Towards randomized OSPAR sub-sampling of plastic litter on urban riverbanks

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Abstract

Urban river systems are hotspots for plastic pollution. To be able to collect data on these locations a method was developed based on proven OSPAR-methodology. The project aims to create a tool that delivers quick but reliable data in order to create awareness on plastic riverine pollution, to be used in educational and citizen science context.

Several experiments were conducted as part of an iterative process to come to a randomized sub-sampling method. First three different methods were tested: a standard OSPAR methodology, a random stratified method and a method focusing on hotspots on a transect. Following these experiments an inventory of spatial distribution was made by creating a sampling grid of 10m x 5m. A clear high-water mark could be recognized, leading to a randomized sub-sampling method focusing on these highest plastic waste densities.

Random sub-sampling gives a good indicative view of amount, distribution and composition of plastic riverine litter on urban riverbanks. The OSPAR categorization has been simplified and reorganized in order to improve applicability for untrained students and citizen scientists. This has led to an easier and faster method for inventory of urban riverbanks.

Introduction

The pollution of plastics in aquatic environments originates to a large extend from urban riverine systems[1,2,3]. To quantify the amount and determine the composition of plastic litter in riverine systems several methods have been proposed[4,5,6]. A lot of focus has been on sampling of riverbanks, regularly involving citizen science methodologies[7,8]. The Schone Rivieren (clean rivers) project[9] is often seen as a best practice for riverbank sampling[10,11]. This methodology, based on OSPAR protocols[12], focusses on natural riverbanks by measuring stretches of 100m length, but in urban areas river litter tends to accumulate at narrower stretches on artificial embankments. To be able to measure urban plastic riverine litter a method was developed to deal with these urban hotspots, in a comparative manner to OSPAR-rivers. This was done as part of the IMPETUS project (Innovative Measurement Tool Towards Urban Environmental Awareness)[13] with students water management of Rotterdam University of Applied Sciences (RUAS) during campaigns at Rijnhaven Rotterdam, The Netherlands, in 2019-2021.

The aim of the project is to develop easy but reliable tools to create insight in and awareness of environmental issues, such as plastic riverine pollution, in different European cities.

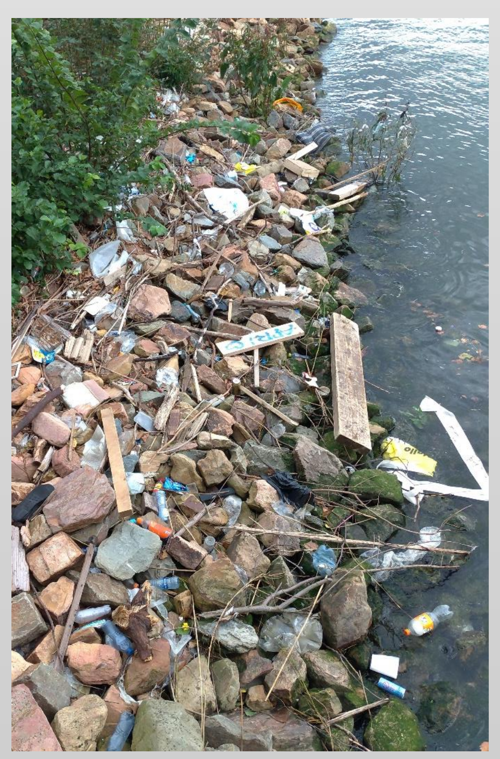

Figure 1. Plastic litter on Artificial embankment at Rijnhaven Rotterdam.

Design & Methods

For sampling of highly polluted urban riverbanks the existing OSPAR-rivers method for 100 m, as develop for the Schone Rivieren project by Stichting de Noordzee (English: the Northsea Foundation) is used as a framework[9]. In order to develop a randomized sub-sampling method an iterative process has been followed.

First several groups of students were asked to carry out a reconnaissance of 3 methods: 1) a standard OSPAR-river measurement in which different student groups sample 10m of riverbank instead of 100m. The results of the combined 10m measurements lead to a full 100m sampling result; 2) For the length of 50 m transect parallel to the waterline a 1m x 1m quadrat at 10 random stratified locations is sampled. Quadrats are randomly selected every 5 meters along the transect by throwing a dice with the numbers on the dice corresponding to the relative distance to the waterline (see figure x); 3) At 5 randomly picked spots (using online randomizer.org[14] to generate unique numbers between 0 – 50 m) along the high water level mark a 50 x 50 cm quadrat have been sampled. See figure 2 for a schematic display of the methods used.

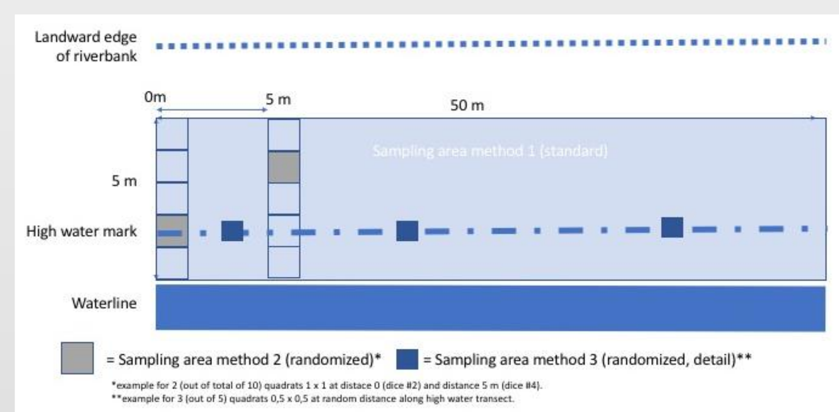

Figure 2. Set up of preliminairy experiments.

Secondly measurements to get better insight in the spatial distribution of plastic waste on the riverbank were carried out. A stretch of 10 m riverbank has been divided into a grid of 1m² squares (see figure 3). Each square has been sampled and photographed.

Based on the results of steps 1 and 2 the method for randomized sub-sampling has been adjusted. This last method consists of randomized sub-sampling along the high-water mark. For the visible high-water mark, recognized by a high density of organic and non-organic litter and debris deposited by the last high-water level, a 1m² quadrat is sampled at 10 random distances (again using randomizer.org) along a 100m transect (see figure 4).

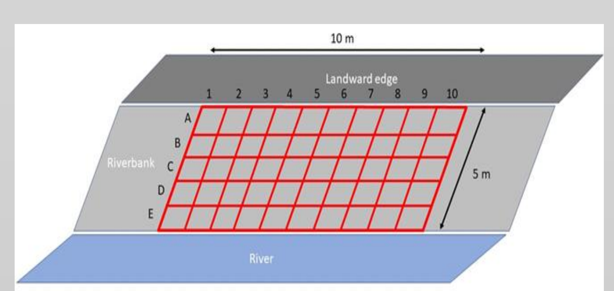

Figure 3 Sampling grid for spatial variation

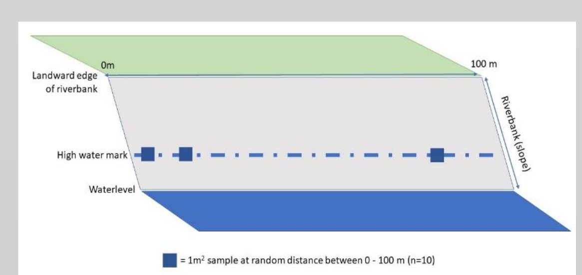

Figure 4. Randomized sub-sampling design.

Measurements have been carried out by students Water Management of Rotterdam University of Applied Sciences (RUAS) at a riverbank location at Rijnhaven Rotterdam. Students have been given a brief introduction on site in which the method and OSPAR-categorization have been explained..

After several measurements students have been asked for their view on practical applicability and suggested improvements. Based on these evaluations iterative adjustments to the method have been implemented.

Results

Preliminairy experiments. The 3 tested methods show high variation in number of plastic items encountered. Method 3 focusses on high water mark deposits and involves more detailed observations. Therefore average numbers for this method are significantly higher. However, variation is also high for different series within each method (Please note that different stretches of riverbank were observed).

Composition for all three methods is similar with plastic bags, plastic/polystyrene fragments 2,5 > < 50 cm and candy/crisp packaging and/or food containers as top 3 items.

Evaluation of the methods showed that the extensive list of items and unfamiliarity with the types raises question for reliability of categorization. Also it was found that quality of the detailed measurements of 0,5m2 quadrats was dependent on enthusiasm of students. The 'traditional' OSPAR method was deemed too time consuming in high density spots.

Spatial distribution. To get a better understanding of distribution of plastic litter along the riverbank a sampling grid was constructed. This gives a clear indication of the high-water mark, where >86% of all items was found. It also demonstrates that litter distributes heterogenous over the transect, with highest densities in the first meters (figure 5). Analysis of composition has shown that polystyrene particles (Styrofoam) <2,5 cm make up 54% of all items observed. This is primarily due to single Styrofoam balls which are present due to broken down Styrofoam pieces. These items are similar in presence as nurdles (plastic granules). When the Styrofoam particles are left out of the analysis then PU-foam, Styrofoam (>2,5 cm) and small pieces (<2,5 cm) of soft and hard plastic are the main items (figure 6).

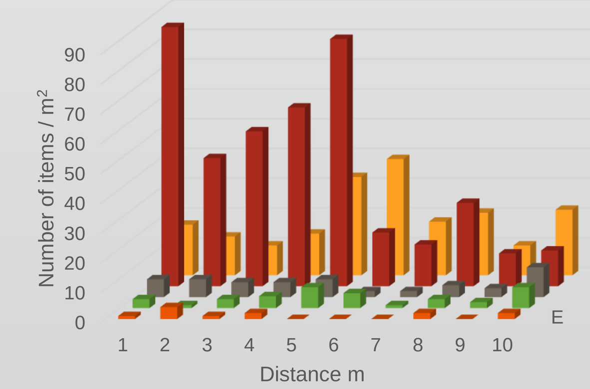

Figure 5. Spatial distribution of plastic litter in sample grid of 10 x 5 m.

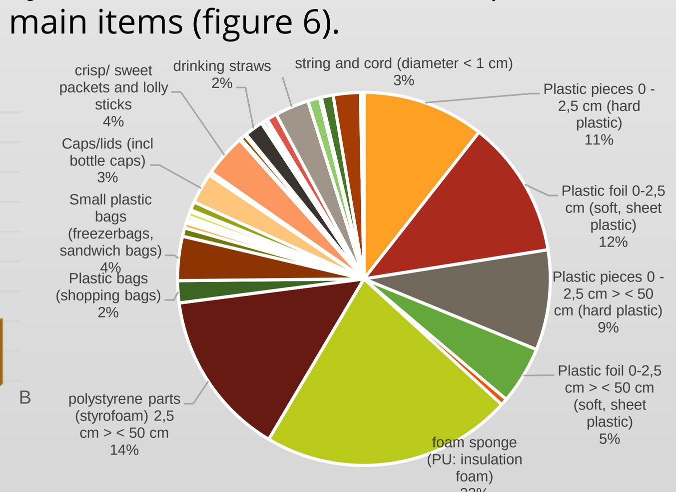

Figure 6. Composition of plastic litter, excluding styrofoam particals <2,5 cm

Randomized sub-sampling. For 3 series of randomized sub-sampling along high water mark a similar trend can be recognized (figure 7). High densities for a serie in the first 10m is primarily due to small soft and hard plastics. Medium unidentified items are the category most present, with plastic foil (2,5 – 50cm) as most observed item (20% of total). Nurdles are found in 50% of all measured 1m² quadrats, Styrofoam in 40% of samples.

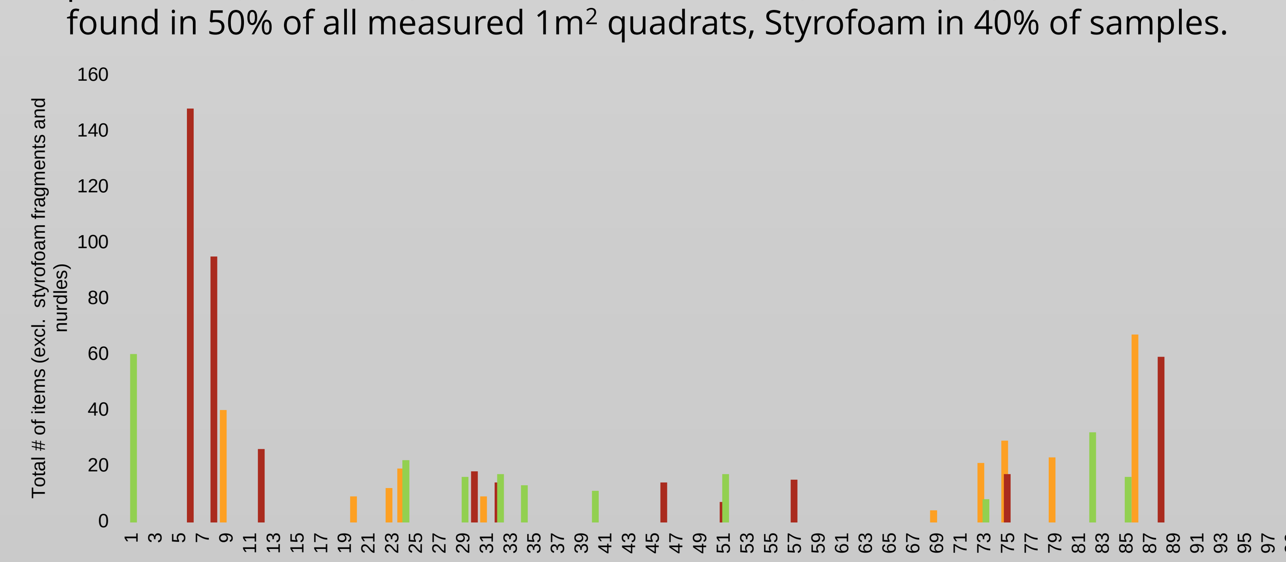

Figure 7. Density of plastic litter along 100 m transect for 3 series of random 1m² quadrats.

Conclusion

Randomized sub-sampling allows for less time-consuming monitoring of plastic riverine litter on urban riverbanks. Simplification of categories and random sub-sampling have increased the applicability for reconnaissance monitoring. Amount and composition of plastic waste give a good indicative insight on the level of plastic pollution, and the item categories give sufficient detail to compare with OSPAR measurements and determine potential sources. The tool developed thereby is suitable to create awareness on plastic pollution and gather data in urban environments.

Further elaboration on the randomized sub-sampling methodology is recommended: stratified random sampling by dividing the transect in sections with random samples can lead to more detail on spatial distribution and lowers variation. To improve validation of results more samples should be taken to even out temporal and spatial variation. Comparative measurements between randomized and 'traditional' OSPAR is recommended.

To increase applicability for education and citizen science the items and categories could be simplified further and made visually clear for more reliable and faster recognition.

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