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Brief Report

Litter Selfie: A Citizen Science Guide for Photorecording Macroplastic Deposition along Mountain Rivers Using a Smartphone

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Abstract: Macroplastic pollution in mountain rivers can threaten water resources, biodiversity, and the recreational values provided by them. The first step towards evaluating and then mitigating these risks is the systematic collection of reliable and spatially uniform data on the amount and type of macroplastics deposited in different land covers occurring in a mountain river channel. To maximise the opportunity for the large-scale collection of such data using the citizen science approach, we propose in this study an illustrated step-by-step guide to sample the macroplastic deposited along mountain rivers and to record the collected information using a photo taken by smartphone and a simple online form. Our guide includes three steps: (i) the location of sampling plots across 3–4 predefined surface covers occurring in mountain rivers of temperate climate, (ii) the hand collection of macroplastic deposited in them, and (iii) the photorecording and archiving of information on macroplastics collected using a smartphone and an online form. The proposed guide can allow for the low-cost collection of data on macroplastic deposition in mountain rivers on regional and global scales. The collected data can be further analysed by environmental scientists to quantify the amount and types of macroplastic deposited and to evaluate the resulting risks. They can be also used as illustrative materials to increase the awareness of local communities about the plastic pollution problem.

Keywords: plastic sampling; field work; mountain river; citizen science; macroplastic pollution

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1. Introduction

Mountain rivers are known as pristine ecosystems supporting a high biodiversity and numerous resources for human being (e.g., water and recreation) [1,2]. Recent evidence suggests, however, that in populated areas, these ecosystems are currently polluted by macroplastics (plastic particles > 5–25 mm) [3–6]. This pollution can negatively affect the riverine biota (e.g., via ingestion and entanglement) and the aesthetic value of mountain river landscapes. Moreover, the input of macroplastics to a mountain river channel can accelerate its fragmentation process, resulting in the production of secondary microplastics, which can pollute mountain river water resources [7]. This can ultimately reduce the benefits that mountain rivers provide for human populations living along the river [2,8,9]. The problem of macroplastic disposal into mountain rivers seems to be especially enhanced in populated areas of mountain river catchments where the concentration of residential and transport infrastructures occurs within flat-valley bottoms, offering numerous sources of macroplastic emissions and allowing for their disposal into river channels [3,7,10].

The first step towards evaluating and mitigating the risks resulting from macroplastic deposition along mountain rivers involves the collection of uniform information on its abundance levels within diverse emergent surface types occurring in mountain river valleys (e.g., unvegetated sediments, non-woody vegetation, woody vegetation, and woody debris) [6]. These diverse surface types produce different potentials for macroplastic deposition, resulting from their different positions in the mountain river corridor and diverse surface roughness values [6,11]. Previous studies have documented that the amount of macroplastics deposited in a mountain river channel highly differs among locations with different channel morphologies, vegetation covers, and abundances of woody debris forms [6]. Thus, the type of land cover occurring in a river channel zone, where macroplastics are transported by flowing water, can be seen as a factor that importantly modulates the trajectories of their deposition in the fluvial system, which can last from days to centuries [11,12]. Moreover, the characteristics of the place where a macroplastic is deposited (e.g., exposure to sunlight or water) can also determine the potential for its fragmentation via biochemical and physical forces, influencing the emission of secondary microplastics [7]. Thus, collecting information on the amount and type of macroplastics deposited in specific zones along the mountain river can ultimately help us to not only assess the amount of plastic stored in a given river unit (see [11]), but also to (i) estimate how much of them can be further remobilised or fragmented, creating future risks for biota and humans life not only in the mountains, but also downstream [6], and (ii) to locate the river valley sections where future clean-up actions are the most necessary and can be the most effective.

Recent reports demonstrated that the citizen science approach can be an effective tool for large-scale data collection concerning riverine macroplastic pollution (see, e.g., [4,13–15]). However, an adequate performance of the entire sampling procedure, including the collection, counting, and categorising of macroplastic items, can be time-consuming and problematic for non-experienced users [13].

In this paper, we aim to overcome this challenge by presenting a guide that involves the engagement of non-expert users only for the sampling and photorecording of macroplastics deposited in the plot (10 m^2) located within four strictly defined emergent surface types that commonly occur in mountain river valleys. To minimise the bias resulting from non-specialist users counting and categorising macroplastic debris, our guide assumes the involvement of non-specialists only for the sampling and recording of collected items by taking geolocated photos using an online form available at https://arcg.is/Sffyn (accessed on 9 August 2023). The future identification of the number (items/m^2) and types (e.g., polymer composition) of macroplastic items collected is conducted by experts (e.g., environmental scientists with experience in riverine plastic pollution research) using these geolocated photos. The proposed method can allow for the large-scale collection of data on the macroplastic deposition levels along mountain rivers and their utilisation for scientific and clean-up purposes. The collected photos illustrating the amount of macroplastics deposited in the given locations of rivers can also be used as illustrative materials to increase the awareness of local communities about the plastic pollution problem.

2. The Field Guide for Macrolitter Sampling along Mountain Rivers

The entire procedure described in this guide should be performed in a mountain river of temperate climate during the second part of the spring or the first part of the fall when dense vegetation cover and snow cover do not occur. For safety reasons, the sampling can only be performed during low flow conditions. The workflow of our guide includes three steps (Figure 1A).

2.1. Setting the Sampling Plot Locations (Step 1)

The first step involves the selection of the locations for the sampling plots. These locations should be selected in the emergent area located close to the flowing water. The selected plots should not be located in close proximity to the plastic emission sources (e.g., dumping sites, transport, buildings, and tourist infrastructures) (Figure 2A). Setting the sampling plots near the flowing water is important because this allows for the recording of macroplastic abundances, which result from its upstream transport by the river and from the local conditions controlling its trapping efficiency (e.g., river hydrodynamics and type of vegetation). The avoidance of local sources of plastic emissions in this zone limits the potential for bias resulting from increased abundances of macroplastics close to them. Mountain rivers can have very diverse channel morphology and related vegetation patterns (Figure 2), and previous studies have found that this diversity substantially controls the amount of macroplastics deposited in a river [6]. Specifically, highly rough surfaces (e.g., woody debris and woody vegetation) trap significantly more macroplastics than other surfaces with a lower surface roughness (e.g., bare sediments and non-woody vegetation) [6]. To record the range of macroplastic abundances among these surface types, we recommend collecting macroplastics from plots located in the following surface types in each sampling location selected along the river (Figures 1, 2C and 3):

(1) Unvegetated sediment surfaces (mud, sand, gravel, and boulders);
(2) Surfaces covered with grass and/or herbaceous vegetation (non-woody vegetation);
(3) Surfaces with shrubs and trees (woody vegetation) (Figures 2 and 3);
(4) Surfaces with woody debris (Figure 4).

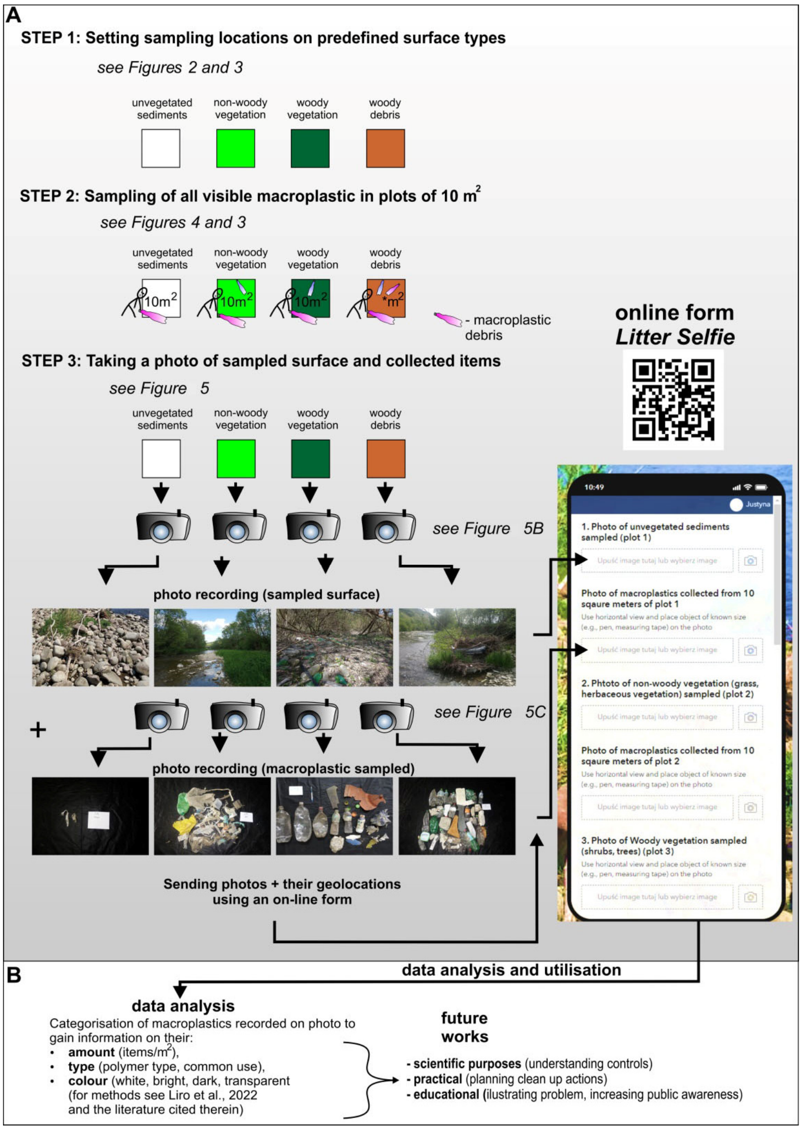

Figure 1. The outline of the steps described in the presented guide (**A**) and macroplastic characteristics which can be gained by analysis of collected data (for methods see [6]) (**B**), * the sampling area of plots located on woody debris is set flexibly (see Section 2.1).

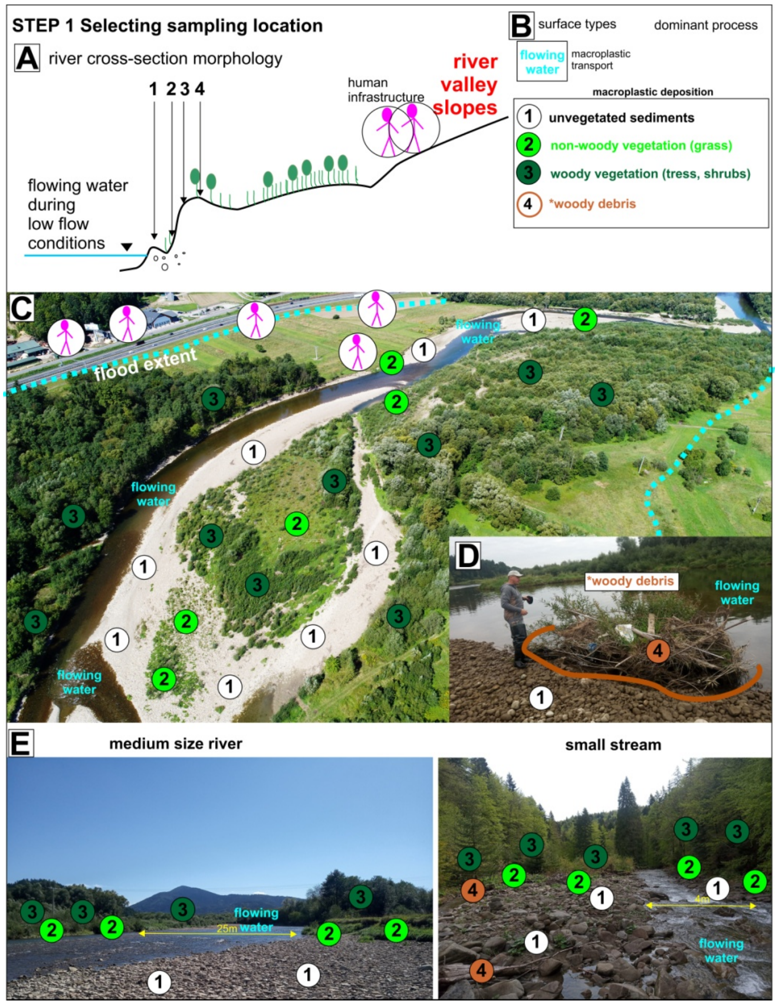

Figure 2. An example of locations of sampling plots along the river cross-section (**A**). The numbers indicate surface cover types occurring along the mountain river in a temperate climate (**B**). The photos show these surface covers (**C**,**D**) in rivers of different sizes (**E**), * the sampling area of plots located on woody debris is set flexibly (see Section 2.1).

The sampling of the above surface types in each surveyed location allows for the recording of information on the range of macroplastic deposition for locations having the same input from the upstream section of the river catchment [16]. This also provides us with an opportunity to compare the amount and types of macroplastics deposited on the same surface types along the river course, which then allows for the evaluation of the importance of catchment-scale plastic emission sources [11,17].

We suggest starting the entire procedure of locating sampling plots by selecting a riverbank zone with a gentle slope (see Figure 3A). This allows for a safe survey performance and provides a greater potential for us to locate sampling plots within a well-developed variety of surface types in each location. Steep and high channel banks, commonly occurring along the channelised rivers, should be avoided because these do not allow for safe surveys and typically present much worse developed land covers and morphological gradients (see Figure 3A). Then, to select locations of sampling plots with different surface covers, we recommend walking across the selected, gentle riverbank up to the flowing water. This can be the main river channel or one of the side channels in the case of multi-thread rivers. When the flowing water is reached, we recommend seeking a place where unvegetated sediments occur and where it is surrounded by vegetation (non-woody or woody). The first plot should be located on the unvegetated sediment surfaces in close proximity to the nearest vegetation site (non-woody or woody). The second plot should be located in close proximity to the first one, on a surface covered by non-woody vegetation (grass or herbaceous vegetation). In the same way, the third plot should be located close to plot 2. Woody debris can occur on all of the mentioned surface types (see [6]). The location of the woody debris plot should be set as close as possible to the other sampled plots (10 m^2). The size of the woody debris plots that need to be sampled is not as strictly defined in our guide as it is for the other types of sampled surfaces (for details, see Section 2.2 and Figure 4). The locations of the sampling plots being as close as possible to each other allows us to obtain data on the range of macroplastic deposition occurring on the different surface types in one location along the river. If unvegetated sediments do not occur in a given location, the sampling should start from the second plot (non-woody vegetation). Similarly, if other surface types (woody vegetation and woody debris) do not occur in a given location, the sampling should cover only the existing surface types (Figure 3B). In this case, only two surface covers are sampled in that location.

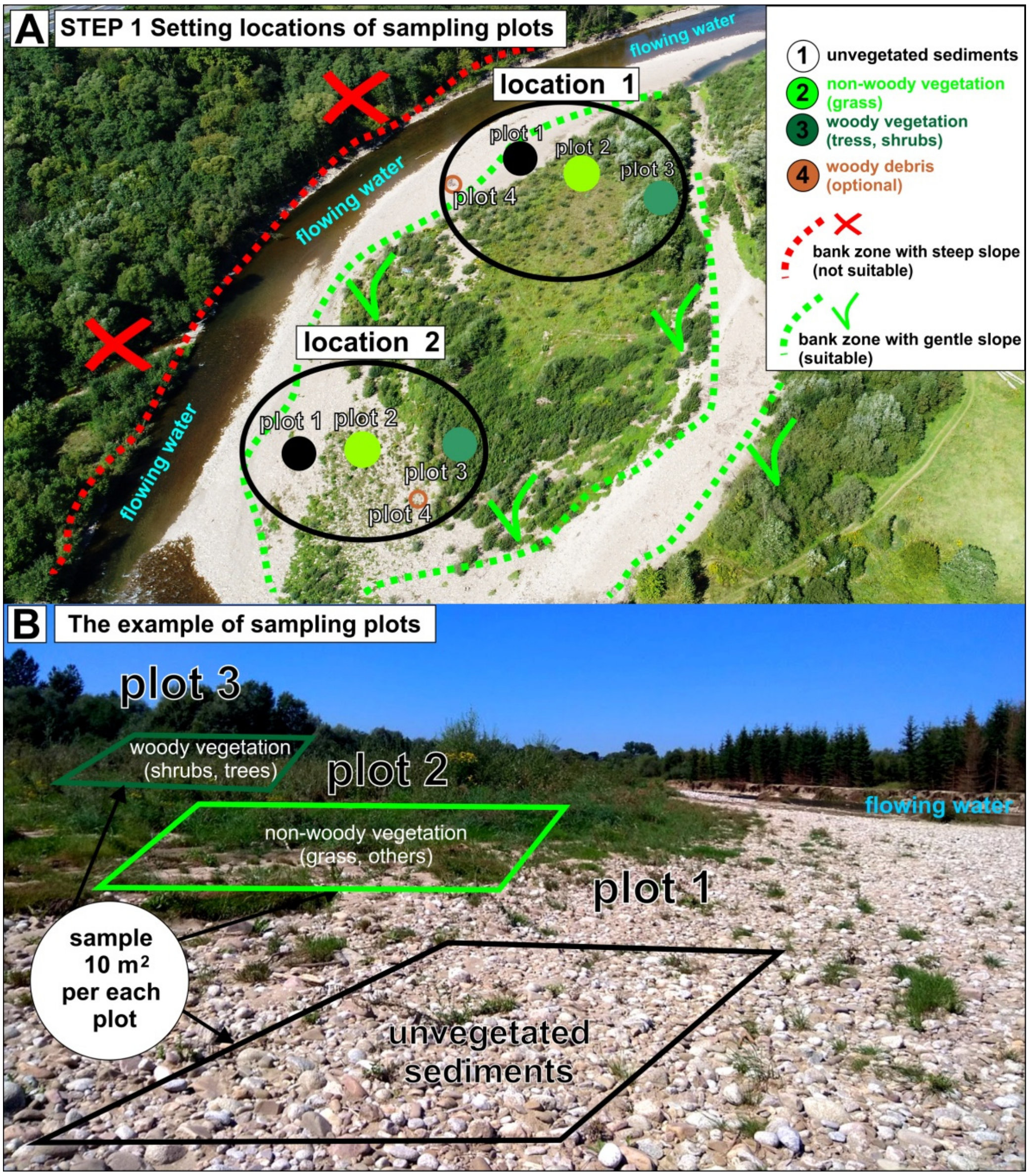

Figure 3. An example of sampling locations (**A**) and a field view of the plots located on unvegetated sediments (plot 1), non-woody vegetation (plot 2), and woody vegetation (plot 3) (**B**). For photos illustrating the plots with woody debris, see Figure 4.

Figure 4. Example of sampling plots located on emergent surfaces with woody debris.

2.2. Macroplastic Sampling and Photorecording (Steps 2 and 3)

Prior to the sampling, the area of each plot should be determined using a measuring tape or other devices and marked in the field (e.g., using stones, tree branches, etc.) to allow for an easy sampling performance within the stable surface areas. The shape of the plot can be set flexibly according to the local settings. For example, in smaller streams with narrow bank zones, it can be useful to use elongated (e.g., rectangular shaped) plots (e.g., 1 × 10 or 2 × 5 m) (Figure 3B). If circle-shaped plots are used, the object for measuring the radius (~1.8 m) of a 10 m^2 circle should be used (e.g., measuring tape). The only requirement is a stable 10 m^2 area of plot. Only a sampling plot area located in a woody debris area can be set flexibly, depending on the woody debris deposition form size (see Figure 4). For wood jams smaller than 10 m^2, we recommend sampling their entire area. For wood jams larger than 10 m^2, the sampling plots (10 m^2) should be located in the middle point of the wood jam.

Sampling is conducted via the hand collection of macroplastic items that are visible when walking through the plot (Figure 5A). For safety reasons, this procedure should be performed while wearing sanitary gloves. After the sampling stage, all collected items should be placed on a uniform background together with the scaling object (e.g., pen, ruler, and tape), and the photos should be taken with a horizontal view (see Figure 5B). There is no requirement to clean or label the collected items before taking a photo. For very large objects that are difficult to fit into a photograph, an additional photo showing them in the place of deposition should be taken.

The photos of the sampled surfaces and the macroplastic items collected from them should be uploaded using an online form available at https://arcg.is/Sffyn (accessed on 9 August 2023) (see Figure 5B,C). The information about the geolocation of the sampled plots is captured automatically when a GPS signal is available in the sampling location. For a location without a GPS signal, it can be also added manually on the map that is available in the online form.

If possible, following the sampling and photographing of the collected macroplastic items, they can be properly utilised.

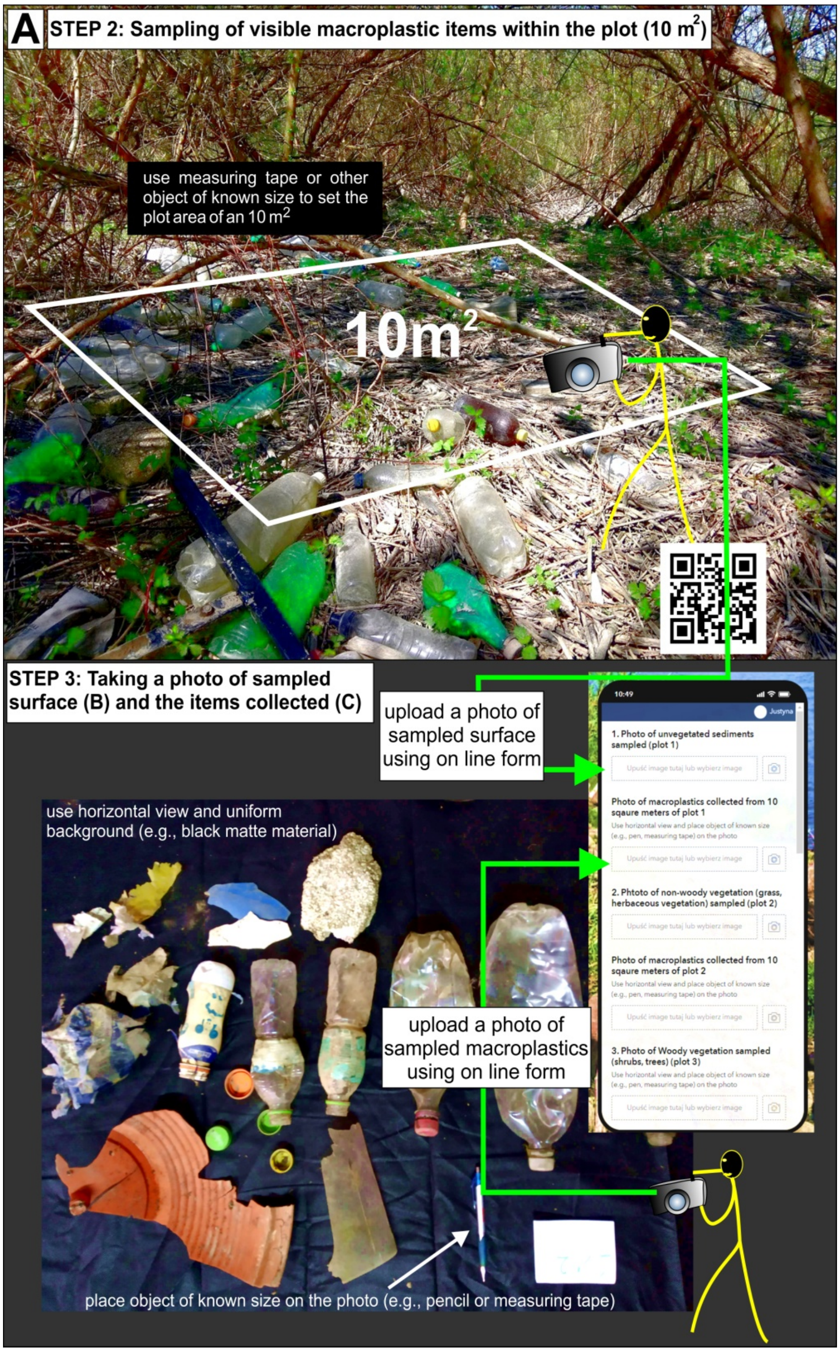

Figure 5. An example of macroplastic litter seen on sampling plot surface (**A**). The photo taking of sampling plot surface (**B**) and the collected macroplastic items (**C**).

3. Summary

Our guide describes the step-by-step protocol for non-expert users to collect raw data on macroplastic deposition along mountain rivers. The workflow proposed in our guide is limited in comparison to other citizen science protocols used for macroplastic sampling (e.g., [10,14,18]), as it involves non-expert users only for the performance of macroplastic sampling and photorecording of the raw data collected. The counting and categorisation of macroplastic items by non-expert users is not performed in the field or in the laboratory, as was conducted during other protocols (e.g., [13–15]). In our guide, the involvement of non-expert users is finalised after they take photos of the sampling surface and macroplastics collected from it and send the photos using an online form. The recorded photos together with their geolocations can be then used by experts to obtain the data on macroplastic abundances (items/m^2), polymer composition (%), and colour (see, e.g., [6]). The photos of the collected macroplastic items can be, for example, used to recognise categories of macroplastics according to the polymer type and its common use (see, e.g., [6,19]). Such data can be then used as a base for evaluating the sources of macroplastic emissions and their further fragmentation potential in river channels [7]. The information on the polymer composition and colour (e.g., white, bright, transparent, or dark) of macroplastic items can also help to evaluate the utility of a given location for future clean-up actions. For example, white or bright macroplastic items should be more readily noticed by persons undertaking sampling on vegetated surfaces or on woody debris than dark ones (see [6]). Our approach can be seen as a compromise between the amount of data collected in the field and the potential for its easy, fast, and large-scale performance by non-experts. In other words, our protocol is maximally simplified to allow non-experts to easily and rapidly perform targeted fieldwork in predefined surface types, whereas the analyses that can generate the most bias (the counting and categorisation of macroplastic items and data loss) are performed by experts. However, in comparison to other guides, our approach requires an increased involvement from the experts, who have to count and categorise the macroplastics that are visible on the photos taken by the non-experts. In fact, this can increase the cost and time needed to obtain the final data on macroplastic storage [11]. However, on the other hand, the performance of these steps by experts can help to achieve adequate accuracy and comparability of results collected in different sites, which can allow for the harmonisation of results on regional and global scales [20]. Previous studies have reported the statistically significant differences between the litter items collected by volunteers and professionals [13], and the problems faced when volunteers counted and categorised the litter, which led to the exclusion of the results collected by some groups in the field (e.g., [15]). The loss of data collected by groups in the field have also been reported as a result of the lack of localisation in the sampling place [14]. Such missing information was highlighted as a substantial limitation to obtaining reliable results on riverine macroplastic storage using previous citizen science approaches (e.g., [14,18]). The recording of information on plot surface characteristics, its location, and macroplastics items by using the proposed online form can minimise these problems and increase the cross-comparability of the final data obtained in different locations (see [20]).

Finally, the proposed citizen science workflow can be easily adapted to the photorecording and mapping of macroplastic deposition (or other processes, e.g., illegal dumping site mapping) in other types of rivers.

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