Citizen consumer and civic Action Group

Microplastics findings in Kodungaiyur

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1. INTRODUCTION

Look around you. How many plastic items do you see? A lot? Since its inception only a few decades ago, it would not be an exaggeration to say that plastic has taken over our lives. However, the world is increasingly becoming aware/conscious that this invention is proving to be a great, toxic nuisance. While plastics can be seen almost everywhere, there is the additional problem of microplastics - extremely small pieces of plastics, invisible to the naked eye, and turning up everywhere they shouldn't be. Researchers are finding them in our oceans, in the air we breathe, soils, lakes, rivers, groundwater, in living organisms and in even the food we eat . The most dangerous reality of this is humans are interacting with these small plastic particles every day unintentionally, without their knowledge.. They are even showing up in rainwater samples collected from the Rocky Mountains with another study finding thousands of microplastic particles raining in the Pyrenees, 75 miles from the nearest city in France (demonstrates how pervasive this modern pollution is). Aggravated by the copious use of throw-away plastics (e.g. packaging material), the proportion of plastic contributing to municipal waste at present constitutes 12% of waste generated worldwide. With the growing global (mis-)use of plastics, their release to the environment is only going to skyrocket.

Microplastics are largely resistant to biological degradation and may also act as vectors for bacteria and viruses. Ecological concerns related to microplastics include their ability to absorb persistent organic pollutants (POPs) which can be transferred to animal tissues, causing bioaccumulation of POPs, and irritation of digestive tissues following ingestion. Most research has determined that microplastic contamination is ubiquitous in ecosystems worldwide. The potential impact of microplastics on public health and ecosystems is a growing public concern and has been on the top of the agenda of decision makers for some time now. So far mostly marine microplastic pollution has gained much traction but terrestrial microplastic pollution is estimated at 4 to 23 times higher than marine microplastics pollution, depending on the environment.

1.1. So, what are microplastics?

The term "microplastic" was formally introduced in 2004 in the study titled 'Lost at Sea: Where Is All the Plastic?'. There is currently no internationally agreed definition of microplastics. The ECHA (European Chemicals Agency) defines microplastics as "any (synthetic) polymer or polymer containing solid or semisolid particles that are not liquid or gas and having a size smaller than 5 mm in at least one external direction". Microplastics are often classified into two categories: primary and secondary. Primary microplastics are intentionally added to products like skin-care products and toothpaste. Secondary microplastics (MP) are unintentionally released during the use or the subsequent life-cycle stages of plastic containing materials and goods through wear and tear (broken down into even smaller pieces). When plastic particles break down, they gain new physical and chemical properties. Different studies have shown certain discrepancies on the range of MP sizes as well as an evolution of the terminology according to their impact as shown in figure 1.

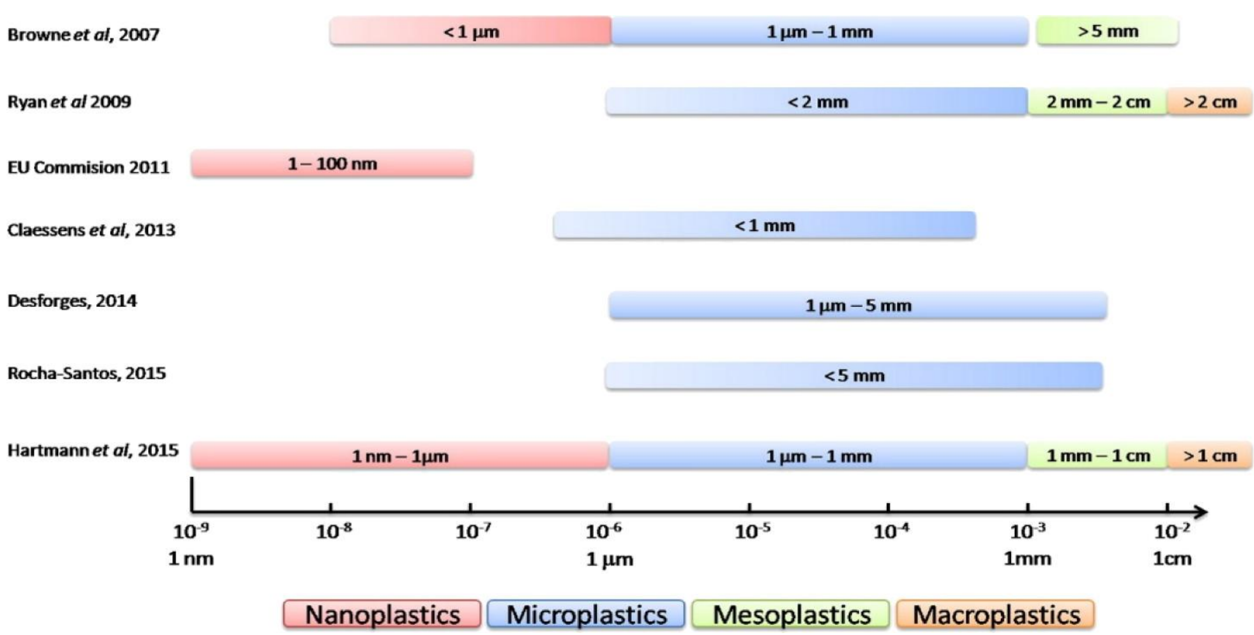

Figure 1: Definition of plastics as proposed by different authors (Source:shorturl.at/dpJ29)

The sustained and irresponsible growth of plastics production, unsustainable design of some plastic products, their packaging and application of plastic materials even where unnecessary has led to significant amounts of plastic waste being released into the terrestrial and aquatic ecosystems. Estimated movement of microplastics from the economy to the terrestrial and marine environment is shown in figure 2. The study of microplastics is a relatively new area of investigation and several challenging open questions still need to be addressed including evaluating the extent and relevance of their impacts on both aquatic life and human health. Ingredients in some plastics, such as polyvinyl chloride, can cause cancer. Phthalates are used to soften some types of plastics that can mimic the activity of hormones. These false hormones can cause unexpected changes in how cells grow and develop. The impacts of microplastics depend on their chemical composition and, possibly, their structure or shape. At present, no one knows how long it takes for microplastics to move through the human body, but the longer microplastics stay in our bodies, the greater the exposure and subsequently greater are the health impacts . Our drinking water comes from lakes, rivers and groundwater aquifers, and most of these are tainted with microplastics mainly because of unsustainable business practices. The World Health Organization (WHO) has recently called for a further assessment of microplastics in the environment and their potential impacts on human health.

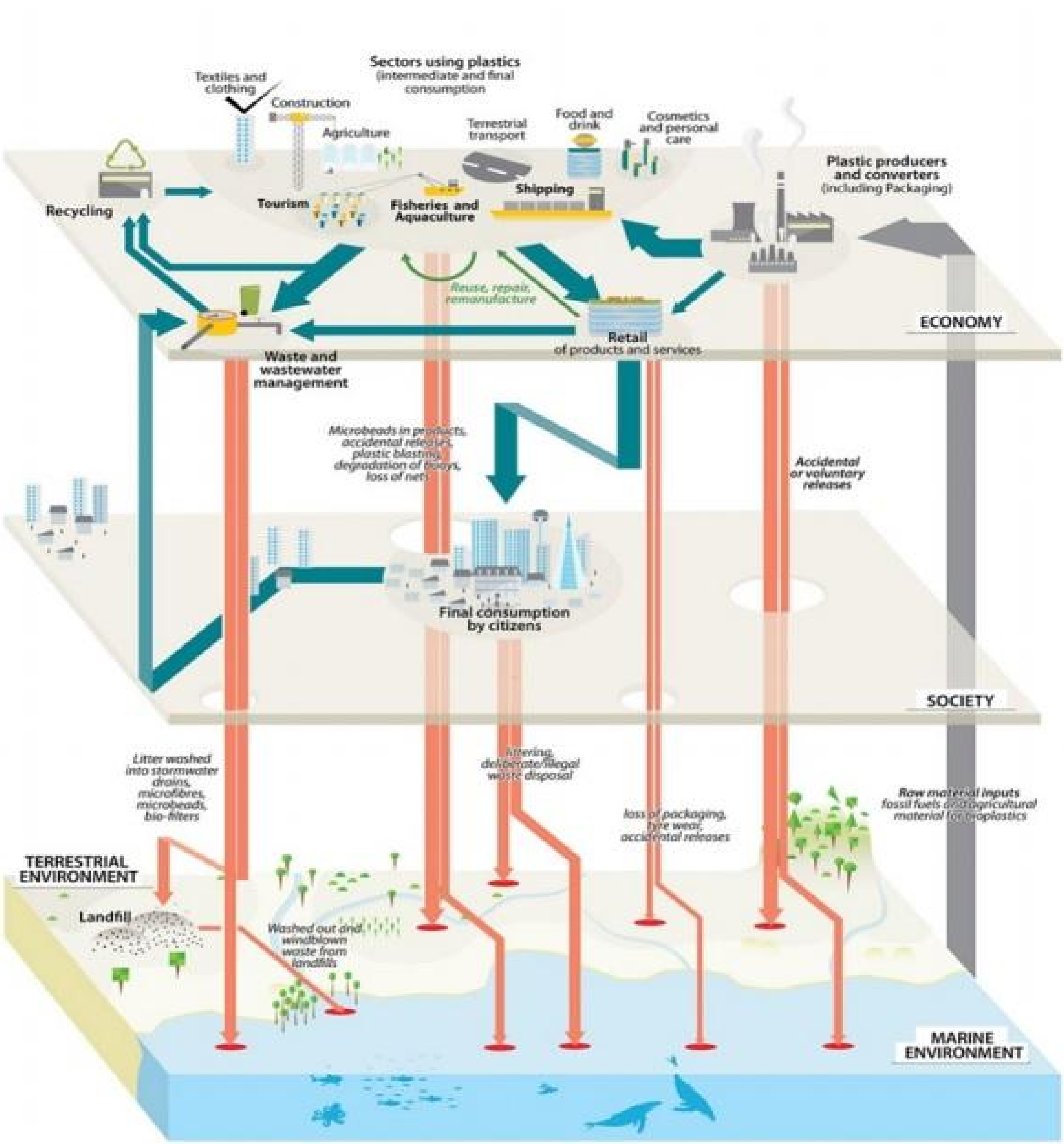

Figure 2: Movement of plastics from the economy to the terrestrial and marine environment
(Source: https://www.sapea.info/topics/microplastics/)

2. Research Methodology

At present, a standardised test method for analysing microplastics in water does not exist and WHO, other universities and research institutions have undertaken activities to work towards developing an internationally agreed upon and standardised analytical set of methods that allows comparisons of analytical results and define an appropriate methodological framework when studying MP.

There is an absolute lack of standardised method or guidelines for sampling water for microplastics. There is also no recognised international protocol for sample preparation (sampling, extraction, purification) and different analytical techniques for identification (polymer identification, particle size and mass) are applied (FT-IR (micro)-spectroscopy, Raman micro-spectroscopy, field flow fractionation, TGA-GC or pyr-GC, TEM/SEM, optical microscopy).

Depending on several literature reviews the determination of microplastics in water samples has been divided into 5 steps: sampling, separation, clean up, identification, and confirmation (Figure 3). The steps involved in the sampling process can be seen in figure 4.

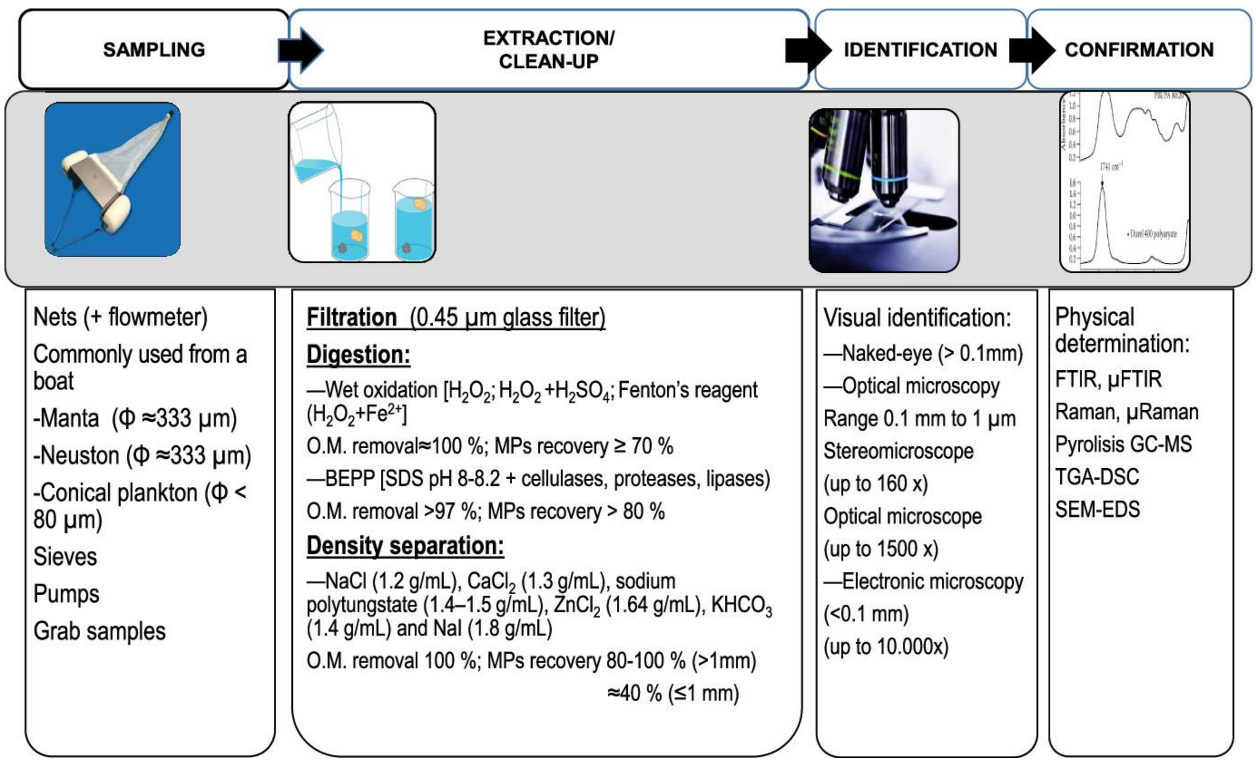

Figure 3: Different steps involved in sampling and analysis of MPs in water (Source: shorturl.at/diFRW)

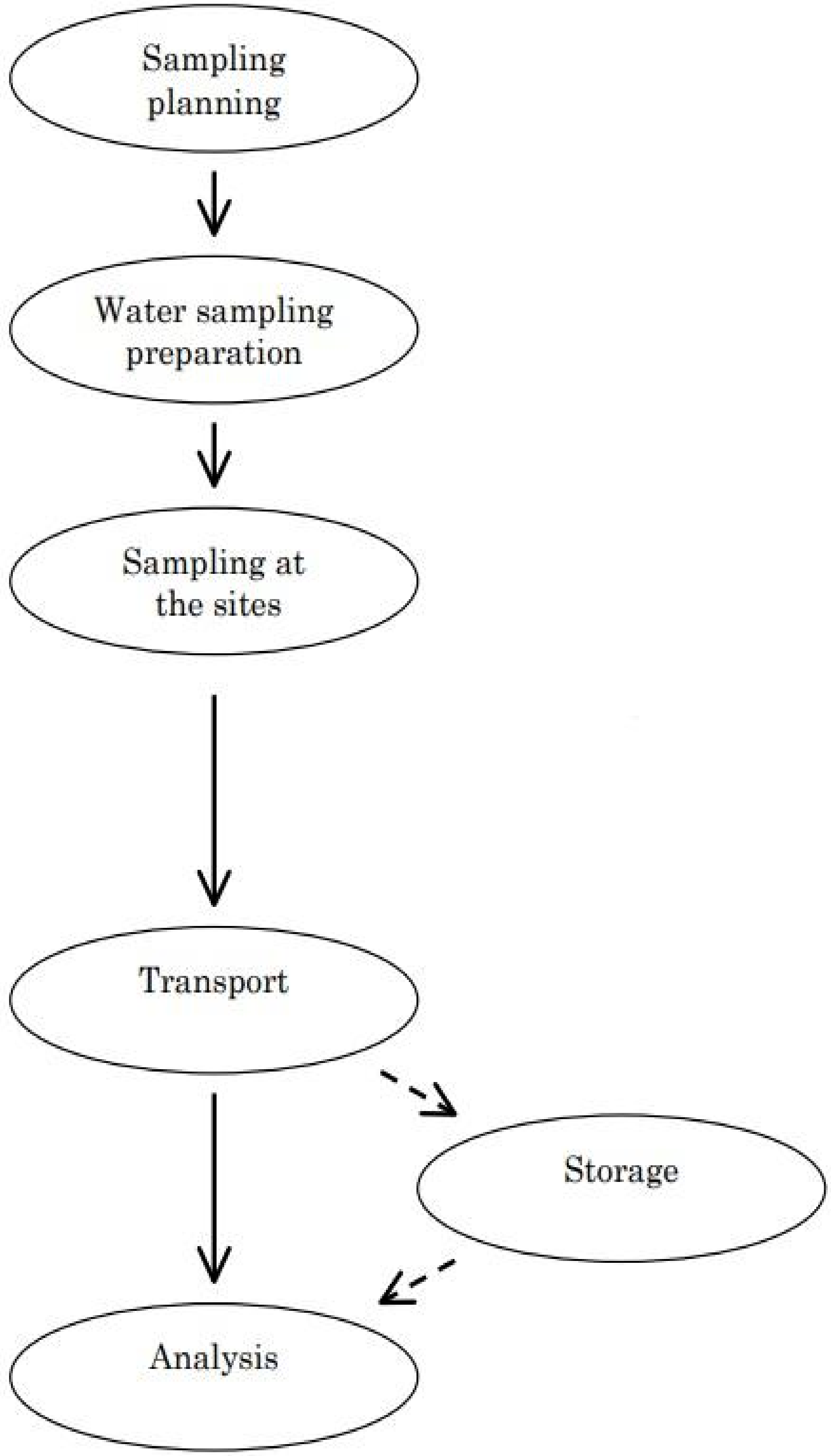

Figure 4: Flow chart showing different steps involved in sampling process

We have identified 40 locations (Figure 5) around the study area, the Kodungaiyur dumpyard, where plastics have been dumped in the ground layer after layer for the last 30-40 years.We have followed the grab sampling method. The locations are selected strategically in such a way that we have groundwater samples as near as 100 meters from the dumpyard and not more than 4000 meters radially with reference to the perimeter of the dumpyard. Kodungaiyur dumpyard is being used by the Greater Chennai Corporation (formerly known as the Corporation of Madras) from the last 30-40 years to dump all kinds of waste which also includes the plastic waste mostly created due to unsustainable practices by the manufacturers of this plastic.

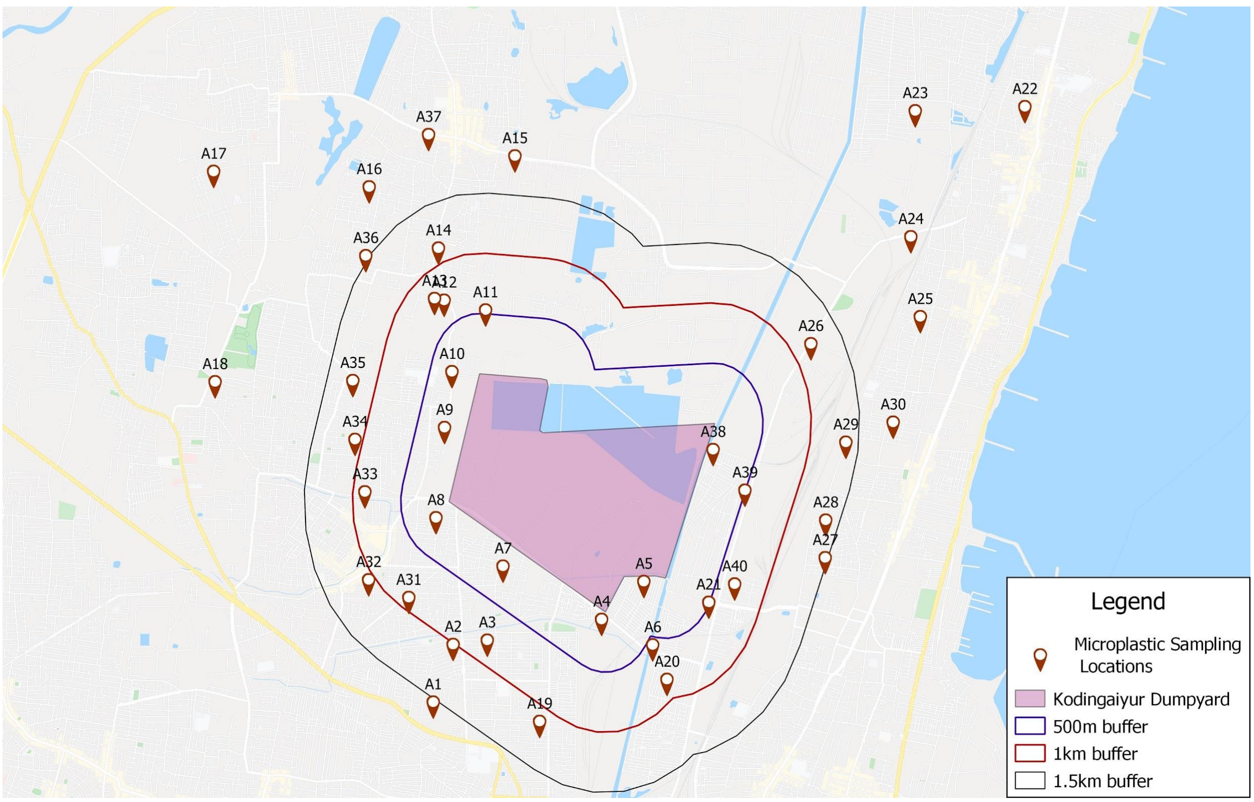

Figure 5: Locations to collect groundwater samples

Groundwater samples were collected during mid-January, 2020 and well water samples were collected from taps with untreated water. The water samples were collected not only to test for microplastics but also heavy metals. Heavy metals are added to plastics in order to improve the plastic features with light stabilisers, polymers or flame retarding agents. These additives are not bonded chemically to the matrix of polymeric materials and leach out under the influence of several physicochemical factors such as sunlight, temperature, type of solvents and also the pH of the stored commodity and release toxic substances to air, water and soil.

We measured temperature, pH, electrical conductivity (EC) and salinity on the field for each sample. A bucket is used to collect the groundwater from the source first and then the water is transferred to the respective bottles for heavy metals and microplastics identification (Figure 6). Sample bottles are washed 3-4 times with water from the exact site of sampling prior to taking the samples into the bottles and the water is carefully and gently poured into bottles by making sure that there are no bubbles. Samples for heavy metals were collected in 250 ml HDPE bottles which are washed with 10 % v/v nitric acid and then rinsed several times with pure (deionised) water before sampling and samples for microplastics were collected in sterilized 1-litre borosilicate glass clear reagent bottles with Teflon lined caps (Figure 6). We have made sure that sampling tools and containers are contamination free throughout the time of sampling by treating them according to the prescribed grab sampling guidelines.

Figure 6: Samples for microplastics and heavy metals testing

All the samples were ~90% filled with the water sample so as to provide space above the surface of the water sample to allow thorough mixing just prior to analysis and each sample was labelled clearly by using a water-resistant ink (Figure 7). For each sample a form has been prepared in advance to enter details such as sampling date, sample code, the start and finish time of sampling, an accurate position of the sampling site (an accurate G.I.S position), and persons responsible for handling the sample right from collection to transport to the laboratory. In addition, climatic conditions such as temperature, humidity and atmospheric pressure have been recorded in the form. After the collection, the samples are packed in ice and stored in ice-filled coolers. At the end of the day all the collected samples were transported to the laboratory in the same ice-filled coolers and kept refrigerated at 4°C until analysis. 40 samples have been collected over a span of two days.

Figure 7: HDPE bottle with labelling ‘A6’

3. Results and discussion

Based on the study we have decided that two microplastics particles per filter is considered as the minimum concentration for assuming microplastic contamination in a sample. University of Madras has analysed the samples in their laboratory using 0.45 µm filter and FTIR spectrometer. Microplastics are categorised based on their colours in this study. Colours are important because brown, for example, is often indicative of natural fibres. Other parameters for separating natural fibres from synthetic fibres include uniformity, thickness, and texture. All the 40 samples were found to be contaminated with microplastics with varying concentrations. The quantified result of microplastics is shown in figure 8.

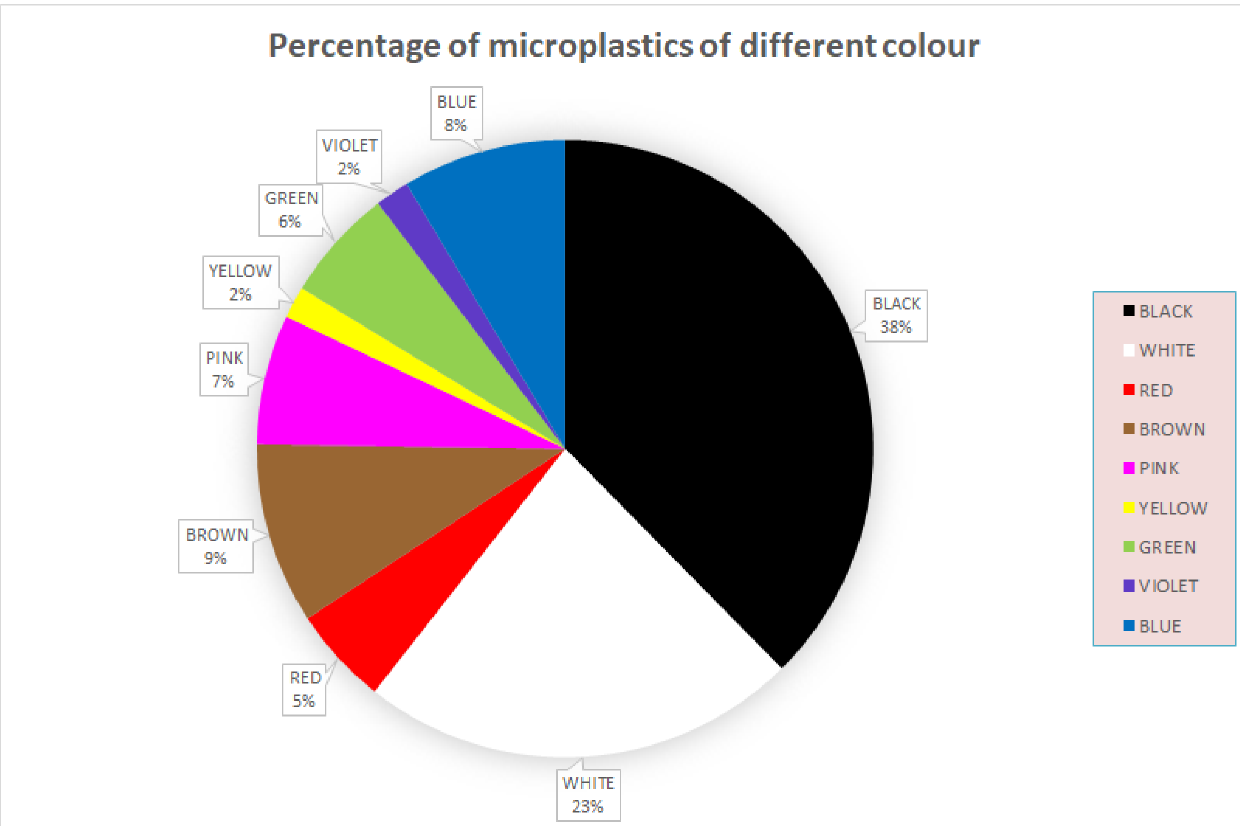

Figure 8: Pie Chart showing percentage of microplastics of different colour in the combined 40 samples

9 samples out of the 40 samples are within the radius of 500 metres from the Kodungaiyur dumpyard and on an average each sample had around 23 particles of microplastics per litre. 10 samples were in the region of 1000 metre radius from the Kodungaiyur dumpyard and each of these samples had an average of 23 microplastics/litre. 10 samples are in the region of 1500 metre radius from the Kodungaiyur dumpyard and each of these samples had an average of 17

microplastics/litre. Microplastics are of different classes and they can be in the shape of bead, fragment, fibres and foam. The analysis indictes that the bead, fragments and foam type microplastics are nil and the fibre class are the dominant microplastics present in the study area. 40 samples contained a total of 896 (Figure 9) microplastics and black microplastics (38%) (Figure 8) occupy the highest percentage followed by white microplastics. It is already a proven fact that black plastics are the most difficult type of plastic to recycle. Microplastics present in sample A5 can be seen in the figure 10. Black plastic trays are often used to package ready meals, as well as trays for meat, fruit and vegetables. It’s seen as the most appealing way to present many foods (another agenda by the producers), because the dark plastic makes colourful foods stand out well in contrast. One of the major causes for the high contamination of groundwater samples (500-1000 metres range) by microplastics is due to the leaching that is happening from the dumpyard filled with plastic waste. All the microplastics fibres found in the groundwater points to the fact that the water is not suitable for drinking purposes. When the water contaminated with microplastics is heated at 100 degrees Celsius it might also release dioxins which are carcinogenic. Most of the plastics melt well above 100 degrees Celsius but PVC (plastics with number 3) melts at as low as 75 degrees Celsius.

SAMPLE NO.	BLACK	WHITE	RED	BROWN	PINK	YELLOW	GREEN	VIOLET	BLUE	Total no. of microplastics per Litre
A1	7	20	4	2	5	3	6	9	9	65
A2	7	13	2	0	8	1	4	1	0	36
A3	16	6	4	2	17	0	5	1	3	54
A4	9	9	2	1	7	0	0	1	10	39
A5	3	4	0	0	0	0	0	0	0	7
A6	5	11	2	0	2	0	6	0	0	26
A7	9	4	0	4	0	0	6	0	1	24
A8	5	5	1	0	0	2	0	1	0	14
A9	6	15	0	0	0	3	0	0	2	26
A10	12	2	0	2	0	0	1	0	1	18
A11	28	4		4	0	0	0	0	0	36
A12	6	6	1	1	0	0	1	0	0	15
A13	9	2	0	12	0	0	1	0	2	26
A14	4	0	1	6	0	0	1	0	1	13
A15	8	0	1	1	0	0	0	0	0	10
A16	20	13	5	0	0	0	3	0	0	41
A17	8	1	0	4	0	0	0	0	0	13
A18	8	2	1	2	0	0	0	0	3	16
A19	2	11	0		6	0	5	0	2	26
A20	9	5	0	0	1	0	1	0	0	16
A21	20	2	0	8	3	0	0	0	3	36
A22	7	3	1	1	1	0	0	0	2	15
A23	10	2	0	3	0	0	0	0	2	17
A24	9	0	0	4	2	0	1	1	4	21
A25	5	0	0	1	1	0	0	0	2	9
A26	4	3	0	0	1	0	0	1	2	11
A27	9	6	2	0	0	0	1	1	0	19
A28	14	7	2	0	1	0	0	0	1	25
A29	4	0	1	10	0	0	1	0	1	17
A30	2	2	2	0	1	0	0	0	4	11
A31	3	7	0	0	0	0	0	0	5	15
A32	4	5	1	1	0	0	0	0	2	13
A33	7	2	1	4	0	0	0	0	4	18
A34	3	5	2	0	0	0	2	0	0	12
A35	13	5	1	2	0	0	0	0	2	23
A36	9	0	1	2	1	0	0	0	1	14
A37	10	20	4	1	3	6	7	0	6	57
A38	5	4	2	5	1	0	0	0	0	17
A39	6	0	1	1	0	0	1	0	1	10
A40	12	0	1	1	0	0	0	0	1	15

Figure 9: Count of different coloured microplastics in the 40 samples collected

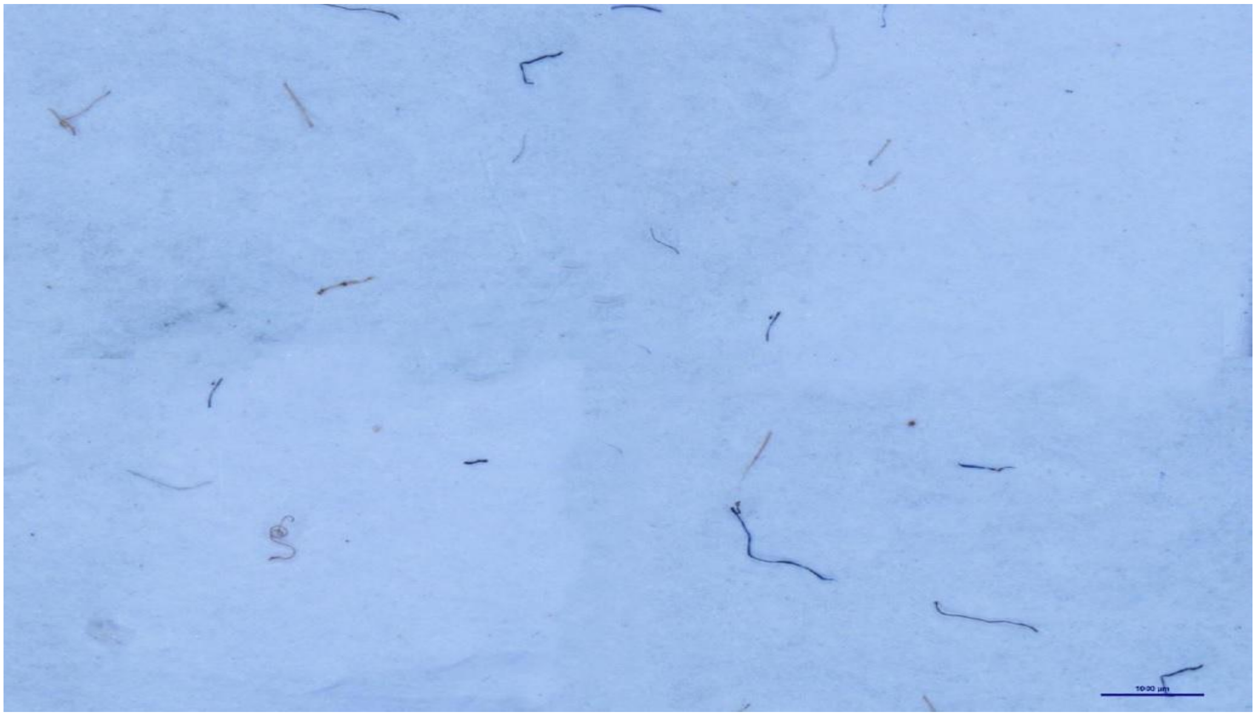

Figure 10: Microplastics in sample A5

Groundwater samples were also collected to test the presence of heavy metals in the study area. Iron, Nickel, Copper, Manganese, Chromium, Lead, Zn and Cobalt are the heavy metals that have been selected to identify as these are some of the most predominantly used heavy metals in various plastic products. The Bureau of Indian Standards (BIS) in 2012 has released their latest guidelines for the permissible and acceptable limits for various heavy metals. The permissible and acceptable limits for the selected heavy metals as per BIS 2012 are presented in the figure 11.

Heavy Metal	Bureau of Indian Standards (BIS) 2012	
	Permissible Limit (ppm)	Acceptable Limit (ppm)
Iron	0.3	0.3
Nickel	0.02	0.02
Copper	1.5	0.05
Manganese	0.3	0.1
Chromium	0.05	0.05
Lead	0.01	0.01
Zn	15	5
Cobalt	No Guideline	No Guideline

Figure 11: Acceptable and permissible limits for selected heavy metals as per BIS 2012

These heavy metals have direct or indirect impact on the human body/ health. Some of these heavy metals such as copper, cobalt, iron, nickel, magnesium, molybdenum, chromium, selenium, manganese and zinc have functional roles which are essential for various diverse physiological and biochemical activities in the body. However, some of these heavy metals in high doses can be harmful to the body while others such as cadmium, mercury, lead, chromium, silver, and arsenic in minute quantities have deleterious effects in the body causing acute and chronic toxicities in humans. Some of the heavy metals and their effects on different organs is presented in table 1. Except for four samples, all of them had Lead (Pb) concentration well above the permissible and acceptable limit (Figure 12 & 13). Nickel (Ni) have been detected above the permissible limit in 50% of the samples and Manganese (Mn) and Chromium (Cr) have been detected above the permissible limit in 25% of the samples (Figure 13).

Metal	Target Organ	Clinical effects
Chromium (Cr)	Pulmonary	Ulcer, Perforation of Nasal Septum, Respiratory Cancer
Manganese (Mn)	Nervous System	Central And Peripheral Neuropathies
Lead (Pb)	Nervous System, Hematopoietic System, Renal	Encephalopathy, Peripheral Neuropathy, Central Nervous Disorders, Anemia
Nickel (Ni)	Pulmonary, Skin	Cancer, Dramatis

Table 1: Heavy metals and their effects on different body organs

Sample No.	Iron (Fe)	Nickel (Ni)	Copper (Cu)	Manganese (Mn)	Chromium (Cr)	Lead (Pb)	Zinc (Zn)	Cobalt (Co)
A1	0.041	0.053	0.002	0.003	0.018	0.064	0.045	0.009
A2	0.017	0.032	0.012	0.018	0.011	0.046	0.001	0.004
A3	0.029	0.005	0.005	0.007	0.015	0.023	0.006	0.028
A4	0.079	0.031	0.017	0.018	0.014	0.021	0.038	0.006
A5	0.015	0.003	0.013	0.029	0.11	0.052	0.029	0.016
A6	0.11	0.004	0.006	0.558	0.032	0.187	0.029	0.012
A7	0.075	0.065	0.015	0.005	0.047	0.205	0.046	0.035
A8	0.104	0.027	0.022	0.089	0.004	0.149	0.009	0.012
A9	0.063	0.01	0.013	0.029	0.013	0.07	0.039	0.04
A10	0.037	0.038	0.011	0.072	0.022	0.007	0.013	0.015
A11	0.071	0.064	0.011	0.164	0.078	0.195	0.032	0.01
A12	0.089	0.03	0.019	0.122	0.106	0.178	0.038	0.037
A13	0.094	0.021	0.013	0.577	0.035	0.1	0.025	0.01
A14	0.031	0.032	0.011	0.022	0.009	0.002	0.019	0.025
A15	0.045	0.032	0.01	0.029	0.008	0.118	0.007	0.004
A16	0.104	0.039	0.01	0.278	0.026	0.043	0.031	0.021
A17	0.002	0.004	0.001	0.012	0.073	0.057	0.01	0.019
A18	0.15	0.009	0.013	0.015	0.012	0.013	0.009	0.024
A19	0.068	0.002	0.007	0.012	0.09	0.004	0.021	0.021
A20	0.013	0.006	0.006	0.032	0.001	0.086	0.027	0.031
A21	0.117	0.03	0.003	0.044	0.044	0.036	0.016	0.029
A22	0.06	0.029	0.011	0.035	0.052	0.053	0.002	0.026
A23	0.105	0.018	0.012	0.357	0.003	0.018	0.014	0.014
A24	0.056	0.017	0.016	0.003	0.03	0.075	0.02	0.014
A25	0.043	0.016	0.011	0.513	0.055	0.165	0.016	0.025
A26	0.048	0.036	0.007	0.025	0.003	0.016	0.074	0.015
A27	0.028	0.025	0.009	0.025	0.027	0.051	0.007	0.011
A28	0.099	0.04	0.004	0.051	0.03	0.053	0.013	0.01
A29	0.131	0.039	0.002	0.048	0.026	0.018	0.025	0.031
A30	0.013	0.03	0.004	0.047	0.05	0.019	0.069	0.007
A31	0.294	0.011	0.007	0.43	0.083	0.009	0.36	0.026
A32	0.089	0.005	0.005	0.015	0.064	0.015	0.047	0.015
A33	0.058	0.023	0.005	0.059	0.022	0.058	0.058	0.014
A34	0.021	0.018	0.013	0.019	0.005	0.059	0.017	0.017
A35	0.117	0.068	0.018	0.042	0.104	0.145	0.036	0.048
A36	0.003	0.005	0.01	0.021	0.097	0.036	0.007	0.015
A37	0.115	0.024	0.006	1.18	0.022	0.105	0.02	0.025
A38	0.124	0.019	0.01	0.034	0.017	0.038	0.03	0.014
A39	0.061	0.006	0.011	0.033	0.019	0.065	0.048	0.019
A40	0.042	0.017	0.009	0.295	0.04	0.013	0.028	0.025

Figure 12: Concentration of heavy metals in ppm detected in the water samples (Values in red colour indicate that the detected value is higher than the acceptable limit)

Sample No.	Iron (Fe)	Nickel (Ni)	Copper (Cu)	Manganese (Mn)	Chromium (Cr)	Lead (Pb)	Zinc (Zn)	Cobalt (Co)
A1	0.041	0.053	0.002	0.003	0.018	0.064	0.045	0.009
A2	0.017	0.032	0.012	0.018	0.011	0.046	0.001	0.004
A3	0.029	0.005	0.005	0.007	0.015	0.023	0.006	0.028
A4	0.079	0.031	0.017	0.018	0.014	0.021	0.038	0.006
A5	0.015	0.003	0.013	0.029	0.11	0.052	0.029	0.016
A6	0.11	0.004	0.006	0.558	0.032	0.187	0.029	0.012
A7	0.075	0.065	0.015	0.005	0.047	0.205	0.046	0.035
A8	0.104	0.027	0.022	0.089	0.004	0.149	0.009	0.012
A9	0.063	0.01	0.013	0.029	0.013	0.07	0.039	0.04
A10	0.037	0.038	0.011	0.072	0.022	0.007	0.013	0.015
A11	0.071	0.064	0.011	0.164	0.078	0.195	0.032	0.01
A12	0.089	0.03	0.019	0.122	0.106	0.178	0.038	0.037
A13	0.094	0.021	0.013	0.577	0.035	0.1	0.025	0.01
A14	0.031	0.032	0.011	0.022	0.009	0.002	0.019	0.025
A15	0.045	0.032	0.01	0.029	0.008	0.118	0.007	0.004
A16	0.104	0.039	0.01	0.278	0.026	0.043	0.031	0.021
A17	0.002	0.004	0.001	0.012	0.073	0.057	0.01	0.019
A18	0.15	0.009	0.013	0.015	0.012	0.013	0.009	0.024
A19	0.068	0.002	0.007	0.012	0.09	0.004	0.021	0.021
A20	0.013	0.006	0.006	0.032	0.001	0.086	0.027	0.031
A21	0.117	0.03	0.003	0.044	0.044	0.036	0.016	0.029
A22	0.06	0.029	0.011	0.035	0.052	0.053	0.002	0.026
A23	0.105	0.018	0.012	0.357	0.003	0.018	0.014	0.014
A24	0.056	0.017	0.016	0.003	0.03	0.075	0.02	0.014
A25	0.043	0.016	0.011	0.513	0.055	0.165	0.016	0.025
A26	0.048	0.036	0.007	0.025	0.003	0.016	0.074	0.015
A27	0.028	0.025	0.009	0.025	0.027	0.051	0.007	0.011
A28	0.099	0.04	0.004	0.051	0.03	0.053	0.013	0.01
A29	0.131	0.039	0.002	0.048	0.026	0.018	0.025	0.031
A30	0.013	0.03	0.004	0.047	0.05	0.019	0.069	0.007
A31	0.294	0.011	0.007	0.43	0.083	0.009	0.36	0.026
A32	0.089	0.005	0.005	0.015	0.064	0.015	0.047	0.015
A33	0.058	0.023	0.005	0.059	0.022	0.058	0.058	0.014
A34	0.021	0.018	0.013	0.019	0.005	0.059	0.017	0.017
A35	0.117	0.068	0.018	0.042	0.104	0.145	0.036	0.048
A36	0.003	0.005	0.01	0.021	0.097	0.036	0.007	0.015
A37	0.115	0.024	0.006	1.18	0.022	0.105	0.02	0.025
A38	0.124	0.019	0.01	0.034	0.017	0.038	0.03	0.014
A39	0.061	0.006	0.011	0.033	0.019	0.065	0.048	0.019
A40	0.042	0.017	0.009	0.295	0.04	0.013	0.028	0.025

Figure 13: Concentration of heavy metals in ppm detected in the water samples (Values in red colour indicate that detected value is higher than the permissible limit)

4. Conclusion

Even though the study is not done seasonally to have a definite understanding of the presence of microplastics in the study area, the initial sampling indicated the presence of microplastics around the Kodungaiyur dumpyard. Lead and other heavy metals detected are responsible for causing cancer and other respiratory problems. Analysis of our symptoms diary survey conducted in the same study area showed that the same symptoms have been reported by the residents, people working in scrap shops, and conservancy workers.

Apart from the lack of standardised test methods for analysing microplastics, the other biggest hindrance to the study of microplastics is the lack of information about all the substances that are in a particular plastic. The only thing the consumer can find out about the plastic at the moment is the recycling code at the bottom which is normally etched into the plastic. It gives very rough and (vague)information about the kind of plastic being used but nothing about possible additives. The claim for an obligatory declaration of all additives is important because we have seen from the sample results that additives have migrated from the plastic and released into the environment.

The decisions relating to the design of plastic products, the material used for it and its packaging and sources required to do research and develop a sustainable material or alternatives to problem materials are in the hands of producers and they should be held responsible for managing this waste as well. Figure 2 clearly shows these decisions are taken at the economic stage and the citizens don't have a say in these decisions. The notion of producers pointing fingers at the citizens and local authorities for the plastic pollution crisis is highly hypocritical and needs to undergo a major overhaul.. The threat of microplastics, those invisible small fragments of plastic, is looming large and it’s the producers who should be held accountable.

Health and environment are the most precious assets available to humanity. To tackle the assault on it by plastic pollution, we need combined, collective, and interacting efforts of producers, citizens, policymakers, and governance systems.