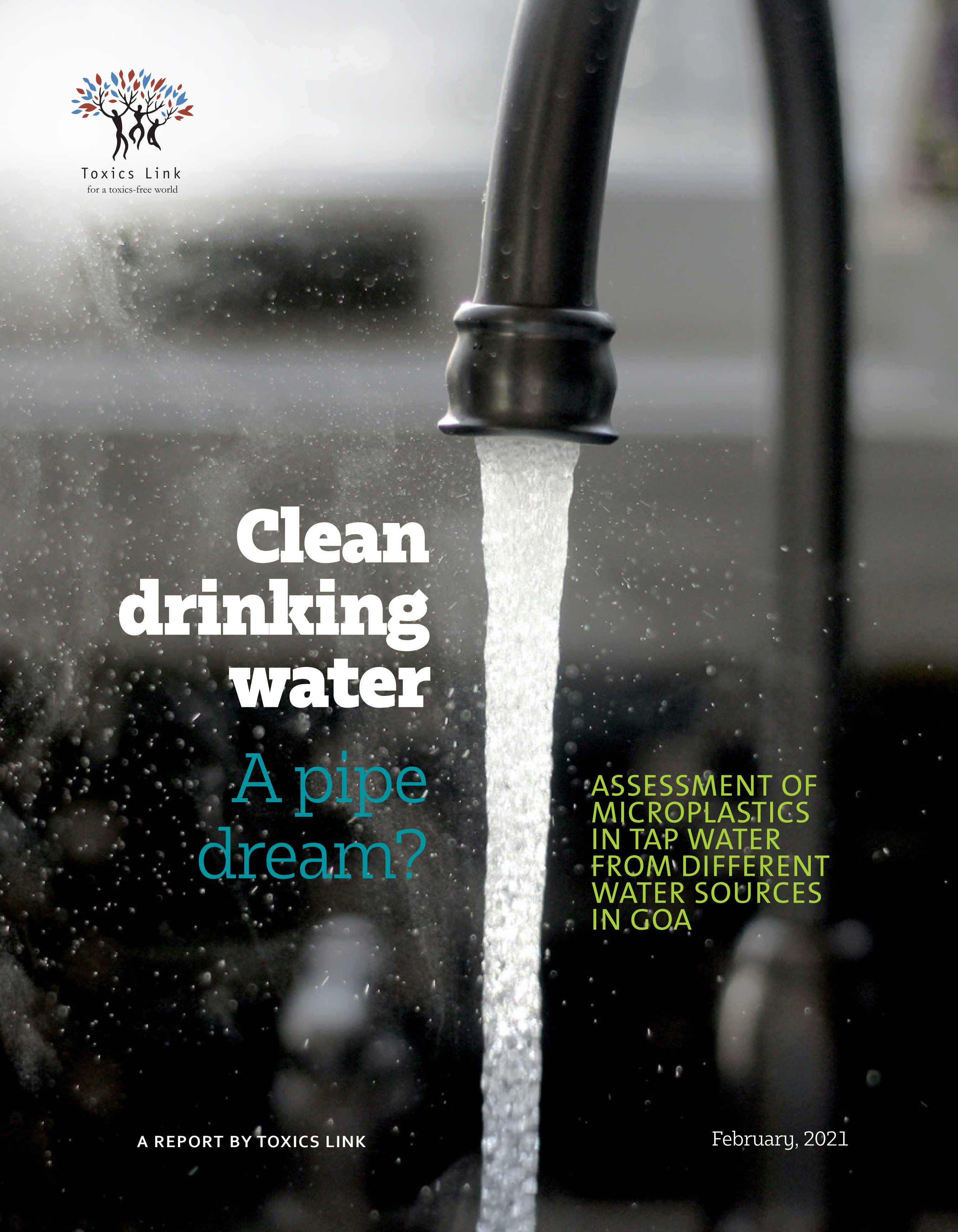
Toxics Link
for a toxics-free world



Clean drinking water

A pipe dream?

ASSESSMENT OF MICROPLASTICS IN TAP WATER FROM DIFFERENT WATER SOURCES IN GOA

A REPORT BY TOXICS LINK

February, 2021

About Toxics Link

Toxics Link is an Indian environmental research and advocacy organization set up in 1996, engaged in disseminating information to help strengthen the campaign against toxic pollution, provide cleaner alternatives and bring together groups and people affected by this problem. Toxics Link's mission statement is "Working together for environmental justice and freedom from toxics". We have taken it upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world." Toxics Link has unique expertise in the areas of hazardous, medical and municipal wastes, international waste trade, and the emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous, heavy metal contamination etc. from the environment and public health point of view. We have successfully implemented various best practices and have brought in policy changes in the aforementioned areas apart from creating awareness among several stakeholders.

Acknowledgement

We would like to thank Mr. Ravi Agarwal, Director, Toxics Link for his continued guidance and encouragement. We are grateful to Mr. Satish Sinha, Associate Director, Toxics Link who guided us through the entire research process and helped us in shaping the study. Our sincere thanks to Sushant Figueiredo, who helped us in collection of water samples from the treatment plants in Goa.

Our sincere thanks is due to all team members of Toxics Link for their valuable inputs and suggestions.

Research Team

Principal Investigator:	Dr. Mahua Saha, COD, CSIR-NIO, Dona Paula, Panjim, Goa Priti Mahesh, Chief Programme Coordinator, Toxics Link
Inputs:	Dr. Amit, Programme Coordinator, Toxics Link

Toxics Link
for a toxics-free world

Toxics Link

H2 (Ground Floor), Jungpura Extension
New Delhi - 110014, India
Phone: 91-11-24328006, 24320711
Fax: 91-11-24321747
www.toxicslink.org

Toxics Link
for a toxics-free world

Clean drinking water A pipe dream?

ASSESSMENT OF MICROPLASTICS IN TAP WATER FROM DIFFERENT WATER SOURCES IN GOA

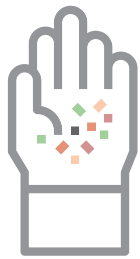
A REPORT BY TOXICS LINK

Contents

Introduction

Plastic pollution has become a widespread environmental issue. As a new type of pollutant, microplastics have received some attention in recent years and have been recognized as emerging marine pollutants of significant concern, due to their persistence, ubiquity and toxic potential (Engler, 2012; Rochman et al., 2014; Wang et al., 2016). Generally, plastics with sizes less than 5mm are defined to be microplastics (Andrady 2011). They are highly persistent in the environment and are, therefore, accumulating in different marine ecosystems at increasing rates (Woodall et al., 2014; van Sebille et al., 2015; Suaria et al., 2016; Cózar et al., 2017; Waller et al., 2017).

Microplastics can be classified as primary and secondary microplastics. The primary MPs are produced by the unintentional release of intermediate plastic feedstock (i.e. pellets, nurdles or microbeads from personal care products) (Anderson et al., 2017). Examples of primary microplastics include microbeads found in personal care products, plastic pellets (or nurdles) used in industrial manufacturing and plastic fibres used in synthetic textiles (e.g., nylon). Primary microplastics enter the environment directly through any of the various channels—for example, product use (e.g., personal care products being washed into wastewater systems from households), unintentional loss from spills during manufacturing or transport, or abrasion during washing (e.g., laundering of clothing made with synthetic textiles). These products, such as facial scrubs have been identified as potentially important primary sources of MPs to the environment especially marine (Conkle et al., 2018). Secondary MPs are defined as fragments of larger plastic items that suffer fragmentation, found both in marine and terrestrial habitat (Thompson et al., 2004; Ryan et al., 2009). Weathering also causes the breakdown of large plastic into tiny fragments (Arthur et al., 2009). Another important process is photodegradation by ultraviolet radiation from sunlight, which results in chemical bond cleavage of polymer matrix by the oxidation process (Barnes et al., 2009).



MPs pollution has a profound effect on the marine ecosystem, as well as the terrestrial ecosystem, due to the association of MPs with pollutants like POPs and other hydrophobic pollutants, heavy metals and pathogenic microbes

MPs pollution has a profound effect on the marine ecosystem, as well as the terrestrial ecosystem, due to the association of MPs with pollutants like POPs and other hydrophobic pollutants, heavy metals and pathogenic microbes (Dehghani et al., 2017). The small size and complex morphological characteristics of microplastics make them easily ingested by organisms

(Ding et al., 2018). Ingested microplastics may cause complex effects, such as exerting toxic effects on nerves, altering the metabolism of lipids and energy, and causing toxic genetic and immune responses (Avio et al., 2015; Ding et al., 2018). In addition, hydrophobicity and hardness as well as the strong floating ability make microplastics a desirable carrier for trace chemicals, viruses and bacteria in seawater (Zettler, Mincer, and Amaral-Zettler 2013). Some microplastics pass along the food chain, accumulate through the trophic level, and eventually enter the human body (Yang et al., 2018) and may affect human health. Recent studies show that microplastics with small sizes (0.25 ± 0.061 m) may be taken up by human stratum corneum cells (Triebskorn et al., 2019). Microplastics have been shown to induce oxidative stress in the human brain and epithelial cells (Schirinzi et al., 2017). These results show that potential risks of microplastics should not be ignored.

Freshwater resources are often important sources of drinking water and hence presence of microplastics in freshwater may contribute microplastics to drinking water.

Currently most studies on microplastics focus on the marine environment, while work on freshwater environments accounts for less than 4% of the reports (Lambert and Wagner 2018). Microplastics enter freshwater environments in a number of ways: primarily from surface run-off and wastewater effluent (both treated and untreated), but also from combined sewer overflows, industrial effluents, degraded plastic waste and atmospheric deposition. Although some of the microplastics in freshwater enter the ocean through the rivers, the rest remains in the freshwater. Peng et. al., (2017) compared the microplastics in freshwater and marine environments and found that the abundance of microplastics in freshwater is not much different from that in the marine environment.

Freshwater resources are often important sources of drinking water (Koelmans et al., 2019) and hence presence of microplastics in freshwater may contribute microplastics to drinking water. So far, a few studies have shown that microplastics are present in bottled water and tap water (Mason, Welch, and Neratko 2018; Kosuth, Mason, and Wattenberg 2018) and that people are exposed to microplastics through drinking water (Li et al., 2019). These reports have attracted widespread attention from the scientific community and the media. However, it is important to recognize that due to the variations in economic development and levels of waste management in various regions, the pollution situation of microplastics may vary dramatically among different regions. Thus, it is necessary and important to understand the microplastics contamination in tap water in specific regions. Understanding the distribution of microplastics in tap water will not only provide data support for the study of microplastic pollution in the world but also develop awareness of the current microplastic pollution.

The present study is expected to provide the first comprehensive outline on the extent of microplastic pollution in water in Goa.


DRINKING WATER


Aqua spice

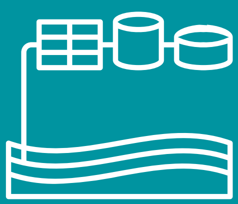
Objectives and Methodology

Clean drinking water is essential to life – and it's everyone's right. Sustainable Development Goal Target 6.1 calls for universal and equitable access to safe and affordable drinking water. The target is tracked with the indicator of "safely managed drinking water services" – drinking water from an improved water source that is located on the premises, available when needed, and free from faecal and priority chemical contamination.

Over the past few years, several studies have reported presence of microplastics in treated tap and bottled water, raising questions and concerns about its impact on human health. There is little focus on this in India as there is very little information available on the presence of microplastics in Indian tap water systems. The purpose of this report is to increase understanding on the issue of microplastics in drinking water in the country and to influence policy and management actions as well as trigger research on the subject.

Specific Objectives

Assess the presence of microplastics in tap water in Goa



Understand the effectiveness of water treatment plants in Goa in removal of microplastics

Inform local government of the findings and advocate for effective treatment mechanism

Study Sampling

A total of 11 water samples were collected from different locations in Goa. Out of eleven water samples, five tap water samples were collected from residential areas of Margao, Panjim, Mapusa, Marcel and Canacona. The remaining six samples were collected from three different water treatment plants (WTPs), Assonora, Opa and Salaulim, both pre-treated and post-treated. Samples from WTPs were taken to understand the level of pollution of MPs in the water source and also if the treatment resulted in some change. The source of the tap water sample for Mapusa is from Assonora WTP, Panjim and the Marcel tap water source is from Opa WTP and Margao tap water source is from Salaulim WTP. However, WTP related to Canacona tap water samples could not be collected and analyzed.

A total of 11 water samples were collected from different locations in Goa

Materials and Methods

The water was collected at each location with a volume of 5L, filtered using vacuum filtration unit containing a filter paper of 47mm diameter and 5µm pore size. Finally, the filter papers were transferred into the labelled petriplates and dried in the oven at 40º C until they fully dried. The apparatus used were thoroughly rinsed with deionized water before the commencement of the next sample filtration.

Fig 1: Filtration unit

Identification and quantification of microplastics

All filter papers were examined under a Leica Stereozoom microscope with scope 40x and zoom 16x for plastics resembling microplastics based on their size, colour, shape and structure. The Leica LAS EZ software was used for quantification and identification of microplastics like particles. Microplastics were photographed, counted and categorized based on their length, colour and type (e.g. fiber, fragment, etc.); by guidelines produced by the MSFD technical group and marine litter (Galgani et al., 2013). Number of microplastics were recorded separately for each filter and then summed for each sample. Representative types of particles were observed with the help of microscope and were stored at room temperature for the FTIR spectroscopic analysis and for further confirmation and identification of polymer type.

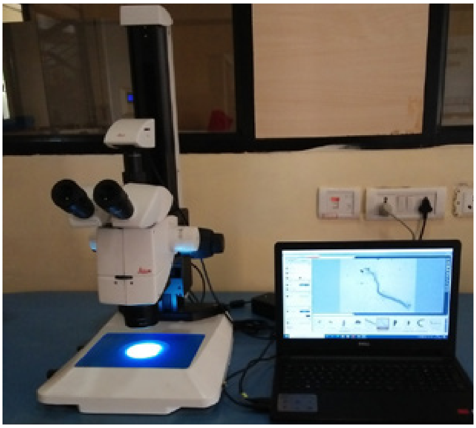


Fig 2: Stereo-zoom microscope

µ-FTIR analysis

The composition of MPs in each filter paper was identified by using Micro-Fourier transform infrared spectroscopy (µ-FTIR) with advanced imaging and microscopy (AIM). The specification of FTIR was as follows; Made of Shimadzu, IR tracer and AIM view software, spectrum resolution 16cm^{-1}; number of scans:100 per sample; mirror used for background correction and advanced AIM correction. Blank filter was examined to check the airborne contamination. The test spectra obtained was compared with the known library spectra for reference.

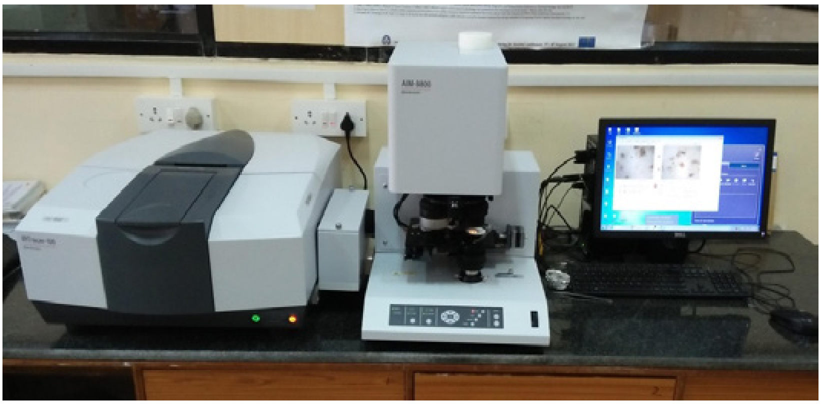
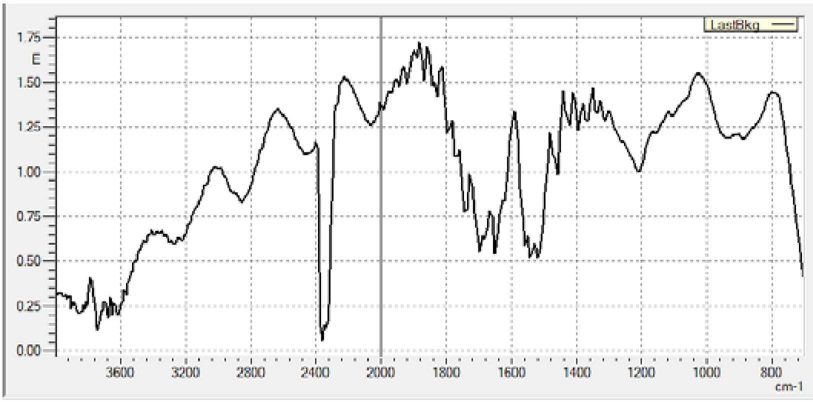


Fig 3: FTIR-AIM

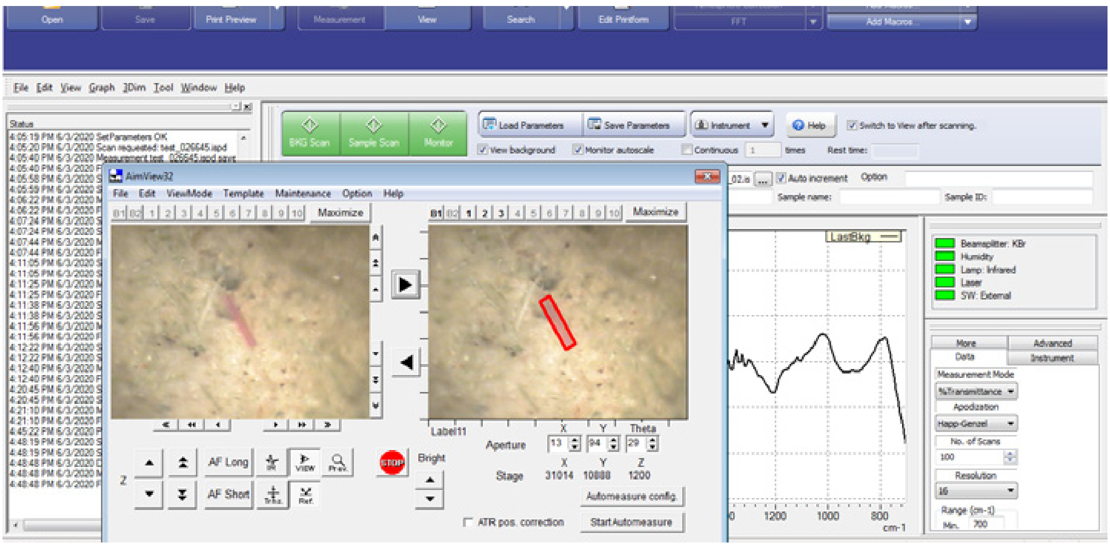
Calibration procedure before sample analysis



Background scan before analysis of MP samples in FTIR (IR Tracer- 100)

The samples were analyzed by using Micro-Fourier transform infrared spectroscopy (FTIR, Model: Shimadzu) attached with Advanced Imaging & Microscopic in the reflectance mode. Mirror was used for background correction (using Lab solution software) before the particle polymer detection. The IR light hits the sample from above and reflects back to the detector thus, spectra are produced for that particular MP sample. It is observed between the mid-infrared regions i.e. 700- 4500 cm^{-1} with 100 scans per sample with resolution of 16 cm^{-1}.

µ- FTIR analysis of MPs in AIM viewer software for the polymer detection



B

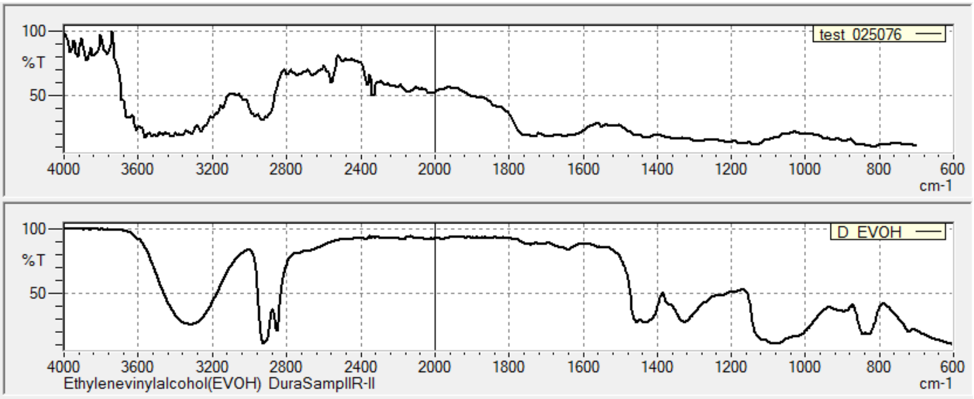
Here the samples were analyzed for the polymer identification using AIM software. First we select the aperture for the selected MP particle and a background scan is run which is followed by sample scan of the selected aperture shown in the red box in the figure.

Major Polymer spectra found in MPs

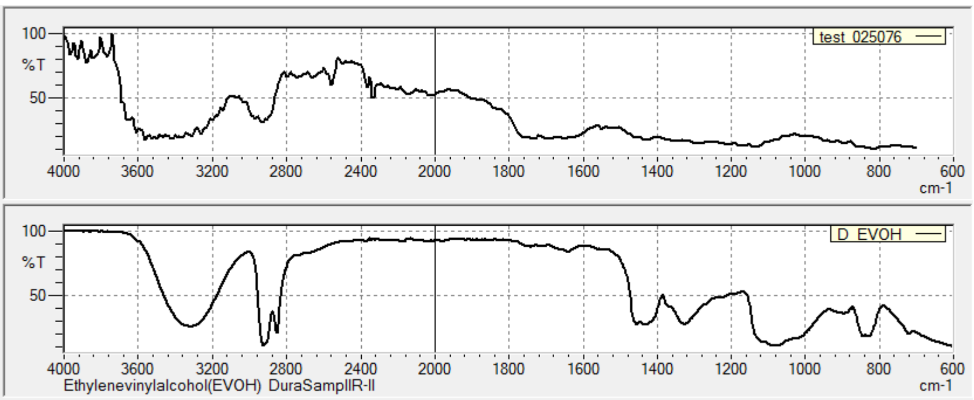
After the spectras are produced for the MP particles the spectra obtained are matched with the FTIR polymer library for the confirmation of the specific polymer in the particle which is already mentioned below the spectra.

The figures, given below also show the polymer library with other possible matchings of spectra and their respective scores and thus we chose the highest matching score for our final results.

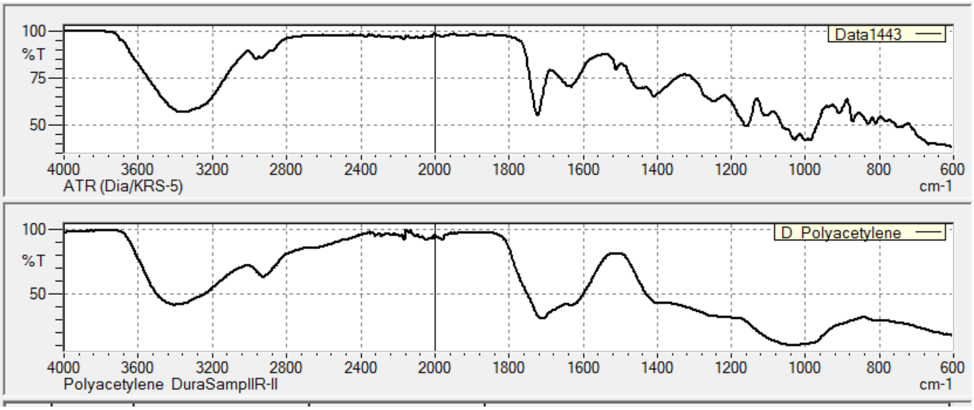
(A) Ethylene vinyl alcohol (EVOH)



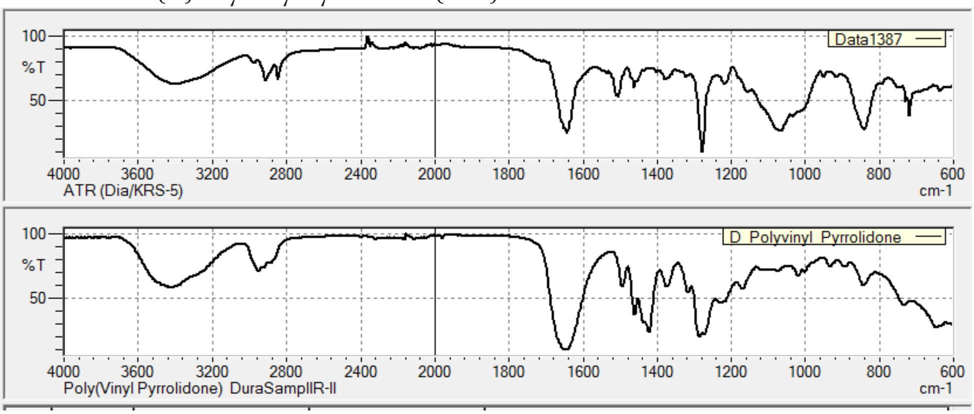
(B)Polyvinyl chloride (PVC)



(C) Polyacetylene



(D)Poly Vinyl Pyrrolidone (PVP)



Quality assurance and quality control

The microplastics extraction in water and subsequent examination of the filter papers was carried in compliance with the recent findings in MPs contamination prevention methodologies (Woodall et al., 2015; Wesch et al., 2017). Glasswares were rinsed thoroughly twice with distilled/deionised water before using for experiment and white cotton lab coat and mask worn during the experiment was non-polymer in nature. The whole experimental setup was done in a sterile area. Furthermore, filter papers were not exposed to air and were kept under a clean air laminar flow hood and maintained in a clean petri dish. Samples were covered with foil paper after dissection and when not in use. Glass lids were used while observing under microscope to avoid contamination. Moreover, non-existence of any airborne microfiber was confirmed in three replicates of blank filter paper to eliminate the probability of contamination by air.


BERGKAMP
10

Findings

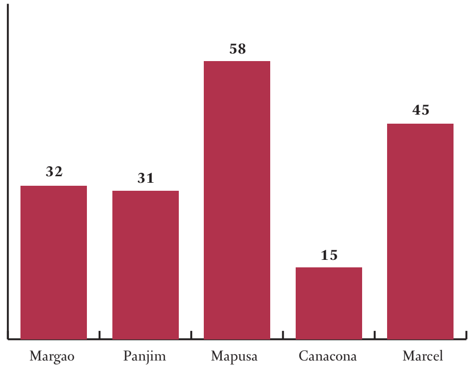
Goa with a land area of 3,702 square km and a coastline of 105 km is India's smallest state located on the west coast along the Arabian Sea. It is a prime tourist location, both for national as well as international tourists. Though Goa has a population of 1.459 million residents as per the 2011 census, the city has a high floating population. Goa has seven major rivers, namely, Zuari, Mandovi, Terekhol, Chapora, Galgibag, Kumbarjua canal, Talpona and the Sal. According to the Public Works Department, Government of Goa, the present water supply demand in the state is catered through seven regional water supply schemes installed at Opa, Assonora, Sanquelim, Salaulim, Canacona, Dabose and Chandel. Goa is credited as the first state in India to provide 100% tap water connections in its rural households, covering around 2.30 lakh houses. The main sources of drinking water in Goa are rivers. Water from different rivers is supplied to the nearest drinking water treatment plants for the treatment process and the transportation of water is being done via PVC/Iron pipe. Assonora WTP receives water from Amthane dam, and Valvanti river which originates from the Western Ghats, mountain ranges of Karnataka. This WTP caters to Mapusa through the pipelines. Opa WTP received water from the Khandepar river which is also originating from Karnataka, and catering to Panjim and Marcel.

Abundance of MPs

The water samples collected from different sources were subjected to analysis for assessing presence of microplastics. Shockingly, MPs were detected in all tap water samples as well as water samples collected from different WTPs. Though their number varied (Table 1), their presence, especially in tap water samples, raises serious concern about microplastic exposure for the residents.

MPs were found in all water samples collected from Goa

A total of 288 MP particles were found in eleven water samples i.e., tap water (Mapusa, Panjim, Marcel, Margao and Canacona) and Water Treatment Plants (Assonora, Opa and Salaulim) by using a stereozoom microscope. The abundance of microplastics varied from 15-58 MPs/5L, 15-34 MPs/5L and 5-18MPs/5L in tap water (pre-treated and post–treated respectively). Among all the water samples MPs were predominantly found in Mapusa (58 MPs/5L) followed by Marcel (45MPs/5L), Opa pre-treated (34 MPs/5L), Margao (32 MPs/5L), Panaji (31MPs/5L), Assonora pre-treated (28 MPs/5L), Assonora post-treated (18 MPs/5L), Canacona (15 MPs/5L), Salaulim pre-treated (15 MPs/5L), Opa post-treated (7 MPs/5L) and Salaulim post treated (5MPs/ 5L). The MPs found in all the 3 post-treated samples were relatively low as compared to other water samples (Table 1). The high numbers of MPs in tap water samples could be due to the transportation of water through PVC pipelines to households.



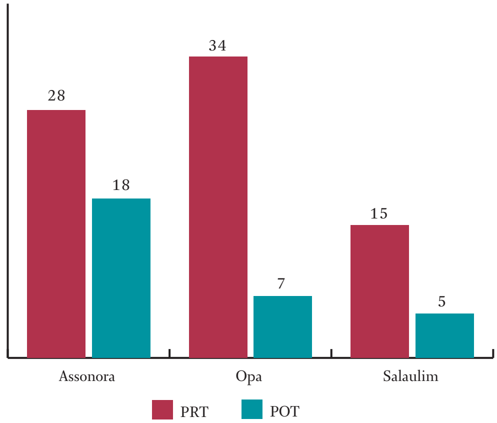


Fig 4: Presence of MPs in all samples

Table 1:Abundance, shape and size distribution of MPs in tap water and WTPs samples

		Abundance	Shape			Size distribution			
S.N	Locations	Total no. of MPs/5L	% Fibers	% Fragments	% Films	<20μm	20μm-100μm	100μm-300μm	300μm-1000μm
1	Margao	32	71.875	21.875	6.25	7	16	9	0
2	Panjim	31	54.84	45.16	0	14	9	8	0
3	Mapusa	58	60.34	39.66	0	22	22	13	1
4	Canacona	15	66.67	33.33	0	5	7	3	0
5	Marcel	45	71.11	28.89	0	13	16	16	0
6	Assonora PRT	28	64.29	35.71	0	4	16	8	0
7	Assonora POT	18	55.6	38.9	5.6	7	7	4	0
8	Opa PRT	34	64.71	35.29	0	9	19	6	0
9	Opa POT	7	42.86	57.14	0	4	3	0	0
10	Salaulim PRT	15	66.67	26.67	6.67	4	5	6	0
11	Salaulim POT	5	100	0	0	0	4	1	0

In recent years, studies on microplastics in drinking water have found that tap water and bottled water contain small numbers of microplastics. In one study on 259 individual bottles of water from 11 different brands and 27 different batches, the results showed that microplastics appeared in 93.0% of the samples, with an average of 10.4 items/L (Mason, Welch, and Neratko 2018). Kosuth, Mason, and Wattenberg (2018) also found that more than 81% of the 159 globally sourced tap water samples contained microplastic particles with an average of 5.6 items/L. According to statistics, the microplastic abundance in tap water in this study was (5.24± 3.24 items/L) which is relatively similar with the earlier studies. Dris et. al., (2017) reported, that there were 0.3 to 1.5 items/m3 microplastics in the air/atmosphere of Paris. Some of these microplastics in the air enter the water with the airflow, and the rest remain in the atmosphere. When rainfall occurs, the microplastics in the air enter the water body directly with the rainfall, thus affecting the distribution of microplastics in the water (Dris et al., 2016). The microplastic pollution of water sources and drinking water treatment processes may affect microplastics removal rate. In this study the abundance of MPs found in tap water samples are relatively high as compared to the post-treated water samples which suggests that the contamination of MPs in the water may be during the process of transportation since most of the water lines are made of PVC pipes. Plastic pipes in drinking water distribution systems may be an important source of microplastic.

Plastic pipes in drinking water distribution systems may be an important source of microplastic

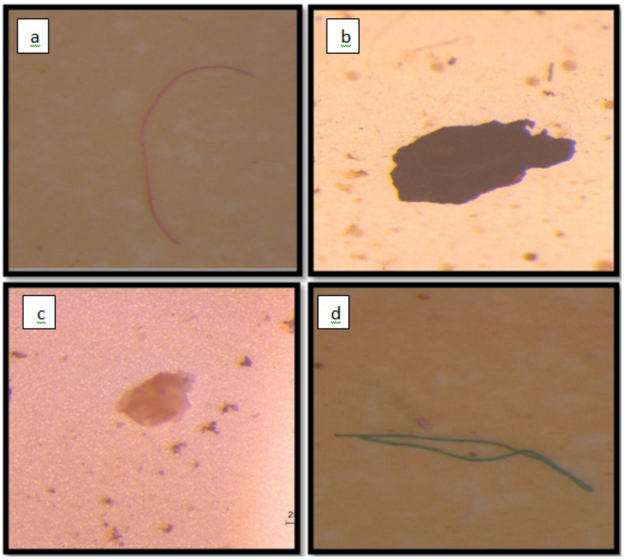


Fig 5: Stereoscopic images of MPs in tap water, fibers a) and d) , fragment b), film c)

Shape of MPs

The MPs comprised 3 types of shapes, namely fiber, fragment and film based, on the stereomicroscope analysis (Fig 5). Of three shapes, fibers were the most abundant morphotype in tap water samples ranging from 54.84% to 71.87%, followed by fragments 21.87% to 45.16% and films 0-6.25%. In pre-treated water samples also, fibers were the most common shape in the range of 64.29% to 66.67% followed by fragments 26.67% to 35.71% and films 0-6.67% respectively whereas in post-treated water samples the range of fibrous MPs was 42.86% to 100% followed by fragments 0-57.14% and films 0-5.6%. In terms of shapes in all the collected water samples fibers were the most common followed by fragments and films except in Opa POT sample wherein fragments (57.14%) were more abundant than fibers (42.86%) (Fig 6). Fiber is the most common form of microplastic found in most seawater and freshwater samples (Ivar doSul and Costa 2014; Lambert and Wagner 2018). The widely detected fibers are associated with large-scale production of plastic materials and are primarily derived from the peeling of plastic products and clothing (Browne et al., 2011).

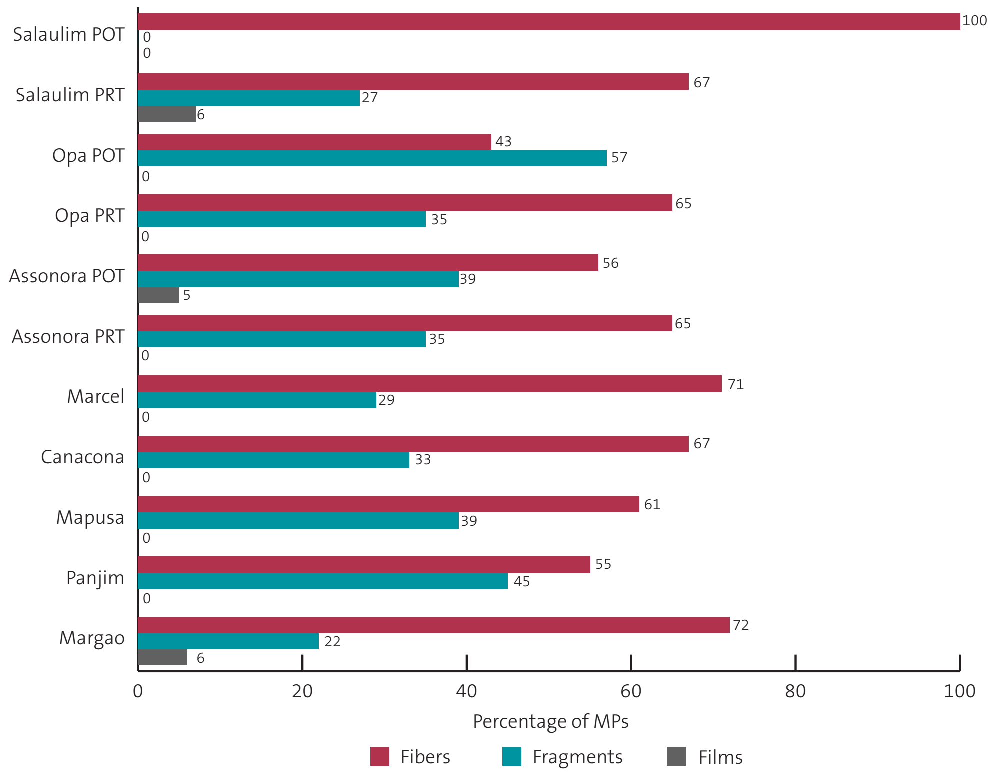


Fig 6: Percentage of MPs found in stereoscopic analysis.

Size distribution of MPs

The size range of three major categories of MPs i.e. fibers, fragments and film were measured during stereoscopic analysis. In all the water samples MPs were dominantly found in the size range of and 20 µm -100 µm followed by <20 µm and 100 µm -300 µm. In the size range 300 µm- 1mm the MPs were least commonly found (Fig 7). Pivokonsky et al. (2018) which demonstrated that most of the microplastics (up to 95%) are within the size range of 1 - 10 µm. Additionally, Pivokonsky et al. (2018) demonstrated that no microplastic was bigger than 100 µm in the treated water samples. Mintenig et al. (2019) found that all microplastics were in a size range of 50 to 150 µm. However, our study also revealed the presence of particles > 300 µm in the tap water samples, it could be due to the lack of effectiveness of the drinking water treatment plant. Microplastics of small size in tap water cannot be detected by human senses, and may be swallowed by humans.

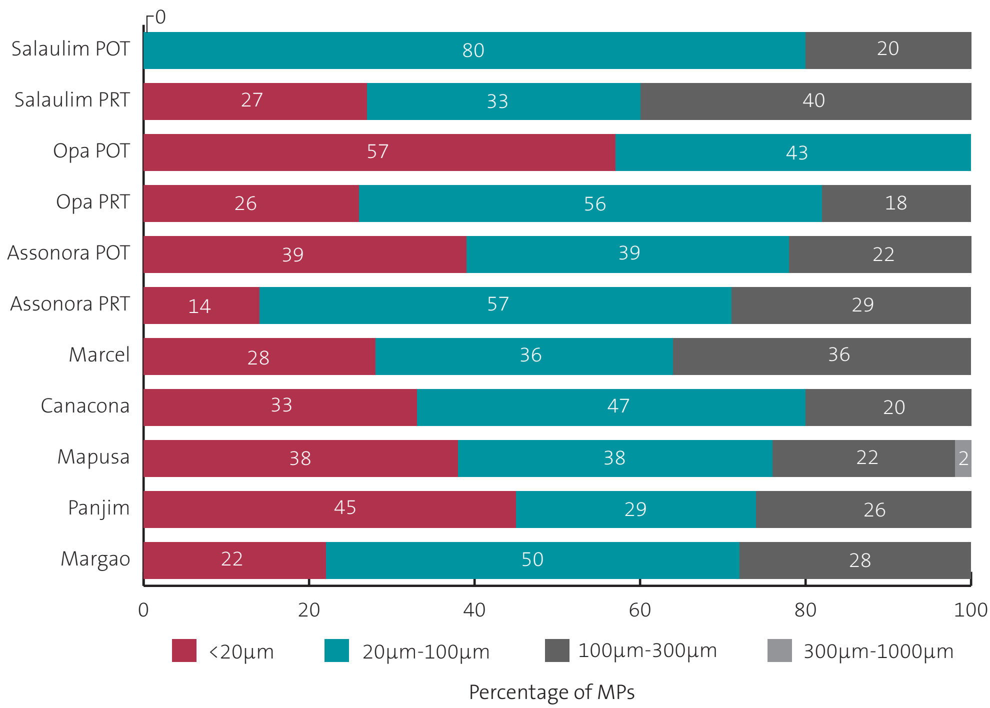


Fig 7: Percentage of size of MPs found in all the tap water samples

Colour

A total of seven different colours (black, blue, red, grey, brown, green and transparent) were identified in all the locations. Black coloured MPs were dominant in all the water samples followed by blue, red, grey, brown, green and transparent (Fig 8). Industry adds pigments to polymers, such as different colored alkyd resins are used in marine application plastics. The yellow to orange-colored toys may contain lead chromate pigments (Greenway and Gerstenberger, 2010; Shtykova et al., 2006). The black MPs might have been released into the environment during transportation through black-coloured plastic pipes or may be through abrasion of tires on the road surfaces as regular wear and tear (Wik and Dave, 2009). Polyester fibers are blue, while polyamide fibers are whitish grey and they are thinner than polyester ones. Blue-coloured MPs were also most commonly found which might originate from fishing nets or the use of other packaging plastic products. The main sources of the transparent and white microplastics are plastic carry bags and packaging materials and can also be sourced from the fishing lines (Cole et al., 2014).

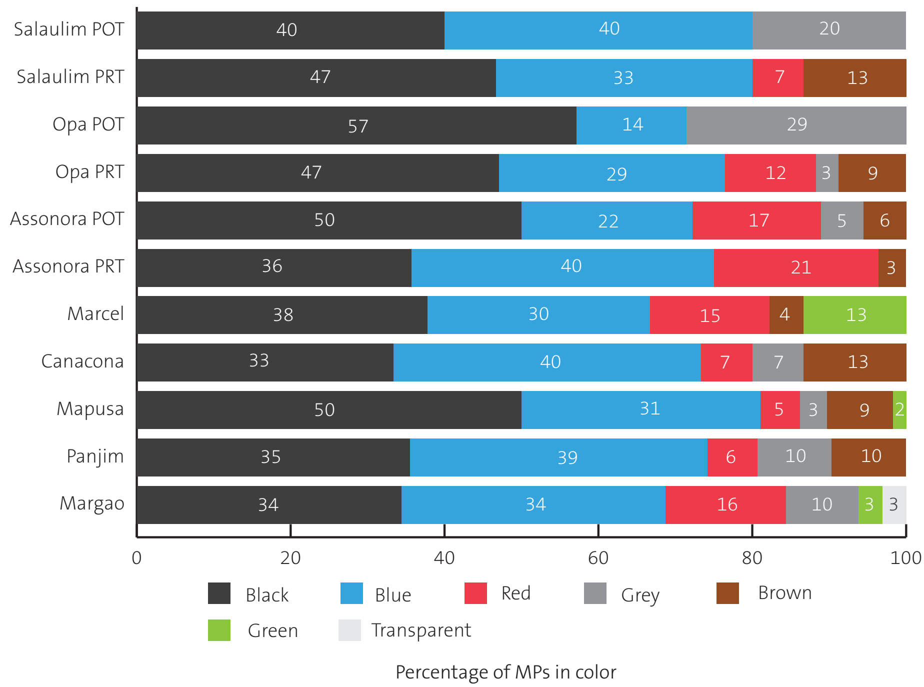


Fig 8: Percentage of Different coloured MPs found in all the water samples

Polymer types

µ-FTIR analysis was carried out for all the MPs found and was able to successfully identify 129 MP particles in all the locations. A total of 26 different polymer types were found. Among all the MPs analysed in FTIR analysis, Polyacetylene (28.40%) was found to be maximum followed by EVOH (Ethylene Vinyl Alcohol) (25.93%), Styrene/ Isoprene ABA block copolymer (9.88%), Polyvinyl Alcohol (9.88%), Polyamide (8.64%), PVC (8.64%) and Polyvinyl Pyrrolidone (8.64%) (Fig 8 a, b and c). Highest level of microplastics abundance was found in Mapusa. Among MPs present in Mapusa, the maximum concentration of (EVOH) Ethylene vinyl alcohol was found. It may be due to the drainage of untreated wastewater into the river, small industries etc., EVOH is a formal copolymer of ethylene and vinyl alcohol. Due to its strong barrier against oxygen and gas, food packaging manufacturers use EVOH in their packaging structure to extend the shelf life of food products.

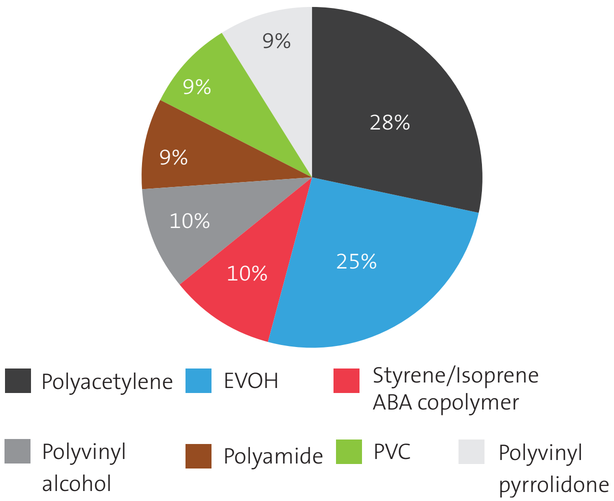


Figure 9: Polymer found in all samples

The Increase of microplastics concentration in tap water of Mapusa has been noticed as compared to its sources, it could have occurred due to the transportation of water through the PVC pipelines. In case of the Margao sample, polyacetylene was found to be the maximum among the all the MPs present in the sample.

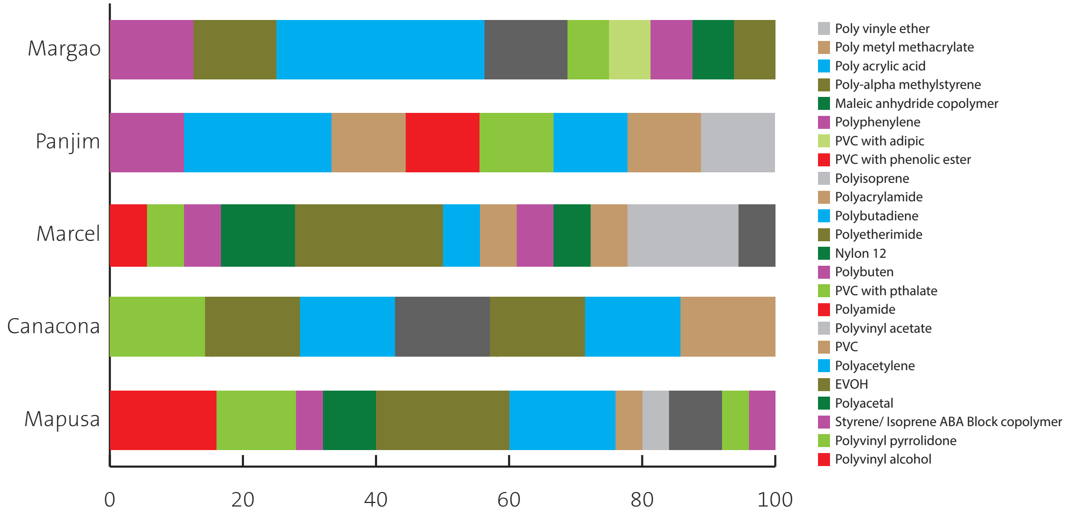


Fig 10a: Percentage of dominant polymer types detected in all the tap water samples

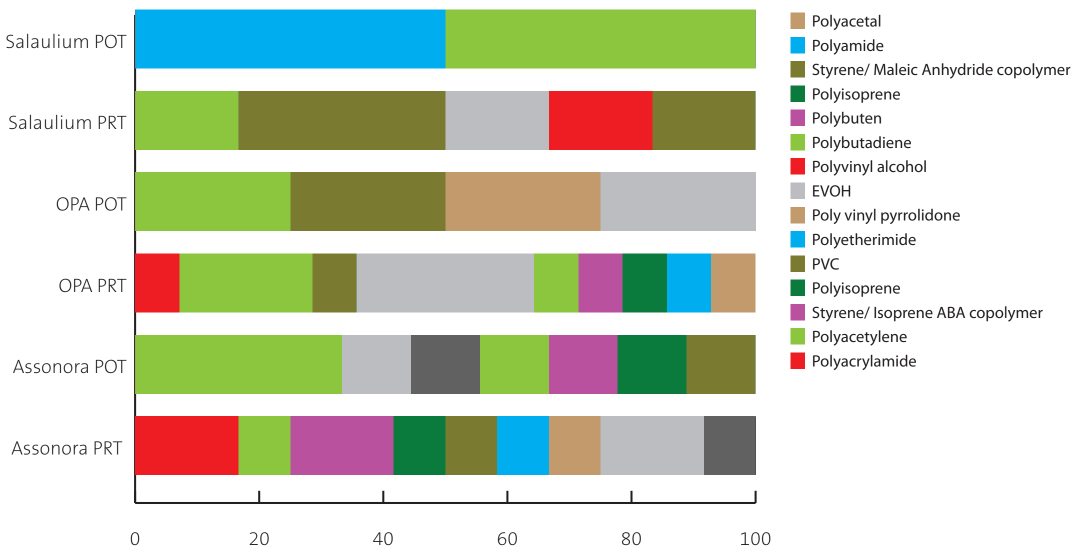


Fig 10b: Percentage of dominant polymer types detected in all the pre-treated and post-treated water samples

Polypropylene (PP) fibers were found in typically blue or red color (Vianello et al., 2013). PP is widely used in packaging, fishery, textile industries, and it is also largely manufactured and consumed in the world (Hidalgo-Ruz et al., 2012; Tiwari et al., 2019). Polyvinyl pyrrolidone is widely used in the personal care products, such as shampoos, toothpastes and in paint. It is also used as a special additive for batteries, ceramics, fiberglass, inks, and inkjet paper. Polyacetylene is mainly used as a doping agent in electronic devices like organic batteries due to its thin, stretchable film making ability to induce conductivity (Ron Dagani, 1981). EVOH has applications in food packaging, drugs, cosmetics, and other perishable products because of its superior barrier properties. It is often used in a multilayer co-extruded film structure with materials such as HDPE, PP and PET (*Impact Plastics blog*). PVC has replaced building materials *viz* wood, metal, that does not discolour or corrode whereas plasticized PVC is mainly used in pipelines, domestic appliances, wallpapers, medical equipment, toys and footwear). The occurrence of PVC MPs, might be due to usage of PVC pipeline in the supply of water to households from water treatment plants or main water supply pipeline. They are also used in the manufacture of swipe cards, credit cards, pharmaceuticals packaging, garments etc. (Dowarah et al., 2020. The wearing of the pipes might contribute to the abundance of PVC microplastics in the sediments (Vahidi et al., 2016). Laundry wastewater may be a significant source of nylon particles, since nylons are widely used in textiles, such as clothes and ropes.

Conclusion and recommendations

The abundance and characteristics of microplastics present in tap water was determined. Eleven different water samples were analysed for contamination of MPs. Out of eleven water samples, five tap water samples were collected from five different cities (Margao, Panjim, Mapusa, Marcel and Canacona) and remaining six samples were collected from three different water treatment plants (Assonora, Opa and Salaulim).

A total of 288 MP particles were found in eleven water samples i.e., tap water (Mapusa, Panjim, Marcel, Margao and Canacona) and Water Treatment Plants (Assonora ,Opa and Salaulim) by using stereozoom microscope. A total of 26 different polymer types were found. The size of microplastics ranged from < 20 µm to 1000 µm, while microplastics smaller than 100 µm were dominant. Fibre was the most dominant category found in both tap water and treatment plant samples. Among all the MPs analyzed in FTIR analysis, Polyacetylene was found to be maximum followed by EVOH (Ethylene Vinyl Alcohol), Styrene/ Isoprene ABA block copolymer, Poly vinyl alcohol, Polyamide, PVC, and Polyvinyl pyrrolidone.

This study fills the knowledge gap in the field of microplastics contamination in tap water, and much attention should be paid into their sources and removal, especially for small-sized microplastics. Once ingested via tap water, there is the potential for exposure to chemical contaminants absorbed to the microplastics and any additives in microplastics. Therefore, microplastics may cause toxicity in the human body (Schirinzi et al., 2017), and microplastics in tap water should not be overlooked. Although the water treatment process may reduce a portion of the microplastics, some microplastics still remain in tap water. However, although there is no documented evidence till date that ingesting microplastics can directly harm human health, the potential threat of microplastics cannot be ignored. Packaging materials, fishing net, PVC pipes, cloth fibres etc., may be the sources for the most microplastic materials obtained during the study, which is mainly due to the mismanaged solid waste and lack of effective wastewater treatment facilities.

Microplastics may cause toxicity in the human body.

In the future, detailed research is needed for different states on the increased risks of microplastics caused by drinking water distribution systems, especially by different types of plastic pipes.

However, more research is needed in the field of MPs in water treatment.

A) Plastic-packed drinking water bottles, packed food and beverages should be studied further for the presence of microplastics and smaller nanoplastics.

B) The occurrence of microplastics pollution in different commercial products such as flavored coffee drinks and vitamin water still requires additional research.

C) The presence of microplastics in the body or in scuba divers or water sports trainers needs to be researched.

D) Investigating MPs removal by distinct treatment steps at DWTPs working under ordinary conditions is required.

E) Possible water enrichment of MPs during the conventional treatment processes at DWTPs needs further investigation.

F) Optimizing current treatment technologies or inventing new processes aimed at the removal of MPs or their problematic fractions that would remain in treated water after passing through an unaltered process ought to be looked at.

References

- Anderson, P. J., Warrack, S., Langen, V., Challis, J. K., Hanson, M. L., &Rennie, M. D. (2017). Microplastic contamination in lake Winnipeg, Canada. Environmental pollution, 225, 223-231.
- Andrady, A. L. (2011). Microplastics in the marine environment. Marine pollution bulletin, 62(8), 1596-1605.
- Vianello, A., Boldrin, A., Guerriero, P., Moschino, V., Rella, R., Sturaro, A., Ros, L. Da. (2013) Microplastic particles in sediments of Lagoon of Venice, Italy: first observations on occurrence, spatial patterns and identification Estuar. Coast. Shelf Sci., 130, 54-61.
- Arthur, C., Baker, J., Bamford, H. (2009). In: Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris, 9– 11 September 2008, NOAA Technical, Memorandum NOS-OR&R30.
- Avio, C. G., Gorbi, S., Milan, M., Benedetti, M., Fattorini, D., d'Errico, G., ...&Regoli, F. (2015). Pollutants bioavailability and toxicological risk from microplastics to marine mussels. Environmental Pollution, 198, 211-222.
- Barnes, D. K., Galgani, F., Thompson, R. C., &Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 1985-1998.
- Conkle, J. L., Del Valle, C. D. B., & Turner, J. W. (2018). Are we underestimating microplastic contamination in aquatic environments?. Environmental management, 61(1), 1-8.
- Cózar, A., Martí, E., Duarte, C. M., García-de-Lomas, J., Van Sebille, E., Ballatore, T. J., &Troublè, R. (2017). The Arctic Ocean as a dead end for floating plastics in the North Atlantic branch of the Thermohaline Circulation. Science advances, 3(4), e1600582.
- Dehghani, S., Moore, F., & Akhbarizadeh, R. (2017). Microplastic pollution in deposited urban dust, Tehran metropolis, Iran. Environmental Science and Pollution Research, 24(25), 20360-20371.
- Ding, J., Zhang, S., Razanajatovo, R. M., Zou, H., & Zhu, W. (2018). Accumulation, tissue distribution, and biochemical effects of polystyrene microplastics in the freshwater fish red tilapia (Oreochromis niloticus). Environmental pollution, 238, 1-9.
- Engler, R. E. (2012). The complex interaction between marine debris and toxic chemicals in the ocean. Environmental science & technology, 46(22), 12302-12315.
- Greenway, J.A., Gerstenberger. S. (2010). An evaluation of lead contamination in plastic toys collected from day care centers in the Las Vegas Valley, Nevada, USA Bull. Environ. Contam. Tox., 85, 363-366.
- Lambert, S., & Wagner, M. (2018). Microplastics are contaminants of emerging concern in freshwater environments: an overview. In Freshwater microplastics (pp. 1-23). Springer, Cham.
- Cole, M., Webb, H., Lindeque, P.K., Fileman, E.S., Halsband, C., Galloway, T.S. (2014) Isolation of microplastics in biota-rich seawater samples and marine organism. Sci. Rep., 4, 4528
- Shtykova, L., D. P, Ostrovskii., M. Nydén, Jacobsson. (2006) Interaction between medetomidine and alkyd resins: NMR and FTIR investigation of antifouling marine paint model systems. J. Appl. Polym. Sci., 99, 2797-2809
- Pivokonsky, M., Cermakova, L., Novotna, K., Peer, P., Cajthaml, T., & Janda, V. (2018). Occurrence of microplastics in raw and treated drinking water. Science of the Total Environment, 643, 1644-1651.

- Rochman, C. M., Kurobe, T., Flores, I., &Teh, S. J. (2014). Early warning signs of endocrine disruption in adult fish from the ingestion of polyethylene with and without sorbed chemical pollutants from the marine environment. Science of the Total Environment, 493, 656-661.
- Ryan, P. G., Moore, C. J., van Franeker, J. A., &Moloney, C. L. (2009). Monitoring the abundance of plastic debris in the marine environment. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 1999-2012.
- Schirinzi, G. F., Pérez-Pomeda, I., Sanchís, J., Rossini, C., Farré, M., & Barceló, D. (2017). Cytotoxic effects of commonly used nanomaterials and microplastics on cerebral and epithelial human cells. Environmental Research, 159, 579-587.
- Suaria, G., Avio, C. G., Mineo, A., Lattin, G. L., Magaldi, M. G., Belmonte, G., ...&Aliani, S. (2016). The Mediterranean Plastic Soup: synthetic polymers in Mediterranean surface waters. Scientific reports, 6, 37551.
- Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., ... & Russell, A. E. (2004). Lost at sea: where is all the plastic?. Science, 304(5672), 838-838.
- Tong, H., Jiang, Q., Hu, X., & Zhong, X. (2020). Occurrence and identification of microplastics in tap water from China. Chemosphere, 126493.
- Triebskorn, R., Braunbeck, T., Grummt, T., Hanslik, L., Huppertsberg, S., Jekel, M., ... & Ruhl, A. S. (2019). Relevance of nano-and microplastics for freshwater ecosystems: a critical review. TrAC Trends in Analytical Chemistry, 110, 375-392.
- Van Sebille, E., Wilcox, C., Lebreton, L., Maximenko, N., Hardesty, B. D., Van Franeker, J. A., ... & Law, K. L. (2015). A global inventory of small floating plastic debris. Environmental Research Letters, 10(12), 124006.
- Waller, C. L., Griffiths, H. J., Waluda, C. M., Thorpe, S. E., Loaiza, I., Moreno, B., ...& Hughes, K. A. (2017). Microplastics in the Antarctic marine system: an emerging area of research. Science of the Total Environment, 598, 220-227.
- Wang, J., Tan, Z., Peng, J., Qiu, Q., & Li, M. (2016). The behaviors of microplastics in the marine environment. Marine Environmental Research, 113, 7-17.
- Woodall, L. C., Sanchez-Vidal, A., Canals, M., Paterson, G. L., Coppock, R., Sleight, V., ...& Thompson, R. C. (2014). The deep sea is a major sink for microplastic debris. Royal Society open science, 1(4), 140317.
- Zettler, E. R., Mincer, T. J., & Amaral-Zettler, L. A. (2013). Life in the “plastisphere”: microbial communities on plastic marine debris. *Environmental science & technology*, 47(13), 7137-7146.
- Peng, J., Wang, J., & Cai, L. (2017). Current understanding of microplastics in the environment: occurrence, fate, risks, and what we should do. Integrated Environmental Assessment and Management, 13(3), 476-482.
- Koelmans, A. A., Nor, N. H. M., Hermsen, E., Kooi, M., Mintenig, S. M., & De France, J. (2019). Microplastics in freshwaters and drinking water: critical review and assessment of data quality. Water research, 155, 410-422.
- Mason, S. A., Welch, V. G., & Neratko, J. (2018). Synthetic polymer contamination in bottled water. Frontiers in chemistry, 6, 407.
- Tiwari, M., Rathod, T., Ajmal, P., Bhangare, R., Sahu, S. (2019) Distribution and characterization of microplastics in beach sand from three different Indian coastal environments
- Mar. Pollut. Bull., 140, 262-273
- Kosuth, M., Mason, S. A., & Wattenberg, E. V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. PloS one, 13(4), e0194970.

- Li, Y., Li, M., Li, Z., Yang, L., & Liu, X. (2019). Effects of particle size and solution chemistry on triclosan sorption on polystyrene microplastic. Chemosphere, 231, 308-314.
- Galgani, F., Hanke, G., Werner, S. D. V. L., & De Vrees, L. (2013). Marine litter within the European marine strategy framework directive. ICES Journal of Marine Science, 70(6), 1055-1064.
- Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., Thiel, M. (2012) Microplastics in the marine environment: a review of the methods used for identification and quantification. Environ. Sci. Technol., 46, 3060-3075.
- Woodall, L. C., Gwinnett, C., Packer, M., Thompson, R. C., Robinson, L. F., & Paterson, G. L. (2015). Using a forensic science approach to minimize environmental contamination and to identify microfibres in marine sediments. Marine pollution bulletin, 95(1), 40-46.
- Wesch, C., Elert, A. M., Wörner, M., Braun, U., Klein, R., & Paulus, M. (2017). Assuring quality in microplastic monitoring: About the value of clean-air devices as essentials for verified data. Scientific reports, 7(1), 1-8.
- Do Sul, J. A. I., Costa, M. F., & Fillmann, G. (2014). Microplastics in the pelagic environment around oceanic islands of the Western Tropical Atlantic Ocean. Water, Air, & Soil Pollution, 225(7), 2004.
- Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines woldwide: sources and sinks. Environmental science & technology, 45(21), 9175-9179.
- Pivokonsky, M., Cermakova, L., Novotna, K., Peer, P., Cajthaml, T., & Janda, V. (2018). Occurrence of microplastics in raw and treated drinking water. Science of the Total Environment, 643, 1644-1651.
- Mintenig, S. M., Löder, M. G. J., Primpke, S., & Gerdts, G. (2019). Low numbers of microplastics detected in drinking water from ground water sources. Science of the total environment, 648, 631-635.
- Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., & Tassin, B. (2017). A first overview of textile fibers, including microplastics, in indoor and outdoor environments. Environmental Pollution, 221, 453-458.
- Dris, R., Gasperi, J., Saad, M., Mirande, C., & Tassin, B. (2016). Synthetic fibers in atmospheric fallout: a source of microplastics in the environment?. Marine pollution bulletin, 104(1-2), 290-293.
- Schwabl, P., Köppel, S., Königshofer, P., Bucsics, T., Trauner, M., Reiberger, T., & Liebmann, B. (2019). Detection of various microplastics in human stool: a prospective case series. Annals of internal medicine, 171(7), 453-457.
- Possatto, F. E., Barletta, M., Costa, M. F., do Sul, J. A. I., &Dantas, D. V. (2011). Plastic debris ingestion by marine catfish: an unexpected fisheries impact. Marine pollution bulletin, 62(5), 1098-1102.
- Zhang, D., Liu, X., Huang, W., Li, J., Wang, C., Zhang, D., & Zhang, C. (2020). Microplastic pollution in deep-sea sediments and organisms of the Western Pacific Ocean. Environmental Pollution, 259, 113948.
- Dagani, t.(1981). Organic battery uses Polyacetylene electrodes. Chemischer Informationsdienst, 12(22), no-no.
- https://blog.impactplastics-ct.com/blog/what-is-evoh-and-how-is-it-used-in-food-packaging
- Dowarah, K., Patchaiyappan, A., Thirunavukkarasu, C., Jayakumar, S., &Devipriya, S. P. (2020). Quantification of microplastics using Nile Red in two bivalve species Pernaviridis and Meretrixmeretrix from three estuaries in Pondicherry, India and microplastic uptake by local communities through bivalve diet. Marine Pollution Bulletin, 153, 110982

Some of our publications on Plastic (available on our website):

1. Environmental Illusion: The non-woven bag (2020)
2. Single use plastic: The last straw (2020)
3. Microplastic Factsheet (2018)
4. ~~Eco~~ personal care product: Microplastics in Cosmetics (2018)
5. WEEE Plastic and Brominated Flame Retardants (2016)
6. Plastic Study in Kolkata (2015)
7. Plastic and Environment: Assessing the Impact of the Complete Ban on Plastic Carry Bag (2014)
8. Improving plastic management in Delhi (2012)
9. Brominated Flame Retardant Spreading the fire (2011)

Please look at the Plastic section on our website for posters and other awareness materials.

Toxics Link
for a toxics-free world

H2 (Ground Floor),
Jungpura Extension,
New Delhi - 110014
India
Tel: 91-11-24328006, 24320711
Fax: 91-11-24321747

https://www.instagram.com/toxics_link/
https://www.facebook.com/toxicslink
https://twitter.com/toxicslink
https://www.youtube.com/user/toxicslink2012
www.toxicslink.org