TOWARDS DEVELOPING A RAPID CITIZEN SCIENCE-BASED MACROPLASTIC MONITORING PROTOCOL FOR RIVERS AND WETLANDS: A CASE STUDY OF THE UMSUNDUZI RIVER
SAMPLING PROTOCOL

S Murugan, W Evans, S Ndlovu, M Mnikathi

WATER RESEARCH COMMISSION

TT 939/2/24

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Report to the

Water Research Commission

by

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Institute of Natural Resources

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1. INTRODUCTION

The technical sampling protocol designed for infield use represents a crucial component of the broader initiative aimed at comprehensively addressing macroplastic pollution in rivers and wetlands. Developed through collaborative efforts between scientists and citizen scientists, this protocol serves as a pivotal tool in the systematic assessment of plastic pollution levels and the identification of priority areas for mitigation efforts.

Driven by the expertise of scientists, the desktop site selection process lays the foundation for effective fieldwork. Drawing upon scientific knowledge and data, sampling sites are identified based on factors such as current landuse, hydrological dynamics, and ecological sensitivity. These selected sites serve as focal points for intensive infield sampling activities. Collaborating closely with scientists, citizen scientists play a crucial role in implementing the technical sampling protocol during infield operations. Trained and guided by scientists, citizen scientists engage in the collection, cleaning, sorting, and analysis of plastic debris found in rivers and wetlands. Under the supervision of scientists, citizen scientists adhere to standardized procedures to ensure the accuracy and reliability of collected data.

The protocol encompasses various stages to facilitate comprehensive data collection and analysis. Upon arriving at designated sampling sites, citizen scientists conduct systematic surveys along the edges and banks of rivers, as well as along wetlands. Throughout the sampling process, emphasis is placed on thoroughness and attention to detail to capture a representative snapshot of macroplastic distribution and abundance. Following the collection of plastic debris, citizen scientists clean and sort the samples according to predefined categories. This sorting process enables the classification of plastic debris based on type and origin, providing valuable insights into pollution sources and trends. Subsequently, the analysed data is subjected to statistical analysis to identify patterns and prioritize pollution hotspots.

The collaborative nature of this sampling protocol underpins the importance of harnessing both scientific expertise and community engagement in tackling environmental challenges. By empowering citizen scientists to actively participate in data collection and analysis, this protocol not only enhances the scalability and efficiency of monitoring efforts but also fosters a sense of ownership and stewardship among local communities. For a comprehensive understanding of the development, implementation, and outcomes of the technical sampling protocol, refer to the full technical report, which provides detailed insights into its evolution and application in the context of combating macroplastic pollution in rivers and wetlands.

2. MACROPLASTIC SAMPLING PROTOCOL

2.1 DESKTOP SITE SELECTION

Site selection is critical to this investigation since it affects the density and type of waste sampled (Tasseron et al., 2020). To commence infield sampling, a high-level desktop prioritisation is required to establish potential sampling regions. ArcGIS 10.8.2 is recommended to create a fishnet over the study area, similar to the fishnet-based technique employed by Xu et al., (2017) using national landcover data. A fishnet is a feature class that has a grid of rectangular cells, similar to a quarter degree square (QDS) system. Each rectangle in the grid measured 250 hectares and had 20 rows and 20 columns.

Thereafter, a land use classification exercise is performed to identify areas that are prone to plastic pollution, using the assumption that:

1. More accumulation of plastics occurs on the inner and outer bends of a river than on a straight stretch of river (Corcoran et al., 2019);
2. Landuse activities closer, i.e. proximity, to the river may interact more frequently and may contribute to plastic pollution (Alam et al., 2019);
3. Wetlands and rivers act as plastic traps and transport mechanisms; and
4. Certain land use activities contribute more to pollution than others (i.e. formal residence vs informal residence) (Moss et al., 2021).

To highlight landuse activities that contribute to plastic pollution, the latest South African National Landcover 2020 should be reclassified into the categories shown in Table 1 below. This method ensures that sample sites are chosen in a spatially representative manner. These landcover activities are then weighted 1-10 (1 = lowest plastic contributor and 10 = highest plastic contributor).

Table 1: Landcover classification and weighting

Landcover Type	Final Weighted Score
Landfill	9
Informal residential	9
Road	8
1:100-year flood line	7
Wetlands	7
Industry	7
Urban recreational	6
Formal residential	6
Commercial	6
Villages/small holdings	5

A pivot table is used to convert the total area for each land use per grid to a percentage. The weights mentioned above are then multiplied by these proportions and added together to yield a total grid score. The final sites are chosen at the discretion of the team leader (specified in Team composition),

who should prioritise team safety and accessibility to the site. Furthermore, if a priority grid has wetlands that have been extensively modified/transformed to the point where they can no longer function as a wetland, or if a grid is largely riverine with little wetland area to sample, alternate grids can be chosen.

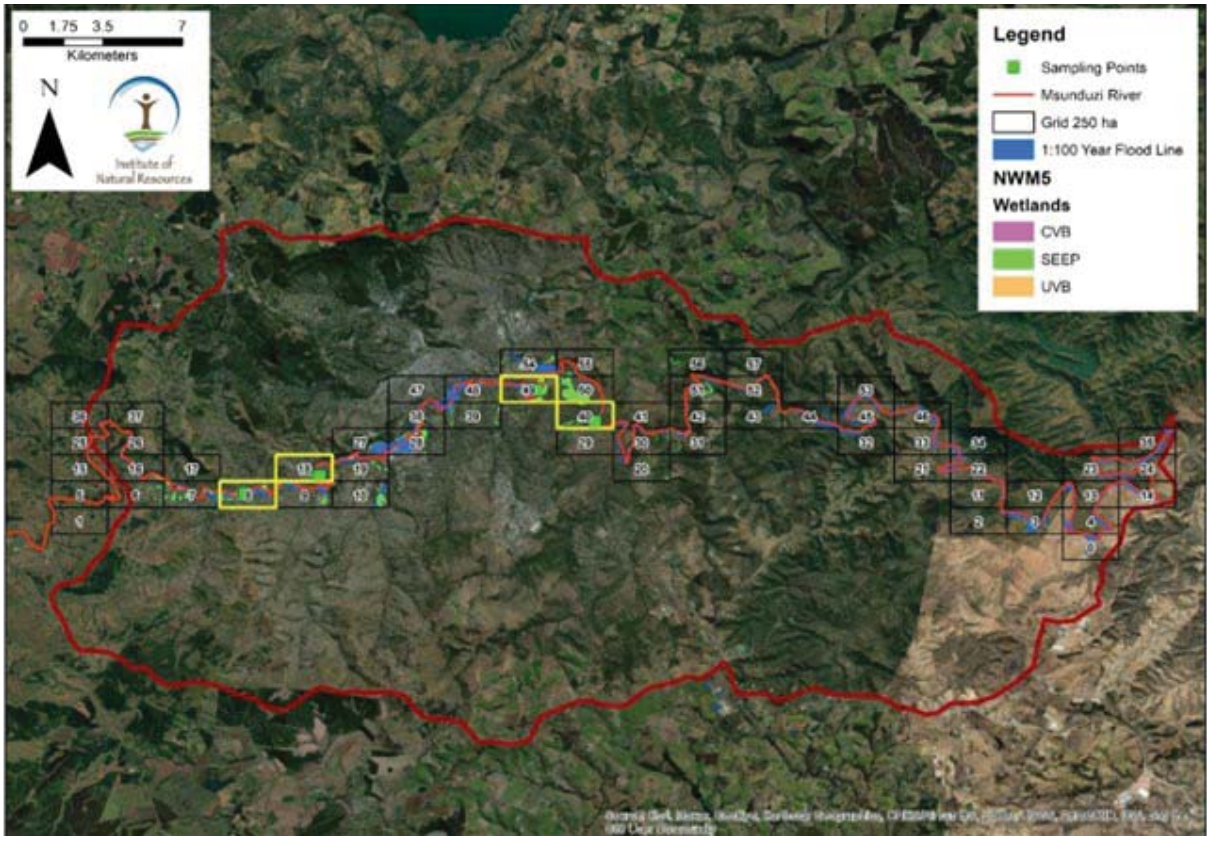


Figure 1: Output of the desktop site selection process within the uMsunduzi Catchment

A disturbance profile was generated for each site using a combination of desktop and in-situ inspection (visual evaluation) of disturbances (following Govender et al., 2020). The intensity of the disturbances was determined using a typology and scoring system developed for estuaries by Govender et al., (2020). At each sample event, all sites will be scored. Human settlements, industrial activity, recreational parks, roads/access, and unlawful dumping are among the disruptions that will be considered. Each disturbance can carry a score between 0 - 4 (0 = absent, 1 = low, 2 = moderate, 3 = high and 4 = very high) and each site can be awarded a maximum of 20 (sum of all disturbances per site) and expressed as a total disturbance score (TDS).

2.2 RIVER SAMPLING

2.2.1 Team Composition

This citizen science method of monitoring macroplastic in rivers and wetlands should be carried out by one Team Leader, and at least three trained citizen scientists (roles and responsibilities defined in the table below). Teams should have one Visual Assessor and two Plastic Samplers. The Visual Assessor should be most familiar with the plastic categories described in the Plastic Typology and main land

uses and activities, while the Plastic Samplers need only be familiar with the typology and sampling methods.

Table 2: Team composition and responsibilities

Role	Responsibility
Team Leader	Site identification Team management Data entry and quality check Data analysis Reporting
Visual Assessor	River and Wetland Sample Point selection Visual sampling • Site Characterisation Data Sheet • Plastic Typology Data Sheet Instream sampling Label sample bags Note taking Plastic sorting in the lab Reporting to the Team Leader
Plastic Samplers	River edge sampling River bank sampling Wetland edge sampling Set up transects Collect plastic Reporting to the Team Leader

Health and safety

Your health and safety are the most important. Do not put yourself in danger, here are some things to remember to keep you and your team safe:

- Don't try to cross big rivers, sample on just one side
- Don't cross highways or busy roads
- Don't pick up medical or hazardous waste (including hygiene products, plasters, bandages, syringes, condoms etc). Instead, report it to your Visual Assessor and Team Leader
- Make sure that the river bank is stable before walking on it
- Don't try walk through the wetland, it might be deep
- Do not touch anything that might be hazardous, including medical syringes (with or without needles), plasters, condoms, bandages, sanitary products. Instead, ask your scribe to make a note of what you have found, or take a picture and send it to the Plastic Sorter.

2.2.2 River sampling

a. River point selection

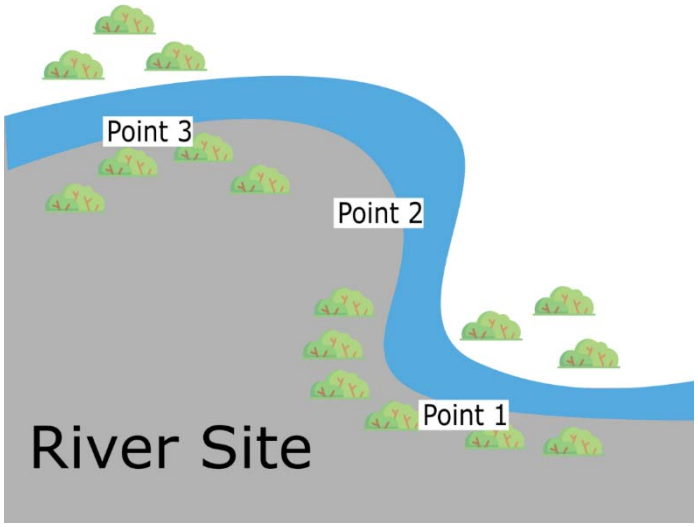
The location of the site will be sent to you by the Team Leader. Once at the site, choose your starting point. Make sure it is safe to walk along the river. If the river bank is too steep, or there is too much bush along the edge of the river, walk upstream and downstream until you find a better starting point.

Complete River Sampling

- River Sampling Point 1 (1. Visual, 2. Instream, 3. Edge, and 4. Bank Sampling)
- Walk 50 – 100 meters upstream
- River Sampling Point 2 (Instream, Edge and Bank Sampling)
- Walk 50 – 100 meters upstream
- River Sampling Point 3 (Instream, Edge and Bank Sampling)

When choosing your Sampling Points, make sure:

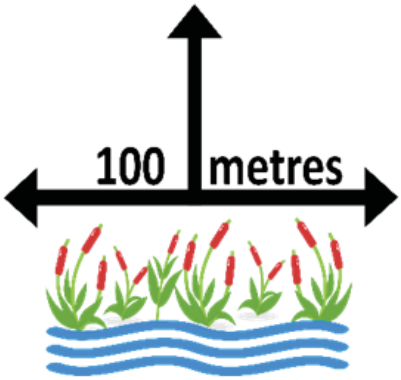
- All three points are on the same side of the river;
- At least one of the points should be an area with a lot of vegetation;
- If the river bank is too steep for sampling, walk up or downstream until the bank flattens and it is safe to sample;



b. River sampling techniques

Four types of sampling techniques will be undertaken for rivers:

- Visual (x1)
- Instream (x3)
- Edge (x3)
- Bank (x3)



c. Visual sampling

From Point 1, walk 100m upstream, 100m downstream, and 100m away from the river, like in the diagram on the right. Remember, one big step (stride) is about 1 meter, so take 100 strides to walk 100 meters. Complete the following two steps while walking:

- **Site Characterisation**
    - Look for key impacts such as industry, roads, and residential areas in the area;
    - Fill out the Site Characterisation Data Sheet when you get back to the starting point.

- **Identify Plastic**
    - Walk in a straight line;
    - Identify all the main types of plastic while walking – do not spend a long time trying to work out how much of each type of plastic you see along your walk;
    - Complete the Plastic Typology Checklist while you are walking.
    - The following datasheet can be used during the visual assessment

Name:
Date:
Time:
Site:

Item	Composition	Properties	X
Soft drinks	Polyethylene Terephthalate (PET)	Clear, tough, barrier to moisture, can add colour	
Disposable water bottles			
Biscuit trays			
Salad dressing			
Salad domes			
Combs			
Rope			
Shopping bags	High-Density Polyethylene (HDPE)	Hard or semi flexible, waxy surface	
Freezer bags			
milk bottles			
Juice bottles			
Shampoo bottles			
Detergent bottles			
Crates			
Detergent containers			
Toys			
Cosmetic containers	Polyvinyl chloride (PVC)	Strong, tough, can be clear or colour can be added	
Electrical pipes			
Plumbing pipes			
Wall cladding			
Cling wrap	Low-density polyethylene	Strong, flexible, waxy surface, scratches easily	
Garbage bags			
Squeeze bottles			
Irrigation tubing			
Bottles	Polypropylene	Hard but flexible, waxy surface	
Ice cream tubs			
Chip bags			
Microwave dishes			
Garden furniture			
Kettles			
Lunch boxes			
Take-out containers			
Disposable cups and plates			
Disposable cutlery	Polystyrene	Clear, glassy, rigid	
CD Cases			
Meat trays	Expanded polystyrene	Foam	
Plastic food boxes			
Plastic CDs and DVDs	Other	Includes polycarbonate, polyctide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon	
Large water bottles with multiple-litre capacity			
Wigs, artificial hair			
Eyeglasses			
Lighting fixtures			

Name:
Date:
Time:
Site:

	Presence (mark with X)
Commerce	
Shopping centre	
Takeaway/Restaurants	
Informal traders	
Agriculture	
Subsistence	
Commercial	
Residential	
Township	
Sub urban	
City	
Rural/Village	
Religion & Recreation	
Sports	
Culture	
Religious activities	
Park	
Fishing	
Other	
Highway	
Tar road	
Dirt road	
Foot path	
Industry	
Illegal dumping	

Figure 2: Field data sheets used to record visual assessment data

Equipment needed: Clipboard, pencil, datasheets.

Remember:

- Do not repeat the visual sampling at River Point 2 and Point 3
- Clearly write the site name, date, your name, and contact details on each data sheet.

d. Instream sampling (3 x 1 minute)

For the Instream Sampling, look at the river and work out which way the river is flowing, then put the net in the river so that the opening face the opposite direction of flow. Make sure that the whole net is under water. Make sure that the net is just below the surface of the river, the top of the net should be less than 30cm from the surface. Once the net is in the river, start the stop-watch and hold the net still for one minute (60 seconds). If you see any plastic drifting past while you are holding the net in place, do not move the net to catch the plastic.

After one minute, remove the pool net from the river and carefully tip it into a labelled ziplock bag. Turn the net inside-out inside the ziplock bag and shake the net for 10 seconds. If some of the plastic is too big for the ziplock bag, you can put it in a new black bag, be sure to put a label in the bag.

Equipment needed: Clipboard, pencil, datasheets, ziplock bags, pool net, stopwatch, gloves.

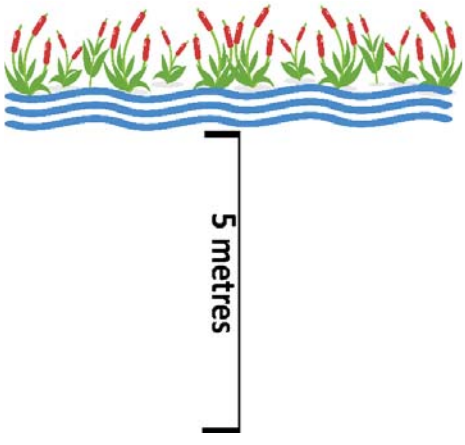
e. Edge sampling (3 x 5 meter transects)

- At Point 1, hammer a stake into the ground next to the river (approx. 2 m away from the edge of the river)
- Use the rope to measure 5 meters upstream from the first stake (see picture on the right)
- Put the second stake into the ground 5 meters away from the first stake,
- 5 m pick and walk along the transect and collect visible plastic within 1 m of the 5-meter rope,
- Place all plastic from the transect into a labelled ziplock bag,
- Repeat Edge sampling at Point 2 and Point 3 (total distance covered = 15 m),
- At least one of the samples should be in an area with more vegetation,
- At least one of the samples should be in an area with less vegetation,
- Repetitions should be 50 - 100 meters apart.

Equipment needed: pool net, bucket, ziplock bag, clipboard, pencil, datasheet, stake, 5-meter rope

f. Bank sampling (3 x 5 meter transects)

- At Point 1, hammer a stake into the ground next to the river (approx. 2 m away from the edge of the river),
- Use the rope to measure 5 meters away from the river, going up the bank (see picture on the right),
- Put the second stake into the ground 5 meters away from the first stake,
- 5 m pick and walk along the transect and collect visible plastic within 1 m of the 5-meter rope,
- Place all plastic from the transect into a labelled ziplock bag,
- Repeat Bank sampling at Point 2 and Point 3 (total distance covered = 15 m),
- At least one of the samples should be in an area with more vegetation,
- At least one of the samples should be in an area with less vegetation,
- Transects should 50 - 100 m apart.



Equipment needed: pool net, bucket, ziplock bag, clipboard, pencil, datasheet, stake, 5-meter rope.

2.2.3 Wetland sampling

Not all the techniques used in the river sampling will be used in the wetland sampling.

a. Wetland point section

The location of the Wetland Site will be sent to you by the Team Leader. Once at the site, start by identifying the edge of the wetland. An area is a wetland if it has the following:

- Waterlogged soil;
- Water-loving plants; and
- A high water table.

If soil is waterlogged, it means that it is full of water. The water table refers to the level in the ground where all the soil below this level is waterlogged (full of water).

Make sure it is safe to walk along the wetland. If there is no safe access to the wetland, walk around the wetland until you find a more suitable starting point. Then choose your starting point (Point 1). Complete Wetland Sampling (Visual, and Edge Sampling) at Point 1, then walk 50 - 100 meters around the wetland and repeat Edge Sampling at Point 2. Finally, walk 50 - 100 meters around the wetland again and repeat Edge Sampling at Point 3. When choosing your sampling Points, make sure to remember:

- All three Points should be on the edge of the wetland;
- Do not put yourself in danger – don't try walk through the wetland or walk through an unsafe area. Your safety is the most important!

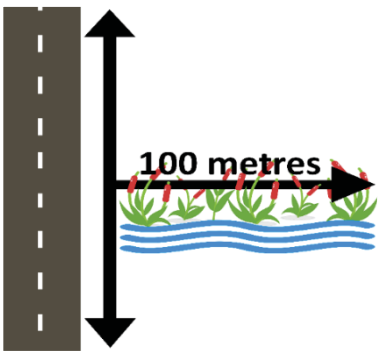
b. Wetland sampling techniques

Two types of sampling techniques will be undertaken for wetlands:

- Visual (x1)
- Edge (x3)

c. Visual inspection

From Point 1, walk 100m upstream, 100m downstream, and 100m away from the wetland. Do two things while walking:

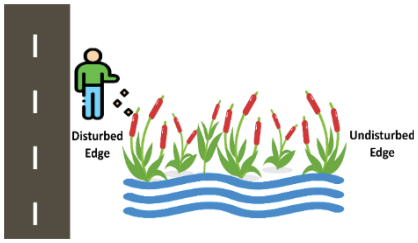


- Site Characterisation

  o Take note of key impacts such as land use, population density, in the area.

  o Fill out the Site Characterisation Data Sheet when you get back to the starting point

- Identify the disturbed edges and the undisturbed edges of the wetland. The disturbed edges are usually the edges with the best access/closest to footpaths and roads. Disturbed edges have more waste and the plants might be more damaged.



- **Identify Plastic**
  - Walk in a straight line;
  - Identify all the main types of plastic while walking – do not spend long trying to work out which types of plastic you see along your walk;
  - Complete the Plastic Typology Data Sheet while you are walking.

Equipment needed: Clipboard, pencil, datasheets

Remember:

- Do not repeat the Visual Inspection at Wetland Point 2 and Point 3;
- Clearly write the site name, date, your name, and contact details on each data sheet.

d. Edge sampling (3 x 5 meter transects)

- At Point 1, hammer a stake into the ground next to the wetland (about 1 m away from the edge of the wetland);
- Use the rope to measure 5 meters away from the first stake and put the second stake in the ground;
- 5 m pick and walk along the transect and collect visible plastic within 1 m of the rope;
- Place all plastic from the transect into a labelled ziplock bag,
- Repeat Edge sampling at Point 2 and Point 3 (total distance covered = 15 m),
- Repetitions should be 50 - 100 meters apart.

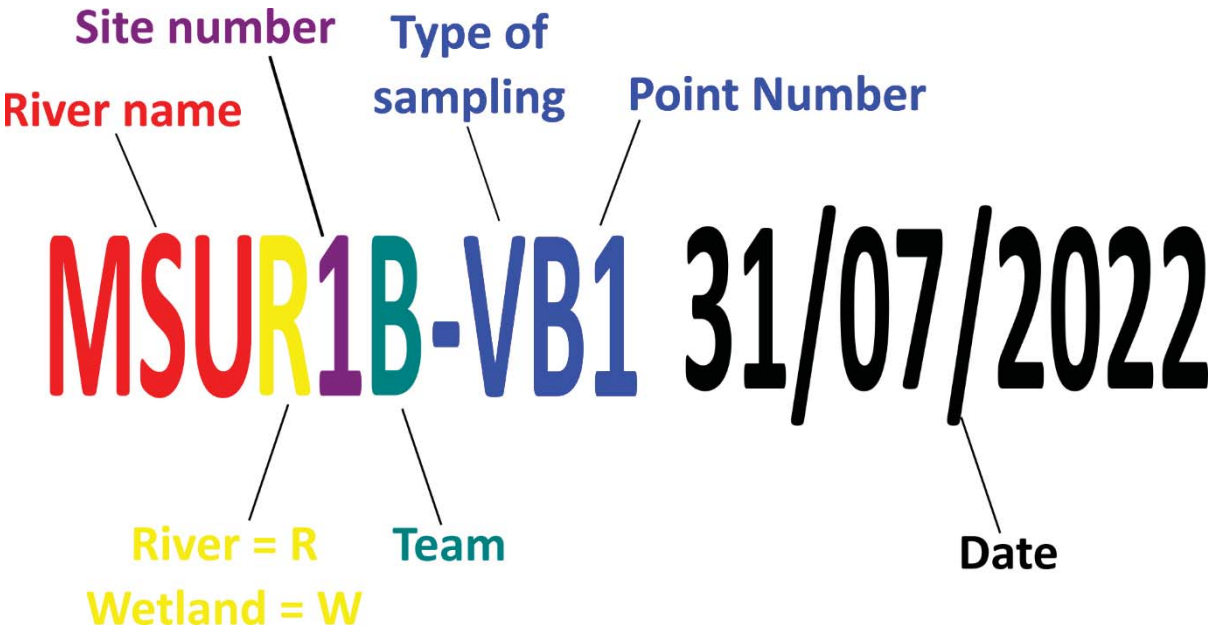
Equipment needed: pool net, bucket, ziplock bag, clipboard, pencil, datasheet, stake, 5-meter rope

Important considerations:

- To ensure everyone collects data in the same way, searching should be done from a standing position. When looking for plastic, do not bend over. Walk up straight and look down.
  - Should you see any pieces of plastic while you are bending down to pick something up, you should pick up the additional pieces of plastic.
- Do not touch anything that might be hazardous, including medical syringes (with or without needles), plasters, condoms, bandages, sanitary products. Instead, ask your scribe to make a note of what you have found, or take a picture and send it to the Plastic Sorter.
- REMEMBER TO LABEL EVERY BAG BEFORE STARTING THE NEXT POINT!

2.2.4 Labelling of sampling bags and data sheets

All samples should be labelled according to the following:



Where:

River name – first three letters from the river (or nearby river)

River or Wetland (R = River, W = Wetland)

Site number – there might be more than one site on a river or a wetland

Team – each team will be given a letter, from A – Z

Type of Sampling (see flow chart) –

- **Rivers**
  - Instream (In)
  - Bank
    - Vegetated Bank (VB)
    - Unvegetated Bank (UB)
  - Edge
    - Vegetated Edge (VE)
    - Unvegetated Edge (UE)
- **Wetlands**
  - Disturbed Edge (DE)
  - Undisturbed Edge (UE)

Point number –

- **Point 1** is where you start
- **Point 2** is your second point
- **Point 3** is your third point

Date – today's date

2.2.5 Data analysis

Once the samples have been collected, they will be taken back to the laboratory for analysis.

e. Washing and cleaning samples

Empty the sampled plastics collected from the first site into the tub/container according to the sampling method that was carried out. Fill the tub/container with water and add bleach to disinfect. Soak the plastics for 20 minutes to dissolve or soften the dirt and any other debris found on/in plastic samples. Using a brush, wash/scrub the plastics to remove tough stains/dirt/mud/grass, and rinse with clean water thereafter. Once the plastics have been rinsed, spread them out on a flat surface and leave to air dry overnight.

Equipment needed: tub/container, water, bleach, brush, gloves

Remember to:

- Separate or remove the plastic if the sample is made of more than two types of plastics, i.e. coke bottles (cap and the labels).

f. Sorting, categorizing, photographing and quantifying

Start by ensuring the plastics are dry as any residual water will affect the weight of the sample. Identify the recycling number on the back or bottom of the plastic sample. If the number is not visible, use the typology sheet to determine the properties of the plastics, i.e. is it soft, flexible, hard, clear/colored, twists bends etc. (see Table 3). Based on properties and its uses, sort each plastic sample into the various plastic categories. After sorting the samples spread the plastics out again and photograph

Table 3: Plastic categories used to develop macroplastic typology for citizen science river and wetland monitoring

CATEGORY	ITEMS	CHEMICAL COMPOSITION
1	Cooldrink bottles, Water bottles, Salad dressing bottles, Medicine bottles, Peanut butter bottles, Combs, Rope, Tote bags, Carpet	Polyethylene Terephthalate
2	Milk jugs, Juice containers, Grocery bags, Bin bags, Motor oil containers, Shampoo and conditioner bottles, Soap bottles, Detergent containers, Bleach containers, Toys	High-Density Polyethylene
3	Plumbing pipes, Tile, Shoes, Gutters	Polyvinyl chloride
4	Cling wrap, Sandwich bags, Squeezable bottles for condiments such as honey and mustard, Grocery bags, Frozen food bags, Flexible container lids	Low-density polyethylene
5	Disposable nappies, Tupperware, Kitchenware, Margarine tubs, Yogurt containers, Prescription bottles, Bottle caps, Take-out containers, Disposable cups, and plates	Polypropylene
6	Disposable coffee cups, Plastic food boxes, Packing foam	Polystyrene
7	Plastic CDs and DVDs, Large water bottles with multiple-liter capacity, medical storage containers, Eyeglasses, Lighting fixtures	(polycarbonate, polyctide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon)

Equipment needed: camera, lab sheet

Remember to:

- Always check for the recycling number first
- Use the plastic typology as a guide

Figure 3: Citizen scientists at work cleaning and sorting plastic

2.2.6 Counting and weighing

For each plastic category, count the number of plastics that were sampled and record on a data sheet similar to Table 4. Samples will be weighed using a 4-digit, electronic balance. The samples must be weighed indoors in closed room, free from winds and must be placed on a counter free from vvibrations. This can be achieved by placing it on a quarts counter table or stainless-steel tray. Ensure that the balance is level by checking that the bubble on the balance is centralised. Using the balance, weigh the plastics in each category, and record on the data sheet provided. The balance records up to 4 decimal places. Ensure to capture all decimal points as often small/light weight pieces of plastic are often sampled. Other samples collected in the field may be too large to fit in the balance. In these cases, use a portable hanging scale. Hook a zip-lock bag onto the scale and insert the sample into the zip-lock bag to get a reading.

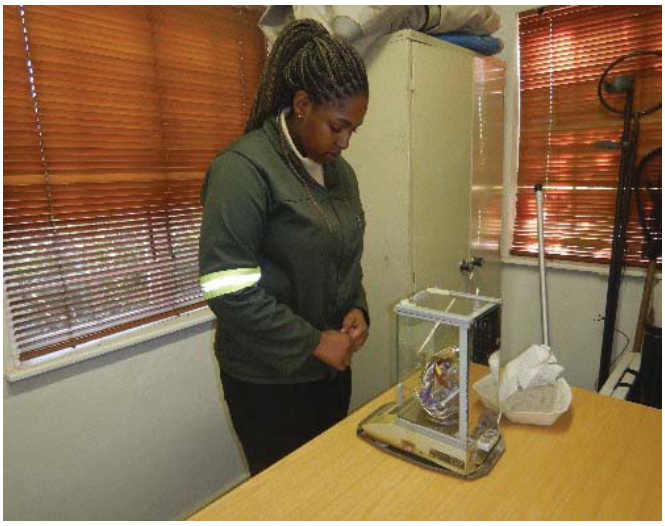


Figure 4: Citizen scientist weighing plastic sample using a 4-digit electronic balance

Table 4: Macroplastic weight data recording sheet

Site: 1/Team A													
Date02/08/22		RIVER									WETLAND		
Plastic type/category	Quantity	IN1	IN2	0	UEP1	UBP1	VEP2	UB2	VEP3	VBP3	WDE1	WDE2	WDE3
PET	n	0	0	0	1	1	0	1	0	0	4	0	0
	g	0	0	0	20	25	0	12	0	0	130	0	0
HDPE	n	0	0	0	6	7	23	0	11	14		6	13
	g	0	0	0	1.8465	5	245	0	31	75		21.59	50
PVC	n	0	0	0	0	0	0	0	0	0	0	0	0
	g	0	0	0	0	0	0	0	0	0	0	0	0
LDPE	n	0	0	1	11	35	33	10	5	15		13	22
	g	0	0	0.021	8.453	20	150	11.8346	59.499	6.6765		12.36	20
PP	n	0	0	0	3	10	3	7	10	0	0	20	18
	g	0	0	0	8.853	100	35	2.035	35.0615	0	0	85	50
PS	n	0	0	0	8	0	0	6	0	0	0		13
	g	0	0	0	7.6753	0	0	0.5881	0	0	0		19.1289
OTHER	n	0	0	0	0	0	3	0	1	3	0	5	4
	g	0	0	0	0	0	65	0	0.045	65	0	1.0366	0.075

IN - Instream
UEP - unvegetated edge point
UB - unvegetated bank point
VEP - vegetated edge point
VBP -vegetated bank point
WDE - wetland disturbed edge

2.2.7 Analysis

Based on the data provided, a series of statistical analysis can be run and visually illustrated.

3. REFERENCES

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