnenje, arbitražna odločba, recenzija

- Kraigher, H. (1995) Recenzija članka "Kalan,J., Kalan, P., Simončič, P. (1995) Bioindikacija onesnaženosti gozdov z žveplom na osnovi vsebnosti žvepla v asimilacijskih delih gozdnega drevja. Zbornik gozd.in les. 47 pp.85-116."

3.08 Poročilo o meritvah, preizkusih ipd.

3.09 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

3.10 Umetniške stvaritve in poustvaritve

3.11 Radijski in TV prispevki

3.12 Razstave

3.13 Organiziranje znanstvenih in strokovnih sestankov

- ALIS LINK PROJECT NO. 250: Cytokinin production by mycorrhizal fungi and spruce seedlings (British Council), Prof.dr.David E. Hanke, Deparment of Plant Sciences, University of Cambridge, U.K., april 1991 - september 1994 - izmenjava po treh dvostranskih delovnih obiskov s predavanji letno.
- TEMPUS M_JEP 4667 - 92-95: Bioindication of Forest Site Pollution - Development of Methodology and Training, Univerze v Ljubljani, Cambridgeu, Münchnu in Grazu, september 1992 - avgust 1995, organizatorka sodelovanja z GIS.
- TEMPUS M_JEP 4667 - 92-95: organizacija mednarodnega srečanja z naslovom International Colloquium on Bioindication of Forest Site Pollution - Development of Methodology and Training - BIOFOSP, TEMPUS M_JEP 4667, Gozdarski inštitut Slovenije, Ljubljana, 22. - 31. August 1995, sofinancirano s strani Ministrstva za znanost in tehnologijo RS.
- TEMPUS M_JEP 4667 - 92-95: članica programskega in organizacijskega odbora ter so-predsedujoča na znanstveni sekciji 'Mineral Nutrition and Hormonal Regulation in the System Mycorrhizosphere - Higher Plant and Stress', dne 24.08.1995, GIS, Ljubljana.
- TEMPUS M_JEP 4667 - 92-95: organizacija delavnice z naslovom: Forest Research Plot on Pokljuka. BIOFOSP, 30.08.1995.

3.14 Predavanja - gostovanja na tuji univerzi

3.20 Druga dela

- Kraigher, H., Agerer, R. (1994) Types of ectomycorrhizae on Norway spruce from two differently polluted forest research plots in Slovenia. In: Fungi and environmental change, BMS 11th General Meeting, Silsoe College, Cranfield University, 28.-31.03.1994, Poster no. 8.
- Kraigher, H. (1995) Predstavitev dosežkov raziskovalne skupine za gozdno biologijo in ekologijo ter predlogov projektov temeljnega (1, vodja H.K.) in aplikativnega (1, vodja H.K.) raziskovanja na področju biotehnike v letu 1996. Javna predstavitev dne 27.09.1995, MZT, GIS, Ljubljana.
- Kraigher, H., Božič, G. 1995. Presentation of the project on Influences of polluted air on the Triglav National Park, part Forest, and of the principles in establishing the forest research plot on Pokljuka. International Colloquium on Bioindication of Forest Site Pollution - BIOFOSP, Workshop 3, Pokljuka, 30.08.1995, Ljubljana, TEMPUS M-JEP 04667.
- Kraigher, H. (1995) Botanika s fiziologijo (vaje): Osnove mikroskopije. GIS in BF, Ljubljana, 1 p.

4. SEKUNDARNO AVTORSTVO (se upošteva pri izpisu)

4.1 Uredništvo

- Članica Komisije za tisk GIS (izdaje monografij, Strokovnih in znanstvenih del ipd.).
- Zbornik gozdarstva in lesarstva, GIS in Odd. za gozdarstvo BF (od leta 1994 dalje).
- Hojka Kraigher, Franc Batič, David Hanke, Reinhard Agerer and Dieter Grill (Eds.) (1995) Proceedings of the International Colloquium on Bioindications of Forest Site Pollution: Development of Methodology and Training - BIOFOSP, TEMPUS M-JEP 04667, August 22-31, 1995, 336p. Issued by Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana and Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia.

4.2 Mentorstvo

Delovna mentorica mladim raziskovalcem:

- Gregor Božič (vitalizacija, magistrant, 1994 dalje)
- Samar Al-Sayegh-Petkovšek (magistrantka, uradno od 1994-1996)
- Polona Kalan (magistrantka, 1994-1995)
- Mirko Medved (doktorant, 1996)

Neformalna mentorica diplomantki:

- Barbara Bohinc (1995-1996)

4.3 Prevod

- EARTH, QUIZMASTER A+ (1994) Dorling Kindersley Limited, U.K. (v pripravi za tisk , Mladinska Knjiga, Ljubljana)

4.4 Ilustracije

4.5 Drugo

- Znanstveno sodelovanje - izpopolnjevanje v tujini: ALIS LINK PROJECT NO. 250: Cytokinin production by mycorrhizal fungi and spruce seedlings (British Council), Prof.dr.David E. Hanke, Deparment of Plant Sciences, University of Cambridge, U.K., april 1991 - september 1994, delovni obiski v Cambridgeu: 1991 (3 mes.), 1992 (3 mes.), 1993 (3 mes.), 1994 (3 mes.).
- Znanstveno sodelovanje - izpopolnjevanje v tujini: TEMPUS JEP 4667 - 92-95: Bioindication of forest site pollution - Development of Methodology and training, Univerze v Ljubljani, Cambridgeu, Münchnu in Grazu, delovni obiski: 1992 - München (dvakrat), 1993 - München (dvakrat), 1994 - München (dvakrat), Cambridge (enkrat)

BIBLIOGRAFIJA ZA LETI 1994-95: M. KRIŽMAN

1.01

1. N. Drndarski, **M. Križman**, Radioisotopes in periphyton and sediments from the Kolubara river and its tributaries, Water Research, 28(1994), str.1471-1474.
FAKTOR VPLIVA PO SCI: 1.490

2. J. Vaupotič, **M. Križman**, J. Planinić, I. Kobal, Radon level reduction in two kindergartens in Slovenia, Health Physics, 66(1994), str.568-572.
FAKTOR VPLIVA PO SCI: 0.629

3. J. Vaupotič, **M. Križman**, J. Planinić, J. Pezdič, K. Adamič, P. Stegnar, I. Kobal, Systematic indoor radon and gamma measurements in kindergartens and play schools in Slovenia, Health Physics, 66(1994), str.550-556.
FAKTOR VPLIVA PO SCI: 0.629

4. **M. Križman**, A.R. Byrne, L. Benedik, Distribution of ^{230}Th in milling wastes from the Žirovski vrh uranium mine (Slovenia), and its radioecological implications, J. Environ. Radioact. 3(1995), str. 223-235.

1.05

1. **M.J. Križman**, Radioactivity in the viccinity of former uranium mine, Quark'95, Ljubljana (1995), str. 81-82.

2. V. Miklavčič, **M. Križman**, B. Poljanšek, M. Čebokelj, Radioaktivnost v Zavratcu, Idrijski razgledi XXXIX 1994, izd. Mestni muzej Idrija, (1995).

1.10

1. J. Peter, **M. Križman**, Langzeit-umweltuberwachung von radon und seinen zerfallsprodukten durch kontinuerliche alfa-spektrometrie, Fachverband fuer Strahlenschutz: Physik und Messtechnik, Karlsruhe, 1994, (1994), str.792-797.

1.11

1. **M. Križman**, Environmental radioactivity at the former "Žirovski vrh" uranium mine and dose assessment, 2nd Symposium of Croatian Radiation Protection Association, Zagreb, 1994, Proceedings, (1994), str.125-130.

2. **M. Križman**, Radon v delovnem in bivalnem okolju, Neionizirna in ionizirna sevanja, Bled, 1994, Zbornik referatov, (1994), str.1-19.

3. L. Mljač, **M. Križman**, Radon in sevanje gama v zgradbah iz elektrolitske opeke v Velenju, 2nd Symposium of Croatian Radiation Protection Association, Zagreb, 1994, Proceedings, (1994), str.299-304.

1.12

1. R. Ilić, **M. Križman**, J. Skvarč, Z. Jeran, A national survey of indoor radon concentrations in dwellings in Slovenia, Symposium on Radiation in Neighbouring Countries in Central Europe, Portorož, 1995, Book of Abstracts, (1995), str.28.

1.13

1. **M. Križman**, Planning on environmental restoration in Slovenia, 2nd IAEA Workshop on Environmental Restoration of Contaminated Sites in Central and Eastern Europe, Pieštany, 1994, (1994).

2. **M. Križman**, Z. Logar, Technologies for and implementation of environmental restoration projects in Slovenia, 3rd Workshop on Environmental Restoration in Central and Eastern Europe, Praha, 1994, (1994).

3. Z. Logar, **M.J. Križman**, Planning environmental restoration in Slovenia: Progress report, 2nd IAEA Workshop on Regional Technical Co-operation Project on Environmental Restoration of Contaminated Sites in Central and Eastern Europe (1995-96), Sofia, (1995).

1.14

1. **M. Križman,** Kontinuirna spektrometrija alfa radonovih kratkoživih potomcev v okolju Rudnika urana, 9th Symposium Spectroscopy in Theory and Practice, Zbornik povzetkov, Bled 1995, str. P-29

1.15

1. A. Fajgelj, **M. Križman**, J. Škrk, P. Stegnar, Living with radiation, Radiation Protection in Neighbouring Countries in Central Europe, Obergurgl, 1993, Proceedings, (1994), str.483-486.

2. **M. Križman**, P. Stegnar, Atmospheric radon concentrations in the environment of uranium mill tailings in Slovenia, Radiation Protection in Neighbouring Countries in Central Europe, Obergurgl, 1993, Proceedings, (1994), str.422-426.

3. J. Vaupotič, **M. Križman**, J. Pezdič, P. Stegnar, I. Kobal, Examples of high indoor radon concentrations in kindergartens and play schools in Slovenia, Radiation Protection in

Neighbouring countries in Central Europe, Obergurgl, 1993, Proceedings, Vol. 3, (1994), str.418-421.

2.13

1. **M. Križman**, Koncentracije radona v bivalnem prostoru Slovenije; predlog intervencijskih nivojev, IJS delovno poročilo, DP-7102, (1994).

2. **M. Križman**, D. Konda, Meritve radioaktivnosti za ugotavljanje ničelnega stanja na področju ugreznine nad Brnico, IJS delovno poročilo, DP-6960, (1994).

3. **M. Križman**, D. Konda, Posebne strokovne podlage za pripravo ureditvenih načrtov za sanacijo površin po končanem rudarjenju, IJS delovno poročilo, DP-6951, (1994).

4. **M. Križman**, L. Mljač, Koncentracije radona v bivalnem okolju Slovenije, metodologija ocenjevanja prejetih doz, IJS delovno poročilo, DP-7074, (1994).

5. **M. Križman**, P. Stegnar, Meritve radioaktivnosti v okolju rudnika urana Žirovski vrh in ocena vplivov na okolje, IJS delovno poročilo, DP-7046, (1994).

6. **M. Križman**, P. Stegnar, Poročilo o meritvah radioaktivnosti v okolju rudnika urana Žirovski vrh za leto 1993, IJS delovno poročilo, DP-7073, (1994).

7. **M. Križman**, P. Stegnar, D. Konda, Določitev parametrov za ureditev odlagališča jamske jalovine na Jazbecu, IJS delovno poročilo, DP-6986, (1994).

8. L. Mljač, P. Stegnar, **M. Križman**, Radiološki vpliv odlagališča pepela na okolico, Letno poročilo za leto 1993, ERICO DP-14/94, (1994).

9. B. Smodiš, **M. Križman**, K. Al-Sabti, Z. Jeran, Ekološki monitoring odlagališča pepela, žlindre in produktov odžveplanja, Projekt EKO-MON, ERICO DP-14/94, (1994).

10. M. Zupan, **M. Križman**, F. Knez, Problem radona in sanacija otroškega vrtca v Idriji, Skupno delovno poročilo ZRMK in IJS, 5/520-25/94, (1994).

11. M. Lesjak, U. Miklavžič, **M. Križman**, Standardi varstva okolja pred ionizirajočimi sevanji, AMES delovno poročilo, AMES DP-101, (1994), str.1-39.

12. M. Humar, J. Skvarč, R. Ilić, **M. Križman**, Z. Jeran, R. Šajn, Koncentracije radona v bivalnem okolju Slovenije, IJS delovno poročilo, DP-7164, (1995).

13. **M. Križman**, L. Benedik, Poročilo o vplivih rudnika urana Žirovski vrh na okolje, IJS delovno poročilo, DP-7172, (1995).

14. **M.J. Križman**, Radon in njegovi razpadni produkti v okolju Rudnika urana Žirovski vrh - Evaluacija kontinuirnih meritev radonovih kratkoživih potomcev v atmosferi, IJS

delovno poročilo DP-7322, (1995).

15. **M. Križman**, Poročilo o meritvah radioaktivnosti v okolju Rudnika urana Žirovski vrh za leto 1993, IJS delovno poročilo DP-7247/95, (1995).

16. L. Mljač, **M. Križman**, Radioaktivnost površinskih voda in sedimentov kot posledica odlaganja elektrofiltrskega pepela TEŠ, Delovno poročilo ERICo DP-63/95, (1995).

17. **M. Križman**, L. Benedik, Poročilo o vplivih rudnika urana Žirovski vrh - Obstoječe stanje pred pričetkom izvajanja del trajnega prenehanja izkoriščanja uranove rude in preprečevanja posledic rudarjenja, IJS delovno poročilo, DP-7102/95, (1995).

V. Bibliografija in drugi raziskovalni rezultati:

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

Batič F., Grill D., Kalan J., Ribarič Lasnik C., (1995). IMPACT OF EMISSION GASES FROM THE THERMAL POWER PLANT IN ŠOŠTANJ ON THE BIOCHEMICAL STRUCTURE OF NORWAY SPRUCE NEEDLES (*Picea abies (L.)* Karst.). Acta Pharmaceutica, 2, Supplement I, 1995.

1.08 Objavljeno predavanje na znanstveni konferenci

Ribarič Lasnik C., Batič F., Grill D, (1995). ANTIOXIDANTS AS INDICATOR OF STRESS IN NORWAY SPRUCE. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:51-54.

Ribarič Lasnik C., Stropnik B., (1995). THE THEMAL POWER PLANT IN ŠOŠTANJ AND ITS EFECTS ON FORESTS - THE FOREST RESEARCH PLOT IN ZAVODNJE. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:319-322.

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

Batič F., Macarol B., Ribarič Lasnik C., Strniša A., Vidergar-Gorjup N., Klemenčič S., Medvešček M., (1994). POSKUS UGOTAVLJANJA OZONA V ZRAKU Z OBČUTLJIVIM KULTIVARJEM TOBAKA (*Nicotiana tabacum* (L.) cv. BEL W). Zbornik posvetovanja: Varstvo zraka za izboljšanje stanja v Sloveniji. Bled, 28-30 marec 1994, str. 37-50.

Ribarič Lasnik C., Batič F., Grill D., (1994). VPLIV ONESNAŽENEGA ZRAKA NA BIOKEMIJSKO ZGRADBO SMREKOVIH IGLIC NA VPLIVNEM OBMOČJU TERMOELEKTRARNE ŠOŠTANJ. Zbornik svetovanja: Varstvo zraka za izboljšanje stanja v Sloveniji. Bled, 28-30 marec 1994, str. 51-54.

Ribarič Lasnik C., Batič F., Virant Klun I., Grill D., (1994). DETERMINATION OF MULTIPLE STRESS IN NORWAY SPRUCE FROM TWO FOREST SITES IN SLOVNIA BY BIOCHEMICAL ANALYSIS OF NEEDLES. Abstracts "Air Pollution & Multiple Stresses", p. 61, 16th International Meeting for Specialists in Air Pollution Effects on Forest Ecosystems (IUFRO). 7-9 september 1994. Fredericton, New Brunswick, Canada.

3. IZVEDBENA IN DRUGA (V KNJIŽNICAH) NEDOSTOPNA DELA

3.06 Elaborat, predštudija, študija

Ribarič Lasnik C., (1995). PREGLED RAZISKAV IN PREDLOG IMISIJSKEGA MONITORINGA GOZDNEGA EKOSISTEMA. Sintezna študija za Mestno občino Velenje. ERICo Velenje.

Mag. Cvetka Ribarič Lasnik, dipl. biologinja
Velenje, 17. jan. 1996

V. Bibliografija in drugi raziskovalni rezultati:

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članki

Al Sayegh Petkovšek S., Kraigher H., Batič F., Gogala N., Agerer R. (1995). MYCORRHIZAL POTENTIAL OF TWO FOREST RESEARCH PLOTS IN ZAVODNJE IN MISLINJA. Acta Pharm. 45 (1995) 333-336.

1.14 Objavljeni poster ali povzetek posterja na znansveni konferenci

Al Sayegh Petkovšek S., Kraigher H., Batič F., Gogala N., Agerer R. (1994). ECTOMYCORRHIZAL POTENTIAL OF TWO SOIL SUBSTRATES- A POT EXPERIMENT. Fourth European Symposium on Mycorrhizas. Granada, 11-14 July, Spain.

3. IZVEDBENA IN DRUGA NEDOSTOPNA DELA

3.05 Poročilo o raziskovalni ali razvojni nalogi

Al Sayegh Petkovšek S. (1994). MIKORIZNI POTENCIAL TAL GOZDNIH PLOSKEV V IMISIJSKEM OBMOČJU TERMOELEKTRARNE ŠOŠTANJ. Poročilo za leto 1993. ERICo Velenje, Zavod za ekološke raziskave Velenje. Marec 1994.

S. Al Sayegh Petkovšek

Samar Al Sayegh Petkovšek, dipl. biologinja
Velenje, 17. 1. 1996

BIBLIOGRAFIJA 1994 , 1995:

Ime in Priimek: **Primož SIMONČIČ**

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

SIMONČIČ, P., 1995. The influence of acid rain on conditions for mineral nutrition of Norway spruce (*Picea abies (L.) Karst.*) seedlings. Acta Pharm., 45, 2, suppl. I, s. 369 - 373.

SIMONČIČ, P. 1995. Preskrbljenost gozdnega drevja z mineralnimi hranili na 16 km x 16km bioindikacijski mreži. Ljubljana, Zbornik gozdarstva in lesarstva 47, s. 117 -130.

KALAN, J., KALAN, P., SIMONČIČ, P. 1995. Bioindikacija onesnaženosti gozdov z žveplom na osnovi vsebnosti žvepla v asimilacijskoi delih gozdnega drevja. Zbornik gozdarstva in lesarstva, 47, s. 85-116

KALAN, J., KALAN, P., SIMONČIČ, P. 1995. Proučevanje gozdnih tal na stalnih raziskovalnih ploskvah. Zbornik gozdarstva in lesarstva, s. 57-84

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

1.05 Poljudni članek

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci
1.07 Objavljeno vabljeno predavanje na strokovni konferenci
1.08 Objavljeno predavanje na znanstveni konferenci
1.09 Objavljeno predavanje na strokovni konferenci

KALAN J., SIMONČIČ P. 1993. Belastung von Waldoekosystemen durch Schwefel- Stickstoff- und Fluordepositionen. Programm und Kurzfassungen der Votraege und Poster, Internationales Symposium "Stoffeintraege aus der Atmosphaere und Waldbodenbelastung in den Laendern von ARGE ALP und ALPEN-ADRIA, Berchtesgaden, Bayerisches Staatministerium fuer Landesentwicklung und Umweltfragen, Muenchen; s. 237-247.

KALAN, J., SIMONČIČ, P. 1994. Vpliv onesnaženega zraka na gozdna tla. Zbornik s posvetovanja Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji. Bled, 28. - 30. 3. 1994 ZTI - Zavod za tehnično izobraževanje Ljubljana. s. 14/1 - 14/13.

SIMONČIČ, P., KALAN, P., BOGATAJ, N. 1994. Vpliv imisijskih poškodb na vodno funkcijo gozda. Zbornik: XVI. Gozdarski študijski dnevi. Biotehniška fakulteta, Oddelek za gozdarstvo, Ljubljana, s. 215 - 226

KALAN, P., HUDNIK, V., SIMONČIČ, P. 1995. Evaluation of forest soil sampling methodology. Proceedings of the International Colloquium on "Bioindication of forest site pollution - development of methodology and training". Ljubljana, TEMPUS M-JEP 04667, 22. 8. - 30. 8. 1995, s. 131-134.

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci

KALAN, P., HUDNIK, V., SIMONČIČ, P. 1995 Evaluation of forest soil sampling methodology after determination of some elements by AAS. In: Spestroscopy in theory and Practice, 9th Symposium, Bled 11. - 13. 04. 1995 s. 40.

JURC, M., JURC, D., GOGALA, N., SIMONČIČ, P. 1995. Endophytes of Austrian pine needles as indicators of pollution. Proceedings of the International Colloquium on "Bioindication of forest site pollution - development of methodology and training". Ljubljana, TEMPUS M-JEP 04667, 22. 8. - 30. 8. 1995, s. 165 - 172.

KALAN, P., HUDNIK, V., SIMONČIČ, P. 1995 Evaluation of forest soil sampling methodology, Proceedings of BIOFOSP, Ljubljana p. 135 - 138.

SIMONČIČ, P., KALAN, P. 1995 Comparison of the anual cycle of sulphur content in spruce needles from heavily polluted and less polluted areas, Proceedings of BIOFOSP, Ljubljana p. 131 - 134.

1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci
1.12 Objavljeni povzetek predavanja na znanstveni konferenci
1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci
1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi
1.17 Poglavje ali samostojni sestavek v strokovni knjigi

1.18 Sestavek v enciklopediji

1.19 Objavljena recenzija, prikaz knjige, kritika

1.20 Predgovor, spremna beseda

1.21 Polemika, diskusijski prispevek

1.22 Objavljeni intervju

1.23 Umetniški sestavki (notni zapisi, pesmi, novele...)

1.25 Drugi članki ali sestavki

SIMONČIČ, P. 1995. Foliar analysis. In: Oak decline in Slovenia, Endbericht uber die Arbeiten 1994, Ljubljana, Wien, GIS, Institut fur Waldoekologie BOKU; s. 72- 84

KOVAČ, M., SIMONČIČ, P., BOGATAJ, N. BATIČ, F., JURC, D., HOČEVAR, M. 1995: Monitoring gozdnih ekosistemov in propadanja gozdov, priročnik za terensko snemanje podatkov, Gozdarski inštitut Slovenije.

URBANČIČ M., SIMONČIČ P. 1995. Navodila za določevanje pH vrednosti mineralnega dela gozdnih tal na terenu. 1s.

SIMONČIČ, P. 1995: Gozdna tla, Poročilo o stanju okolja. Ljubljana, MVO, 1995, v tisku.

Bibliografija: Mag. Tomaž SINKOVIČ

1. Članki in sestavki

1.01 Izvirni znanstveni članek

Batič, F., **T. Sinkovič**, B. Javornik 1995. Morphological and genetic variability of *Quercus robur* L. populations in Slovenia. Zbornik gozdarstva in lesarstva 46:75-96.

Bojka Kump, **Tomaž Sinkovič**, Branka Javornik 1995. Identification of 1BL/1RS wheat-rye translocation by N-banding. Res. Reports Biotehnical Faculty of the University of Ljubljana, 65, 1995, p. 19-24.

Bernik, R., T. Godeša, **T. Sinkovič** 1995. Analiza vlečnih sil pri obnovi travinja z vsejavanjem. (The Analysis of Dragging Forces for Sodseeding). Sodobno kmetijstvo 28 (95) 3, 103-106.

Tomaž Sinkovič, Franc Batič, Branka Javornik, Helmut Guttenberger, Dieter Grill 1996. Detection of Interspecies Hybrids in Plants by Fluorescence in situ Hybridization, using Total Genomic DNA as a Probe. Phyton (Austria) in press.

Simona Rogl, Branka Javornik, **Tomaž Sinkovič**, Franc Batič 1996. Characterization of oak (*Quercus* L.) seed proteins by electrophoresis. Phyton (Austria) in press.

1.08 Objavljeno predavanje na znanstveni konferenci

Tomaž Sinkovič, F. Batič, B. Javornik 1995. Fluorescence *in situ* hybridization a tool for detecting interspecies hybrids in plants. Proc. of BIOFOSP, Ljubljana, August, 22-31. 1995:233-242.

Simona Rogl, Branka Javornik, **Tomaž Sinkovič**, Franc Batič 1995. Characterization of oak (*Quercus* L.) seed proteins by electrophoresis. Proc of BIOFOSP, Ljubljana, August, 22-31. 1995:227-232.

Batič, F., **T. Sinkovič**, B. Javornik 1994. Evaluation of pedunculate oak (*Quercus robur* L.) populations in Slovenia. Proc. of Impact of Plant Biotechnology on Agriculture, Rogla 1994: 251-265.

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

Franc Batič, Polona Kalan, Tone Kralj, Hojka Kraigher, Boštjan Gomišček, Promož Simončič, **Tomaž Sinkovič**, Martin Šolar 1995. Bioindication of Air Pollution and Natural Stresses on Forests of Triglav National Park in Slovenia. 8th International Bioindicators Symposium, 22-28 May 1995, Česke Budejovice, Czech Republic, Abstracts p. 5.

F. Batič, B. Javornik, R. Mausar, **T. Sinkovič**, 1995. New Methods in Evaluation of Oaks (Quercus L.) in Slovenia. Caring of the Forest: Research in a changing World. IUFRO XX World Congress, 6-12 August, 1995, Tampere, Finland. Poster Abstracts, 126. p. 73.

2. Monografije in druga zaključena dela

2.03 Univerzitetni učbenik

Sinkovič T., F. Batič, F. Šuštar 1994. Seznam pomembnejših rastlin in navodila za računanje krmne vrednosti travne ruše za študente študija kmetijstva, smer agronomija in smer zootehnika. Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, 47s.

Batič, F., T. Wraber, **T. Sinkovič** 1995. Pregled rastlinskega sistema, seznam rastlin in navodila za pripravo študentskega herbarija za študente gozdarstva in krajinske arhitekture. Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo.

Borut Smodiš

BIBLIOGRAFIJA

1. ČLANKI IN SESTAVKI

1.01. Izvirni znanstveni članek

1. **B. Smodiš**, F. De Corte, A. De Wispelaere: *Nuclear data and measurements for the $^{130}Ba(n,\gamma)^{131}Ba$ reaction*, J. Radioanal. Nucl. Chem., Letters, 186 (2) 183 (1994).
2. X B. Stropnik, A. R. Byrne, **B. Smodiš**, R. Jaćimović: *Air pollution monitoring in the Šalek valley, Part 2: Elemental composition of size-fractionated lignite coal-combustion particles during Šoštanj TPP operation*, Acta Chim. Slovenica 41/1/ 65 (1994).
3. X **B. Smodiš**, B. Stropnik: *Use of nuclear and nuclear-related analytical techniques in studies of trace and minor elements in air pollution*, Analyst, 119 2061 (1994).
4. J. Pavičić, **B. Smodiš**, M. Škreblin, I. Kregar, P. Stegnar: *Embryo-larval tolerance of **Mytilus galloprovincialis**, exposed to elevated seawater metal concentrations II. Stage-specific fluctuations in sensitivity toward Zn and Cd and their bioaccumulation into veliger larvae*, Comp. Biochem. Physiol., 109/1/ 37 (1994).
5. **B. Smodiš**, M. Dermelj, R. Jaćimović: *Determination of trace elements in tobacco using different techniques of neutron activation analysis*, J. Radioanal. Nucl. Chem., Articles, 190/1/ 3 (1995).

1.04. Strokovni članek

1. **B. Smodiš**: *Nuclear and nuclear-related methods for studying the environment and human health*, Quark, 1995, str. 78-81.

1.06. Objavljeno vabljeno predavanje na znanstveni konferenci

1. M. Svetina Gros, S. Pirc, **B. Smodiš**: *The influence of bulk precipitation on soil and spring water near the Šoštanj thermal power plant*, Tempus Workshop on Ecotoxicology and environmental standards, Ljubljana, 1994, Zbornik referatov str. 185-191.

1.08. Objavljeno predavanje na znanstveni konferenci

1. M. Svetina Gros, S. Pirc, **B. Smodiš**, B. Stropnik: *Element enrichments in soil near the Šoštanj thermal power plant, Slovenia*, International Meeting for Young Researchers in Applied Geology, Lausanne, Švica, 1994, Zbornik referatov str. 199-203.
2. Z. Jeran, R. Jaćimović, **B. Smodiš**: *Epiphytic lichens in air pollution studies of heavy metals in Slovenia*, 2nd International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Budimpešta, Madžarska, 1994, Zbornik referatov str. 212-214.
3. **B. Smodiš**, R. Jaćimović: *Estimating errors in the experimental determination of neutron fluence spectra*, 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-31 - 2-35.
4. **B. Smodiš**, L. Benedik, A. R. Byrne, M. Dermelj, A. Fajgelj, I. Falnoga, R. Jaćimović, Z. Jeran, P. Stegnar, V. Stibilj, B. Stropnik, Z. Šlejkovec: *Status of NAA in Slovenia: Achievements and applications*, 13th European TRIGA Users Conference, Bled, 1994, Zbornik referatov str. 2-20 - 2-23.

5. Z. Jeran, R. Jaćimović, V. Lupšina-Miklavčič, **B. Smodiš**, F. Batič: *Ugotavljanje onesnaženosti zraka s kovinami in radionuklidi z uporabo biomonitorjev - lišajev*, Varstvo zraka, stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled, 1994, (1994), Zbornik referatov str. 19/1-19/13.
6. J.J. Rant, **B. Smodiš**: *Neutron and x-ray radiography in the conservation of the Roman dagger and sheath*, 4th International Conference on Non-Destructive Testing of Works of Art, Berlin, 1994, (1994), Zbornik referatov str. 31-36.
7. **B. Smodiš**, R. Jaćimović, Z. Jeran, B. Stropnik, V. Miklavčič, P. Stegnar: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, Applied Research on Air Pollution Using Nuclear-Related Analytical Techniques, Vienna, 1994, Report on First Research Co-ordination Meeting, NAHRES-19, IAEA, (1994), Zbornik referatov str. 173-180.
8. M. Dermelj, L. Benedik, A. R. Byrne, R. Jaćimović, **B. Smodiš**, V. Stibilj, Z. Šlejkovec: *A Review of analytical activities at "Jožef Stefan" Institute in the field of trace element determination in food articles using NAA*, FAO Meeting on Food Composition Activities in Eastern Europe, Modra, Slovaška, 1995, Zbornik referatov str. 91-95.
9. Z. Jeran, R. Jaćimović, **B. Smodiš**, F. Batič: *The use of lichens in atmospheric trace element deposition studies in Slovenia*, BIOFOSP, Ljubljana, 1995, Zbornik referatov str. 147-152.
10. **B. Smodiš**, Z. Planinšek, P. Stegnar: *Determination of $^{89+90}Sr$*, Final Report on an IAEA Co-ordinated Research Programme, Dunaj, Avstrija, IAEA/AL/088, 1995, str. 186-192.
11. **B. Smodiš**, R. Jaćimović, B. Stropnik, M. Svetina: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, Applied Research on Air Pollution Using Nuclear-Related Analytical Techniques, Vienna, 1994, Report on the Second Research Co-ordination Meeting, NAHRES-26, IAEA, (1995), Zbornik referatov str. 15-1 - 15-10.

1.12. Objavljeni povzetek predavanja na znanstveni konferenci

1. **B. Smodiš**: *Quality assessment of the k_0 standardization method of neutron activation analysis*, Analytical quality control and reference materials: life sciences, Rome, 1994, Abstracts, (1994), str.79.
2. R. Jaćimović, A. Trkov, **B. Smodiš**: *Nuclear constants for activation analysis of some nuclides and comparisons with experimentally measured values*, 2nd Regional Meeting: Nuclear Energy in Central Europe, Portorož, 1995, Abstracts, (1995).
3. Z. Jeran, R. Jaćimović, **B. Smodiš**, F. Batič, H. Wolterbeek: *Atmospheric heavy metal pollution in Slovenia derived from results for epiphytic lichens*, 6th International Hans Wolfgang Nuerneberg Memorial Symposium on Metal Compunds in Environment and Life, Jülich, 1995, Book of abstracts, (1995), str.73.
4. M. Svetina, **B. Smodiš**, Z. Jeran, R. Jaćimović: *Mikroelementi v vodnem krogotoku Šaleške doline*, 9. simpozij spektroskopija v teoriji in praksi, Bled, 1995, Knjiga povzetkov, (1995), str.101.

1.14. Objavljeni poster ali povzetek posterja na znanstveni konferenci

1. M. Svetina-Gros, **B. Smodiš**: *Bulk precipitation deposition of air pollutants and its influence on the chemical quality of forest spring water in the Šalek valley*, International Symposium on Environmental Contamination in Central and Eastern Europe, Budapest, 1992, Proceedings, (1993), str.160-162.
2. A. Holcman, **B. Smodiš**: *Heavy metal content in hen's eggs*, Trace Elements in Man and

Animals - TEMA 8, Dresden, 1993, Zbornik referatov str. 249-250.

3. **B. Smodiš**: *Vzorčevanje in večelementna analiza mikroelementov kot onesnaževalcev zraka*, Varstvo zraka, stanje in ukrepi za izboljšanje stanja v Sloveniji, Bled, 1994, (1994), Zbornik referatov str. 111-115.
4. M. Svetina Gros, **B. Smodiš**, Z. Jeran, R. Jaćimović: *Trace elements in the precipitation of the Šalek valley, Slovenia*, 2nd International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Budimpešta, Madžarska, 1994 (1995), Zbornik referatov str. 876-878.
5. **B. Smodiš**, Z. Šlejkovec, A.R. Byrne, M. Rossbach: *Speciation of arsenic and mercury in mussels from the German Environmental Specimen Bank*, 13. International Symposium "Chemistry of the Mediterranean", Rovinj, 1994, (1994), Zbornik referatov str. 75-77.
6. A. Holcman, V. Stibilj, V. Knez, **B. Smodiš**: *The relationship between arsenic content in feed and in hens eggs*, 6th European Symposium on the quality of egg and egg products, Zaragoza, Španija, 1995, Zbornik povzetkov str. 419-424.
7. M. Dermelj, V. Stibilj, M. Franko, J. Štupar, **B. Smodiš**, B. Gregrorič, D. Pokorn: *Elemental composition of daily diet samples from some old peoples' homes*, 8th European Conference on Food Chemistry, Vienna, 1995, Proceedings Current Status and Future Trends in Analytical Food Chemistry.Vol. 3, (1995), str.737.

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.11. Poročilo o znanstveno-raziskovalni nalogi

1. Zaključno poročilo o opravljenem delu na znanstveno-raziskovalni nalogi **J2-2240**: *Uporaba lišajev kot bioloških indikatorjev pri študiju onesnaževanja zraka v Sloveniji s težkimi kovinami, toksičnimi elementi in radionuklidi* (1994).

2.12. Poročilo o razvojno-raziskovalni nalogi

1. Zaključno poročilo o opravljenem delu na področju aplikativnega raziskovanja v okviru CRP **V1-6602**: *Ugotavljanje obremenjenosti tal z naravnimi in umetnimi radionuklidi* (1995).

2.13. Elaborat, predštudija, študija

1. **B. Smodiš**: *Final report on the research/training activity between The European Union and Forschungszentrum Jülich GmbH*, IJS DP-6931 (1994).
2. D. Abramič, K. Al-Sabti, I. Arčon, M. Bele, L. Benedik, A. Blinc, R. Blinc, B. Borštnik, M. Brecl, M. Budnar, N. Bukovec, P. Bukovec, A. Cvelbar, I. Čadež, M. Čopič, U. Delalut, A. Demšar, F. Dimc, M. Dobršek, M. Drab, I. Falnoga, M. Fele-Baureman, R. Gabrovšek, L. Golič, J. Grdadolnik, M. Hribar, A. Jamnik, H. Janžekovič, A. Jesih, V. Kaučič, I. Kobal, S. Kobe, A. Kodre, M. Kosec, M. Kovač, M. Krajnc, S. Kralj, P. Kump, V. Kveder, G. Lahajnar, K. Lutar, T. Malavašič, B. Malič, T. Marčac-Grahek, V. Marinkovič}, T. Meden, S. Milićev, I. Milošev, M. Mozetič, A. Muehleisen, B. Navinšek, M. Nečemer, B. Orel, P. Panjan, A. Paulin, S. Pejovnik, P. Pelicon, M. Petrič, S. Petriček, M. Pleško, B. Praček, A. Prodan, N. Ramšak, M. Remškar, B. Saje, A. Sever-Škapin, J. Slunečko, **B. Smodiš**, S. Spruk, P. Šegedin, Ž. Šmit, M. Štuhec, J. Štupar, E. Tratar-Pirc, I. Turel, B. Udovic, V. Vlachy, F. Vodopivec, N. Zabukovec-Logar, B. Zalar, D. Zavrtanik, A. Zidanšek, B. Žemva, M. Žitnik: *A multipurpose x-ray beamline at ELETTRA : the scientific case and the conceptual design*, IJS DP-7083, (1994).
3. **B. Smodiš**: *Project Progress Report Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, IJS DP-7086 (1994).

4. **B. Smodiš**, M. Kri`man, K. Al-Sabti, Z. Jeran: *Ekološki monitoring odlagališča pepela, žlindre in produktov odžveplanja*, Projekt EKO-MON, ERICO DP-14/94, (1994).
5. **B. Smodiš**, R. Jaćimović, B. Stropnik, M. Svetina *Gros:Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, IJS DP-7181 (1995).
6. R. Jaćimović, **B. Smodiš**: *Homogeneity testing of IRMM Al-Co alloy samples for certification analysis*, IJS DP-7186 (1995).
7. **B. Smodiš**: *Trace element air pollution monitoring studies in Slovenia using nuclear analytical techniques*, IJS DP-7272 (1995).
8. A. Byrne, M. Dermelj, **B. Smodiš**, Z. Šlejkovec, V. Stibilj, R. Jaćimović: *Improvements in neutron activation analysis procedures for the certification of reference materials*, IJS DP-7302 (1995).
9. **B. Smodiš**, R. Jaćimović: *An impulse to exploit NAA as a manageable and competitive analytical tool in industry and environmental sanitation in Hungary, The Czech Republic and Slovenia, 2nd Progress Report*, IJS DP-7303 (1995).
10. **B. Smodiš**, L. Benedik, M. Križman: *Ugotavljanje obremenjenosti tal z naravnimi in umetnimi radionuklidi*, IJS DP-7314 (1995).

4. SEKUNDARNO AVTORSTVO

4.2. Mentorstvo

1. Magistrsko delo Marte Svetina Gros: *Vpliv padavin na tla in vodne izvire na območju Termoelektrarne Šoštanj*, 1994.

BIBLIOGRAFIJA 1994 , 1995:

Ime in Priimek: Igor SMOLEJ

1.09 Objavljeno predavanje na strokovni konferenci

SMOLEJ, I. 1994. Pomen vode za uspevanje in večnamensko rabo nižinskih mokrih gozdov. V: Gozd in voda. Zbornik seminarja, Poljče, 11. - 13. oktober 1994, Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za gozdarstvo, Ljubljana, s. 77 - 90

2.04 Drugi učbeniko z recenzijo (srednje in nižješolski...)

ČURIN,V./ OCEPEK,R./ PETKOVŠEK,Z./ SEVNIK,T./ SMOLEJ, I./ VRŠČAJ, D. 1994. Spoznavanje narave za 4. razred osnovne šole. 14 izdaja. Državna založba Slovenije, Ljubljana, 93 s.

ČURIN,V./ OCEPEK,R./ PETKOVŠEK,Z./ SEVNIK,T./ SMOLEJ, I./ VRŠČAJ, D. 1995. Spoznavanje narave za 4. razred osnovne šole. 15 izdaja. Državna založba Slovenije, Ljubljana, 93 s.

ČURIN,V./ PETKOVŠEK,Z./ SEVNIK,T./ SMOLEJ, I. 1995. Conoscenza della natura per la IV classe delle scuole elementari. 1a ed., ed. ridotta. Državna zalcžba Slovenije, Ljubljana, 86 s.

2.11 Poročilo o znanstveno - raziskovalni nalogi

HAGER, H./ SMOLEJ, I. 1994. Oak decline in Slovenia. Zwischenbericht zum Forschungsprojekt. Institut für Waldökologie an der Universität für Bodenkultur, Wien, 15 s.

SMOLEJ, I./ HAGER, H. 1995. Oak decline in Slovenia. Endbericht über die Arbeiten 1994. Gozdarski inštitut Slovenije, Institut für Waldökologie - BOKU, Wien, 213 s.

2.20 Druge monografije

CIMPERŠEK, M./ SMOLEJ, I. 1995. Po gozdovih zdravilišča Rogaška Slatina. Zdravilišče Rogaška Slatina, Sklad kmetijskih zemljišč in gozdov, Gozdno gospodarstvo Celje, Rogaška Slatina, 42 s.

3.12 Razstave

JURC, D./ SMOLEJ, I./ BOGATAJ, N. 1994. Ogroženost gozdov v Sloveniji. 33. Kmetijsko - gozdarski sejem, Kranj. Gozdarski inštitut Slovenije, Zavod za gozdove Slovenije, Tehniški muzej Slovenije, Ljubljana, 5 s.

SMOLEJ, I./ BOGATAJ, N./ JURC, D. 1994. Varujmo gozd - gozd nam bogati življenje. Mednarodni sejem Tehnika za okolje, Ljubljana. Gozdarski inštitut Slovenije, Zavod za gozdove Slovenije, Tehniški muzej Slovenije, Ljubljana, 5 s.

SMOLEJ, I. 1995. Celostni monitoring učinkov onesnaženega zraka na ekosisteme. 2. Slovenski festival znanosti, Ljubljana, 4 - 6.10.1995. Gozdarski inštitut Slovenije, Ljubljana, 9 s.

Dr. Boris Stropnik

V. Bibliografija in drugi raziskovalni rezultati:

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

Stropnik B., Byrne A. R., Smodiš B., Jaćimović R.: AIR POLLUTION MONITORING IN THE ŠALEK VALLEY: Part 2: ELEMENTAL COMPOSITION OF SIZE-FRACTIONATED LIGNITE COAL-COMBUSTION PARTICLES DURING ŠOŠTANJ TPP OPERATION. Acta Chim. Slovenica, 41/1/65, (1994).

Smodiš B., **Stropnik B.**: USE OF NUCLEAR AND NUCLEAR-RELATED ANALYTICAL TECHNIQUES IN STUDIES OF TRACE AND MINOR ELEMENTS IN AIR POLLUTION. Analyst, 119 2061, (1994).

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci

Stropnik B. (1995). THE ANALYSIS OF AEROSOLS AND THEIR INFLUENCE ON THE SURROUNDINGS OF THE ŠOŠTANJ POWER PLANT. Ecotoxicology and Enviromental Standards. Special Issue TEMPUS. University of Ljubljana, 183-184, 1995

1.08 Objavljeno predavanje na znanstveni konferenci

Smodiš B., Jaćimović R., Jeran Z., **Stropnik B.**, Miklavčič V., Stegnar P., TRACE ELEMENT AIR POLLUTION MONITORING STUDIES IN SLOVENIA USING NUCLEAR ANALYTICAL TECHNIQUES, IAEA, NAHRES-19, Vienna 1994.

Svetina Gros M., Pirc S., Smodiš B., **Stropnik B.** (1994). ELEMENT ENRICHMENTS IN SOIL NEAR ŠOŠTANJ THERMAL POWER PLANT, SLOVENIA. International meeting for young researchers in applied geology. Lausanne, 199-203, 1994.

1.12 Objavljeni povzetek predavanja na znanstveni konferenci

Smodiš B., Benedik L., Byrne A. R., Dermelj J. , Fajgel A., Falnoga I., Jaćimović R., Jeran Z., Stegnar P., Stibilj V., **Stropnik B.**, Šlejkovec Z. (1994). STATUS OF NAA IN SLOVENIA: ACHIEVEMENTS AND APLICATIONS. Thirteen European Triga users conference. Institut Jožef Stefan Ljubljana. 20-22, 1994.

1.16 Poglavje ali samostojni sestavek v strokovni knjigi

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.08 Doktorska disertacija

Stropnik B. (1994) ANALIZA AEROSOLOV IN NJIHOV VPLIV V OKOLICI TERMOELEKTRARNE ŠOŠTANJ, Doktorska disertacija, Univerza v Ljubljani, Fakulteta za narovoslovje in tehnologijo, VTOZD kemija in kemijska tehnologija, Ljubljana, 1994

Marta Svetina

BIBLIOGRAFIJA

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

X Svetina Gros M., Smodiš B., Pirc S. (1993). FOLLOWING THE WATER CYCLE IN THE ŠALEK VALLEY BY THE INAA METHOD. Acta Chimica Slovenica 40/3/1993, pp. 243-253.

X Svetina M., Smodiš B., Jeran Z., Jaćimović J., (1995). TRACE ELEMENTS IN THE WATER CYCLE OF THE ŠALEK VALLEY, SLOVENIA, USING INAA, Journal of Radioanalytical and Nuclear Chemistry, Vol. 204, No. 1, Elsevier Science, Lausanne.

1.04 Strokovni članek

Svetina Gros M. (1994). VPLIV PADAVIN NA TLA IN VODNE IZVIRE NA OBMOČJU TERMOELEKTRARNE ŠOŠTANJ, ZBORNIK 1994/95 Zbirke Šaleški razgledi, 11. zvezek, 150-178, Velenje.

1.05 Poljudni članek

Ojsteršek A., Pokorny B., Šalej M., Groznik P., Svetina M. (1995). VPLIV ONESNAŽENEGA ZRAKA NA TLA IN VODNE IZVIRE V ŠALEŠKI DOLINI. Almanah občin Velenje, Šoštanj in Šmartno ob Paki za leto 1994. februar 1995. Velenje.

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci

Svetina Gros M., Smodiš B. & Pirc S. (1994). THE INFLUENCE OF BULK PRECIPITATION ON SOIL AND SPRING WATER NEAR THE ŠOŠTANJ THERMAL POWER PLANT, Ecotoxicology and Environmental Standards (TEMPUS), Predavanje z referatom, Ljubljana.

1.09 Objavljeno predavanje na strokovni konferenci

Svetina Gros M., Pirc S., Smodiš B., Stropnik B. (1994). ELEMENT ENRICHMENTS IN SOIL NEAR ŠOŠTANJ THERMAL POWER PLANT, SLOVENIA. International meeting for young researchers in applied geology. Lausanne, 21 April 1994. Predavanje z raferatom.

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci

Svetina Gros M., Smodiš B., Jeran Z. & Jaćimović J. (1994). TRACE ELEMENTS IN THE PRECIPITATION OF THE ŠALEK VALLEY, SLOVENIA. Second International Symposium on Environmental Contamination in Central and Eastern Europe, Posterska predstavitev z raferatom, Budimpešta.

Svetina M. & Bole M. (1995). DOLOČANJE SULFATA V VZORCIH PADAVIN, 9. Simpozij Spektoskopija v teoriji in praksi z mednarodno udeležbo, Posterska predstavitev, Bled.

Svetina M., Jeran Z., Jaćimović J., Smodiš B., (1995). MIKROELEMENTI V VODNEM KROGOTOKU ŠALEŠKE DOLINE. 9. Simpozij 'Spektoskopija v teoriji in praksi ' z mednarodno udeležbo, posterska predstavitev, Bled.

1.21 Polemika, diskusijski prispevek

Svetina Gros M. (1994). MI IN EKOLOGIJA ALI KJE SI, EKOLOGIJA?, ZBORNIK 1994/95 Zbirke Šaleški razgledi, 11. zvezek, 194-203, Velenje.

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.09 Magistrsko delo

Svetina Gros M. (1994). VPLIV PADAVIN NA TLA IN VODNE IZVIRE NA OBMOČJU TERMOELEKTRARNE ŠOŠTANJ. Magistrsko delo. Univerza Edvarda Kardelja v Ljubljani, Fakulteta za naravoslovje in tehnologijo, VTOZD Montanistika. Ljubljana.

3. IZVEDBENA IN DRUGA NEDOSTOPNA DELA

3.05 Poročilo o raziskovalni ali razvojni nalogi

Svetina Gros M. (1994). VPLIV PADAVIN IN TAL NA KEMIČNE LASTNOSTI VODE, letno poročilo za leto 1993, ERICo Velenje.

Svetina M. (1995). VPLIV PADAVIN NA TLA IN VODNE IZVIRE NA OBMOČJU TERMOELEKTRARNE ŠOŠTANJ, Letno poročilo za leto 1994, ERICo Velenje.

3.06 Elaborat, predštudija, študija

Stropnik B., Ribarič Lasnik C., Mljač L., Kugonič N., Svetina M., Rošer Drev A., Ramšak R., Bole M., Flis J., Al Sayegh Petkovšek S., Šterbenk E., Beričnik J., (1995). SINTEZNA ŠTUDIJA, ERICo Velenje, Velenje.

3.14 Predavanje

Šterbenk E., Drev-Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina Gros M., Ramšak R., Beričnik-Vrbovšek J. (1994). VARUJMO IN OHRANIMO ŠALEŠKO DOLINO, Zbornik, Občinska zveza prijateljev mladine Velenje, ERICo Velenje.

Šterbenk E., Drev-Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina M., Ramšak R., Beričnik-Vrbovšek J. (1995). VARUJMO IN OHRANIMO ŠALEŠKO DOLINO, Zbornik, Občinska zveza prijateljev mladine Velenje, ERICo Velenje.

4. SEKUNDARNO AVTORSTVO

4.1 Uredništvo

Svetina M. (1996), ZBORNIK RAZISKOVALNEGA TABORA BELE VODE '95, Zborka Okolje, Št. 1, ERICo Velenje, Velenje.

4.2 Mentorstvo

Svetina Gros M. (1994). KRAŠKI POJAVI V OKOLICI HUDE LUKNJE. Poročilo o delu na Raziskovalnem taboru Škale 94, ERICo Velenje.

Svetina M. (1995). GEOLOGIJA BELIH VOD IN OKOLICE. Poročilo o delu na Raziskovalnem taboru Bele Vode 95, ERICo Velenje.

BIBLIOGRAFIJA 1994, 1995:

Ime in Priimek

Mihej URBANČIČ dipl. inž. gozd

1. ČLANKI IN SESTAVKI

1.01 Izvirni znanstveni članek

1.02 Pregledni znanstveni članek

1.03 Predhodna objava

1.04 Strokovni članek

URBANČIČ, M./ ELERŠEK, L., 1994. Bolj prehranjene smrekove sadike so manj prizadete zaradi saditvenega šoka. Zbornik gozdarstva in lesarstva, 43, Ljubljana Str. 109-132; Ref. 9

ELERŠEK, L./ GRZIN, J./ URBANČIČ, M., 1994. Rast rdečega hrasta (Quercus rubra L.) in močvirskega hrasta (Quercus palustris Muench.) v nasadih Dobruška gmajna in Korita. Gozdarski vestnik, Vol.52, št.3, Ljubljana. Str. 136-144; Ref. 15

ELERŠEK, L./ URBANČIČ, M., 1994. Rast smrekovih nasadov, osnovanih na opuščenih kmetijskih zemljiščih. Gozdarski vestnik, Vol. 52, št. 4, Ljubljana. Str. 190-198: Ref. 9

ELERŠEK, L./ GRZIN, J./ URBANČIČ, M., 1994. Dobra rast nekaterih topolovih klonov na Ljubljanskem barju. Sodobno kmetijstvo, 27, 1/94, Ljubljana. Str. 30-32

1.05 Poljudni članek

1.06 Objavljeno vabljeno predavanje na znanstveni konferenci
1.07 Objavljeno vabljeno predavanje na strokovni konferenci

1.08 Objavljeno predavanje na znanstveni konferenci
1.09 Objavljeno predavanje na strokovni konferenci

1.10 Objavljeni razširjeni povzetek predavanja na znanstveni konferenci
1.11 Objavljeni razširjeni povzetek predavanja na strokovni konferenci

1.12 Objavljeni povzetek predavanja na znanstveni konferenci
1.13 Objavljeni povzetek predavanja na strokovni konferenci

1.14 Objavljeni poster ali povzetek posterja na znanstveni konferenci
1.15 Objavljeni poster ali povzetek posterja na strokovni konferenci

1.16 Poglavje ali samostojni sestavek v znanstveni knjigi
1.17 Poglavje ali samostojni sestavek v strokovni knjigi

1.18 Sestavek v enciklopediji

1.19 Objavljena recenzija, prikaz knjige, kritika

1.20 Predgovor, spremna beseda

1.21 Polemika, diskusijski prispevek

1.22 Objavljeni intervju

1.23 Umetniški sestavki (notni zapisi, pesmi, novele...)

1.25 Drugi članki ali sestavki

KRAIGHER, H./ BATIČ, F./ URBANČIČ, M., 1995. The Forest Plot on Pokljuka. Proceedings of the International Colloquium on Bioindication of Forest Site Pollution: Development of Methodology and training. TEMPUS M-JEP 04667. 22.-31. avgust 1995. Ljubljana. Str. 327-328

2. MONOGRAFIJE IN DRUGA ZAKLJUČENA DELA

2.01 Znanstvena monografija

2.02 Strokovna monografija

2.03 Univerzitetni učbrnik

2.04 Drugi učbeniko z recenzijo (srednje in nižješolski...)

2.05 Ostalo učno gradivo (zapiski predavanj, zbirka vaj...)

2.06 Priročniki, slovarji, leksikoni

2.07 Bibliografija

2.08 Doktorska disertacija

2.09 Magistrsko delo

2.10 Specialistično delo

2.11 Poročilo o znanstveno - raziskovalni nalogi

2.12 Poročilo o razvojno - raziskovalni nalogi

2.13 Elaborat, predštudija, študija

URBANČIČ, M., 1994. Tolmač litološko-pedološke karte M 1:25000 za bohinjske gozdove. Elaborat s pedološkimi kartami, (e-422). Gozdarski inštitut Slovenije, Ljubljana. 37 str.

2.14 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

2.15 Posnetek glazbenega dela

2.16 Umetniška dela

2.17 Katalog razstave

2.20 Druge monografije

3. IZVEDENA IN DRUGA (V KNJIŽNICAH) NEDOSTOPNA DELA

3.01 Patentna prijava

3.02 Patent

3.03 Tehniška izboljšava (nova tehnologija)

3.04 Programska oprema

3.05 Poročilo o raziskovalni ali razvojni nalogi

3.06 Elaborat, predštudija študija

3.07 Izvedeniško mnenje, arbitražna odločba, recenzija

URBANČIČ, M., 1995. Lastnosti tal na vzorčnih mestih za ekofiziološke in biokemične raziskave smrek v vplivnem območju termoelektrarne Šoštanj. Ekspertiza, (p-362). Gozdarski inštitut Slovenije, Ljubljana. 14 str.; Ref. 6

URBANČIČ, M., 1995.Soil profile description from the beech forest with durmast oak on the hill Rožnik. Ekspertiza. Gozdarski inštitut Slovenije, Ljubljana. 2 str.

URBANČIČ, M/ KALAN, P., 1995. Pedološke razmere in antropogena degradacija gozdnih tal v kampu Ukanc. Ekspertiza. Gozdarski inštitut Slovenije, Ljubljana. 7 str.; Ref. 5

URBANČIČ, M., 1995. Poročilo o udeležbi na FSCC pedološkem tečaju v Gentu. Gozdarski inštitut Slovenije, Ljubljana. 1 str.

URBANČIČ, M./ KALAN, P., 1995. Izsledki dendrometrijskih in pedoloških proučevanj na stalni raziskovalni ploskvi "Pri Šijcu" v TNP. Ekspertiza. Gozdarski inštitut Slovenije, Ljubljana. 28 str.

3.08 Poročilo o meritvah, preizkusih ipd.

3.09 Projektna dokumentacija (idejni projekt, izvedbeni projekt)

3.10 Umetniške stvaritve in poustvaritve

3.11 Radijski in TV prispevki

3.12 Razstave

3.13 Organiziranje znanstvenih in strokovnih sestankov

3.14 Predavanja - gostovanja na tuji univerzi

3.20 Druga dela

4. SEKUNDARNO AVTORSTVO (se upošteva pri izpisu)

4.1 Uredništvo

4.2 Mentorstvo

4.3 Prevod

4.4 Ilustracije

4.5 Drugo

1. ČLANKI IN SESTAVKI

1.14 Znanstveni članki

Beričnik Vrbovšek J. (1994). ANALYSIS OF PIGMENTS IN NORWAY SPRUCE NEEDLES BY HPLC. ERICo Velenje, Zavod za ekološke raziskave. International Symposium on Chromatographic and Electrophoretic Techniques. Bled. 10 - 13 oktober 1994.

1.05 Poljudni članki

Beričnik Vrbovšek J., Ramšak R. (1994). OŽIVLJENO VELENJSKO JEZERO. ERICo Velenje, Zavod za ekološke raziskave. Rudar. Velenje. Oktober 1994.

Šterbenk E., Beričnik Vrbovšek J., Bole M., Rošer-Drev A., Ramšak R. (1995). ERICo Velenje, Institut za ekološke raziskave. JEZERA, KI JIH NE BI BILO, ČE NE BI BILO PREMOGOVNIKA. Delo - znanstvena priloga. Ljubljana. 13.9.1995.

Beričnik Vrbovšek J., Ramšak R. (1996). ERICo Velenje, Institut za ekološke raziskave. PONOVNO ŽIVLJENJE V VELENJSKEM JEZERU. Gea. Ljubljana. Januar 1996.

3. IZVEDBENA IN DRUGA NEDOSTOPNA DELA

3.05 Poročilo o raziskovalni ali razvojni nalogi

Beričnik Vrbovšek J., Bole M., Ramšak R., Rošer-Drev A. (1994). VPLIV ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA ODPLAVA PEPELA (AVGUST 1993 - JANUAR 1994). ERICo Velenje, Zavod za ekološke raziskave. Velenje. Februar 1994.

Beričnik Vrbovšek J., Bole M., Mljač L., Ramšak R., Rošer-Drev A. (1994). LETNO POROČILO O VPLIVU ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA ODPLAVA PEPELA (AVGUST 1993 - JULIJ 1994). ERICo Velenje, Zavod za ekološke raziskave. Velenje. Avgust 1994.

Beričnik Vrbovšek J., Bole M., Mljač L., Ramšak R., Rošer-Drev A. (1994). LETNO POROČILO O VPLIVU ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA TRANSPORTA PEPELA (FEBRUAR - DECEMBER 1994). ERICo Velenje, Zavod za ekološke raziskave. Velenje. Februar 1995.

Beričnik Vrbovšek J., Bole M., Ramšak R., Rošer-Drev A. (1995). POLLETNO POROČILO O VPLIVU ODLAGALIŠČA PEPELA NA POVRŠINSKE VODE ZARADI ZAPIRANJA KROGOTOKA ODVEČNE VODE HIDRAVLIČNEGA TRANSPORTA PEPELA (JANUAR - JUNIJ 1995). ERICo Velenje, Zavod za ekološke raziskave. Velenje. Julij 1995.

3.14 Predavanja

Šterbenk E., Drev Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina M., Ramšak R., Beričnik Vrbovšek J., Al Sayegh Petkovšek S. (1994). VARUJMO IN OHRANOMO ŠALEŠKO DOLINO. Zbornik, Občinska zveza prijateljev mladine, ERICo Velenje.

Šterbenk E., Drev Rošer A., Kugonič N., Mljač L., Flis J., Bole M., Svetina M., Ramšak R., Beričnik Vrbovšek J., Al Sayegh Petkovšek S. (1995). VARUJMO IN OHRANOMO ŠALEŠKO DOLINO. Zbornik, Občinska zveza prijateljev mladine, ERICo Velenje.

Julija Beričnik Vrbovšek, dipl. ing. kemije

Contributions to the Lichen Flora of Slovenia I. Epiphytic Lichens of the Snežnik Area.

Martin GRUBE, Franc BATIČ & Helmut MAYRHOFER

Zusammenfassung: GRUBE, M., BATIČ, F. & MAYRHOFER, H. 1995. Beiträge zur Flechtenflora von Slowenien I. - Epiphytische Flechten des Snežnik Gebietes. - Herzogia *11*: 189 - 196.

Eine erste Untersuchung der Flechtenflora des Snežnik („Krainer Schneeberg") wird vorgelegt. 160 Taxa (einschließlich acht lichenicoler Pilze und zwei nicht lichenisierter Arten) werden nachgewiesen, darunter einige seltene ozeanische Arten. Die Geographie, die Geologie, das Klima und die Vegetation des Untersuchungsgebietes werden beschrieben. Die Verbreitung ausgewählter Flechten, die Rolle schonender forstlicher Eingriffe durch Einzelstammnutzung für das Vorkommen und die Erhaltung von seltenen Arten werden diskutiert.

Abstract: GRUBE, M., BATIČ, F. & MAYRHOFER, H. 1995. Contributions to the lichen flora of Slovenia I. - Epiphytic lichens of the Snežnik area. - Herzogia *11*: 189 - 196.

The lichen flora of the Snežnik („Krainer Schneeberg") is investigated for the first time. 160 taxa (with eight lichenicolous fungi and two non lichenized species) including several rare oceanic species are reported. Geography, geology, climate and vegetation of the region are described. The local distribution of selected lichens, and the effect of forest exploitation by single tree cutting on the occurrance and conservation of rare species are discussed.

Key words: Flora of Slovenia, Snežnik, epiphytic lichens, distribution, bioindication.

Introduction

A joint program between Slovenia and Austria entitled „Bioindikation in belasteten und unbelasteten Gebieten" started in 1991. The research was focused on environmental and air pollution studies, which are important for the Slovenian agricultural economy, since more than 50% of the country is covered by forests. Parts of the ongoing research program are therefore dedicated to passive biomonitoring with lichens, which are well-known bioindicators. Various monitoring methods using lichens have been worked out in different European countries (e.g. BESCHEL 1958, HAWKSWORTH & ROSE 1970, HERZIG & URECH 1991). However, it is often necessary to adapt monitoring techniques to new areas and the first step towards bioindication studies is clearly a better knowledge of the lichen flora occurring in the region under study.

The history of lichen studies in Slovenia dates back to the second part of the last century, when GLOWACKI & ARNOLD (1870), GLOWACKI (1871) and GLOWACKI (1874) reported on lichens of the southern regions of former Austria, and when KERNSTOCK (1893) published a contribution to the lichen flora of Styria. All of these regions are nowadays included in parts of Slovenia. The number of known lichens in Slovenia increased to 269 when Kušan

Acta Pharm. 45 (1995) 387–390

Measurements of some physiological parameters as a productivity index in poplar clones: *P. trichocarpa* Torr. et. Gary, *P. deltoides* March. cv. »Lux«, *P. x euramericana* (Dode) Guinier cv. regenerata, *P. x euramericana* (Dode) Guinier cv. »Panonia«

GREGOR BOŽIČ[1*]
FRANC BATIČ[2]

[1]*Slovenian Forestry Institute*
Večna pot 2, 61000 Ljubljana, Slovenia

[2]*Agronomy department, Biotechnical Faculty,*
University of Ljubljana, Jamnikarjeva 101,
61000 Ljubljana, Slovenia

Production of poplar wood is based on growing selected crossbreeds and clones and is an important source in the wood economy. Investigations of different poplar crossbreeds involve biological, ecological and cultivation methods. Our work is based especially on measurements of certain physiological parameters. We tried with net photosynthesis, stomatal conductivity, transpiration, mesophyll carbon-dioxide concentration, photosynthetic pigment contents in leaves and water use efficiency measurements to estimate the maximal potential productivity of poplar clones in the juvenile phase.

Chosen poplar clones are of great economic interest, because of the useful timber, the productivity and the vegetative propagation of plants.

MATERIALS AND METHODS

Investigated materials were supplied from a poplar forest plantation on the Ljubljana marshes. Measurements were made in summer 1991. For the above mentioned measurements, we chose leaves from one year old long sprouts of different poplar clones: *P. trichocarpa* Torr. et Gary, *P. deltoides* Marsh. cv. »Lux«, *P. x euramericana* (Dode) cv. regenerata, *P. x euramericana* cv. »Panonia«. In the clone *P. x euramericana* cv. »Panonia« leaves from plants with two years roots were collected (1/2), in other clones with four years. Physiological parameters were measured every two weeks in July, August

* Correspondence

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Mycorrhizal potential of two forest research plots in Zavodnje and Mislinja

SAMAR AL SAYEGH-PETKOVŠEK[1]
HOJKA KRAIGHER[2*]
FRANC BATIČ[2]
NADA GOGALA[3]
REINHARD AGERER[4]

[1]*ERICo Velenje, Koroška 64, 63320 Velenje, Slovenia*

[2]*Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia*

[3]*Department of Biology, University of Ljubljana, Aškerčeva 12, 61000 Ljubljana, Slovenia*

[4]*Institute for Systematic Botany, University of Munich, Menzingerstrasse 67, D-800 München 19, Germany*

The main direct polluters in the Šaleška valley are the Thermoenergetic Power Plant Šoštanj and the Coal Mine in Velenje. Our study was included among studies of the impact of air pollution on the changing of mycoflora and mycorrhizas. Air pollutants can influence mycorrhiza directly by influencing the soil charateristics and indirectly by effects on the host plant (1). The number of species and species diversity of fungi is lowered (2). Pollution stress is higher, the development of the root system and the ability to form mycorrhizae are poorer (3).

METHODS

Two differently polluted forest research plots were chosen, with the plot in Mislinja being relatively less polluted plot than the plot in Zavodnje. The plots were monitored by modified mycorrhizal potential method (3). Soil samples (OhAh horizont) were

* Correspondence

Zbornik gozdarstva in lesarstva, 46, 1995, s. 75 - 96

GDK 176.1 Quercus robur (L.) : 181.6 / .7 : 165.3 : (497.12)

MORPHOLOGICAL AND GENETIC VARIABILITY OF PEDUNCULATE OAK (*QUERCUS ROBUR* L.) POPULATIONS IN SLOVENIA

Franc BATIČ *, Tomaž SINKOVIČ **, Branka JAVORNIK ***

Abstract

The article presents a taxonomic study carried out in three pedunculate oak populations in Slovenia by leaf morphometry and by DNA analysis with RAPD markers. About one hundred leaves were sampled from five trees from three seminatural pedunculate oak stands in the Sub-pannonian vegetation region of Slovenia. Samples were collected from the well lit upper part of the tree crowns, and only leaves from short twigs were analysed. Leaf samples were herbarised, and measured and assessed in the laboratory. Leaf dimension (lamina length and width, peticle length, number of lobe pairs) were measured and characters like type of leaf pubescence and leaf lamina base type were assessed. Analyse of leaf morphometry showed that all sampled trees belonged to the *Quercus robur* L. species. Nevertheless, on some trees, leaves also showed characters typical of sessile oak (*Quercus petraea* /Matt./ Leibl.), especially the leaf lamina base type and number of lobe pairs. Other parameters analysed were within the variation of pedunculate oak. More populations of both oak species should be analysed, especially when growing together, in order to obtain reliable data for taxonomic studies of oak hybrids and population genetic diversity by means of classic leaf and acorn morphometry and molecular markers.

Key words: pedunculate oak, morphology, multivariate analysis, RAPD markers, genetic polymorphism, natural hybridisation

MORFOLOŠKA IN GENETSKA VARIABILNOST POPULACIJ DOBA (*QUERCUS ROBUR* L.) V SLOVENIJI

Izvleček

Delo predstavlja taksonomske raziskave pri treh populacijah doba in vključuje morfometrijske meritve listov in DNK analizo z uporabo RAPD markerjev. Analizirali smo do 100 listov iz petih označenih dreves v subpanonskem vegetacijskem območju. Nabrali smo jih dobro osvetljene zgornje tretjine krošnje samo s kratkih poganjkov. Liste smo herbarizirali, merili in ovrednotili v laboratoriju. Ovrednoteni parametri listov so obsegali dolžino in širino listne ploskve, dolžino listnega peclja, število listnih krp, tip listnega dna in gostoto ter tip dlačic na listih. Raziskave morfometrijskih podatkov listov so pokazale, da raziskovana drevesa pripadajo dobu (*Quercus robur* L.). Posamezna drevesa na različnih ploskvah kažejo nekatere morfološke lastnosti gradna (*Quercus petraea* /Matt./Liebl.), posebej tip listnega dna in število listnih krp. Ostali morfološki parametri so v okviru variacijske širine doba. Analizirati bi morali večjo populacijo dreves predvsem v mešanih sestojih, kjer omenjeni vrsti rasteta skupaj. Podatki iz večje populacije bi bolj zanesljivo prikazali taksonomske probleme hibridov pri hrastih s primerjavo klasičnih morfoloških parametrov in molekularnih markerjev.

Ključne besede: dob, morfologija, multivariantna analiza, RAPD markerji, genetska variabilnost, naravna hibridizacija

* Prof., dr., dipl. biol., Argonomy dept., Biotehnical faculty, University in Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

** Assist., mag., dipl. biol.,Argonomy dept., Biotehnical faculty, University in Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

*** Prof., dr., dipl. ing., food tech.l., Argonomy dept. Biotehnical faculty, University in Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

Zbornik gozdarstva in lesarstva, 47, 1995, s. 131 - 144

GDK: 114.521.7 : 425.1 : 181.45 : (497.12)

BIOINDIKACIJA OZONA V TROPOSFERI Z OBČUTLJIVIM KULTIVARJEM TOBAKA *(Nicotiana tabacum L. cv. BelW3)*

Franc BATIČ *, Sabina KLEMENČIČ **, Metka JENČIČ- MEDVEŠEK ***, Bogdan MAČAROL ****, Andrej STRNIŠA *****, Cvetka RIBARIČ - LASNIK ******, Natalija VIDERGAR *******.

Izvleček:

V okviru raziskav umiranja gozdov in opazovanja kakovosti zraka v okolici virov onesnaženja, smo za bioinidikacijo ozona kot enega izmed zračnih onesnaževalcev uporabljali občutljivi kultivar *Nicotiana tabacum L.* cv. 'BelW3'. V letih 1988-1992 smo med junijem in oktobrom na izbrana mesta izpostavili po tri do pet rastlin kultivarjev 'BelW3' in 'BelB'. Mesta izpostavitev so bila izbrana glede na podnebje, nadmorsko višino in stopnjo onesnaženosti zraka. Za izpostavitev tobaka in prikaz nastalih poškodb rastlin smo uporabili metodo, ki jo je opisal Ashmore (ASHMORE, BELL 1980). Na vseh izpostavitvenih mestih smo potrdili prisotnost ozona. Tobačni listi so bili najbolj poškodovani v okolici obeh slovenskih termoelektrarn.

Ključne besede: onesnaženost zraka, ozon, bioindikacija

BIOINDICATION OF TROPOSPHERIC OZONE BY SENSITIVE CULTIVARS OF TOBACCO *(Nicotiana tabacum* L. cv. BelW3*)*

Abstract

In the scope of forest die-back studies and monitoring of air quality in the surroundings of air pollution sources a bioindication of ozone as air pollutant was carried out by the use of sensitive tobacco cultivar *Nicotiana tabacum L.* cv. 'BelW3'. The monitoring was carried out in the period between 1988 and 1992. Tobacco plants were transplanted each year between June and October, three to five plants of cultivars 'BelW3' and 'BelB' per chosen site of exposure. Sites were chosen according to a climate type, altitude, and air pollution level in Slovenia. The method described by ASHMORE (Ashmore Bell 1980) was used for transplantation of tobacco plants and ozone damage assessment. The presence of ozone was proved on all sites of exposure, but the most severe damage occurred in the leaves of tobacco transplanted near the greatest thermal power plant.

Keywords: air pollution, ozone, bioindication

* Prof., dr., dipl. biol., Biotehniška fakulteta, Odd. za agronomijo, 61000 Ljubljana, Jamnikarjeva 101, SLO
** Dipl. biol., OŠ Vitka Pavliča, Hrastnik, SLO
*** Prof. biol., Bolnica Trbovlja, SLO
**** absolvent biologije, MSIRK Ljubljana, SLO
***** absolvent gozdarstva, Radeče, SLO
****** Mag., ERICO, Velenje, SLO
******* Dipl. biol., Občina Zagorje ob Savi, SLO

Zbornik gozdarstva in lesarstva, 47, 1995, s. 5 - 56

GDK: 114.521.7 : 172.9 : 152.58 : 181.45 : (497.12)

BIOINDIKACIJA ONESNAŽENOSTI OZRAČJA V GOZDOVIH Z EPIFITSKIMI LIŠAJI

Franc BATIČ *, Anton KRALJ **

Izvleček

Prispevek podaja pregled uporabe različnih metod bioindikacije onesnaženosti gozdov v Sloveniji s poudarkom na spremljanju onesnaženosti zraka v gozdu z epifitskimi lišaji. Podrobneje so prikazani rezultati popisa epifitskih lišajev pri popisu propadanja gozdov 1991 in delno primerjava popisov v letih 1993 in 1994. Popis propadanja iz leta 1991 je zadnji, obsežnejši popis propadanja na mreži 4 x 4 km, medtem ko so vsakoletni popisi, tudi l. 1993 in 1994 le na mreži 16 x 16 km. Metoda popisa epifitskih lišajev temelji na popisu pokrovnosti in pogostnosti steljk skorjastih, listastih in grmičastih lišajev na šestih najbolj primernih drevesih na mestu popisa propadanja gozdov. Na podlagi ocene številčnosti in pokrovnosti lišajskih steljk je izračunan indeks atmosferske čistoče, posebej za dnišča debel, debla v prsni višini in krošnje. Izračuni indeksa so prikazani za popisne ploskve kot celoto in posebej za smreko, bukev, hrast in jelko. Visoke vrednosti indeksa (razpon 0-54 za celo drevo, 0-18 za opazovanja po stratum h) kažejo bogato lišajsko obrast in čist zrak, medtem ko majhne vrednosti indeksa pomenijo revno lišajsko obrast in domnevno onesnažen zrak. Vrednosti indeksa atmosferske čistoče kažejo na veliko onesnaženje zraka, še posebej v okolici večjih znanih emisijskih virov, pa tudi ponekod, koder ni lokalnih onesnaževalcev zraka. Vrednosti indeksa so po pričakovanju najnižje v krošnjah, pri drevesnih vrstah, pa je lišajska vegetacija najrevnejša na bukvi. To kaže na vpliv kislih odložin v padavinah, ki pa se ne pojavlja le v z žveplovimi spojinami močno onesnaženi osrednji in severovzhodni Sloveniji, ampak tudi v s padavinami bogatih predelih zahodne Slovenije, kjer takšnega stanja glede na domače vire onesnaženja ozračja ne bi pričakovali. Rezultati popisov lišajev so pokazali, da so epifitski lišaji tudi v gozdovih dobri kazalci onesnaženja zraka. Ta preprosta metoda kartiranja lišajev daje dobre rezultate in je primerna za velikopovršinska kartiranja, kadar ni dovolj časa in sredstev za kartiranje lišajskih vrst.

Ključne besede: propadanje gozdov, onesnaženje zraka, bioindikacija, epifitski lišaji

BIOINDICATION OF AIR POLLUTION IN FORESTS BY EPIPHYTIC LICHENS

Abstract

The article deals with an overview of bioindication methods of air pollution used at Slovenian forest decline inventories, and more detaily with the bioindication of air pollution by epiphytic lichen vegetation. The results of epiphytic lichen vegetation assessment in forest die-back inventory carried out in 1991 are presented completly, and partly also the comparison of the results of the inventories carried out in 1993 and 1994. The inventory of forest decline in 1991 was carried out on a 4 x 4 km grid, while each years' inventories, e.g. those in 1993 and 1994 were limited only to a 16 x 16 km grid. The method of epiphytic lichen vegetation mapping in forest decline inventories is based on the assessment of cover and frequency of fructicose, foliose and crustose lichen thalli in a group of six of the most convenient trees for epiphytic lichen observation of the 24 trees included into forest decline inventory at a plot. On the basis of the assessment of the cover and frequency of all three lichens thalli types, the index of atmospheric purity was calculated for each assessed tree and together for the plot. Index values were determined separately for tree crowns, trunks at the breast height and for the base of the trunks. Index data are presented separately for observations on Norway spruce, common beech and hornbeam, silver fir and oaks and also computed together regardless trees species on which lichens were observed. High values of index (0-54 for a whole tree, 0-18 for separate tree strata) indicate rich epiphytic lichen vegetation and clean air, low values indicate poor epiphytic lichen vegetation and presumably polluted air. Index values show that air pollution in Slovenian forest is rather high, especially in the vicinity of the major known air pollution sources but also in some areas without known local emmisions of air pollutants. As expected, index values of atmospheric purity are the lowest when calculated for tree crowns, yet among the values calculated for tree species the common bech with hornbeam show the lowest data due to the type of crown and bark quality of these two tree species. This can indicate the influence of acid precipitation, not only in the sourroundings of the sources of high sulphur dioxide pollution in central and north-east parts of Slovenia but also in higher elevations in west and south-west parts which are rich in rainfall but without major local emmisions. The results obtained by this simple method of epiphytic lichen mapping proved lichens as good air pollution indicators also in forests. The method is suitable for large scale mapping where species mapping is not possible due to limited time and funds.

Key words: forest decline, air pollution, bioindication methods, epiphytic lichens.

* Prof., dr., dipl. biol., Biotehniška fakulteta, Oddelek za agronomijo, 61000 Ljubljana, Jamnikarjeva 101, SLO

** Dipl. inž. mat., Gozdarski inštitut Slovenije, 61000 Ljubljana, večna pot 2, SLO

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versity of Ljubljana
otechnical Faculty
onomy Department
ter for Plant Biotechnology
Breeding
ead: Prof. Ph. D. Branka Javornik

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631.523(045)=20

Research paper
Raziskovalno delo

IDENTIFICATION OF 1BL/1RS WHEAT-RYE TRANSLOCATION BY N-BANDING

Bojka KUMP*, Tomaž SINKOVIČ**, Branka JAVORNIK***

ABSTRACT

-ven bread wheat cultivars having donors of 1BL/1RS translocation in their pedigree were sen for cytological analysis by the N-banding technique to confirm the presence of slocation. All of the analysed cultivars showed an unbanded terminal short arm of the B chromosome and, in addition, seven cultivars had an extra paracentromeric N-band -licating differences in the size of translocation.

words: wheat, chromosomes, N-bands

IDENTIFIKACIJA 1BL/1RS PŠENIČNO-RŽENE TRANSLOKACIJE Z N-BANDINGOM

IZVLEČEK

potrditev zastopanosti translokacije smo z N-banding tehniko citološko analizirali enajst ranih kultivarjev navadne pšenice, ki imajo v rodovniku donorja 1BL/1RS translokacije. Vsi nalizirani kultivarji imajo neobarvan terminalni del kratkega kraka 1B kromosoma, sedem ltivarjev pa ima še dodatno paracentromerno N-progo, kar kaže na razlike v dolžini nslokacije.

ljučne besede: pšenica, kromosomi, N-proge

ITRODUCTION

ethods of differential staining are very useful in cytological research of wheat and other gher plants for chromosome identification and detecting the presence of foreign romosomal segments. Banding techniques enable precise studies of the karyotype of

* M. Sc. Agr., SLO-61111 Ljubljana, Jamnikarjeva 101, P. O. Box 95

M. Sc. Agr., ibid.

** Associated Prof. Ph. D. Agr., ibid.

UNIVERZA V LJUBLJANI
BIOTEHNIŠKA FAKULTETA
ODDELEK ZA AGRONOMIJO

TOMAŽ SINKOVIČ, FRANC BATIČ, FRANCE ŠUŠTAR

SEZNAM POMEMBNEJŠIH RASTLIN IN NAVODILA ZA RAČUNANJE KRMNE VREDNOSTI TRAVNE RUŠE

ZA ŠTUDENTE ŠTUDIJA KMETIJSTVA,
SMER AGRONOMIJA IN
SMER ZOOTEHNIKA

LJUBLJANA 1994

Detection of Interspecies Hybrids in Plants by Fluorescence *in situ* Hybridization, Using Total Genomic DNA as a Probe

By

Tomaž Sinkovič[1], Franc Batič[1], Branka Javornik[1], Helmut Guttenberger[2], Dieter Grill[2]

Key words: cytology, bread wheat, fluorescence *in situ* DNA hybridization, genomic probe

Summary

Total genomic DNA probe preparation and the non-isotopic biotin probe labelling technique are described. The use of an excess of unlabelled competitor DNA from a related plant species gives more constant results in determing whole plant genomes with *in situ* experiments on plant hybrids. Results of fluorescence *in situ* hybridization for detecting alien rye chromatin and localisation on metaphase chromosomes and interphase nuclei in the bread wheat cultivar 'Yugoslavia', which carries a 1BL.1RS translocation are shown. The advantage of the use of total genomic biotin labeled probes for *in situ* hybridizations is that it requires less effort than preparing species specific probes and the ease of interpretation of results. The extraction of a high quantity of species specific DNA of high quality, probe preparation and labelling are the most important steps.

Introduction

In situ hybridization has become a powerful diagnostic tool, it is nowadays possible to detect single and low copy DNA sequences, perform physical mapping of genes (Mukai et al. 1991), detect chromosomal aberrations like deletions, translocations, substitutions etc. Repetitive sequences (Cuadrado and Jouve 1994), whole chromosome (Schöndelmaier et al. 1993) and whole genome detections (Bennet and Thomas 1991) are also possible with specially prepared and labelled probes. The results of *in situ* hybridization contributed a new understanding of plant genome organisation to phylogenetic plant studies (Leitch et al. 1991). Advantage of fluorescence *in situ* hybridization include the use of simultaneously doubly or triply labelled probes (Mukai et al. 1993), multicolour detections of DNA sequences in interphase nuclei (Rawlins & Shaw 1990), and its less time consuming nature. The plant cell wall can effect the accessibility of a labelled probe to a chromosome and the plant protoplasm can cause a relatively high background in the commonly used squash preparations. Ambros et al. (1986) attempted to overcome the problem by the use of

[1] Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, SLOVENIA
[2] Institut für Pflanzenphysiologie, Karl-Franzens Universität Graz, Schubertstrasse 51, 8010 Graz, AUSTRIA

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Franc BATIČ, Ivan SMOLE

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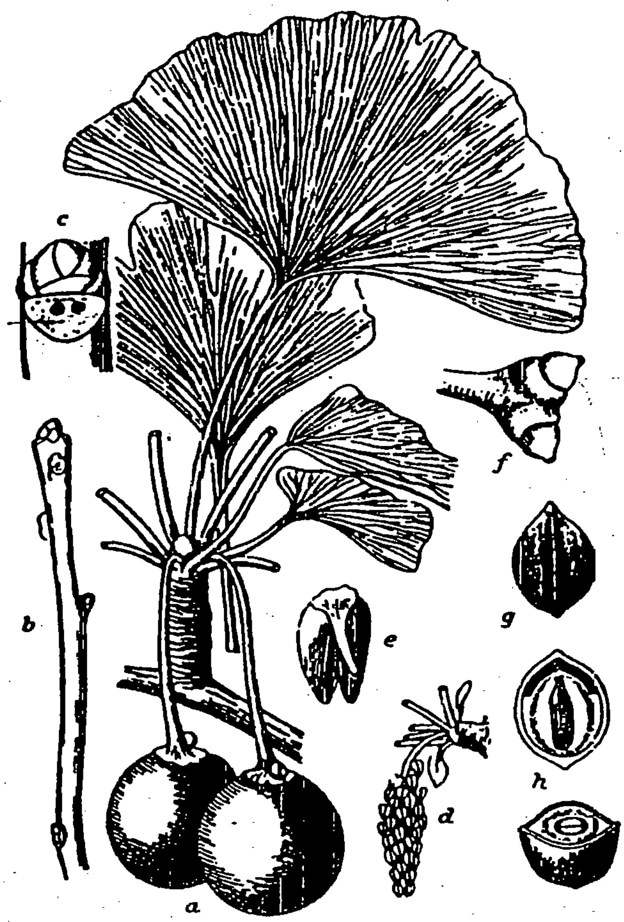

Ljubljana, 1 9 9 4

ZTI - ZAVOD ZA TEHNIČNO IZOBRAŽEVANJE

"Kako bi se lahko prodalo ali kupilo nebo ali toplota zemlje, ko vendar nismo lastniki svežine zraka in bistrine voda? Beli človek pa se do zemlje, svoje matere in do svojega brata neba vede, kot da bi bile to stvari, ki jih lahko kupiš, ukradeš ali prodaš kakor živino ali nakit...."

Iz pisma indijanskega poglavarja Seattle Abrahamu Lincolnu l. 1854

VARSTVO ZRAKA
STANJE IN UKREPI ZA IZBOLJŠANJE STANJA V SLOVENIJI

AIR QUALITY MANAGEMENT
STATE OF THE ART IN SLOVENIA AND MEASUREMENTS FOR ITS IMPROVEMENT

Bled, 28.-30.3.1994

Zbornik je tiskan na recikliranem, okolju prijaznem papirju, za katerega ni padlo nobeno drevo.

Izdal: ZAVOD ZA TEHNIČNO IZOBRAŽEVANJE
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Za mnenja in podatke v posameznih sestavkih so odgovorni avtorji.

Po mnenju Ministrstva za znanost in tehnologijo št. 415 - 01 - 124/94 z dne 14. 03. 1994 se za zbornik VARSTVO ZRAKA plačuje 5 % davek od prometa proizvodov.

BIOINDIKACIJA ONESNAŽENOSTI ZRAKA IN NJEN POMEN PRI VZPOSTAVITVI INTEGRALNEGA MONITORINGA

Franc BATIČ *

ABSTRACT

BIOINDICATION OF AIR POLLUTION AND ITS SIGNIFICANCE IN ESTABLISHMENT OF INTEGRAL BIOMONITORING

The article deals with basic principles of using plants as bioindicators of air pollution. Types of plant bioindicators such as indicators, testers and monitors are presented and rules of bioindication are briefly described. Bioindication of different levels, from biochemistry of plant cells to ecosystem, are commented and short history of bioindicators' use is described. The significance of bioindication of air pollution is discussed in comparison with chemical measurements of air pollutants. At the end some conclusions about the use of bioindication methods in forthcomming ecological monitoring are drawn and the present state of bioindication in Slovenia is discussed.

UVOD

Že od prazgodovine je človek uporabljal rastline in živali za spoznavanje kvalitete svojega okolja. Zgodnji kmetovalci so po rastlinskih združbah ocenjevali kvaliteto tal in njihovo primernost za kmetovanje. Kasneje je bila na iskušnjah kmetovalcev, gozdarjev in botanikov v fitocenologiji in ekologiji izdelana bioindikacijska vrednost posameznih rastlinskih vrst, ki odražajo lastnosti rastišča (vlažnost, sušnost, osvetljenost, zbitost, kislost, itd..)(1). Še kasneje so organizme, rastline, živali, glive in mikrobe začeli uporabljati za ocenjevanje vplivov dejavnosti človeka na okolje (2,3,4,5), najprej v vodnih ekosistemih in nato še v kopenskih. Onesnaževanje ozračja je star pojav, ki spremlja razvoj človeštva. Kemijska narava snovi, ki jih je človek sproščal v ozračje se je močno spremenila od prvih, pretežno poljedelskih in živinorejskih skupnosti do današnje industrijske in postindustrijske družbe razvitega sveta. Negativne posledice učinkov nečistoč-polutantov v zraku na živi svet so postale hitro očitne. V skrbi za zdravje ljudi, uspevanje kmetijskih kultur in gozdov in varovanje narave so kmalu pričeli meriti količine škodljivih snovi v zraku. To je vodilo k postavljanju normativov za še dovoljene koncentracije polutantov v zraku in k izboljšavi tehnoloških postopkov, vse v skrbi za čistejši zrak. Namen tega prispevka je predstaviti pomen biondikacije in njeno mesto v integralnem monitoringu onesnaženosti zraka in okolja.

*Prof. dr. Franc Batič, Oddelek za agronomijo, Biotehniška fakulteta, Jamnikarjeva 101, 61000 Ljubljana

UGOTAVLJANJE ONESNAŽENOSTI ZRAKA S KOVINAMI IN RADIONUKLIDI Z UPORABO BIOMONITORJEV - LIŠAJEV

Z. Jeran[1], R. Jaćimović[2], V. Lupšina-Miklavčič[3], B. Smodiš[4], F. Batič[5]

[1,2,3,4]Institut "Jožef Stefan", Jamova 39, Ljubljana
[5]Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, Ljubljana

ABSRACT

During recent years epiphytic lichens were introduced to monitor heavy metal and radionuclide air pollution in Slovenia. Some indicative results of our studies on air pollution around the Uranium mine and mercury speciation in air around the Hg-mine, using Hypogymnia physodes are presented. Also the results of multielemntal analysis of transplanted lichens exposed in three different regions of Slovenia (urban-industrialized, rural-nonindustrialized and near a coal fired power plant) are discussed.

UVOD

Okolje, predvsem pa zrak, je vse bolj onesnaženo. Zaradi industrijske dejavnosti, prometa, kmetijstva, pridobivanja energije (toplarne, termoelektrarne, individualna kurišča) v okolju naraščajo koncentracije kovin in nekovin, med katerimi so nekateri elementi lahko tudi toksični (Pb, Cd, Hg,...).

Za ugotavljanje onesnaženosti okolja se v svetu že več kot 25 let poleg direktnih metod vzorčevanja uporabljajo tudi živi organizmi bioindikatorji / biomonitorji, ki so bodisi rastline (lišaji, mahovi, borove ali smrekove iglice, trave, ...) ali živali. Organizmi se namreč izredno hitro odzivajo na spremembe v okolju. Reakcije organizmov, ki so biokemične, fiziološke, morfološke, pa lahko opazujemo ali merimo. O bioindikaciji govorimo takrat, ko organizem ali del organizma, daje informacijo o kvaliteti okolja. Biomonitoring pa imenujemo dolgoročno spremljanje okolja s pomočjo bioidikatorjev / biomonitorjev. Martin in Coughtrey[(1)] sta postavila nekaj kriterijev, ki jih mora

1 mag.Zvonka Jeran, dipl.biol., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

2 Radojko Jaćimović, dipl.ing.fiz., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

3 mag.Vesna Lupšina-Miklavčič, dipl.ing.kem., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

4 dr.Borut Smodiš, dipl.ing.kem., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

5 prof.dr. Franc Batič, dipl.biol., Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, 61000 Ljubljana

ONESNAŽEVANJE OZRAČJA IN KOPENSKI EKOSISTEMI: I.PREUČEVANJE ONESNAŽENOSTI OZRAČJA S KARTIRANJEM EPIFITSKIH LIŠAJEV

AIR POLLUTION AND TERRESTRIC ECOSYSTEMMES: I. INVESTIGATION OF AIR POLLUTION BY MAPPING OF EPIPHYTIC LICHENS

Franc BATIČ
Prirodoslovno društvo Slovenije, Zavod Republike Slovenije za šolstvo in šport, Osnovne in srednje šole
Slovenije

ABSTRACT

The article presents the youth research action in which air pollution in Slovenia is assessed by mapping of epiphytic lichens. Pupils from secondary and middle schools take part of the action, guided by their teachers under the supervision of Natural History Society of Slovenia. A very simple bioindication method for air quality is used, namely the mapping of epiphytic lichens' thalli types (crustose; foliose and fruticose). An index of atmospheric purity is calculated from the mapping data for each observed site which has been chosen according to air pollution level, topography and availability of suitable trees. The main goal od the action is environmental education of youth and their teachers by observation of organisms in nature with modest means and simple methods.

UVOD

Prirodoslovno društvo Slovenije nekaj več kot po desetih letih ponovno organizira mladinsko raziskovalno akcijo, v kateri učenci in dijaki in njihovi mentorji - učitelji preučujejo in zasledujejo stanje in stopnjo onesnaženosti okolja v svojem kraju. Podobno kot leta 1977 smo začeli s preučevanjem onesnaženosti ozračja. V ta namen smo uporabili za učence in dijake primerno metodo bioindikacije ugotavljanja onesnaženosti zraka s pomočjo epifitskih lišajev (1).
Epifitski lišaji so zaradi svoje zgradbe in prilagoditev na epifitski način življenja izredno občutljivi na onesnažen zrak in v njem propadejo prej kot višje rastline. Še posebej so občutljivi na tako imenovano "klasično onesnaženje zraka", to je na onesnaženje z žveplovimi spojinami in dimom, ki so v Sloveniji še vedno vodilni onesnaževalci zraka. Pojavljanje in izginotje posamezne lišajske vrste ali vrst z določenim steljke je v tesni povezavi s stopnjo onesnaženosti zraka na

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Prirodoslovno društvo Slovenije,
Novi trg 2, 61000 Ljubljana

Bioindikacija ozona v troposferi z občutljivim kultivarjem tobaka *Nicotiana tabacum L.* Bel W3

BIOINDICATION OF TROPOSPHERIC OZONE BY SENSITIVE CULTIVARS OF TOBACCO *(Nicotiana tabacum L. Bel W3)*

[1]Franc BATIČ, [2]Sabina KLEMENČIČ, [3]Metka JENČIČ-MEDVEŠEK, [4]Bogdan MACAROL, [5]Andrej STRNIŠA, [6]Cvetka RIBARIČ-LASNIK, [7]Natalija VIDERGAR-GORJUP.

ABSTRACT

In the scope of forest die-back studies and monitoring of air quality in surroundings of air pollution sources a bioindication of ozone as air pollutant was carried out by use of sensitive tobacco cultivar *Nicotiana tabacum L. cv. Bel W3*. The monitoring was carried out in the period between 1987 and 1992, and some data for the year 1991 are presented in the article. Tobacco plants were transplanted each year between June and October, three to five plants of cultivars Bel W3 and Bel b per chosen site of exposure. Sites were chosen according to climate type, altitude, and air pollution level in Slovenia. The method described by ASHMORE (30) was used for transplantation of tobacco plants and ozone damage assessment. The presence of ozone was proved on all sites of exposure, but the most severe damages occurred on the leaves of tobacco transplanted nearby the greates thermal power plant.

UVOD

Troposferski ozon predstavlja približno 10 % od vsega ozona v zemeljski atmosferi in vzdržuje ravnovesje med nekaterimi sestavinami zraka. Ozon v troposfero vdira iz stratosfere ali pa nastaja v sami troposferi pri fotolizi dušikovega dioksida in v prisotnosti ogljikovodikov. Prav hitremu naraščanju antropogenih virov ogljikovodikov, dušikovih oksidov in ogljikovega monoksida

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[1]Prof. dr. Franc BATIČ, Oddelek za agronomijo, Biotehniška fakulteta, Jamnikarjeva 101, Ljubljana
[2]Sabina KLEMENČIČ, dipl. biol., Skupščina občine Hrastnik
[3]Metka JENČIČ - MEDVEŠEK, prof. biol., Bolnica Trbovlje
[4]Bogdan MACAROL, ABSOLVENT BIOLOGIJE, Skupnščina mesta Ljubljane
[5]Andrej STRNIŠA, absolvent gozdarstva, Radeče
[6]Mag. Cvetka RIBARIČ - LASNIK, ERICo, Velenje
[7]Natalija VIDERGAR GORJUP, bipl. biol., SO Zagorje ob Savi

VPLIV ONESNAŽENEGA ZRAKA NA BIOKEMIJSKO ZGRADBO SMREKOVIH IGLIC NA VPLIVNEM OBMOČJU TERMOELEKTRARNE ŠOŠTANJ.

[1]RIBARIČ LASNIK C. [2]BATIČ F., [3]GRILL D.,

[1]ERICo Velenje, Koroška 64, 63320 Velenje, Slovenija

[2]Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, 61000 Ljubljana, Slovenija

[3]Institut für Pflanzenphysiologie, der Karl-Franzes, Universität Graz, Schubertstrasse 51, A-8010 Graz, Austria

ABSTRACT

At the area influenced by stack gases from thermal power plant in Šoštanj (North Central Slovenia) the biochemical parameters of Norway spruce needles were analysed in several growing seasons. Sampling sites were selected according to the degree of damage forests, and measured or predicted air pollution. Apart from forest die-back inventory, the following biochemical parameters of Norway spruce (*Picea abies* (L.) Karsten) were analysed in four classes of needles: content of macronutrients, age and seasonal pattern of photosynthetic pigment content, content of water soluble thiols and ascorbic acid, and activity of enzyme peroxidase. A very strong impact of pollution on spruce was determined, and the area of affected forest was proved to be much larger than suspected by earlier meteorological investigations.

UVOD

Termoelektrarna Šoštanj (TEŠ) je največji onesnaževalec zraka v Slovenji. Letno emitira v ozračju okoli 90.000 ton CO_2, 11.000 ton NO_X, 8.000 ton prašnih delcev, fluoride in druge zračne onesnaževalce. Termoelektrarna leži na dnu Šaleške doline na 300m nadmorske višine. Zahodna pobočja doline so dokaj visoka in dosežejo 1550m, medtem ko so vzhodno nižja, dosežejo 900m nadmorske višine. Dolina je dobro prezračena, razen v času stabilnega vremena, ko se pojavi temperaturna inverzija, ostane zrak nepremešan. Pojavljata se dve temperaturni inverziji. Prva se pojavlja do 100 m nad dnom doline, druga pa na nadmorski višini 1100 do 1200 m nadmorske višine[1)].

[1] mag. Cvetka RIBARIČ LASNIK, ERICo Velenje, Koroška 64, 63320 Velenje, Slovenija

[2] prof. dr. Franc BATIČ, Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, 61000 Ljubljana, Slovenija

[3] prof. dr. Dieter GRILL, Institut für Pflanzenphysiologie, der Karl-Franzes, Universität Graz, Schubertstrasse 51, A-8010 Graz, Austria

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Evaluation of pedunculate oak (*Quercus robur* L.) populations in Slovenia

F. BATIČ, T. SINKOVIČ and B. JAVORNIK

Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

Key words: pedunculate oak, morphology, multivariate analysis, molecular markers, genetic polymorphism, natural hybridization

Abstract

The article presents a taxonomic study carried out in three peduculate oak populations in Slovenia by leaf morphometry and DNA analysis. About one hundred leaves were sampled from five trees from three seminatural pedunculate oak stands in the Sub-pannonian vegetation region of Slovenia. Samples were collected from the well lit upper part of the tree crowns, and only leaves from short twigs were analysed. Leaf samples were herbalised, and measured and assessed in the laboratory. Leaf dimension (lamina length and width, petiole length, number of lobe pairs) were measured and characters like type of leaf pubescence and leaf lamina base type were assessed. RAPD markers were used for genomic DNA analysis.

Analysis of leaf morphometry showed that all sampled trees belong to the *Quercus robur* L. species. Nevertheless, on some trees, leaves also showed characters typical of sessile oak (*Quercus petraea* /Matt./ Leibl.), especially the leaf lamina base type and number of lobe pairs. Other parameters analysed were within the variation of peduculate oak. The hybrid status of these trees was not confirmed by DNA analysis. More populations of both oak species should be analysed, especially when growing together, in order to obtain reliable data for taxonomic studies of oak hybrids and population genetic diversity by means of classic leaf and acorn morphometry and modern DNA analysis.

Introduction

Lowland forests of oaks are the most changed forest ecosystems in Slovenia, as elsewhere in Europe. Due to agricultural activity and urbanisation, they have been transformed into cultural steppes and urban areas. Only a few remnants of them remain, and even they suffer from various disturbances like a changed water table, input of fertilisers, air pollution impact, cuttings etc. A new kind of forest decline has also seriously affected oak forests throughout Europe. The situation is not improving

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Bioindication in forest decline studies: concepts and practice

Dieter GRILL[1], Franc BATIČ[2], Michael TAUSZ[1]

[1] Institut fuer Pflanzenphysiologie, Karl-Franzens-Universitaet Graz, Schubertstrasse 51, 8010 Graz, AUSTRIA
[2] Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, SLOVENIA

Key words: bioindication, forest decline studies, air and soil pollution, plant response, TEMPUS, Slovenia.

Abstract

This article deals with use of several bioindication methods in forest decline studies within an international TEMPUS project carried out in Slovenia. The aim of the project was to introduce and connect different bioindication methods in order to improve methods and qualify the research staff working in this field of research in Slovenia. The following bioindication methods were introduced or adapted for forest decline research in Slovenia: biochemical and physiological markers of air pollution / stress impacts on forest trees (University of Graz: photosynthetic pigments, thiols, ascorbic acid, protective enzyme systems; University of Cambridge: plant hormones; University of Munich: mineral nutrition of forest trees); epiphytic lichens as indicators of air quality on forest sites (University of Graz, University of Ljubljana); determination of types of ectomycorrhizae as indicators of forest soil condition (University of Munich, University of Ljubljana). The significance and practical use of bioindication methods in environmental studies is also discussed.

Introduction

Three years ago a TEMPUS project, entitled "Bioindication of forest site pollution: Development of methodology and training" (TEMPUS JEP 4667), was initiated. According to the idea of TEMPUS projects there were two ECE countries, The United Kingdom (Department of Plant Sciences, University of Cambridge) and Germany (Institut fuer Systematische Botanik, Ludwig Maximilian Universitaet, Muenchen), Austria (Institut fuer Pflanzenphysiologie and Institut fuer Botanik, Karl-Franzens-Universitaet Graz) as non ECE country and Slovenia (Department of Agronomy, Biotechnical Faculty, University of Ljubljana and Slovenian Forestry Institute, Ljubljana) as an eligible, east/middle European country to which such co-operation was primarily

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Bioindication of air pollution by epiphytic lichens in forest decline studies in Slovenia

Franc Batič[1], Helmut Mayrhofer[2]

1 Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia
2 Institut für Botanik, Karl-Franzens Universitaet Graz, Holteigasse 6, 8010 Graz, Austria

Key words: bioindication, air pollution, epiphytic lichens, forest decline, Slovenia.

Abstract

The article deals with use of epiphytic lichen as bioindicators of air polution at forest decline studies in Slovenia. First studies of this kind were base on mapping of cover and frequency of crustose, foliose and fructicose epiphytic lichens on trees which were assessed also for the decline symptoms. Since 1985 epiphytic lichen vegetation has been assessed by this methods and results, expresed as a lichen map of Slovenia were used as an air quality indicator for plots of forest die-back inventory. In case studies of forest decline, in collaboration with lichenologist from Graz university, Austria, all epiphytic lichen species were mapped in order to obtain better measure of air quality in the area studied. Very polluted and stil clean and well preserved forest were investigated. From the material collected and determined a lichen herbarium has been established on the Slovenian Forestry Institute. Possibilities of further research and use of epiphytic lichens as air quality indicators are discussed.

Introduction

Bioindicators are organisms or their communities which respond to environmental factors through their life functions (Arndt et al. 1987). The same holds for bioindicators of air pollution. Epiphytic lichens are among the best known and extensively used bioindicators of air pollution (Skye 1968, Ferry et al. 1973, Hawksworth & Rose 1976, Derülle 1978, Nash III & Wirth 1988, Richardson 1988, etc.). They have been used as passive and active bioindicators of air pollution in many urban and industrial regions of Europe, North America and

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Fluorescence *in situ* hybridization – a tool for detecting interspecies hybrids in plants

Tomaž Sinkovič, Franc Batič, Branka Javornik

Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

Key words: cytology, oak hybrids, fluorescence *in situ* DNA hybridization, genomic probe.

ABSTACT

Preliminary results and methodology related to the use of the fluorescence *in situ* hybridization technique for detection of plant hybrids are presented. Total genomic DNA probe preparation and the non-isotopic biotin probe labelling technique is presented. The use of an excess of unlabelled competitor DNA from a related plant species gives more constant results in determing whole plant genomes with in situ experiments on plant hybrids. Preliminary results of fluorescence *in situ* hybridization for detecting alien rye chromatin and localisation on metaphase chromosomes and interphase nuclei in the bread wheat cultivar Yugoslavia are described. The methodology for detection of interspecies hybrids of common and sessile oak with fluorescence *in situ* hybridization is given. The advantage of the use of total genomic biotin labelled probes for *in situ* hybridization is that it requires less effort than preparing species specific probes and the ease of interpretation of the results. The technique of fluorescence *in situ* hybridization is less species specific than other cytological techniques for higher plants and almost the same methodology can be used for detection of oak hybrids. The extraction of a high quantity of species specific DNA of high quality and probe preparation and labelling are the most important step.

INTRODUCTION

In situ hybridization has become a powerful diagnostic tool since its first description (Gall and Pardue, 1969). It is nowadays possible to detect single and low copy DNA sequences, perform physical mapping of genes (Mukai et al., 1991), detect chromosomal aberrations like deletions, translocations, substitutions etc. Repetitive sequences (Cuadrado and Jouve, 1994; Masahiro et al. 1992), whole chromosome (Schöndelmaier et al., 1993)

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The use of lichens in atmospheric trace element deposition studies in Slovenia

Zvonka Jeran[1], Radojko Jaćimović[1], Boris Smodiš[1], Franc Batič[2]

[1] Jožef Stefan Institute, Jamova 39, SI-61111 Ljubljana, Slovenia

[2] Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101. SI-61000 Ljubljana, Slovenia

Key words: lichens, index of atmospheric purity, trace elements, factor analysis.

Abstract

In 1992, a monitoring survey on a national scale was carried out using *Hypogymnia physodes* (L.) Nyl. as a biomonitor for trace element air pollution. The primary aim was to analyse epiphytic lichens collected at 86 sampling locations of the 16 x 16 km bioindication grid using k_0-based instrumental neutron activation analysis (k_0-INAA), and X-ray fluorescence spectrometry (XRF) for sulphur and lead, to obtain information about the levels of elements in the atmosphere and to identify significant pollution sources. The geographical concentration patterns of the trace elements obtained from the lichen data were mapped and compared with the index of atmospheric purity (IAP) calculated on the basis of data from lichen thalli type mapping, obtained on a more dense bioindication grid in 1991.

The results obtained showed good agreement between the mapping of sulphur and trace elements with the status of lichen vegetation. The most exposed regions with elevated trace element levels and lower values of IAP were in the north-western Alpine part of Slovenia which coincides with high precipitation, and in the east of Slovenia, where many local pollution sources are situated.

Introduction

Determination of atmospheric pollution generally requires a wide network of sampling sites and the use of technical equipment to measure air particulate matter and deposition. Usually such monitoring programmes over

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Mycobioindication of forest site pollution

Hojka Kraigher[1], Franc Batič[2], Reinhard Agerer[3]

[1] Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia

[2] Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

[3] Institute for Systematic Botany, Menzingerstrasse 67, 80638 München, Germany

Key words: mycobioindication, types of ectomycorrhizae, forest site pollution.

Abstract

Types of ectomycorrhizae on Norway spruce were determined in soil cores from two differently polluted forest research plots from the emmission zone of the Šoštanj Thermal Power Plant (TPP). The two plots are comparable regarding site characteristics, but polluted differently by the emmissions from the TPP. During the vegetation season 1993, 21 soil cores were taken from each plot. In these all fine root & ectomycorrhizal root tips were counted and the percentages of different types were calculated. Additionaly, soil & mycorrhizae from underneath fungal fruit bodies were taken in order to characterize new types of ectomycorrhizae. Classical anatomical methods and molecular tools were applied for identification. 17 types of ectomycorrhizae were determined on 28443 root tips in soil cores from the heavily polluted plot (Zavodnje). The predominant types were *Paxillus involutus, Xerocomus badius, Picerhiza parallela & Piceirhiza inflata.* On the less polluted plot (Mislinja) 24 different types were determined on 38502 root tips in equal volume and number of soil cores. The most frequent types were *Hydnum rufescens, Amphinema byssoides, Piceirhiza oleiferans, Cenococcum geophilum & Lactarius lignyotus.* Mycobioindication of forest site pollution through selective sensitive (here *Hydnum rufescens*), in comparison to unsensitive (here *Paxillus involutus*), fungal species in ectomycorrhizae is discussed.

Introduction

Mycorrhizae represent the main spatial and temporal linkage between different constituents in a forest ecosystem (Dighton, Boddy, 1991). Their functional compatibility, physiology and tolerance to different stress factors is species specific (Harley, Smith, 1983; Gianinazzi-Pearson, 1984; Gogala, 1991). Therefore knowledge on the ectomycorrhizal types - species composition and their abundance is necessary in order to understand the functioning of a forest ecosystem (Wollmer, Kottke, 1990).

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Antioxidants as indicators of stress in Norway spruce needles

C. Ribarič Lasnik[1], F. Batič[2], D. Grill[3]

1 ERICo, Velenje Ecological Research & Industrial Cooperation, Koroška 64, 63320 Velenje, Slovenija

2 Agronomy Department, Biotechnical faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenija

3 Institut für Pflanzenphisiologie, der Karl-Franzens Universität Graz, Schubertstrasse 51, 8010 Graz, Austria

Key words: Picea abies, stress factors, sulphur, ascorbic acid, thiols, pigment content, peroxidase activity.

Abstract

Among a variety of stress indicators for early identification of Norway spruce (*Picea abies* (L.) Karsten) decline the sulphur content, photosynthetic pigment content, activity of the enzyme peroxidase, watersoluble thiols and ascorbic acid in four age classes of five spruce needles were analysed. The ten sampling sites were selected according to the degree of forest decline, sea level, distances from the Thermal Power Plant Šoštanj and air pollution.

Introduction

One of the theories about the causes of forest decline is the theory about multiple stress (Cowling, 1989). The vegetation of Šaleška valley and its suorroundings is also exposed to stress conditions such as cold, drought, lack of mineral nutrients in the soil, and the pollution of air and soil. Gas air pollutants (SO_2, photooxidants, HF, etc.) are one of the reasons for forest decline (Osswald, Senger, Elstner 1977). In chloroplast sulphur dioxide becomes toxic because of photooxidation of sulphite to sulphate. Results are sulphite radicals $SO_3^{-\cdot}$ and reactive $O_2^{-\cdot}$ which peroxidate lipids and proteins (Preiser, Liada, Yang 1982). Toxic effect of SO_2 is also the inhibition of ribulose-1,5 biphosphate-carboxilase (Ziegler 1975). Ozone also includes the catalysis of free radicals (Lee, Halliwell 1986, Mehlhorn et al 1986) or the molecules of ozone, which is a strong oxidant, cause the peroxidation of lipides and the oxidation of pigment proteins (Sakaki, Kondo, Sugahara 1983). Inside the stroma of chloroplast is detoxification system which reduces various oxygen sorts by using NADPH over ascorbic acid and glutation (Foyer, Halliwell 1967). Coniferous as well as decidous trees increase the content of antioxidants after SO_2 or ozone fumigation; the content also increases because of extreme climatic conditions (drought, cold) (Bermandinger, Guttenberger, Grill 1990; Pfeifhofer 1989; Olszyk, Tingley 1984). Numerous biochemical parameters such as thiols, ascorbic acid, enzyme peroxidase and some photosynthetic pigments are protective or detoxification mechanisms which protect lipides and proteins (photosynthetic pigments, chloroplast membranes) from oxidants and maintain balance in plants. Xantophylls (neoxanthin, zeaxantin, lutein,

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Proceedings
of the
International Colloquium
on

Bioindication of Forest Site Pollution: Development of Methodology and Training

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Reinhard AGERER and Dieter GRILL

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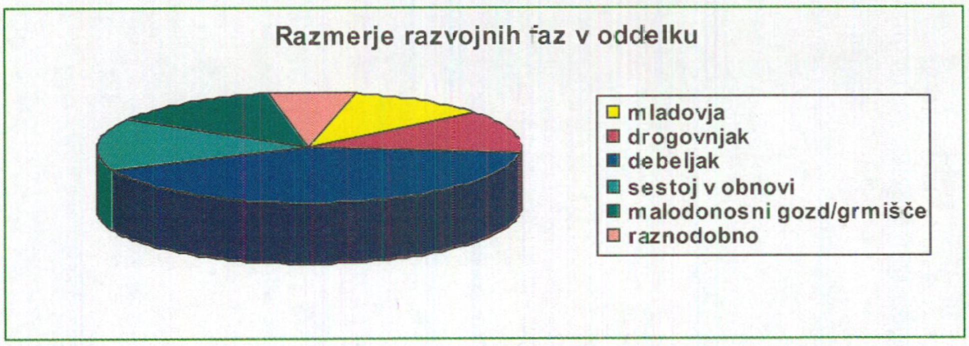
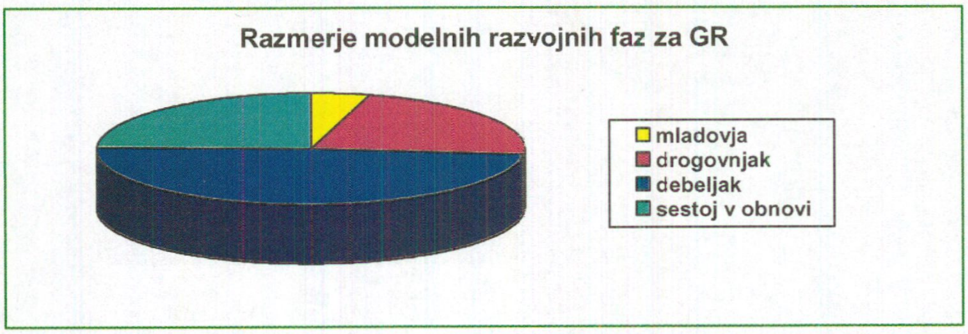
VSEBINA

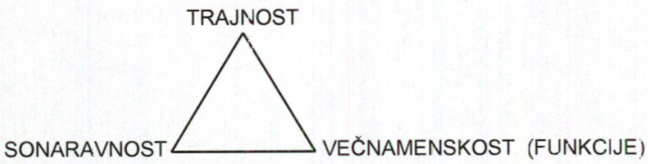
sekcija posterji





Kot je videti iz grafikona, se realno stanje oz. razmerje razvojnih faz približuje modelnemu: Mladovja že preraščajo v drogovnjak, delež sestojev v obnovi pa se bo po predvidenih ukrepih tudi nekoliko povečal – delno sicer na račun debeljaka in delno na račun malodonosnega gozda. Grmišče oz. malodonosni gozd ob potoku na vzhodnem delu oddelka predstavlja ekocelico in bogati oddelek ter s tem prispeva k večnamenskosti in sonaravnosti.

Tudi trajnost donosov z njegovo prisotnostjo ni prizadeta. V tem oddelku ni pričakovati težav z doseganjem trajnosti oz. stabilnosti (zaradi samega obsega in ugodnega razmerja razvojnih faz).



Oddelek je precej pester tako po drevesni sestavi (bogata rastišča) kot tudi po razmerju razvojnih faz in je zanimiv primer ravnotežja med lesno proizvodnjo in drugimi (predvsem ekološkimi) funkcijami.

Analytical Division of the Slovenian
Chemical Society

BLED'94

International Symposium on Chromatographic and Electrophoretic Techniques

Bled (Slovenia), October 10 - 13, 1994

BOOK OF ABSTRACTS

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J.RADIOANAL.NUCL.CHEM.,LETTERS 186 (2) 183-188 (1994)

NUCLEAR DATA AND MEASUREMENTS FOR THE $^{130}Ba(n,\gamma)^{131}Ba$ REACTION

B. Smodiš, F. De Corte*+, A. De Wispelaere*,

"Jožef Stefan" Institute (IJS), University of Ljubljana, Jamova 39, SLO-61111 Ljubljana, Slovenia

*Laboratory of Analytical Chemistry, Institute for Nuclear Sciences (INW), University of Gent, Proeftuinstraat 86, B-9000 Gent, Belgium

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Although k_0-factors and related nuclear data for 122 radionuclides of interest in (n,γ) reactor neutron activation analysis have been tabulated, there are still some reactions attracting interest with respect to the accuracy of the literature data. The present paper deals with the reaction $^{130}Ba(n,\gamma)^{131}Ba$, for which a more accurate half-life is proposed, together with re-evaluated Q_0 and k_0 factors. The new values are 11.53 days for T, 21.3 for Q_0, and for the k_0's 3.90×10^{-5}, 2.75×10^{-5}, 1.92×10^{-5} and 6.48×10^{-5} for the γ-rays at 123.8 keV, 216.1 keV, 373.2 keV and 496.3 keV, respectively.

INTRODUCTION

During the development of the k_0- standardization method, much effort has been put into the experimental determination of the nuclear constants for (n,γ) reac-

+Senior Research Associate of the National Fund for Scientific Research.

Akadémiai Kiadó, Budapest
Elsevier Sequoia S. A., Lausanne

Journal of Radioanalytical and Nuclear Chemistry, Articles, Vol. 190, No. 1 (1995) 3–11

DETERMINATION OF TRACE ELEMENTS IN TOBACCO USING DIFFERENT TECHNIQUES OF NEUTRON ACTIVATION ANALYSIS

B. SMODIŠ, M. DERMELJ, R. JAĆIMOVIĆ

Jožef Stefan Institute, University of Ljubljana, Jamova 39, P.O. Box 100, SL-61111 Ljubljana (Slovenia)

(Received October 21, 1994)

Quantitative data on trace elements in two tobacco leaf (candidate) reference materials OTL–1 and VTL–2 prepared by the Polish Academy of Sciences and the Institute of Nuclear Chemistry and Technology, Warsaw, Poland, are presented and compard to recommended values, where available. By instrumental neutron activation analysis (INAA), as well as by radiochemical technique (RNAA) 30 elements were quantitatively determined and fair agreement was found between the results and recommended values for the first material.

Trace elements have an important role in physiological processes in all living organisms.[1] Besides the essential elements, necessarily required for their existence and appropriate growth, plants can also take up a number of toxic elements from the soil. The composition of the soil and its pH value, its ion exchange capacity, the use of various fertilizers and agricultural sprays, climatic conditions and the characteristic absorptive properties of the plant can all influence the concentration levels and different chemical forms of essential or toxic inorganic constituents in different parts of plant materials. Among them, tobacco holds a leading position as an article of human consumption and is one of the most frequently used plants in the study of mineral composition and nutrition.

During smoking volatile elements, including essential or toxic ones such as As, Hg, I, Sb and Se, can pass from cigarette smoke into the human body and can be accumulated in different chemical forms in blood, lungs, liver and especially in kidneys. From the view point of health studies connected with smoking, and further from the aspect of the uptake of these elements by plants, and for timely prevention of their excessive uptake into tobacco, a knowledge of the reliable concentration levels of the above mentioned elements in soil, tobacco leaves and not least, in cigarette smoke, are very interesting and important. Investigations of some of these elements in tobacco have a long history (e.g. arsenic), but for some (e.g. antimony), data are very scarce. Until recently both elements were considered solely as toxic ones, but new literature data show evidence for the essentiality of As, while for Sb its beneficial or toxic effects for living organisms are still in the phase of extensive investigation.[2] Selenium for instance, is an essential

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Embryo–larval tolerance of *Mytilus galloprovincialis*, exposed to elevated seawater metal concentrations—II. Stage-specific fluctuations in sensitivity toward Zn and Cd and their bioaccumulation into veliger larvae

J. Pavičić,* B. Smodiš,† M. Škreblin,† I. Kregar† and P. Stegnar†

*Center for Marine Research—Zagreb, Institute "Rudjer Bošković", Zagreb, Croatia; and †Departments of Biochemistry and of Nuclear Chemistry, Institute "Jožef Stefan", Ljubljana, Slovenia

Acute intoxication of selected embryo–larval stages of *M. galloprovincialis* within successive 8-hr exposure intervals by elevated zinc and cadmium seawater concentrations, indicated stage- and metal-specific variations appearing in different proportions in normally developed straight-hinge veliger larvae. Zinc was found to be markedly more toxic than cadmium, particularly within the period of early cleavage and blastula stages. Embryos undergoing tissue differentiation and formation of the trochophora stage were substantially more sensitive regarding both metals tested in comparison with later veliger stages. Combined cadmium–zinc toxicity within each exposure interval tested appears to be less than additive, possibly associated with a markedly higher level of induced MT. The ability of developing embryos to concentrate seawater zinc ($CF^{65}Zn = 399$) was approximately 2.5 times higher than for cadmium ($CF^{109}Cd = 160$), which may also contribute to the observed difference in their tolerance levels.

Key words: *Mytilus galloprovincialis*; Veliger larvae; Cd; Zn; Metal toxicity; Metallothionein; Developmental toxicity; Metal bioaccumulation.

Comp. Biochem. Physiol. 109C, 37–46, 1994.

Introduction

Some of the previously published toxicity studies have indicated that different life history stages of marine bivalve molluscs display substantial fluctuations in tolerance toward various toxic substances, including trace metals (Calabrese and David, 1970; Pavičić and Järvenpää, 1974; Lehnberg and Theede, 1979; Ringwood, 1993). Early embryo–larval development up to the straight-hinge veliger stage, achieved 48 hr post-fertilization, was the most frequently used phase for toxicological testing. According to previously reported results, cadmium, as a typical pollutant, was recognized to be markedly less toxic than zinc and copper which were considered essential microelements (Calabrese *et al.*, 1973; Martin *et al.*, 1981; Pavičić, 1981; Pavičić

Correspondence to: J. Pavičić, Center for Marine Research—Zagreb, Institute "Rudjer Bošković", Zagreb, Croatia.
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Use of Nuclear and Nuclear-related Analytical Techniques in Studies of Trace and Minor Elements in Air Pollution

Borut Smodiš

Jožef Stefan Institute, University of Ljubljana, Jamova 39, P.O. Box 100, SLO-61111 Ljubljana, Slovenia

Boris Stropnik

ERICo Velenje, Koroška 64, SLO-63320 Velenje, Slovenia

Among nuclear and nuclear-related analytical techniques, neutron activation and X-ray fluorescence analysis are particularly useful for environmental studies owing to their non-destructive character and multi-element capability. In this work, procedures for k_0-standardized instrumental neutron activation analysis (INAA) and energy-dispersive X-ray fluorescence (EDXRF) spectrometry for trace and minor elements in air pollution studies were investigated. The methods applied were validated by the analysis of suitable reference materials: NIST (National Institute for Standards and Technology) SRM 1633a Coal Fly Ash, NIST SRM 1570 Spinach, NIST SRM 3087 Metals on Filter Media and BCR (Community Bureau of Reference) CRM No. 128 Fly Ash on Artificial Filter. Using INAA, 20 experimentally obtained elemental values out of 21 certified and all 29 experimentally obtained values compared with 'consensus' values (for the elements where no certified numbers are available) in two SRMs were statistically indistinguishable. Also, the contents of 28 elements in candidate NIST SRM 1573a Tomato Leaves are reported. The EDXRF results were statistically indistinguishable from certified values for eight out of nine elements in NIST SRM 3087. The detection limit for this method is around at 0.1 μg cm^{-2} per element, so in BCR CRM No. 128, which is intended for ambient air pollution data, only Fe and Zn out of 14 elements reported in the certificate were detected with acceptable precision (*i.e.*, 10%) owing to the very low air particulate matter loading, lying in the region of only 250 μg cm^{-2}.

Keywords: Instrumental neutron activation analysis; energy-dispersive X-ray fluorescence spectrometry; air pollution; standard reference material

Introduction

In various countries in Europe and throughout the world, much effort is being devoted to air pollution studies of various contaminants. Among them, toxic and heavy metals represent an important group of air pollutants to be considered. As far as sampling is concerned, two general approaches exist: the collection of air particulate matter (APM)[1] by impaction, precipitation, centrifugation or filtration and the use of suitable air pollution biomonitors.[2] Whereas the first approach is mostly suitable for detailed quantitative studies of local, short-range, medium-range or global transport of pollutants, including health-related studies when collecting different fractions of APM, the second approach aims at a cheap but still reliable means of air quality status determination in a country or a region.

The analysis of samples for their bulk minor and trace element contents is governed by the sample type, the elements of interest, the sensitivity, precision and accuracy needed and the availability of (or access to) the technique. The choice of multi-element methods available includes inductively coupled plasma mass spectrometry (ICP-MS), X-ray fluorescence (XRF) spectrometry, ion beam analysis (IBA) [*i.e.*, particle-induced X-ray emission (PIXE) and proton-induced gamma-ray emission (PIGE)] and nuclear activation analysis [instrumental neutron activation analysis (INAA), prompt gamma neutron activation analysis (PGNAA), charged particle activation analysis (CPAA)]. For handling solid samples, nuclear activation analysis, XRF and PIXE are the most appropriate as they are non-destructive methods.

Apart from total reflection X-ray spectrometry[3] or synchrotron radiation X-ray fluorescence,[4] which require expensive and sophisticated equipment and/or analytical procedures, it has been shown[5,6] that relatively simple EDXRF using radionuclide excitation sources can also be efficiently used in air pollution research. In addition, the filters analysed by this technique can subsequently be submitted to analysis by other techniques, which is not the case when using other methods.

Activation analysis has also been extensively used for such studies[7–9] and numerous reviews comparing various analytical methods can be also found in the literature.[10,11] Extensive references may also be found in the biennial reviews appearing in *Analytical Chemistry*, *e.g.*, ref. 12. However, no papers reporting the use of the k_0 standardization method of INAA in air pollution research have been published, to our knowledge. This technique[13] combines the advantage of absolute standardization (offering the possibility of determining all the radionuclides appearing in the accumulated gamma spectra, in contrast to relative standardization, where only the elements for which standards have been co-irradiated can be determined), and overcomes the drawback of strict rigidity to local irradiation and counting conditions, as in single-comparator standardization. The accuracy of the k_0 method is better than that of absolute NAA, owing to the use of experimentally determined nuclear constants instead of the literature values.

The aim of this work was the development of procedures and protocols for the two methods available in our laboratory, INAA and EDXRF, for the analysis of APM and air pollution biomonitors, mainly by testing the performance of both techniques by analysis of suitable standard reference materials (SRMs). For INAA the k_0 standardization technique[14] was applied and for EDXRF radionuclide excitation sources were used.

In this paper the results for SRMs are presented, showing the accuracy and possibilities of each of the two methods of analysing materials for following minor and trace-element air pollution, together with a discussion of their drawbacks.

Acta Chimica Slovenica 41/1/1994, pp. 65-82

AIR POLLUTION MONITORING IN THE ŠALEK VALLEY
PART 2: ELEMENTAL COMPOSITION OF SIZE-FRACTIONATED LIGNITE COAL-COMBUSTION PARTICLES DURING ŠOŠTANJ TPP OPERATION

B. Stropnik[*+], A. R. Byrne[*], B. Smodiš[*], R. Jaćimović[*]

[*] "Jožef Stefan" Institute, University of Ljubljana, Jamova 39, 61111 Ljubljana, Slovenia

[+] ERICo Velenje, Koroška 64, 63320 Velenje, Slovenia

ABSTRACT

In order to study the influence of the coal-fired Šoštanj thermal power plant (TPP) on the environment, the elemental composition of lignite, electrostatically precipitated (ESP) fly ash (two stages) and size fractionated escaping fly ash particles (four fractions), sampled in mid-stack, was determined for 39 elements by k_o-instrumental activation analysis (INAA), and for Cd and Pb by ETAAS. The mass weighted mean concentrations for coal, fly ash and escaping stack fly ash were used to obtain enrichment ratios, and to estimate the mass balance for these elements during TPP operation, including estimates of the total annual stack emissions.

chato

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FOLLOWING THE WATER CYCLE IN THE ŠALEK VALLEY BY THE INAA METHOD

M. Svetina Gros [1], B. Smodiš [2], S. Pirc [3]

1 ERICo Velenje, Ecological Research & Industrial Cooperation, Koroška 64, 63320 Velenje, Slovenia

2 "J. Stefan" Institute, University of Ljubljana, Jamova 39, 61111 Ljubljana, Slovenia

3 Department of Geology, University of Ljubljana, Aškrčeva 12, 61000 Ljubljana, Slovenia

Abstract. In order to define the content and concentration range of inorganic substances dissolved in bulk precipitation and their impact on the chemical quality of forest water, investigations in forest areas were initiated in the Šalek valley in Slovenia. Podvolovljek, which is located 30 km from the Šoštanj Thermal Power Plant, was chosen as a control area. The programme includes research on three watersheds where sampling of bulk precipitation deposition in the open, leachate water at 50 cm soil depth and spring water are performed. The

watersheds provide an ideal field laboratory in which deposition and cycling of airborne trace contaminants can be examined (1,2). Due to its multielement character, instrumental neutron activation analysis (INAA) was chosen as a suitable analytical method to determine trace elements in water samples (3). The preliminary results showed that the average arsenic, chromium and zinc concentrations in the forest areas are under the maximum permitted limit for spring water, but evidence for the influence of the Šoštanj Thermal Power Plant on arsenic and chromium concentrations was found.

Introduction

The Šoštanj Thermal Power Plant is a large regional SO_2, NO_x and dust emission source. Its measured emission for 1990 was 93000 tons of SO_2, 12400 tons of NO_x and 5700 tons of dust (4).

In order to identify the causal relationships between forest damage, anthropogenic emissions and the consequences in runoff and soil water, investigations on the deposition of inorganic substances in forest areas have been initiated in the Šalek valley in Slovenia (5). The present investigation includes two watershed experiments in calibrated catchments (Zavodnje and Veliki vrh), located within a 10 km radius around the coal-fired power plant and one reference area in the Savinian Alps (Podvolovljek). Due to the characteristics of the watersheds these sites offer an ideal field laboratory in which deposition and cycling of airborne trace contaminants derived from atmospheric emission related to energy technology can be examined (6). The initial focus of the investigation was centred on the

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1. Stropnik, Ivo

44073472

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Kulturni center Ivana Napotnika Velenje
Založništvo Pozoj
Velenje, 1994

VSEBINA LETOŠNJEGA ZBORNIKA

ja doline v mnogo tesnejši povezavi z rudnikom kot z ostalimi dejavniki, ki imajo tudi vpliv na gospodarski razvoj doline. Zato naj ta prispevek izzveni predvsem kot razmišljanje o posledicah odkopavanja lignita, o odpravljanju negativnih posledic, o dobrih in slabih straneh rudarjenja in o vplivu nadaljnjega delovanja rudnika na perspektivo razvoja doline, saj je v tem podjetju zaposleno veliko število delavcev, posredno pa je nanj vezano največje število zaposlenih v Šaleški dolini. Zato je perspektiva razvoja Šaleške doline bolj kot z ostalimi industrijskimi panogami povezana s strategijo razvoja premogovništva in energetike v Republiki Sloveniji ter je od nje v veliki meri odvisna.

Gledano z očmi delavca Rudnika lignita Velenje perspektiva razvoja Šaleške doline sploh ni črna, temveč nasprotno: bolj kot "dolina smrti" nas plaši usoda te doline v primeru "neugodne" državne energetske strategije. Problem onesnaženosti doline bo mogoče rešiti v naslednjih nekaj letih in prepričani smo, da bomo po letu 2000 lahko govorili o Šaleški dolini kot energetskem gigantu, ki pokriva 30 % potreb države po energiji brez ekološko spornih dejavnikov.

Nenazadnje moramo omeniti dejavnosti s področja rekultivacij prizadetih zemljišč. Te so pri razvoju doline še kako pomembne in imajo eno od odločilnih vlog vzporedno z reševanjem ekološke problematike, saj je potrebno vsa uničena zemljišča povrniti v stanje, ki omogoča revitalizacijo uničenega prostora.

LITERATURA

1. 100 let Rudnika lignita Velenje, REK RLV, junij 1975
2. M. Tamše, S. Meh: Odlaganje pepela in žlindre iz TEŠ v nasip med Velenjskim in Družmirskim jezerom, Rudarsko-metalurški zbornik, Ljubljana 1989
3. Premogovnik v Šaleški dolini, Hidrogeološka služba RLV, 1991
4. Sanacijski program čiščenja odpadnih vod RLV na območju NOP, Hidrogeološka služba RLV, september 1993
5. M. Medved, M. Tamše, S. Meh: Možnosti odlaganja in skladiščenja odpadnih snovi v jamah RLV, Velenje, marec 1992
6. Inženirski biro Januš: Tehniško - ekonomska študija izkoriščanja termalne vode v Lajšah, Velenje, september 1991

UDK 556.3

Marta Svetina-Gros
ERICo - *Zavod za ekološke raziskave Velenje*

VPLIV PADAVIN NA TLA IN VODNE IZVIRE NA OBMOČJU TERMOELEKTRARNE ŠOŠTANJ1

(Razprava je skrčena predstavitev magistrske naloge, ki jo je avtorica zagovarjala leta 1994 na Odseku za geologijo na FNT v Ljubljani pod mentorstvom prof. Simona Pirca in somentorstvom dr. Boruta Smodiša)

Ali ima dež očeta
in kdo plodi dežne kapljice?
(Jobova knjiga, 38, 28)

V Šaleški dolini so bile na dveh gozdnih lokacijah opravljene ekološke raziskave, katerih namen je bil pridobiti čim več podatkov o vsebnosti in o koncentracijskih območjih anorganskih komponent, raztopljenih v padavinah, talni raztopini in vodnih izvirih. Z nalogo smo v Sloveniji prvič uvedli metodo malega povodja, v kateri uporabljamo povirje kot naraven laboratorij, kjer sledimo delu vodnega cikla v gozdnem ekosistemu. Kot glavna analitska metoda je bila uporabljena k_0-standardizacijska metoda INAA, s katero so bili v vzorcih voda določeni sledni elementi in težke kovine. Rezultati analize kažejo na povečane vsebnosti in koncentracijska območja elementov v tleh, padavinah, talni raztopini in vodnih izvirih v bližini Termoelektrarne Šoštanj. V padavinah so še posebej povečane koncentracije Al, As, Ba, Br, Fe, Cd, Co, Cr, Cu, Sb in Zn. Narejena je bila tudi ocena letne masne bilance elementov v povirju, s katero je bila ugotovljena velika akumulacija Cd, Cr, Fe, Mn, NH_4^+, Pb, Rb, Sb, Se in Zn v gozdnem ekosistemu.

UVOD

Z vedno večjo uporabo fosilnih goriv in razširitvijo kemične in druge industrije je atmosfera vse bolj obremenjena s številnimi snovmi, ki so človeku in rastlinam škodljive, kot so: žveplov dioksid (SO_2), dušikov dioksid (NO_2); škodljive snovi, ki nastajajo pri fotokemičnih procesih v atmosferi: dušikovi oksidi (NO_x), ozon (O_3) in peroksiacetilnitrat (PAN); vodikov fluorid (HF), vodikov klorid (HCl), fluorirani in klorirani ogljikovodiki; aluminijeve, kadmijeve in živosrebrove spojine; razni odpadki, ki vsebujejo radioaktivne snovi in številne druge spojine, ki jih še zelo slabo poznamo.

Raziskave po svetu kažejo, da je umiranje gozdov v veliki meri odvisno od onesnaženja atmosfere. V zadnjih letih so postavili nekaj hipotez, ki razlagajo vlogo onesnaževalcev pri propadanju gozdov v Evropi. Glavne kemijske snovi, ki prispevajo k propadanju gozdov, so ozon in drugi fotokemijski oksidanti, žveplov dioksid, dušikove spojine, kisle usedline, težke kovine in organske snovi (Hinrichsen, 1986).

K zakisanju padavin prispevajo največ žveplov dioksid in dušikovi oksidi, nekoliko še vodikov klorid, fluorid in druge snovi, ki raztopljene v zračni vlagi tvorijo močne mineralne kisline. Te snovi padajo na zemljo kot kisli dež, sneg, megla ali kot kisli trdni delci. Raziskave so pokazale (Krug & Frink, 1983), da lahko kisle usedline iz listov in iglic izpirajo kalij, kalcij in magnezij. Rastline skušajo nadomestiti primanjkljaj v listih z intenzivnejšim črpanjem teh elementov iz tal. Če teh hranilnih snovi v tleh primanjkuje, postanejo zaradi pomanjkanja hranil rastline bolj občutljive na klimatske pogoje. Poleg tega kisle usedline spreminjajo tudi sestavo tal; pomembne hranljive snovi se spirajo, hkrati pa se mobilizira aluminij, ki uničuje fine koreninice rastlin. Vpliv kislega dežja na spremembe v sestavi tal je odvisen od njihove puferske zmogljivosti. Tla, ki vsebujejo veliko kalija ali kalcija, npr. na apnencu in peščenjaku, niso tako občutljiva kot tla na kislih magmatskih kamninah, npr. tonalitu in andezitnem tufu. To je tudi razlog, zakaj znanstveniki pripisujejo kislemu dežju pri umiranju gozdov večjo vlogo v Evropi kot v ZDA.

Težke kovine se usedajo na zemljo bodisi s padavinami ali pa kot suhi trdni delci. Igličasti gozdovi imajo pri tem vlogo ogromnih filtrov, ki prestrezajo suhe in mokre usedline.

Z iglic se težke kovine izpirajo v zgornjo plast tal, kjer ovirajo biološko aktivnost encimov in s tem mikroorganizmov, predvsem gliv in bakterij. Te zato počasneje razgrajujejo visokomolekularne organske spojine (celulozo, škrob in lignin) na sestavine, ki predstavljajo za rastline osnovne hranljive snovi. Na ta način se zmanjšata biološka aktivnost in hitrost mineralizacija v onesnaženih tleh, s tem pa se poruši normalen

biokemijski krog. Študije so pokazale (Puckett, 1988), da težke kovine prizadenejo tudi neposredno rastline, predvsem mahove in lišaje, ki nimajo zunanje povrhnjice, ki bi jih varovala. Druge rastline pa sprejemajo težke kovine v glavnem skozi korenine, posebno v kislih tleh. Tla, onesnažena s težkimi kovinami, zavirajo normalen razvoj korenin, kar rastline oslabi. V kombinaciji z drugimi onesnaževalci lahko kopičenje težkih kovin v tleh resno ogrozi delovanje gozdnega ekosistema.

Znano je katastrofalno stanje slovenskih gozdov. Popis iz leta 1985 je pokazal, da je prizadetih že več kot polovica slovenskih gozdov (Hrček, 1987).

Največji vir emisije škodljivih snovi v zrak so pri nas termoelektrarne na premog. Med njimi je na prvem mestu Termoelektrarna Šoštanj, ki onesnažuje zrak bolj kot oba druga najpomembnejša termoenergetska objekta skupaj (Termoelektrarna Trbovlje in Toplarna Ljubljana). Zaradi njene emisije dimnih plinov je najbolj prizadeto ozemlje občine Velenje. Onesnaženje škoduje gozdovom, posebno tistim, ki rastejo v predgorskem in gorskem svetu na nekarbonatnih kamninah. Na emisijskem območju TEŠ je zastavljeno že precej raziskav, ki iz različnih vidikov ugtavljajo vplive TEŠ na okolje. Merijo onesnaženost zraka, padavin in vodnih tokov; ugotavljajo stopnjo poškodovanosti gozdov, stanje epifitske lišajske vegetacije, ocenili so obremenjenost gozdov z žveplom na osnovi kemijske analize smrekovih iglic in gozdnih tal v vplivnem območju TEŠ.

Kljub zelo široko zastavljenemu programu ekoloških raziskav na vplivnem območju TEŠ pa je zelo malo znanega o lastnostih padavin, kako le-te vplivajo na tla in na talno raztopino in s tem na prehranjevanje rastlin, posredno pa preko prehranjevalne verige in vodnih izvirov tudi na zdravje živali in človeka. Zelo malo ali skoraj nič ni znanega o elementih v sledovih, ki jih izpušča v zrak TEŠ. Ker gre za mikroelemente, že minimalno povečanje koncentracij v naravi lahko privede do porušitve ravnovesja. Glede na to, da kisle usedline in težke kovine igrajo zelo pomembno vlogo pri propadanju gozdov, poleg tega pa lahko njihovo povečanje ogrozi tudi zdravje živali in človeka, smo s to raziskovalno nalogo želeli pridobiti čim več uporabnih podatkov o anorganskih polutantih v padavinah, talni vodi in vodnih izvi-rih. Pri tem smo v Slovenijo vpeljali novo metodo raziskovanja, ki se imenuje metoda malega

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From the Editor-in-Chief **Professor** T. Braun

December 11, 1995

Dear Svetina,

It is my special pleasure to inform you that your manuscript

Trace elements in the water cycle of the Salek Valley, Slovenia, using INAA

(reg.no. 4204)

has been accepted for publication. It will appear as soon as possible. /in Vol.204, No.1, 1996/

Yours sincerely
Professor T. Braun

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DETERMINATION OF URANIUM AND THORIUM AT ULTRA TRACE LEVELS BY RADIOCHEMICAL NEUTRON ACTIVATION ANALYSIS

L. Benedik, A. R. Byrne

"J. Stefan" Institute, Nuclear Chemistry Department, University of Ljubljana, Jamova 39, P.O. Box 100 SLO-61111 Ljubljana, Slovenia

Nanogram and picogram quantities of uranium and thorium were determined in different biological materials and reference materials. Regarding the favourably sensitive nuclear characteristics of uranium and of thorium but the very different half lives of their induced nuclides ^{239}U and ^{233}Pa, two approaches were used. In the first approach uranium and thorium were determined separately, and in the second these elements were determined simultaneously in a single sample. This latter method is based on the double irradiation LICSIR technique (1). Radiochemical separation of uranium was based on TBP extraction and of protactinium with TOPO. As an original solution to the problem of recoveries, the chemical yields of ^{239}U and ^{233}Pa were measured in each sample aliquot using added ^{235}U and ^{231}Pa radioisotopic tracers. The limits of detection were about 1 $pg.g^{-1}$ for U, and for a 200 h irradiation about 20 $pg.g^{-1}$ for Th.

INTRODUCTION

There are several very sensitive analytical methods for determination of uranium and thorium. Alpha spectrometry following radiochemical separation (2,3), isotope dilution mass spectrometry (4,5,6), inductively coupled plasma mass spectrometry (7,8,9), and neutron activation analysis are all used. However radiometric methods are time consuming, need large samples due to the low specific activity of U and Th and

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SIMULTANEOUS DETERMINATION OF TRACE URANIUM AND THORIUM BY RADIOCHEMICAL NEUTRON ACTIVATION ANALYSIS

L. BENEDIK, A. R. BYRNE

"Jožef Stefan" Institute, University of Ljubljana, Jamova 39, P.O. 100, SLO-61111 Ljubljana (Slovenia)

(Received October 21, 1994)

A method for the simultaneous, radiochemical neutron activation analysis of uranium and thorium at trace levels in biological materials is described, based on a technique known as LICSIR, in which a double neutron irradiation is employed. In the first, long irradiation ^{233}Pa (27.0 d) is induced by neutron capture on ^{232}Th and then the sample is cooled for several weeks. A second short irradiation to induce ^{239}U (23.5 m) is followed by a rapid sequential radiochemical separation by solvent extraction of ^{239}U with TBP and ^{233}Pa with TOPO. Chemical yields of ^{239}U and ^{233}Pa were measured for each sample aliquot using added ^{235}U and ^{231}Pa tracers from the γ-spectra of the separated fractions. The technique was validated by quality control analyses.

Data on the low levels of uranium and especially thorium present in different biological samples are scarce and variable. Radiometric methods based on α-spectrometry are very time-consuming, need large samples and are limited by reagent blanks. Radiochemical neutron activation analysis (RNAA) is an excellent method for determining low concentrations of U and Th due to its high sensitivity and virtual freedom from blank problems.

Thorium is almost always determined in NAA from ^{233}Pa (27.0 d) produced on neutron irradiation by ^{232}Th(n, γ)^{233}Th$\rightarrow$^{233}Pa, since ^{233}Th (22.3 m) offers lower sensitivity and a short half-life. Uranium, and uranium with thorium, is often determined via ^{239}Np (2.35 d) via the reaction ^{238}U(n, γ)^{239}U (23.5 m)$\rightarrow$^{239}Np. However, difficulties in determining the chemical yields of ^{239}Np and ^{233}Pa remain due to lack of suitable γ-emitting radioisotopes of Np and Pa. Thus they are usually measured in prior tracer experiments and assumed to remain constant, which can lead to errors. On the other hand, for determination of uranium, ^{239}U offers increased sensitivity under normal irradiation conditions, especially if a well-type detector is used for the 74.7 keV γ-rays of ^{239}U, as well as being more rapid. For example, using ^{239}U, nanogram[2-5] and picogram[5,6] (L.o.D. 1–2 pg · g^{-1}) quantities can be determined.

In the present work, this ^{239}U approach using selective TBP extraction (F$^-$ is used as a masking reagent) and determination of the chemical yield from the 185.7 keV peak of ^{235}U from the added uranium carrier,[5,6] was combined with a determination of Th via a long prior irradiation to induce ^{233}Pa. After cooling for 2–3 weeks, a second short

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DETERMINATION OF LEAD, CADMIUM AND THALLIUM BY NEUTRON ACTIVATION ANALYSIS IN ENVIRONMENTAL SAMPLES

A. FAJGELJ, A. R. BYRNE

Jožef Stefan Institute, University of Ljubljana, Jamova 39, P.O. Box 100, SLO-61111 Ljubljana (Slovenia)

(Received October 21, 1994)

A radiochemical procedure for simultaneous determination of lead (^{203}Pb), thallium (^{202}Tl) and cadmium (^{115}Cd→^{115m}In) after fast neutron activation, based on ion-exchange separation from bromide medium and additional purification steps for Pb and Tl is described. Radioactive tracers ^{210}Pb and ^{109}Cd were used for determination of the chemical yields of Pb and Cd; for Tl it was determined gravimetrically. Two standard reference materials, BCR CRM No. 146 Sewage Sludge and NIST SRM 1633a Coal Fly Ash were analyzed and satisfactory agreement with certified values was obtained.

The determination of lead by neutron activation analysis (NAA) is widely regarded as virtually impossible at the concentrations found in environmental samples. Whereas NAA is a very powerful technique for nearly all other heavy and trace metal or metalloids, its inability to determine Pb is a weakness in environmental research. A very similar conclusion can be made for thallium (unless β-counting of ^{204}Tl is considered). Additionally, only few standard or certified reference materials (SRMs/CRMs) with certified or even consensus values exist for Tl,[1,2] which reflects the lack of input from NAA, the major method employed in RM certification.

Lead, thallium and cadmium are all interesting trace elements and also important pollutants, which can normally be found together in environmental samples, and often require joint determination. The possibilities of cadmium determination by neutron activation analysis are very well known, while lead and thallium are usually not considered at all by the activation analyst, particularly if γ-counting is to be the method of quantitation. However, with fast neutron activation some nuclides offer analytical possibilities. To clarify the theoretical aspects of simultaneous determination of Pb, Tl and Cd, Table 1 sets out neutron induced reactions of possible analytical interest for these three elements. The reactions ^{208}Pb(n, 2n) or ^{207}Pb(n, n)^{207m}Pb (0.8 s) have been used by a few research workers possessing rapid transfer facilities with precise timing for irradiation and counting of ^{207m}Pb in the cyclic mode, i.e., short irradiation – rapid transfer – short count, and repeating this cycle until sufficient counts have accumulated in the γ-ray peak measured (569.7 keV). However, the technique is of limited sensitivity, has not produced many real results, and is expensive to set up and operate. As a non-destructive technique, it also suffers from high count rates in some matrices,

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Distribution of ^{230}Th in Milling Wastes from the Žirovski vrh Uranium Mine (Slovenia), and its Radioecological Implications

Milko Križman, Anthony R. Byrne & Ljudmila Benedik

Nuclear Chemistry Department, Jožef Stefan Institute, 61001 Ljubljana, Slovenia

(Received 2 March 1994; accepted 12 June 1994)

ABSTRACT

Thorium-230, together with ^{238}U and ^{226}Ra, was determined (mainly by γ-spectrometry) in samples from the waste piles at Boršt and Jazbec in the vicinity of the former uranium mine at Žirovski vrh, Slovenia. Activity (and in the case of uranium, also mass) balances for these nuclides were constructed for the overall operation of the mine and yellow cake plant, using experimental data and known data on ore and uranium production, and nuclide emissions to the environment.

All the ^{226}Ra resulting from ore exploitation is presently contained in the Boršt tailings pile. However, because of the very high content of ^{230}Th in red mud deposited at Jazbec, where 60% of this nuclide is found, the majority of ^{226}Ra will be found at the Jazbec pile in the future, due to its ingrowth from ^{230}Th over the next few thousand years.

The long-term radioecological consequences of this untypical finding for rehabilitation of the site, and its safe management are discussed in this paper.

INTRODUCTION

During the milling process most of the radionuclides present in uranium ore — up to 70% — are discharged to the environment with the tailings. Naturally, this waste material is highly depleted in uranium, so the major

Urinary Excretion of Uranium and Dietary Intake

Dear Editors:

THE PAPER "Diurnal urinary volume and uranium output in uranium workers and unexposed controls" by D. W. Medley et al. (1994) provides interesting data on urinary excretion and gut uptake of uranium, particularly for non-exposed controls where good values are lacking, and especially since the analytical results were obtained by a new phosphorescence technique. However, we feel that some points made in the paper need comment and critical discussion.

1) In the Materials and Methods section the authors state that "The LLD using this method is lower than that obtained by other methods. . ." This is incorrect. The limit of detection of the isotope dilution-thermal ionization MS method (Kelly et al. 1987) is evidently lower: fuller details of this method were reported (Kelly et al. 1983) in a paper describing its use for certification of uranium in reference materials, including urine, at NIST, Washington. Also, the limit of detection reported for RNAA (Byrne and Benedik 1991) of 1–2 pg g^{-1} is well below that of Medley et al. (1994). Unfortunately none of these papers are cited by Medley et al., which is a pity since they are concerned with uranium determination at trace level in urine (and other biological materials).
2) As concerns the experimental design used by Medley et al. (1994), in the footnote to Table 6 it is stated that the drinking water consumption of the subjects was assumed to be 2,000 mL d^{-1}, of which half was considered to be drunk at work and half at home. In view of the effort involved in urine collection and analysis, it seems a lost opportunity not to have at least measured this intake, and better, to have quantified its uranium content. It would have been a simple matter to ask the subjects to use a graduated drinking cup and record their consumption: further, duplicate portions could have easily been collected and thus actual uranium intakes determined.

Moreover, since other fluid intake is not mentioned, presumably consumption of other drinks was ignored. However, it is known that milk, cola and similar soft drinks, fruit juices, beer, coffee, and tea contribute a significant proportion of fluid intake in U.S. males.

In view of all these uncertainties over actual uranium intake with fluids, it seems unreasonable to give estimated uranium intakes (Table 6) to five significant figures accuracy! (There is also a printing error in this column; intake of subject 1A should presumably be 20,448 ng).

3) The authors state that intake of uranium from food can be ignored in comparison to intake from drinking water and this assumption is the basis for their calculated gut uptake factors. We question if this a totally valid assumption. The total dietary intake of uranium has been estimated in a number of studies, and both early works (e.g., Hamilton 1972) and later ones (e.g., Singh and Wrenn 1989), agree well on a value of around 1 or perhaps 1–2 $\mu g\ d^{-1}$. Recently we reported (Benedik and Byrne 1991) uranium levels in U.S. total diets prepared at NIST by G. V. Iyengar in cooperation with USDA-FDA, based on their nationwide market basket surveys involving blending of hundreds of dietary components. Five regional U.S. diets were found to contain from 1.5 to 5.3 $\mu g\ kg^{-1}$ uranium (dry weight basis), with a mean of 2.5 ± 2.0. (Similar values were found for total diets from six other countries.) In the above mentioned diets (Hamilton 1972) drinking water was not included, while the U.S. diets contained only 500 mL. Thus, given a consumption of about 0.5 kg dry diet d^{-1}, daily uranium intake would be in the range of 750 to 2,650 ng (mean 1,250 ng). This is not negligible in relation to the estimated uranium intake from drinking water of workers 1 and 2, and of controls 2A and 3A, described by Medley et al. (1994). This may account for some of the variability in the gut uptake factors they calculated on the basis of estimated drinking water intake alone. It might also cast doubt on their statement in the Abstract that the GI uptake factor was inversely proportional to the total intake via drinking water.
4) The authors did not comment on the urinary uranium concentrations they report for six unexposed controls (range 4–58, mean 22.5, median 17 ng L^{-1}). Many literature values are higher than these, but they are in good agreement with values we reported (Byrne and Benedik 1991) for 10 nonexposed controls of 3–49, mean 13 and median 9 ng L^{-1}. It is of interest that, as pointed out many years ago (Welford and Baird 1967), given an accepted dietary intake of 1 $\mu g\ d^{-1}$ and a 1% GI uptake factor, the calculated urinary level for a Reference Man (1.4 L urine excreted per day) should be about 7 ng L^{-1}. The fact that many values in the literature (including those in Welford and Baird) are much higher, is probably mainly due, as we discussed before (Byrne and Benedik 1991), to inadequate limits of detection in other methods, which are greater than 20 ng L^{-1}, as well as to possible contamination and insufficient control of blanks and other quality control procedures. The same point was later made (Wrenn et al. 1992) in a review of literature data on the uranium content of urine.
5) Finally, we would end on a positive note and suggest that analysis of whole blood by the phosphorescence technique would be rewarding (if matrix effects can be eliminated). Current models, based on a range of literature values for human blood of 0.1–1.4 ng mL^{-1} (ignoring some even higher values) (Singh and Wrenn 1989; Wrenn et al. 1985; Fisenne and Perry 1985) suggesting a mean of around 0.5 ng mL^{-1}, postulate a circulating blood pool of uranium of 2500 ng, supposedly maintained by a G.I. uptake of only about 10 ng d^{-1} (i.e., urinary excretion); as pointed out elsewhere (Wrenn et al. 1985) this seems unlikely. Hence it would be of value if Medley et al. (1994) could confirm the uranium values of only some pg mL^{-1} (about two orders of magnitude lower) we found (Byrne and Benedik 1991) in whole blood. Indeed, in some recent samples prepared using state-of-the-art contamination-free blood sampling and handling techniques by Jacques Versieck in Gent, Belgium, we found levels of uranium in whole blood, serum, and red blood cells to be at our limit of detection of 1–2 pg mL^{-1} (unpublished).

ANTHONY R. BYRNE
LJUDMILA BENEDIK
Department of Nuclear Chemistry, J. Stefan Institute
61111 *Ljubljana, Slovenia*

References

Benedik, L.; Byrne, A. R. Trace uranium determination in foodstuffs and diets by radiochemical neutron activation analysis. In: Proceedings of the Seventh Symposium on Trace Elements in Man and Animals. Zagreb, Croatia: Institute for Medical Research and Occupational Health; 1991:33–12–33–13.

Byrne, A. R.; Benedik, L. Uranium content of blood, urine and

APPLIED ORGANOMETALLIC CHEMISTRY, VOL. 9, 305–313 (1995)

Arsenobetaine and Other Arsenic Species in Mushrooms

A. R. Byrne,*† Z. Šlejkovec,† T. Stijve,‡ L. Fay,‡ W. Gössler,§ J. Gailer§ and K. J. Irgolic§
† Jožef Stefan Institute, Ljubljana, Slovenia, ‡ Nestlé Research Centre, Lausanne, Switzerland, and § Karl-Franzens University, Graz, Austria

Arsenic species in arsenic-accumulating mushrooms (*Sarcosphaera coronaria*, *Laccaria amethystina*, *Sarcodon imbricatum*, *Entoloma lividum*, *Agaricus haemorrhoidarius*, *Agaricus placomyces*, *Lycoperdon perlatum*) were determined. HPLC/ICP MS and ion-exchange chromatography–instrumental neutron activation analysis (NAA) combinations were used. The remarkable accumulator *Sarcosphaera coronaria* (up to 2000 mg As kg^{-1} dry wt) contained only methylarsonic acid, *Entoloma lividum* only arsenite and arsenate. In *Laccaria amethystina* dimethylarsinic acid was the major arsenic compound. *Sarcodon imbricatum* and the two *Agaricus* sp. were found to contain arsenobetaine as the major arsenic species, a form which had previously been found only in marine biota. Its identification was confirmed by electron impact MS.

Keywords: arsenic species; mushrooms; methylarsonic acid; dimethylarsinic acid; tetramethylarsonium ion; arsenobetaine; arsenite; arsenate; HPLC/ICP MS; IC/INAA

1 INTRODUCTION

In contrast to a wealth of data on arsenic compounds in marine systems, hardly any information is available on terrestrial biota. Total arsenic concentrations are generally low in terrestrial plants, but certain higher fungi can accumulate this element. Known accumulators include *Laccaria amethystina*[1-6] and *Laccaria fraterna*[3] (*ca* 100 mg kg^{-1} dry weight), *Agaricus* sp.,[5,7] *Ramaria pallida* and *Macrolepiota procera*,[8,9] *Lycoperdon perlatum*,[5,8-10] and especially *Sarcosphaera coronaria*,[4] where up to 2000 mg kg^{-1} (dry weight) were found. Recently we showed[11] that the arsenic accumulated in the edible mushroom *Laccaria amethystina* is almost all in the form of scarcely toxic dimethylarsinic acid (DMA).

Quite apart from its scientific interest in relation to the cycling of arsenic in the environment, the arsenic compounds present in edible mushrooms are obviously of concern to the consumer (and the regulating authorities), because arsenic compounds vary considerably with respect to their toxicity. Inorganic compounds of arsenic are more toxic than organic derivatives. Certain organic arsenic compounds such as arsenobetaine (AB) and arsenocholine appear to be not toxic at all.

The aim of the work reported in this paper was the identification of arsenic compounds in arsenic-accumulating mycorrhizal and saprophytic mushrooms. Because the identification of arsenic compounds is to a certain extent methodologically dependent, the results should be confirmed by more than one technique. Hence, high-performance liquid chromatography (HPLC) coupled to an inductively coupled plasma–mass spectrometer (ICP–MS)[12] and ion-exchange chromatography with detection of arsenic by instrumental neutron activation were used.[13]

2 EXPERIMENTAL

2.1 Reagents and standards

$NaH_2PO_4 \cdot 2H_2O$, H_3PO_4, $NaAsO_2$ and $Na_2HAsO_4 \cdot 7H_2O$ of p.a. quality were purchased from Merck. Methylarsonic acid (MA, m.p. 156 °C) and dimethylarsinic acid (DMA, m.p. 190 °C) were gifts from Vineland Chemical Co. (Vineland, NJ, USA). Arsenobetaine bromide (AB, m.p. 228 °C) was prepared from trimethylarsine and bromoacetic acid.[14] Trimethylarsine

* Author to whom correspondence should be addressed.

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MERCURY AND SELENIUM: PERSPECTIVES FROM IDRIJA*

A.R.Byrne[1], M.Škreblin[1**], I.Falnoga[1], K.Al-Sabti[1], P. Stegnar[1,2], M.Horvat[1,3]

1. J.Stefan Institute, 61000 Ljubljana, Slovenia

2. International Atomic Energy Agency (IAEA), Vienna, Austria

3. Marine Environment Laboratory, IAEA, Monaco

ABSTRACT

In view of revived interest in the toxic effects of mercury vapour, particularly from dental amalgam, some studies on exposed humans and animals and the interaction of mercury with selenium are reviewed.

Results on the co-accumulation of mercury and selenium in the thyroid, pituitary, brain and kidney of mercury miners from Idrija are collated and updated, and compared to similar data from other laboratories.

Some other local studies relevant to the toxicity of mercury vapour and its interrelation with selenium are described. These include research on rats exposed in the mercury mine, where the kinetics of absorption and excretion of mercury, its modelling, and the behaviour of endogenous selenium and copper were followed.

Another study describes work on speciation in blood compartments, cord blood and placenta of mothers in groups of fish eaters and non-fish eaters, and the absence in the latter group of a correlation between mercury levels and the number of amalgam

*Presented in part as an invited lecture at the International Symposium "Status Quo of Dental Amalgam", European Academy, Otzenhausen, Germany, April 29 - May 1, 1994.

**Present address: "PLIVA" Pharmaceutical Co., Zagreb, Croatia

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Production of hair intercomparison materials for use in population monitoring programmes for mercury and methylmercury exposure

S.F. Stone[1], F.W. Backhaus[2], A.R. Byrne[3], S. Gangadharan[4], M. Horvat[5], K. Kratzer[6], R.M. Parr[1], J.D. Schladot[2], R. Zeisler[1]

[1] International Atomic Energy Agency, Department of Research and Isotopes, POB 100, A-1400 Vienna, Austria
[2] Research Centre KFA, Institute for Applied Physical Chemistry, Jülich, Germany
[3] Jožef Stefan Institute, Ljubljana, Slovenia
[4] Bhabha Atomic Research Centre, Analytical Chemistry Division, Trombay, Bombay, India
[5] International Atomic Energy Agency, Marine Environment Laboratory, Monaco
[6] Czech Technical University in Prague, Department of Nuclear Chemistry, Prague, Czech Republic

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Abstract. Ten kilograms of hair obtained from India were used as the basis for two intercomparison materials, one with natural low levels of mercury and methylmercury, and one with an elevated level of methylmercury. The latter was produced by labeling the hair with a solution containing methylmercury. To convert the hair into homogeneous powders, cryogenic milling was utilized. 70% of the final material passed through a 0.075 mm sieve. Subsequent studies were carried out to establish the homogeneity of the materials and the stability of the methylmercury label. The materials will be distributed in an international intercomparison, the results from which will be used to obtain recommended values for total mercury and methylmercury.

Introduction

The monitoring of population exposure to forms of mercury, especially organic forms, such as methylmercury, has gained importance because of the toxicological effects of mercury compounds on the nervous system [1]. Population monitoring using hair analysis has been proven to be an effective method, due to bioconcentration and relative ease of sample collection as compared to blood samples. To validate the measurements from such studies, proper quality assurance materials at varying levels are required. Several hair reference materials have been available in the past, but have not been certified for their methylmercury content. In addition, some of these materials are no longer available, or contain predominantly inorganic mercury. In order to at least partially meet the need for such studies, it was decided to develop two hair intercomparison materials; one characteristic of a low natural level of methylmercury, and the other representing an exposed population with a higher level of methylmercury. The production of these proposed reference materials was achieved through international co-operation of personnel and laboratories.

Correspondence to: S.F. Stone

Materials and methods

Sample collection

A large quantity of human hair (35 kg and 25 kg) was obtained in two lots from Thirumala Tirupati Devasthanam, Tirupati, India. Preliminary processing of each batch (physical cleaning, washing with acetone, water, and finally with acetone) was done at Tirupati, yielding a total of 10 kg of hair of acceptable quality for further processing. The lots were then mixed together at the Bhabha Atomic Research Centre (BARC). The material was cut into uniform (5–10 mm) lengths, using clean stainless steel scissors, and cleaned with acetone and deionized water following the procedure approved by the World Health Organization (WHO) and used in a previous International Atomic Energy Agency (IAEA) research program [2]. All washing and mixing operations were carried out using acid-cleaned polyethylene containers. The material was then split into two portions, each approximately 5 kg, sealed in polyethylene bags and was radiation sterilized at 50 kGy using the facility at ISOMED of the Board of Radiation and Isotope Technology (Bombay, India). Following radiation sterilization, the two portions were sent to the IAEA in Vienna, Austria.

Labeling with methylmercury

One portion of the hair (5 kg) was labeled with methylmercury at the Czech Technical University in Prague to

Lichenologist 27(5): 375–385 (1995)

TRANSPLANTED EPIPHYTIC LICHENS AS BIOMONITORS OF AIR-CONTAMINATION BY NATURAL RADIONUCLIDES AROUND THE ŽIROVSKI VRH URANIUM MINE, SLOVENIA

Z. JERAN*, A. R. BYRNE* and F. BATIČ‡

Abstract: Samples of *Hypogymnia physodes* were transplanted to the environment of the former uranium mine at Žirovski vrh, Slovenia for two exposure experiments. The levels of the long-lived radionuclides, ^{238}U, ^{226}Ra and ^{210}Pb in lichen material were measured after 4 and 7 months in the first experiment, and 4, 8 and 12 months in the second, and compared with the levels in lichens growing *in-situ* from the same sampling locations. They were also compared with the nuclide levels found in air particulates by gamma spectrometry obtained at the regular site monitoring stations. The results showed that each of the radionuclides had its own distribution pattern in this environment. The highest ^{226}Ra levels were found in lichens in the near vicinity of the dry-tailings pile, while U concentrations were high in the valley of the confluence of the Todraščica and Brebovščica streams close to the former yellow-cake production plant in Todraž, and then decreased downstream. ^{210}Pb was the most uniformly distributed radionuclide and exhibited the highest level. The results also confirm that active biomonitoring with transplanted lichens can be a useful and cheap supplement to instrumental air pollution monitoring.

Introduction

Lichens, especially epiphytic ones, are widely used as indicators and/or monitors of air contamination (Ferry *et al.* 1973; Hawksworth & Rose 1976; Martin & Coughtrey 1982; Puckett 1988). They are efficient accumulators of many elements, particularly heavy metals and radionuclides that are released into the atmosphere because of natural and human activities. Their remarkable accumulative capacity for pollutants is based on their highly specialized nutrition strategy, as they filter practically all their nutrients from the air, rain and fog. Not only vital nutrients and trace elements, but also a variety of pollutants are taken up with the same efficiency. Investigations using lichens to monitor air quality have been carried out not only around known pollution sources such as coal-fired power plants, steel works, or other industrial and urban centres, but also to identify such possible sources (Puckett 1988; Sloof & Wolterbeek 1991; Herzig *et al.* 1989). Although there are many papers dealing with heavy-metal air pollution using lichens, only a few of them deal with enhanced levels of uranium (U) series radionuclides as a consequence of U mining/milling and yellow-cake production (Boileau *et al.* 1982; Beckett *et al.* 1982; Pettersson *et al.* 1988; Sheard 1985*a*,*b*).

*'Jožef Stefan' Institute, Jamova 39, SLO-61111 Ljubljana, Slovenia.
‡Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, SLO-61111 Ljubljana, Slovenia.

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ELSEVIER

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JOURNAL OF CHROMATOGRAPHY A

Determination of trace amounts of selenium in poultry feedstuffs by gas chromatography

Vekoslava Stibilj*[,a], Marjan Dermelj[a], Anthony R. Byrne[a], Tatjana Šimenc[b], Jasna M. Stekar[b]

[a] Jožef Stefan Institute, Nuclear Chemistry Department, University of Ljubljana, 61 001 Ljubljana, Slovenia
[b] Biotechnical Faculty, Zootechnical Department, University of Ljubljana, Ljubljana, Slovenia

Abstract

In view of the importance of establishing reliable selenium concentration levels in different kinds of feedstuffs, the purpose of this work was to develop optimum experimental conditions for the isolation and GC determination of selenium as its chelate with 4-nitro-1,2-diaminobenzene. It was shown that ignition of the sample in an oxygen flask followed by reduction of Se(VI) to Se(IV) and the formation of 5-nitro-2,1,3-benzoselenadiazole chelate in HCl medium is a relatively rapid procedure giving a low blank value and allowing the determination of selenium in commercial feedstuffs and similar biological samples. The method was validated by the analysis of suitable certified or standard reference materials.

1. Introduction

Until 1957, selenium was known only as one of the most toxic elements. In that year, Schwarz and Foltz [1] identified selenium as a constituent of cellular glutathione peroxidase (GSH-Px) and since then its presence in enzymes such as plasma GSH-Px, phospholipid hydroperoxide GSH-Px, I iodothyronine-5′-diiodinase and selenoprotein P has been established, thus providing evidence for the involvement of selenium in numerous metabolic processes [2–4].

Symptoms of Se deficiency in poultry are manifested as exudative diathesis, fibrosis of the pancreas, fibrosis of the skeletal musculature and muscular dystrophy, whereas permanent excessive doses of selenium in poultry feed can cause blind staggers, alkali disease and acute toxicity, which are manifested in a decrease in egg laying and flying capability, in different anomalies of the embryo, incidence of paralysis and limping, liver cirrhosis, loss of feathers, etc. [5–7].

According to the Enviromental Health Criteria [8], the daily requirement of selenium in poultry is 30–50 $\mu g\ kg^{-1}$, provided that the amount of vitamin E in the daily ration is adequate. The major part is provided by grains, which are the main component of their feedstuffs and can contain, according to literature data [9], very variable amounts of selenium.

The legal regulation for the quality of different feeds in Slovenia specifies a minimum content of 150 $\mu g\ kg^{-1}$ of Se for dry poultry feedstuffs when added in the form of sodium selenite or selenate. The corresponding regulation for the maximum allowed amounts of harmful constituents in dry poultry feedstuffs permits a limiting value of 500 $\mu g\ kg^{-1}$ of Se. In spite of

* Corresponding author.

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DETERMINATION OF ORGANOARSENIC COMPOUNDS IN URINE AND BLOOD AFTER SEAFOOD CONSUMPTION AND EXPOSURE TO INORGANIC ARSENIC

Z. Šlejkovec, A.R. Byrne, M. Dermelj
"Jožef Stefan" Institute, Jamova 39, Ljubljana, Slovenia

Inorganic arsenic, MA, DMA, Asß and TMA-ion were determined in urine samples using an ion exchange method combined with instrumental neutron activation analysis. The excretion of arsenic species in urine following seafood consumption was studied and simultaneously blood arsenic concentrations were determined. The arsenic species present in the urine of some workers occupationally exposed to inorganic arsenic were also determined. The method was checked by the analysis of the standard reference material DORM 1.

INTRODUCTION

Most arsenic in the marine environment is present as the non-toxic organic compound $(CH_3)_3As^+CH_2COO^-$ (arsenobetaine, Asß) known since 1977[1]. Other forms of arsenic in the sea are inorganic arsenic (inorg.As), methylarsonic (MA) and dimethylarsinic acid (DMA), which are mostly present in water. The tetramethyl arsonium ion (TMA-ion), trimethylarsine oxide (TMAO) and arsenolipids were found in some marine animals (mussels, shrimp, crab, fish) and arsenosugars in some algae[2,3]. Consumption of seafood leads to an intake of Asß and other arsenic compounds.

On the other hand man can be exposed to inorganic arsenic, which is very toxic compared to less toxic organoarsenic compounds. Smelter workers, glass producers,

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^{81m}Se TRACER FOR DETERMINATION OF THE CHEMICAL YIELD IN RADIOCHEMICAL NEUTRON ACTIVATION ANALYSIS OF SELENIUM

V. STIBILJ, M. DERMELJ, A. R. BYRNE

"Jožef Stefan" Institute, Jamova 39, 61000 Ljubljana (Slovenia)

(Received December 13, 1993)

A radiotracer method is described for measurement of the chemical yield in radiochemical neutron activation analysis of selenium using the ^{75}Se (120 d) induced nuclide. It is based on ^{81m}Se (57 min) radioisotopic tracer, prepared immediately before its use in the radiochemical separation procedure, by neutron irradiation of highly enriched ^{80}Se. The recovery of selenium is calculated from the 103 keV γ-peak of ^{81m}Se in the separated selenium fraction used for quantitation of ^{75}Se. The technique is illustrated by results for biological reference materials of good accuracy and reproducibility.

It is well recognized that determination of individual chemical yields in radiochemical neutron activation analysis (RNAA) improves the quality of the procedure and the reliability of the resulting data by eliminating one of the more important sources of error, the uncontrolled nonconstant recovery. HEYDORN[1] has given a detailed treatment of the yield correction and its influence on precision and accuracy.

In RNAA determination of selenium via the reaction ^{74}Se(n,γ)^{75}Se (120 d), after sample destruction and radiochemical separation of selenium, it is our experience that the recovery of selenium carrier is never quantitative and usually varies over 10% or even 15%, irrespective of the details of the sample destruction and isolation procedures. This probably reflects the volatility of selenium and its multivalent character (incomplete conversion of forms). Hence a yield measurement is desirable to obtain high quality data.

Of the various methods available for recovery measurement, the radioisotopic tracer technique has several advantages (some of the desirable properties of such tracers and newer examples of their use were given by SCHELHORN et al.[2] and by BYRNE).[3] When the radiotracer is measured simultaneously with the induced (indicator) nuclide, the yield measurement procedure is not only simplified by one stage and efficient, but also increased in accuracy by compensating for factors affecting the count such as geometry, pile-up or dead time losses, the yield becoming an overall yield. For selenium when ^{75}Se is the indicator nuclide, the only practicable radioisotopic tracer is ^{81m}Se (57 min), with a desirable low energy γ-ray of 103 keV. (See Table 1). This isotope has

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Spectrophotometric Determination of the Chemical Yield in Radiochemical Neutron Activation Analysis of Selenium

Vekoslava STIBILJ, Marjan DERMELJ, Mladen FRANKO and Anthony R. BYRNE

Jožef Stefan Institute, P.O.B. 100, 61111 Ljubljana, Slovenia

A spectrophotometric method for measuring the chemical yield in radiochemical neutron activation analysis of selenium in feedstuffs and biological materials is described. The method is based on measuring the absorbance at 350 nm, which is due to the 5-nitro-2,1,3-benzoselenadiazole complex formed between selenium and 4-nitro-1,2-diaminobenzene. The technique was checked against radiotracer techniques using ^{75}Se or ^{81m}Se, and was illustrated by results for different botanical samples and certified reference materials.

Keywords Selenium, spectrophotometry, radiochemical neutron activation analysis, chemical yield, biological material

Although selenium is known to be an essential element for humans and animals[1-3], excessive quantities of this element can result in toxic effects or other anomalies.[4-8] The range of recommended selenium concentrations is relatively low (100 μg kg^{-1}) and narrow.[9] Sensitive and accurate analytical methods are therefore required for determining selenium in feedstuffs and biological tissues.

Several analytical methods, such as fluorometry, hydride-generation atomic absorption spectrometry (HGAAS), radiochemical and instrumental neutron activation analysis (RNAA, INAA) and gas chromatography (GC-ECD)[10-12], are currently available for determining selenium in the μg kg^{-1}, and even sub μg kg^{-1}, concentration range. Each of these methods has both advantages and disadvantages. RNAA, for example, provides excellent sensitivity and minimum possibilities of sample contamination.[13-19] However, it is time consuming and too expensive for routine work. For this reason RNAA is mostly used as a reference method in intercomparison analyses and in the certification of reference materials.

One of the crucial steps during the analysis of selenium in biological materials is sample decomposition. In this step selenium can be either lost due to the relatively high volatility of the element and its compounds and/or because of precipitation. In the case of RNAA[15-19], additional losses of selenium, which reflect its multivalent character, might occur during the decomposition because of an incomplete conversion of different Se forms. All such losses affect the chemical yield, which may vary over 10 or even 15%. Hence, determining the chemical yield for each sample is necessary to obtain high-quality data.

Various methods based on gravimetry, electrochemical techniques, spectrophotometry, reactivation or the use of radiotracers were demonstrated to be useful for a recovery measurement in RNAA.[20] Particularly radiotracer techniques have been widely used for this purpose, owing to their relative simplicity.

Two selenium isotopes appear to be suitable as radiotracers: ^{75}Se ($t_{1/2}$=120 d. E_γ=136, 264, 400 keV) and ^{81m}Se ($t_{1/2}$=57 min, E_γ=103 keV). While ^{75}Se seems to be more favorable, due to its longer half-life, it obviously cannot be used for a simultaneous chemical-yield measurement during the RNAA of Se, because ^{75}Se is also the nuclide induced by neutron activation. ^{75}Se radiotracer can, therefore, only be used preliminary measurements to estimate the average chemical yield of the RNAA procedure.

From this point of view, the ^{81m}Se radiotracer technique[21] offers several advantages which result from a simultaneous measurement of the induced nuclide and the radiotracer. This simplifies the yield measurement by one step, and makes it more efficient and more accurate by compensating for factors which affect the count, such as the geometry, pile-up or dead-time losses. However, this technique requires the use of highly isotopically enriched ^{80}Se in order to avoid any significant co-production of ^{75}Se in the ^{81m}Se tracer upon neutron irradiation. Besides, due to the relatively short half-life, the ^{81m}Se radiotracer cannot be used in radiochemical procedures which require longer times for their completion.

Among other techniques for a chemical-yield measurement in the RNAA of selenium, which were studied in this laboratory, reactivation to induce ^{81m}Se from added carrier selenium may be employed.[14] However, this technique requires the re-irradiation of an aliquot of the separated Se fraction and a second count. Such effects as the evaporation of organic solvents during neutron irradiation should be considered.

Spectrophotometric determination of the chemical yield in the case of RNAA based on the extraction of Se^{IV} as the carbamate[14] was also attempted, but without

(121)

Some Improvements in the Quality of NAA Procedures and the Reliability of the Results

A. R. BYRNE

Department of Nuclear Chemistry, "J. Stefan" Institute, 61000 Ljubljana, Slovenia

ABSTRACT

After considering the need for quality control in NAA, the concept of quality in NAA procedures themselves is discussed, and some important factors identified. Two approaches to improve quality are then described in more detail. The first concerns the unique ability of NAA using different isotopic reactions and different modes (INAA/RNAA) to provide independent data sets in the same laboratory, thus allowing internal validation or crosschecking. The second discusses the need for chemical yield measurements in RNAA and the advantages of the radioisotopic tracer technique. Some recent advances and further possibilities for this use of tracers are listed.

Index Entries: Neutron activation analysis; radiochemical NAA; quality control; independent data; crosschecking; chemical yields; radioisotopic tracers.

INTRODUCTION

An important practical point to be considered in relation to the quality of results from neutron activation analysis (NAA) is any *a priori* decision taken before analysis on the degree of quality required or affordable for reasons of cost. Because of advances in the sensitivity, accuracy, and multielement character of competing techniques, there is increasing commercial pressure on NAA laboratories to provide determinations in a suboptimum manner as concerns the quality of the procedure and the quality-assurance (QA) measures. Are we justified in cutting corners, e.g.

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Vol 43-45 (1994) 529-537

Comprehensive RNAA of Cadmium, Cobalt, Nickel, and Copper Using ^{109}Cd, ^{57}Co, and Reactor-Produced ^{67}Cu as Radioisotopic Yield Monitors

A. R. BYRNE* AND M. DERMELJ

Department of Nuclear Chemistry, "J. Stefan" Institute, 61000 Ljubljana, Slovenia

ABSTRACT

An existing radiochemical NAA procedure for Cd, Co, and Cu was improved to allow determination of individual radiochemical yields by the radioisotopic tracer technique, thus eliminating errors owing to variable recovery. ^{109}Cd was used as tracer for Cd determination via $^{115}Cd/^{115m}In$, ^{57}Co for Co via ^{60}Co, and potentially for Ni via ^{58}Co, whereas as a novelty ^{67}Cu, produced by reactor irradiation of ZnO of natural isotopic composition (by the ^{67}Zn [*n,p*] ^{67}Cu reaction) was used for Cu via the indicator nuclide ^{64}Cu. The simple production and purification of ^{67}Cu by anion exchange is described. Results for biological RMs are given and discussed.

Index Entries: Radiochemical NAA; copper; cobalt; cadmium; ^{67}Cu; radiochemical yield.

INTRODUCTION

One of the major potential errors in radiochemical neutron activation analysis (RNAA) is variation of the chemical yield of the separation. The advantages of individual yield measurements have been discussed thoroughly by Heydorn *(1)*, who also coined the term "comprehensive NAA" for a procedure in which the yield of the separation is measured. Apart from yield measurements based on chemical analysis of carrier recovery and the reactivation technique, the use of a suitable radioisotopic tracer

*Author to whom all correspondence and reprint requests should be addressed.

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DEPARTMENT OF CHEMISTRY

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LA JOLLA, CALIFORNIA 92093-0314
(619) 534-5499
FAX: (619) 534-5743

10 01. 1994
314

Fax: 3M 540

~~Dr. L. Kosta~~
~~J. Stefan Institute~~
Medical Faculty
University of Ljubljana
Ljubljana
Slovenia

January 5, 1994

Dear Dr. Kosta:

From April 29 to May 1, the European Academy will be holding a conference on physiological effects of mercury derived from dental amalgam, which will also focus on natural detoxification mechanisms by way of mechanisms such as the formation of mercury-selenium complexes. As a co-organizer of this conference, I would like to invite you to deliver a lecture on your pioneering work on the mercury miners of Idrija. Should you be unable to participate personally, we would appreciate it very much if you could send one of your colleagues. We will pay your travel and lodging expenses. The conference will be held at the European Academy Center of Otzenhausen, which is near Worms, in Germany. I would be happy if you could let me know as soon as possible, preferably by FAX (number see below) whether you can accept this invitation.

Sincerely,

G.N.Schrauzer
Professor of Chemistry
FAX (USA) 619 534 5743

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BIOTEHNIŠKA FAKULTETA
ODDELEK ZA AGRONOMIJO

mag. Hojka KRAIGHER, dipl biol., dipl.inž.gozd.

CITOKININI IN TIPI EKTOMIKORIZE PRI SADIKAH SMREKE (*Picea abies* (L.) Karst) KOT KAZALCI ONESNAŽENOSTI GOZDNIH RASTIŠČ

DOKTORSKA DISERTACIJA

CYTOKININS AND TYPES OF ECTOMYCORRHIZAE ON NORWAY SPRUCE SEEDLINGS (*Picea abies* (L.) Karst) AS INDICATORS OF FOREST SITE POLLUTION

DOCTORAL DISSERTATION

Ljubljana, 1994

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(619) 534-5499
FAX: (619) 534-5743

Dr.Anthony R. Byrne
University of Ljubljana
Jozef Stefan Institute
Nuclear Chemistry Department
Ljubjana
Slovenia

January 15, 1994

Dear Dr.Byrne:

Thank you so much for responding to my letter to (the late) Dr.Kosta. I am sorry that I was unaware of his death; the more I now wish to see that the work he and you were doing is receiving international attention. As you may not yet know, there is a lot of turmoil now in Germany because Degussa, the largest producer of dental amalgams, suddenly announced they were stopping to make it. Other companies have followed suit, and there is now somewhat of a hysteria developing in Germany concerning the safety, or lack thereof, of dental amalgam fillings. Some persons already wish to promulgate a zero-tolerance limit for mercury, causing many people with amalgam fillings to be greatly concerned. The forthcoming conference will address the issue of amalgam toxicity and discuss protective measures. Selenium is a major factor here, because as you well know, it detoxifies selenium quite efficiently.

Because of yours and Dr.Kosta's work your lecture will be of utmost importance. The title which you suggest, "Mercury and Selenium: Recent Developments in Slovenia" sounds fine, although you can leave off Slovenia in the title, if you wish, as your findings no doubt have universal significance.

Within the next few days you will receive a communication from Dr.H.Porcher, Director of "biosynposia", the organizer of the conference, with further details.

I am looking forward to meeting you at the conference. As you probably know, I am the Editor of the Journal Biological Trace Element Research. We have published a paper by Dr.I.Falnoga on mercury recently, and perhaps we could publish a version of your talk in this journal as well.

Sincerely yours and best regards,

G.N.Schrauzer
Professor of Chemistry

UNIVERZA V LJUBLJANI
FAKULTETA ZA NARAVOSLOVJE IN TEHNOLOGIJO
ODDELEK ZA KEMIJO IN KEMIJSKO TEHNOLOGIJO

Boris STROPNIK

ANALIZA AEROSOLOV IN NJIHOV VPLIV V OKOLICI TERMOELEKTRARNE ŠOŠTANJ

Disertacija

Ljubljana, 1994

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p. p. 531

Komisija za podiplomski študij
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PASSIVE BIOMONITORING WITH EPIPHYTIC LICHENS FOR ASSESSING TRACE ELEMENT AIR POLLUTION IN SLOVENIA

Zvonka JERAN[1], Franz BATIC[2], Radojko JACIMOVIC[1]

[1] *„Jožef Stefan" Institute, Jamova 39, SLO–61111 Ljubljana, Slovenia*

[2] *University of Ljubljana, Biotechnical faculty, Department of Agronomy, Jamnikarjeva 101, SLO–61111 Ljubljana, Slovenia*

In 1992, a monitoring survey on a national scale was carried out using *Hypogymnia physodes* (L.) Nyl. as a biomonitor for trace element air pollution. Lichen samples were collected from 86 sampling points of a regular 16 x 16 km bioindication grid. The k_0–method of instrumental neutron activation analysis (INAA) was used for trace element determination, and X–ray fluorescence spectrometry for sulphur analysis. The geographical concentration patterns of the trace elements obtained from the lichen data were mapped using the Surfer programme and compared with the index of atmospheric purity (I#P) calculated on the basis of data from lichen thalli types mapping, obtained on a more dense bioindication grid in 1991.

The results obtained showed good agreement between the mapping of sulphur and trace elements with the status of lichen vegetation. The most exposed region with elevated trace element levels and lower values of IAP were in the north–western Alpine part of Slovenia which coincides with high precipitation, and in the east of Slovenia, where many local pollution sources are situated.

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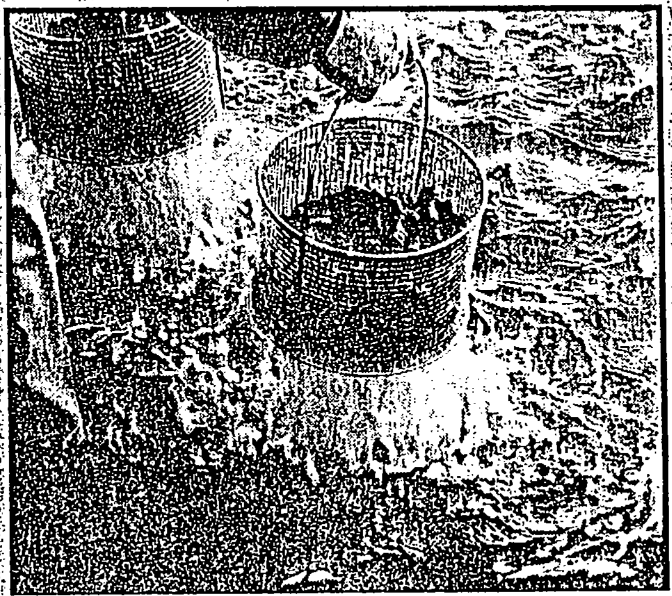

Book of Abstracts

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ATMOSPHERIC HEAVY METAL POLLUTION IN SLOVENIA DERIVED FROM RESULTS FOR EPIPHYTIC LICHENS

Z. Jeran, R. Jaćimović, B. Smodiš, F. Batič[1], H.Th. Wolterbeek[2]

"J.Stefan" Institute, Jamova 39, 61111 Ljubljana, Slovenia
[1]Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61111 Ljubljana, Slovenia
[2]Delft University of Technology, Interfaculty Reactor Institute, Mekelweg 15, 2629 JB Delft, The Netherlands

In 1992, a monitoring survey was started on the national scale in Slovenia using the epiphytic lichen *Hypogymnia physodes* (L.) Nyl. The primary aim was to analyse lichens to obtain information about the levels of elements in the atmosphere and to identify significant pollution sources.

H. physodes was collected in the period from September to November 1992 from almost all 86 sampling points of the 16x16 km bioindication grid of Slovenia. More than 30 elements were determined in each of the samples using the k_0-method of instrumental neutron activation analysis.

Monte Carlo-Assisted Factor Analysis was applied to a data set of the 28 elements As, Ag, Ba, Br, Ce, Cd, Co, Cr, Cs, Fe, Ga, Hf, Hg, K, La, Mo, Na, Rb, Sb, Sc, Se, Sr, Sm, Tb, Th, U, W and Zn, which were selected from the elements determined as the most important ones for identification of pollution sources. A Monte Carlo approach was used to give more insight into the uncertainties and significance levels of the factor analysis results. It was found that concentration patterns in lichens yielded 9 factors (source types), which are presented and discussed in detail in the work. The geographical patterns of the contributions of all factors are also shown.

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ABSTRACTS

ZBORNIK POVZETKOV

Bled, 10.-13. APRIL, 1995

UGOTAVLJANJE STANJA ONESNAŽENOSTI SEDIMENTOV V VODAH ŠALEŠKE DOLINE Z UPORABO INSTRUMENTALNE NEVTRONSKE AKTIVACIJSKE ANALIZE

POLLUTION STATUS OF SEDIMENTS IN WATER BODIES IN THE ŠALEK VALLEY BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

Borut Smodiš, Marjan Dermelj, Radojko Jaćimović, Boris Stropnik[1]
Institut Jožef Stefan, SI-61111 Ljubljana, Jamova 39, Slovenija
[1]ERICo SI-63320 Velenje, Koroška 64, Slovenija

Rast industrializacije in z njo povečana naseljenost povzročata, da se tudi v naš, slovenski prostor, steka vse več tujih primesi.
Med dokaj onesnažena in morda že kritična področja v Sloveniji prištevamo tudi Šaleško dolino, kjer se zaradi rudarjenja lignita in obratovanja TE Šoštanj spreminja njena konfiguracija ter onesnažujejo zrak in vodotoki.
Za ugotavljanje stanja in časovnih sprememb v stopnji onesnaženja voda so, poleg vode same in živih organizmov v njej, zelo pomemben medij tudi usedline.
Na osnovi predhodnih preiskav smo odvzeli usedline na 15 vzorčevalnih mestih in jih po ustreznih predpisih pripravili za analizo. Numerične vrednosti za 40 elementov v vsakem vzorcu (pretežno težkih kovin), ki so višje od meje detekcije, smo določili z instrumentalno nevtronsko aktivacijsko analizo (INAA), osnovano na k_0 -faktorjih. Zanesljivost rezultatov smo preverili s pomočjo analiz ustreznih certificiranih referenčnih materialov. Rezultati, ki so predstavljeni grafično in z ustreznimi komentarji, nakazujejo predvsem lokalno onesnaženje z nekaterimi težkimi kovinami kot posledico vpliva delovanja TEŠ.

Abstract

The growth of industrialization and the associated increase in population have also led in Slovenia to the great part of pollution. Among polluted and possibly critical areas in Slovenia the Šalek valley should be included, where due to the lignite mining industry and the Šoštanj thermal power plant changes the configuration of the terrain and contamination of air and waters have occured.
Next to water itself and aqueous organisms, sediments are very important media for evaluation of the status of water pollution.
On the basis of previous work the sediments were sampled from 15 different places and prepared for analysis using an appropriate protocol. Concentrations for 40 elements in each sample (mainly metals), which were higher than the limits of detection, were determined by the use of the k_0 -based instrumental neutron activation analysis (INAA). The reliability of the results obtained was checked by the use of certified reference materials. The results, which are presented graphically together with comments, show mainly local pollution with heavy metals as a consequence of the operation of the Šoštanj power plant.

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SPEKTROSKOPIJA V TEORIJI IN PRAKSI

ABSTRACTS

ZBORNIK POVZETKOV

Bled, 10-13 APRIL, 1995

MIKROELEMENTI V VODNEM KROGOTOKU ŠALEŠKE DOLINE

TRACE ELEMENTS IN THE WATER CYCLE OF THE ŠALEK VALLEY

Marta Svetina[1], Borut Smodiš[2], Zvonka Jeran[2] in Radojko Jaćimović[2]
[1] *ERICo Velenje, Zavod za ekološke raziskave, Koroška 64, 63320 Velenje, Slovenija*
[2] *Institut "J. Stefan" Ljubljana, Jamova 39, 61000 Ljubljana, Slovenija*

Z nalogo smo v Sloveniji prvič uvedli metodo malega povodja, v kateri uporabljamo povirje kot naraven laboratorij, kjer sledimo delu vodnega cikla v gozdnem ekosistemu. Program zajema raziskave na treh zlivnih območjih, na katerih vzorčujemo padavine na odprtem prostoru, talno vodo v globini 50 cm in vodne izvire. Kot glavna analitska metoda je bila uporabljena instrumentalna nevtronska aktivacijska analiza na faktorjih k_0 (INAA), s katero so bili v vzorcih voda določeni sledni elementi in težke kovine. Rezultati analize kažejo na povečane vsebnosti in koncentracijska območja elementov v tleh, padavinah, talni raztopini in vodnih izvirih v bližini Termoelektrarne Šoštanj. V padavinah so še posebej povečane koncentracije As, Au, Ba, Co, Cr, Cu, Sb, Sc in Zn. Primerjava koncentracij mikroelementov v padavinah s tistimi v vodnih izvirih, kaže, da se v tleh akumulirajo Au, As, Cr, Sb, Sc in Zn. Z raziskavo smo prikazali uporabost INAA za določanje nekaterih toksičnih mikroelementov v okolju.

Abstract:

The small watershed technique was introduced for the first time in Slovenia: this provides an ideal field laboratory where the water cycle in forested ecosystems can be followed. The programme includes research on three watersheds where sampling bulk precipitation deposition in the open, seepage water at 50 cm soil depth and spring water is performed. As the main analytical method for determination of trace elements and heavy metals in water samples the k_0- based method of INAA was used. The analytical results showed an increased content and concentration range of trace elements in soil, precipitation, soil water and spring water in the vicinity of the Šoštanj Thermal Power Plant. As, Au, Ba, Co, Cr, Cu, Sb, Sc, and Zn are increased in precipitation. The comparison of trace element concentrations in precipitation samples with those in spring waters revealed the fact that Au, As, Cr, Sb, Sc, and Zn are accumulated in soil. We demonstrated that the k_0- based method of INAA as a multielement nondestructive technique is a highly suitable approach to determining some toxic trace elements in the environment.

13th EUROPEAN TRIGA CONFERENCE

Abstracts

BLED, SLOVENIA
September 26-28, 1994

Status of Neutron Activation Analysis in Slovenia: Achievements and Applications

Borut Smodiš, Ljudmila Benedik, Anthony R. Byrne, Marjan Dermelj, Radojko Jaćimović, Zvonka Jeran, Vekoslava Stibilj, Zdenka Šlejkovec
J. Stefan Institute, Ljubljana, Slovenia

During the past decades the determination of trace elements in biological and environmental samples has been a subject of continual interest in the biomedical and environmental sciences for assessing nutritional status, diagnosis of disease, identifying systemic intoxication and/or monitoring of environmental exposures, and following pathways.

Such assessments are firmly based on the use and on the continuous development of reliable analytical methods for determination of very low concentration levels of essential or toxic elements. Among them neutron activation analysis (NAA) in both its radiochemical (RNAA) and instrumental (INAA) forms is very useful.

In using the Institute's 250 kW TRIGA Mark II reactor for determination of ultra trace quantities of elements As, Cd, Co, Cu, Hg, I, Mn, Mo, Ni, Sb, Se, Sn, Th, U and V, different radiochemical methods, mostly based on solvent extraction separations, have been developed.

Apart from RNAA, instrumental NAA is also much used in the Department of Nuclear Chemistry of the J. Stefan Institute, where the k_0 - based technique has been implemented, allowing determination of 63 elements in samples with various matrices.

These methods allow measurement of the total concentration of elements, and in refined forms also studies of their speciation and binding to proteins.

According to the nature of NAA (high sensitivity for several elements, negligible matrix influence on analytical results, small probability for sample contamination), the Department of Nuclear Chemistry acted several times as a reference laboratory for Hg determinations in the United Nations Environment Program (UNEP) and in International Atomic Energy Agency (IAEA) programs, or as an external cooperating analyst for the National Institute of Standards and Technology (NIST), as well as in many IAEA reference materials certification exercises. The results of these analyses are quoted in many of their certificates of analysis.

Together with measurements of the content and distribution of radionuclides, both man-made and natural, these methods form the foundation for a wide program of studies mainly concerned with environmental pollution, radio ecology and life sciences. Some typical results will be outlined.

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Rall 9

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THIRTEEN EUROPEAN TRIGA USERS CONFERENCE

PROCEEDINGS

HELD AT
J. STEFAN INSTITUTE, LJUBLJANA, SLOVENIA

SEPTEMBER 26-28, 1994

INSTITUT "JOŽEF STEFAN"

Status of NAA in Slovenia: Achievements and Applications

B. Smodiš L. Benedik, A.R. Byrne, M. Dermelj, A. Fajgelj, I. Falnoga, R. Jaćimović, Z. Jeran, P. Stegnar, V. Stibilj, B. Stropnik, Z. Šlejkovec
J.Stefan Institute, Ljubljana, Slovenia

Abstract

During past decades the accurate determination of trace element concentrations has been a subject of enormous interest for many fields such as nutrition, clinical chemistry and biochemistry, veterinary science, agriculture, environmental sciences, etc.

Among reliable analytical methods for determination of very low concentration levels of essential and toxic elements NAA in both its forms, RNAA and INAA, is very useful, and is also well-known as a reference method /1/.

When using INAA the matrix usually has a negative influence on the ratio between the signal and background. This results in poorer accuracy and higher limits of detection. Such difficulties may be avoided in most cases through application of RNAA methods which, on the basis of carefully chosen experimental conditions, offer selective isolation of the desired radionuclide(s). Further, the addition of carriers and/or radiotracers enables the determination of the chemical yield for each analyzed sample.

In using the Institute's 250 kW TRIGA MARK II Reactor for determination of ultra trace quantities of different elements various radiochemical methods have been developed which are briefly presented in the text below, and have been used to study their levels in human and biological samples, environmental samples and SRMs.

1. Determination of U and Th

For simultaneous determination of uranium and thorium via ^{239}U (23.5 min) and ^{233}Pa(27 d) radionuclides, the so-called LICSIR technique (Long Irradiation, Cooling, Short Irradiation, Radiochemistry) was used. The separation of the induced radionuclides is based on solvent extraction with TBP and TOPO and the chemical yield for the two elements is determined using the radioisotopic tracers ^{235}U and ^{231}Pa /2,3/, respectively.

2. Determination of I and Se

Quantitative determination of both elements in the same sample aliquot via ^{128}I and ^{75}Se after double irradiation (LICSIR technique) of the sample is based on combustion in oxygen followed by solvent extraction (redox cycle for extraction and stripping of iodine, and extraction of the Se chelate 5-nitro-3,1,2-benzoselenadiazole /4/. The chemical yield for I was determined spectrophotometrically and for Se either spectrophotometrically /5/ or by using the radioactive tracer ^{81m}Se /6/.

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PROCEEDINGS

HELD AT
J. STEFAN INSTITUTE, LJUBLJANA, SLOVENIA

SEPTEMBER 26-28, 1994

INSTITUT "JOŽEF STEFAN"

Estimating Errors in the Experimental Determination of Neutron Fluence Spectra

Borut Smodiš, Radojko Jaćimović
J. Stefan Institute, Ljubljana, Slovenia

Abstract

For characterisation of the neutron fluence shape in a reactor, two parameters are relevant: (1) the thermal-to-epithermal fluence rate ratio ($f = \varphi_{th} / \varphi_e$), and (2) the parameter α in the $1/E^{1+\alpha}$ epithermal spectrum representation. Both parameters are determined experimentally, thus introducing errors in the results. The influence and propagation of these errors can be also calculated. These characteristics were experimentally determined for some irradiation channels in the TRIGA Mark II reactor of the Jožef Stefan Institute, and the experimental errors introduced compared to calculated ones. A comparison between the experimentally obtained uncertainties and the calculated ones is outlined and the influence of particular parameters on error propagation when determining α and f are elucidated.

Introduction

Reactor neutron activation analysis (NAA) is mostly based on (n,γ) reactions with thermal and epithermal neutrons. The thermal neutron spectrum shape is usually described by a Maxwell-Boltzman distribution, and the epithermal part can be approximated by a $1/E^{1+\alpha}$ dependence.

When characterising the neutron fluence rate for absolute or k_0 - based neutron activation analysis (NAA), two quantities describing the contribution of epithermal activation, namely a (accounting for the nonideality of the epithermal part of the neutron spectrum) and f [subcadmium (thermal)-to-epithermal neutron fluence rate ratio], should be introduced into the equations for concentration calculation. They have to be experimentally determined for each particular irradiation channel, thus introducing uncertainties in the results. When calculating the values of α and f from the experimental measurements, some other parameters enter the relevant equations, such as Q_0 (resonance integral to 2200 m s^{-1} cross-section ratio), F_{Cd} (correction factor for transmission of epithermal neutrons through Cd), and $\bar{E}_r$ (effective resonance energy), so that uncertainties in these parameters should also be considered.

The errors and their propagation depend on the method of determining α and f and on the monitors used.

For experimental determination of these two parameters, various methods have been proposed by De Corte and coworkers /1/. Methods for a-determination can be classified into three groups, based on Cd-ratio ("Cd-ratio for multi-monitor"-method), Cd-covered ("Cd-covered multi-monitor"-method) and bare irradiation

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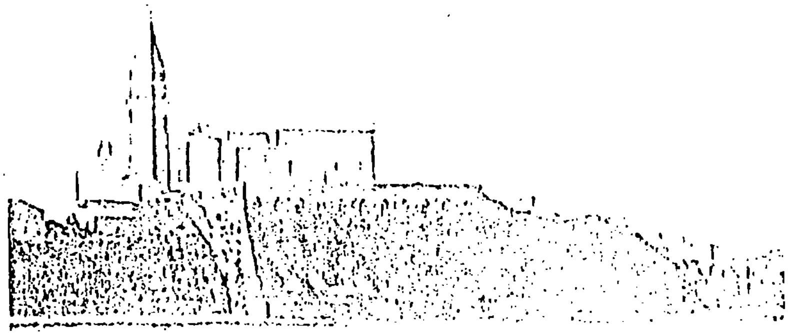

11. to 14. September 1995
Portorož, Slovenia

Nuclear constants for activation analysis of some nuclides and comparisons with experimentally measured values

R. Jaćimović, A. Trkov, B. Smodiš

"Jožef Stefan" Institute, Ljubljana, Jamova 39, Slovenija

Abstract

Neutron activation analysis requires a knowledge of the values for the Westcott g factors, the resonance integral I_0 and 2200 $m \cdot s^{-1}$ cross section σ_0 for the (n,γ) reaction. Sometimes the quantity Q_0 is used instead, defined as the ratio I_0/σ_0. The concept of the corrected resonance integral $I_0(\alpha)$ is introduced to take into accont of the deviation of the epithermal flux from the "1/E" distribution where α is defined to describe the spectrum in the form "$1/E^{1+\alpha}$". $I_0(\alpha)$ can be approximately expressed in terms of α, the effective resonance energy $\bar{E}_r$ and I_0, defined for a pure 1/E spectrum.

The required constants can be calculated from data in evaluated nuclear data libraries. For this purpose neutron data for all the nuclides of interest were retrieved from the JEF 2.2 evaluated nuclear data files [1]. The 1994 version of the ENDF/B pre-procesing codes [2] was used for data processing. A methodology for calculating $\bar{E}_r$ was developed which does not depend on the availability of the single level Breit-Wigner resolved resonance parameters.

A sensitivity study was carried out to investigate the influence of the parameter α on $\bar{E}_r$. The range of α from -0.08 to +0.08 was considered, which covers the span of values most commonly incountered in practical applications. The sensitivity of I_0 to temperature due to Doppler broadening was also investigated.

The results obtained have been compared to those reported in [3,4]. Furthermore,

REGIONAL CONGRESS

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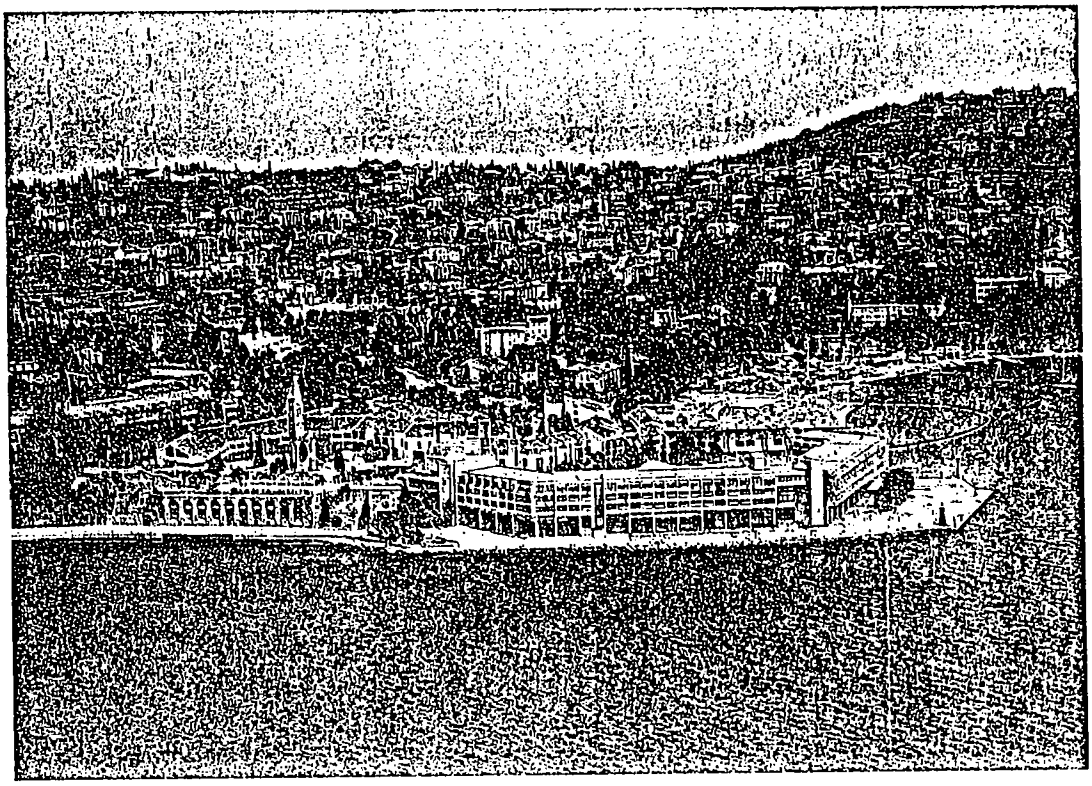


BOOK OF ABSTRACTS

PP52

NATURAL AND ARTIFICIAL RADIONUCLIDES IN LICHENS AS AIR POLLUTION MONITORS

Z. Jeran[1], R. Jaćimović[1], Franc Batič[2], A. Prosenc[1]

[1] Jožef Stefan Institute, Jamova 39, 61111 Ljubljana, Slovenia
[2] Biotechnical Faculty, Department of Agronomy, Jamnikarjeva 101, 61111 Ljubljana, Slovenia

Epiphytic lichens, symbiotic organisms composed of an algae and fungus, are efficient accumulators of many elements, particularly heavy metals and radicnuclides that are released into the atmosphere because of natural or human activities. In 1992 a national biomonitoring programme was initiated covering the whole territory of Slovenia to measure the levels of some natural (^{210}Pb, ^{40}K, U, Th) and artificial (^{137}Cs, ^{134}Cs) radionuclides in the epiphytic lichen *Hypogymnia physodes* L. (Nyl.) as to obtain information on their levels in our environment.

The epiphytic lichen *Hypogymnia physodes* L. (Nyl.) was collected at 86 sampling points of the 16 x 16 km bioindication grid of Slovenia and the levels of ^{210}Pb, ^{40}K, ^{134,137}Cs were determined by direct counting of dry samples using gamma spectrometry. U and Th levels were determined by the k_0-standardisation method of Instrumental neutron activation analysis.

The results are presented as geographical isocontours cf radionuclide activity on a national scale. The geographical distribution of radionuclides obtained from lichen data were divided into 7 classes according to percentile values (10, 30, 50, 70, 90 and 95 %) and were mapped using the Surfer programme.

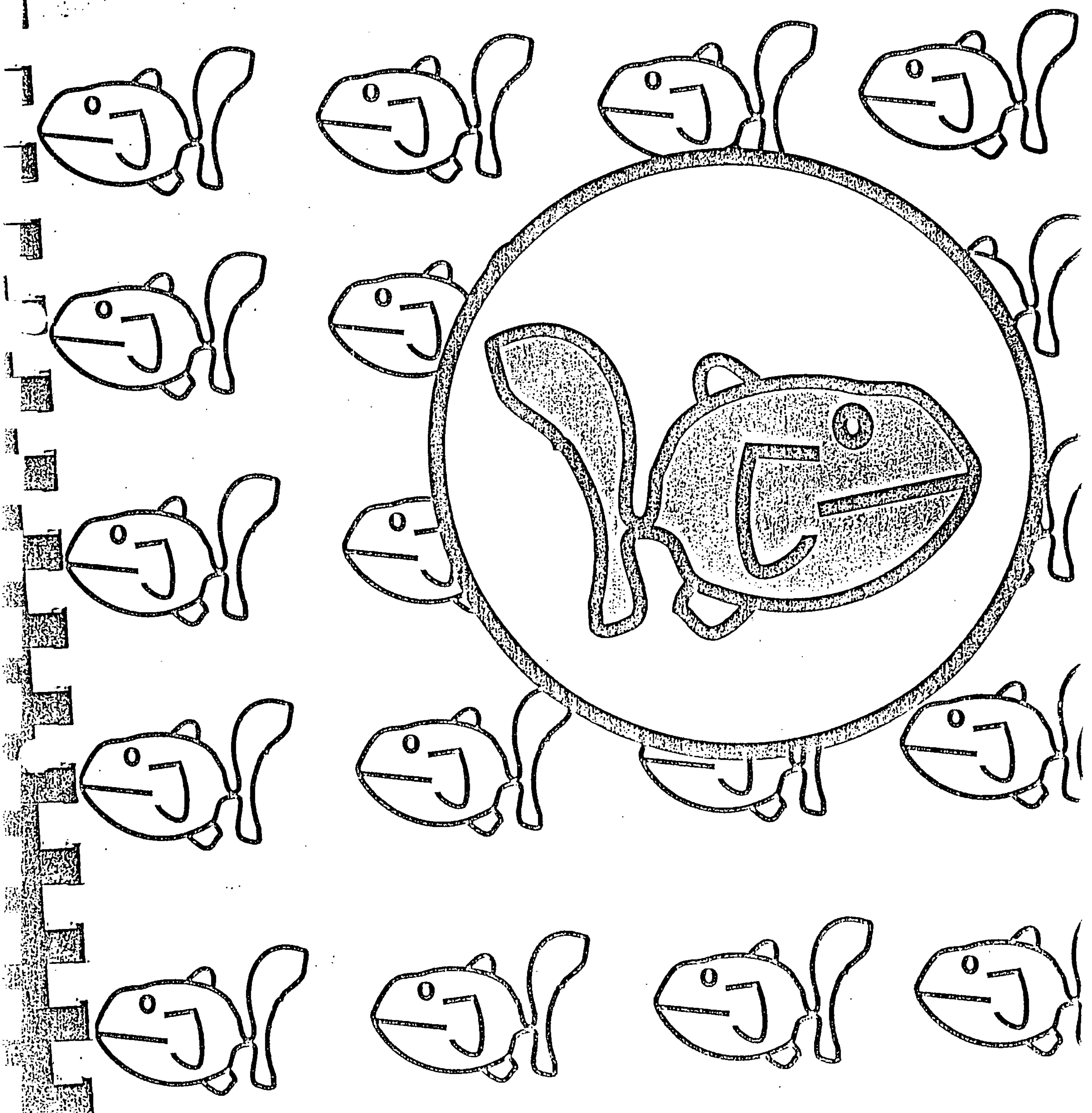
Each of the radionuclides analysed has its own geographical distribution pattern as a consequence of its origin. ^{210}Pb is the long lived radionuclide produced in the atmosphere by radioactive decay of its gaseous parent ^{222}Rn, ^{40}K, U and Th are natural radionuclides contained in the lithosphere, but $^{137+134}$Cs were released to the atmosphere during the Chernobyl accident and in atmospheric nuclear tests.

The mean value of ^{210}Pb was about 600 mBq g^{-1}, with the highest activity levels up to 1900 mBq g^{-1} in lichens collected in the southern - Dinaric region of Slovenia.

^{40}K levels were in the range between 65 - 290 mBq g^{-1}. Elevated levels were found in NW and W parts and at some locations in the east of Slovenia. Also the U and Th levels in lichens were low as expected, with mean value of 0.12 and 0.29 µg g^{-1}, respectively. The highest activity of both Cs-isotopes was found in samples from the north and north-west parts of Slovenia, which are known to have received the highest amounts of precipitation during the period following the Chernobyl accident.

1. simpozij živilske kemije in 2. posvetovanje o praktični uporabi evropskih predpisov za živila z mednarodno udeležbo

1st Symposium on Food Chemistry and 2nd Conference on Practical Application of European Legislation on Foodstuffs



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23., 24., 25. mai 1995

NEUTRON ACTIVATION ANALYSIS OF ESSENTIAL AND TOXIC TRACE ELEMENTS IN FOOD ARTICLES

M.Dermelj, V.Stibilj, A.R.Byrne, L.Benedik, Z.Šlejkovec, R.Jaćimović, B.Smodiš
"J. Stefan" Institute, Laboratory for Radiochemistry, 61000 Ljubljana, Slovenia

The major route for entry of essential and toxic elements into living organisms is via the food-chain. This fact and the recommendations of WHO and other bodies on daily allowances or maximum tolerable intakes of trace elements entering man via foodstuffs together create the need for accurate and reliable determination of microgram and nanogram quantities of essential and toxic elements in various food articles. This is a subject of enormous interest for many fields and research disciplines.

Despite the availability of numerous modern analytical techniques, reliable data on microconstituents in food articles are still scarce, unsatisfactory and doubtful for a number of trace elements. Among reliable methods for determination of very low concentration levels of essential and toxic elements neutron activation analysis (NAA) in both its forms, RNAA (radiochemical) and INAA (instrumental), is very useful, and is also well-known as a reference method.

Accordingly, for determination of trace quantities of the elements As, Cd, Co, Cu, Hg, I, Mo, Ni, Sb, Se, Sn, Th, U, V etc. various radiochemical methods have been developed in our laboratory and used to study the levels in human and biological samples.

The best way to validate the analytical procedures developed and of monitoring the reliability of the results obtained, is by the analysis of compositionally similar certified SRMs. The good agreement of our data with certified values shows the reliability of the radiochemical procedures developed.

Current Status and Future Trends in Analytical Food Chemistry

Proceedings of the Eight European Conference on Food Chemistry (EURO FOOD CHEM VIII)

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Poster Presentations

Austrian Chemical Society (GÖCh)
Working Party on Food Chemistry, Cosmetics and Tensides
A-1010 Vienna, Nibelungengasse 11, Austria

APPLICABILITY OF NEUTRON ACTIVATION ANALYSIS (NAA) IN QUANTITATIVE DETERMINATION OF SOME ESSENTIAL AND TOXIC TRACE ELEMENTS IN FOOD ARTICLES

Marjan Dermelj, Vekoslava Stibilj, Anthony R. Byrne, Ljudmila Benedik, Zdenka Šlejkovec, Radojko Jaćimović, Borut Smodiš

"J. Stefan" Institute, 61000 Ljubljana, Slovenia

The major route for entry of essential and toxic elements into living organisms is via the food-chain. This fact and the recommendations of WHO and other bodies on daily allowances or maximum tolerable intakes of trace elements entering man via foodstuffs together create the need for accurate and reliable determination of microgram and nanogram quantities of essential and toxic elements in various food articles. This is a subject of enormous interest for many fields and research disciplines.

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Određivanje aktivnosti ^{90}Sr mjerenjem Čerenkovog zračenja u aerogelu

D. Brajnik[a,b], S. Korpar[c] R. Jaćimović[a] G. Medin[d*] M. Starič[a] A. Stanovnik[a,b]

[a] Institut "Jožef Stefan", Ljubljana, Slovenija

[b] Elektrotehnički fakultet, Ljubljana, Slovenija

[c] Tehnički fakultet, Maribor, Slovenija

[d] Prirodno - matematički fakultet, Podgorica, Jugoslavija

ABSTRACT

The high radiotoxicity of the fission product ^{90}Sr requires quick and accurate assessement of its presence in the environment. The work describes a method of determination of ^{90}Y (E_β^{max} = 2.27 MeV, $T_{1/2}$ = 64 h), the daughter of ^{90}Sr (E_β^{max} = 0.546 MeV, $T_{1/2}$ = 28.5 y), on the basis of Cherenkov radiation of the β particles in a silica aerogel. The relatively high end-point energy of the ^{90}Y β spectrum, together with a suitably chosen aerogel refractive index and thus electron threshold energy, permits elimination or at least a considerable reduction of the interference of other β emitters with lower end-point energies. The interference of γ emitters is reduced by using a thin, transmission multiwire proportional chamber in coincidence with the aerogel Cherenkov detector. Any possible contribution of other radionuclides to the count rate may be monitored by the shape of the Cherenkov pulse height spectrum, which depends sensitively on the electron energy. With an aerogel refractive index of 1.055, which corresponds to an electron threshold energy of 1.1 MeV, we have obtained an efficiency of $5.3 \cdot 10^{-3}$ for $^{90}Sr/Y$. The background counting rate of $15 \cdot 10^{-3}$ s^{-1} is stable ($\sigma = 0.9 \cdot 10^{-3}$ s^{-1}) and allows the determination of 1 Bq of $^{90}Sr/Y$ activity in a few hours of measurement of a thin sample.

IZVOD

Visoka radiotoksičnost fisijskoga produkta ^{90}Sr zahtjeva brzu i tačnu ocjenu njegove prisutnosti u okolini. Rad opisuje metodu za određivanje ^{90}Y (E_β^{max} = 2.27 MeV, $T_{1/2}$ = 64 h), potomka ^{90}Sr (E_β^{max} = 0.546 MeV, $T_{1/2}$ = 28.5 godina), na osnovu Čerenkovog zračenja β čestica u silicijevom aerogelu. Srazmjerno visoka maksimalna energija β spektra ^{90}Y i primjerno izabran indeks prelamanja aerogela omogućavaju eliminisanje ili značajno smanjivanje prinosa emitera s nižim maksimalnim energijama spektara β. Korišćenje multižične komore u koincidenciji sa detektorom Čerenkovog zračenja znatno smanjuje pozadinu zraka γ. Moguće prinose od drugih emitera možemo pratiti na osnovu promjene oblika raspodjele Čerenkovih signala po visini, s obzirom na izražajnu zavisnost od energije elektrona. Pomoću aerogela čiji je indeks prelamanja 1.055, što odgovara energiji praga 1.1 MeV za emitovanje Čerenkove svjetlosti, postigli smo efikasnost $5.3 \cdot 10^{-3}$ za $^{90}Sr/Y$. Brojačka gustoća pozadine $15 \cdot 10^{-3}$ s^{-1} je stabilna ($\sigma = 0.9 \cdot 10^{-3}$ s^{-1}) i omogućava određivanje $^{90}Sr/^{90}Y$ aktivnosti približno 1 Bq za nekoliko časova mjerenja tankog uzorka.

* Odgovorni autor

A. Stibbe

Trace Elements in Man and Animals - TEMA 8

PROCEEDINGS OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON TRACE ELEMENTS IN MAN AND ANIMALS

Editors: M. ANKE, D. MEISSNER & C.F. MILLS
Friedrich Schiller University, Institute for Nutrition and Environment, Jena, Germany
Institute of Clinical Chemistry and Laboratory Diagnosis, Dresden-Friedrichstadt Hospital, Dresden, Germany
Rowett Research Institute, Aberdeen, UK

VERLAG MEDIA TOURISTIK

Heavy metal content in hen's eggs

Holcman, A., B. Smodis

University of Lubljana, Zootechnical Department, Biotechnical Faculty, 61230 Domzale and Jozef-Stefan-Institute, 61111 Ljubljana, Slovenia

INTRODUCTION

A hen's egg represents an important item of food in human nutrition. When an egg is studied the question of its content of heavy metals appears. It is known that heavy metals are present in eggs if hens are fed a diet containing heavy metals(1). Therefore, the question is if the concentration of heavy metals in eggs reflects the pollution of the environment. In the present research the contents of arsenic, cadmium, mercury and lead in eggs from intensive and free-range systems of hen rearing were studied.

MATERIAL AND METHODS

Three intensive and three free-range systems of rearing of hens were chosen. In the free-range system eggs were sampled from hens which pastured and were fed on home-produced fodder. These farms are situated in the vicinity of bigger cities, a motor-way and a generating plant, i.e. in areas where pollution with heavy metals can be expected. In the intensive system of rearing the hens were fed with complete feeding mixtures for laying hens. From each sampling site nine eggs were taken, grouped into three samples of three eggs, from which three samples of yolk and three samples of white were prepared. Concentrations of Pb and Cd were determined by atomic absoption spectroscopy (AAS) (2,3), of Hg by cold vapour atomic absorption spectroscopy (CVAAS) (4) and of As by neutron activation analysis (NAA) (5,6).

RESULTS

Concentrations of As, Cd, Hg, expressed in $ng.g^{-1}$ of lyophilised sample showed that more of these heavy metals was accumulated in the white, while Pb was accumulated in the yolk. But the total fresh yolk contained more heavy metals (except Hg) than the fresh white. In the studied samples the mean values of the concentrations of heavy metals tended to a higher content of heavy metals in free-range eggs in comparison with eggs from commercially kept hens (table 1 and 2).

SUMMARY

Heavy metal contents in egg yolks and whites from intensive and free range systems of rearing were studied. Tabulated results expressed in lyophilised matter showed that heavy metals accumulated more in white than in yolk except for Pb. The mean values showed a trend to higher contents of heavy metals in free range eggs than in eggs from commercially kept hens.

NAHRES-19
Vienna, 1994

APPLIED RESEARCH ON AIR POLLUTION USING NUCLEAR-RELATED ANALYTICAL TECHNIQUES

Report on the First Research Co-ordination Meeting

Vienna, Austria, 30 March - 2 April 1993

INTERNATIONAL ATOMIC ENERGY AGENCY

TRACE ELEMENT AIR POLLUTION MONITORING STUDIES IN SLOVENIA USING NUCLEAR ANALYTICAL TECHNIQUES

S.B. SMODIŠ[1], R. JAĆIMOVIĆ[1], Z. JERAN[1], B. STROPNIK[2], V. MIKLAVČIČ[1], P. STEGNAR[1]

[1]"Jožef Stefan" Institute, University of Ljubljana, Jamova 39, P.O.Box 100, SLO-61111 Ljubljana, Slovenia
[2]ERICo, Koroška 64, SLO-63320 Velenje, Slovenia

Abstract

In the past, only a few investigations have been performed in Slovenia concerning trace elements, toxic elements, heavy metals and radionuclides in the atmosphere. During recent years, several projects were initiated, involving health-related studies connected to air pollution in highly exposed areas, mapping the status of air pollution in the whole country using biomonitors, as well as some specific research, i.e. involving studies of mercury speciation in the atmosphere around a mercury mine or concentration levels of radionuclides in biomonitors around a uranium mine. Since all these projects were or are of a preliminary nature, in this report, the emphasis is mainly on the methodology and analytical development (neutron activation analysis and X-ray spectrometry), and to a lesser extent on the results obtained up to now. Efforts are being put into co-ordination of all the presently running projects in order to complement the results and to make an unified database for their later evaluation and statistical interpretation.

1. SCIENTIFIC BACKGROUND AND SCOPE OF THE PROJECT

In various countries in the world much effort is devoted to the air pollution studies connected with environmental impact and human health-related studies. In this respect, an important part of such research is devoted to the application of natural materials (mosses, lichens, grasses, ferns, tree rings, feathers, hair, *etc.*) as indicators/monitors of trace-element air pollution. Many studies are concerned with changes in species abundance, morphology and/or the physiology of the relevant organisms, all, however, without the ability to apportion these changes to any particular atmospheric pollution component.

In other studies the elemental content of the organism/material are measured, mostly aimed at the determination of relative changes observed with respect to variations in distances to a priori known pollution sources (highways, industrial complexes, *etc.*), without obtaining any quantitative information about the actual levels of the pollutants in the atmosphere. Much attention is paid to interspecies and intersubstratum calibrations, all resulting from problems arising from gaps in the abundance of the organisms/materials, due to their degree of sensitivity to total air pollution and/or other effects.

So far insight into the uptake mechanisms of atmospheric pollution components in natural materials is still lacking, and consequently little is known of the quantitative relationships between element concentrations in the monitor and those in the atmosphere.

RAPID INSTRUMENTAL AND SEPARATION METHODS FOR MONITORING RADIONUCLIDES IN FOOD AND ENVIRONMENTAL SAMPLES

Final Report on an IAEA Co-ordinated Research Programme

Vienna, Austria, 1995

IAEA/AL/088, Vienna (1995)

A report prepared by the IAEA's
Physics, Chemistry and Instrumentation Laboratory
Agency's Laboratories, Seibersdorf
Division of Research and Isotopes
P.O. Box 100, A-1400 Vienna, Austria

FAO
MEETING ON FOOD COMPOSITION ACTIVITIES IN EASTERN EUROPE

April 22-27, 1995 Modra
SLOVAKIA

FINAL REPORT

Food and Agriculture Organization, ROME
Food Research Institute, BRATISLAVA

May 1995

A REVIEW OF ANALYTICAL ACTIVITIES AT "JOŽEF STEFAN" INSTITUTE IN THE FIELD OF TRACE ELEMENT DETERMINATION IN FOOD ARTICLES USING NAA

M.Dermelj, L.Benedik, A.R.Byrne, R.Jaćimović, B.Smodiš, V.Stibilj, Z.Šlejkovec
"Jožef Stefan" Institute, Laboratory for Radiochemistry, 61000 Ljubljana, Slovenia

The major route of essential and toxic elements into living organisms is via the food-chain. This fact and the recommendations of WHO and other bodies on daily allowances or maximum tolerable intakes of trace elements entering man via foodstuffs together create the need for accurate and reliable determination of microgram and nanogram quantities of essential and toxic elements in various food articles. This is a subject of enormous interest for many fields and research disciplines (1).

Despite the availability of numerous modern analytical techniques, reliable data on microconstituents in food articles are still scarce, unsatisfactory and doubtful for a number of trace elements. Among reliable methods for determination of very low concentration levels of essential and toxic trace elements neutron activation analysis (NAA) in both its forms, RNAA (radiochemical) and INAA (instrumental), is very useful, and is also well-known as a reference method (2).

Utilizing the possibilities offerd by our 250 kW TRIGA MARK II Reactor for determination of trace quantities of essential and toxic elements, and to study the levels of these elements in human, biological and food samples, various radiochemical methods have been developed in our laboratory and were published in more detail elsewhere, for example: for U and Th (3), I and Se (4-6), Cd, Co and Cu (7), V (8), Ni and Co (9), for total As and its species (10-12), Hg and Se (13), Sn (14) etc.

The best way to validate the analytical procedures developed and of monitoring the reliability of the results obtained, is by the analysis of compositionally similar certified SRMs. The good agreement of our data with certified values demonstrated the reliability of the radiochemical procedures developed (Table 1).

The total concentration of the element alone gives little information about its possible effects on living organisms, such as toxicity or bioavailability; for this, determination of the chemical forms, i.e. speciation analysis, is required. From this point of view ion exchange methods for separation of arsenic species (inorganic arsenic, monomethylarsonic and dimethylarsinec acid, arsenobetaine, tetramethylarsonium ion) in various biological samples and the determination of total arsenic in the separated fractions using INAA were developed (11,12) involving As-speciation in urine, sea-food, mushrooms etc., following preliminary extraction into methanol (Table 2).

Apart from RNAA, INAA is also much used in our Laboratory for Radiochemistry, where the k_0-based technique has been implemented for multielemental analysis of environmental and other samles, which allows determination from 30-50 elements (Table 3) in one sample aliquot (15,16).

According to the nature of NAA (high sensitivity for many elements, negligible influence of the matrix on analytical results, small probability of sample contamination) which with care allows accurate and reliable results, and on the basis of experience in investigation and determination of trace elements in man and his environment, the IAEA invited our laboratory to take an active part as a reference laboratory for determination of the elements As, I, Sn and V in two coordinated WHO-IAEA projects aimed at producing definitive data for about 20 trace elements in total diet samples and in human milk samples collected from different countries (Table 4).

In addition, for many years our laboratory has cooperated with NBS (now NIST), Gaithesburg, USA, as an external cooperating laboratory in the certification of new biological and other reference

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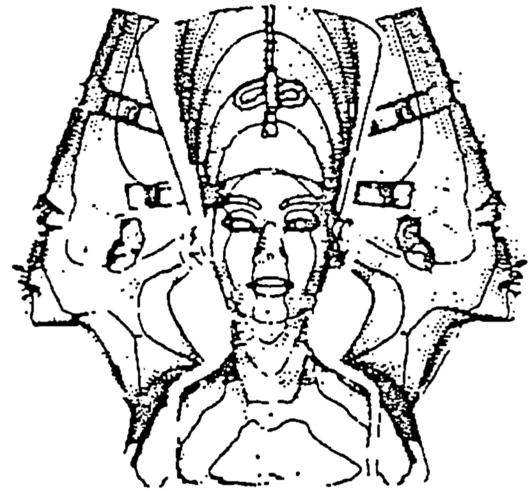

4th International Conference Non-Destructive Testing of Works of Art

4. Internationale Konferenz Zerstörungsfreie Untersuchungen an Kunst- und Kulturgütern

Berlin 3. - 8. Oktober 1994

Summary:

The applications demonstrated in this report clearly show that the X-ray backscatter imaging technique offers great capabilities in conventional material testing in principle, but also for monument preservation, archaeology and any kind of artistic object. The examples presented here show that the door has been opened to a completely new field, giving the experts new inspection possibilities and thus new insights into their precious objects.

The comparison of X-ray radioscopy and X-ray backscatter imaging clearly shows that these two techniques are complementary to each other. The backscatter technique reveals information about an object from the surface down to a certain depth range, and image details are localized in all three dimensions without the need of reconstruction. Image contrasts are mainly due to local density variations. Standard radiography has a larger penetration depth for test objects, and it is a bulk technique. Normally the third dimension is lost due to the 2D-projection, and image contrasts are mainly due to global density changes.

Acknowledgment

Part of this work would not have been possible without the support of the Landesmuseum Schleswig, the Stiftung Wartburg at Eisenach, the Institut für Denkmalspflege in Hannover and the DMF e.V at Ober-Eglfing.

References:

[1] R.S. Holt et al., Gamma-ray scattering techniques for non-destructive testing and imaging; Nucl. Instr. Meth. 221 (1985) p. 98

[2] J. Kosanetzky, G. Harding et al., Compton Backscatter Tomography of Low Atomic Number Materials; Non-Destructive Testing, Proc. 4th ECNDT, London ed. J.M. Farley, R.W. Nichols; Pergamon Press, New York (1988), p. 2118-2132

[3] W. Roye, The ComScan Backscatter Technique - Proc. 12th WCNDT, Amsterdam (1989) p. 31-36

[4] Philips data sheet ComScan 160, Compton X-ray Backscatter Inspection System

[5] W. Niemann und W.Roye, Neuartige Anwendung der Röntgenrückstreutechnik "ComScan" in der Archäologie und der Denkmalspflege (in German). DGZfP Berichtsband 37, S.157 (1993)

[6] R.Aniol, Landesmuseum Schleswig, Private communication

Deutsche Gesellschaft für Zerstörungsfreie Prüfung e.V., Berlin
4. Internationale Konferenz Zerstörungsfreie Untersuchungen an Kunst- und Kulturgütern
4th International Conference on Non-Destructive Testing of Works of Art

J.J. Rant, Z. Milic, I. Nemec, J. Istenic, B. Smodis, Ljubljana (SLO)

Neutron and x-ray radiography in the conservation of the roman dagger and sheath

Neutronen- und Röntgendurchstrahlung bei der Konservierung eines römischen Dolches mit Scheide

Abstract

A roman dagger, inserted in a sheath, was found in Ljubljanica river. The find was examined by X-ray and neutron radiography as complementary NDE techniques. NR was found useful in the detection of the thin waterlogged wood plates inserted in the sheath and helped in the determination of their function. ED XRF was used for local determination of elemental composition of metal and enameled structures of the sheath.

1. Introduction

In December 1992 a dagger, inserted in a sheath was found on a bottom of the Ljubljanica river near Črna vas, 5km south of Ljubljana, the capital of Slovenia. The find was acquired by Narodni muzej (National Museum) in Ljubljana within a research project "Archeological Survey of the Ljubljanica River " [1]. The length of the dagger inserted in the sheath is 34.3cm. The dagger and the sheath are made of iron. One side of the sheath and the hilt with the pommel are decorated with metal and enamel inlays. Undoubtedly the weapon is a roman dagger (*Pugio*). It was not found in a datable context, but on analogies it can be dated in the 1st century A.D.[1].

Roman daggers are rare finds, especially skilfully ornamented and well preserved. Therefore it was decided to perform a detailed and complex analysis of the find using complementary nondestructive examination (NDE) methods: X-ray radiography (XR) and thermal neutron radiography (NR) and applying simple computer image enhancement techniques. As qualitative nondestructive analytical technique the energy dispersive X-ray fluorescence spectrometry (ED XRF) was applied. The goals of the NDE were:

1. To determine the condition and the internal structure of metal parts (XR)
2. To check the possibility to detect remnants of organic materials (e.g waterlogged wood or leather) shielded by metal layers (NR)
3. To detect and identify traces of materials used for enameled and metal inlays (ED XRF)
4. To reveal features of the manufacturing technology of the weapon (XR, NR, ED XRF)

[1] Project leader Assoc.Prof.Dr.T.Knific, National Museum, Ljubljana, Slovenia

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The use of lichens in atmospheric trace element deposition studies in Slovenia

Zvonka Jeran[1], Radojko Jaćimović[1], Boris Smodiš[1], Franc Batič[2]

1 Jožef Stefan Institute, Jamova 39, SI-61111 Ljubljana, Slovenia

2 Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, SI-61000 Ljubljana, Slovenia

Key words: lichens, index of atmospheric purity, trace elements, factor analysis.

Abstract

In 1992, a monitoring survey on a national scale was carried out using *Hypogymnia physodes* (L.) Nyl. as a biomonitor for trace element air pollution. The primary aim was to analyse epiphytic lichens collected at 86 sampling locations of the 16 x 16 km bioindication grid using k_0-based instrumental neutron activation analysis (k_0-INAA), and X-ray fluorescence spectrometry (XRF) for sulphur and lead, to obtain information about the levels of elements in the atmosphere and to identify significant pollution sources. The geographical concentration patterns of the trace elements obtained from the lichen data were mapped and compared with the index of atmospheric purity (IAP) calculated on the basis of data from lichen thalli type mapping, obtained on a more dense bioindication grid in 1991.

The results obtained showed good agreement between the mapping of sulphur and trace elements with the status of lichen vegetation. The most exposed regions with elevated trace element levels and lower values of IAP were in the north-western Alpine part of Slovenia which coincides with high precipitation, and in the east of Slovenia, where many local pollution sources are situated.

Introduction

Determination of atmospheric pollution generally requires a wide network of sampling sites and the use of technical equipment to measure air particulate matter and deposition. Usually such monitoring programmes over

TABLE 4 - FATTY ACID COMPOSITION OF YOLK CHOLESTEROL ESTERS (MEAN VALUES EXPRESSED AS %).

	Groups									EMS* (DF 41)
	MO	SO	CSO	BTSO	PF	FO	CFO	BT	CO	
C 16:0	41.91 ab	42.70 ab	41.86 ab	37.55 b	38.92 ab	38.75 ab	36.75 b	38.67 ab	44.77 a	0.00129
C 16:1	15.59 ab	11.83 ab	11.07 ab	12.20 ab	15.37 ab	15.96 ab	9.97 b	14.84 ab	17.16 a	0.00259
C 18:0	12.46	14.20	14.00	12.94	14.24	11.39	14.94	12.15	13.45	0.00111
C 18:1	23.19 AB	23.56 AB	25.21 AB	30.61 A	25.00 AB	28.03 AB	31.68 A	26.39 AB	19.52 B	0.00311
C 18:2 (ω6)	6.86	7.71	7.87	6.91	6.47	5.88	6.67	7.95	5.10	0.00124
U:S	0.85	0.76	0.81	1.01	0.89	1.00	0.94	0.98	0.73	0.00245

a, b: $P < 0.05$; A, B: $P < 0.01$

* Error mean square of data transformed in the arcsin of the square root of the percentage.

THE RELATIONSHIP BETWEEN ARSENIC CONTENT IN FEED AND IN HENS EGGS

A. Holcman[1]*, V. Stibilj[2], V. Knez[1], B. Smodis[2]

[1] Zootechnical Department, Biotechnical Faculty, University of Ljubljana, 61230 Domzale, Slovenia
[2] Jozef Stefan Institute, 61111 Ljubljana, Slovenia

RELACIONES ENTRE EL CONTENIDO DE ARSÉNICO EN EL PIENSO Y EN LOS HUEVOS DE GALLINA

RESUMEN

Tres grupos de seis gallinas fueron alimentados durante doce días con dietas que contenían 7,5, 15.0 y 30,0 mg As kg^{-1} (en forma de As_2O_3). Se incluyó en la prueba un grupo de control. Las gallinas de cada grupo se dividieron en 3 subgrupos. Los huevos de dos gallinas, puestos en tres días, formaban una muestra compuesta. El contenido de As en la yema y la clara de los huevos fue determinado por duplicado por análisis de activación de neutrones radioquímicos.

Con el incremento del contenido de As en la dieta de las aves, aumentó también su contenido en la yema y la clara de los huevos, pero pareció alcanzarse una meseta con bastante rapidez. La relación entre el contenido de As en la yema y la clara es casi constante (1:3) en los tres grupos de gallinas, con independencia del nivel de As en el pienso.

SUMMARY

Three groups of six hens were fed for twelve days with diets containing 7.5, 15.0 and 30.0 mg As kg^{-1} (in the form of As_2O_3). A control group was included in the trial. The hens from each group were formed into 3 subgroups. The eggs of two hens, laid in three days, formed a composite sample. The As content in the egg whites and yolks was determined in duplicate by radiochemical neutron activation analysis.

With increasing As content in the poultry feedstuff, its content in egg yolk and white also increased, but a plateau appears to be reached quite rapidly. The ratio between the As content in yolk and in white is nearly constant (1:3) for all three groups of hens, irrespective of the level of As in the feed.

INTRODUCTION

Several experiments on animals showed that arsenic is an essential element for some species (rats, hens, guinea pigs, goats), and even for man (1). There is no danger of an arsenic deficit because forage and food contain more arsenic than animals and people need. The toxicity of arsenic is more known than its essentiality. In the environment (soil, water, air)

VI EUROPEAN SYMPOSIUM ON THE QUALITY OF EGG AND EGG PRODUCTS

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WPSA SPANISH BRANCH

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B. Smodiš, Z. Planinšek, P. Stegnar
Department of Nuclear Chemistry

J.Stefan Report
DP 5101/88

DETERMINATION OF Sr-89/90

SAMPLE PREPARATION PRIOR TO THE ANALYSIS OF $^{89+90}Sr$

1. Sediments:

Dry in drying oven at 105°C overnight and sieve through a 250 um sieve. 100-200 g of dried and sieved sediment is needed for analysis.

2. Fruit and vegetables:

Clean and chop 1-2 kg of samples, weigh and dry in an oven overnight at 105°C. Weigh dried sample and calculate the % of dry matter. Ignite the sample in a muffle owen (see ignition of samples - procedures). The temperature should be raised carefully to 550°C (the sample can burn at approximately 200-300°C if the temperature is raised too rapidly). Weigh the ash.

3. Milk

Fresh milk could be used for analysis if a high activity of Sr-90 is expected. Otherwise freeze dry 2-3 l of milk. Calculate the % of dry weight. Ignite at 550°C. Again, the temperature shoud be raised carefully. Weigh the ash.

4. Meat

Cut 1-2 kg fatless meat (reject sinews) into small pieces and dry it at 105°C. Calculate the % of dry weight. Ignite the sample at 550°C.The temperature should be raised carefully, particurally in the range from 200 to 350°C in order not to loose sample due to spattering. Weigh the ash.

5. Fish:

a) Small fish:
Take 1-2 kg of sample, gutted and well washed, cut into pieces and dry at 105°C in oven. Calculate the % of dry weight. Ignite at 550°C. Raise the temperature successively, being extremely careful in the range from 150-350°C. Weigh the ash.

b) Large fish:
Analyse separately muscle and bone. Remove internal organs and skin. Wrap the sample in aluminium foil, heat at 105°C in a drying oven for

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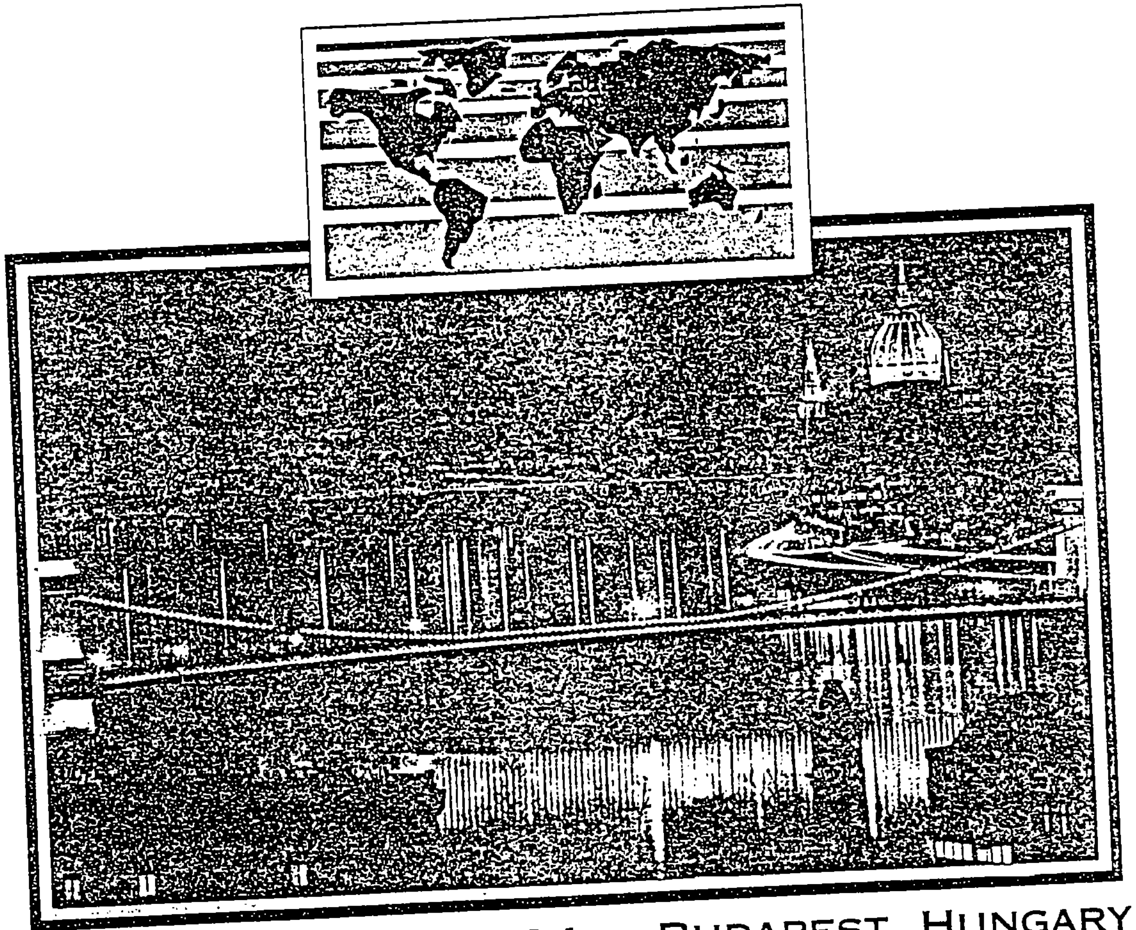

September 20-23, 1994 • Budapest, Hungary

Symposium Proceedings

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References

[1] Addiscott,T.M., Whitmore,A.P., Powlson,D.S.: Farming, fertilizers and the nitrate problem. CAB Int., Wallingford UK (1991)

[2] Campbell,C.A., Read,D.W.L., Biederbeck,V.O., Winkleman,G.E.: The first 12 years of a long term crop rotation study in south-western Saskatchewan - nitrate-N distribution in soil and N uptake by the plant. Can. J. Soil Sci. 63:563-578. (1983)

[3] Hofman,G., Ruymbeke,M., Ossemerct,C., Ide, G.: Residual nitrate-N in sandy loam soils in moderate marine climate. Pedologie 31:329-346. (1981)

[4] Ito,O., Matsunaga,R., Katayama,K., Tobita,S., Adu Gyamfy,J.J., Rao,T.P., Gayatri Devi,Y.: Nitrate in soil solution under sorghum and pigeonpea in monocrop and in intercrops. Transactions of the 15th World Congress of Soil Science, Acapulco, Mexico. Vol.5b. pp 48-49. (1994)

[5] Füleky Gy.: Nitrate movement in brown forest soil as affected by nitrogen fertilization. In: Welte, E. and Szabolcs I. (eds.) Proc. 5th Int. Symposium of CIEC, 1-4 September, 1987 Balatonfüred, Hungary. 123-136. CIEC Goltze-Druck. Goettingen. (1989)

[6] Németh T.: Fertilizer recommendations - Environmental aspects. Zeszt. Probl. Post. Nauk Roln. 400:95-104 (1993)

[7] Németh T.: Nitrate-N accumulations in the soil profiles of long-term fertilizer experiments. Agrokémia és Talajtan 43: ...... (1994) (in press)

[8] Németh T., Kádár I., Kovács G.: Nitrate, sulphate and water soluble salt accumulation in the soil profile of a long-term fertilization experiment (in Hungarian). Agrokémia és Talajtan 36 -37: 109-126. (1988)

[9] Ruzsányi L.: Crop nutrient demand and effective fertilization (in Hungarian). Agrofórum. 3 (March 1992) pp 38-40. (1992)

TR... ELEMENTS IN THE PRECIPITATION OF THE ŠALEK VALLEY, SLOVENIA

M.Svetina Gros:
ERICo Velenje, Ecological Research & Industrial Cooperation, Koroška 64, 63320 Velenje, Slovenia., Tel.: 386 63 855 321
B.Smodiš; Z.Jeran; J.Jačimović:
"J. Stefan" Institute, University of Ljubljana, Jamova 39, 61111 Ljubljana, Slovenia., Tel.: 386 61 188 5450

Abstract

Rainwater samples were collected in the Šalek valley from June 1992 to July 1993. Bulk precipitation was obtained with continuously open collectors. The samples were collected monthly in polyethylene bottles (which contained nitric acid prior to collection), filtered and analysed by the k_0-standardisation method of reactor instrumental neutron activation analysis (INAA). 45 trace elements were determined in water samples and filtrates. Elemental analysis of precipitation showed that some trace elements can be used to characterise the Šoštanj Thermal Power Plant (e.g. Cd, As, Hg). Some typical differences were observed between the collection sites in the Šalek valley and a reference site at Podvolovljek (35 km away).

Introduction

"Rain" in common understanding is evidently the deposition of water vapour condensed in the atmosphere and reaching the ground to complete the water cycle. However, it contains more than the pure water of condensation, since as it falls from clouds through the atmosphere it will absorb gases and wash-out particulate aerosols during its passage. The major source of atmospheric trace elements is coal combustion in electric power plants and industrial boilers [1]. Some trace pollutants, most commonly Se, Au, Pb, Sn, Cd, Br, and Te, can exceed their normal concentration in air 1000 times in the vicinity of such sources. Since the composition of rain reflects atmospheric and climatic conditions, it is not unexpected that it differs between sites, and from year to year, and even from shower to shower [2]. The atmospheric deposition of trace elements, mainly the heavy metals, contributes to contamination of all the other components of the biosphere, e. g., waters, soil, and vegetation [3]. In the late 1970's long-range transport of trace elements was recognized and soon after it was realised that natural cycles of elements in the environment can be altered not only in the vicinity of emission sources but also several thousand kilometres away from emission source regions [4]. As the toxic hazards of various elements to human health and the environment became recognised, there is increasing interest in studying the behaviour of trace elements in the neighbourhood of the Šoštanj Thermal Power Plant.

Precipitation sampling

Bulk precipitation samples were collected from two sites in the Šalek valley: Veliki vrh

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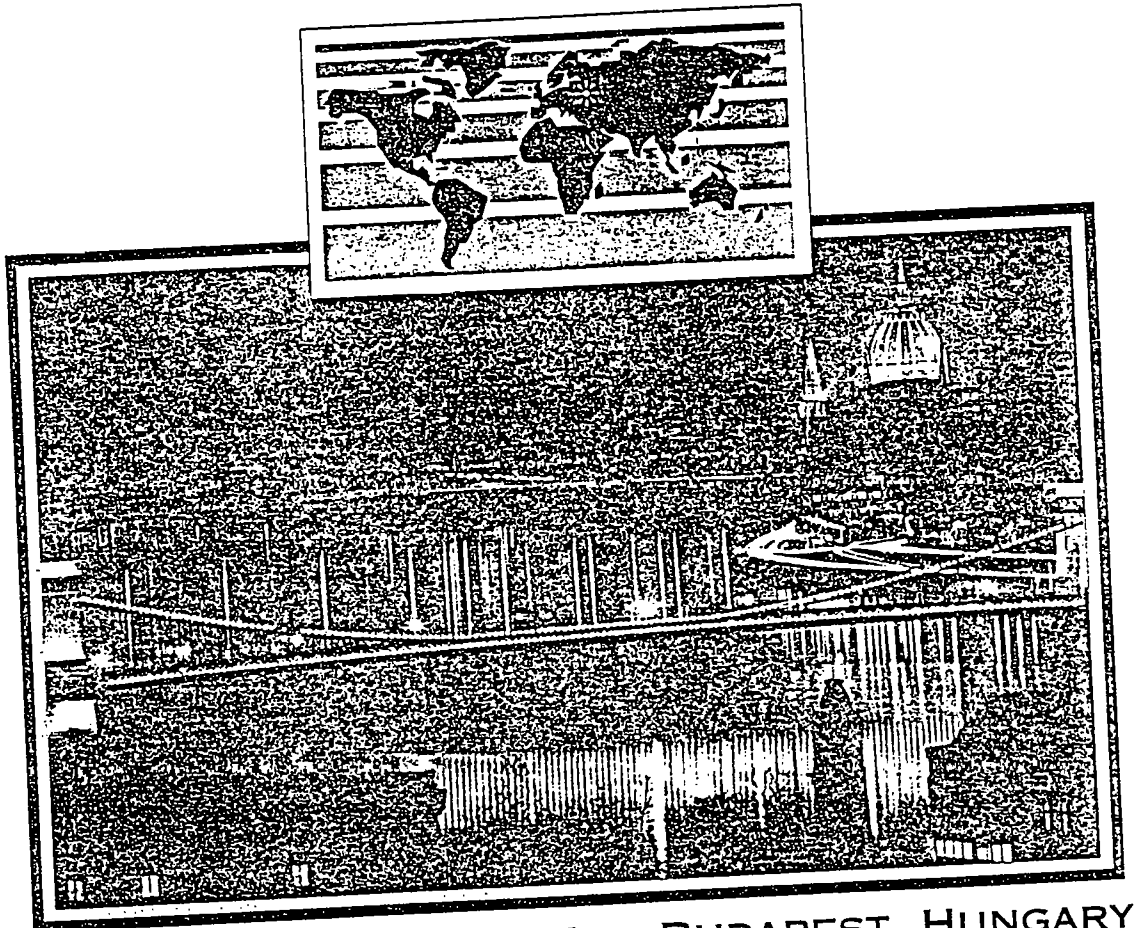

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Distribution of Microconstituents Between Marine Compartments

Rovinj, Croatia

May 11-18, 1994

EPIPHYTIC LICHENS IN AIR POLLUTION STUDIES OF HEAVY METALS IN SLOVENIA

Z. Jeran; J. Jaćimović; B. Smodiš:
"J.Stefan" Institute, Jamova 39, 61111 Ljubljana, Slovenia, Tel.:+386 61 1885 450
F. Batič
Biotechnical Faculty, University of Ljubljana, Agronomy Department, Jamnikarjeva 101, 61111 Ljubljana, Slovenia, Tel.:+386 61 123 11 61

Abstract

Epiphytic lichens were introduced as monitors into air pollution studies of trace elements in Slovenia. In this paper the concentration levels of more than 30 elements in the transplanted epiphytic lichen *Hypogymnia physodes* (L.) Nyl. exposed at four locations (two in the vicinity of a coal fired-power plant, and two reference locations) for 8 months, are presented. The results for transplanted lichens are compared with in situ growing lichens where possible, including lichens collected along the Šalek valley where the coal fired power plant is situated. The influence of the power plant on the concentrations of the elements determined in the transplanted lichens is discussed. The k_0-method of neutron activation analysis, using the TRIGA Mark II reactor at the "Jožef Stefan" Institute, was employed for multielemental nondestructive analysis.

Introduction

Lichens, especially epiphytic ones, are widely used as indicators and/or monitors of air contamination [1,2,3]. They are known to be very sensitive to gaseous pollutants such as SO_2, NO_x, HF, O_3 and PAN (peroxyacetyl nitrate) [3,4], but on the other hand they are also efficient accumulators of many elements, particularly heavy metals and radionuclides which are released into the atmosphere because of natural and human activities. Investigations using lichens to monitor air quality have been carried out not only around known pollution sources such as coal fired power plants, steel works, or other industrial and urban centres, but also to identify such possible sources [3,5,6].

There are two possibilities for using lichens as biomonitors for trace element or radionuclide contamination. The first, which is also the most frequently used, is so-called passive biomonitoring, that is collection of lichens already present in the study area. Alternatively, when lichens are absent from an area, especially in heavily polluted areas, such as big cities, around power plants and smelters, then transplanted lichens may be used to monitor pollution over a certain period (active biomonitoring). In particular, the epiphytic species *Hypogymnia physodes* has been shown to be one of the most suitable lichen monitors (in situ or transplanted) of atmospheric metal concentrations in central Europe [6,7,8]. This species is also widely distributed in Slovenia. Investigations using epiphytic lichens to monitor heavy metal and radionuclide air pollution in Slovenia begun in 1987 [9,10]. The aim of this work is to present some of our results for trace element air pollution using transplanted *H. physodes*, around the Šoštanj Thermal Power Plant, which is the largest coal-fired power plant in Slovenia. It has three stacks 100, 150 and 200 m high, equipped with electrostatic filters and is also a large regional SO_2, NO_x and dust emission source. Its measured emissions for 1992 were 94 120 tons of SO_2, 9009 tons of NO_x, 6085 tons of fly ash and unknown quantities of other pollutants [11].

Sampling and sample preparation

In November 1990, samples of in-situ *H. physodes* were collected at 4 elevated sites (900 - 1500 m a.s.l.) at Smrekovec, 15 km W of the Šalek valley (SM in Table 1) for trace element determination. Samples were taken from Norway spruce (*Picea abies*) at a height of 1.5-2 m above ground level.

In September 1992, twigs of Norway spruce covered with *H. physodes* were collected at Mislinjski jarek (MJ), about 20 km NE of the Šalek valley, and the same day transplanted at four locations: Zavodnje (ZA) and Veliki vrh (VV) which are within a 10 km radius around the coal-fired power plant, and two reference locations, Podvolovljek (PV), 29 km to the SW, and Ljubljana (LJ), 75 km SW of the Šalek valley (Fig.1). Veliki vrh and Zavodnje are occasionally strongly polluted by SO_2. At each station the lichen material was tied with a nylon thread onto a wooden holder at a height of 1.5-2 m above ground and exposed for 3, 6 and 8 months. Where possible in-situ growing lichens were also collected.

In the laboratory all samples were separated from the bark substratum with plastic tweezers, and adhering particles removed. The samples were made brittle by immersion in liquid nitrogen and homogenized in a ZrO mortar with ZrO ball using a vibratory Micro-Pulveriser mill.

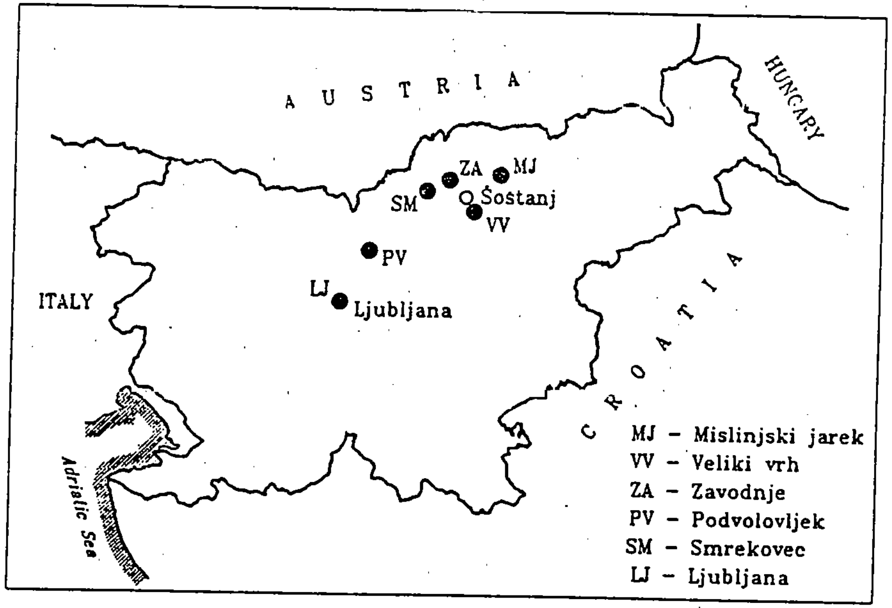

Fig. 1 Map of sampling sites.

Speciation of Arsenic and Mercury in Mussels from the German Environmental Specimen Bank

B. Smodiš[1], Z. Šlejkovec[1], A.R. Byrne[1], M. Rossbach[2]

[1]"Jožef Stefan" Institute, Ljubljana, Slovenia
[2]KFA Jülich, Germany

As is now well known, the total concentration of an element gives no information on its toxic effects; these depend on the chemical form of the element and its compounds. Hence speciation analysis is a basic condition for meaningful environmental and other studies. Elements of particular concern in this category include mercury, arsenic, tin and selenium.

However, speciation analysis is still in its infancy and major problems related to methodology and quality control exist, many results are methodologically dependent, and questions relating to the quantitative or reproducible extraction of species in unchanged form, especially from solid samples, are unsolved.

Hence, there exists an urgent need for speciation reference and study materials, and improved, standardized, verified speciation methods. As a response to this demand, the newer materials collected in national environmental sample or specimen banks (ESB) could form the basis for the required improvements, since they are natural matrix materials of well defined origin, collected according to strict handling and storage protocols. The fresh, homogenized environmental materials stored over liquid nitrogen in the German ESB at Jülich represent samples with many of the ideal characteristics of potential or candidate speciation reference materials, or so-called 3rd generation CRMs. This concept also allows the long-term stability of species in samples to be investigated.

In the present work the speciation of arsenic (and mercury) in two mussels (*Mytilus edulis* and *Mytilus galloprovincialis*) collected from the Baltic and Adriatic Seas, respectively, and stored in the ESB at Julich was undertaken as a first step towards realization of the above -mentioned goals. Arsenic was speciated by open column cation and anion exchange chromatography, followed by instrumental neutron activation analysis of the individual fractions as an element - specific detection method[1]. The major species found was arsenobetaine (AsB), as expected. Mercury was determined as total and methyl mercury by CV - AAS with or without prior separation of organic Hg by anion exchange[2].

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RENCONTRE INTERNATIONALE DES JEUNES CHERCHEURS EN GÉOLOGIE APPLIQUÉE

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EPFL GEOLEP

ELEMENT ENRICHMENTS IN SOIL NEAR THE ŠOŠTANJ THERMAL POWER PLANT, SLOVENIA

M. Svetina Gros*, S. Pirc**, B. Smodiš***, B. Stropnik*

*ERICo Velenje, Ecological Research & Industrial Cooperation, Koroška 64, 63320 Velenje, SLOVENIA

**Department of Geology, University of Ljubljana, Aškerčeva 20, 61000 Ljubljana, SLOVENIA

***"J. Stefan" Institute, University of Ljubljana, Jamova 39, 61111 Ljubljana, SLOVENIA

Abstract

The state of an environment is determined by the geological setting (the element concentrations of natural origin in rocks and soils) and the additional pollution by human activity. The original concentrations of elements in rocks and soil are sometimes much higher than guideline values in regulations on soil contaminants. The present study is the first systematic research project on the distribution of element contents in rocks and soils in the Šalek valley, Slovenia.
Elemental concentrations in soil were analysed by energy dispersive X-ray fluorescence spectroscopy (ED XRF). The results are discussed in terms of the geological structure of the underlying rocks and anthropogenic activities.

Introduction

The Šalek valley is one of the most polluted areas in Slovenia. The coal-fired Šoštanj Thermal Power Plant is a large regional SO_2, NO_x and dust emission source, and the main reason for the pollution. Its measured emissions for 1990 were 93,000 tons of SO_2, 12,400 tons of NOx and 5,700 tons of fly ash and unknown quantities of other pollutants (7).
In the Šalek valley several environmental pollution studies have been made in which generally the effects of industrial activities were investigated. But the Šalek valley consists of a number of geological formations and their overlying soils have different chemical composition. Before evaluating the man-made pollution patterns, the original element content of rocks has to be determined (3). For this reason the distribution of environmentally important elements in the Šalek valley was studied with the aim of estimating the element contents in soil on different rocks. The mean geological formations outcropping in the Šalek valley are the following:

- gravel, sand, clay, coal (Pliocene and Villafranchian)
- conglomerate, sandstone, marl (Helvetian)
- sandstone, marl and dacitic tuff (Eggenburgian)
- marl, sandy marl, sandstone, andesitic tuff, andesite (Egerian)
- tonalite (Oligo-Miocene)
- mostly dolomite and limestone (Triassic)
- granite (Permian)
- gray and black limestone, gray dolomite (Upper Permian)
- black shale, quartz sandstone and conglomerate (Carboniferous)

Methods

Soil samples were taken from 26 sites in a general 4x4km grid (Gauss-Krüger coordinates), and in a 2 x 2 km grid in agricultural and industrial areas (5). The samples were taken from four different depths: 0-5 cm, 5-10 cm, 10-20 cm and 40-50 cm (2). The average soil sample from each point in the grid was prepared as a composite of 3 subsamples. The samples were taken with a plastic shovel. The quantity of each sample was approximately 1 kg. In the laboratory the samples were homogenised, dried at 30°C and passed through a 2 mm plastic sieve. The dried soil samples were ground in an agate mill.

VARSTVO ZRAKA

STANJE IN UKREPI ZA
ZBOLJŠANJE STANJA V SLOVENIJI

AIR QUALITY
MANAGEMENT IN SLOVENIA

Bled 28. do 30. marca 1994

VZORČEVANJE IN VEČELEMENTNA ANALIZA MIKROELEMENTOV KOT ONESNAŽEVALCEV ZRAKA

Borut Smodiš[1]

ABSTRACT

Collection procedures for atmospheric particulate matter for multielement analysis are briefly described. Six suitable analytical techniques for measuring trace elements in air particulate matter are presented. These techniques are neutron activation analysis, X-ray fluorescence, particle-induced X-ray emission analysis, atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, and inductively coupled plasma mass spectrometry. The relative advantages and disadvantages of the various texhniques are discussed to some extent.

UVOD

Raziskave suspendiranih delcev v zraku (APM-"air particulate matter") predstavljajo pomemben del proučevanja atmosfere in procesov v njej. Razlogi za vzorčevanje in analizo APM so zelo različni; tako lahko vzorčujemo celokupni APM z namenom izdelave ocene tveganja zaradi izpostavljenosti populacije, vzorčevanje je lahko namenjeno ugotavljanju koncentracij APM glede na zakone o kakovosti zraka, ali pa študijam transporta, pretvorb in depozicijskih procesov v atmosferi. Ti raznoliki nameni pogojujejo različne pristope k vzorčevanju in analizi. Pri tem ne obstaja samo en protokol, ki bi dal zadovoljive rezultate pri vseh različnih študijah. Predvsem fizikalne in kemijske lastnosti vzorca namreč pogojujejo izbiro vzorčevalnika, zbiralnega medija in analizni protokol. Tako npr. zahteva vzorčevanje na oddaljenih mestih daljši čas zbiranja kot vzorčevanje v urbaniziranih predelih, kar je seveda povezano s povečanimi stroški in rabo bolj občutljivih analitskih metod, saj so elementne koncentracije v atmosferi tudi za en red velikosti nižje kot v mestih.
V zadnjih letih se neprestano povečuje število izpopolnjenih tehnik za elementno analizo. Raziskovalci, ki proučujejo sledne elemente in težke kovine v zraku, imajo težavno nalogo izbrati najustreznejšo. Pri izbiri je pomembno več faktorjev; najpomembnejši so namen raziskave, občutljivost, zanesljivost in natančnost uporabljene metode, pa tudi cena instrumenta, dostopnost tehnike, zahtevnost dela z njo, hitrost analiz in cena analiz. V tem prispevku smo pripravili kratek pregled nekaterih primernih metod za elementno analizo APM.

---

[1]dr. Borut Smodiš, dipl. inž. kem., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

Borut

VARSTVO ZRAKA

STANJE IN UKREPI ZA ZBOLJŠANJE STANJA V SLOVENIJI

AIR QUALITY MANAGEMENT IN SLOVENIA

Bled 28. do 30. marca 1994

UGOTAVLJANJE ONESNAŽENOSTI ZRAKA S KOVINAMI IN RADIONUKLIDI Z UPORABO BIOMONITORJEV - LIŠAJEV

Z. Jeran[1], R. Jaćimović[2], V. Lupšina-Miklavčič[3], B. Smodiš[4], F. Batič[5]

[1,2,3,4]Institut "Jožef Stefan", Jamova 39, Ljubljana
[5]Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, Ljubljana

ABSRACT

During recent years epiphytic lichens were introduced to monitor heavy metal and radionuclide air pollution in Slovenia. Some indicative results of our studies on air pollution around the Uranium mine and mercury speciatior in air around the Hg-mine, using Hypogymnia physodes are presented. Also the results of multielemntal analysis of transplanted lichens exposed in three different regions of Slovenia (urban-industrialized, rural-nonindustrialized and near a coal fired power plant) are discussed.

UVOD

Okolje, predvsem pa zrak, je vse bolj onesnaženo. Zaradi industrijske dejavnosti, prometa, kmetijstva, pridobivanja energije (toplarne, termoelektrarne, individualna kurišča) v okolju naraščajo koncentracije kovin in nekovin, med katerimi so nekateri elementi lahko tudi toksični (Pb, Cd, Hg,...).

Za ugotavljanje onesnaženosti okolja se v svetu že več kot 25 let poleg direktnih metod vzorčevanja uporabljajo tudi živi organizmi bioindikatorji / biomonitorji, ki so bodisi rastline (lišaji, mahovi, borove ali smrekove iglice, trave, ...) ali živali. Organizmi se namreč izredno hitro odzivajo na spremembe v okolju. Reakcije organizmov, ki so biokemične, fiziološke, morfološke, pa lahko opazujemo ali merimo. O bioindikaciji govorimo takrat, ko organizem ali del organizma, daje informacijo o kvaliteti okolja. Biomonitoring pa imenujemo dolgoročno spremljanje okolja s pomočjo bioidikatorjev / biomonitorjev. Martin in Coughtrey[(1)] sta postavila nekaj kriterijev, ki jih mora

[1] mag.Zvonka Jeran, dipl.biol., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

[2] Radojko Jaćimović, dipl.ing.fiz., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

[3] mag.Vesna Lupšina-Miklavčič, dipl.ing.kem., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

[4] dr.Borut Smodiš, dipl.ing.kem., Institut "Jožef Stefan", Jamova 39, 61000 Ljubljana

[5] prof.dr. Franc Batič, dipl.biol., Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, 61000 Ljubljana

Tempus
JEP 4724-94/3

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Postgraduate Study of Water Resources Management and Sanitary Engineering

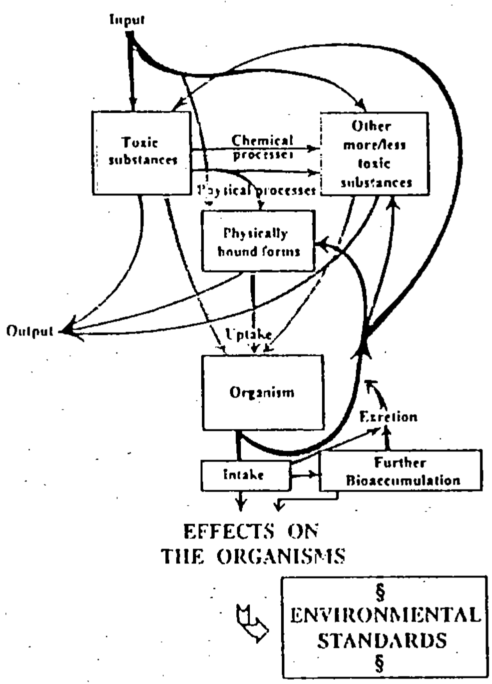
Joint European Project

Coordinator: Franci Steinman

PROCEEDINGS OF THE TEMPUS WORKSHOP ON

Ecotoxicology and environmental standards

Ljubljana 14th-18th Nov. 1994



EDITORS:
DAMJANA DROBNE
Department of Biology, University of Ljubljana
FRANCI STEINMAN
Faculty for Civil Engineering and Geodesy

THE INFLUENCE OF BULK PRECIPITATION ON SOIL AND SPRING WATER NEAR THE ŠOŠTANJ THERMAL POWER PLANT

Marta Svetina Gros[1], Simon Pirc[2], Borut Smodiš[3]

[1] ERICo Velenje - Ecological Research & Industrial Cooperation, P. O. Box 22, Velenje, Slovenia
[2] Department of Geology, University of Ljubljana, Aškerčeva 20, Ljubljana, Slovenia
[3] Department of Nuclear Chemistry, "J. Stefan" Institute, Jamova 39, Ljubljana, Slovenia

Abstract

In order to obtain more data on the content and concentration range of dissolved inorganic substances in bulk precipitation, soil water and spring water, investigations in two forest areas were performed in the Salek valley. The small watershed technique was introduced for the first time in Slovenia: this provides an ideal field laboratory where the water cycle in forested ecosystems can be followed. As the main analytical method for determination of trace elements and heavy metals in water samples, the k_0- standardisation method of INAA was used. The analytical results showed an increased content and concentration of elements in soil, precipitation, soil water and spring water in the vicinity of the Šoštanj Thermal Power Plant. Al, As, Ba, Br, Fe, Cd, Co, Cr, Cu, Sb and Zn are increased in precipitation.

Introduction

The Šalek valley is one of the most polluted areas in Slovenia. The coal-fired Šoštanj Thermal Power Plant (TPP) is a large regional SO_2, NO_x and dust emission source, and the main reason for the pollution. Its measured emissions for 1990 were 93 000 tons of SO_2, 12 400 tons of NO_x and 5 700 tons of fly ash and unknown quantities of other pollutants.

Among source categories, coal combustion in electric power plants is one of the major sources of atmospheric trace elements and as such the subject of emission inventories [1]. On the basis of their geogenic occurrence in coal it was concluded that As, Cd, Hg, Pb, and Tl have the highest emission rates as a result of coal combustion. Comparative studies have shown that As, Cd, Hg, Pb, Sb, Se, Te, and Tl are emitted to 50 % and more in the gaseous state while the other metals were found chiefly in the ash [2]. Recently Stropnik et al. measured the emission of trace elements from the TPP [3].

The biogeochemical cycles of metals are considerably less well known. In many cases it is difficult to decide whether a metal or its compound has been anthropogenically channelled into a natural cycle or whether a novel route has been started. It was estimated [2] that in many cases the contribution of anthropogenic emissions are considerably larger than of the natural ones. Metals may be divided into non-critical ones, highly toxic and relatively accessible ones, and toxic but hardly soluble or rare ones. Members of the first group are Na, K, Mg, Ca, Fe, Li, Rb, Sr, Al, Si, while the second group comprises: Be, Co, Ni, Cu, Zn, Sn, As, Se, Te, Pd, Ag, Cd, Pt, Au, Hg, Te, Pb, Sb, and Bi. Toxic but of very low solubility or very rare are: Ti, Hf, Zr, W, Nb, Ta, Re, Ga, La, Os, Rh, Ir, Ru, and Ba. Metals can be transported in the atmosphere in gaseous form or as aerosols, so that volatility is a characteristic of prime importance. According to Garrels et al. [4], the following volatility sequence of elements can be defined: Hg > As > Cd > Zn, Sb > Bi > Tl > Mn > Ag, Sn, Cu > In, Ga.

It should be noted, that irrespective of the manifold possibilities of atmospheric transport, the main environmental route of metals is via aquatic systems.

In order to identify the causal relationships between forest damage, anthropogenic emissions and the consequences in runoff and soil water, investigations on the deposition of inorganic substances in forest areas have been initiated in the Šalek valley in Slovenia.

The present investigation includes two watershed experiments in calibrated catchments (Zavodnje and Veliki vrh), located within a 10 km radius around the coal-fired power plant and one reference area in the Savinian Alps (Podvolovljek), 30 km SW from the TPP. Due to the characteristics of the watersheds these sites offer an ideal field laboratory in which deposition and cycling of airborne trace contaminants derived from atmospheric emission related to energy technology can be examined.

NAHRES-26
Vienna, 1995

APPLIED RESEARCH ON AIR POLLUTION USING NUCLEAR-RELATED ANALYTICAL TECHNIQUES

Report on the Second Research Co-ordination Meeting

Menai, Australia, 27-31 March 1995

INTERNATIONAL ATOMIC ENERGY AGENCY

TRACE ELEMENT AIR POLLUTION MONITORING STUDIES IN SLOVENIA USING NUCLEAR ANALYTICAL TECHNIQUES

B. Smodiš[1], R. Jaćimović[1], B. Stropnik[2], M. Svetina Gros[2]

[1]*Jožef Stefan Institute, Jamova 39, P.O.Box 100, SI-61111 Ljubljana, Slovenia*
[2]*ERICo, Koroška 64, SI-63320 Velenje, Slovenia*

Up to now, only a few investigations have been performed in Slovenia involving comprehensive studies of trace elements, toxic elements, heavy metals and radionuclides in the atmosphere. The aim of the project is development and application of nuclear and nuclear-related analytical techniques for air pollution studies, leading to formation of a database concerning the trace element air pollution of Slovenia. In this report, the emphasis is on the methodology and analytical development (neutron activation analysis and X-ray spectrometry), and to a lesser extent on the results obtained up to now. Analytical results for several certified reference materials of similar matrix as the real samples investigated are presented and discussed.

1. SCIENTIFIC BACKGROUND AND SCOPE OF THE PROJECT

The general scope of the project is a better knowledge of the state of air pollution in Slovenia by performing environmental studies involving determination of trace element air pollution from industrial emissions by analysing airborne particulate matter, bulk precipitate and biomonitors. On successful completion of the project, an improvement in development and application of nuclear and nuclear-related analytical techniques will be achieved, and a database concerning trace element air pollution of Slovenia will be obtained, possibly leading to appropriate decisions in environmental control. Particular research objectives are:

1. To improve and further develop analytical techniques for multielement characterization of the materials analysed, including speciation of some particular pollutants (e.g. Hg).

2. To study in more detail some highly polluted areas (e.g. surroundings of a coal-fired power plant) by applying a more dense monitoring network and possibly studying health effects caused by the plant on the population living nearby.

3. The application of epiphytic lichens as indicators of toxic heavy metal air pollution in Slovenia in order to get information about the geographical gradients for particular pollutants.

Close collaboration has been established with the Biotechnical Faculty (Department of Agronomy) of the University of Ljubljana, and the Slovenian Institute of Forestry in Ljubljana concerning identification of lichen species and

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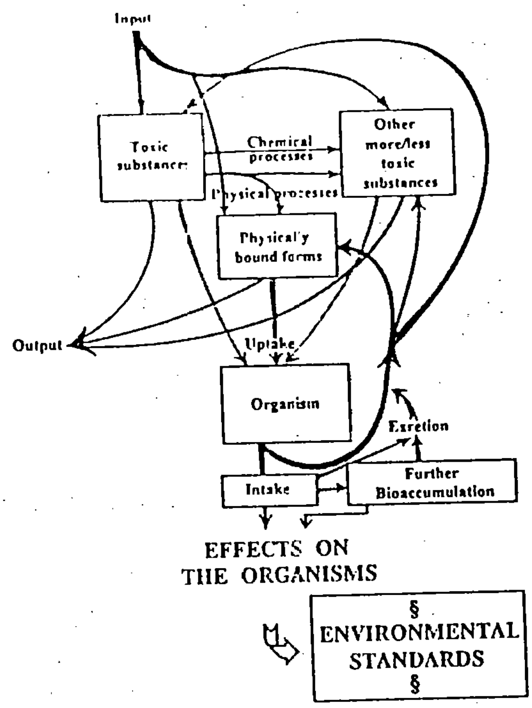

EDITORS:

DAMJANA DROBNE

Department of Biology, University of Ljubljana

FRANCI STEINMAN

Faculty for Civil Engineering and Geodesy

ABSTRACTS

NINTH INTERNATIONAL CONFERENCE ON MODERN TRENDS IN ACTIVATION ANALYSIS

1995 September 24-30
Seoul, Korea

organized by the

Korea Institute of Geology, Mining and Materials

in cooperation with the

International Atomic Energy Agency,
Korean Society of Analytical Sciences

and M. Katoh, NTT Interdisciplinary Research Laboratories, Japan

16:35 Log No.240, Radiochemical Neutron Activation Analysis for the Determination of Trace Concentrations of Chlorine in Reactor Materials: The Analysis of Stainless Steels, S.J. Parry, B.A. Bennett, R. Benzing, D. Redpath and J. Harrison, Imperial College of Science, United Kingdom

16:50 Log No.59, Neutron Activation Analysis for Studying Prostate Elements, V.Ye. Zaichick, T.V. Sviridova and A.A. Zhavoronkov, Medical Radiological Research Centre, Russia

17:05 Log No.235, Amazon River Estuary : Assessment of Trace Elements in Bottom Sediments, L.B.L.S. Lara, E.A.N. Fernandes, H. Oliveira and M.A. Bacchi, Centro de Energia Nuclear na Agricultura, Brazil

17:20 End of Session-VIII

19:00 **Conference Banquet**

THURSDAY, 1995 September 28, a.m.

6

SESSION-IX : SEPARATION TECHNIQUES

Chairs : Dr. G. Revel (France) & Dr. R. Dybczynski (Poland)

08:10 Log No.187(Invited), Simultaneous Radiochemical Neutron Activation Analysis of Uranium and Iodine in Biological and Environmental Samples, M. Dermelj and A.R. Byrne, "J. Stefan" Institute, Slovenia

08:35 Log No.243(Invited), Determination of Trace Amounts of Rare Earth and Representative Elements by Chemical Neutron Activation Analysis, S.J. Yeh, H.T. Yang, C.S. Tsai, C.P. Lin and C.N. Ke, National Tsing Hua University, Taiwan

09:00 Log No.265, Determination of Nanogram Levels of Vanadium in Seawater by Preconcentration Neutron Activation Analysis, A.I. Kulathilake and A. Chatt, Dalhousie University, Canada

09:15 Log No.168, Application of Neutron Activation Analysis in the Fission Molybdenum Separation Study, D. Wu, S. Landsberger and G. Vandegrift, University of Illinois, U.S.A.

09:30 Log No.23, Determination of Isotopic Abundance of Osmium and Ruthenium in Meteorites by Pretreatment and Radiochemical Neutron Activation Analysis, C.F. Chai, Y.Z. Liu and X.Y. Mao, Institute of High

Log No. 187

SIMULTANEOUS RADIOCHEMICAL NEUTRON ACTIVATION ANALYSIS OF URANIUM AND IODINE IN BIOLOGICAL AND ENVIRONMENTAL SAMPLES

M. Dermelj and A.R. Byrne

"J. Stefan" Institute, Jamova 39, 61111 Ljubljana, Slovenia

The determination of medium- and long-lived nuclides can be combined with short-lived ones if a second, brief irradiation is made before processing, in the so-called LICSIR technique (Long Irradiation, Cooling, Short Irradiation, Radiochemistry). Thus a radiochemical neutron activation method for determination of uranium was first developed based on the ^{235}U fission product ^{133}I ($t_{1/2}$ = 20.8 h) released from the irradiated sample by oxygen flask ignition, and separated by solvent extraction with an iodine-iodide redox cycle. Then by reactivating the cooled sample before ignition for a few minutes one or two days after the first irradiation, with an iodine standard, the $^{127}I(n,\gamma)$ product ^{128}I ($t_{1/2}$ = 25 min) can also be quantified in the iodine spectrum with ^{133}I. Non-combustible inorganic materials (e.g. sediment, soil, etc) can be successfully ignited after mixing with excess cellulose powder. Chemical yields for iodine were determined spectrophotometrically in the organic phase, while homogeneously spiked Whatman cellulose powder was used as uranium standard. Possibilities for the simultaneous analysis of additional volatile elements such as Hg and Se also exist. Results for some suitable SRMs are presented, and the general features of the LICSIR technique discussed.

Društvo jedrskih strokovnjakov Slovenije
Nuclear Society of Slovenia

Annual Meeting of NSS '94
Letno srečanje DJS '94

proceedings

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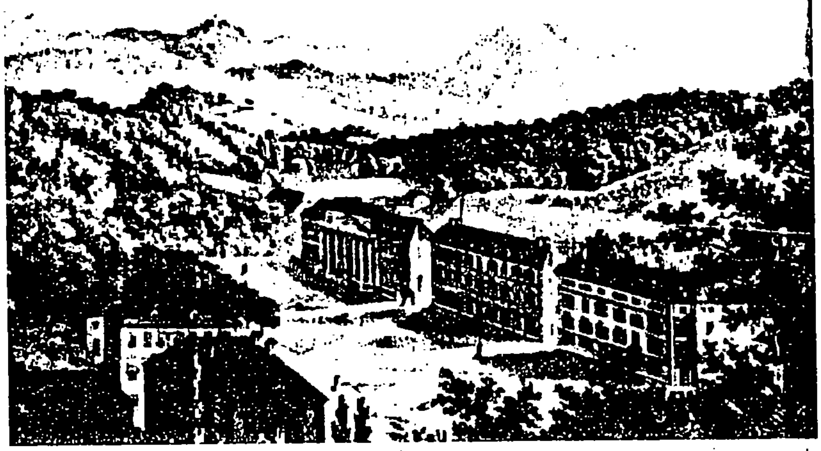

Rogaška Slatina, Slovenija
September 18 to 21, 1994

European Nuclear Society

Annual Meeting of the Nuclear Society of Slovenia
Rogaška Slatina, SLOVENIA, 18.-21. September 1994

DETERMINATION OF URANIUM AND THORIUM BY RADIOCHEMICAL NEUTRON ACTIVATION ANALYSIS

L. Benedik, A. R. Byrne
"J. Stefan" Institute, Nuclear Chemistry Department,
Jamova 39, P.O. Box 100 SLO-6111 Ljubljana, Slovenia

INTRODUCTION

Data on the low levels of uranium and especially thorium, present in different biological samples, are scarce and variable, in spite of the fact that there are several very sensitive analytical methods for their determination. Alpha spectrometry following radiochemical separation(1,2), isotope dilution mass spectrometry(3,4,5), inductively coupled plasma mass spectrometry(6,7,8), and neutron activation analysis (NAA) are all used. However, radiometric methods are time consuming, need large samples due to the low specific activity of U and Th and are thus limited by reagent blanks. As well as isobaric interferences, MS methods are also affected by blanks at ultratrace levels. Radiochemical neutron activation analysis (RNAA) is an excellent method for determining U and Th due its high sensitivity, its virtual freedom from blanks and insensitivity to matrix problems, and thus offers unique possibilities for ultratrace analysis using selective radiochemical separations.

Pergamon

Wat. Res. Vol. 28, No. 6, pp. 1471–1474, 1994

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RADIOISOTOPES IN PERIPHYTON AND SEDIMENTS FROM THE KOLUBARA RIVER AND ITS TRIBUTARIES

N. DRNDARSKI[1] and M. KRIŽMAN[2]*

[1]Institute of Nuclear Sciences—Vinča, 11 001 Beograd, P.O. Box 522, Serbia and Jožef Stefan Institute, 61111 Ljubljana, P.O. Box 100, Slovenia

(First received December 1991; accepted in revised form September 1993)

Abstract—The site-specific concentrations of the fission radionuclide ^{137}Cs, an activation radionuclide ^{134}Cs and the naturally occurring radionuclides ^{40}K, ^{238}U, ^{226}Ra and ^{232}Th were determined by γ-spectroscopy in periphyton and sediment samples collected from the Kolubara River and its tributaries. Various concentration ratios were calculated in order to explain the bioaccumulation and distribution of radioisotopes in the Kolubara River ecosystem. The total γ activities of river sediments collected at the selected locations were also calculated. The concentrations of radiocesium per square meter of sediments were compared to the concentrations of ^{137}Cs for the regional soil after the Chernobyl accident. The presence of radioactive isotopes, such as ^{137}Cs and ^{134}Cs, in the Kolubara River environment from the Chernobyl fallout was evident.

Key words—radionuclides, fission, activation, naturally occurring, concentration ratio, periphyton, sediment

INTRODUCTION

A radioecological study of the Kolubara River was initiated in 1990, 4 years after the Chernobyl accident. This river rises from two rivulets, the Obnica and the Jablanica, and together with its tributaries drains 3650 km^2 before entering the Sava River. It is 117 km long, with a maximum water flow of 28 m^3 s^{-1} and minimum water flow of 1 m^3 s^{-1}. Its main tributaries, which are shallow and fast flowing, are the Gradac, the Tamnava and the Peštan. The extent of the Kolubara River and its tributaries is shown in Fig. 1.

Gamma-ray spectroscopy has been applied to determine the activities of ^{230}U, ^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs and ^{134}Cs in sediments and periphyton collected from the Kolubara River and its tributaries. The results of the analyses are used to estimate the background activity level, accumulation and long-term retention patterns of these fission radionuclides in the Kolubara River environment. Furthermore, the results provide useful data for evaluation of the principal routes of exposure and dose to man and other living beings.

EXPERIMENTAL

Sample collection

The periphyton and sediment samples were collected from the sampling sites indicated in Fig. 1. Sampling was carried out on two occasions in May and October 1990 when the water levels were low. The sediments were collected by a grab sampler or shovel from 2 to 10 cm depth and the periphyton was sampled manually by hand.

Sample pretreatment

The periphyton and sediment samples were dried at 105°C to a constant weight. The caked samples were then finely ground and 3 g subsamples of periphyton and 150 g of sediment were taken for γ- spectroscopic analysis. The sample collection and pretreatment procedures have been

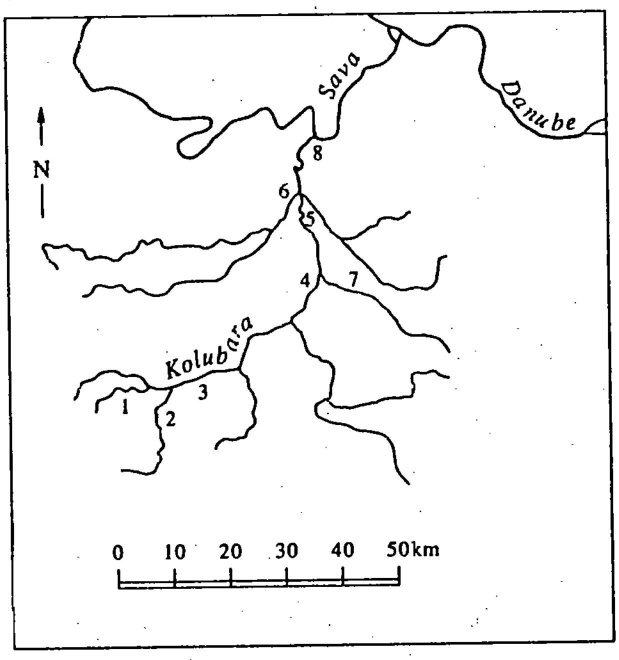

Fig. 1. Sketch of the Kolubara River and its tributaries. 1, Jablanica (at Jovanje); 2, Gradac (downstream of Deguria); 3, Kolubara (at Brewery); 4, Kolubara (at Divci); 5, Kolubara (at Slovac); 6, Tamnava (300 m before the mouth); 7, Peštan (300 m before the mouth); 8, Kolubara (at Obrenovac).

*Author to whom all correspondence should be addressed.

RADON LEVEL REDUCTION IN TWO KINDERGARTENS IN SLOVENIA

J. Vaupotič,* M. Križman,* J. Planinić,† and I. Kobal*

Abstract—**Remedial actions were carried out in two kindergartens with average heating season radon concentrations of about 2,000 Bq m^{-3}. The first kindergarten is built on sedimentary gravel and the second one on fly ash and cinder fill. In both cases, radon accumulated in a sub-floor channel (service tunnel). The channels were opened at both ends. Natural ventilation of the tunnels did not produce a sufficient reduction in radon concentration. A fan was mounted in one kindergarten to ventilate the channel for 20 min three times each day, thus reducing radon levels to an acceptable value.**
Health Phys. 66(5):568–572;1994

Key words: **radon, indoor; children; spectroscopy, alpha; ventilation**

INTRODUCTION

IN A SURVEY of indoor radon in kindergartens and play schools in Slovenia, instantaneous air concentrations were obtained under closed conditions by alpha scintillation cells (Vaupotič et al. 1992). In 72% of cases, the concentration was below 100 Bq m^{-3}, while in sixteen cases it exceeded 800 Bq m^{-3} (Vaupotič 1994). In two cases it exceeded 2,000 Bq m^{-3}, and mitigation actions were taken.

METHODS AND RESULTS

The Medvode and Zelena jama kindergartens were identified by the initial survey as the two with the highest concentrations. Additional measurements were made with alpha scintillation cells, and CR-39 track etch detectors[‡] were exposed for 3 mo in order to obtain average radon concentrations. Concentrations were found to be high in all the rooms of both buildings as seen in Figs. 1 and 2. In both cases, the ground was suspected to be the main radon source: the first building is built on sedimentary gravel, while the second is on fly ash and cinder. Both are one-story buildings of the slab-on-grade type, partly built over a basement. The first one has a total surface area of 500 m^2 in 8 rooms with about 180 children, and the second one 600 m^2 in 14 rooms with about 200 children.

In order to see daily variations, the ^{218}Po concentration was followed by an EDA WLM-300[§] instrument over a period of 1 wk. As seen from Figs. 3 and 4, the high early morning concentration in one of the rooms in the kindergarten with the highest radon concentration (room 1 in Figs. 1 and 2) dropped substantially during the working regime in the morning, but did not reach acceptably low values. Thus, the Ministry of Health decided to close both kindergartens and required remedial actions.

REMEDIATION

As is usual practice (Leovic et al. 1988; Dixon and Gregory 1992), the architectural drawings of both buildings were first inspected to estimate the main radon entry route and to plan appropriate mitigation measures, keeping costs as low as possible. As depicted in Figs. 1 and 2, in both buildings a sub-floor channel runs beneath the building near the front main wall, containing the tap and hot water and central heating pipes. The floor slab is made of poured concrete and the channel is covered with pre-cast concrete panels. The total floor surface is covered with wood parquet. When the parquet was removed and the channel was uncovered in the rooms with the highest radon concentration, we realized that the concrete slab itself was properly made but the sub-floor channel was not isolated from the ground. Soil gas and radon could enter the channel and then move into the room, because neither the joints between the floor slab and the cover panels nor the space between the panels themselves was sealed. This resulted in high radon concentrations in the rooms when the floor was uncovered.

It was believed that appropriate sealing of the cover panel joints would reduce radon concentrations substantially. In order to verify this, in each building the cover panel joints in the room with the highest radon concentration (room 1 in Figs. 1 and 2) were sealed by cement mortar. As a result, the concentration was reduced, but only by a factor of 2 to 3. It was decreased down to the building average concentration.

* "J. Stefan" Institute, Ljubljana, Jamova 39, P. O. Box 100, Slovenia; †Department of Education, Strossmayer University, Osijek, P. O. Box 44, Croatia.

‡ CR-39, TASTRAK, Solid State Nuclear Track Detector, Bristol, United Kingdom.

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§ EDA WLM-30 Working Level Monitor, EDA Instruments Inc., 4 Throncliffe Park Drive, Toronto, Canada M4H 1H1.

Paper

SYSTEMATIC INDOOR RADON AND GAMMA MEASUREMENTS IN KINDERGARTENS AND PLAY SCHOOLS IN SLOVENIA

J. Vaupotič,* M. Križman,* J. Planinić,† J. Pezdič,* K. Adamič,* P. Stegnar,* and I. Kobal*

Abstract—Systematic measurements of indoor radon concentrations and gamma dose rates were carried out in the 730 kindergartens and play schools in Slovenia that, together, care for 65,600 children. The main method for indoor radon measurement was direct sampling in alpha scintillation cells, but in cases with an increased instantaneous radon concentration, the additional methods of track-etch detectors and alpha spectroscopy were applied. In 528 kindergartens and play schools (72%), radon concentrations were below 100 Bq m^{-3}, with a geometric mean of 58 Bq m^{-3}. In 16 kindergartens and play schools (2.2%), radon concentrations exceeded 800 Bq m^{-3}. In all cases, the main reason for a high indoor radon concentration was the geological structure of the soil. Gamma dose rates were measured with a portable scintillation counter, but in the Ljubljana region thermoluminescence dosimeters were also exposed. The results ranged from 30 to 295 nGy h^{-1}, with a geometric mean of 88 nGy h^{-1}.
Health Phys. 66(5):550–556; 1994

Key words: radon, indoor; children; detector; etched-track; dosimetry, thermoluminescent

INTRODUCTION

INDOOR radon concentrations depend strongly on radium sources in the soil and on the geological characteristics of the soil. Other contributions are more or less influenced by human activities. Slovenia is a very heterogeneous country, geologically, and thus is an interesting site for radon investigations.

The first indoor radon (^{222}Rn) measurements in Slovenia were carried out in 1986 in about 150 apartments at several geologically interesting locations. They were in the urban center of Ljubljana, the granite rock area of Pohorje, the Gorenjska region with buildings built of volcanic material, the town of Velenje with buildings of fly ash brick, the Zasavje area with a coal-fired thermal plant, a fly ash pile and a phosphate ore processing plant, and around the uranium mine at Žirovski vrh (Kobal et al. 1988a and b). In 1990, determination of indoor radon concentrations in about 150 apartments built of fly ash bricks followed, but the number of these preliminary measurements was too low for estimation of radon exposure.

It was thus decided that indoor radon concentrations would be systematically screened, first in all the kindergartens and play schools, then in schools, and finally in selected apartments and homes in Slovenia.

Various factors, such as the geological characteristics of the soil, building materials, dwelling type, indoor air radon characteristics, microclimatic parameters, and life style in the dwelling (ventilation) all influence the indoor radon concentration. So far, there has been no mathematical model able to predict with satisfactory reliability the radon concentration in the indoor environment from all these data. This was the reason (and the small size of the country enables it) why indoor radon rates in all the kindergartens and play schools were surveyed in our study.

In this study, the gamma dose rate, although not of primary interest, was also recorded in all the sampling places.

MATERIALS AND METHODS

The kindergartens and play schools in Slovenia vary in their construction, age, heating system, ventilation, and occupancy habits. Most of them are single story buildings, about 20 y old, but there are also older buildings. The majority of the kindergartens and play schools are in urban centers. Hours of operation are from 5:30 a.m. to 4:30 p.m. Children usually arrive at the kindergartens and play schools between 7 and 8 a.m. and spend 6–8 h there. The age of children ranges from 1–7 y.

In 1989, the EPA (Environmental Protection Agency) issued two publications (U.S. EPA 1989a and b) on radon measurements in schools. Here, the EPA recommended screening measurements under closed conditions, the results of which are used to forecast

* "J. Stefan" Institute, Ljubljana, Jamova 39, P.O. Box 100, Slovenia; † Department of Education, Strossmayer University, Osijek, P.O. Box 44, Croatia.

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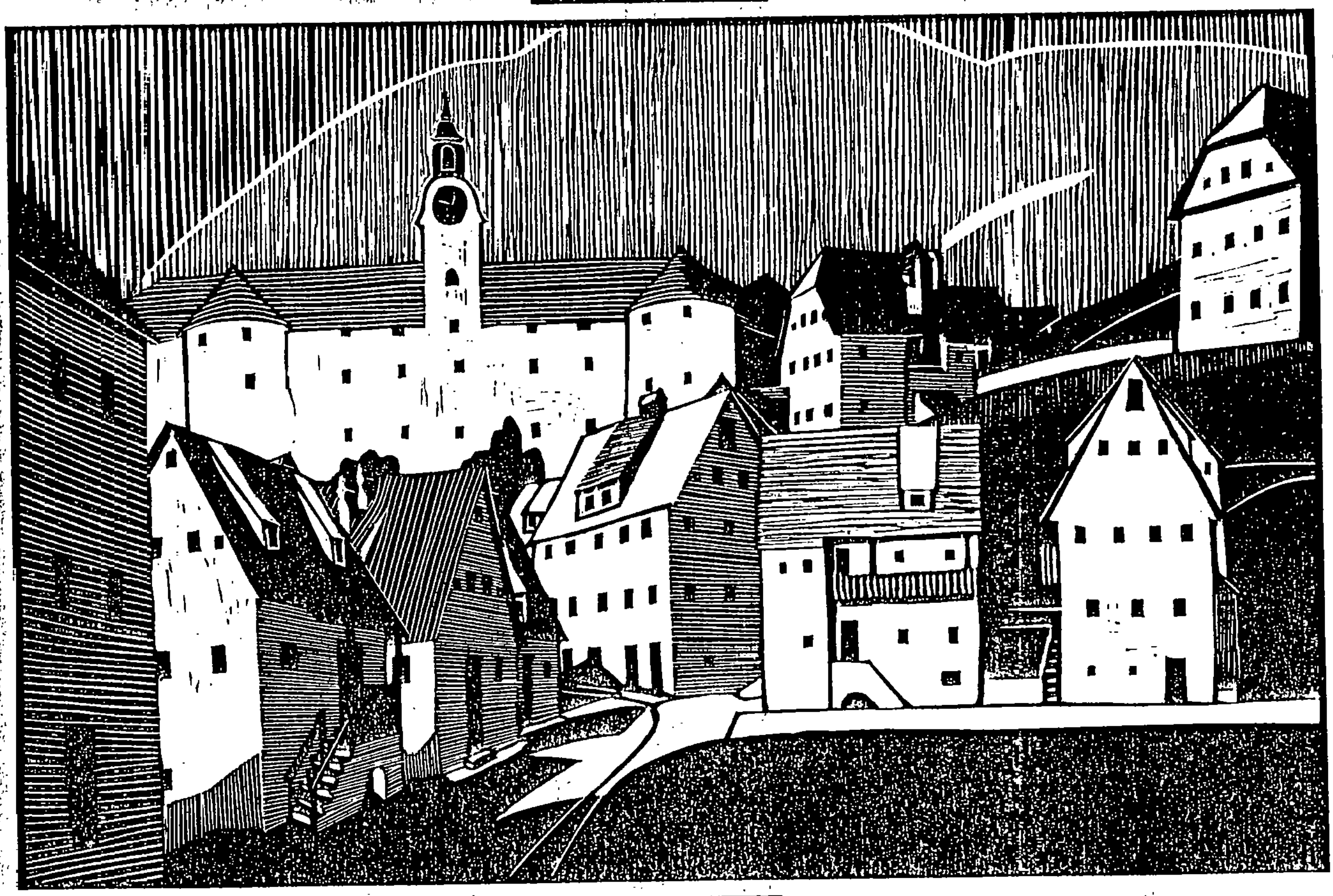

IDRIJSKI

RAZGLEDI

VESNA MIKLAVČIČ, MILKO KRIŽMAN, BLAŽ POLJANŠEK, MATEJ ČEBOKELJ

RADIOAKTIVNOST V ZAVRATCU

Radioaktivnost in človek

Fizikalne količine v zvezi z radioaktivnim sevanjem

Razpolovni čas ($t_{1/2}$)

Čas, v katerem razpade polovica vseh atomov oziroma njihovih jeder, imenujemo razpolovni čas. Razpada določenega posameznega atoma se ne da natančno napovedati, lahko pa se točno določi razpolovni čas skupine istovrstnih jeder. Po enem razpolovnem času nam ostane še 1/2 začetnih jeder, po dveh 1/4, po treh 1/3,.... Razpolovni čas je od elementa do elementa zelo različen lahko je to le nekaj delčkov sekunde ali pa več milijard let.

Aktivnost (A)

Aktivnost radioaktivnega vira je število razpadov v časovni enoti. Enota za aktivnost je becquerel. Enota enega becquerela nam pove, da v eni sekundi razpade eno jedro.

Absorbirna doza (D)

Absorbirna doza je količina, ki pove, kolikšna energija se je absorbirala v snovi na enoto mase. Enota je gray (Gy). Definirana je za vse vrste ionizirajočih sevanj in za vse snovi z izvorom. Hitrost absorbirane doze je definirana z razmerjem med absorbirano dozo in časom, merimo jo z Gy/h.

Ekvivalentna doza (H)

Absorbirana doza ne opisuje dovolj dobro bioloških posledic v človekovem telesu, zato so v radiološko zaščito uvedli novo količino, ki ob absorbirani energiji v enoti mase človeškega organizma upošteva tudi značilnost posameznih vrst sevanja. To količino imenujemo ekvivalentna doza, ki je definirana s produktom med absorbirano dozo in faktorjem kvalitete sevanja. Ekvivalentno dozo merimo v sieverthih (Sv). Hitrost doze je definirana kot razmerje med ekvivalentno dozo in časom. Merimo jo v Sv/h.

Nekaj o sevanju in radioaktivnosti

Vsako sevanje je tok delcev ali pa oddana energija v obliki elektromagnetnega valovanja. Prisotno je povsod v človekovem okolju in človek ga uspešno izkorišča in uporablja. V glavnem sevanja delimo na ionizirajoča in neionizirajoča. Ta delitev je predvsem posledica učinkov, ki jih različna sevanja povzročajo na živo snov. Tako so neionizirajoča sevanja: svetloba, toplotno sevanje, radijski valovi, ultravijolično sevanje, ultrazvok in mikrovalovi. Ionizirajoča sevanja pa so: radioaktivno sevanje, rentgensko sevanje in tudi sevanje TV zaslonov. Osnovna značilnost ionizirajočega sevanja je nastanek ionov ali ionizacija pri prehodu skozi snov. Vir kateregakoli sevanja je lahko naraven ali pa ga je ustvaril človek.

Eno od ionizirajočih sevanj predstavlja tudi radioaktivnost. Radioaktivnost je lastnost nekaterih elementov, da z razpadom jedra prehajajo v energetsko stabilnejše stanje; pri tem prehodu pride do izsevanja različnih vrst žarkov. Radioaktivnost kot pojav je leta 1896 odkril francoski fizik Henri Becquerel pri proučevanju fluorescence. Zanimalo ga je predvsem, katera od fluorescenčnih snovi oddaja žarke X. Pred svetlobo zaščitene fotografske plošče je skupaj s kristalom fluorescenčne snovi nameraval izpostaviti sončni svetlobi. Ker se je takrat začelo obdobje slabega vremena, ni mogel nadaljevati s poskusi, zato je že pripravljene fotografske plošče spravil za nekaj dni v predal. Ko je ploščo razvil, je ugotovil, da je plošča vseeno močno potemnela. Sevanje, ki ga je snov oddajala, očitno ni bilo odvisno od zunanje svetlobe. Pojav je Marie Curie prvič poimenovala radioaktivnost.

Sevanja, ki jih oddajajo nestabilna ali radioaktivna jedra, niso med seboj enaka; že kmalu po odkritju so ugotovili, da oddaja radijev preparat različne vrste sevanj, ki so jih poimenovali po njihovem vedenju v močnem električnem ali magnetnem polju. Tako je poznanih več vrst ionizirajočih sevanj in jedrskih razpadov. Znano je sevanje alfa, ki je zelo neprodorno in prodre le v površino kože ter ga popolnoma ustavi že list papirja. Sevanje beta je prodornejše od sevanja alfa, vendar ga zaustavi že plošča iz aluminija debeline nekaj milimetrov. Sevanje gama oziroma gama žarki so elektromagnetno valovanje, ki ga emitirajo nestabilna jedra. To elektromagnetno valovanje je lahko zelo prodorno, saj žarki gama prodrejo skozi papir, plastiko, tkivo, železo, beton. Lahko gredo skozi ves človekov organizem in se pri tem le malo absorbirajo. Skozi zrak lahko prepotujejo nekaj sto metrov. Popolnoma jih absorbira en meter betona ali pa

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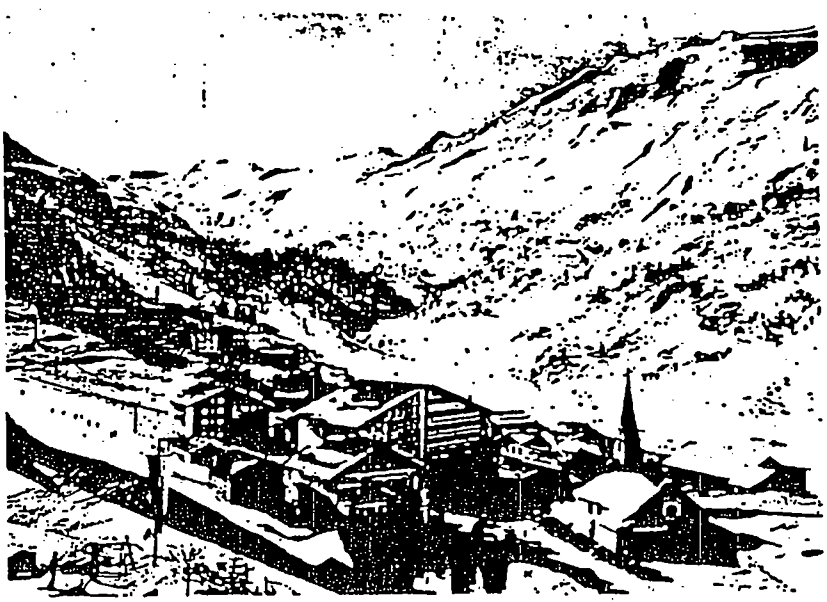

28–30 April 1993

OBERGURGL / TYROL, AUSTRIA

PROCEEDINGS

VOLUME 3

"LIVING WITH RADIATION" IN SLOVENIA (1988 - 1992)

A. Fajgelj[1], M. Križman[1], P. Stegnar[1] and J. Škrk[2]

1. *"J. Stefan" Institute, Jamova 39, P.O.Box 100, 61111 Ljubljana, SLOVENIA*
2. *Institute of Oncology, Zaloška 2, 61105 Ljubljana, SLOVENIA*

In this work the efforts which research workers have made in Slovenia in the last five years towards public information and education in the field of radioactivity and radiation are reviewed in condensed form. The most important examples of books, booklets, articles and TV-series are presented.

INTRODUCTION

In Slovenia, although a relatively small country, with an area of 20251 km^2 and 2 million inhabitants, many different sources of ionizing radiation exist. There is a nuclear power plant (Krško - 632 MW$_e$), a low power research reactor (Ljubljana - 250 kW) and a uranium mine (Žirovski vrh - mining and milling ceased in 1990). Beside nuclear facilities, there are many sources of technologically enhanced natural radioactivity e.g. large fly ash deposits, building materials made of fly ash, waste deposits from non-uranium mining and phosphate rock processing , etc. In some Slovenian regions relatively high indoor radon concentrations were found, originating from geological and other sources, and radioactive deposits.

Public interest in radiation greatly increased after the Chernobyl accident in 1986. At the same time, intensive political changes in Slovenia and the formation of a "green movement" influenced public relations and reactions to exposure to ionizing radiation. However, in this case the need for correct, objective and understandable information to be available about the general facts on radiation and radiation protection became evident.

The topic of radiation is not an easy one at all; a relatively large background knowledge is needed for good understanding of radiation protection problems and also for critical evaluation of measurement results., etc. Here the contribution of scientists and research workers from this field plays an important role.

Surprisingly, the first book about radiation written in the Slovenian language "The Secret of Radioactivity"[1] was issued only twelve years after Becquerel's discovery. However, numerous subsequent publications oriented to public awareness have been prepared. But, as well as some other activities e.g. the annual "Open day" at the "J. Stefan Institute", short contributions on TV and radio, small advertising pamphlets, newspaper

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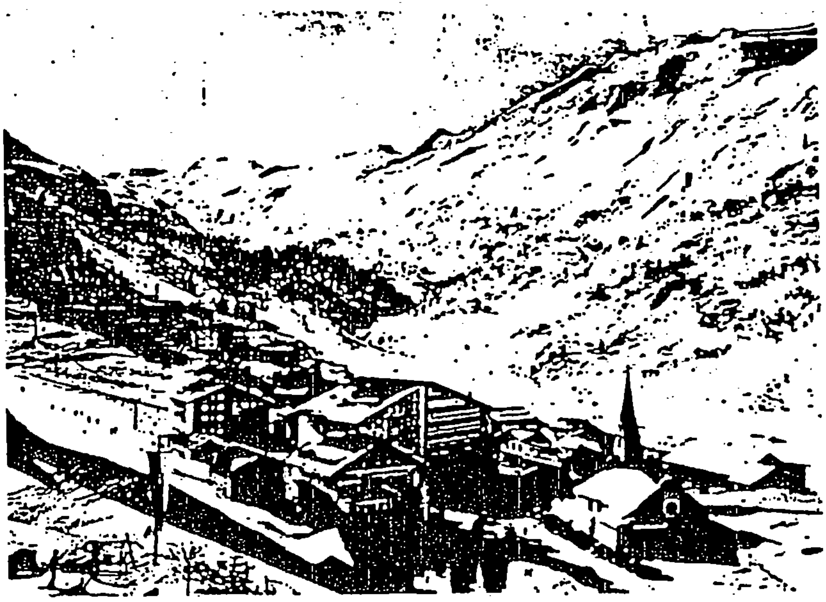

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ATMOSPHERIC RADON CONCENTRATIONS IN THE ENVIRONMENT OF URANIUM MILL TAILINGS IN SLOVENIA

M.Križman, P.Stegnar
"Jožef Stefan" Institute, University of Ljubljana, Jamova 39
SLO-61111 Ljubljana, Slovenia

Abstract - The levels of radon and its short-lived daughters in air were measured in the nearby surroundings of the dry tailings pile at the "Žirovski Vrh" uranium mine, situated on the slope of a hill. Different techniques were used, mainly charcoal adsorbers and continuous radon daughter monitors. Maximal radon concentrations were found at the (northern) lower part of the tailings pile, at the same height where a temperature inversion layer exists. Typical daily averages were about 50-80 Bq/m^3, and can temporarily exceed 250 Bq/m^3. In a valley below, concentrations were essentially lower, and upwards of the tailings pile concentrations dropped to levels of about 15 Bq/m^3. Continuous measurements of radon daughters showed that the main impact occurs only for a short period of each day, namely in the late afternoon when cold air moves over the tailings down to the valley of the Todraščica stream. The radon flux from the bare tailings was measured using the charcoal adsorption technique and a field experiment with different cover layers was prepared.

INTRODUCTION

Radon concentrations in the vicinity of uranium mill tailing piles were already measured in different environments (1-4). The very common conclusion based on these studies is that levels of radon, originating from the U mine and mill tailings, sharply decrease to environmental values at distances of some hundreds of metres. For the "Žirovski Vrh" Uranium Mine the authors (5) reported that an enhancement of radon levels was observed even at large distances of a few kilometres; due to the meteorological and topographical characteristics of the mine environment air masses, rich in radon, are obviously channeled along the narrow valley far away, without a significant decrease in Rn-222 concentrations.

Outdoor radon concentrations were measured as a part of the radioactivity surveillance programme of the uranium mine. In the middle of 1990 the "Žirovski Vrh" uranium mine ceased operation because of its low uranium content (0.08 % U_3O_8) and production of yellow cake stopped after five years of operation. Besides other U-ore deposits, over 600.000 tons of uranium mill tailings were transported during the operation to a dry deposit on the slope of the surrounding hill. The tailings pile is almost 40.000 m^2 in area, located at an elevated position, half a kilometre distant from and 100-150 metres above the valley. It is approximately 2 km from the mine and mill facilities (Fig 1). Since this area lies well above the average local temperature inversion layer, an efficient dispersion of exhaled radon should be expected. The impact of radon emission on environmental concentrations is estimated in relation to the decommissioning requirements.

MATERIALS AND METHODS

Based on prospective measurements of gamma dose-rate, different samples of tailings were taken in order to determine an average content of the main radionuclides U-238, Ra-226, Th-230 and Pb-210 by gamma spectrometric analysis. A germanium detector was calibrated with U and Ra-226 standards (IAEA and NIST). About 0.15 kg of dried sample was sealed in cylindrical plastic containers and stored almost a year before being analyzed,

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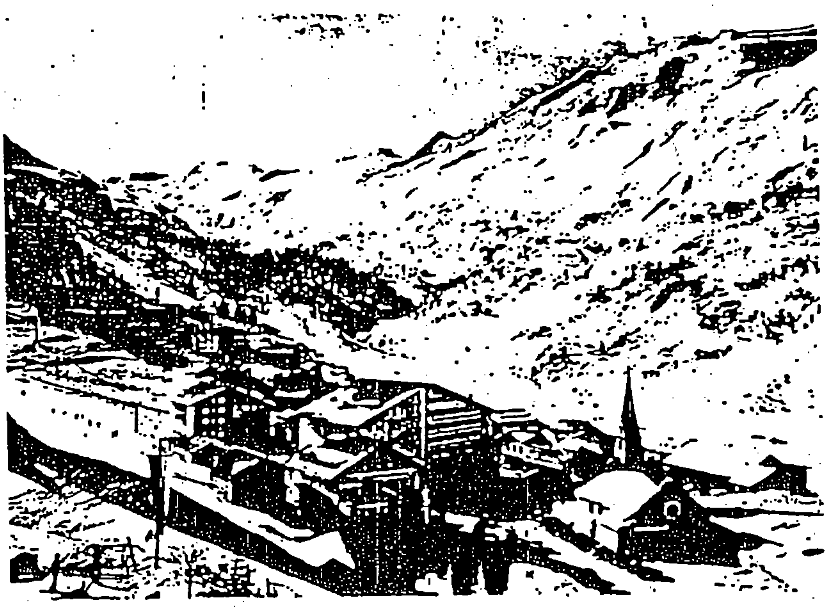

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VOLUME 3

EXAMPLES OF HIGH INDOOR RADON CONCENTRATIONS IN KINDERGARTENS AND PLAY SCHOOLS IN SLOVENIA

J. Vaupotič, M. Križman, J. Pezdič, P. Stegnar, I. Kobal

"J. Stefan" Institute, Jamova 39, P.O.Box 100, Ljubljana, Slovenia

ABSTRACT

Systematic measurements of indoor radon concentrations in all the 730 kindergartens and play schools in Slovenia were carried out. The basic method was direct sampling of air into alpha scintillation cells, but in cases with increased indoor radon concentrations track-etch detectors and alpha spectroscopy were also applied. In 72% of kindergartens and play schools instantaneous indoor radon concentrations were below 100 Bq m^{-3}, with a geometric mean of 58 Bq m^{-3}. In 16 cases it exceeded 800 Bq m^{-3}, with the highest value of 5750 Bq m^{-3}.

INTRODUCTION

After several preliminary indoor and outdoor radon studies in the last ten years in Slovenia (Kobal et al. 1988), in the 1990 winter period a new indoor radon project started. The programme was planned to cover all the 730 kindergartens and play schools in the first stage, about 800 selected schools and some public buildings in the second stage, and finally, selected houses and flats. The first step was finished in 1991. In 16 cases (2.2%) indoor radon concentrations (instantaneous values obtained by alpha scintillation cells) exceeded 800 Bq m^{-3} and in six cases they were above 1500 Bq m^{-3}, and hence the Ministry for Health and Welfare of the Republic of Slovenia required remedial actions for two of them. Now the second step of the programme is being performed and up till now indoor radon concentrations in about 550 primary and secondary schools have been measured. The results of this radon survey study will also be useful in preparing action levels for indoor radon for Slovenia. At the present time the recommendations of World Health Organization are being used.

SAMPLING AND MEASUREMENTS

The kindergartens and play schools vary in their age, construction, ventilation and occupancy habits. Most of them are single storey buildings, about twenty years old. The working time is from 5.30 a.m. to 4.30 p.m. Children usually come between 7 and 8 a.m. and spend six to eight hour there. The age of the children is from 1 to 7 years.

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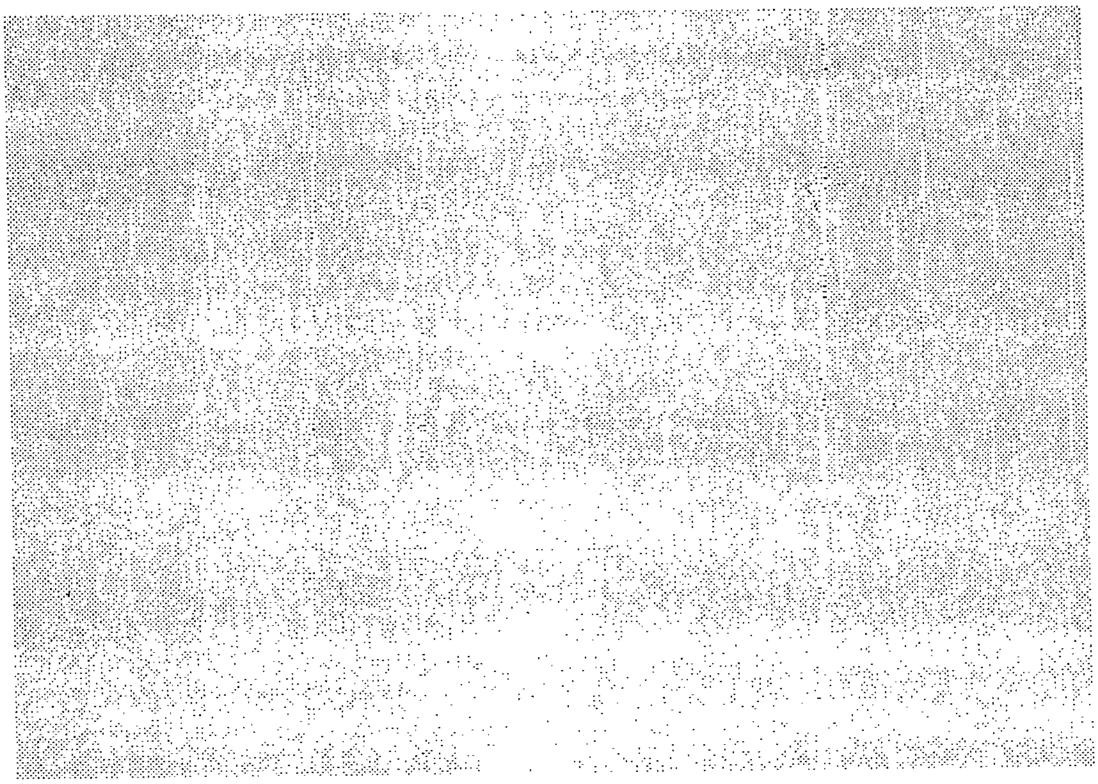

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Edited by Denis Glavič Cindro

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LANGZEIT-UMWELTÜBERWACHUNG VON RADON UND SEINEN ZERFALLSPRODUKTEN DURCH KONTINUIERLICHE α-SPEKTROMETRIE [1]

LONG TERM ENVIRONMENTAL MONITORING OF RADON AND ITS DECAY PRODUCTS WITH CONTINOUS α-SPECTROMETRY

J. E. Peter
GSF- Forschungszentrum für Umwelt und Gesundheit, Neuherberg, 85764 Oberschleißheim

M. Križman
Institut "Jožef Stefan", Jamova 39, SLO-61111 Ljubljana, Slowenien

Zusammenfassung

Für die kontinuierliche Messung der Luftkonzentration von Radon und seinen Zerfallsprodukten wurden automatische Meßstationen entwickelt. Jede Station besteht aus einem Sampler mit PIPS-Detektor und Multichannel-Analyser, einer Pumpe und einer Steuerungs- und Registriereinheit, die die Speicherung der stündlich erfaßten Spektren auf Diskette erlaubt. Die Erfassung von Spektren und die hohe Zeitauflösung sind erforderlich, um den Einfluß möglicher Radonquellen zu bestimmen. Meteorologische Parameter können mit der gleichen Zeitauflösung simultan registriert werden. Die Stationen arbeiten vollautomatisch und erfordern nur etwa alle 14 Tage einen Wechsel des Filters und der Datendiskette. Eine wichtige Anforderung war die Robustheit der Stationen gegen extreme Witterungsbedingungen.

Ein Netzwerk dieser Stationen ist seit etwa vier Jahren in der Umgebung eines Uranerzbergwerks in Slowenien im Betrieb und hat dort seine Brauchbarkeit bewiesen. Die Ergebnisse zeigen wie erwartet einen starken Zusammenhang der Zerfallsproduktkonzentrationen mit den meteorologischen Parametern. Obwohl Radon in der Atmosphäre über große Distanzen transportiert wird, können unter bestimmten Bedingungen lokale Einflüsse identifiziert werden. Die Ergebnisse der Messungen dienen zur Bewertung der zusätzlichen Exposition der Bevölkerung in der Umgebung des Bergwerks bzw. der Halden.

Summary

Automatic instruments have been developed for the continuous measurement of the concentration of radon and its progeny in air. Each instrument consists of a sampler including a PIPS-detector and a Multi-Channel-Analyser, a pump and an unit for control and storage of the hourly recorded spectra on floppy disk. The use of spectrometry and the high time resolution are necessary for the identification of possible radon sources. Meteorologic conditions are recorded at the same time intervals. The devices operate unattended with the exception of the replacement of filters and diskettes every 14 days. An important feature of the instruments is their robustness in respect to severe meteorological conditions.

A network of these devices was installed around an uranium mine in Slovenia and has proved its usefulness in about four years of operation. The results show a strong dependency of air concentrations on meteorologic parameters. Although radon can be transported over great distances in air, local influences can be separated under certain conditions. The results have been used to assess the additional exposure of the population in the vicinity of the mine or the tailings pile, respectively.

[1] Das Vorhaben wurde im Auftrag des Bayerischen Staatsministeriums für Landesentwicklung und Umweltfragen durchgeführt

HDZZ CRPA

ZBORNIK RADOVA DRUGOGA SIMPOZIJA HRVATSKOGA DRUŠTVA ZA ZAŠTITU OD ZRAČENJA

PROCEEDINGS OF THE SECOND SYMPOSIUM OF THE CROATIAN RADIATION PROTECTION ASSOCIATION

Urednici / Editors
Zdenko Franić
Dragan Kubelka

Zagreb
1994

RADON IN SEVANJE GAMA V ZGRADBAH IZ ELEKTROFILTRSKE OPEKE V VELENJU

Ljiljana Mljač
ERICo Velenje - Zavod za ekološke raziskave
Velenje, SLOVENIJA

Milko J. Křižman
Institut "Jožef Stefan"
61000 Ljubljana, SLOVENIJA

UVOD *Zaradi uporabe pepela v gradbeništvu so lahko prebivalci, ki živijo v zgradbah iz elektrofiltrske opeke, dodatno izpostavljeni ionizirajočim sevanjem. Elektrofiltrska opeka (v nadaljevanju EFE opeka) vsebuje več kot 75 % pepela s povečanimi koncentracijami naravnih radionuklidov U-Ra razpadne vrste. Stanovalci so tako izpostavljeni povišanim koncentracijam radona ter povečanemu sevanju gama zaradi radioaktivnosti gradbenega materiala (1)*
V Velenjski tovarni gradbenega materiala so v letih od 1960 do 1986 med drugim izdelovali gradbene elemente iz elektrofiltrskega pepela (2). Ocenjujejo, da je samo na področju Štajerske iz EFE opeke zgrajeno nekaj deset tisoč stanovanj, od tega je veliko število individualnih hiš in stanovanjskih blokov zgrajeno prav v Velenju, kjer živi približno 30.000 prebivalcev.
Namen naše raziskave je bil, da ugotovimo, kolikšna je izpostavljenost stanovalcev sevanju v različnih bivalnih okoljih, to je v zgradbah iz materiala s povišano radioaktivnostjo (EFE opeka), v zgradbah z običajno radioaktivnostjo (navadna opeka) in v zgradbah z nizko radioaktivnostjo (beton).

METODE DELA

Meritve radioaktivnega sevanja smo opravili predvsem v zgradbah iz EFE materiala, za primerjavo pa smo merili radon in sevanje gama tudi v zgradbah iz navadne opeke in iz betona. Iz primerjave rezultatov smo lahko ugotovili, kolikšen prispevek ima na koncentracije radona in na sevanje gama gradbeni material. Oba parametra smo merili tudi na prostem. V bivalnem okolju smo opravljali meritve v prostorih, kjer se ljudje zadržujejo največ časa, to so dnevni prostori in spalnice. V EFE zgradbah smo izbrali 16 merilnih mest, v zgradbah iz navadne opeke 5 merilnih mest in 5 merilnih mest v zgradbah iz betona. Na prostem smo izbrali 5 merilnih mest.
Pri meritvah radioaktivnega sevanja smo uporabili različne metode merjenja. Za merjenje koncentracij radona preko daljšega obdobja smo uporabili detektorje jedrskih sledi CR-39. S to metodo dobimo povprečne vrednosti za daljše časovno obdobje vključno z dnevnimi in sezonskimi nihanji koncentracij radona. Za ugotavljanje koncentracij radona v krajših intervalih (48-urno povprečje) smo uporabili metodo adsorpcije radona na aktivnem oglju. Koncentracije radonovih

HDZZ CRPA

ZBORNIK RADOVA DRUGOGA SIMPOZIJA HRVATSKOGA DRUŠTVA ZA ZAŠTITU OD ZRAČENJA

PROCEEDINGS OF THE SECOND SYMPOSIUM OF THE CROATIAN RADIATION PROTECTION ASSOCIATION

Urednici / Editors

Zdenko Franić

Dragan Kubelka

Zagreb

1994

ENVIRONMENTAL RADIOACTIVITY AT THE FORMER "ŽIROVSKI VRH" URANIUM MINE AND DOSE ASSESSMENT

Milko J. Križman
Jožef Stefan Institute
61000 Ljubljana, SLOVENIA

INTRODUCTION *The former uranium mine at Žirovski vrh is situated in the small village of Todraž, in northwest Slovenia, 35 km distant from the Austrian and Italian borders and 30 km from Ljubljana, the capital. The mining area lies in a subalpine region of the country, in a deep valley with frequent temperature inversions (about 50 % of the year). Some hundreds of people live in the area within a radius of 2 km from the mine. Relatively low grade ore (less than 0.1% U_3O_8) was excavated and treated in the period 1985-1990. Radioactive wastes, such as chemical tailings of about 600,000 tons were deposited on the slope of a hill, about 100-150 m above the small and narrow valley. The waste rock deposit (1.5 millions tons of spoil, with a content of 70 ppm U_3O_8) and a temporary deposit of some thousand tons of uranium ore are located near the bottom of the main valley. These two sites are now planned to be restored. The aim of this paper is to present the radiological impact to the environment in terms of enhanced radioactivity and the related public exposure nowadays, in close-out period*

MATERIALS AND METHODS

The regular environmental monitoring programme, based mainly on US Regulatory Guide No. 4.14, started in 1985 and has covered all the critical pathways. After cessation of mining and milling during still lasting closure period, the surveillance program has been further running continuously, together with dose assessment. Measurements of environmental radioactivity were performed at numerous places in the nearby vicinity and also at points distant from the mine. Results obtained were compared with those measured simultaneously at reference point(s), lying beyond the influence of the mine sources. On this basis the contribution of the mine radioactivity to the environment was estimated.

Several sampling and measuring techniques were used. Air particles were collected on filters and counted by a high resolution gamma spectrometry. Radon determination was performed with nuclear track detectors and charcoal canisters, and for radon daughters determination we mainly used continuous measurements by alpha spectrometry. Uranium in water was determined by neutron activation analysis and chemical separation, and radium-226 by the sorption-emanation method. Radioactivity in soils and sediments was measured by gamma-spectrometry, and low levels of radionuclides in food and crops were determined using a well-type germanium detector. We use thermoluminescent

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1994-10-13

Dear Mr. Krizman,

SUBJECT: RER/9/022 IAEA TC Regional Project on Environmental Restoration in Central and Eastern Europe, Third Workshop, Rez, Czech Republic, 12-16 December 1994

A Regional Project on Environmental Restoration in Central and Eastern Europe has been in operation since 1992 to address the very serious issue of environmental contamination, resulting primarily from mining and milling of uranium ore and to a lesser extent from other nuclear activities in the region. Two workshops have been held so far; the first one in Budapest, Hungary, in October 1993, which dealt with the subject of identification and characterization of radioactivity contaminated sites in the region and the second workshop at Prestany, Slovak Republic, in April 1994, which focused on the planning and preparation for environmental restoration.

It is now planned to hold the projects third Workshop at Rez, Czech Republic, from December 12-16, 1994. This Workshop will build upon the technical information presented at the previous two workshops and deal more specifically with the subject relating to technologies available for environmental restoration in the countries of the region. A visit to a uranium mining site has also been planned in order to get a closer view of the real problems associated with such activities.

I am pleased to invite you to this Workshop and kindly request you to prepare a lecture and written paper on the lines detailed in the enclosed job description. Presentation of comprehensive information on the state-of-art activities in your country would help in the assessment of problem and consequently in the planning of future Agency supported activities in this area.

In accordance with IAEA rules and practices, daily subsistence allowance (DSA) and international travel from your home country to Řez and return will be paid for eligible members of the workshop. Please confirm your participation as soon as possible but no later than 7 November 1994.

Yours sincerely,

M. Samiei
Head, Middle East & Europe Section
Division of Technical Co-operation
Programmes

Attachments:

Mr. M. Krizman
Institute Joseph Stefan
Jamova 39
61111 Ljubljana
Slovenia

INTERNATIONAL ATOMIC ENERGY AGENCY

Regional Technical Co-operation Project on Environmental Restoration in Central and Eastern Europe

Second Workshop, Slovak Republic, 11-15 April 1994

Provisional Agenda

Monday, 11 April

10:00 - 12:30
1. Opening of the Meeting, [illegible]
   Administrative Information
2. [illegible] of the Project [illegible]
3. [illegible]
4. [illegible]
5. [illegible]

14:00 - 17:30
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]

17:30 [illegible]

Tuesday, 12 April

[illegible]

08:30 - 12:30
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]

[illegible]

14:00 - 17:30
14. [illegible]
15. [illegible]
16. [illegible]
17. [illegible]

Wednesday, 13 April

Chairperson Mr. P. Sandru (Romania)

08:30 - 12:30	18.	PER in the Russian Federation, presentation and discussion (Speaker A. Nechaev)
	19.	PER in Ukraine, presentation and discussion (Speaker C. Rudy)
	20.	PER in Belarus, presentation and discussion (Speaker G. Sharovarov)
	21.	PER in Khazakhastan, presentation and discussion (Speaker M.A. Akhmetov)

Chairperson Mr. B. Sunblad (Sweden)

14:00 - 17:30	22.	PER in Poland, presentation and discussion (Speaker A. Piestrzynski)
	23.	PER in Slovenia, presentation and discussion (Speaker M. Krizman)
	24.	PER in Croatia, presentation and discussion (Speaker A. Saler)
	25.	USA second presentation (Speaker G. Westerbeck)

Thursday, 14 April

Chairperson Mr. E. Ettenhuber (Germany)

08:30 - 11:30	26.	PER in France, second presentation (Speaker H. Camus)
	27.	PER in Bulgaria, presentation and discussion (Speaker A. Dimitrov)
12:30 - 17:30	28.	In-field visit to a contaminated site, Slovak Republic

Friday, 15 April

Chairperson Mr. A. Slavik (Slovak Republic)

09:00 - 12:00	29.	Summary review of the workshop (Chairperson)
	30.	Instructions for authors of papers
	31.	Consideration and approval of the work plan for future project activities
	32.	Closing of the meeting

Notes

1. Coffee breaks will normally be from 10:00 - 10:30 and 15:00 - 15:30. Lunch breaks will normally be from 12:30 - 14:00 (Thursday 11:30-12:30)

2. The time allowed for each presentation will be 30-40 minutes, followed by a 15 minute discussion.

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1994-03-29

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SPEKTROSKOPSKA SEKCIJA

9. Symposium

SPECTROSCOPY IN THEORY AND PRACTICE

9. simpozij

SPEKTROSKOPIJA V TEORIJI IN PRAKSI

ABSTRACTS
ZBORNIK POVZETKOV

Bled, 10-13 APRIL, 1995

KONTINUIRNA SPEKTROMETRIJA ALFA RADONOVIH KRATKOŽIVIH POTOMCEV V OKOLJU RUDNIKA URANA CONTINUOUS ALPHA SPECTROMETRY OF RADON SHORT-LIVED DECAY PRODUCTS IN THE U-MINE ENVIRONMENT

Milko Križman
Institut Jožef Stefan, Jamova 39, 61111 Ljubljana

Merilnik za kontinuirno spektrometrijo alfa radonovih kratkoživih potomcev na zračnih filtrih so razvili na GSF ISS (Neuherberg); sestoji iz procesorsko vodenega merilnega dela skupaj s silicijevim planarnim detektorjem (PIPS) in glavne kontrolne enote z disketnim zapisom podatkov. V okviru mednarodnega sodelovanja Bavarska-Slovenijan na skupnem projektu je bila postavljena mreža teh merilnikov na območju rudnika urana Žirovski vrh, tako na odlagališčih kot v neposredni okolici z namenom, da bi bolje spoznali razširjanje in obnašanje sproščenega radona, njegove ravni v okolju, časovna obdobja s povišanimi koncentracijami in časovne intervale z ekstremno nizkim ravnotežjem med radonom in njegovimi kratkoživimi potomci.
Iz analize spektrov alfa Rn-potomcev (^{218}Po, ^{214}Po) in iz razmerja vrhov je mogoče sklepati na starost radona: višje vrednosti razmerja ^{218}Po/^{214}Po (več kot 0.4) pomenijo nizek faktor ravnotežja in označujejo "mladi" radon, ki izhaja iz bližnjih emissijskih virov. Razmerje pod vrednostjo 0.1 pomeni, da je radon "star", to je blizu ravnotežja s svojimi potomci in bolj oddaljen od lokacije svojega izvora. Alfa spektrometrija radonovih potomcev je pomebna metoda za razumevanje mehanizmov onesnaževanja zraka zaradi emisije radonovih virov, istočasno pa služi kot koristno orodje pri oceni izpostavljenosti prebivalstva sevanju. Namen predstavitve tega dela je tudi pokazati nekaj značilnih in posebnih primerov obnašanja radona v bližini jalovišč nekdanjega rudarjenja in predelave uranove rude na Žirovskem vrhu.

Abstract

Special instrumentation for continuous alpha-spectrometric measurements of short-lived radon decay products on air filters was developed at GSF ISS (Neuherberg); it consists of a processor controlled measuring unit with a passivated implanted planar silicon detector and a main control unit. In the framework of a Bavarian-Slovenian cooperative project, a network of several instruments was installed around the "Žirovski vrh" uranium mine area, on disposal sites and in their nearby surroundings in order to study the dispersion and behaviour of released radon, its environmental levels, time intervals with elevated concentrations and time intervals with extremely low equilibrium between radon and its short-lived progeny. Alpha spectra of radon decay products (^{218}Po, ^{214}Po) were analyzed and from the ratio of the two peaks the age of radon in air was estimated. Higher values of the ^{218}Po/^{214} (more than 0.4) mean a low equilibrium factor and indicate "young" radon, which released from adjacent sources. Ratio values below 0.1 mean that radon is "old", i.e. nearly in equilibrium with its daughters and more distant from location of its origin. Alpha-spectrometry of radon daughters is an important aid for understanding the mechanism of ambiental air contamination from radon emission sources and is at the same time a useful tool for estimation of corresponding public exposure. The aim of this presentation is also to show some special and typical cases of radon behaviour in the vicinity of uranium mining and milling disposal sites.

›nse to logging and roads:
paper PSW-146, Pacific
Berkeley, 12 p.
Vetrh.. Magistrsko delo.
porosity in Slovenia. Paper
ıe Interaction, July 4-8,
raziskovalnih ploskvah hrasta
:d for IUFRO P3.08.00
..ing, Germany, 5 p.
Effects of Timber Harvesting
t Oregon. Forest Science,
ıter Balance of the Subalpine
General Technical Report
al tests of HUSQVARNA
:minar "Soil, tree, machine

GOZD IN VODA
Oddelek za gozdarstvo Biotehniške fakultete, Univerza v Ljubljani, str. 215 – 226
GDK 116.11 : 116.91

VPLIV IMISIJSKIH POŠKODB NA VODNO FUNKCIJO GOZDA

N. Bogataj, P. Simončič

Izvleček

Škodljive snovi se iz onesnaženega zraka prenašajo v gozdne ekosisteme z atmosferskim depozitom v tla, vegetacijo in vode z mokrim (padavine) in suhim depozitom. Na Gozdarskem inštitutu Slovenije (GIS) zbiramo padavine v gozdu po "troughfall" metodi. V začetku avgusta 1993 smo začeli tedensko vzorčiti padavine na vrtu GIS na prostem, na gozdni meji pod krošnjo javora in pod krošnjami smrek ter tok vode po deblu javora. Vzorčenje je potekalo do začetka septembra 1994. V padavinskih vzorcih smo določili pH vrednost, elektroprevodnost, vsebnosti Ca, Mg, K, NH_3 , Pb, SO_4 in NO_3. Rezultati analiz so pokazali, da je vnos škodljivih snovi najmanjši na prostem in najvišji pod smrekovo krošnjo.

Ključne besede: imisija, depozit, gozd, vode

EFFECTS OF EMISSION–INDUCED DECLINE OF THE FOREST ON ITS HYDROLOGICAL FUNCTION

Abstract

Noxious substances of air pollution are transmitted to the forest ecosystem through atmospheric depositions, both wet and dry depositions, affecting the forest floor, vegetation and water. Throughfall method was used by the Forestry Institute of Slovenia, Ljubljana, to collect data on precipitation in the forest. From early August 1993 to early September 1994, weekly sampling of precipitation was conducted in different places of the garden of the institute: in the open, under the crown of a Norway maple and under Norway spruce crowns on the edge of à forest, and with Norway maple stemflow. Precipitation samples were analyzed as to pH value, electrical conductivity, and the Ca, Mg, K, NH , Pb, SO_4, and NO_3 content. Results of the analysis show that the input of noxious substances was the lowest in the open and the highest under a Norway spruce crown.

Key words: emissions, deposition, forest, water

Nevenka BOGATAJ, dipl. ing. gozd., mag. Primož SIMONČIČ, dipl. ing. les., Gozdarski inštitut Slovenije, Večna pot 2, 61000 Ljubljana

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UDK 114.12 : 116.91 : 181 . 48 :37

VAROVANJE VODNE VLOGE GOZDOV PRI TRANSPORTU LESA V SLOVENIJI

R. Robek, P. Kalan, L. Kutnar

Izvleček

Spremembe vodnih razmer pri transportu lesa so posledica sprememb fizikalnih lastnosti tal, pri čemer se spreminjata zunanja morfologija tal in količina ter struktura por. Poleg sprememb v dinamiki odtoka transport lesa povzroča tudi spremembe kakovosti vode, vendar pa ugotovljene koncentracije svinčevih spojin v površinskih vodah na prometnicah ne presegajo dopustnih vrednosti za pitno vodo. Ugotovili smo šibke zakonitosti spreminjanja vlažnosti tal v prečnem profilu, vendar je vrednotenje sprememb oteženo zaradi povezanega delovanja ostalih ekoloških faktorjev. Zmanjševanje nastalih motenj je mogoče doseči s selektivnimi raziskavami, z ukrepi gozdarske politike ter izobraževanjem v vodozbirnih območjih.

Ključne besede: transport lesa, vodna vloga gozda, indikatorske vrednosti rastlin, poroznost tal, svinec

PROTECTING THE HYDROLOGICAL ROLE OF THE FOREST FROM THE IMPACT OF WOOD TRANSPORT IN SLOVENIA

Abstract

Changes in the water conditions when transporting wood are the result of altered physical properties of the soil, which also alters the exterior morphology of the soil and the quantity and structure of pores. Besides changes in the runoff dynamics, wood transport also gives rise to changes in water quality, although the concentration of lead compounds found in surface waters along transport routes do not exceed the allowable drinking water levels. We found weak principles of altering wetness of the soil in a cross-section profile, however the assessment of the changes is hindered due to the linked activities of other ecological factors. The introduced disturbances can be reduced with the help of selective studies and measures introduced in the forestry policy and through the education of administrators in catchment areas.

Key words: wood transport, hydrologic role of the forest, indicator values of vegetation, ground porosity, lead

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Mag. Robert ROBEK, dipl. ing. gozd., Polona KALAN, dipl. ing. kem., Lado KUTNAR, dipl. ing. gozd., Gozdarski inštitut Slovenije, Večna pot 2, 61000 Ljubljana

loskva, 165 p.
p.
demii Nauk SSSR, Moskva,
oskva, 359 p.
ceučeloviho hospodareni s cili
Prace Vyskumneho ustavu
t forests for soil and water
Communicatiopnes Instituti
bok na stok rek. Lesnoe
lesa. Nauka, Novosibirsk,
Moskva, 236 p.
metcentra SSSR, vyp.153,
Lesovedenie i lesovodstvo, 3,
ennost', Moskva, 241 p.
pomlajencu na Pohorju. Mscr.
6 p.
ut. Forstarchiv, 7/8, pp.
skva, 376 p.
18
ij lesnyh resursov. Lesovedenie,
32, 2
odnye resursy. Nauka, Moskva,
ov. In Dokl.sov. učenyh na
kva, T.1, pp.79-98
. Leningrad, 286 p.
enen Sommer 1973. Forst und

GOZD IN VODA
Oddelek za gozdarstvo Biotehniške fakultete, Univerza v Ljubljani, str. 77 – 90
GDK 114.447 : 116.3 : 181.3 : 182.2 : (497.12*13 Črni log)

POMEN VODE ZA USPEVANJE IN VEČNAMENSKO RABO NIŽINSKIH MOKRIH GOZDOV

I. Smolej

Izvleček

Od ekoloških dejavnikov je za rast in razvoj gozda v poplavnih ravninah najpomembnejši vodni režim. V razvoju gozdnih združb so odločilne že majhne razlike v globini, velikosti nihanja podtalnice in pogostnosti poplav. Spremembe vodnega režima imajo zato lahko daljnosežne posledice za uspevanje teh gozdov. Zaradi obilice vode prihaja med gozdnim in vodnim gospodarstvom do neskladja pri večnamenski rabi gozdov. Prispevek opisuje Črni log pri Lendavi, kjer je vodno gospodarstvo uporabilo poplavni gozd črne jelše za zadrževalnik visokih voda reke Ledave. K rešitvi neskladij bi lahko pripomoglo sodelovanje panog pri postavljanju optimalne večnamenske rabe.

Ključne besede: večnamenska raba gozda, nižinski mokri gozd, sukcesija, dobrodejni pomen gozda, vodni režim, zadrževalnik, črna jelša

SIGNIFICANCE OF WATER FOR GROWTH AND MULTIPLE-PURPOSE USE OF FLOODPLAIN FORESTS

Abstract

The most important ecological factor for the growth and development of floodplain forests is the water regime. Small differences in the water table, the extent of the groundwater oscillation and the frequency of floods are decisive to the development of forest communities. The vast amount of water has led to discord between forest and water management in regard to the multi-purpose use of forests. The contribution describes Črni log near Lendava where the water management authorities used the flooded Črnje forest as an embankment for holding back the high water of the Ledava river. A solution to this discord might be found in cooperation between professional fields in determining optimum multi-purpose use.

Key words: multiple-purpose use of forest, floodplain forests, succession, beneficial functioning of forest, water regime, flood-control reservoir, black alder

Mag. Igor SMOLEJ, dipl. Ing. gozd., Gozdarski inštitut Slovenije, Večna pot 2, 61000 Ljubljana

stanja v Sloveniji. Bled, 28.-
e, Ljubljana, s. 15-18
.. Blatt- und Nadelproben für
?/34, s. 847-848.
an Fichte und anderen
lebenden Nadeljahrgänge und
ünden
rest Decline and Air Pollution.
en 1985. Ergebnisse der
anstalt, Wien, (tipkopis).
sedaten des Österreichischen
issen vorangegangener Jahre.
Bundesversuchsanstalt. Institut
, 70 s.
zdov v Sloveniji leta 1990.
o.
Typ: "SULMHOMAT 12 ADG".
Messtechnik, Bochum.

Zbornik gozdarstva in lesarstva, 47, 1995, s. 117 - 130

GDK: 160.24 : 161.1 + 181.45 + 425.1

PRESKRBLJENOST GOZDNEGA DREVJA Z MINERALNIMI HRANILI NA 16 x 16km BIOINDIKACIJSKI MREŽI

Primož SIMONČIČ*

Izvleček

Pri proučevanju propadanja gozdnega drevja na območju Slovenije so sodelavci Inštituta za gozdno in lesno gospodarstvo začeli l. 1985 nabirati vzorce iglic smreke, črnega in rdečega bora na točkah 16 x 16km bioindikacijske mreže. Arhivirani rastlinski material smo uporabili za splošno oceno preskrbljenosti gozdnega drevja z mineralnimi hranili na točkah mreže za obdobje od 1987. do 1991. leta. V enoletnih iglicah smo poleg skupnih vsebnosti žvepla določili še vsebnosti glavnih rastlinskih hranil: dušika, magnezija, fosforja, kalija in kalcija. Ocena je pokazala slabo preskrbljenost gozdnega drevja z dušikom in s fosforjem. Vsebnosti magnezija so v petih letih nihale od dobre (preskrbljenosti na večini bioindikacijskih točk) do slabše preskrbljenosti, razmeroma ugodne pa so prehranske razmere glede vsebnosti Ca in K.

Ključne besede: propadanje gozda, bioindikacija, bioindikacijska mreža, mineralno hranilo, vsebnost mineralnih hranil, Picea abies, smreka, Slovenija

THE PROCUREMENT OF FOREST TREES WITH MINERAL NUTRIMENTS ON THE 16 X 16 KM BIOINDICATION NETWORK

Abstract

Within the study of the forest damage in Slovenia, in 1985 the collaborators of the Forest and Wood Economy Institute started to collect samples of spruce, Austrian pine and Scotch pine needles at the points of the 16 x 16 km bioindication network. The registered biological material was used for a general assessment of the procurement of forest trees with mineral nutrients at the points of the 16 x 16 km network in the period from 1987 to 1991. Beside the total sulphur content in current-year needles the content of the main plant nutrients have been determined: nitrogen, magnesium, phosphorus, potassium and calcium. The assessment of the procurement of forest trees with mineral nutriments showed a deficient procurement with nitrogen and phosphorus. The magnesium content varied in the five years from a good procurement on the majority at the bioindication points to worse procurement, while the nutrition conditions regarding the Foliar content of calcium and potassium have been relatively favourable.

Key words: forest decline, bioindication, bioindication net, mineral nutritian, spruce, Picea abies, Slovenia

* Mag., dipl. inž. les., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

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Zbornik gozdarstva in lesarstva, 47, 1995, s. 85 - 116

GDK 160.201:160.26:425.1:181.45:(497.12)

BIOINDIKACIJA ONESNAŽENOSTI GOZDOV Z ŽVEPLOM NA PODLAGI VSEBNOSTI ŽVEPLA V ASIMILACIJSKIH DELIH GOZDNEGA DREVJA

Janko KALAN *, Polona KALAN **, Primož SIMONČIČ ***

Izvleček

Po izkušnjah raziskav, ki so bile izvedene v letih 1985-1993 na točkah osnovne bioindikacijske mreže (16 x 16 km), sklepamo, da je bioindikacija onesnaženosti zraka z žveplovim dioksidom po metodi analize vsebnosti žvepla v iglicah smreke, črnega in rdečega bora zelo primerna in tudi dovolj zanesljiva za ugotavljanje ogroženosti gozdov zaradi žveplovega dioksida. Gozdovi na območju Alp, Trnovskega gozda, Snežnika, Javornika, širšega kočevsko-ribniškega območja in Gorjancev so najmanj obremenjeni z žveplom. Najbolj obremenjeni gozdovi pa so na območju Koroške, Celja, Ljubljane, Zasavja, Maribora in Prekmurja. Vsebnost žvepla se je v zadnjih letih povečala na bmočjih ob meji z Italijo, Hrvaško in Madžarsko ter v bližini močnih emisijskih virov v notranjosti Slovenije.

Ključne besede: bioindikacija, analiza, iglice, žveplo, ovrednotenje, Slovenija

BIOINDICATION OF FOREST POLLUTION WITH SULPHUR BASED ON SULPHUR CONTENT IN ASSIMILATION PARTS OF FOREST TREES

Abstract

Based on the research carried out in 1985-1993 on the points of the basic bioindication network (16 x 16 km) it can be concluded that the bioindication of air pollution with sulphur dioxide by the method of sulphur content analysis in the needles of the Norway spruce, Scots pine, black pine is highly convenient and reliable for the establishing of forest endangerment due to sulphur. The forests in the region of the Alps, Trnovski gozd, Snežnik, Javornik, the broader Kočevje - Ribnica region and the Gorjanci are the least burdened by sulphur. The greatest burden was established in Koroško, in the region of Celje, Ljubljana, the region along the Sava river, in the vicinity of Maribor and in the Prekmurje. In the last five years the content of sulphur has increased in the zones along the border with Italy, Croatia and Hungary and the vicinity of strong emission sources in the central part of Slovenia.

Key words: bioindication, analysis, needles, sulphur, evaluation, Slovenia

* Dipl. inž. gozd., Gozdarski Inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO
** Dipl. inž. kem., Gozdarski Inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO
*** Mag., dipl. inž. gozd., Gozdarski Inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

Zbornik gozdarstva in lesarstva, 47, 1995, s. 57 - 84

GDK: 114 _ _ 013 : 181.45 _ _ 010 : (497.12)

PROUČEVANJE GOZDNIH TAL NA STALNIH RAZISKOVALNIH PLOSKVAH

Janko KALAN *, Polona KALAN **, Primož SIMONČIČ ***

Izvleček

V Sloveniji postavljamo sistem raziskovalnih ploskev za trajno opazovanje gozdnih ekosistemov. Opisana so merila za izbiro ploskev, na katerih proučujemo gozdna tla. Navedeni so tudi napotki za terenske in laboratorijske preiskave tal ter prikaz analiznih rezultatov.

Ključne besede: tla, gozd, raziskovalna ploskev, raziskava, metoda dela, Slovenija

THE STUDY OF FOREST SOIL IN PERMANENT RESEARCH PLOTS

Abstract

In Slovenia a system of research objects for permanent monitoring of forest ecosystems is being set up. The criteria regarding the selection of objects used for the study of forest soil are described and the instructions for filed and laboratory investigations as well as analysis results are given.

Keywords: soil, forest, research plots, investigations, methods, Slovenia

* Dipl. inž. gozd., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO
** Dipl. inž. kem., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO
*** Mag., dipl. inž. gozd., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

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August, 22-31. 1995: 333-335

The Forest Research Plot on Pokljuka

Hojka Kraigher[1], Franc Batič[2], Mihej Urbančič[1]

1 Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia

2 Agronomy Department, Biotechnical Faculty, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

Key words: forestry, research plot, stress physiology, subalpine forest ecosystems, bioindication, Norway spruce, Pokljuka, Triglav National Park

Abstract

The Forest Research Plot was chosen on a typical site for the Pokljuka plateau. It is covered by a supposedly autochtonous old Norway spruce stand with rejuvenation centres. Data on the physiological parameters can be used as representative values for a subalpine Norway spruce stand. The studies include: standard site and dendrological parameters, physiological parameters (foliar analysis, antioxidants, hormones and aminoacids in spruce needles), genetical and biochemical analysis (isoenzymes and molecular markers), microbiological activity (acid phosphatase, rate of decomposition, number and occurrence of fungal decomposers of wood and litter) and studies of symbionts and pathogens of Norway spruce (mapping of fruitbodies of mycorrhizal fungi, types of ectomycorrhizae, endophytes, epiphytes - lichens and phytopathological surveys). All physiological and ecological studies are planned to be repeated at certain time periods in order to understand better the functioning of the forest ecosystem on Pokljuka.

Introduction

A few years ago an interdisciplinary project was initiated in the area of the Triglav National Park (TNP), entitled 'Air pollution in the Triglav National Park and its impacts on forests and water - Athmosphere and the National Park'. The research team on bioindication, including the Forest Biology and Ecology Research Group from the Slovenian Forestry Institute, the Applied Botany and Plant Physiology Research Group from the Agronomy Department, and collaborators from the TNP headquarters, have been leading the studies within the subproject 'Forest'.The main objectives of the studies include i) monitoring of the physiological state of the forests in the TNP in comparison to the state of forests elsewhere in Slovenia and in neighbouring alpine countries; ii) analysis of the forest ecosystems from different aspects and on different levels in order to understand better the causes and mechanisms of decline due to several stress factors, from the climatic, edaphic and biologic to anthropogenic ones, which are represented by environmental pollution, forest management and management of other natural resources; iii) protection of natural and cultural heritage within the area of the Triglav National Park.

The studies were organized i) on the part of the Slovenian Forest Decline Monitoring Network (4x4 km), which falls into the area of the TNP; ii) on three altitude profiles (Bled-Pokljuka, Kranjska gora-Kurji vrh, Vrsnik-Planina v Plazeh), all starting at ca 900 m and ending at ca 1600 m high; iii) on the permanent Forest Research Plot (FRP) on Pokljuka.

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Some aspects of interpretation of forest trees defoliation data

Nevenka Bogataj

Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia

Key words: Forest decline, monitoring, quality control, defoliation, trend, Slovenia.

Summary

The evaluation of data on the forest tree condition is a weak point in forest decline monitoring as it enables only a very rough estimate of the state of forest health. The paper analyses the interpretation of the forest tred defoliation data in order to estimate their relevance and applicability. Quality control results of defoliation assessment in Slovenia are presented and the state of defoliation with its changes in the years 1987, 1991, 1993, 1994 on the 16 km grid.

1 INTRODUCTION

Forest damages in Slovenia are documented partly by regular forest management planning and primarily by sampling on the systematic plot grid. The evaluation of forest tree data collected on this grid has been a weak point of forest monitoring in Slovenia. The European model of forest damage evaluation is based on the defoliation and discoloration of forest trees (ANONYMUS,1987). A practical model of damage class calculation on the basis of other forest tree properties was developed in Slovenia (ŠOLAR, 1989). The model can be supplemented by using the subtraction method that enables the determination of the defoliation unexplained by known damages (JURC,1988). Additional data for the evaluation of forest condition are: index of atmospheric purity calculated from the number and covering of lichens (BATIČ, 1989), sulfur content in spruce (*Picea abies)* and pine (*Pinus nigra)* needles (KALAN, 1987). However, determination of forest health condition is mostly based on the defoliation data.

2 METHODOLOGY

2.1 Defoliation as a sign of tree disturbances

Defoliation is the most frequently used characteristic in determining the forest health condition in Europe. It reflects the environment and development of a tree, therefore is not specific and can not be used as a diagnostic tool unhesitatingly (INNES, 1993b). The following alternative symptoms are used in detailed and research oriented analyses: visual changes in shape, size, surface characteristics, color and number of leaves, changes of normal growth and development patterns, changes in normal flushing and senescence patterns, changes in physiologic processes (photosynthesis, respiration, transpiration, mineral nutrition, nutrient transportation,

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Mycobioindication of forest site pollution

Hojka Kraigher[1], Franc Batič[2], Reinhard Agerer[3]

[1] Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia

[2] Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia

[3] Institute for Systematic Botany, Menzingerstrasse 67, 80638 München, Germany

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Key words: mycobioindication, types of ectomycorrhizae, forest site pollution.

Abstract

Types of ectomycorrhizae on Norway spruce were determined in soil cores from two differently polluted forest research plots from the emmission zone of the Šoštanj Thermal Power Plant (TPP). The two plots are comparable regarding site characteristics, but polluted differently by the emmissions from the TPP. During the vegetation season 1993, 21 soil cores were taken from each plot. In these all fine root & ectomycorrhizal root tips were counted and the percentages of different types were calculated. Additionaly, soil & mycorrhizae from underneath fungal fruit bodies were taken in order to characterize new types of ectomycorrhizae. Classical anatomical methods and molecular tools were applied for identification. 17 types of ectomycorrhizae were determined on 28443 root tips in soil cores from the heavily polluted plot (Zavodnje). The predominant types were *Paxillus involutus, Xerocomus badius, Picerhiza parallela & Piceirhiza inflata.* On the less polluted plot (Mislinja) 24 different types were determined on 38502 root tips in equal volume and number of soil cores. The most frequent types were *Hydnum rufescens, Amphinema byssoides, Piceirhiza oleiferans, Cenococcum geophilum & Lactarius lignyotus.* Mycobioindication of forest site pollution through selective sensitive (here *Hydnum rufescens*), in comparison to unsensitive (here *Paxillus involutus*), fungal species in ectomycorrhizae is discussed.

Introduction

Mycorrhizae represent the main spatial and temporal linkage between different constituents in a forest ecosystem (Dighton, Boddy, 1991). Their functional compatibility, physiology and tolerance to different stress factors is species specific (Harley, Smith, 1983; Gianinazzi-Pearson, 1984; Gogala, 1991). Therefore knowledge on the ectomycorrhizal types - species composition and their abundance is necessary in order to understand the functioning of a forest ecosystem (Wollmer, Kottke, 1990).

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Endophytes of Austrian pine needles as indicators of pollution

Maja Jurc[1], Dušan Jurc[1], Nada Gogala[2], Primož Simončič[1]

1 Slovenian Forestry Institute, Večna pot 2, P.O. Box 523-X, 61001 Ljubljana, Slovenia
2 Biology Department of Biotechnical Faculty, University of Ljubljana, 61000 Ljubljana, Slovenia

Key words: *Pinus nigra* Arn., fungal endophytes, air pollution.

Abstract

Endophytic fungi species composition in healthy needles of Austrian pine (*Pinus nigra* Arn.) was investigated at eight locations in Slovenia. Results from October 1994 and January 1995 isolations were compared with analyses of macronutrients, sulphur and lead content of the needles. About 80 species of microfungi were revealed. From the observations and measurements described it was not possible to discriminate between the effects of environmental factors and effects of air pollutants. The pollution load of all measured elements is low and the environmental factors are very diverse. From the dendrogram of isolation frequencies it seems that the age of the tree affects the species composition and frequencies of endophytes to the greatest extent.

Introduction

The importance of fungi in forest ecosystems as decomposers, pathogens, endophytes and mycorrhizal partners makes them of vital interest in the research of mechanisms of forest life. Of these different fungal functions the least known about is the ecological role of endophytes. These are fungi that in a certain phase of their life cycle invade inner tissues of plants without causing visible symptoms of damage to their host. There is evidence that some endophytic fungi may live in a mutualistic symbiosis with their host (Petrini 1986, Carrol 1988), either acting directly as antagonists or inducing plant response against plant pathogens and herbivores. Fungal endophytes have been isolated in a wide range of plants; most conifers examined so far host endophytic fungi (Carroll, Muller & Sutton 1977, Carroll & Carroll 1978, Sieber-Canavesi & Sieber 1987, Sieber 1989).

There are indications that endophytic species composition and the frequency of colonisation are significantly dependent from the vitality of the host and from the degree of air pollution being negatively correlated with the degree of air pollution (Barklund & Rowe 1983). Simulated acid rain treatment reduced the number of isolated endophytes in birch leaves by approximately 25% (Helander et all. 1993). Sieber (1989) reports that air pollutants are suspected as a possible cause of changes in endophyte populations of Norway spruce and white fir.

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Evaluation of forest soil sampling methodology

Polona Kalan[1], Vida Hudnik[2], Primož Simončič[1]

[1] Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia
[2] Slovenian Chemistry Institute, Hajdrihova 19, 61000 Ljubljana, Slovenia

Key words: forest, soil, sampling methodology, statistical evaluation, tolerable error, number of subsamples.

Abstract

Forest soil was sampled on two different observation plots by following well described methodology. Sampling sites had been chosen in places with typical soil conditions for the observed forest site. To make sampling easier some natural forest site characteristics were considered.

Mg, Zn and Cd were determined by atomic absorption spectroscopy in all samples. Results were statistically evaluated and different sources of variance were estimated. It was also estimated whether the number of samples was sufficient for our requirement for accuracy of analytical results.

Introduction

The quality of the measurement results depends on the quality of sampling from observing matter, sample preparation and pre-treatment. If we want to make the sampling as good as is possible, we have to develop a precise description of sampling methodology and make a good plan for field work. By following the methodology and the plan during sampling, it is possible to judge the sampling accuracy by using different statistical techniques. (4, 5).

If sampling is bad, the sample does not represent typical characteristics of the observing matter. In such cases it is not possible to correct or eliminate the uncertainty caused by sampling by performing the analysis as carefully as possible.

Due to its importance, we have to pay particular attention to the sampling and the laboratory sample preparation. It is not possible to control that part of analytical procedure by using standards and reference materials like we normally can do with measurements (2, 3). If we want to make the sampling as good as possible, we have to develop a precise sampling methodology. By following such methodology during sampling, it is possible to judge the sampling accuracy (4, 5).

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Comparision of the annual cycle of sulphur content in spruce needles from heavily polluted and less polluted areas

P. Simončič, P. Kalan

Slovenian Forest Institute, Večna pot 2, 61000 Ljubljana, Slcvenija

Abstract

Needles of twenty years old spruces from Prednji vrh, in the area affected by the Šoštanj power station, and from Pokljuka (Alps region, with a relatively unpolluted environment), were analysed for total sulphur content (S_t). Measurements were taken in a period between April and August twice monthly and in the period from August to April every four weeks (May 1993 - June 1994). Sulphur content in one and two years old spruce needles from Prednji vrh were much higher (one year old needles 2.06-2.50 mg/g needle dry weight, 1993) than in needle samples from Pokljuka (one year old needles 1.05-1.25 mg/g needle dry weight, 1993).

Introduction

Measurements of total sulphur content in spruce needles have been used as an indicator of the presence of SO_2 in the air for many years. In 1883 they tried to find out if SO_2 affected plants (Schoeder und Reuss, HUETTL, 1992). Sulphur is an essential nutrient but, if its content in plant material is too high it accumulates in leaves and needles. Plants are accepting sulphur trough roots in form of SO_4^{2-} ions or in SO_2 gas form, which is taken up by leaves and needles via open stomata (FIEDLER, THAKUR 1985). Total sulphur concentrations in the foliar part of plants have between 7 to 10% nitrogen concentrations (SCHULZE, 1989). Literature cites many different levels of total sulphur content in one and two year old needles, which are used as a criterion for an estimation of SO_2 impact on forest trees. Huettl (HUETTL, 1992) states critical values of total sulphur contents in one and two years old spruce needles from 1.1 mg

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Cytokinins in Norway spruce seedlings as tester organisms of forest soil pollution

Hojka Kraigher[1], David E. Hanke[2]

[1] Slovenian Forestry Institute, Večna pot 2, 61000 Ljubljana, Slovenia
[2] Department of plant Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EA, U.K.

Key words: isopentenyladenine-type cytokinins, Norway spruce seedlings, bioindication, model system.

Abstract

Cytokinins were analysed by a combined HPLC-ELISA method in needles of Norway spruce seedlings. The seedlings were grown *in vitro* on sterilized or nonsterile soil substrates from two differently polluted forest research plots. Differences were predominantly found in the isopentenyladenine-type of cytokinins. These were elevated in seedlings, grown on polluted soils in comparison to those, grown on soils from the unpolluted plot. A possible explanation might be in the change of the metabolism in the roots due to pollution stress (when grown on sterilized substrates) or in change of the mycorrhizosphere organisms (when grown on nonsterile soil substrates). The model system using Norway spruce seedlings as tester organisms for soil pollution is discussed.

Introduction

Several forest decline symptoms can reflect disturbances in hormonal balances of forest trees. On this view cytokinins can enhance the resistance of plants to various forms of stress, reduce the dominance of the apical bud, delay scenescence of plants and stimulate the development of chloroplasts (Kaminek, 1992). The cytokinin content in needles of mature spruce trees was shown to correlate with different degrees of damage (Von Schwartzenberg, Hahn, 1991). It can also be affected by different species and strains of mycorrhizal fungi (Kraigher *et al*, 1993), while the range of these can vary according to pollution (Wollmer, Kottke, 1990; Taylor, 1995, this issue). For this study cytokinin contents in needles of Norway spruce seedlings, grown *in vitro* on soil substrates from two differently polluted forest research plots, were analysed. In a separate study (Kraigher *et al*, 1995, this issue) a different community of ectomycorrhizal types - fungal species was found to occur on the two plots.

Methods

Two differently polluted forest research plots of the Slovenian Forestry Research Institute in the emmission area of the Šoštanj Thermal Power Plant (TPP) (North Slovenia) were chosen for this study. The two plots (850

Mycorrhiza (1995) 5:175–180

ORIGINAL PAPER

Hojka Kraigher · Reinhard Agerer · Branka Javornik

Ectomycorrhizae of *Lactarius lignyotus* on Norway spruce, characterized by anatomical and molecular tools

Abstract The ectomycorrhizae of *Lactarius lignyotus* on Norway spruce are comprehensively described by morphological and anatomical characteristics. Identification of ectomycorrhizae was performed by tracing mycelia to the fruitbodies and also by molecular tools, using polymerase chain reaction (PCR) amplification of the fungal DNA. The newly described ectomycorrhiza is compared to ectomycorrhiza of the related *Lactarius picinus*. The amplified DNA products of the two fungi and their ectomycorrhizae could be distinguished by characteristic fragments after digestion with *Hin*fI.

Key words Ectomycorrhizae · Characterization and identification · *Lactarius lignyotus* · Polymerase chain reaction (PCR) · Restriction digest

Introduction

Ectomycorrhizae of eight species of the genus *Lactarius* occurring on Norway spruce are well described (Agerer 1987–1993). In our study we describe the ectomycorrhizae of *Lactarius lignyotus* Fr. on Norway spruce, *Picea abies* (L.) Karst., by morphological and anatomical parameters (Agerer 1991). The identification was possible by tracing mycelia from the fruitbodies to mycorrhizae. The descriptions are compared to the ectomycorrhizae of a closely related species, *Lactarius picinus* Fr. (Agerer 1986). Furthermore, we employed molecular tools for identification of ectomycorrhizae as suggested in the review by Bruns et al. (1991). For molecular identification, we analysed fungal variability of the internal transcribed spacer (ITS) region in the nuclear ribosomal units using two taxon-specific primers which have been shown to amplify the basidiomycete component in ectomycorrhizae (Gardes and Bruns 1993). The comparison of digested fragments of amplified DNA from the two fungi and mycorrhizae of *L. lignyotus* was shown to be fungus specific, fast and reproducible.

Considered as part LV of the series
"Studies on ectomycorrhizae" of the Institute
for Systematic Botany, Munich; part LIV: Agerer et al. (1994)

H. Kraigher (✉)
Forestry Institute of Slovenia, Večna pot 2,
SI-61000 Ljubljana, Slovenia
Tel.: +386 61 123 1343; Fax: +386 61 273 589

R. Agerer
Institute for Systematic Botany, Ludwig-Maximilians University,
Menzingerstrasse 67, D-80638 München, Germany

B. Javornik
Center for Plant Biotechnology and Breeding,
Agronomy Department, Biotechnical Faculty,
University of Ljubljana, Jamnikarjeva 101,
SI-61000 Ljubljana, Slovenia

Materials and methods

Isolation and characterisation of ectomycorrhizae

Natural mycorrhizae and attached rhizomorphs were isolated from soil (O_H/A_H layer) in mixed pro-naturally managed Norway spruce stands in north Slovenia (Mislinja, close to Velenje, belonging to the Pohorje mountain range, at 850 m above sea level). Methods for isolation and characterisation of ectomycorrhizae (morphological and anatomical features) and the terms necessary for exact descriptions are according to Agerer (1991) and Agerer (1987–1993). For extraction of DNA, polymerase chain reaction (PCR) and digestion of the amplified products, the methodology of Gardes and Bruns (1993) was slightly adapted.

DNA extraction

DNA from frozen tissues (10–300 mg of sporophore tissue or ectomycorrhizae) was thawed in 600 µl of 2×CTAB lysis buffer (100 mM Tris-HCl pH 8.0, 1.4 M NaCl, 20 mM Na_2-EDTA, 2% CTAB, 0.2% mercaptoethanol) and incubated at 68°C. After chloroform-isoamyl alcohol (24:1) extraction, DNA was precipitated in cold isopropanol for 30–60 min. The pellet was washed with 70% ice-cold ethanol, dried and resuspended in 150 µl TE buffer (1 mM Tris-HCl, 0.1 M Na_2-EDTA pH 8.0). Prior to amplification, the quantity of DNA was measured fluorometrically and diluted 10-, 100- and 500-fold in sterile double-distilled water.

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The influence of acid rain on conditions for mineral nutrition of Norway spruce (*Picea abies* (L.) *Karst.*) seedlings

PRIMOŽ SIMONČIČ

Slovenian Forestry Institute,
Večna pot 2, 61000 Ljubljana,
Slovenia

The effects of polluted air on the conditions of mineral nutrition of spruce were studied in greenhouse experiments and in natural environment, namely the area within the range of influence of the Šoštanj coal-fired power station. We used controlled conditions to monitor changes in mineral nutrition of the spruce, the effects of acid rain on spruce seedlings and changes in the chemical composition of percolate (3). By adding various acid solutions to the Ahr containers filled with the substrate of a mineral layer from Osankarica on Pohorje (distric brown soil on tonalite), we simulated the influx of sulphate and nitrate ions into the forest ecosystem of the area of Zavodnje, which is located within the range of influence of the Šoštanj station. The greenhouse experiment lasted nine and a half months (May 1 1989 to February 12 1990).

MATERIALS AND METHODS

We placed spruce seedlings into homogenous substrate in greenhouse containers and watered them with deionized water (control) and four acid solutions. The acid solutions used were:

1. concentration of 9.82 mg SO_4^{2-}/L (in the form of H_2SO_4, pH 3.98);
2. concentration of 29.5 mg SO_4^{2-}/L (in the form of H_2SO_4, pH 3.58);
3. concentration of 2.88 mg NO_3^- and 9.82 mg SO_4^{2-}/L (in the form of H_2SO_4 and HNO_3, pH 3.95) and
4. concentration of 2.88 mg NO_3^-/L (in the form of HNO_3, pH 4.53).

Before and after the experiment we analysed the soil substrate. The parameters and methods used were as follows: pH in H_2O solution (pH meter), organic carbon (C) – Carmhomat 8-ADG device (dry ashing), total N (Kjeldahl method), K, P and Mg accessible to plants (Al-method and Schachtschable method), exchangeable bases (K^+, Na^+, Ca^{2+}, Mg^{2+}) – after percolation of the sample with N ammonium acetate with flame photometer (K^+, Na^+) and with AAS (Ca^{2+}, Mg^{2+}), H^+ (extractant $BaCl_2$ and 0.55 N trietanolamin), CEC, base cations (S) and base saturation (V).

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Cytokinins in Norway spruce seedlings grown on different soil substrates

HOJKA KRAIGHER[1*]
DAVID E. HANKE[2]

[1]*Slovenian Forestry Institute, Večna pot 2, Ljubljana, Slovenia*

[2]*Dept. of Plant Sciences, Univ. of Cambridge, Cambridge, U.K.*

Several forest decline symptoms can reflect disturbances in hormonal balances of forest trees. On this view cytokinins can enhance the resistance of plants to various forms of stress, reduce the dominance of the apical bud, delay scenescence of plants and stimulate the development of chloroplasts (1). The cytokirin contents in needles of mature spruce trees was shown to correlate with different degrees of damage (2). They can also be affected by different species and strains of mycorrhizal fungi (3), while the range of these can vary according to pollution (4). For this study the cytokinin contents in the needles of Norway spruce seedlings, grown on two differently polluted soil substrates, for which different abundance of ectomycorrhizal types was shown previously in soil samples (results not shown), were analysed.

METHODS

Two differently polluted forest research plots of the Slovenian Forestry Institute, on district kambisols, at 850 m altitude, in the emmission area of the Thermal Power Plant (TPP) Šoštanj (North Slovenia) were chosen for this study. The plot in Zavodnje represented a heavily polluted plot, while the plot in Mislinja represented a comparatively less polluted but in all other respects similar forest research plot as in Zavodnje. The predominant tree species on both plots is Norway spruce (*Picea abies* (L.) Karst). The sieved and dryed soil samples were analysed according to standard procedures (after 5) in the Soil Science Laboratory. PH in KCl was determined at 3.82 for Zavodnje and at 3.52 for

* Correspondence

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...wis, A. H. Fitter, I. J. Alekx-

Acta Pharm. 45 (1995) 333–336

Mycorrhizal potential of two forest research plots in Zavodnje and Mislinja

SAMAR AL SAYEGH-PETKOVŠEK[1]
HOJKA KRAIGHER[2*]
FRANC BATIČ[2]
NADA GOGALA[3]
REINHARD AGERER[4]

[1]*ERICo Velenje, Koroška 64,*
63320 Velenje, Slovenia

[2]*Slovenian Forestry Institute, Večna pot 2,*
61000 Ljubljana, Slovenia

[3]*Department of Biology,*
University of Ljubljana, Aškerčeva 12,
61000 Ljubljana, Slovenia

[4]*Institute for Systematic Botany,*
University of Munich,
Menzingerstrasse 67,
D-800 München 19, Germany

The main direct polluters in the Šaleška valley are the Thermoenergetic Power Plant Šoštanj and the Coal Mine in Velenje. Our study was included among studies of the impact of air pollution on the changing of mycoflora and mycorrhizas. Air pollutants can influence mycorrhiza directly by influencing the soil charateristics and indirectly by effects on the host plant (1). The number of species and species diversity of fungi is lowered (2). Pollution stress is higher, the development of the root system and the ability to form mycorrhizae are poorer (3).

METHODS

Two differently polluted forest research plots were chosen, with the plot in Mislinja being relatively less polluted plot than the plot in Zavodnje. The plots were monitored by modified mycorrhizal potential method (3). Soil samples (OhAh horizont) were

* Correspondence

(1995) 187–190.

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ırtl for revising the English

(1990) 45.

˙30 (1993) 201.

Verkeij, *Plant Physiol.* 103 (1993)

Press, New York 1972.

(1993) 1.
1994.
:o, *Verbreitungsatlas der Farn- und*
1992.

Acta Pharm. 45 (1995) 191–197

Impact of emmission gases from the thermal power plant in Šoštanj on the biochemical structure of Norway spruce needles (*Picea abies* (L.) Karst.)

FRANC BATIČ[1*]
DIETER GRILL[2]
POLONA KALAN[3]
CVETKA RIBARIČ-LASNIK[4]

[1]*Agronomy Department, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 61000 Ljubljana, Slovenia*

[2]*Institute für Pflanzenphysiologie, Karl-Franzens Universität Graz, Schuberstrasse 51, Austria*

[3]*Institute for Forest and Wood Economy, Večna pot 2, 61000 Ljubljana, Slovenia*

[4]*ERICo Velenje, Koroška 64, 63320 Velenje, Slovenia*

The article presents data from the biochemical analysis of Norway spruce needles sampled in a profile over a highly polluted Alpine valley in central north Slovenia. The investigation was carried out in order to determine the emission area of the thermal power plant, situated in the valley bottom and representing the greatest air pollution source in Slovenia. Nine sampling sites were chosen in the surroundings, differing in distance to the thermal power plant, orography, forest health status and air pollution level. Needles were sampled in early September 1992 using a prescribed IUFRO sampling methodology. Analysis of chlorophyll, ascorbic acid, water soluble thiols, and total sulphur content and analysis of peroxidase activity were chosen as biochemical markers of the air pollution impact on Norway spruce. Low values of chlorophyll and ascorbic acid content and high total sulphur content in needles confirmed a high sulphur dioxide impact on the forests, especially on the more polluted sites nearest to the thermal power plant. Thiol analysis of needles and measurements of the activity of the enzyme peroxidase did not give the expected results. The analysed biochemical parameters of Norway spruce needles were found to be suitable tools for screening sulphur dioxide air pollution impact on forests, expecially in early diagnosis and in cause-consequence relationship studies of forest die-back.

Keywords: air pollution, forest decline, *Picea abies* (L.) Karst, bioindication, biochemical needle analysis.

The thermal power plant in Šoštanj is the largest air pollution source in Slovenia. Annually it emits approximately 90,000 t of SO_2, 11,000 t of NO_x, 8,000 t of dust particles and undetermined quantities of fluorides and other air pollutants. It is situated at an altitude of 300 m in an Alpine valley bottom in central North Slovenia. The western slopes of the valley are fairly high, reaching 1550 m, while the eastern ones are lower, reaching

* Correspondence

Slovensko kemijsko društvo, spektroskopska sekcija

9. simpozij
Spektroskopija v teoriji in praksi
Zbornik povzetkov, Bled 10-13 April 1995

PREVERJANJE USTREZNOSTI METODOLOGIJE VZORČENJA GOZDNIH TAL NA OSNOVI ANALIZE VSEBNOSTI ELEMENTOV Z AAS

EVALUATION OF FOREST SOIL SAMPLING METHODOLOGY AFTER DETERMINATION OF SOME ELEMENTS BY AAS

Polona Kalan[1], Vida Hudnik[2], Primož Simončič[1]
[1]Gozdarski inštitut Slovenije, Večna pot 2,61000 Ljubljana, Slovenija
[2] Kemijski inštitut Slovenije, Hajdrihova 19, 61000 Ljubljana, Slovenija

Metodologijo vzorčenja gozdnih tal proučujemo na dveh poskusnih ploskvah pod hrastovim sestojem.

Opravili smo poskusno vzorčenje po metodologiji, ki jo uporabljamo za raziskavo gozdnih tal na stalnih raziskovalnih ploskvah. Odvzemna mesta smo izbirali tako, da so imela tla na teh mestih čim bolj značilne lastnosti opazovanega gozdnega rastišča.

V vseh odvzetih vzorcih smo določili vsebnost nekaterih makro- in mikroelementov z AAS. Rezultate meritev smo uporabili za statistično ugotavljanje števila odvzetih vzorcev, ki zagotavljajo reprezentativnost lastnosti opazovane poskusne ploskve.

Na osnovi dobljenih rezultatov smo ocenili ustreznost izbrane metodologije vzorčenja.

Abstract

Forest soil sampling methodology is studied on two observation plots under the oak canopy.

Test sampling had been made by following methodology that is used for forest soil research on permanent observation plots. Sampling sites had been chosen on places with typical soils of the observed forest site.

Some macro- and microelements were determined by the AAS in all samples. It was estimated by statisticall calculation of the results whether the number of samples assures representativity of the characteristics for observed plots.

Forest soil sampling methodology was finally evaluated by using calculated results.

KONFORMACIJA
EtO-Ac-L-Ala
V $CDCl_3$ S POMOČJO NMR, IR
CONFORMATION
OF EtO-Ac-L-A
IN $CDCl_3$ BY NMR, IR AND

Jurka Kidrič, Alenka Mencej, Jože Gr
National Institute of Chem

NMR konformacijska analiza kaže, da in
konformacije. S kombinacijo temperturni
ugotovili, da dipeptida asociirata nad k
asociacije za Ala in Glu NH skupine te
izomeri je v okviru napake. Z molekula
ustreza termodinamskim parametrom.

A

NMR conformational analysis of t
conformations in $CDCl_3$. Variable t
measurements show that dipeptides ass
of association and the enthalpies were
groups. The influence of the dipeptide
limit. A model of the dimer in acco
derived by molecular mechanics.

Vlado Čurin / Rudi Ocepek / Zdravko Petkovšek / Tatjana Sevnik / Igor Smolej / Dušan Vrščaj

SPOZNAVANJE NARAVE

za 4. razred

DZS

LJUBLJANA 1994

Učbenik so napisali
Vlado Čurin, prof., Rudi Ocepek,predm.učit.,prof.dr.Zdravko Petkovšek, Tatjana Sevnik,prof., mag.Igor Smolej, mag. Dušan Vrščaj

Rokopis so strokovno pregledali
prof.dr.Nada Gogala, Darinka Plut, učit.razr.pouka, prof.dr.Tatjana Verčkovnik

Rokopis sta jezikovno pregledali
Mija Longyka in Alenka Kobler

Konzulentka z Zavoda Republike Slovenije za šolstvo in šport
Cveta Žumer

Strokovni svet Republike Slovenije za vzgojo in izobraževanje je na seji dne 31. 3. 1994 sprejel sklep št. SŠ-601-51/94 o podaljšanju veljavnosti učbenika za eno leto.

Po mnenju ministrstva za šolstvo in šport št. 415-26/94 z dne 14. 2. 1994 sodi knjiga med proizvode, za katere se plačuje 5-odstotni davek od prometa proizvodov.

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1. Čurin, Vlado

39138048

Institut für Waldökologie
an der Universität für Bodenkultur, Wien

Zwischenbericht zum

Forschungsprojekt:

Oak Decline in Slovenia

erstellt von:
H. Hager
Institut für Waldökologie, Wien

und
I. Smolej
Gozdarski Institut Slovenije

im Auftrag des Bundesministerium für Wissenschaft und Forschung

Oak decline in Slovenia

Endbericht über die Arbeiten 1994

Gozdarski Institut Slowenije - Slovenian Forestry Institute
Vecna pot 83
SLO - 61000 LJUBLJANA

und

Institut für Waldökologie - BOKU
Peter Jordanstraße 82
A - 1190 WIEN

Mai 1995

OAK DECLINE IN SLOVENIA -
annual report for the period July 1993 - June 1994

prepared by Igor Smolej and H. Hager in cooperation with the subproject leaders

CONTENTS

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725.75(497.12 Rogaška Slatina)

CIMPERŠEK, Mitja
Po gozdovih zdravilišča Rogaška Slatina / (zamisel in besedilo Mitja Cimperšek, Igor Smolej; fotografije Mitja Cimperšek, Igor Smolej, Marijan Močivnik, Hrvoje Oršanič; ilustracije Marijan Močivnik, Samo Jenčič). - Rogaška Slatina : Zdravilišče ; Ljubljana : Sklad kmetijskih zemljišč in gozdov ; Celje : Gozdno gospodarstvo, 1995

1. Gl. stv. nasl. 2. Smolej, Igor
51511552

Po mnenju Ministrstva za kulturo z dne 18.07.1995,
št. 415 - 650/95 šteje knjiga med proizvode,
za katere se plačuje 5% davek od prometa proizvodov.

Po gozdovih zdravilišča Rogaška Slatina

III.4. OAK DECLINE ASSESSMENT IN THE YEAR 1993

Nevenka BOGATAJ

1. Introduction

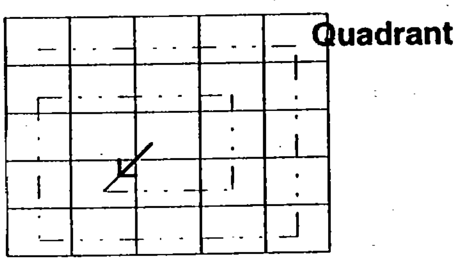
In 1993 the first assessment of crown conditions was made by visual assessment of the trees on nine permanent research plots on different sites in Slovenia. The aim of the assessment of the health status of these oak trees is, to get the first insight on the temporal course and dynamics of oak decline, and by comparing it with repeated future observations, to improve the knowledge about oak as a species. These goals should be achieved by assessment of individual tree health status. The assessment is done by a coded description of crown, bark and stump, and their respective damages and diseases.

2. Method

The health of oaks was visually assessed with the method, which originates from the method for assessment and monitoring of forest decline, as it of course applies to oak species.

There were nine plots observed, on each plot 48 trees (2x24) were chosen for observation. Starting point for the selection and assessment of oaks was the central quadrant of the plot. If there were not enough trees, the observer moved from the central quadrant to the next southwestern quadrant. In the case, that even in those two quadrants, there were not enough trees for assessment, the observer proceed to the next quadrant by the following scheme:

Plot



The assessment form was generally identical with the form used for the overall forest decline assessment in Slovenia. It was only altered by adding two characteristics from the Austrian form for assessment of oak decline, these were „other discoloration“, and „secondary sprouts on branches“. In total the form contains two parts:

- evidence of position of the tree and a
- coded assessment of signs and diseases: of bark, crown and roots (18 parameters).

PROUČEVANJE PROPADANJA GOZDOV IN SPREMEMB V EKOSISTEMIH V SLOVENIJI

Dušan JURC*, Nevenka BOGATAJ*

Abstract

The article describes the tasks which are performed by the Forestry Institute of Slovenia in the frame of International Cooperative Programs (ICP) of the UN/ECE Convention on Long Range Transboundary Air Pollution, and the work which is planned for future. Our engagement is traditional and wide in the ICP for assessment and monitoring of air pollution effects on forests and this year we are starting the two years introductory phase to conduct the programme of the ICP on integrated monitoring of air pollution effects on ecosystems. The results of forest die-back inventory 1993 are presented. There is no major shift detected in the health condition of Slovene forests in comparison with the year 1991, but the overall trend of slight improvements of health condition of forests from previous years has stopped.

UVOD

S propadanjem gozdov označujemo vzročno nepojasnjeno poškodovanost gozdov, ki je v 80. letih zajela praktično celo severno zemeljsko poloblo. Z ozirom na splošnost in velikopovršinskost omenjenega pojava je le-ta za Slovenijo še posebno pomemben. Gozd je tu zaradi svoje mozaične razporeditve osnovni krajinski element, ki stabilizira tokove energije in materije v prostoru (filtracija zraka, umirjanje vetrov, protierozijska zaščita, blaženje klimatskih ekstremov, zadrževanje vode), zagotavlja pestrost živalskih in rastlinskih vrst na celotnem prostoru, ne le v gozdu. Velik je njegov gospodarski pomen. Pojav propadanja gozdov zmanjšuje sposobnost gozda za opravljanje teh funkcij. V splošnem se pojav kaže v defoliaciji drevja, odmiranju vej in delov krošenj, v morfoloških in fizioloških spremembah, ki v končni fazi vodijo do propada drevesa. Gledano dolgoročno in velikoprostorsko je pojav zaskrbljujoč in zadeva tako posameznika kot družbo v celoti.

V svetovnem merilu so bile postavljene številne hipoteze o vzrokih propadanja gozdov. Danes ima največ zagovornikov teorija multiplega stresa, ki pojav razlaga kot posledico časovne in prostorske koncentracije stresov za rastline (onesnaženi zrak, klimatski ekstremi, neuravnoteženost hraniv v tleh, načini gospodarjenja z gozdom, sproščanje toksičnih snovi v tleh itd.), ki lokalno ali velikopovršinsko preidejo prag tolerance drevesnih vrst in povzročajo najprej fiziološke, nato vidne poškodbe in propadanje gozda. Onesnaženi zrak je bistveni škodljivi dejavnik, ki ga vključujejo številne hipoteze, vlada pa velika neenotnost v oceni njegovega pomena: je to sprožilni dejavnik propadanja gozdov, le dodatni ali tisti, ki drevo predisponira za večjo občutljivost na ostale strese? Ker se propadanje gozdov kaže predvsem kot velikopovršinski pojav, ga je vzročno nemogoče povezovati z lokalnimi viri onesnaževanja zraka. Razumevanje pojava in njegovo sledenje zato ne more biti omejeno na geografsko

* mag. D. J., dipl. biol., N. B., dipl. inž. gozd., Gozdarski inštut Slovenije, Večna pot 2, p.p. 523-X, 61001 LJUBLJANA

GDK: 238:176.1 Quercus rubra L., Quercus palustris Muench.

Rast rdečega hrasta *(Quercus rubra L.)* in močvirskega hrasta *(Quercus palustris Muench.)* v nasadih Dobruška gmajna in Korita

The Growth of *(Quercus rubra L.)* and *(Quercus palustris Muench.)* in the Dobruška gmajna and Korita Plantations

Lado ELERŠEK*, Mihej URBANČIČ**, Jože GRZIN***

Izvleček

Eleršek, L., Urbančič, M., Grzin, J.: Rast rdečega hrasta *(Quercus rubra L.)* in močvirskega hrasta *(Quercus palustris Muench.)* v nasadih Dobruška gmajna in Korita. Gozdarski vestnik, št. 3/1994. V slovenščini s povzetkom v angleščini, cit. lit. 15.

Rast rdečega hrasta je bila ugotavljana v dveh nasadih na potencialnih rastiščih združb *Pseudostellario-Quercetum* roboris in *Querco-Fagetum*, rast močvirskega hrasta pa v nasadu na rastišču *Pseudostellario-Quercetum*. Na teh pred sadnjo hrastov opuščenih kmetijskih zemljiščih so bili ugotovljeni za obe vrsti dobri volumenski prirastki, zaradi katerih ju lahko uvrščamo med hitro rastoče drevesne vrste. Tudi pri redki saditvi obeh hrastov (1667 sadik na hektar) v nasadu Dobruška gmajna so se oblikovala po treh desetletjih kvalitetna drevesa.

Ključne besede: rdeči hrast, močvirski hrast, nasad, eksota, hitrorastoča drevesna vrsta

Abstract

Eleršek, L., Urbančič, M., Grzin, J.: The Growth of Quercus rubra L. and Quercus palustris Muench. in the Dobruška gmajna and Korita Plantations. Gozdarski vestnik, No. 3/1994. In Slovene with a summary in English, lit. quot. 15.

The growth of Quecus rubra L. was established in two plantations in potential natural sites of the Pseudostellario-Quercetum roboris and Querco-Fagetum associations and the growth of Quercus palustris Muench. in a plantation in the Pseudostellario- Quercetum natural site. In these, before the planting of oak trees abandoned agricultural sites, high volume increments were established for both tree species, because of which they can be ranked among high growing tree species. Even with thin planting of both oak species (1667 plants per hectare) in the Dobruška gmajna plantation, high quality trees have developed after three decades.

Key words: Quercus rubra L., Quercus palustris Muench., plantation, exotic tree species, fast growing tree species

1 UVOD
1 INTRODUCTION

V današnjem času tudi na svojih naravnih rastiščih v velikem obsegu propadajo nekatere domače drevesne vrste, kot so jelka, dob, domači kostanj idr., za kar krivimo onesnaženo ozračje in padavinsko vodo, bolezni in škodljivce ter spremenjeno podnebje, ob tem pa ugotavljamo, da nekatere tuje drevesne vrste te spremembe prenašajo bolje. Zagovorniki tujih drevesnih vrst tudi navajajo, da so številne eksote izginile iz naših gozdov v času ledenih dob in bi lahko danes, v spremenjenih pogojih, tu spet našle svoje mesto (Eleršek 1987).

Tujerodnih drevesnih vrst pa ne cenijo le v nekaterih gospodarsko razvitih Evropskih državah, ampak tudi drugje. O tem med drugim poročajo naši študentje gozdarstva iz obiska mednarodnega srečanja študentov gozdarstva v Braziliji (Gartner 1992), kjer so si v državi Sao Paulo ogledali donosne plantaže evkaliptusa (Eucaliptus grandis), ki so ga v južno Ameriko prinesli iz Avstralije. V novi domovini raste celo hitreje, saj dosegajo drevesa sedemletne plantaže že debelino 20 do 30 cm in višino 20 do 25 m.

Domovina rdečega hrasta je severna Amerika, od koder je bil prinesen v Evropo

* L. E., dipl. inž. gozd., ** M. U., dipl. inž. gozd., *** J. G., teh. sod., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

GDK: 238 Picea abies (497.12)

Rast smrekovih nasadov, osnovanih na opuščenih kmetijskih zemljiščih

The Growth of Norway Spruce Plantations, founded on Abandoned Agricultural Land

Lado ELERŠEK*, Mihej URBANČIČ**

Izvleček

Eleršek, L., Urbančič, M.: Rast smrekovih nasadov, osnovanih na opuščenih kmetijskih zemljiščih. Gozdarski vestnik št. 4/1994. V slovenščini s povzetkom v angleščini, cit. lit. 9.

Prikazani so rezultati dendrometričnih analiz rasti smrekovih nasadov iz 50 objektov, ki so bili od leta 1957 do 1974 posajeni na opuščenih kmetijskih zemljiščih v različnih gozdnogospodarskih območjih Slovenije. Na objektih se so pri starosti nasadov od 16 do 33 let lesne zaloge gibale med 128 in 582 m^3/ha, povprečni volumenski prirastki pa med 7,1 in 20,6 m^3/ha.

Ključne besede: smreka, drevesni nasad, opuščeno kmetijsko zemljišče

Synopsis

Eleršek, L., Urbančič, M.: The Growth of Norway Spruce Plantations, founded on Abandoned Agricultural Land. Gozdarski vestnik, No. 4/1994. In Slovene with a summary in English, lit. quot. 9.

The article presents the results of dendrometric analyses, dealing with the growth of Norway spruce plantations consisting of 50 objects, which were in the years from 1957 to 1974 founded on abandoned agricultural land in various forest management regions of Slovenia. The trees of the plantations aged from 16 to 33 years evidenced growing stock between 128 and 582 m^3/ ha and the average volume increments between 7.1 and 20.6 m^3/ha.

Key words: Norway spruce, tree plantation, abandoned agricultural land

1 UVOD

1 INTRODUCTION

Gozdnega drevja pri nas ne sekamo samo v gozdu, ampak tudi na kmetijskih in drugih negozdnih površinah, kot so zaraščeni pašniki, drevoredi ob poteh, strnjeni drevesni nasadi, zasajeni na opuščenih kmetijskih zemljiščih in drugje. Po podatkih Splošnega združenja gozdarstva Slovenije so gozdarji odkupili v obdobju od leta 1974 do 1978 povprečno 21.700 m^3 lesa na leto, posekanega zunaj gozda, od tega dobri dve tetjini iglavcev (Eleršek 1981). Seveda pa smo posekali na teh površinah še veliko več.

Pri nas in v svetu se je v preteklih letih na številnih slabših ali odročnejših kmetijskih zemljiščih opustilo kmetovanje in sadilo gozdno drevje, največkrat smreka. To se še vedno dogaja, nekateri kmetijski ekonomisti pa predvidevajo zaradi viškov kmetijskih pridelkov še intenzivnejše opuščanje slabših kmetijskih zemljišč.

Zunajgozdni strnjeni smrekovi nasadi so sicer podobni gozdnim nasadom, a se od njih vendarle razlikujejo. Gozdni nasadi se razvijajo v drugačnem, bolj naravnem okolju in jih gojimo po načelih gozdne proizvodnje. Gozd naj bi opravljal številne funkcije, med katerimi lesnopredelovalna vloga ni vedno najpomembnejša. Za drevesne nasade zunaj gozda pa je pomembna predvsem njihova proizvodna funkcija, to je pridelovanje velike količine lesa v relativno kratkem času (Božič 1990). Taki nasadi pa so več ali manj začasna izraba opuščenih kmetijskih zemljišč, ki bi ostala drugače slabše izkoriščena ali neizkoriščena. Po letu 1981 smo na inštitutu v okviru naloge "Nasadne oblike in intenzivnostni načini pridelave lesa zunaj gozda" začeli proučevati tudi mlajše smrekove nasade, zasajene na opuščenih kmetijskih zemljiščih.

* L. E., dipl. inž. gozd., ** M. U., dipl. inž. gozd., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

GOZDARSKI INŠTITUT SLOVENIJE

SLOVENIAN FORESTRY INSTITUTE

Večna pot 2, 61000 Ljubljana, p.p. 523-X, Slovenija
telefon: 386 61 + 1231343
telefax . 386 61 + 273589

Mihej URBANČIČ , Polona KALAN

IZSLEDKI DENDROMETRIJSKIH IN PEDOLOŠKIH PROUČEVANJ NA STALNI RAZISKOVALNI PLOSKVI "PRI ŠIJCU" V TNP

Poročilo raziskovalne naloge
"Onesnaženost zraka v Triglavskem narodnem parku in njegov vpliv na gozd in vode"
(s šifro 105)

Ljubljana, 1995

GOZDARSKI INŠTITUT SLOVENIJE
SLOVENIAN FORESTRY INSTITUTE

Večna pot 2, 61000 Ljubljana, p.p. 523-X, Slovenija
telefon: 386 61 + 1231343
telefax . 386 61 + 273589

Mihej URBANČIČ, Polona KALAN

PEDOLOŠKE RAZMERE IN ANTROPOGENA DEGRADACIJA GOZDNIH TAL V KAMPU "UKANC"

Ekspertiza
(za potrebe študije OGULIN A. in sod., 1995: Kamp Ukanc v Bohinju. Ocena vplivov na okolje in variantni predlogi za dolgoročno reševanje problemov obalnega območja Bohinjskega jezera. GIS, Ljubljana, 73 str.)

Ljubljana, 1995

GOZDARSKI INŠTITUT SLOVENIJE
SLOVENIAN FORESTRY INSTITUTE

Večna pot 2, 61000 Ljubljana, p.p. 523-X, Slovenija
telefon: 386 61 + 1231343
telefax . 386 61 + 273589

Mihej URBANČIČ

SOIL PROFILE DESCRIPTION FROM THE BEECH FOREST WITH DURMAST OAK ON THE HILL ROŽNIK

Ekspertiza
(za dr. Jung in dr. Blatsche iz Forst wissenschaftlich Fakultät der LMU München)

Ljubljana, 1995

Gozdarski inštitut Slovenije
Ljubljana, Večna pot 2

Poročilo o udeležbi na FSCC pedološkem tečaju v Gentu

Podpisani **Mihej Urbančič**, samostojni strokovni sodelavec gozdarskega inštituta, sem se udeležil izobraževalnega tečaja o klasifikaciji tal po FAO metodi (v izvirniku: *EU/ICP Forests Soil Classification Training Course (FAO system)*). Potekal je **od 16. do 20. januarja 1995** na univerzi v **Gentu** (Belgija). Tečaj je v sodelovanju z Evropsko unijo organiziralo Usklajevalno središče za gozdna tla (*FSCC - Forest Soil Coordinating Centre*) za pedologe, ki so vključeni v državne inventure stanja gozdnih tal v okviru programa mednarodnega sodelovanja pri ocenjevanju in spremljanju delovanja onesnaženega zraka na gozd. Tečaja se je udeležilo 29 strokovnjakov za tla iz 21-ih evropskih držav. Vodil ga je profesor pedologije dr. Roger Langohr, del predavanj (o interakcijah med tlemi in mineralnimi onesnaževalci) je opravil tudi prof. dr. F. De Coninck, predsednik panela gozdarskih pedologov pri *ICP Forests*. Obravnavali smo sledeče **teme:**

Ponedeljek, 16. januar: Osnovni problemi klasifikacij tal. Zgodovina FAO sistema razvrščanja tal. Problemi pri kartiranju tal. Značilnosti FAO pedoloških kart. Pregled tlotvornih dejavnikov in lastnosti tal z vidika gozdne ekologije.
Torek, 17. januar: Značilnosti in način uporabe FAO/ISRIC navodil za opis talnega profila iz l. 1990 (vir: *Guidelines for soil (profile) description*. 3. (popravljena) izdaja. ISRIC in FAO/ZN, Rim, 1990). Razlike v primerjavi z drugimi viri. Mikropedologija (mikroskopiranje tankih talnih vzorcev). Značilnosti FAO/Unesco legende k pedološki karti sveta (vir: *FAO-Unesco Soil Map of the World. Revised legend.* FAO, Rim in ISRIC, Wageningen, 1989).
Sreda, 18. januar: Povezava FAO sistema razvrščanja tal z ameriško *USDA Soil Taxonomy* in drugimi pedološkimi klasifikacijami. Sestava in kemične lastnosti tal, njihove koloidne lastnosti in puferski sistemi, interakcije med tlemi in mineralnimi onesnaževalci. Ogled FSCC računalniškega centra, kjer zbirajo in obdelujejo podatke iz monitoringov zdravstvenega stanja gozdov držav, članic ICP Forests.
Četrtek, 19. januar: Pregled diagnostičnih horizontov in diagnostičnih lastnosti FAO klasifikacije tal. Pravilna uporaba ključa za določanje talnih skupin in talnih enot (praktične vaje iz klasifikacije s terenskimi in laboratorijskimi podatki za konkretne talne profile). Postopek v primeru, če manjkajo nekateri podatki, potrebni za klasifikacijo (včasih je možno na osnovi drugih podatkov z določeno stopnjo verjetnosti sklepati, kakšen je manjkajoči podatek, nekateri podatki pa so nujno potrebni).
Petek, 20. januar: Ocena FAO klasifikacijskega sistema. Predstavitev (tudi z diapozitivi): Edafski dejavniki v gozdni ekologiji Zonienskega gozda (bukovi sestoji na nikoli obdelanih tleh, ki so se razvila na puhlici (*loess-u)*. Te gozdne površine, ki leže jugovzhodno od Bruslja, so od človeka najmanj vplivane v tem delu Evrope)

Na tečaju so bile obravnavane številne teme in problemi teoretičnega in praktičnega značaja s področja raziskav gozdnih tal.Glavni namen tečaja pa je bil naučiti udeležence pravilno uporabljati FAO sistem klasifikacije tal, ki naj bi se zaradi zahtev po kompatibilnosti podatkov uporabljal v vseh državah, ki sodelujejo pri mednarodnem monitoringu gozdnih tal z raziskavami najnižje in srednje stopnje zahtevnosti. To pedološko klasifikacijo bomo uporabljali tudi v Sloveniji pri zbiranju in vrednotenju podatkov o gozdnih tleh na ploskvah 16x16km nacionalne mreže in na stalnih ploskvah, namenjenih poglobljenim raziskavam.

V Ljubljani, 26. januar 1995

Sestavil:
Mihej URBANČIČ

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BOLJ PREHRANJENE SMREKOVE SADIKE SO MANJ PRIZADETE ZARADI SADITVENEGA ŠOKA

Mihej URBANČIČ*, Lado ELERŠEK**

Izvleček

Prikazan je vpliv spomladanskega gnojenja smrekovih presajenk (ki so bile vzgojene iz zakoreninjenih potaknjencev) v zadnjem letu pred izkopom na rast in prehranjenost teh sadik v drevesnici in nato na rast v nasadu. Bolj pognojene sadike so imele večjo višinsko in debelinsko rast šele v dvoletnem nasadu.

Ključne besede: smrekova sadika, zakoreninjenec, presajenka, mineralno gnojilo, pozno gnojenje, pedološka in foliarna analiza, prehranjenost sadike, gozdni nasad

NORWAY SPRUCE SEEDLINGS, WHICH ARE BETTER PROVIDED WITH NUTRIENTS, ARE LESS AFFECTED BECAUSE OF PLANTING SHOCK

Abstract

The influence of the spring fertilization in the year before the digging up on the growth and the nutrition status of the Norway spruce seedlings (they were brought up from the rooted cuttings) in the nursery and on the growth of spruce plants after setting in plantation is shown. More fertilized plants had in average better stem diameter and vertical growth not earlier than in a 2-year old plantation.

Key words: spruce plant, root cutting, seedling, mineral fertilizer, late fertilization, soil and foliar analysis, nutrient status of a seedling, forest plantation

* dipl. inž. gozd., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO
** dipl. inž. gozd., Gozdarski inštitut Slovenije, 61000 Ljubljana, Večna pot 2, SLO

in kliče k sodelovanju različne stroke, od naravoslovnih in tehničnih, do družboslovnih in humanističnih.

Dr. Anton Prosen s Fakultete za arhitekturo, gradbeništvo in geodezijo v svoji razširjeni disertaciji nakazuje nekaj zanimivih rešitev.

V šestih poglavjih, kolikor jih delo obsega, nam najprej predstavi pomen in metode planiranja pri urejanju prostora, nato nas popelje na kratek sprehod po zgodovini nastajanja slovenske agrarne krajine, temu pa sledi prikaz zakonskih in strokovnih rešitev s poudarkom na bavarskih izkušnjah, upoštevajoč značilnosti in posebnosti slovenskega prostora.

Težišče dela predstavlja četrto poglavje, kjer so podani temelji za sonaravno urejanje kmetijskega prostora. Avtor podaja ekološki koncept varstva narave za različne naravne sisteme, predstavi pa tudi metode nege krajine in možnost preverjanja posegov v prostor. Ob tem bi si gozd morda zaslužil nekoliko več pozornosti, saj navsezadnje pokriva več kot polovico slovenskega prostora. V petem poglavju obravnava vprašanje prenove in razvoja vasi, tako z gospodarskega kot tudi ekološkega stališča in zaokrožuje delo z vtisom perspektiv pri bodočem urejanju slovenskega kmetijskega prostora.

Delo dr. Prosena je tudi pomemben prispevek k bogatenju slovenskega strokovnega jezika na tem področju, saj je v njem zbranih in prvič poslovenjenih mnogo strokovnih izrazov. Vsekakor si zasluži, da ga vzamejo v roke tudi pripadniki stroke, ki se ponaša s pionirstvom na področju sonaravnosti. Tudi gozdar lahko izve marsikaj novega o urejanju prostora ob upoštevanju naravne in kulturne dediščine, ali, kot pravi avtor sam, »s spoštovanjem do preteklosti in z mislijo na prihodnje rodove«.

Alenka Korenjak

GDK: 945.25

N. BOGATAJ

Učitelji biologije OŠ Janka Ribiča, Veržej

Učna pot ob mrtvici reke Mure

Oblikovno privlačna knjižica prihaja iz tistega dela Slovenije, ki ga Slovenci ne poznamo prav dobro in jo zato še posebno toplo pozdravljam. Enako naklonjeno sprejemam dejstvo, da so se avtorji v prvi vrsti podpisali s skupnim nazivom, ki poleg potrebe po tovrstnem izdelku kaže in nas opominja na določeno pripadnost, za katero v času modnega vzpona managerjev in »vstopanja v Evropo« preradi pozabljamo. Škoda je nameniti knjižico »le« učiteljem biologije. Ponudimo jo lahko predvsem in tudi njim, prav gotovo pa bi na pot z radovedno pozornostjo stopili posamezniki različnih ciljnih skupin, če bi le vedeli zanjo. Avtorji bi tako ob nekaterih razširitvah vsebine predstavljali oporno točko volje in znanja o nekem prostoru in času ter tako vzpostavili komunikacijo s širšim interesnim okoljem, kar je nedvomno eden od namenov in funkcij izobraženca, da ne rečem učitelja.

Učna pot je predstavljena v devetnajstih fotografijah skupaj z naslovnico in s pregledno karto (kateri manjka oznaka merila). Opremljena je z znakom poti in opisana na dvaindvajsetih straneh na osnovi vsebin učnega načrta za 5. in 6. razred osnovne šole. V knjižici pogrešam razlago znaka in formalno osebno izkaznico poti (dolžina, nadmorska višina, smer, ...). Glede na to, da poimenovanje poti navaja reko in enega od redkejših biotopov, bi pričakovala geografsko opredelitev Mure in definicijo vsaj mrtvice, če ne že naštetja drugih redkih biotopov, ki jih ob njej lahko najdemo (logi, gaji, ...). Nekateri so bili nedavno tega predstavljeni v Gei. Ne vem, ali je knjižica oziroma učna pot strogo biološka. Širitev vsebine bi bila sicer dobrodošla, čeprav ni

NEVENKA BOGATAJ

GDK: 971:181.45

10. sestanek UN/ECE ICP-Forests

Lillehammer, 25. maj–1. junij 1994

Norveška je organizirala 10. srečanje držav, podpisnic LRTAP (ženevske Konvencije o daljinskem transportu onesnaženega zraka prek meja), ki izvajajo monitoring zdravstvenega stanja gozdov v okviru mednarodnega programa ICP-Forests. 61 udeležencev iz 31 držav je v konferenčnem centru blizu Lillehammerja pozdravil predstavnik norveškega Ministrstva za kmetijstvo g. Oluf Aalde. Zaporedje delovnih točk je tradicionalno, posebno pozornost so letos posvetili povezovanju med skupinami, ki delujejo znotraj Konvencije.

Ker so v teku prizadevanja, da bi se omogočila primerljivost podatkov različnih programov, ugotovitev jasnih povezav med njimi (vsaj znotraj enega programa) ter s kombinacijo indikatorjev prispevati k vzpostavitvi trajnostnega razvoja, so bila definirana področja tesnejšega sodelovanja med različnimi raziskavami. Neposredne vzročno-posledične povezave med onesnaženostjo zraka in poškodovanostjo gozdov, ki bi bila podlaga za mednarodne protokole za zmanjšanje onesnaževanja zraka, monitoring namreč ni nedvoumno pokazal. Predvsem naj bi vzporedili podatke o onesnaženosti zraka (npr. EMEP podatke), meteorološke podatke in podatke o osutosti gozdov. Predstavniki skandinavskih držav so opozorili na napore, ki so jih vlagali v vzporejanje podatkov z meteorološkimi in niso dali uporabnih rezultatov.

Pomembna tema letošnjega srečanja je bil Mednarodni podatkovni center (IDC), ki ga želi ustanoviti predvsem nemški predstavniki. Bliža se namreč desetletnica zbiranja podatkov o propadanju gozdov. Avstrija in Švica imata glede IDC določene zadržke, ostale članice ES pa v principu soglašajo z ustanovitvijo centra. Danska udeleženka je poudarila, da je nemara potreba po centru večja med državami ES, ki imajo financiranje zagotovljeno. Ostale članice in tudi Slovenija pa je delno odvisna od vzhodnega centra. Razprava o proračunu je pokazala, da se večina denarja porabi za polne stroške udeležencev različnih sestankov in seminarjev. Slovenija redno obiskuje le redni letni sestanek podpisnic Konvencije ter sestanke dveh delovnih podskupin. Letos se zaradi finančnih zadržkov nismo mogli udeležiti evropskega referenčnega seminarja pred popisom propadanja gozdov, ki je bil v sredini junija v Luxemburgu. Iz EMEP lestvice preračunani minimalni znesek, ki naj bi ga Slovenija prostovoljno vplačala v skupni proračun, znaša za leto 1994/95 150 USD (enako kot Luxemburg), kar znaša 0,1 % skupnega zneska. Za ilustracijo navajam deleže sosednjih držav: Avstrija 1,59 %, Hrvaška 0,15 %, Italija 6,89 %, Madžarska 0,45 %, ki so jih za letošnje leto že vplačale. Skozi obe navedeni tematiki se je pokazala potreba po preciznejši opredelitvi vloge, nalog in odgovornosti NFC-ja na nacionalni ravni, opredelitev njegovega razmerja do drugih institucij znotraj države in med državami.

Ob predstavitvi tehničnega in zbirnega poročila se je odprlo vprašanje potrebnosti vsakoletnega poročanja v isti obliki. Predstavnika Nizozemske in Danske sta predlagala spremembo sheme tehničnega poročila. Slednje naj bi vsako drugo/tretje leto poglobljeno obravnavalo le del celote, ki nas še posebno zanima. To bi bila npr. zveza med stanjem krošenj in talnimi analizami, zveza med starostnim razredom in stanjem gozda, povezava slednjega z EMEP podatki, klimatskimi regijami ali foliarnimi analizami, časovne primerjave, itd. Prvo izmed takih poročil naj bi izšlo leta 1996 in naj bi vsebovalo časovne primerjave za obdobje 1988–1994. Za obdelave na mednarodni ravni bi skrbel PCC West in pri tem intenzivneje sodeloval z EMEP, CCE, ICP in drugimi zainteresiranimi.

Pri časovnih primerjavah je bila Slovenija navedena le od leta 1991 dalje. Zato sem dopolnila podatke o številu ploskev in dreves za pretekla leta in poudarila potrebo po

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11. redno letno srečanje predstavnikov držav, ki sodelujejo v programu UN/ECE ICP Forests

Srečanje je bilo 28. 5. – 31. 5. 1995 v Pragi na Češkem. Večino izmed 32 sodelujočih držav sta predstavljala po dva predstavnika - eden s pristojnega ministrstva in eden iz strokovne inštitucije, ki se ukvarja s problematiko zdravstvenega stanja gozdov.

Rezultati osnovnega programa dela (level I) obsegajo popis osutosti gozdnega drevja, analizo vsebnosti žvepla in nekaterih hranil v iglicah smreke in črnega bora ter ugotavljanje pH in vsebnosti nekaterih ionov v gozdnih tleh. Rezultati se v obliki datotek originalnih podatkov zberejo v posameznih centrih (Hamburg, Gent, Dunaj), ki so za sumarno obdelavo in prikaz podatkov posebej financirani. Podatki o osutosti gozdnega drevja so bili tokrat prvič analizirani ob pomoči geografskega informacijskega sistema Glavnega kmetijskega direktorata v Bruslju. Na kartah je prikazano stanje od leta 1987 dalje in spremembe med posameznimi leti, pri čemer so podatki za Slovenijo podani od leta 1993 dalje. Gradivo je dostopno v knjižnici Gozdarskega inštituta.

Nekatere bistvene pomanjkljivosti programa kljub desetletju dela še vedno niso odpravljene, npr. izenačitev kriterijev ocenjevanja osutosti med državami. V letnih poročilih o stanju gozdov v Evropi v obliki tabel in kart so zato še vedno opozorila na previdno interpretacijo rezultatov. Poročilo o stanju gozda obsega transnacionalno poročilo in nacionalna poročila. Pomen transnacionalnega poročila narašča, v njem pa je stanje prikazano za vse sodelujoče države, vendar je vedno dodana tudi ločena informacija o stanju za ES. Namenjeno je delovni skupini za učinke (WGE), ki jo je letos predstavljal njen predsednik g. Keith Bull iz britanskega ITE (Institute for Terrestrial Ecology). Kljub naklonjenosti kontinuiteti vseevropske inventure je vendarle očitno, da rezultatov osnovnega programa ni mogoče uporabiti za potrditev neposrednega učinka onesnaženega zraka na gozdove, ki mu je program namenjen. Zato se aktivnost držav ES širi na nova področja. Nastajajo skupni kriteriji za prihodnje raziskave sprememb talne vegetacije, kriteriji za opazovanje meteoroloških spremenljivk ter za analizo prirastka in depozitov na izbranih ploskvah. Nove raziskave naj bi potekale na delu ploskev obstoječe mreže popisa osutosti ali pa na novih subjektivno izbranih ploskvah, ki so reprezentativne za posamezne tipe gozdov v posamezni deželi. 349 ploskev za intenzivne raziskave vpliva onesnaženega zraka na gozdove (level II) je v Evropi že vzpostavljenih, načrtovanih pa je skupno 555 ploskev. Poleg popisa osutosti naj bi se na teh ploskvah kemijsko analiziralo tla, foliarni vzorci ter ugotovilo prirastek in depozite. Le 10% teh ploskev je vzpostavljenih v državah zunaj evropske skupnosti. Najnovejši in tudi najintenzivnejši program raziskav na posamičnih ploskvah v okviru ICP-ja (level III) pa je že prehitel podoben program ES (Integrirani monitoring).

ICP je spričo velikega števila članic za konkretne odločitve, npr. o širitvi programa ali možnih interpretacijah rezultatov, relativno okoren birokratski sistem, zaradi česar je bila oblikovana t.i. znanstveno svetovalna skupina (Scientific Advisory Group).

In kaj je bilo na sestanku pomembno za našo državo?

Nemara predvsem ugotovitev, da kljub postopnemu zaostajanju za aktivnostmi vodilne države (Nemčije) in držav ES nobena izmed sodelujočih niti ne razmišlja o oddaljevanju od skupine, temveč vsaj o vzdrževanju stikov z njo. Breme stroškov za raziskave, ki omogočajo sodelovanje tudi na nivoju intenzivnih raziskav ali celo v integriranem monitoringu, prevzemajo države zunaj ES same, hkrati pa skrbijo za kompatibilnost z zahtevami ES. Konkretne informacije se nanašajo na seminarje, srečanja in roke za oddajo gradiv:

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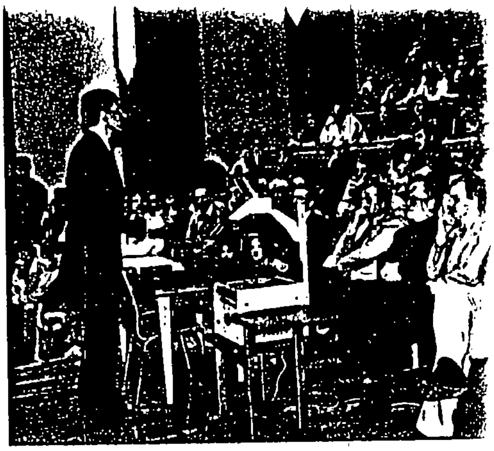

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from external radiation, do not play an important role.

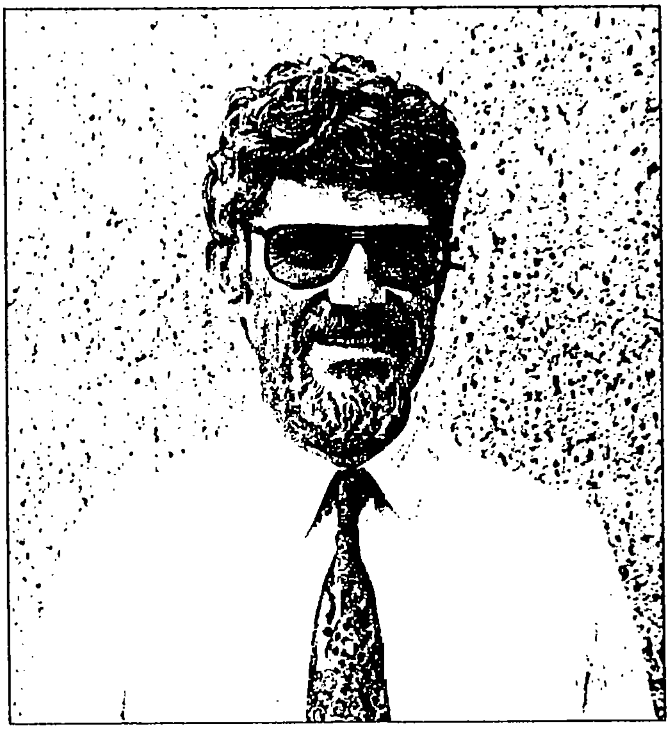
Uranium ore contains much more radioactivity than uranium itself. There are fourteen radioactive isotopes with the same activity in the uranium-radium decay chain. Eight of them are alpha emitters and six of them emit beta radiation. Gamma radiation originates mainly from two isotopes of the chain. The most important radionuclide in the U-chain is the radioactive noble gas radon - namely its isotope 222Rn, which escapes from ore grains and reaches the atmosphere. It there decays to its short lived radioactive daughters and, if inhaled with air, they remain in the lungs and irradiate sensitive lung cells. Epidemiologists estimated that about one tenth of all cases of lung cancer in the general public are caused by radon.

The general approach in mine impact assessment is to cover radioactive contamination in all the media of the living environment. A comparison of results is then made with reference levels and/or preoperational levels where extant. Even the relatively small dimensions of the contaminated sites could cause an appreciable dose contribution to the critical group.

Measurements of environmental radioactivity were performed at numerous places in the near vicinity and the results obtained were compared with those measured simultaneously at reference points lying beyond the influence of the mine sources. The contribution of the mine radioactivity to the environment was estimated on this basis.

Several measuring techniques are used. Air particulates are collected on filters and counted with a high resolution gamma spectrometer. Radon determination is performed with nuclear track detectors and charcoal canisters, and for radon daughters we mainly use continuous measurements by alpha spectrometry. These measurements in particular were - for some years - running in the framework of Slovenian-Bavarian scientific and technical cooperation, partly sponsored by Bayerische Staatsministerium für Landesentwicklung und Umweltfragen. Uranium in water is determined by neutron activation analysis with chemical separation, and radium by the sorption-emanation method. Radioactivity in soils and sediments is measured by gamma-spectrometry, and the low level of radionuclides in food and crops using a well-type germanium detector. We use thermoluminescent dosemeters (TLD) and portable instruments for measuring outdoor gamma radiation levels.

The general approach in dose calculation is a realistic assessment of dose, according to the general recommendations of international bodies such as the International Commission on Radiation Protection (ICRP). All enhanced levels (the differences between the levels in the mine surroundings and at reference points) were assumed to arise from the contribution of the mine.



Milko Križman, M. Sc., specialist in natural radioactivity

The average additional exposure to radon daughters was calculated from actual measured data and the corresponding behaviour model; the calculated effective dose equivalent for adult members of the public is about 0.30-0.35 mSv per year, while children are considered to be the most exposed segment of the population (nearly 0.44-0.50 mSv per year).

Investigations of natural background radiation around the mine area showed that radon concentrations in the majority of old houses were quite high, even up to 1000-2000 Bq/m3 in some cases. However, on average, the annual exposure due to indoor radon progeny is nearly 4 mSv, and thus the overall effective dose from natural sources lies around the value of 5.5 mSv per year.

Mercury in the Environment and Human Exposure Studies

By Anthony R. Byrne

Mercury (Hg) has attracted human interest from ancient times due to its extraordinary physical and chemical properties. Apart from bromine, it is the only chemical element found as a liquid at room temperature. In nature it can be found in elementary form (Hg^0), but more frequently it occurs as purple or dark-red cinnabar, HgS. The main user of Hg is the chlor-alkali industry. In addition, it is used for production of thermometers, as a liquid contact in various electrical products, and also for the production of dental amalgams. The main anthropogenic source of mercury emissions are coal-fired power plants.

In the environment, inorganic mercury can be transformed to organic compounds, mainly methylmercury, which accumulates in fish.

Elemental mercury, as well as most of its compounds, is harmful to living organisms. The toxic effects depend on the chemical and physical form of Hg. Hg and its compounds enter organisms through the respiratory tract, by passage through the skin, and from food consumption.

The Laboratory for Radiochemistry has been concerned with various aspects of Hg determination and its effects on the environment and man for more than 25 years. This work has been stimulated particularly by the vicinity of the world's second largest mercury mine at Idrija. We present here some topics and achievements.

Analytical methods

Two methods for total mercury determination have been developed: neutron activation analysis (NAA) based on volatilization separation of mercury (this method also allows selenium to be determined simultaneously in the same sample aliquot), and cold vapour atomic absorption spectro-

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Jožef Stefan Institute, Nuclear and Methods for Studying Human

By Borut Smodiš

Dr. Borut Smodiš, Head of the Laboratory for Radiochemistry

The Laboratory for Radiochemistry (LR) was constituted within the Department of Environmental Science (DES) in 1995, and is the successor of the Department of Nuclear Chemistry, operating since 1969. There are 14 researchers (3 of them are habilitated at Ljubljana University) and 4 technicians. In 1994, 2 M Sc. and 5 Ph.D. theses were completed in the LR. The staff on average publishes more than 20 publications per year in national and international scientific journals.

The activities of the LR are firmly based on the use and continuous development of analytical methods, both nuclear and non-nuclear (mainly neutron activation analysis - NAA, energy dispersive X-ray fluorescence - EDXRF, cold vapour atomic absorption spectrometry - CVAAS, chromatographic techniques), of radiochemical and radiometric procedures, the use of radiotracers in chemical and biological systems, and some other specific separation methods (e.g. protein separations, metallothionein studies). These methods allow measurement of total concentrations of a wide range of elements in a variety of different specimens, and in refined form, speciation and binding studies. Together with measurements of the content and distribution of radionuclides, both natural and man-made, this is the foundation for a wide programme of basic and applied studies mainly concerned with environmental pollution and the life sciences.

Research projects are financially supported by the Ministry of Science and Technology of the Republic of Slovenia; applied research projects are also supported by the Ministry of Environment and some enterprises. Part of the financial support is derived from international sources and co-operative projects.

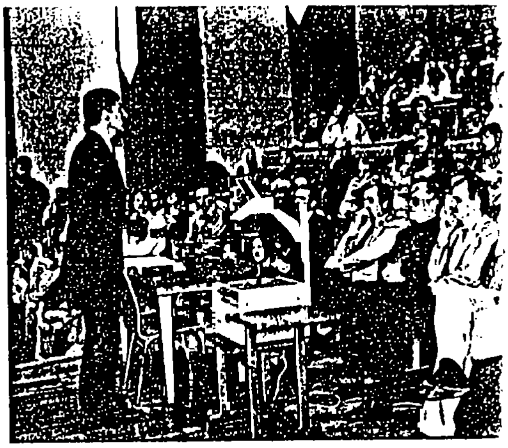
Radioanalytical chemistry is one of the main activities of the LR. This is a scientific field concerned with the use of radioactive nuclides and nuclear radiation for analytical purposes. The main advantages of these methods stem from the extraordinary energy of nuclear reactions and the ensuing radiation, compared to that of common chemical reactions. As a result, extremely small amounts of substances can be detected and monitored in the course of the analytical procedure with great specificity. This usually brings about high sensitivity, speed and simplicity, easy automation and, in many cases, elimination of the chemical handling of the sample. Radioanalytical procedures are used for the solution of those problems for which they are superior to other analytical approaches.

The simplest case of the use of radionuclides in analytical chemistry is the determination of naturally occurring radioactive species. They can be determined by measuring their alpha (α), beta (β) or gamma (γ) activity. These nuclides either decay to stable nuclides or give rise to radioactive decay chains, of which the two most important are those from ^{238}U and ^{232}Th.

The laboratory is well equipped with alpha spectrometers (with surface-barrier detectors), beta counters and gamma spectrometers (with several types of semiconductor Ge detectors).

Radioecological studies, where the fate and cycling of radionuclides in the environment are followed, include those associated with radon, monitoring of critical radionuclides around the former uranium mine at Žirovski vrh, and in the area of the Krško Nuclear Power Plant. In cooperation with other groups at the Jožef Stefan Institute (IJS), a radon survey in Slovenia was elaborated, based on ^{222}Rn measurements in more than 900 Slovenian homes. Among other achievements in this field, radiochemical procedures for determination of ^{230}Th and ^{241}Am using α-spectrometry have been developed. The influence of classical technologies such as mining, power production and phosphate processing on the environment (including chemical pollution, particularly that associated with air particulates) is also studied, and

QUARK



Innovative Technology in Sloveni

- Slovene Ministers about R&D in Slove
- Interviews with Lea Foreign Scientists

ıwer plant, measurements in- ːrmination of selected heavy .. radionuclides in isokinetically stack emitted fly ash, electrofilter coal.

ɜs related to panoramic multi- ınalysis by NAA and EDXRF, cus- ·-is (including speciation of some ɐments) by radiochemical NAA,]GC, measurements of radionu- ıcluding alpha, beta and gamma ıs well as expert opinions relat- he above mentioned topics, are offered to enterprises, and gov- ıl and non-governmental institu-

ɔf the traditions and continuing ·he LR is its strong involvement in ıal co-operation based on basic ed projects. Some of the major , internationally co-ordinated and collaborative projects are as fol-

ırojects "Analytical control in ıt environmental exposure to mer- ·-d "Trace element air pollution g studies in Slovenia using nucle- cal techniques" are supported by ·rnational Atomic Energy Agency m Vienna.

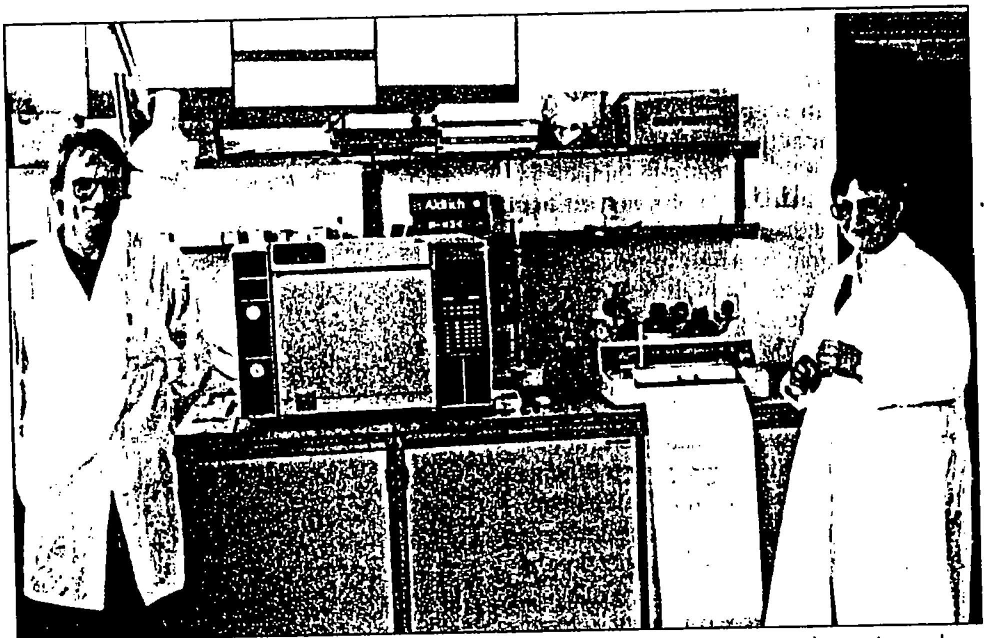
ɔroject "An impulse to exploit .. manageable and competitive an- tool in industry and in environ- ınitation in Hungary, the Czech and Slovenia" is supported by opean Union (EU) by means of ·-rnicus programme.

ipation in COST 99 "Food con- ı and composition data" is also ed by EU.

project "Improvements in NAA ·es for the certification of refer- ıaterials" between IJS (Dr. A.R. ınd the National Institute for Stand- l Materials (Dr. D.A. Becker) is d by the U.S.-Slovene joint board.

: project "Chemical forms of trace · " between IJS (Dr. B. Smodiš) and ıgszentrum Jülich (Dr. H. Emons) rted by "Internationales Büro, For- ;szentrum Jülich".

ɜ of the projects are based on bilat- ɜements or on memoranda of un- ·ding, where mutual interests and research activities exist. The most e ones are with the Universiteit rof. F. De Corte), Karl-Franzens- rsitäet Graz (Prof. K.I. Irgolic), the ·-y of Sciences of the Czech Repub- J. Kučera), Technische Universiteit ɔr. H.Th. Wolterbeek), Technische rsität München (Prof. F. Baumgärt- d Instituto Technológico e Nuclear n (Dr. M. do Carmo Freitas).



Tomaž Vuk, undergraduate student and Dr. Vekoslava Stibilj working with the gas chromatograph.

Radioactivity in the Vicinity of Former Uranium Mine

By M'lko J. Križman

Compared to other countries, the problem of radioactively contaminated sites is small scale in Slovenia. The ma n focus of attention is on the former uranium mining and milling operation at Žirovski Vrh, and planning of its environmental re-habilitation.

Žirovski vrh uranium mine anc its processing plant is situated near the small village of Todraž, in the northwest of Slovenia, 35 km from the Austrian and Italian borders and 30 km from Ljubljana, the capital. The mining area lies in the sub-alpine region of the country, in a deep valley with frequent temperature inversions. Relatively low-grade ore (less than 0.1% U^{308}) was excavated and treated between 1985 and 1990. Production of so-called yellow cake (ammonium di-uranate) provided for the needs of the Krško Nuclear Power Plant.

Some basic facts about the former uranium mine at Žirovski vrh are as follows:

A closed cycle of industrial water was used in the milling process, and radioactive wastes, such as chemical tailings of about 600,000 tonnes were deposited on the slopes of a hill about 100-150 m above the small and narrow valley. The mine exhaust vents (carrying radon) are also situated at the same elevated position, while the sources of radioactive contamination from the milling operation (the waste rock or spoil deposit of low radioactivity, cca.1.5 million tonnes) and from the ore stockpile (some thousand tonnes of uranium ore) are located at the bottom of the valley, i.e. under the average temperature inversion layer. Total annual emission rate of radon from all sources was estimated to be about 20 TBq. In the middle of 1990, the mining and milling of uranium ore ceased.

The regular monitoring programme operated by the Jožef Stefan Institute, with the largest contribution from the Laboratory for Radiochemistry, started simultaneously with the mine complex operation and covered all the critical pathways in 1985. It has been running continuously ever since. In normal practice, the most important consequences of an uranium mine and milling operation are generally observed as contamination of surface waters and groundwaters with uranium, 226Ra, 230Th and 210Pb. The Žirovski vrh mine appears to represent quite an exceptional case: the main radiological impact to the critical group of the population appears to originate from inhalation of radon and its daughters. An extensive data base on radon is thus needed for dose assessment for members of the public. Other pathways, such as inhalation of dust particles with long-lived radionuclides, ingestion of food and water biota and exposure

R E K A P I T U L A C I J A

raziskovalnih rezultatov vseh raziskovalcev na projektu

VRSTA RAZISKOVALNEGA REZULTATA	*Skupno število*
I. OBJAVLJENI ČLANKI V:	***31***
1. Znanstveni reviji: *a) domači;* *b) tuji;* *- s faktorjem vpliva SCI ali SSCI do 1* *- s faktorjem vpliva SCI ali SSCI nad 1*	***11*** ***12*** ***1***
2. Strokovni reviji: *a) domači;* *b) tuji;*	***7***
II. IZDANE KNJIGE:	
1. Znanstvena knjiga: *a) samostojna knjiga pri domači založbi;* *b) sestavek v knjigi domače založbe;* *c) samostojna knjiga pri mednarodno uveljavljeni tuji založbi;* *d) sestavek v knjigi mednarodno uveljavljene tuje založbe;*	
2. Strokovna knjiga: *a) samostojna knjiga pri domači založbi;* *b) sestavek v knjigi domače založbe;* *c) samostojna knjiga pri mednarodno uveljavljeni tuji založbi;* *d) sestavek v knjigi mednarodno uveljavljene tuje založbe;*	
III. OBJAVLJENI PRISPEVKI IZ ZNANSTVENIH KONFERENC IN SESTANKOV, VABLJENA PREDAVANJA:	***26***
1. Referati - razprave iz znanstvenih konferenc in sestankov: *a) v zborniku mednarodnih konferenc in sestankov;* *b) v zborniku domačih konferenc in sestankov;*	***15***
2. Uvodno vabljeno predavanje: *a) na mednarodni konferenci;* *b) na domači konferenci;*	 ***4*** ***7***

IV. PRENOS RAZISKOVALNIH SPOZNANJ IN DOSEŽKOV V PRAKSO:	
1. Patenti: *a) podeljeni doma;* *b) podeljeni v tujini* *c) prijavljeni doma;* *d) prijavljeni v tujini;*	
2. Drugi prenosi spoznanj in dosežkov (opisati):	
3. Ostalo (opisati):	
diplome	***5***
magistrska dela	***3***
doktorska dela	***5***

NAVEDENI NAJ BODO LE TISTI RAZISKOVALNI REZULTATI, KI IZHAJAJO NEPOSREDNO IZ NAVEDENEGA ZNANSTVENO-RAZISKOVALNEGA PROJEKTA.