




## PERSPECTIVE OPEN ACCESS

# Public Participation in EU Legislation? Recommendations for Involving Citizen Scientists in Anthropogenic Litter Research Within the Water Framework Directive

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## ABSTRACT

Anthropogenic litter causes significant harm to the environment on a global scale. Achieving international agreements and establishing corresponding national legislation is essential for solving this prevalent environmental problem. Effective monitoring programmes are also critical for evaluating the environmental status in aquatic (marine and freshwater) environments, as required by the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in Europe. In contrast to the MSFD, the current version of the WFD does not yet include anthropogenic litter pollution as an indicator to evaluate the status of aquatic environments. In order to overcome these shortcomings, we recommend using existing litter data generated by citizen science initiatives as a baseline to establish relevant indicators in the WFD. Further, citizen scientists could contribute to the WFD by taking complimentary samples, for example, at underrepresented smaller streams, adding context and value to data collected at established monitoring stations. The involvement of citizens as actors within an EU Directive would not only help to obtain valuable data on a significant spatial and temporal scale but could potentially also increase the environmental awareness and political engagement of the public. The upcoming revision cycle of the WFD in 2028 presents a unique opportunity to give citizens a voice and opportunity to partake in EU legislative frameworks.

## 1 | Introduction: The Global Plastic Pollution Crisis and European Plastic Policies

Ocean and inland waters have enormous importance for the biosphere and the stability of our climate. Clean water is crucial for life, health and the economy (Sadoff et al. 2020). However,

many water bodies today are contaminated by a wide range of pollutants, among them anthropogenic litter, mainly consisting of plastic items (Consoli et al. 2024; Jambeck et al. 2015; Schwarz et al. 2019). This pollution has far-reaching effects on ecosystems, the economy and human well-being (Beaumont et al. 2019; Thompson et al. 2024). Plastic pollution affects

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a wide range of organisms, including more than 750 marine and freshwater species (Jâms et al. 2020; Kühn and van Franeker 2020). Every year, an estimated amount of 19–23 million tons of plastic litter enter aquatic environments (Borrelle et al. 2020). The problem of anthropogenic litter is not inherent to a certain environment but impacts the ocean (Eriksen et al. 2023; Kühn and van Franeker 2020) and freshwater environments alike, including lakes (Earn et al. 2021) and rivers (Lechner 2020). Marine and fresh waters are hydrologically connected, with rivers acting as major conduits for plastic pollution towards the ocean (Gallitelli and Scalici 2022; Lebreton et al. 2017; Schmidt et al. 2017).

Anthropogenic litter, and especially plastic litter, has been recognized as an issue of global concern that is being addressed by a variety of legislations worldwide (da Costa et al. 2020; Gallitelli et al. 2024; Paloniitty and Ala-Lahti 2024), many of which focus on individual litter items as pollutants, regulating or restricting their use (e.g., Schnurr et al. 2018). The global plastic treaty that is currently being negotiated aims to establish globally binding mechanisms to address the plastic crisis (Dey et al. 2022; Wang and Praetorius 2022), and litter is an indicator for the health of the ocean within the United Nations' Sustainable Development Goal (SDG) 14. Additionally, litter is relevant for other SDGs, though not explicitly expressed as an indicator, for example, SDG 6 (Clean Water and Sanitation) or SDG 12 (Responsible Consumption and Production). In the European Union (EU), extensive legislation has been enacted to address the problem of anthropogenic litter pollution (see overview in Elliott et al. 2020 and Nielsen et al. 2023), for example, by targeting certain single-use items (EU Directive 2019/904), waste and its management (EU Directive 2008/98) or ensuring clean coastal waters (EU Directive 2008/56).

Despite this extensive legislative coverage, the Water Framework Directive (WFD), an overarching directive with the mission to achieve a good status of aquatic environments in European countries, does not yet consider anthropogenic litter pollution. The aim of this article is to (i) discuss the importance of including litter pollution assessments within the WFD, (ii) highlight the potential of already existing litter data originating from large-scale citizen science studies and (iii) illustrate opportunities to involve the general public within design and collaborative research activities (i.e., citizen science) that generate the information to support policy-making processes.

## 2 | The Need to Include Plastic Pollution Assessments Within the Water Framework Directive

The WFD was established in the year 2000 with the aim of improving and protecting the quality of water bodies (EU Directive 2000/60). It requires EU Member States to transform all freshwater bodies and coastal waters up to one nautical mile from the coastline into a 'good status' by 2027. This evaluation is based on 'quality elements', parameters measuring, for example, the abundance and composition of aquatic species, the presence of pollutants such as biocides, pharmaceutical compounds, industrial chemicals and metals, as well as evaluating hydro-morphological structures and changes to aquatic environments

(EU Directive 2000/60; EU Directive 2013/39; also see overview by Arle et al. 2016).

Although anthropogenic litter and their chemical components in the aquatic environment are a well-known environmental problem (Schwarz et al. 2019; Thompson et al. 2024; Wang and Praetorius 2022), the WFD does not yet include any explicit regulation regarding this diverse group of pollutants. Although some of the 'priority substances' assessed by the WFD could originate from plastics (Wesch et al. 2014), and a section of the Directive addresses the 'Estimation and identification of other significant anthropogenic impacts on the status of surface waters' (EU Directive 2000/60, Annex II, Section 1.4), there is no specific mention of anthropogenic litter. This is especially noteworthy as the Marine Strategic Framework Directive (EU Directive 2008/56), concerned with 'good environmental status' of marine waters of the EU, covers anthropogenic litter as defined under Descriptor 10 and spatially overlaps in coastal areas with the WFD (Bigagli 2015).

Numerous authors have already proposed to include anthropogenic litter within the WFD (see, e.g., Black et al. 2019; Borja et al. 2010; Roex et al. 2013; Sheridan et al. 2020; van der Wal et al. 2015; Wesch et al. 2014). In 2022, the European Commission adopted a proposal to amend the WFD and to include an assessment of microplastics (European Commission 2022); the development or adoption of a monitoring method is currently pending.

In line with the above-mentioned studies and authors, we argue that a holistic assessment of anthropogenic litter is required to certify that a water body obtained a good environmental status. This requires broad data with extensive spatiotemporal coverage that includes various types of anthropogenic litter, including macrolitter and mesolitter as well as microplastics. Indicators for this assessment could relate to litter densities (e.g., OSPAR Commission 2010), litter composition (e.g., Morales-Caselles et al. 2021), litter pathways and sources (e.g., Pace et al. 2024) or litter hotspots (e.g., Kiessling et al. 2021; Tasseront et al. 2024). Therefore, this form of pollution should be included within the WFD during its upcoming fourth cycle (2028–2033). Specifically, we suggest that the existing wealth of data about the plastic pollution problem, many of which have been collected by members of the general public in citizen science approaches, should be used to include plastic pollution in the WFD. Citizen science is inherently flexible and is able to innovatively explore emergent issues of environmental concern. Opening up the WFD to encourage collaboration from the public harnesses this potential of citizen science and contributes to the continuous improvement and revision of the WFD.

## 3 | Citizen Science Data—A Baseline for Anthropogenic Litter Assessments in the WFD?

There are numerous initiatives through which the general public has contributed to our understanding of the global plastic pollution crisis (see overviews in Cook et al. 2021; Kawabe et al. 2022; Popa et al. 2022; Rambonnet et al. 2019). Among them are large-scale, international and long-running initiatives such as the International Coastal Cleanup (Ocean Conservancy 2022),

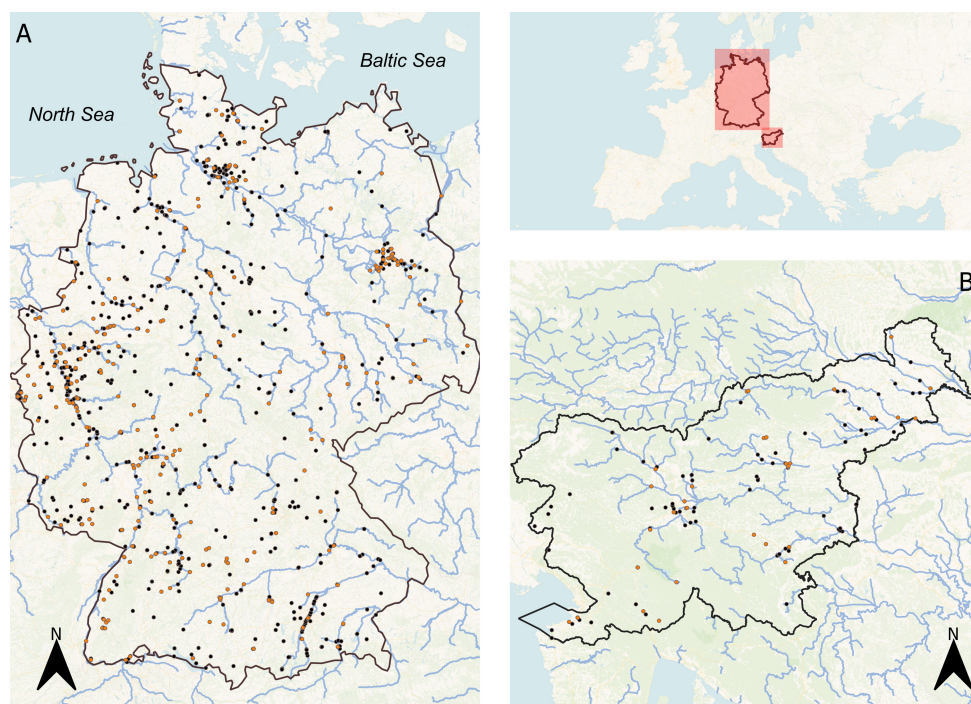
Marine LitterWatch (European Environment Agency [n.d.](#)), Marine Debris Tracker (Jambeck and Johnsen [2015](#)), International Pellet Watch (Ogata et al. [2009](#)) and the initiatives, which we (the authors of this manuscript) coordinate, namely, the Plastic Pirates in Germany and Slovenia (e.g., Kiessling et al. [2019](#); Dittmann et al. [2024](#); <https://www.plastic-pirates.eu/en>) and the Científicos de la Basura ('Litter Scientists') in Latin America (e.g., de Veer et al. [2023](#); <https://cientificosdelabasura.ucn.cl/>).

The Plastic Pirates and Científicos de la Basura have involved thousands of school students as citizen scientists, addressing research questions related to the abundance, composition, pathways and potential sources of litter objects (including microplastics). The resulting data concern the coastal but also the riparian environment, are already extensive in scope and have the potential to be scaled up towards the European level. This is illustrated by the Plastic Pirates initiative, which started in Germany and was then expanded to several Member States of the European Union, currently involving 15 European countries. The initiatives cover large areas also addressed by the WFD (see Figure 1) and could therefore be used to inform the formulation of quality elements to assess anthropogenic litter pollution within the WFD. Additionally, citizen science data can contribute to making better methodological decisions, such as site selection criteria and how anthropogenic litter assessment should be considered under different monitoring approaches of the WFD (Arle et al. [2016](#); EU Directive 2000/60).

Regarding the often-mentioned issue of citizen science data quality, in many instances, citizen scientists have been shown to obtain reliable data suited for the intended research purposes

(see, e.g., Hidalgo-Ruz and Thiel [2015](#); Thiel et al. [2017](#); van der Velde et al. [2017](#); Zettler et al. [2017](#) for anthropogenic litter research and Hoyer and Canfield [2021](#); Peeters et al. [2022](#); von Gönner et al. [2023](#) for further studies relevant to the WFD). In this context, it is especially important to consider the issue of data quality and address it by means of adequate training of volunteers, balancing complexity with feasibility of sampling methods, developing accompanying educational material, implementing data verification strategies and transparently communicating shortcomings (Balázs et al. [2021](#); Dittmann et al. [2022](#); Kosmala et al. [2016](#)). It needs to be emphasized that citizen science is no cheap labour to obtain scientific data (also see arguments by Raman et al. [2023](#)) but that large-scale citizen science initiatives need to be carefully structured and require dedicated coordinating personnel focused especially on quality assurance and communication efforts, as our own experiences have shown (Dittmann et al. [2023](#); Thiel et al. [2023](#)).

There are various factors relevant for aligning the needs of reporting agencies with available citizen science data, which act as barriers to formulate quality elements for the investigation of anthropogenic litter within the WFD. Reporting agencies such as environmental ministries and statistical offices commonly require long-term monitoring data, whereas project-based citizen science studies are usually short-lived and struggle for sustainable funding, which in turn also prevents frequent and systematic communication between citizen science coordinators and reporting agencies (Carlson and Cohen [2018](#); Fraisl et al. [2020](#); Warner et al. [2024](#)). Additionally, data harmonization has been identified as an important challenge, requiring substantial effort to make anthropogenic litter data relevant



**FIGURE 1** | Map of Germany (A) and Slovenia (B) showing Plastic Pirates sampling sites from 2016 to 2023 ( $n = 1275$  sampling sites in Germany and 122 in Slovenia). From the total of 1397 sampling sites, 453 (32%, highlighted in orange) are located within a 1-km radius of established WFD monitoring stations (with operational sampling objectives, European Environment Agency [2020](#)). The 1-km radius was chosen because it is assumed that this is within walking distance of school classes, which the Plastic Pirates programme involves in anthropogenic litter research.



for policy making. In a recent study, Fraisl et al. (2023) reported on how Ghana used citizen science data of anthropogenic litter for official reporting for Sustainable Development Goal 14. This was achieved by compiling data to meet standards of the official monitoring methodology, which enabled project initiators to validate, integrate and report data to the relevant authorities (Fraisl et al. 2023). Other initiatives exist with the overall goal to make citizen science contributions relevant for policy making, including the EMODnet platform (Jack et al. 2019; accessible under <https://emodnet.ec.europa.eu/en>), aiming at aggregating and standardizing scattered data, the publications of the Technical Group Marine Litter, providing guidelines, manuals or photo references on anthropogenic litter in the aquatic environment (accessible under [https://mcc.jrc.ec.europa.eu/main/dev.py?N=41&O=434&titre\\_chap=TG](https://mcc.jrc.ec.europa.eu/main/dev.py?N=41&O=434&titre_chap=TG)), or the EUROqCHARM project, seeking to harmonize plastic pollution assessment methods (<https://www.euroqcharm.eu/>).

#### 4 | Complementary Citizen Science Samplings—Adding Value to Water Framework Directive Data

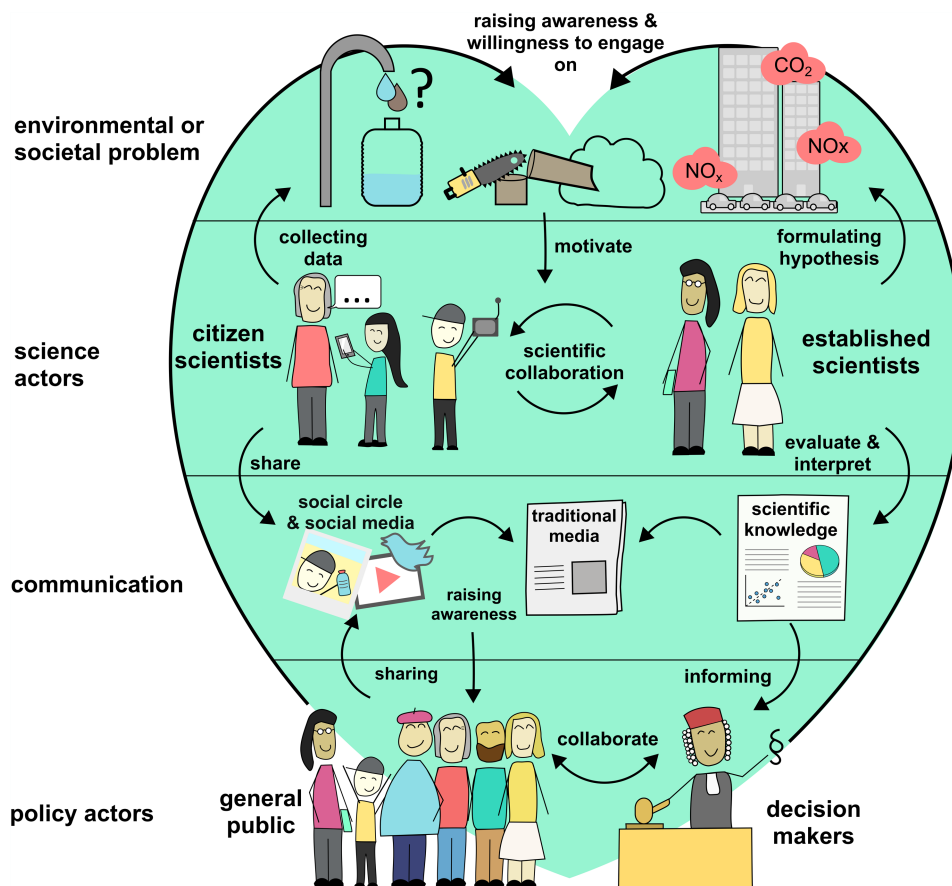
As a further step, we propose to actively engage the public in data collection efforts related to the WFD. Such complementary citizen science samplings and the resulting data would, for example, be useful to cover areas currently not addressed by the WFD and could serve as an early-warning system to detect pollution hotspots as they engage local stakeholders with an inherent interest, and accompanying knowledge of local conditions. Importantly, this complementary sampling cannot replace the mandatory monitoring obligations, which have to remain with the corresponding authorities. One example we envision would be to equip citizen scientist groups with surface microplastic sampling nets, which have shown to be an effective way to detect hotspots of microplastic pollution in rivers, including in smaller streams usually not in the focus of scientific investigations (Kiessling et al. 2021). In Germany, this focus on smaller streams has recently been set by the FLOW project (von Gönner et al. 2024), investigating different environmental aspects such as species composition and obstructions to the natural flow of rivers already in line with current WFD monitoring protocols. Other complementary citizen science samplings could focus on beach and river shores, which currently are not monitored by the WFD, and thereby estimate potential future pollution levels of aquatic environments as the present litter items are likely to be remobilized into rivers over time (Liro et al. 2025). Overall, there is a variety of established citizen science litter sampling protocols potentially suitable to supplement the official monitoring duties of the WFD. Examples include samplings focused on obtaining standardized litter data per surface area (Bravo et al. 2009; Rech et al. 2015) or normalized to linear metres (Philip et al. 2024), observing floating macrolitter from vantage points (González-Fernández et al. 2021), identifying litter sources and polluters (Kiessling et al. 2019; Stanton et al. 2022; Veiga et al. 2016), analysing persistent organic pollutants associated to microplastics (Ogata et al. 2009) or involving people with special skills such as divers or canoeists and thereby obtaining data from sites that are difficult to assess (Camins et al. 2020; Consoli et al. 2020; Cowger et al. 2019; Tasseron et al. 2020).

Although we present a hypothetical scenario to include an assessment of plastic pollution within the WFD, there are citizen science initiatives that sampled specifically according to already existing WFD monitoring guidelines: Peeters et al. (2022) and the FLOW project (von Gönner et al. 2023) present citizen science methods to assess pesticides, identify macroinvertebrates and classify the hydromorphology of water bodies, in line with relevant parameters of the WFD. Similarly, Raman et al. (2023) point out the value of monitoring contaminants of aquatic environments with citizen science approaches and propose a roadmap for combined samplings of several contaminants such as microplastics, pharmaceuticals and pesticides. To our knowledge, these data remain unused to inform the WFD as no communication channels and mechanisms exist that allow for submission of data generated outside of the official WFD monitoring framework.

#### 5 | Fostering Open Science Means Active Participation in EU Directives

The benefits resulting from meaningful collaborative research processes extend to the citizen scientists themselves, for example, by raising their scientific literacy and environmental awareness (e.g., Roche et al. 2020). However, we see the largest potential in furthering the understanding and acceptance of EU-wide legislations among members of the general public and thereby engaging them in political processes they often feel removed from (see, e.g., Dahl et al. 2017 for young people in the EU). Furthermore, many EU citizens are not fully aware of their rights and the available participatory tools within the EU's multilevel governance system (Hierlemann et al. 2022). This lack of knowledge often leads to a sense of exclusion, as citizens do not feel equipped to engage effectively with the EU's decision-making processes (Scholz 2021). Turbé et al. (2019) highlighted the unique value of citizen science initiatives to involve participants in all stages of the policy cycle. Similarly, Oturai et al. (2023) emphasized that the citizen science programme Plastic Pirates can contribute to more stages of the policymaking cycle than most other EU engagement initiatives. Citizen science initiatives therefore offer a perfect opportunity to connect enthusiastic and engaged citizen scientists with decision makers, provided that the collaboration between citizen scientists and established researchers results in scientific knowledge useful for decision-making processes (Figure 2). Further, these initiatives need to be carefully designed to ensure that citizen involvement goes beyond tokenism and that there is a clear, transparent feedback loop where citizens can see how their contributions influence outcomes. This is particularly crucial in maintaining trust and long-term engagement (Eleta et al. 2019). Mahr et al. (2018) pointed out that academic discussion in the field of citizen science often revolves around data quality or the potential for learning of participants, while empowering and democratizing aspects of this research approach are discussed less frequently. This includes intentions to create equal access to research, for example, by involving marginalized communities (Lewenstein 2022).

Some citizen science initiatives largely aligning with official monitoring requirements reported that their results are not yet used by environmental agencies to implement management



**FIGURE 2** | A vision for the collaboration between citizen scientists, established researchers, members of the public and decision makers, leading to effective engagement on environmental or societal problems. Adapted from Thiel et al. (2017).

measures (e.g., Carlson and Cohen 2018; von Gönner et al. 2023). Decision makers seem open to consider citizen science and bottom-up research initiatives, whether this relates to projects closely adhering to established monitoring guidelines of the WFD (Julia von Gönner, FLOW project coordination, personal communication, 18 September 2024) or the topic of public health (Marks et al. 2023). The barriers to use information of these initiatives in policy making can be manifold: Theobald et al. (2015) and Davis et al. (2023) analysed hundreds of citizen science initiatives and found that few publish peer-reviewed studies, that is, missing a key step of science by not making their contributions available in the form of scientific knowledge (Davis et al. 2023 propose calling these initiatives citizen engagement rather than citizen science). Similarly, Oturai et al. (2023) highlighted the value of citizen science initiatives contributing quantitative data for policy making in the European Union. This scientific knowledge subsequently needs to be made available for decision making, requiring a pronounced effort in raising the awareness among policy makers of collaborative research practices including guidelines for their use (Marks et al. 2023), establishing dedicated and scientifically supported communication (e.g., in the form of policy briefs; Arnautu and Dagenais 2021) and meaningful collaborations between governmental actors and researchers to improve the transparency of decision-making processes (MacDonald and Soomai 2019).

These deficits illustrate the need for meaningful interactions and collaborations between citizen science practitioners and

decision makers, requiring an openness for shifting power balances, with transparency as a key value, in order to successfully connect citizen science with policy making (Maia Loureiro and Horta 2024; Turbé et al. 2019; Warner et al. 2024; Figure 2). Going one step further, fostering this collaboration could also enable litter management strategies, which involve local communities (Sinha et al. 2024) and consider socioeconomic factors that are important for the effective policy implementation (Khedr et al. 2023). Using the relatable topic of litter pollution could help to engage members of the public in this regard (Battisti and Gippoliti 2019).

## 6 | Discussion

According to the EU's Open Science policy, 'the general public should be able to make significant contributions and be recognized as valid European science knowledge producers' (European Commission 2024, 107). Further, the MSFD and the WFD call upon the active involvement of the general public (EU Directive 2000/60; EU Directive 2008/56), for example, 'The success of this Directive [the WFD] relies on close cooperation and coherent action at Community, Member State, and local level, as well as on information, consultation and involvement of the public [...]' (EU Directive 2000/60, 2). Clear strategies are necessary to achieve these ambitious goals. At present, the majority of citizen engagement (including citizen science) initiatives operating at a European level only contributed to few

stages of the decision-making cycle and mostly do not provide robust quantitative data that are adequately evaluated and interpreted and thus relevant for policy-making processes (Oturai et al. 2023). On the other hand, several countries such as Ghana, Sierra Leone and Zambia are recognizing the value of citizen-generated data and include data from the initiative FreshWater Watch into official reporting on progress towards the SDGs (Fraisl et al. 2023; Warner et al. 2024). Given this gap between ambitions of the European Commission for public involvement and the current implementation, we call on an active collaboration between citizen scientists, established scientists, the general public and decision makers to include the investigation of litter pollution alongside a complimentary citizen science approach within the WFD (see Figure 2), which differs from citizen engagement approaches, that are less focussed on valid scientific outputs (Davis et al. 2023; as outlined in Section 5).

To be clear, we do not suggest that the general public should take over the responsibility of carrying out monitoring efforts demanded by EU Directives and to be implemented by national authorities (i.e., the constant and structured collection and analysis of data to investigate the advancement towards a specified goal). This would likely lead to underfunded monitoring schemes for which no institution feels responsible. We rather recommend to design a citizen science approach alongside the established monitoring approaches of the WFD and to offer an opportunity for the general public to participate in novel research directly related to policy making. Attaching a citizen science element to the WFD as a policy instrument, explicitly inviting scientific collaboration and exploration as well as subsequent evaluation and interpretation of the data, would ensure that this potential of citizen science studies is tapped into.

Substantial effort is required from multiple parties to implement anthropogenic litter monitoring in the WFD. The successful work of the Task Group Marine Litter (TGML) for the inclusion of marine litter in the MSFD could be a roadmap for this effort (Gago et al. 2016), especially because there is a spatial overlap and therefore shared responsibility between the two directives. This has implications for the coordination of the potential future monitoring in these overlapping regions (Galgani et al. 2024). A similar effort is needed to overcome obstacles in the way of establishing a meaningful framework and mechanism for the involvement of citizens in this process. For example, authorities would have to ensure sufficient support for citizen science and science communication experts so that these can guarantee good data quality and rigorous evaluation and interpretation of data or questions related to socioeconomical barriers in the way of participation (see Nascimento et al. 2018; Pateman et al. 2021).

Despite all these challenges, we are of the opinion that the upcoming 4<sup>th</sup> revision cycle of the WFD in 2028 and the currently debated amendment proposal (European Commission 2022) present a unique opportunity to assess anthropogenic litter pollution and involve the general public within the WFD. With proper amendments, the WFD could act as a model for the effective mitigation of plastic litter, serving as a foundation for the conservation of freshwater and marine environments. This is also in countries with growing contributions to plastic production and pollution, for which the European Union is also directly responsible, for example, through exports of plastic waste

(Bishop et al. 2020). So far, the implementation of the WFD has shown progress in improving the ecological and chemical status of the aquatic environment, with 20% of water bodies having improved their ecological status (Zacharias et al. 2020). These learnings could be transferred by including litter pollution within its scope. Reducing plastic pollution is crucial for maintaining the wellbeing of aquatic ecosystems, as it mitigates harmful impacts on biodiversity, preserves water quality and supports the resilience of ecological processes (Jäms et al. 2020; Thompson et al. 2024; von Gönner et al. 2023).

The multitude of actors already involved in researching the plastic pollution problem (e.g., research institutes, NGOs and members of the general public as citizen scientists) illustrates that solutions require transdisciplinary and international co-operation. Innovative and flexible citizen science approaches present an opportunity to add to more traditional academic investigations and official monitoring mandates (Shirk and Bonney 2018). Using the potential of citizen science therefore not only contributes to the solution of the plastic pollution crisis but also creates transferable knowledge that can be used in present and future directives that tackle transboundary issues. This enhances the democratization of policy-making processes within the European Union, enables mutual learning of involved actors and strengthens environmental and scientific literacy.

## Author Contributions

**Janto Schönberg:** writing – original draft, writing – review and editing, conceptualization, visualization. **Marianne Böhm-Beck:** writing – original draft, writing – review and editing, conceptualization. **Štefan Trdan:** writing – original draft, writing – review and editing, conceptualization. **Mateja Grego:** writing – original draft, writing – review and editing, conceptualization. **Doris Knoblauch:** writing – original draft, writing – review and editing, conceptualization. **Mandy Hinzmann:** writing – review and editing. **Sinja Dittmann:** writing – review and editing, conceptualization. **Katrin Knickmeier:** writing – review and editing. **Uroš Robič:** writing – review and editing. **Martin Thiel:** writing – original draft, writing – review and editing, conceptualization, visualization. **Tim Kiessling:** writing – original draft, writing – review and editing, conceptualization, visualization.

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## Ethics Statement

The authors have nothing to report.

## Conflicts of Interest

The authors declare no conflicts of interest. Doris Knoblauch is an unpaid cochair of a working group of the Scientists' Coalition for an Effective Plastics Treaty.



## Data Availability Statement

The locations of Plastic Pirates sampling sites from 2016 to 2023 in Germany and Slovenia and editable images from this publication are publicly available online (at [10.5281/zenodo.15274664](https://doi.org/10.5281/zenodo.15274664)).

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section.