SPOT DE HOTSPOT

Mapping the micro- and macroplastic hotspots in Delfland

WATERLAB
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Colophon

This report was produced by PULSAQUA, under the TU Delft Citizen Science platform WaterLab umbrella, in assignment of the Waterboard of Delfland (Hoogheemraadschap van Delfland).

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Samenvatting

Op dit moment is plastic afval bijna overal te vinden. In bepaalde omstandigheden kunnen gebieden met een hoge concentratie afval - ook wel "hotspots" genoemd - worden geïdentificeerd. Het doel van dit project was om deze afval hotspots in de regio Delfland in kaart te brengen. Deze informatie is essentieel om duidelijker inzicht te krijgen in de oorzaken en oplossingen van deze plastic hotspots, en om het publiek bewuster te maken van hoe dit wereldwijde probleem verband houdt met hun eigen leven. Uiteindelijk zou dit moeten leiden tot minder plastic in onze waterwegen, wat de waterkwaliteit ten goede zal komen en daarmee de (ecologische) gezondheid zal verbeteren en een schonere omgeving zal opleveren.

Dit project maakt gebruik van Burgerwetenschap, waar vrijwilligers wetenschap bedrijven door monsters te verzamelen en te analyseren. Er werden workshops gehouden voor zowel microplastic als macroplastic verzamelmethoden. Tijdens de microplastics workshop voor plastics kleiner dan 5 mm, construeerden de burgerwetenschappers een microsleepnet, verzamelden ze een monster met hun sleepnet op het water op stand-up paddle (SUP) boards of tijdens een boottocht, en analyseerden ze hun monster. In 81,6% van de sleepnetten werd microplastic gevonden. De voornaamste types die werden gevonden waren kleine fragmenten (53,8%) en polystyreen schuimen (34,8%). Het plastic dat in de sleepnetten werd gevonden, bevatte af en toe ook enkele stukjes mesoplastics (tot 10 mm). Tijdens de macroplastic workshop voor plastics en ander afval groter dan 5 mm, verzamelden de burgerwetenschappers macrozwerfvuil te voet, langs het water lopend, of op het water zoals bij de microplastic methode. Van het gevonden macrozwerfvuil was 70,6% plastic. "Verpakkingen van snoep, snacks en chips" waren het meest gevonden type plastic (61 stuks), hoewel dit qua aantal dicht in de buurt lag van aluminium drankblikjes (62 stuks). Er werd verwacht dat er een verschil zou zijn in de hoeveelheid verzameld afval binnen steden in vergelijking met minder bevolkte gebieden, en dit project weerlegt dat niet, hoewel verder onderzoek nodig zou zijn om de sterkte van de correlatie te testen. In de toekomst worden workshops zoals deze gehouden tijdens dit project ten zeerste aanbevolen, omdat ze door iedereen werden gewaardeerd en een instrument zijn om vrijwilligers in staat te stellen en op te leiden, om verbinding te maken met gemeenschappen, en om de kloof tussen wereldwijde problemen zoals plastic vervuiling en het leven van burgers te overbruggen.

Summary

At present, plastic waste can be found almost anywhere. In certain circumstances, areas of high waste concentration – referred to as “hotspots” – can be identified. The aim of this project is to map these waste hotspots in the region of Delfland. This information is vital for developing clearer insights into the causes and solutions of these plastic hotspots, and to increase public awareness on how this global issue is related to their own lives. In the end this should lead to fewer plastics in out waterways, what will benefit water quality and thus improve (ecologic) health and produce a cleaner environment.

This project utilizes Citizen Science, where volunteers conduct science by collecting and analysing samples. Workshops were held for both microplastic and macroplastic collection methods. In the microplastics workshop for plastics smaller than 5mm, the Citizen Scientists constructed a micro-trawl, collected a sample using their trawl on the water on stand-up paddle (SUP) boards or during a boat trip, and analysed their sample. In 81.6% of the trawls, microplastic was found. The main types found were small fragments (53.8%) and polystyrene foams (34.8%). The plastic found in the trawls occasionally also contained some pieces of meso-plastic (up to 10 mm). In the macroplastic workshop for plastics and other waste larger than 5mm, the Citizen Scientists collected macro litter either on foot, walking along the water, or on the water like the microplastic method. Of the macro litter found, 70.6% was plastic. “Candy, Snack and Chips packaging” was the most found plastic type found (61 pieces), although this was close in number to aluminium drink cans (62 pieces). It was expected that there would be a difference in the amount of litter collected within cities compared to less populated areas, and this project does not disprove this, although further research would need to be conducted to test the strength of the correlation. In the future, workshops such as those run during this project are highly recommended, as they were enjoyed by all and are a tool to empower and educate volunteers, to connect to communities, and to bridge the gap between global issues and citizen’s own lives.

Introduction

Anthropogenic waste has long been a global concern-turned-emergency, from plastic bags in the Mariana trench, to garbage heaps on Mt Everest, to chlorofluorocarbons in the atmosphere. Although the odd piece of litter can be found almost anywhere, in many cases certain circumstances create areas of high waste concentration. A well-known example of this on a large scale is the Great Pacific Garbage Patch. On a smaller scale, these localized areas of high waste concentration – henceforth termed "hotspots" – could include a busy public BBQ area, a closed sluice gate, or dense bushes on a riverbank. This project aims to locate these hotspots specifically in and around water bodies in Delfland region, the Netherlands, by tallying litter found through the help of Citizen Scientists. Citizen Science refers to the involvement of members of the public, who are not formally trained in research methodology, in contributing toward research projects. When properly executed, Citizen Science provides a wealth of untapped information that goes beyond the means of a single researcher, while simultaneously motivating the public. Citizens were involved in the whole trajectory of this project, namely through designing a microplastic trawl, participation in workshops, collecting samples, and inspecting the samples.

The purpose of this project is to gain clearer insights into causes and remedies of hotspots, to increase public awareness on how close this global issue is to their own lives, and with an ongoing goal to facilitate change, such as outlined by the Sustainable Development Goal 6 (clean water and sanitation) and 12 (responsible production and consumption). The project is divided into two main subsections: macro- and microplastics. A piece of plastic is considered macro when it is bigger than 5mm, while any plastic smaller than 5mm is classified as micro. The reason for the separation is the difference in where the macro- and microplastics can be found in and around water bodies and how we are able to collect them. Macro plastics are easier to see, are often found obstructed by features such as riparian vegetation and can be collected by hand. Conversely, microplastics are harder to see, are either floating or suspended in the water, and cannot be collected by hand in any great numbers. Thus, the mini-trawl method for microplastic collection was developed separately from the macroplastic survey, as explained in the methods.

The primary expectation is that population-dense areas and regions with higher levels of industry have proportionately more waste (both micro and macro) compared to water bodies in sparsely populated areas. Additionally, some level of correlation between macro- and microplastic hotspots is expected to be present, for example more microplastics occurring downriver from an area with a greater number of macroplastics, due to these macro pieces breaking down and leading to the formation of microplastics.

Methods

The methods are divided into three subsections: microplastic workshops (including trawl construction, waste collection and sample identification), macroplastic workshops (sample collection and litter identification), and finally data clean-up and analysis.

Microplastics

The microplastic workshop dates and locations for trawl construction and sample collection can viewed in table 1 and 2 of the results section. On each day, the workshops took around two hours, consisting of gathering the materials, instructing, and guiding the participants through the mini trawl construction process, testing the mini trawls in the water, and instruction on how to accurately collect, inspect, and submit microplastic samples. The workshop was arranged in a way that could easily be replicated at home by the participants. The participants were also permitted to take the mini trawl they made at the workshop home with them so they could begin taking samples near their home immediately if desired. An outline of the workshop instructions follows below.

Making the trawl

The trawl was designed in a way that it can easily be constructed at home. The materials required are all found around the house, namely pantyhose or a sheer sock, rope, a tin can, a can opener, two plastic bottles approximately 200-500 ml, five zip ties (or similar), three large beads, and scissors. To make the trawl, you need to open the tin can on both sides and make three holes on one end (fig. 1a), slide the pantyhose or sheer sock over the opening on the opposite end of the tin can and secure (fig. 1b), tie the rope to the three holes in the can, and then zip tie the closed water bottles to either side of the tin can (fig. 1c).

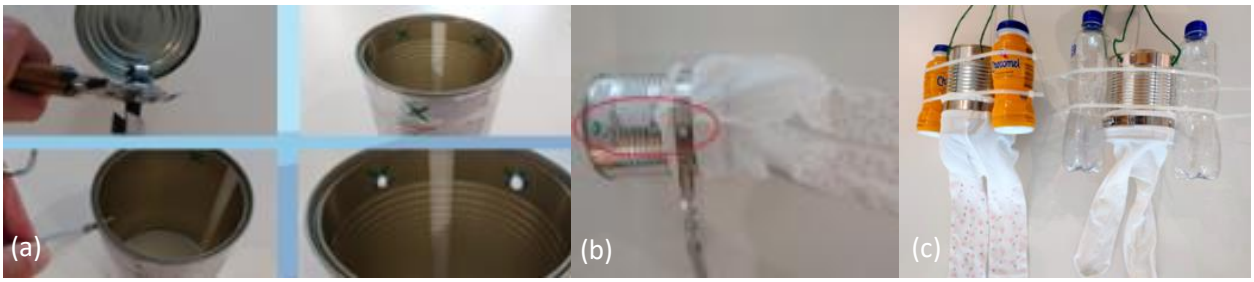


Figure 1. (a) Preparing the tin can by opening both ends and boring holes. (b) Attaching pantyhose with a zip tie or other wrap. (c) Attaching empty and sealed plastic bottles on either side to act as a buoyancy aid.

Collecting the sample on water

Participants were instructed to connect the mini trawl to the back of SUP board, kayak, or boat, and pull the mini trawl along behind the vessel for at least half an hour. As can be seen in figure 2, the trawl was connected to a boat during this particular workshop.

Figure 2. Towing a constructed mini-trawl through the water by boat.

Analysing the sample

Following microplastic collection in the boat, the workshop participants were shown how to inspect the sample collected in the pantyhose with sieves and how to submit the information in the survey. The survey was designed and published using ArcGIS Survey123 and hosted publicly (to those with the link or QR code) on ArcGIS Online. In the survey the participants had to fill in the following information.

- The date, time, duration, and location of their trip on the water.
- The type of plastic, namely:
  - Film: a thin flexible sheet such as cling film or from a plastic bag.
  - Foam: light, polystyrene pieces such as from a takeaway container.
  - Pellet: hard round nuggets of plastic, for example nurdles, which are small pellets used in the production of most plastic products.
  - String: a line of plastic such as fishing line or clothing fibres.
  - Fragment: an irregularly shaped piece of hard plastic that has broken down from larger plastics, such as a broken bottlecap.
- The size (smaller or larger than 5mm) and number of particles found.

Figure 3. Sieving the plant material collected in the trawl to look for micro-plastics.

For the full manuals on building the mini-trawl, collecting samples on the water, and categorizing the microplastic waste found, please visit https://www.tudelft.nl/scd/waterlab/tools-educatie and download the relevant manuals.

Macroplastics

Over the course of the data collection phase, six workshops were held to instruct Citizen Scientists on how to collect litter from hotspots they have identified. The workshops were held

in areas such as the Delftse Hout and the petting zoo Tanthof (for a full list of workshops and participants, see the Results section).

Collecting the sample on water

During the macroplastic workshops, people could use a SUP or could join on a boat. The Citizen Scientists were instructed to look for plastic hotspots near engineered obstructions such as bridges or sharp turns, riverbanks, rivers or canals with a diminished flow rate, river, or canal junction, or anywhere else that might be a waste hotspot. In figure 4, you can see workshop participants taking turns on the SUP boards, looking for litter and placing it in the buckets on their board to catalogue once back on shore. The participants in the macroplastic workshops were asked to collect any man-made litter they found on their route.

Figure 4. Macro-plastic collection on SUP boards by workshop participants. Note the bucket visible in the second image, these were used to collect the waste found in and around the water.

Analysing the sample

After collecting the macroplastics, the participants were asked to fill out a survey (also designed and published using ArcGIS Survey123) to catalogue their findings. The survey consisted of the following questions.

- The date and GPS location.
- The situation of the area, namely:
    - A plant dense riverbank
    - A riverbank with wooden retaining walls or rock/rubble shoreline
    - A groyne (small spit preventing shore erosion)
    - A junction with another waterway
    - An engineered obstruction such as a bridge, sluice gate, or sharp turn
    - Significant decrease in water flow speed, the water is almost stagnant.
- The type of litter (based on a classification of OSPAR), namely:
    - Plastic or polystyrene

- Rubber
- Paper
- Wood
- Metal
- Glass
- Sanitary items
- Medical items
- Textiles

For the full manuals on collecting macroplastic samples and categorizing what you have found, please visit https://www.tudelft.nl/scd/waterlab/tools-educatie and download the relevant manuals, or https://www.thesciencecitizens.com/spot-de-hotspot-macroplastic to watch an instructional video.

Data Clean-up and Analysis

The data collected from the Citizen Scientists through the macro- and microplastic surveys was automatically stored on ArcGIS Online, allowing for quick analyses online or more thorough analyses by downloading the data and running it though R scripts.

Before downloading it from ArcGIS Online, a few small adjustments to the online data were made, such as ensuring the location name given by participants was the same for each survey submitted in the same location. For the clean-up of the data from both surveys, CRAN R version 4.3.1 in RStudio was used, primarily with the packages dplyr and tidyr. The first step was re-formatting the small datasets from 2022 and adding it to the current datasets. The litter found in the macroplastic surveys was categorized according to OSPAR guidelines and coded as numbers, thus, to make analysis smoother (such as the creation of graphs), the codes were matched to their descriptions and these descriptions were added to the same dataset file. Although it would cause some redundancy, the macro- and microplastic datasets were manipulated to contain a single piece of litter per row, which made some analyses more straightforward, depending on the type of analysis. Summary analyses were done using frequency tables and counts on variables such as litter type, location found, and size.

Results

Participants

The macro and micro Spot de Hotspot survey submissions were anonymized; therefore, we cannot draw conclusions based on variables such as exact age or occupation. We can however give an outline of the number and age range of people who participated in workshops and litter drives organized by Pulsaqua and the Water Lab (table 1 and 2). This can help clarify the target audience for future Spot de Hotspot projects or similar.

Figure 5. Four different images of adults and children taking part in Spot de Hotspot micro-plastic workshops.

As can be seen in figure 5 taken during the workshops, the participants in the microplastic mini-trawl workshop were mainly elementary school children with their parents. Adults without children also joined the workshops. Most participants joined without prior subscription. About 327 people attended the Spot de Hotspot workshops, either collecting micro-, microplastic, or both, and the estimated age range of those participants was wide. During the macroplastic workshop done in collaboration with the Canal Cleanup in Delft and together with the John Dewey College in the Hague, both macro- and microplastics were collected. The largest age group that joined the microplastic workshops were elementary school children, however during the macroplastic workshops, the age ranges were more evenly distributed.

Several participants were interviewed during the microplastic workshop held on 2 September 2023, some quotes are written below to get an impression of the workshop.

> *'The workshop was fun and easy to follow, and it is also very educational and fun for adults.'*
>
> *'Making the trawl by yourself is easy to do. And the supping results in a fun combination of activities.'*
>
> *'You don't notice the trawl connected to your sup while supping.'*
>
> *'It is easy to do at home as well.'*

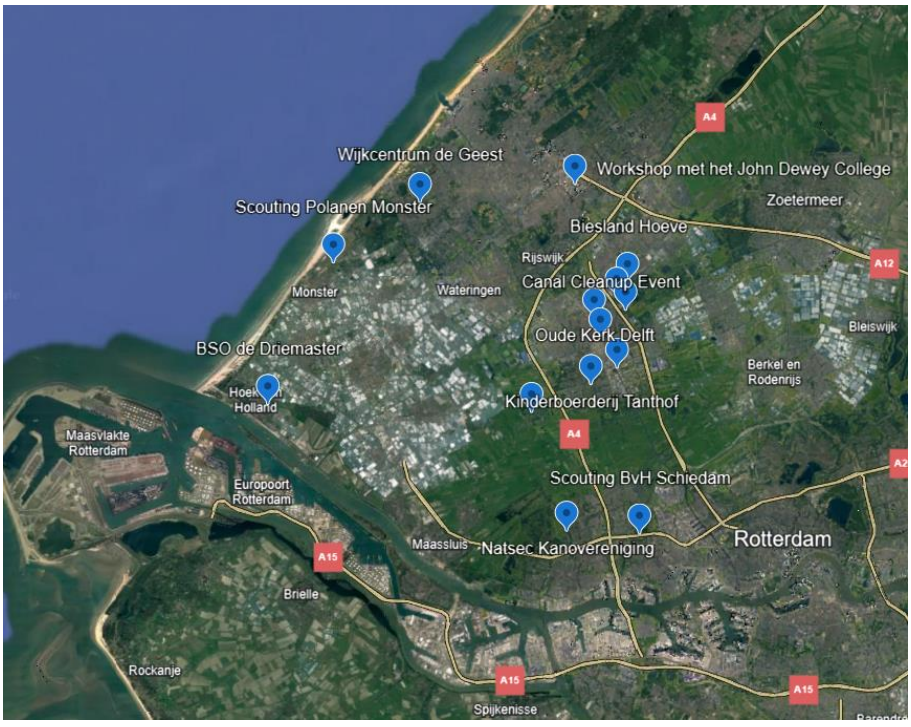
Table 1. Overview of the location, the partner and the participants of the workshops for microplastics.

Date	*Location*	*Partner*	*Number of participants*	*Age (0-12)*	*Age (12-18)*	*Age (18+)*	*Surveys Submitted*
22-10-2022	Schiedam	Scouting BvH de Waterwelpen	15	15	-	-	4
25, 26, & 27-10-2022	Delft	Proteus (individually)	6	-	-	6	-
26-11-2022	Vlaardingse Vaart	St. Jozefschool Schipluiden (individually)	6	6	-	-	1
22-08-2023	Delftse Hout	De Papaver & Knus	15	10	-	5	6
02-09-2023	Biesland Hoeve	Antonie v. Leeuwenhoek Jaar	30	20	-	10	11
04-09-2023	(Trek)Vliet in de Brinckhorst	John Dewey College	30	-	30	-	3
12-09-2023	Vlaardingen	Natsec Kano-vereniging	25	-	-	25	5
13-09-2023	Oude Kerk Delft Centrum	Antonie v. Leeuwenhoek Jaar	5	2	-	3	4
15-09-2023	Boerderij Tanthof – Delftse Hout	Antonie v. Leeuwenhoek Jaar	6	5	-	1	5
24-09-2023	Delft Centre	Canal Cleanup	150	65	25	60	7

Total	**288**	**123**	**55**	**110**	

Table 2. Overview of the location, the partner and the participants of the workshops for macroplastics.

Date	*Location*	*Partner*	*Number of participants*	*Age (0-12)*	*Age (12-18)*	*Age (18+)*	*Surveys Submitted*
22-10-2022	Around Monster	Scouting Polanen	18	-	18	-	3
27-10-2022	Hoek van Holland	BSO de driemaster	11	11	-	-	4
23-08-2023	Boerderij Tanthof – Delfste Hout	Boederij Tanthof	6	3	-	3	3
04-09-2023	(Trek)Vliet in de Brinckhorst	John Dewey College	30	-	30	-	9
16-09-2023	Delftse Hout	World Cleanup Day, Papaver	?				-
20-09-2023	The Hague	WijkZ Wijkcentrum	4	1	-	3	8
24-09-2023	Delft Centre	Canal Cleanup	150	65	25	60	13
		Total	**219**	**80**	**73**	**66**	



Microplastics

A total of 184 pieces of plastic were recorded within 40 mini-trawl survey submissions, from 7 different areas: Delft (22 surveys), Den Haag (3 surveys), Nootdorp (11 surveys), Vlaardingen (5 surveys), Schiedam (4), Schipluiden (3), and Monster (1). Nine of the 40 surveys – at 18.4% – were found to contain no (micro) plastics at all. These were surveys completed in the Nootdorpse plassen (3 surveys with no plastics found), Vlaardingenvaart (1 survey with no plastics found), Delft centre (2 surveys), and the Delftse Hout (3 surveys).

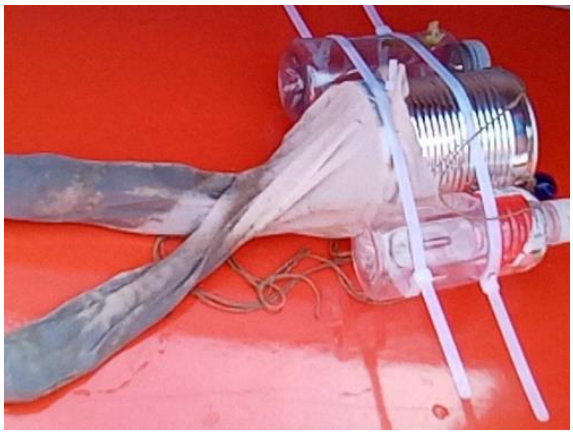


Figure 6. A mini-trawl full of detritus after a sample was taken in a waterway. The next step would be to filter and review the contents for micro-plastics.

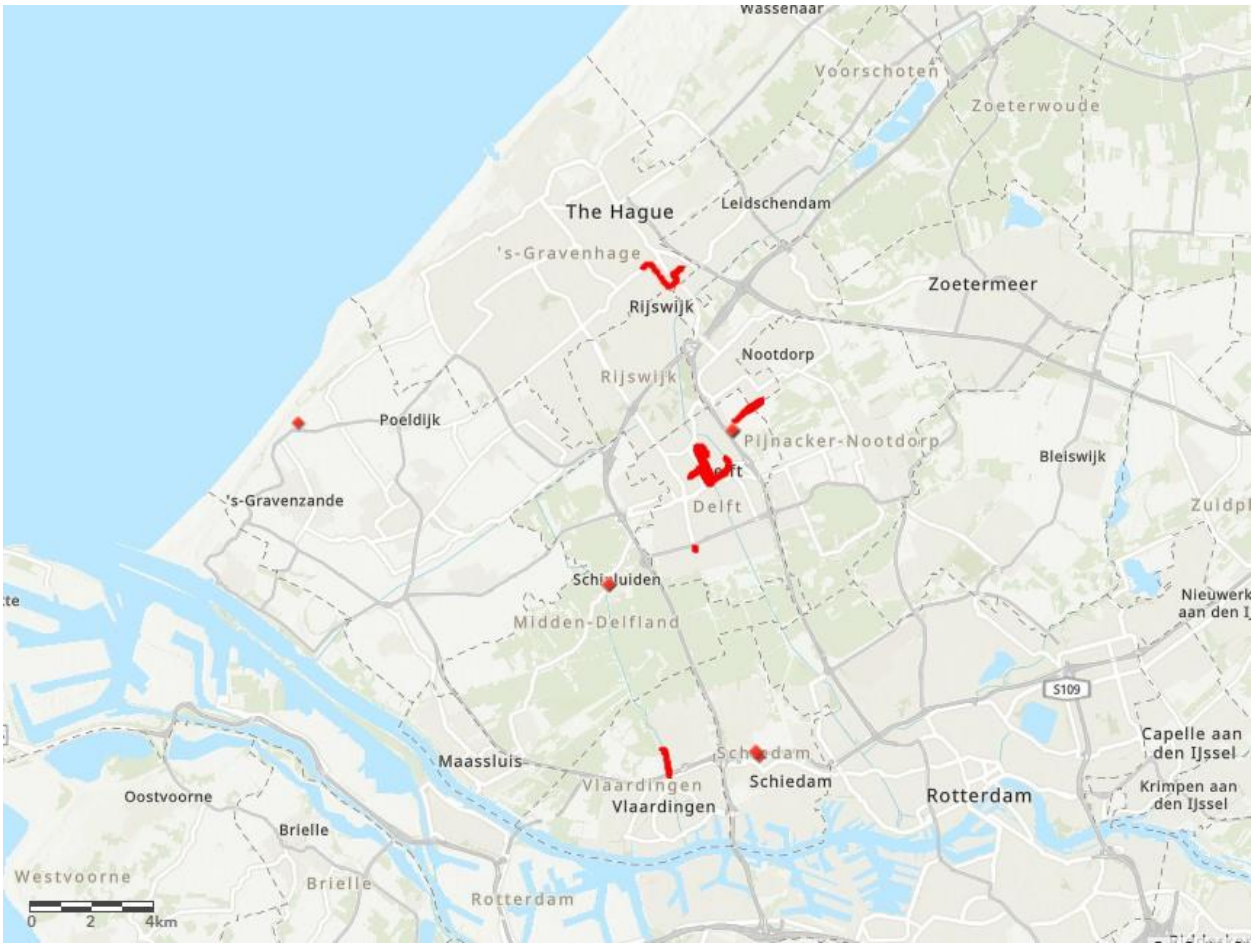


Figure 7 Locations/tracks made when collecting microplastic samples

As stated earlier, the participants in the microplastic survey were required to categorize the microplastics found by size (<5mm or >5mm) and by type (fragment, foam, film, pellet, and string). Thus, the plastics found can be analysed by size, type, and region. Of the pieces found less than 5mm in width there were 155, and the other 29 were greater than 5mm. None of the plastic pieces greater than 5mm submitted in the survey were more than a few centimetres larger (in other words, there were no aluminium cans or chip wrappers submitted in the microplastics survey), as checked through validation photos. Therefore, for the following results the larger pieces are included (henceforth "microplastics" refers to all plastics collected in the trawl and recorded, not just those <5mm). As can be seen in figure 8, most of the microplastics were either fragments (99 pieces, 53.8%) or foam (64 pieces, 34.8%). Both Delft and Den Haag had particularly high levels of foam collected (25 and 31 pieces respectively, figure 9), while in Schipluiden many fragments were found (37). Only two strings were recorded as found (Delft and Schiedam, figure 9).

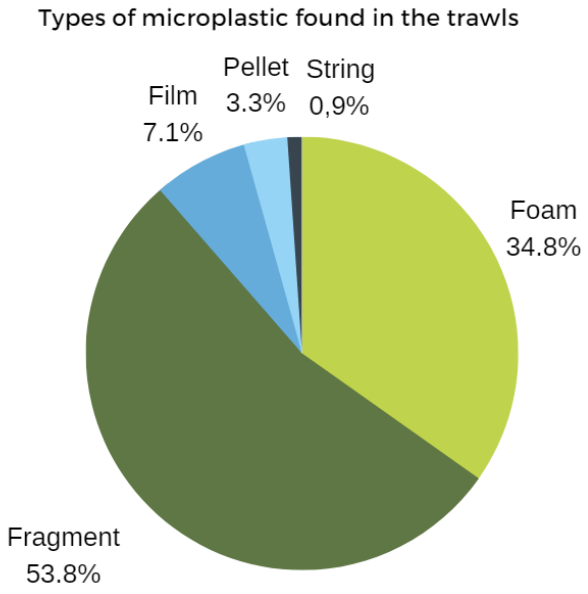


Figure 8. The percentage of each type of microplastic found in the micro-plastic mini-trawls.

Delft and Den Haag not only had high numbers of foam, but along with Schipluiden, had the highest number of microplastics collected (63, 37, and 45 respectively, figure 10), especially given the number of surveys submitted from those cities. Nootdorp (11 surveys), for example, had more surveys submitted than Schipluiden (3 surveys), yet comparatively, 25 fewer pieces of microplastic were found there. It was speculated that there may be a difference between the city centre of Delft compared to the Delftse Hout. Eleven surveys were submitted from the Delftse Hout area, and the same number from the city.

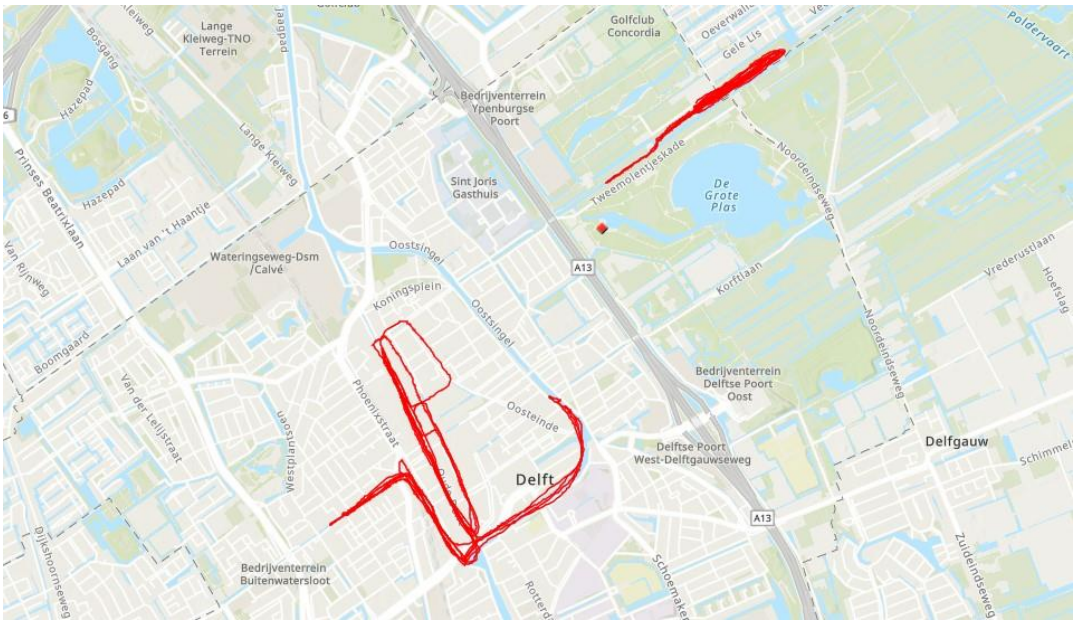


Figure 9 All tracks made in Delft when collecting microplastic samples

Eight of the 11 samples from the Delftse Hout had microplastic present, and 9 of the 11 trawl samples from the city centre had plastic present. In other words, there does not appear to be a difference between the Delftse Hout and Delft city areas for the presence or non-presence of plastic in the trawls. However, there does appear to be a difference in the type of plastics found. In the surveys submitted from the city, there were 2 pellets and 19 foam pieces collected, and in the Delftse Hout there were 4 pellets, 6 foams, 5 films, 1 string and 26 fragments found.

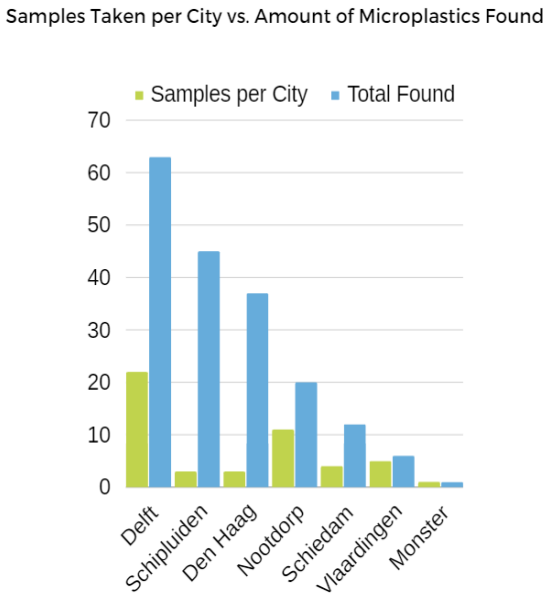


Figure 10. Samples taken per city and the amount of microplastics found per city.

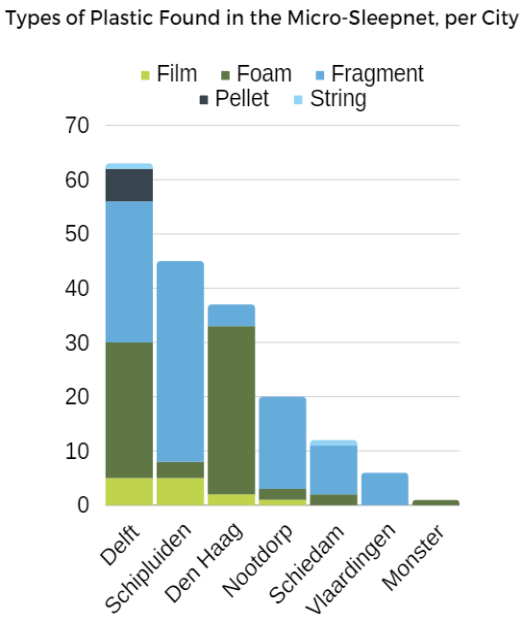


Figure 11. The types of microplastic found per city.

Macroplastics

The macroplastic Spot de Hotspot survey was for collecting any man-made litter along bodies of water, not just plastics, such as glass and textiles. As stated above, Citizen Scientists were also asked to observe the situation in which they found the litter, such as a waterflow decrease. In Figure 14, examples are shown of litter found during this workshop. A wide variety of litter types and sizes were found.

In total, 974 pieces of litter were recorded in the macro-Spot de Hotspot survey, from 54 survey submissions (of which 34 were the 2023 survey, and 20 using the 2022 survey).

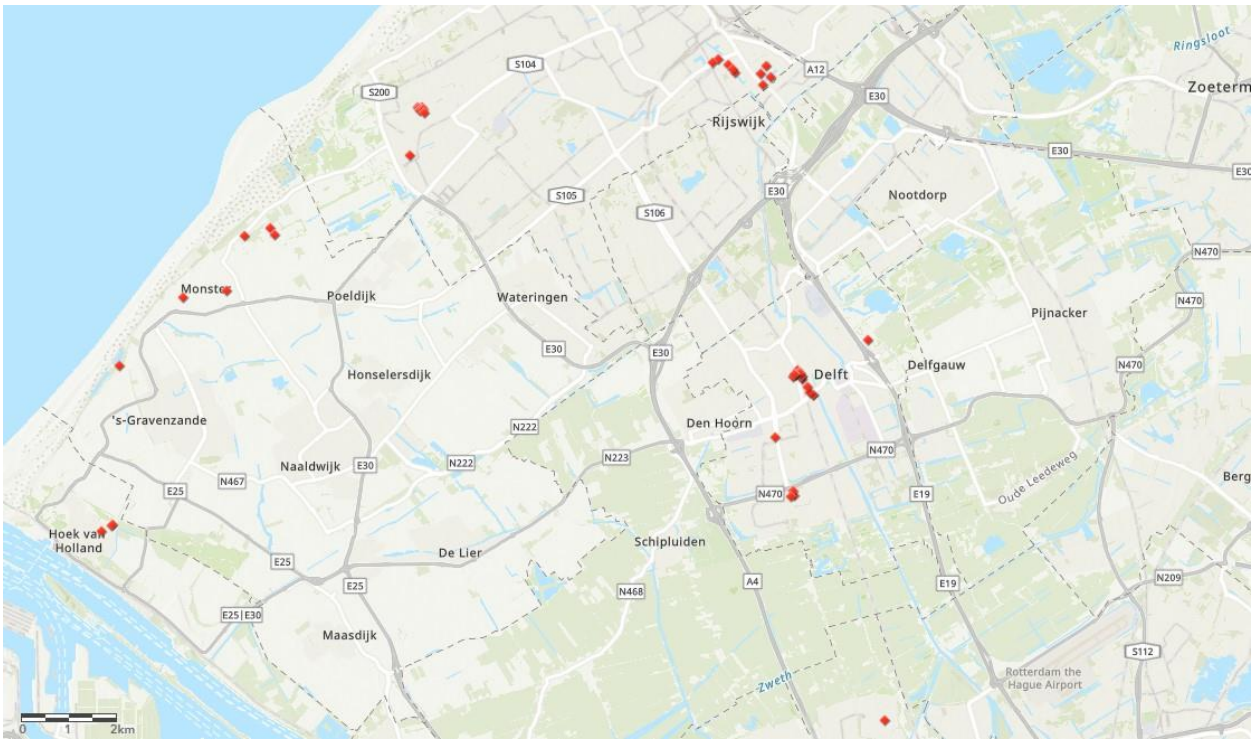


Figure 12 Locations of macroplastic hotspots

Plastic was by far the largest category, with 688 pieces found, followed by metal (105), paper (58), glass (54) and wood (29) (figure 13). Textiles, sanitary items, medical items, and rubber each had fewer than 20 pieces found. Metal pieces found primarily consisted of

aluminium drink cans, of which 62 were found. See also

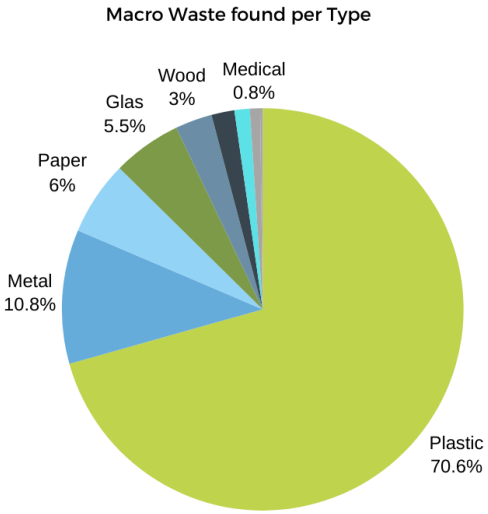


Figure 13.

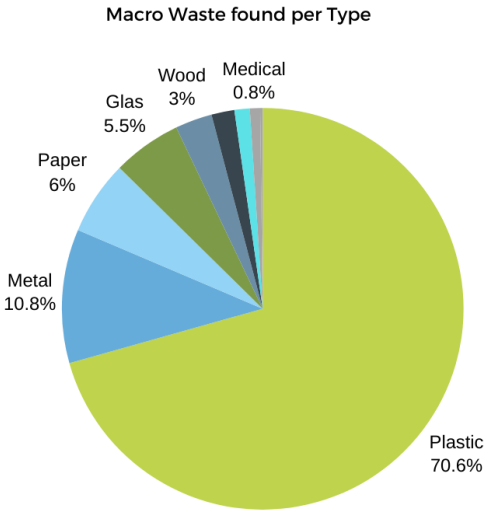


Figure 13. Pie chart of the percentages of each type of macro waste found.

Figure 14. A crate of various pieces of litter collected during a Spot do Hotspot macro-plastics excursion.

The highest subcategories were aluminium drink cans (62), snack and chips packaging (61), undefinable hard plastic pieces 2.5 - 50 cm (56), glass bottles, jars, or parts of them (54), plastic caps and lids (54), undefinable hard plastic pieces 0 - 2.5 cm (51), and plastic drink bottles < 1/2 Liter (50). The aluminium drink cans are the primary reason metal makes up 10.8% of the litter found, as there were more cans found (62) than all the rest of the metal subcategories combined (43).

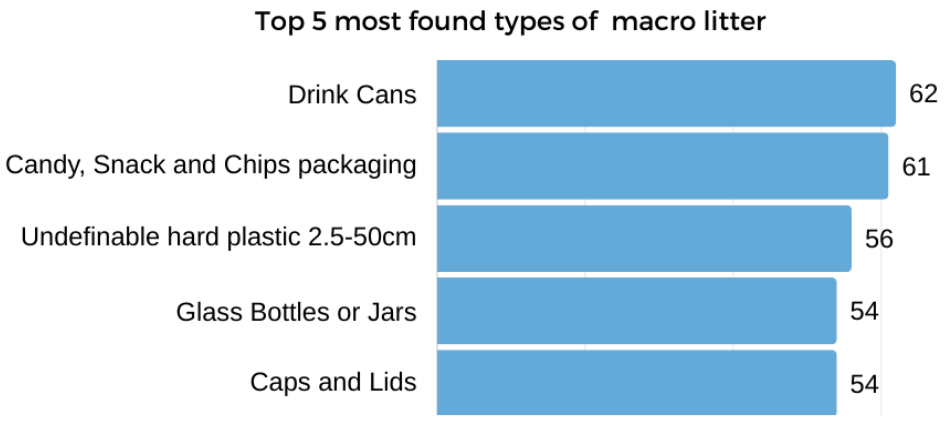


Figure 15. Graph of the the top 5 most found types of macro-plastic litter, following the OSPAR method of categorization.

Alongside the amount and the type of plastic, characteristics of the location in which the piece was found were also recorded, and this could be multiple characteristics per piece of litter. As seen in figure 16, most litter picked up was from an area with either an engineered obstruction such as a bridge (550 hotspots), or a retaining wall or rock/rubble shoreline (359 hotspots). The other characteristics were a waterflow decrease or almost stagnant water (210 hotspots), a river junction (78 hotspots), a plant-dense riverbank (72 hotspots), or other characteristic (315 hotspots). A groyne (small spit of land the prevents shore erosion) was also an option; however, none were marked with this characteristic. Regarding the "Other" category, 18 survey submissions had this marked and were required to fill in a description of what other characteristics they saw. Most of these were simply "canal" (5 surveys) or a variation of "on the edge of the canal" (7 surveys), however some single submissions identified hotspots in the gap between a boat and the shore, by a boat ramp/boat pier, in a port, and by a fishing jetty. In this case boat ramps and piers would count as engineered obstructions.

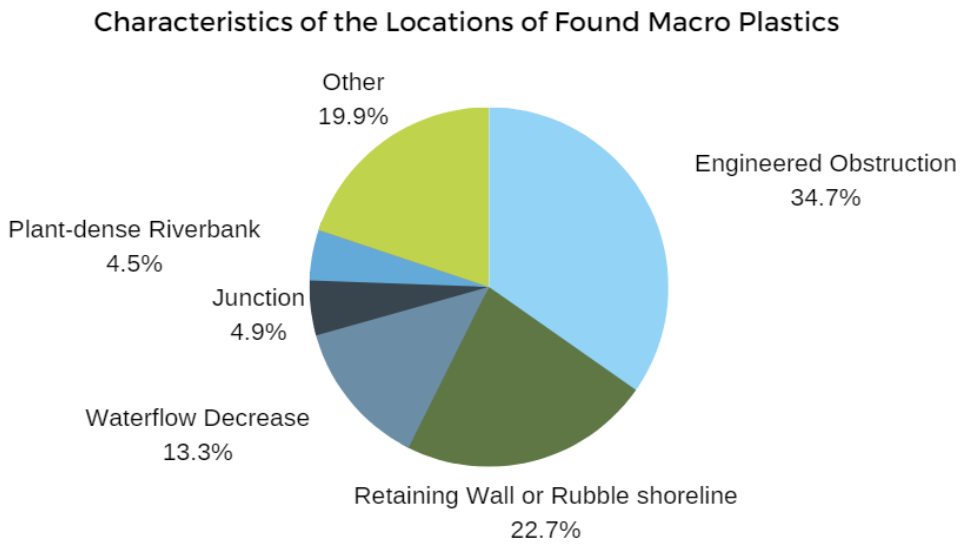


Figure 16. Characteristics of the area surrounding a macro Hotspot, as recorded by participants when submitting a survey. Participants could name more than one characteristic per Hotspot.

Comparison to 'Schone Rivieren' project

The project 'Schone Rivieren' has collected data from the autumn of 2017 till the spring of 2023 and used Citizen Science as well to collect and analyze samples (Source: Schone Rivieren. (2023). Plasticsoep in de Nederlandse rivieren - Het zwerfafval probleem in de rivieren ontrafeld en wat er nodig is om het op te lossen. www.schonerivieren.org). In total, 3026 data points were taken from rivers and riversides. Since this project was focused on canals and other smaller waters near and in the city, it is interesting to see if there is an overlap between the results.

The top three most found plastic types in the 'Schone Rivieren' project were foam, foil, and hard plastic. Foam was found in 61% of the samples. In this project, foam was found 64 times, corresponding to 34.8% of the total microplastic pieces. Foil and hard plastic were not found as much as during the 'Schone Rivieren' project. For example, hard plastic was found 109 times which corresponds to 11.2% of the total macroplastic pieces, and only 27 of the 974 macroplastic pieces found were foil, which is less than 0.03%.

Of all the litter found by the 'Schone Rivieren' project, 89% was plastic. Comparatively, only 70.6% of all the litter found in this project was plastic. The most found plastic items however are in both projects the same, namely: 'Drink cans' and 'Candy, snack and chips packaging'. Also 'bottles and jars' were found often in both studies. One of the biggest contrasts was the number of nurdles (pellets) found. Nurdles were found in 23% of the samples of the 'Schone Rivieren' project. In this project, nurdles (defined as 'pellet' and were only found 6 times (3.3%). This makes sense, since in Schone Rivieren these nurdles are found in the sediment on the riverbanks, and not in the upper water column. Nurdles are heavier and therefore more likely to sediment on the riverbank or riverbed.

Discussion

Implications of the Results

It was hypothesized that population-dense cities and industrial areas would have proportionately more waste (both micro and macro) compared to waterways in quieter regions. The data supports this in some respects, such as the increase in microplastics sampled in Delft and Den Haag compared to Vlaardingen and Schiedam, particularly when considering the surveys-to-total-plastic ratio. However, when zooming in on the Delft region in particular, the wooded area of the Delftse Hout in fact had more litter collected in total than Delft centre. This could be attributed to the fact that the Delftse Hout is close enough to Delft centre to have similarly high numbers of litter pieces, or because it is a highly visited recreational area, especially in summer period. However, most of the samples taken in Delft centre were on a day that there was much duckweed. Taking microplastic samples and analysing them is increasingly harder due to the duckweed overload and can therefore have influenced the results.

Another factor that was not considered in the data analysis of the microplastics, was that the participants could decide themselves what type of boating they used. This means that the participants used a variety of transportation means on the water, from SUPs, to kayaks, to water bikes, to (slow) motorboats. The speed difference between these means has probably influenced a great deal the distance travelled at the same time. This means that most likely a higher volume of water was sampled using motorboats. And this has probably influenced the results. As the survey did not ask to contribute what transportation means was used, this was not taken into account in the analysis.

It was also expected that there would be a visible relationship between macro- and microplastic hotspots, i.e. more microplastics where there are macroplastic hotspots, however this relationship was not examined within the time frame of this analysis, and remains a potential option to explore in future research.

Most of the microplastics found were fragments (53.8%) or foam (34.8%), and it could be that these plastic types are more likely to float on the surface than, for example, a nurdle. The sample collection is limited to the top layer of the water due to the floating of the trawl on the surface. Alternatively, it could be due to circumstances in the area collected, for example Delft and Den Haag potentially have higher levels of foam because the waterways lie near industrial areas, while it could be speculated that the higher levels of fragments found in the Delftse Hout area may be due to picnic litter. Only two strings were found (Delft and Schiedam), which may indicate that microplastics such as fibers from polyester clothing or ropes are rarer in the areas surveyed, or alternatively that they are harder to collect or identify using the mini-trawl method. Perhaps in coastal areas string microplastics would be more numerous due to discarded fishing nets and equipment. It is also very likely that a string is harder to identify by the participants,

without a microscope. Similarly, in the macroplastic survey no litter was found near a groyne. This is most likely because this is not typically present in cities where most of the samples were taken, however it could also be that the Citizen Scientists were not able to recognize it correctly.

One consideration to make when interpreting the results is that litter found on dry land may tend to be more recently discarded, given factors such as wind and cleaning services. Meanwhile, litter found in waterways may have originated months or years earlier and remained in the water, particularly with microplastics in isolated bodies of water such as city canals and lakes. So, the litter collected over the course of this project (2022 and 2023) not only reflects waste present in these years, but in the years preceding.

Reflections and Advice for Future Workshops

The feedback received from the participants during and shortly after the workshops was overall positive. Both the children, their parents, and adults joining without children expressed their enthusiasm for the workshops. Feedback often heard from the participants was that they liked the diversity of activities offered during the workshops. While giving the workshops, we noticed that little guidance was necessary in most cases implying that the manuals were easy to follow and/or the trawl design was easy to execute. Only small children needed assistance while making the trawl, which was often given by their parents. This enthusiasm and independence across the wide age range implies that the workshop is suitable for many different people and the target audience for future similar workshops can be targeted at a wide range of people.

The turnout per workshop varied, which was mainly due to the location. Locations with high walk through of people resulted in a higher number of people joining the workshops. Most participants joined without subscription. Because of this, people started the workshops at different times. This resulted in participants working on different stages of the workshop, which made guiding the participants a bit more intensive and challenging, since the same thing had to be explained multiple times to different participants. Advice for future similar workshops is therefore to more strictly adhere to the timeslots to assure good and structured guidance and to prevent additional work for the ones giving the workshops.

The time of the workshops also played a role in the turnout. For example, the timeslot of 12.00-14.00 on Wednesday was less well visited than the time slot on Wednesday of 14.00-16.00. This can be explained by the school hours. Since many children joined the workshops, the advice is to take the school schedules into account while making the planning of the workshops.

Considerations should be made in finding a replacement for the plastic materials now used for building the micro-trawl.

The manner in which we organized the workshops was mainly by partnering up with organisations that have similar interests but a better local network and audience. We only

realized that this was the best way to go, after half a year. Once we started collaborating with local partners, the reach and engagement of participants became much easier. For future continuation of these workshops, we would therefore recommend continuing in this fashion, and leave the engagement and recruitment of participants to these local partners.

Furthermore, the diversity among the participants that joined due to these different partners was an unexpected benefit. However, when organising these workshops or events, one should consider agreeing very specifically the expectations there are and what is needed to make the workshop but also the data collection a success. For example, how much time is there to give the participants the right instructions, what is expected of the participants, how will they understand what the purpose of the exercise is, and so on. Two of the workshops were held by joining existing events already organized, once with the Papaver during Clean Up day, the other with Canal Cleanup. Exactly these events where the most chaotic, which resulted in little time for instructions, nor in an after evaluation of the meaning of the results. It probably also resulted in less reliable results regarding data collection. On the other hand, you do reach many more people in little time, which could be considered the main priority.

Limitations

The very nature of this project raises some key limitations, some which are more challenging to overcome than others. As with most Citizen Science projects, public motivation plays a big influence on the success of the data collection, particularly motivation to continue contributing beyond workshops and other forms of guided data collection. With this research, the citizens may be motivated by personal achievement, entertainment, or satisfaction (egoism), the upholding of valued principles (principlism) such as environmentalism or integrity, the appearance and welfare of their neighbourhood (collectivism), or the livelihood of future generations (altruism). Many parents came for the sake of their children, and we saw little evidence of workshop participants continuing to do the research again at home. One option to provide additional motivation could be through a points-based system where participants can earn points for each item of litter collected or for the number of locations sampled from, with a leaderboard and “king of the mountain” for cities or regions. This would also benefit sample size.

As with all statistical analyses, the validity and reliability of the data could have been increased with a greater number of sampling locations, and larger samples per location (naturally limited by the amount of litter per location). The number of samples could also be limited by marketing reach. Increasing reach through advertising on social media platforms is an option to increase participation, however this would be at the risk of decreased data quality, as citizens who participate in workshops can learn the process in person, whereas individuals who are recruited to the project through online advertising will need to submit surveys that are self-guided. In addition, the microplastics survey was designed to be workshop-based as not many people own or have access to a boat, kayak, SUP board, or similar. Therefore, it is expected that

more people are capable of continuing macroplastic collection in their own time, but less so for microplastic collection.

A common grievance with Citizen Science is the potential for decreased data precision or quality. This can be countered with techniques such as keeping tasks and explanations straightforward, communicating a clear goal to the participants, providing validation methods such as photos or cross validation with other datasets, and by evaluating the potential for errors and bias in the data before analysis. Methods such as these were used in this project to limit the chance of errors and low-quality data, and to allow for validation post-data collection. Examples include making survey questions compulsory, requiring photos to be taken at different stages of the data collection process, and data inspection before the analyses.

Further Research

As stated above, in the future this project could be improved by expanding the public reach, increasing the number of data points, and allocating more time for data clean-up and analysis. This in turn would allow for more thorough statistical analyses which may provide more clarity to the data. One example of this could be to expand on the correlation between plastics found in cities versus the countryside, which would only be possible with a greater variety of sampling locations both inside and outside of cities. Another example would be to assume the volume of the microplastic mini-trawl and its speed through the water and combine this with length of time in the water and the number of microplastics collected to calculate the microplastics per Liter of water.

An external dataset of the types of neighbourhoods and infrastructure where participants are collecting the litter, such as residential apartment buildings, houses, industrial warehouses, attractions, or shops could be used to explore a reason for litter hotspots. It can already be hypothesized that business and touristic areas have a higher level of litter such as aluminium drink cans and cigarette butts, while industrial areas have higher levels of litter such as plastic sheeting and packing foam. The time of year could also have an effect, as people are more likely to spend time in and around water during the summer months, therefore a time-based experiment over the course of a year may be of some interest.

Currently, the Citizen Scientists who took part in the surveys remain anonymous, however another aspect of the data that could be accounted for is information about the participants. Characteristics such as age, occupation, and education would give a clearer picture of who is motivated to participate and give an indication of the data quality. A probabilistic model could be trained to flag errors and assess the correlation between characteristics of participants and the presence of errors, such as those made by children. If errors are present even in the surveys of participants who, for example, have experience in scientific methodology, it would suggest that the instructions need to be clearer or the steps less complicated.

Conclusions

There are several key findings to take away from the mapping exercise of Spot de Hotspot. First, the microplastic and macroplastic methodologies used in the workshops are good means to map the diversity and locations of micro- and macroplastics together with inhabitants of the region. Second, more then 80% of the microplastic samples contained visible microplastics. Even if the distribution of the microplastics found can not immediately be explained, this confirms and visualizes the extreme situation and spread of microplastic pollution. Third, macroplastic hotspots were indeed found mainly near or at locations defined by obstruction such as bridges, retaining walls, river junctions and plant-dense riverbanks. These are therefore the direct locations to keep in mind when designing measures for direct cleaning. Plastic (macro) was found more than any other material by far, and many of the pieces of litter were candy, snack or chips packaging, or unidentifiable pieces. As you can see, plastic bottles are not among these, while the second biggest number of trash found where metal cans. Deposits on plastic bottles has been obligated since 1st July 2021, while deposits on metal cans was only put in place since 1st of April 2023. The sentence “What does not enter the system, does not need to be cleaned”, is clearly depicted here. One can expect that in a year to two years, metal cans will also be found much less.

Fragments and foam were found the most, and string the least, either due to strings being harder to collect, harder to see and identify in the trawl, or because there were in fact less strings in the areas sampled from. However, fragments come from macroplastics, showing the interdependency between macro- and microplastic pollution. Furthermore, foam mainly comes from construction sites, and one measure that could be considered is to continue the efforts within construction to decrease pollution by foam, either by using other materials, or by ensuring no pollution occurs while using it.

In line with the hypothesis, it appears that less pieces were found in less densely populated areas such as Nootdorp, Vlaardingen and Schiedam, than a city such as Den Haag who counts at least about 5 times the population (apart from Schipluiden and Delft). For Delft however this can be explained since many more samples were taken and is therefore relatively less polluted.

Regarding the workshops, they are important to guide people but would be easier to implement if a schedule can be followed more closely and participants directed to join at regular intervals, as opposed to freely joining mid-session. Despite this obstacle, children and adults alike enjoyed the workshops, particularly the microplastic trawl making and collecting process. The number and attendance of workshops was satisfactory; however, incentives could be created to promote macro litter collection after the workshops.