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Data Article

Geochemical dataset of environmental samples from Idrija urban area, Slovenia

Geokemični podatkovni niz okoljskih vzorcev iz urbanega območja Idrije, Slovenija

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Abstract

This paper presents a dataset containing the results of geochemical analyses of three different urban materials- soil, sediment and household dust from the urban area of Idrija town (Slovenia). Topsoil, subsoil and garden soil were collected on the urban green surfaces. Sediments were collected in the gully pots of the urban drainage system (road sediments) and local streams flowing through Idrija's urban area (stream sediments). Household dust was collected from the vacuum cleaner bags, which were provided by the residents. The geochemical analyses carried out were: (1) multi-elemental analysis (determination of element contents after modified aqua regia digestion by inductively coupled plasma (ICP) mass spectrometry and ICP emission spectrometry (ES) and (2) solid phase Hg thermo-desorption technique (determination of the relative amount of Hg binding forms). These two methods were applied to all investigated materials. Water leaching tests were carried out to determine the water-soluble Hg content in the urban soil by ICP-MS. A modified simulated stomach acid extraction in vitro tests were carried out to determine the bioaccessible Hg content in topsoil and household dust by ICP-MS. The dataset has a fundamental scientific value and is useful for local soil, sediment and household dust quality research, mitigation of pollution evaluation over time and assessment of environmental exposure and related health impacts.

Izvleček

Ta članek predstavlja podatkovni niz, ki vsebuje rezultate geokemičnih analiz treh različnih urbanih materialov – tal, sedimentov in hišnega prahu iz poseljenega območja Idrije. Na urbanih zelenih površinah so bili vzorčeni zgornji in spodnji sloj tal ter vrtna tla. Sedimenti so bili vzorčeni iz obcestnih jarkov drenažnega sistema (cestni sedimenti) in lokalnih potokov, ki tečejo skozi urbano območje Idrije (potočni sedimenti). Hišni prah je bil vzorčen iz vrečk sesalnikov, ki so jih posredovali prebivalci Idrije. Geokemične analize vključujejo (1) več-elementno analizo (določitev vsebnosti elementov po modificirani zlatotopki z induktivno sklopljeno plazmo (ICP) masno spektrometrijo (MS) in ICP emisijsko spektrometrijo (ES)) in (2) termično desorpcijsko analizo oblik vezave Hg (določitev relativne količine Hg oblik vezave). Ti dve metodi sta bili uporabljeni za vse preiskovane materiale. Izvedeni so bili vodni izluževalni testi za določitev vodotopne vsebnosti Hg v izlužkih urbanih tal z ICP-MS ter in vitro izluževalni testi z modificirano simulirano želodčno kislino za določitev biološko dostopne vsebnosti Hg v zgornjem sloju tal in hišnem prahu z ICP-MS. Podatkovni niz ima temeljno znanstveno vrednost in je uporaben za lokalne raziskave kakovosti tal, sedimentov in hišnega prahu, vrednotenje onesnaženosti skozi čas ter oceno izpostavljenosti okolju in s tem povezanih vplivov na zdravje.

Background

The presented dataset is a result of a research work carried out during the preparation of a PhD thesis entitled “Geochemical investigation in Idrija urban area with emphasis on mercury” (Bavec, 2015a). Idrija urban area was selected as a case study. In Idrija and surroundings severe pollution and contamination with mercury exist due to historical mining activity (about 500 years). Idrija is Slovenia’s oldest mining town and was the second largest mercury mine in the world after the mine in Almadén, Spain. The mine was closed in 1995. However, Idrija town was successfully transitioned from a mining town to an industrial town. The goals of the research work were to identify enrichments of elements in the studied materials and investigate the potential sources of elements by using the tools of statistical and spatial analysis (Bavec et al., 2014, 2015, 2017; Bavec, 2015b, 2017). Due to the strong mercury contamination

of the investigated area, it was important to examine the properties of Hg in the studied materials, which would help to better understand the fate of mercury in the urban area of Idrija. Hg binding forms were determined to quantify the fraction of mercury, which is more susceptible to the transformations in the environment (Bavec et al., 2014, 2017; Bavec and Gosar, 2016). Water soluble fraction of Hg in urban soil was determined to indicate the portion of mercury in the soil that is relevant to affect the local water cycle, since surface and/or rainwater can leach and mobilize mercury from the contaminated soils to the deeper soil layers and to the groundwater (Bavec and Gosar, 2016). The bio-accessible fraction of Hg in the soil and household dust was determined to perform risk assessment (Bavec et al., 2018).

Value of the data

- A comprehensive dataset is provided to assess the extent and distribution of urban contamination, especially potentially toxic elements in environmental matrices. Furthermore, the dataset includes geochemical characteristics of Hg to better understand its behavior in different urban matrices, including binding forms, bioaccessibility and water solubility.
- Specific to local authorities, the dataset has high relevance for addressing local environmental issues and can help establish tailored mitigation strategies. The data supports evidence-based decision-making for environmental monitoring, public health, and land use management.
- While focused on Idrija, the dataset provides insights into urban geochemistry that can be extrapolated or adapted to similar urban areas worldwide, particularly those with industrial legacies. It can be used to compare geochemical pollution levels between Idrija and other urban or industrial areas, offering insights into specific pollution sources and patterns.
- The pollution of environmental matrices is related with increasing human health risks. The knowledge about chemical elements distribution in environmental matrices of urban areas helps to develop and improve assessment of environmental exposure and related health impacts.

Experimental design, materials, methods, data validation

Altogether 45 soil, 16 road sediment, 14 stream sediment and 16 household dust sampling locations were established. Regarding soil, 45 topsoil (0-10 cm), 45 subsoil (10-20 cm), 12 duplicate soil (6 topsoil and 6 of subsoil), 4 garden soil and 1 duplicate garden soil sample were collected (sum of all samples = 153). Duplicate soil samples were collected randomly within a radius of 10 m from the primary soil samples to estimate sampling variance. Soil samples were pre-treated in the laboratory only for multi-elemental analysis after aqua regia digestion and soil pH analysis. For all other chemical analyses (soil water content analysis, Hg thermo-desorption technique, water leaching test and bioaccessibility leaching test according to the European Standard Toy Safety Protocol) fresh samples were used. To determine the soil pH, dry samples were gently crushed in a ceramic mortar and sieved through a 2 mm mesh sieve. For multi-elemental analysis after aqua regia digestion the samples were additionally ground in an agate mill. To obtain road and stream sediment (<0.125 mm and <0.04 mm) and household dust (<0.125 mm) analytical fractions, dry sieving was carried out. For sediments, the particle size distribution according to the standard (EN ISO 14688-1:2002) was determined. For Hg thermo-desorption technique, fresh soil and sediment samples and dry household dust samples (<0.125 mm) were used. Further details of sampling and sample preparation were already presented in research papers, that is for soil (Bavec et al., 2015; Bavec and Gosar, 2016, Bavec, 2017; Bavec et al., 2018), road and stream sediments (Bavec et al., 2014; Bavec, 2015b) and household dust (Bavec et al., 2017, 2018). Chemical analytical method procedures applied in each sampled material are described in previously cited papers and are also summarized in detail in the Table 3 together with quality control.

Data description

The dataset includes three separate tables. The number of samples within the dataset is higher (n = 183) than that of actually sampled (n = 153). This is because, for road sediments (n = 16) and stream sediments (n = 14), element contents were measured in two analytical fractions (<0.125 mm and <0.063 mm). This is why the number of sediment samples in the dataset is doubled (60 instead of 30).

Table 1 entitled *"Urban Idrija dataset"* is a catalogue of all collected samples and related data. Each sample has a unique identifier (ID), a type, a name and GPS coordinates (D48/GK, D96/TM and WGS84). However, for household dust samples, GPS coordinates are not shared. Due to the sensitive nature of household dust data and its

associated geographic location (which could potentially reveal a resident's identity if coordinates were shared), participants providing household dust samples were assured that raw data would remain confidential. Researchers or experts interested in using this data for research purposes should contact the authors of this paper to explore the possibility of obtaining household sample coordinates. The rest of the data attributes in the dataset describe a characteristic of a sample determined either during field work (e.g. depth) or in a laboratory during sample preparation (e.g. analytical fraction) or with a specific analytical method (e.g. pH). Altogether, the table consists of 81 attributes.

Table 2 entitled *"The description of attributes within the Urban Idrija dataset (the abbreviation n.d. means no data)"* provides a clear definition of each attribute of a given sample within the Urban Idrija dataset, which is presented in Table 1.

Table 3 entitled *"Chemical and physical method procedures carried out to obtain data, which are included in the Urban Idrija dataset"* provides a detailed description of chemical and physical analytical methods, which were carried out to determine pH, particle size distribution, soil water content, element contents, relative amount of mercury binding forms, water soluble Hg contents and bioaccessibe Hg contents according to the European Standard Toy Safety Protocol.

Data format

Table 1: Microsoft Excel file (.csv format)

Table 2–3: Portable document format (.pdf format)

Data accessibility

The data described is open-source data and has been deposited in DiRROS repository. License: CC-BY 4.0. Data are accessible using the link: to be done. Repository name: DiRROS

Direct URL to data: https://dirros.openscience.si/IzpisGradiva.php?id=23021&lang=slv

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References

AOAC 2016: AOAC official methods of analysis. Guidelines for standard method Performance requirements. Appendix F. Internet: https://www.aoac.org/resources/guidelines-for-standard-method-performance-requirements/ (28.1.2015).

Bavec, Š. 2015a: Geochemical Investigations in Idrija Urban Area with Emphasis on Mercury: Dissertation Thesis. University of Ljubljana, Ljubljana:180 p.

Bavec, Š. 2015b: Geochemical investigations of potentially toxic trace elements in urban sediments of Idrija. Geologija, 58/2: 111–120. https://doi.org/10.5474/geologija.2015.009

Bavec, Š. 2017: Geochemical baseline for chemical elements in top- and subsoil of Idrija. Geologija, 60/2: 181–198. https://doi.org/10.5474/geologija.2017.013

Bavec, Š. & Gosar, M. 2016: Speciation, mobility and bioaccessibility of Hg in the polluted urban soil of Idrija (Slovenia), Geoderma, 273: 115–130. https://doi.org/10.1016/j.geoderma.2016.03.015

Bavec, Š., Biester, H. & Gosar, M. 2014. Urban sediment contamination in a former Hg mining district, Idrija, Slovenia. Environmental Geochemistry and Health, 36/3: 427–439. https://doi.org/10.1007/s10653-013-9571-6

Bavec, Š., Gosar, M., Biester, H. & Grčman, H. 2015. Geochemical investigation of mercury and other elements in urban soil of Idrija (Slovenia), Journal of Geochemical Exploration, 154: 213–223. https://doi.org/10.1016/j.gexplo.2014.10.011

Bavec, Š., Gosar, M., Miler, M. & Biester, H. 2017. Geochemical investigation of potentially harmful elements in household dust from a mercury-contaminated site, the town of Idrija (Slovenia). Environmental Geochemistry and Health, 39: 443–465. http://dx.doi.org/10.1007/s10653-016-9819-z

Bavec, Š., Biester, H. & Gosar, M. 2018: A risk assessment of human exposure to mercury-contaminated soil and household dust in the town of Idrija (Slovenia), Journal of Geochemical Exploration, 187: 131–140. https://doi.org/10.1016/j.gexplo.2017.05.005

Biester, H. & Scholz, C. 1996: Determination of mercury binding forms in soils: mercury pyrolysis versus sequental extraction. Environmental Science & Technology, 31/1: 233–239. https://doi.org/10.1021/es960369h

Biester, H. & Nehrke, G. 1997: Quantification of mercury in soils and sediments – acid digestion versus pyrolysis. Fresenius' Journal of Analytical Chemistry, 358: 446–452. https://doi.org/10.1007/S002160050444

EGS 2016: Urban Geochemistry Project (URGE): EuroGeoSurveys 2015 annual report. EuroGeoSurveys, Brüssels, 17–18. Internet: https://eurogeosurveys.org/egs-publications/urban-geochemistry-project-urge-eurogeosurveys-2016-annual-report/ (28.1.2025)

EN71–3:2002. Safety of toys - Part 3: Migration of certain elements; German version EN 71-3:1994 + A1:2000 + AC:2002. European Committee for Standardization, Brussels, Belgium.

EN ISO 14688–1:2002: Geotechnical investigation and testing — Identification and classification of soil. Part 1: Identification and description.

EPA 2002: Environmental Protection Agency [online]. Method 1631, Revision E: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Absorption Fluorescence Spectrometry, 2002. Internet: https://www.epa.gov/sites/default/files/2015-08/documents/method_1631e_2002.pdf (28.1.2025)

ISO 9001:2008 Quality management systems — Requirements.

SIST ISO 10390:1996 - Soil quality - Determination of pH.