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Global Plastics Leakage Baseline Data Summary Report, Ganges Delta Region, India

Report for fieldwork conducted March 2022

CSIRO Marine Debris Team* in collaboration with Madhyanchal Professional University[¥]

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Citation

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Foreword

Plastic volume in the ocean is increasing rapidly, affecting wildlife, economies, and potentially human health. Recent model projections suggest that somewhere between four and twelve million tons of plastic flow into the world's oceans each year, with much of this waste coming from urban centres (Jambeck et al. 2015). However, to date there has been very little data collected to empirically document the existence and extent of these plumes and to validate the model estimates.

Through this collaborative field-based project, CSIRO is developing the first global, empirical baseline estimate of mismanaged waste entering the coastal and marine environments near major urban centres in countries around the world. The project aims to identify links between land-based waste management and pollution entering the marine environment. The data collected is helping to clarify the magnitude of this pollution to the public, to industry and to policy makers. Learnings from the project can serve as a basis for decision making, and to support social pressure for investment in infrastructure and regulation for improved waste management. We hope the results can also be applied to engage with industry, the retail sector, government, and consumers alike regarding best-practices. We also aim to improve waste management and increase the value of plastic to reduce poverty and create alternative livelihoods that are socially, culturally, economically, and environmentally appropriate and sustainable.

We are carrying out this research in countries all over the world, and thus far have surveyed major metropolitan centres in numerous countries in the Asia Pacific region, as well as South America and Africa. In India, CSIRO and Madhyanchal Professional University joined together to help achieve this goal, with the support of numerous volunteers.

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Acknowledgments

This work has been supported by Madhyanchal Professional University and CSIRO Oceans and Atmosphere, with funding support from Oak Family Foundation. We thank the numerous participants for their efforts in the training sessions and field work. We also thank the citizens, government employees and interested members of the public who are committed to reducing litter, marine debris, and illegal dumping in the environment.

1 Introduction

Increasingly considered a tragedy of the commons of the 21st century (Vince and Hardesty 2016), plastic pollution is a wicked problem. Trash knows no geopolitical borders, moving with people, rivers, through the landscape and ultimately, if not managed properly, it can be lost into the global ocean. We know that mismanaged waste results in negative social, economic and ecological outcomes. There is substantial value in collecting data to help improve our understanding of the sources and drivers of why, when, where, and how waste is lost to the environment. Furthermore, knowing how waste moves through the environment, the impact our waste has on people, communities, wildlife and economies, and how we can implement policies to result in better outcomes, can arm us with the knowledge to make better decisions. Data collected properly and consistently affords us a metric, a tangible means of measuring change through time and space. This is fundamentally important to understand how effective new actions, activities and legislative measures are in terms of reducing waste entering the environment.

In late 2016, CSIRO was successful in securing funds to embark on a world first project which aims to quantify how much waste is leaking to the environment, where it is entering the environment, and to identify interventions that may be successful in stemming the flow of plastic pollution from land to the sea. The primary objective of the project is to use field sampling and mathematical modelling to document the distribution of plastic in the ocean, on the coast and in the nearshore environment generated by major urban centres and surrounding areas that have been identified as having significant waste mis-management losses into the coastal/marine environment. We initially targeted 6-8 major metropolitan areas in different countries around the world, with a focus in Asia. We are focusing on this part of the world because it has been identified as a region of high waste losses to the environment (Jambeck et al. 2015). Furthermore, recent work has suggested that many of the world's major polluting rivers are located in Asia (Lebreton et al. 2017). Rivers are increasingly recognized as critical conduits to plastic waste entering the oceans (Wagner et al. 2019), further highlighting the need for research – such as this – where empirical data is used to ground-truth predictions and inform model-based estimates of waste in the environment.

Understanding the transport of plastics from land into coastal and marine systems is critical for modelling the distribution and trends of plastic in the ocean, estimating its impact on regional economies near sources, and clarifying the magnitude of this pollution to the public, to industry, and to policymakers. With a robust, comparable baseline of information, we not only are poised to evaluate policy effectiveness and change through on-ground activities at local, national and international scales, but we are starting to see these changes happen.

A further objective of the global plastics leakage project is to increase the capacity and skillset for on-ground partners in multiple countries, helping to build the breadth and depth of skills to monitor coastal and ocean health beyond the life of this project. The more people are armed with knowledge and skills across jurisdictions, the better equipped individuals, communities, and governments will be to make the decisions needed to ensure the best outcomes possible to ensure growth, health, wealth and well-being and ensure sustainability and a reduction in waste leaking to the environment.

We hope that the results from this work can help to serve as an international baseline against which progress can be gauged through time and space. Ideally, governments from all levels, from local or municipal to state and national will be able to use the information from this work to inform or underpin policies and decisions that will ultimately lead to a reduction in waste entering the environment. We also hope that the results can provide opportunities to engage with industry regarding best-practices and product identification for major brands which are frequently lost into the environment.

1.1 A Partnership in Action

In January 2022, staff and students from Madhyanchal Professional University worked to quantify the amount of debris coming from land in the metropolitan and surrounding regional areas of Ganga Delta region, India, and arriving at the coast. The Ganga Delta region was selected in collaboration with our partners because it represented an area of significance within the country being located at the junction of the Ganges and Rupnarayan Rivers running into the Hooghly before entering the sea. Furthermore, Dr. Ashutosh Mohanty identified the region as an area that could be sampled within a reasonable time frame (~ 2 weeks) with a team he was able to assemble. Additionally, the region has a river system which could transport debris to the sea, and hence was deemed appropriate in the context of the overall global project. Our ultimate goal was to develop a baseline measurement of debris along an approximately 780 km stretch of coastline and the surrounding riverine and inland areas of Ganges Delta region. To this aim, we conducted field surveys that included coastal, inland, and river-side surveys following a statistically robust and user-friendly sampling methodology. Within a few days of (remote) training provided by the CSIRO team, the crew was ready to tackle the challenge of surveying for litter lost to the environment.

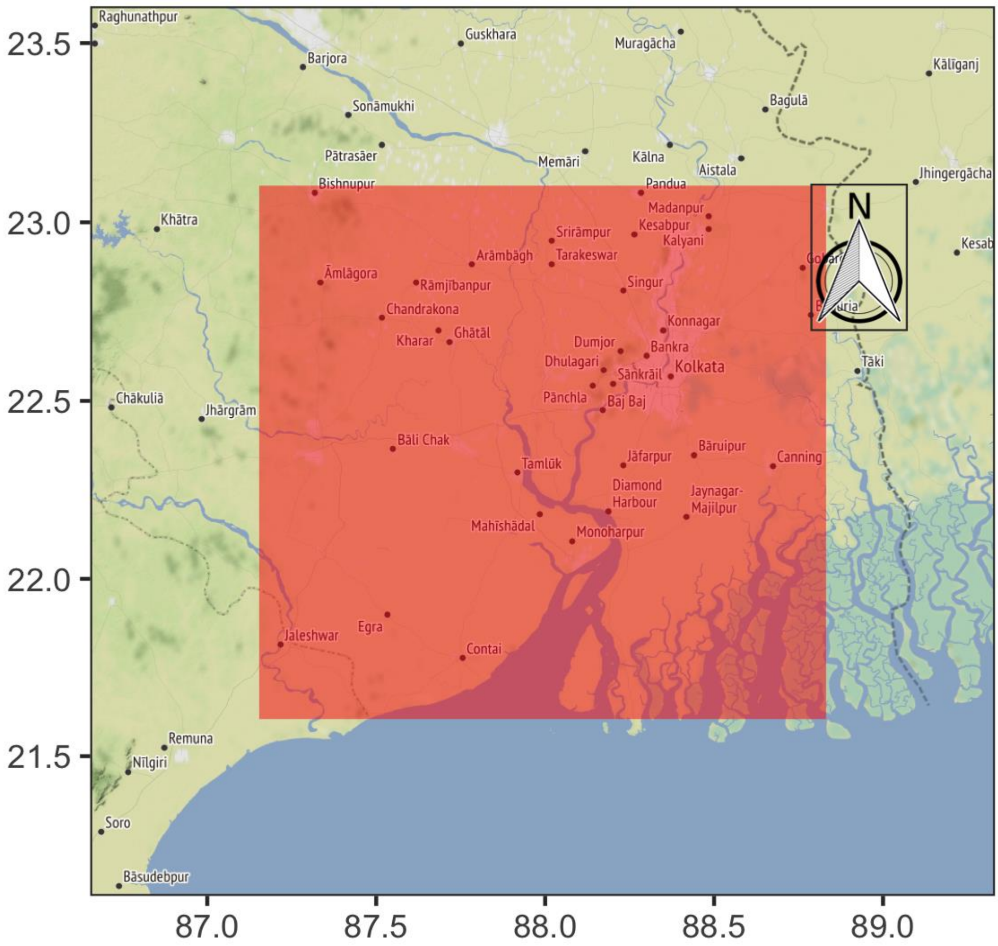

Figure 1: Location of study area.

1.2 Site Selection and Study Area

Our target area included the metropolitan and regional areas surrounding Ganges Delta region. We selected a region with roughly 780 km long coastline from Talasari in the west to the Sundarban National Park in the East. The inland and river sites surveyed extended inland past Pandua in the North.

Survey locations (inland, coastal and river sites) were provided by CSIRO to partners in India, so they could be assessed for suitability and any alterations needed could be made prior to conducting fieldwork. Sites were selected based on a suite of criteria and were intended to sample across the range of a variety of covariates, including population density, land use type, road and transportation networks. We aimed to strike a balance between sites that were representative across the watershed region we were surveying and ensuring travel times between sites were not so long as to make field work impractical.

While all the sites were selected in advance, occasionally chosen site locations could not be accessed in the field. This could be due to a range of reasons, including that the points fell on private land or were unsafe to access. In these instances, surveyors chose the nearest location that was accessible to and in a similar environment as the originally designated site.

The team attended 8 hours of training sessions held remotely over 3 days. During this time, participants and trainers worked together to ensure all participants received consistent, intensive training on how to collect, record, report, and make decisions regarding debris items, site selection characteristics, and other key factors required for consistency in data collection for the different survey methods (coastal, inland, and river). Following the training period, participants divided into a number of teams to carry out fieldwork safely and securely over the chosen study region. The group successfully completed surveys at a total of 90 sites (Figure 2).

1.2.1 Coastal sites

Coastal sites are defined as those sites that occur directly up to the ocean's edge. They could encompass any of a number of substrates and were not limited to sandy beaches. Coastal sites were selected between Talasari in the west to the Sundarban National Park in the east to the at approximately 20 km intervals along the coastline. We selected this interval because this provided us with an adequate or appropriate number of sites to be representative of the coastline as a whole and was enough samples to provide the statistical robustness required for analysis purposes.

1.2.2 Inland sites

To select inland survey sites, we placed a 5 km grid over the study region and selected the centre of each 5 km x 5 km cell. We then used globally available Geographic Information System (GIS) spatial layers to quantify several factors that have been shown in our previous work to be associated with the amount of debris or litter observed (covariates). Covariates included the local population density, land use type, distance to the nearest road, distance to the coast, distance to the nearest river and distance to the nearest railway station. We also used proxies for socio-economic status, including night lights within 1 km radius of the site. Additionally, we included a measurement of the total monetary value of the built environment (both rural and urban), calculated by the United Nations as part of a global exposure dataset aimed at on disaster risk management (GAR15) (UNDDR, 2015). We carried out a stratified random sampling design to select sites that covered, as much as possible, the full spectrum of these covariates that our previous work has identified as important and highly relevant (see Schuyler et al. 2021).

1.2.3 River sites

We used a global GIS data layer of rivers (https://hydrosheds.org/), and subset the layer to select sites every 11 km along the river features, starting at the coast. From this set of points, for ease of access, we selected sites that were less than 2 km from the road and no more than 10 km from another inland site.

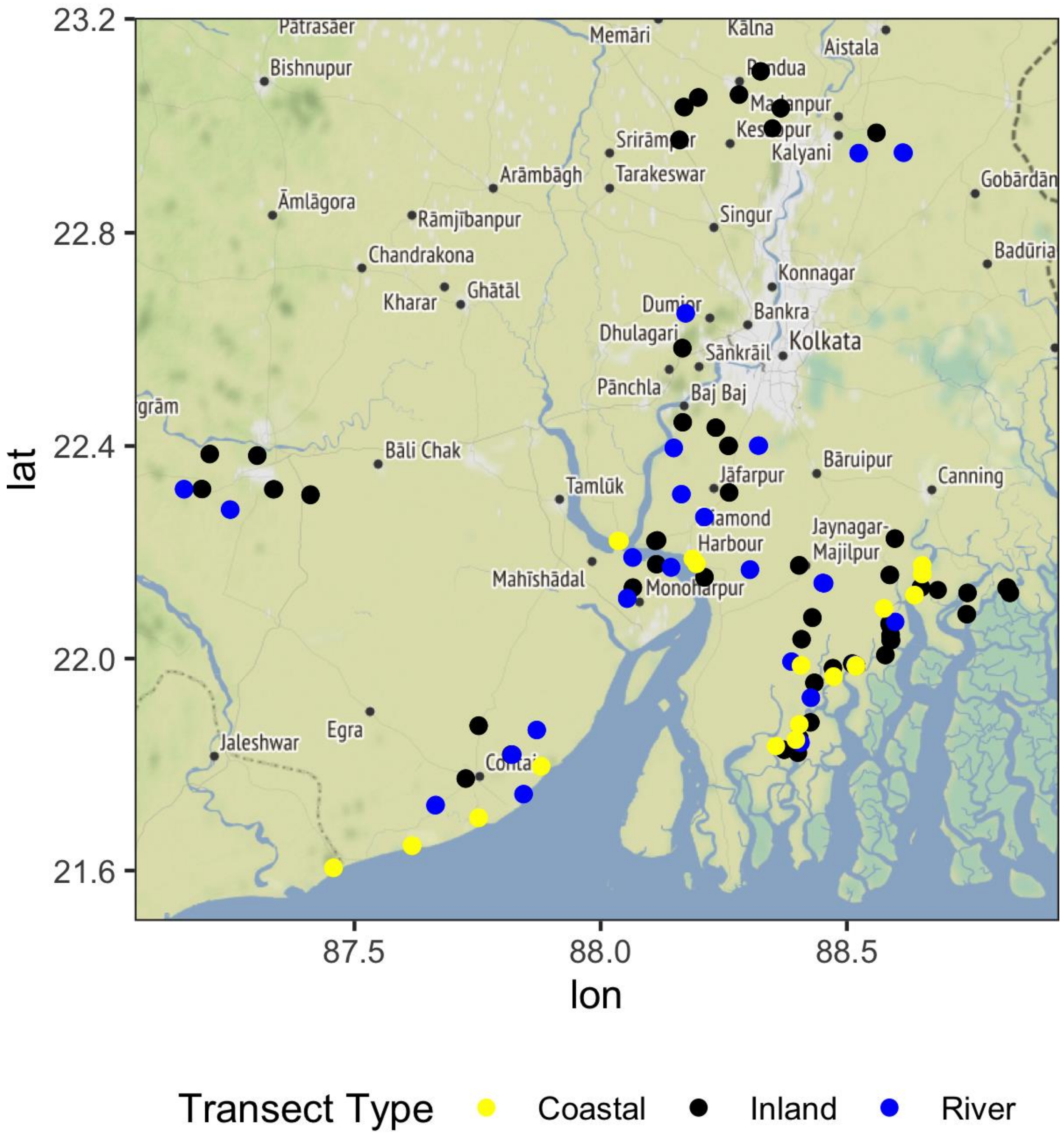

Figure 2: Location of completed surveys in the selected region of India. The yellow points are coastal sites, the black points are inland sites, the blue points are river sites.

2 Methods

All participants learned to search, record data, and lay out transects for river, inland and coastal surveys. Furthermore, participants were provided an electronic copy of CSIRO's survey methods handbook for reference.

Debris was measured at each land-based site type (river, coastal and inland) using a consistent survey method. Once a site was chosen, a Site Information Sheet was completed before any surveys took place. Information was recorded about the site's aspect, accessibility, apparent cleanliness, and number of people present, as well as weather conditions, time of day, and details of the survey recorder.

At each site, a minimum of three and a maximum of six transects were carried out. For river and coastal surveys, transect lengths varied depending on site characteristics such as the width of the shoreline (distance from the waterline to the backshore vegetation) and riverbank height. There was no fixed length for these two survey types, the length of the transect was dependent upon the local environment, and each transect was 2 m wide. For inland surveys, survey dimensions were fixed at either 12.5 m long x 2 m wide, or 25 m long x 1 m wide.

Transects were laid out with a metre tape. For coastal and river transects, the transect always began at the water's edge and ran perpendicular until reaching two meters into the backshore vegetation. For inland transects, the starting point was that which was closest to the GPS location identifying the site. The transect was also divided into ten equal distance intervals that encompassed the full length of the transect. For example, an 18 m long transect would have ten 1.8 m intervals or segments. Typically, two people walked the transect (each surveying a 1 m wide swath) while a third person recorded the debris category for every item found, and whether it was a whole item or a fragment. This information allows us to understand whether the items are likely to have been recently littered or are slightly older and more degraded. Observers were each provided with a string that was one meter wide to ensure only items within the survey width were recorded. This prevents errors that can occur if observers include items that may fall just outside the one meter wide transect zone.

Each item observed was recorded in a debris category. The size class was also recorded for the first item found in each distance interval (and if no item occurs in that distance interval a 0 or dash (-) was recorded). The purpose of recording this size information is to gain an indication of the sizes of items across the each transect. We are striking the balance between time required and important information to collect. We acknowledge it would be too time consuming and labour intensive to record the size of every single item (particularly since we can sometimes report hundreds or even thousands of items on an individual transect).

3 Results and Discussion

A total of 1340 debris items were detected and recorded across the 90 sites surveyed.

The ten most abundant fragment debris items found in the surveys included food wrapper/labels and thin film carry bags (Figure 3). The most common fragment item was food wrapper/label with 55.8% of all fragment items found, followed by thin film carry bag at 23.3%.

The ten most abundant whole debris items found included food wrapper/label, with 48.5% of all whole items found, followed by thin film carry bag at 24.9% (Figure 4).

In terms of debris density, coastal surveys had the highest debris density with 0.26 items found per m2 (Figure 5). Overall, coastal debris density was 1.9 times that observed at river sites, and 1.2 times that observed at inland sites.

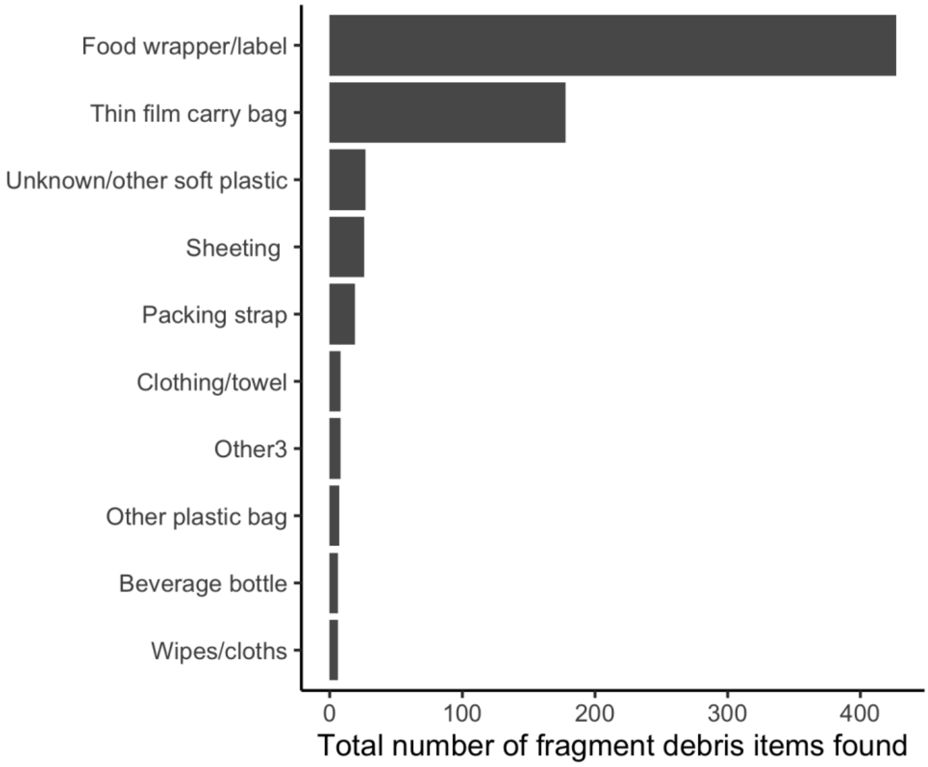

Figure 3: The ten most abundant debris items (fragments) found across the coastal, inland, and river surveys combined.

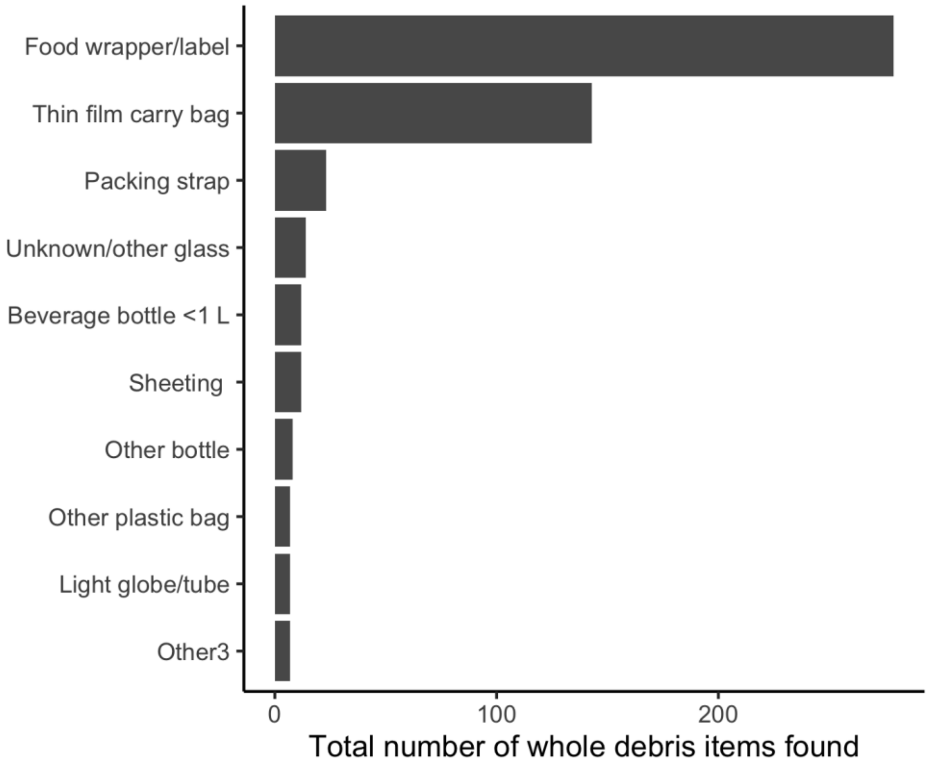

Figure 4: The ten most abundant debris items (whole) found across the coastal, inland, and river surveys combined.

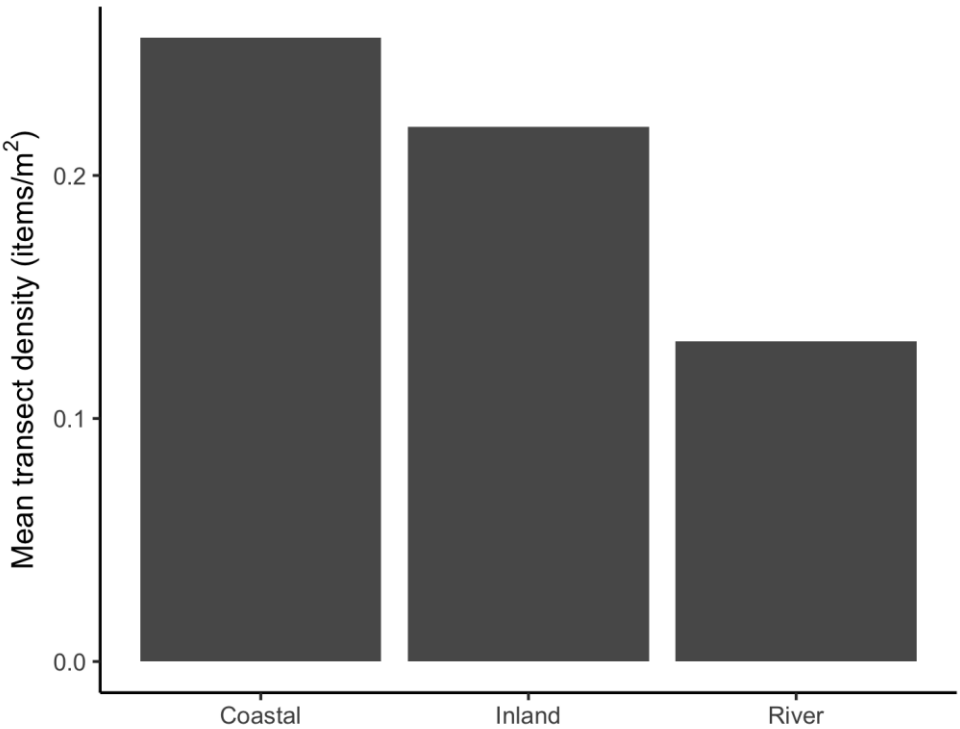

Figure 5: The mean transect density of debris found in the coastal, inland river surveys.

3.1 Coastal Surveys

A total of 53 transects were completed at 18 coastal sites. Overall, 340 items were recorded within coastal surveys. On average, across all transects, 3.2 items of debris per lineal metre of coastline were recorded. If this estimate is representative of the entire 7,516 km of Indian coastline (downloaded from Wikipedia 25/05/2021), this would equate to an estimated total debris load of over 24 million items along the entire coastline of India. We acknowledge that this is at best a ballpark estimate, given the variability in annual weather patterns, coastal topography, population density, and other factors, but it provides a baseline to understand the relative magnitude of the problem.

Food wrapper/label was the most common fragment type found with 128 pieces or 65.0% of the total fragment items recorded. Thin film carry bag was the second most recorded item with 38 items recorded and sheeting was the third most common, with 9 pieces recorded.

Food wrapper/label was the most common whole item found with 87 pieces or 60.8% of the total whole items recorded. Thin film carry bag was the second most recorded item with 32 items recorded and unknown/other glass was the third most common, with 4 pieces recorded.

These results clearly show the prevalence of soft plastics in the survey region, particularly of single use, consumer plastics.

A size class was estimated for 171 debris items with size class 2 being the most common found (size class 2 objects are larger than $1cm^2$, but smaller than 2cm x 2cm). For further information refer to the size class chart in the [Marine Debris Survey Handbook] (https://research.csiro.au/marinedebris /resources/). Of all items recorded, 52% were $16cm^2$ or smaller.

There was substantial variation in the number of debris items observed across the coastal surveys (in the unit of log number of items per lineal metre) (Figure 6). The highest number of items found on a coastal survey was at site IGC12 located at 21.987, 88.518, in the rural area of the Debipur Gurguria region. Of the 46 items recorded at this site, 11 of them were classified as S2_W: Food wrapper/label whole.

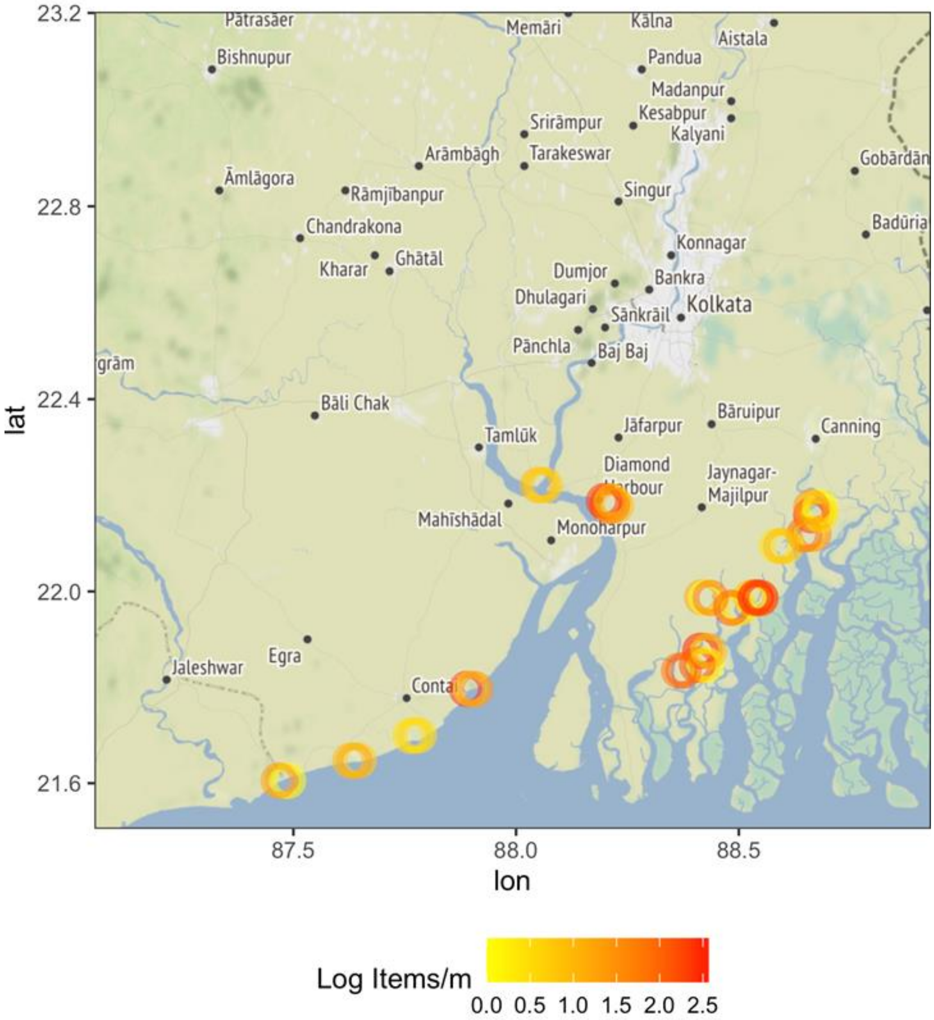

Figure 6: The log number of items per lineal metre for coastal sites in India.

3.2 Inland Surveys

The team completed 144 transects at 49 inland sites across a range of site types including roadways, car parks, natural vegetation and agricultural landscapes. A total of 766 items were recorded on inland transects, equivalent to an average of 0.22 pieces of debris for every square metre of land surveyed.

Food wrapper/label was the most common fragment type found with 226 pieces or 53.7% of the total fragment items recorded. Thin film carry bag was the second most recorded item with 99 items recorded and packing strap was the third most common, with 16 pieces recorded.

Food wrapper/label was the most common whole item found with 168 pieces or 48.7% of the total whole items recorded. Thin film carry bag was the second most recorded item with 82 items recorded and packing strap was the third most common, with 17 pieces recorded.

A size class was estimated for 374 debris items with size class 2 being the most common found (size class 2 objects are larger than $1cm^2$, but smaller than 2cm x 2cm). For further information refer to the size class chart in the Marine Debris Survey Handbook. Of all items recorded, 60% were $16cm^2$ or smaller.

There was substantial heterogeneity in the number of debris items observed across the inland surveys (in the unit of log number of items per square metre) (Figure 7). The highest number of items found on an inland survey was at site IGI134 located at 21.985, 88.519 just south of Kisorpur (Figure 7). Of the 59 items recorded at this site, 26 of them were classified as S2_W: Food wrapper/label whole.

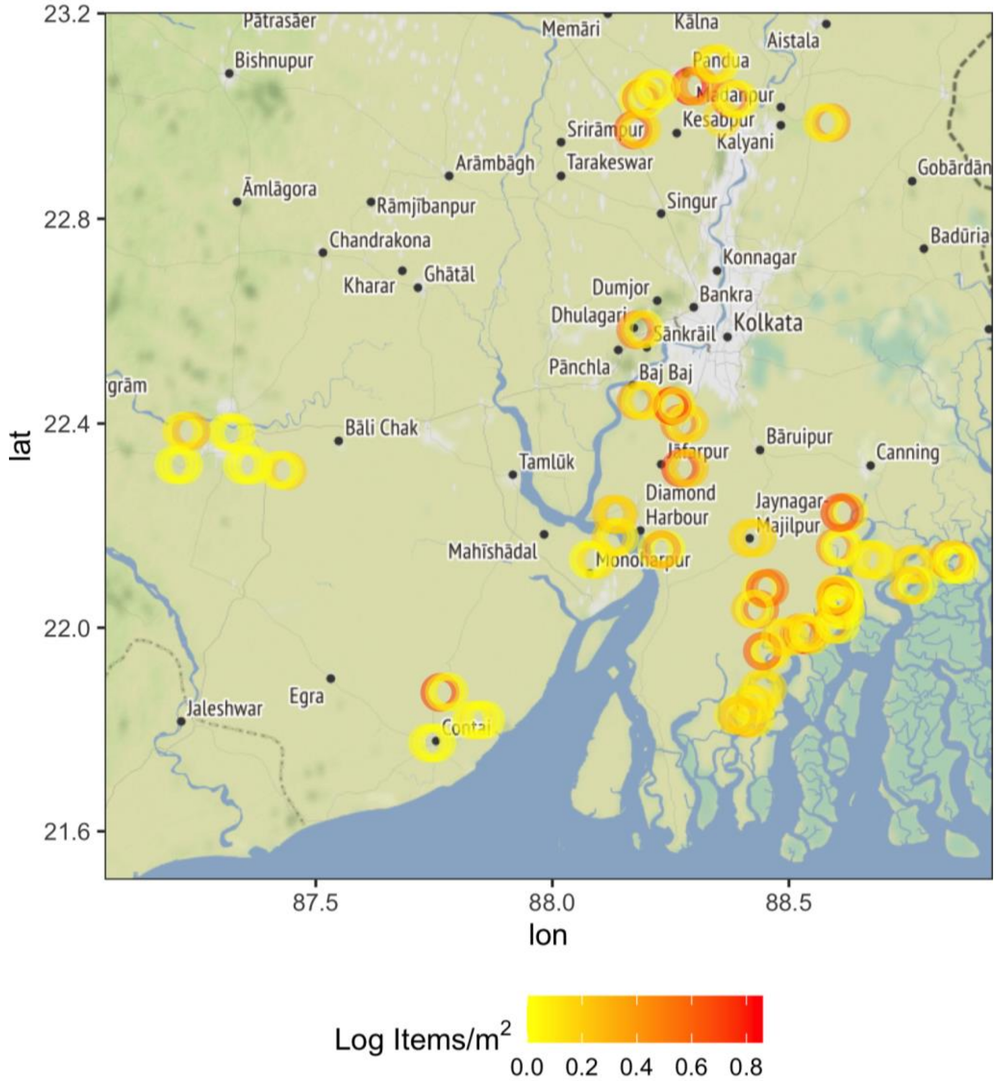

Figure 7: The log number of items per square metre for inland sites in India.

3.3 River Surveys

A total of 71 river transects were conducted at 23 river sites. A total of 234 items were recorded in river surveys, an equivalent of 2.66 pieces of debris for every lineal metre of riverbank surveyed (on average).

Food wrapper/label was the most common fragment type found with 73 pieces or 49.7% of the total fragment items recorded. Thin film carry bag was the second most recorded item with 41 items recorded and sheeting was the third most common, with 11 pieces recorded.

Thin film carry bag was the most common whole item found with 29 pieces or 33.3% of the total whole items recorded. Food wrapper/label was the second most recorded item with 24 items recorded and sheeting was the third most common, with 8 pieces recorded.

A size class was estimated for 153 debris items with size class 3 being the most common found (size class 3 objects are larger than 2cm x 2cm, but smaller than 4cm x 4cm). For further information refer to the size class chart in the Marine Debris Survey Handbook. Of all items recorded, 47% were less than $16cm^2$.

Figure 8 shows the variability in the number of debris items observed across the river surveys (in the unit of log number of items per lineal metre). The highest number of items found on a river survey was at site IGR27 located at 22.949, 88.613 opposite to Haripukuria High School and south of Jalkarampur (Figure 8). Of the 34 items recorded at this site, 10 of them were classified as S1_F: Thin film carry bag fragments.

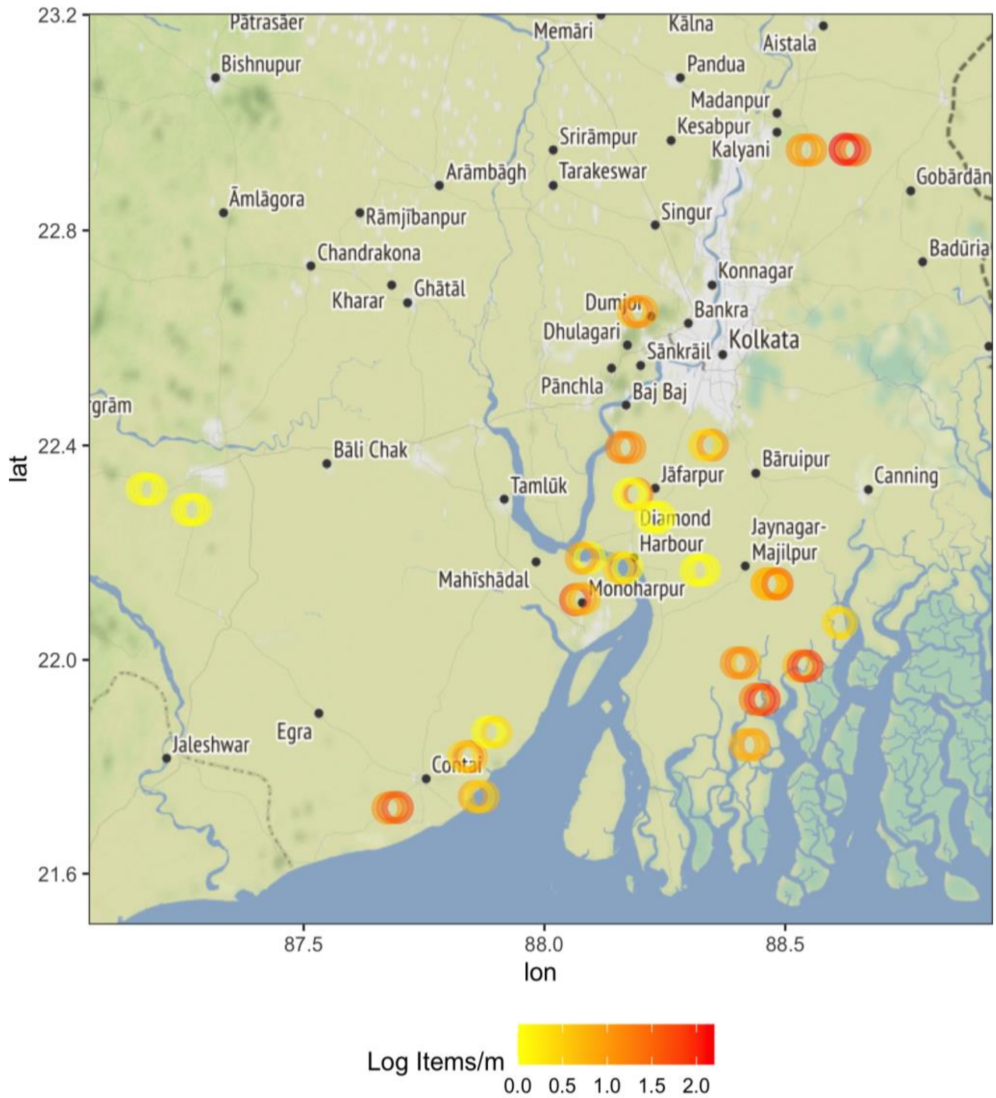

Figure 8: The log number of items per lineal metre for river sites surveyed in the Ganges Delta region.

4 Summary

Surveying the Ganges Delta region of India was a tremendous undertaking. A total of 268 transects (including 53 coastal transects, 144 inland transects, and 71 river transects) were completed. While we acknowledge these data provide a 'snapshot' in time, this information can be used as a baseline against which change and seasonal differences in debris deposition and movement can be compared. Such information provides an important first step that can be used to inform policy and decision making. Furthermore, as new policies or practices are implemented, the data can be used to quantify the changes that may come with such policies, practices or awareness-raising campaigns. We also hope to use these data in conjunction with statistical models to produce figures that highlight the litter plume of this urban and nearby area.

The data collected here contributes to a world first, statistically robust, global baseline study of how much waste is lost to the coastal and marine environment. By using the same methodology and building capacity for individuals in multiple countries around the world, we are better able to make large scale predictions about not only local, but also national, regional and global debris losses into the environment. Additionally, we can look at differences we identify in types and amounts of debris across coastal, inland and riverine areas between countries to identify the drivers that may be similar or different amongst surveyed regions.

Of particular note in this study is the prevalence of thin film carry bags and food wrappers. In river, inland, and coastal transects, these were the top two most commonly surveyed items. India has very recently (July 2022) implemented a single use plastics ban, however the ban does not at this stage include plastic bags, and food packaging would similarly be exempt. The results of this survey, however, can provide baseline data against which future bans could be measured.

It appears that the amount of debris on the Ganges Delta region coastline (3.2 items/m) is lower than the loads estimated along the Australian (10.2 items/m; Hardesty et al. 2016) and United States (16.5 items/m; Hardesty et al. 2017) coastlines based on previous survey work conducted by the CSIRO team. Using this dataset and others collected from around the world, ultimately we will be able to estimate the amount of waste, most of which is plastic, from these plumes that is lost to the open ocean or redeposited back to land. We are also able to discern regional differences that may occur. For instance, the most common debris item found in Kenya was hard plastics compared to Seychelles which was glass. With a robust, comparable baseline of information gathered in multiple major metropolitan centres around the world, we will have the data in hand to evaluate policy effectiveness and change through on-ground activities at local, national and international scales.

Understanding the transport of plastics from land into marine systems is critical for modelling the distribution and trends of plastic in the ocean and estimating its impact on regional economies. This project will clarify the magnitude of this pollution to the public, to industry, and to policy-makers.

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