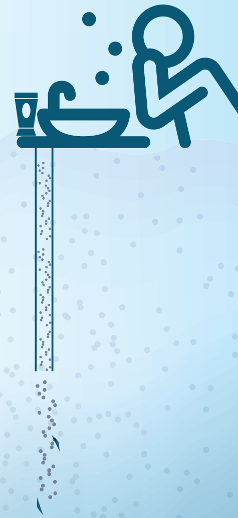
Toxics Link
for a toxics-free world

PERSONAL ~~ECO~~ CARE PRODUCT

Microplastics in cosmetics



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 toxics pollution, provide cleaner alternatives and bring together groups and people affected by this problem.

Toxics Link's Mission Statement - "Working together for environmental justice and freedom from toxics. We have taken 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 a unique expertise in 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 afore mentioned areas apart from creating awareness among several stakeholder groups.

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Contents

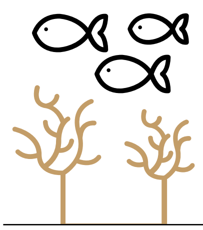
Abbreviation

EDC	Endocrine Disrupting Chemical
IUPAC	International Union for Pure and Applied Chemistry
PCB	Poly Chlorinated Biphenyl
PCCP	Personal Care and Cosmetic Product
PAH	Polycyclic Aromatic Hydrocarbon
PEG	Polyethylene Glycol
POP	Persistent Organic Pollutants
SDG	Sustainable Development Goal
UN	United Nations
WTO	World Trade Organisation
UNEA	United Nations Environment Assembly

An Insight into the Microplastics

Plastic is all around us. For most of us, it is throughout our home, our workplace, our institutions, in the vehicles we travel and in the things that we use. It can be in our clothing, pen, toothbrush, computers, phones, gadgets, utensils, toys and practically everything that we use on day to day basis. If we start listing down plastic around us, the list will be really very, very long. The invention of plastic based on a synthetic polymer in 1907 changed our lives forever – many would say 'for the better' but a growing tribe believes it 'for worse'. But most will agree that the plastic revolution has come at a cost. Although most of the plastic in our life is very apparent, there might be some, like microplastics, which are not so evident but still there.

Microplastics are essentially made of plastic polymers with 'micro' referring to the size as crucial element in defining them.They are characterized as synthetic (man-made) or semi-synthetic, solid particles with high polymer content popularly defined with a size range below 5 mm in their longest dimension. Microplastics, considered as a serious threat to ecosystems and human health, are used as raw materials in a number of products and are also produced from degradation of plastic products. They persist in marine and freshwater environments for years, can be found almost everywhere on earth, can pass through wastewater sewage treatment plants as well as municipal filtration systems, ingested by aquatic species and bio-accumulate and can adsorb persistent organic pollutants. The earliest observation and report of microplastic contamination dates back to 1960s and the abundance has kept increasing over the decades.[1]



more than

80%

of waste that ends up in the ocean is generated on land

Microplastics as defined by various sources

UN Environment recognizes ingredients as microplastics when they are, '***solid phase materials, particulates < 5mm, water insoluble, nondegradable and made of plastic***' in their 'Plastic in cosmetics' report[2]. Microplastics were demonstrated as 'microscopic' particles with diameter in the range of 20 µm in one of the earliest research in 2004, 'Lost at Sea: Where Is All the Plastic?'[3]. Later, the upper size limit was broadened in a first international workshop on microplastic marine debris at National Oceanic and Atmospheric Administration (NOAA). A group of scientist from across the world proposed a maximum size of 5 mm for defining microplastics so that the focus lies on 'possible ecological effects other than physical blockage of gastrointenstinal tracts'[4]. This definition was adopted by majority of the scientific communities globally, but not all. Hence, different size range for microplastics have been considered in different studies, including <1 mm[5,6] <2 mm[7], etc. Existing definitions do have variations on the upper size but do not distinct the lower size limit of microplastics. None of the existing or proposed national bans on microplastics also include any lower size limit. Size ranges of microplastics are generally reported by researchers according to the sampling techniques adopted in the field studies. A number of studies have reported microplastics of size up to 330 microns based on sampling with plankton net, typically with a mesh size of 330 microns. A European Commission technical guidance recommends large microplastics as 1 to 5 mm and small microplastics as 20 µm to 1 mm for sampling during monitoring of microplastics in marine water[8]. However, International Union for Pure and Applied Chemistry (IUPAC, 2012) definition of microparticle dimensions between 100 µm to 0.1 µm (or 100 nm). Hence, nanometer ranges in the lower size are also included in microplastics. The global assessment report of sources, fate and effects of microplastics in the marine environment by GESAMP also considered the size range of 1 nm to <5 mm particles as microplastics for the assessment.[1]

A recent European Commission report reviews the working definition of microplastics as ***'consisting of man-made, conventional plastics including bio-degradable plastics, bio-based analogue plastics and bio-based alternative plastics with a particle size below 5 mm and include nanometer sized plastics as well (nanoparticles)'***[9]. Nano-particles are defined as materials with at least two dimensions between 1 and 100 nm. Biodegradable microplastics are also considered as microplastics as the oxidative degradation of the bio-based products lead to formation of smaller particles and their complete biodegradability in the environment (fresh water, marine and soil) is not measured yet.

Properties of a microplastic trigger the potential risk!

Light weight and durability are the two major characteristics of plastics which make them so widely used. Microplastics – being the tinier forms of the plastics – comes with similar properties but more dangerously impactful. They become highly persistent in the environment with their non-biodegradability. Plastics including micro-plastics undergo biotic and abiotic processes of degradation depending on the environmental conditions as well as the polymer's physical and chemical characteristics. Microbial and enzymatic degradation, weathering triggered mechanical disintegration, photo- or thermal degradation linked to oxidation are the general degradation processes under favourable condition but these are considered negligible in the marine environment and also the last fate of smaller particles or the complete breakdown is still not clear, rather considered to be constant.

Microplastics – often nicknamed as – 'mermaid tears' are heterogeneous in character with varied size, shape, colour, specific density and polymer type. They come in a number of different shapes (like, pellets, fragments, scrubbers, etc.) and varying level of buoyancy when in debris owing to the different densities of its composition plastics[10,11,12]. Hence, they both float and sink and accumulate eventually ensuring their universal presence in the oceans. Because of their small size, different shape, density and also influenced by the varied colours, microplastics are ingested by numerous organisms ranging from planktons to higher organisms, like, fish, marine mammals thus spreading them in the food chains[13]. Such ubiquitous contamination of microplastics of the oceans has become a major concern globally, so much so that world's oceans are now infamously called 'plastic soup'.

These solid particles are too small to be filtered by conventional wastewater treatment facility or municipal water filtration systems. Microplastics are a way for the polluting plastics to reach every little corner of the globe, when unfiltered, including human bodies! Identified as a 'new and emerging' global environmental concern, microplastics are too vast in scale and excessively dispersed to be removed from the environment once contaminated. Any remediation can cause removal of tiny organisms leading to ecological damage because of their plankton sizes[2,14].

Mircoplastics are petroleum derived products with relatively large surface areas which makes them prone to adhering wide range of hydrophobic toxins including persistent organic pollutants, pharmaceuticals, plasticizers, UV stabilizers, flame retardants, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and colorants. Once these contaminated microplastics enter in the marine environment, they are bio-available to organisms as they are small in size and are carried over long distances by water systems. Thus, they introduce toxins to the food-chain, letting them travel throughout the food-web, thereby, magnifying the problems associated with them multiple folds[7,15]. The surface of the micro plastics can have pollutant concentrations up to a million times of that found in the water[16]!

There is a gap of knowledge when it comes to fate of micro beads in air. They can either react with hydroxyl radicals or remain suspended in air for long time. They might also adsorb the other atmospheric pollutants suspended in air. Similarly, fate of micro beads in soil also remains uncharted territory.

Carriers of toxins![9,14]

- Carry hydrophobic organic pollutants
- Contaminants carried: hexachlorinated hexanes, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), organochlorine pesticides
- Many of the contaminants are endocrine disrupting chemicals (EDCs), persistent in the environment (Persistent organic pollutants/ POPs), biomagnifiable and known toxins including those having reproductive toxicity.
- Transports toxins to oceans, arctic and gets ingested in a variety of organisms

Table 1: Microplastics function in different products[8]

Function	Products
Abrasive/exfoliating	Cosmetics, detergents, industrial blasting abrasives
Emulsifier, suspending agent	Cosmetics, detergents, paints
Binding	Cosmetics, paints, inks, concrete
Filler	Construction (wall and joint fillers, self levelling compounds/screeds)
Control release of ingredients	Pharmaceuticals (nanocapsules), cosmetics, fertilisers, crops, detergents (enzymes)
Film forming	cosmetics, polishing agents
Surface coating	paper making, polishing agents
Improved chemical and mechanical resistance	Coatings, paints, floor coatings, polymer cement
Fluid absorbents	nappies, water retainer for farming, agriculture, horticulture
Thickening agent	paints, cosmetics, concrete, oilfield use (drilling fluids)
Aesthetics	coloured microplastics in make-up, structural effects of paints, enhanced gloss level of paints
Flocculant	Waste water treatment, oilfield use, paper making
Dewatering	Paper making, dewatering of sewage sludge, manure
Dispersing agent	Paints, coatings (pigments)
Opacifying agent	Cosmetics
Anti-static agent	Cosmetics / hair care

Primary & Secondary Microplastics

Depending on the source, microplastics are classified as primary and secondary microplastics.

Primary microplastics are manufactured to have a millimetric or sub millimetric size range. They are used in household items, like fillers in furniture, soft-toys, etc., air-blasting media, personal hygiene products, such as, facial-cleanser, toothpaste, exfoliating creams and even in medicines as vectors for drugs.[17] Primary microplastic can also come from the run-off/effluent of plastic product fabrication or manufacturing facilities.[1] The following gives an overview of microplastics' functions and fields of application. As evident from the list of functions (Table 1), the use of microplastics in products goes beyond their exfoliating function; it influences emulsification, viscosity, binding and film forming.

In the primary microplastics, there is an identified list of 67 currently used by the industries[18,19]. Most abundant plastic compounds among microplastics are polypropylene and polyethylene followed by polystyrene, polyester) and aliphatic polyamide present in lower quantities[20]. A primary microplastic eventually finds its way from the product into the environment through water channels and there is no going back.

Secondary microplastics, as the name suggest, are not manufactured but are the breakdown products of larger plastic particles, mainly plastic waste. The process of breaking down of plastic debris can be physical, chemical and biological over time due to the reduction of structural integrity. This continuous process of fragmentation also ensures microplastics formation from almost every plastic waste unmanaged. After all the degradations and decompositions (which is prolonged in the cold marine environment in absence of terrestrial microbes) microplastics remain in the environment for indefinite time period[8]. At times, the impression is that bio-degradable plastic will not lead to this but even that, when subjected to decomposition or degradation, breaks down only the starch content, leaving behind microplastics.

There are some microplastics which fall in between, for example, dust from car and truck tires, synthetic textiles, ropes, paint and waste treatment. These sources of microplastics have been recognized quite recently. A Norwegian Environment Agency review report about microplastics published in early 2015 states it would be beneficial to classify these sources as primary, as microplastics from these sources are added from human society at the "start of the pipe", and their emissions are inherently a result of human material and product use and not secondary defragmentation in nature.[13]

Biodegradable plastics - A potential solution or a bigger threat?

Concerns over the harmful environmental impacts of plastics, have lead to the development and production of biodegradable plastics. The term 'bioplastic', often used for consumers to denote biobased polymer derived from the biomass, is discouraged by IUPAC and noted as 'misleading because it suggests that any polymer derived from the biomass is environmentally friendly'.[21] Among the biodegradable plastics, oxo-degradable plastics (photo-degradable) are commonly promoted. However, they are conventional plastics with additives accelerating the oxidation process. The process leads to a rapid fragmentation of these plastics into microplastics which remain in the environment posing the same threat as any other microplastics.[22] The other types of commercially available biodegradable plastics are, a) starch based (containing the polylacitide/PLA or polygloycolic/PGA polymer chain), b) bacteria based using the polyhydroxyalkanoate (PHA) polymer chain, c) soy based, d) cellulose based, e) lignin based and f) natural fibers reinforcement plastic (bamboo, jute, sisal, etc.)[23]. Of the microplastics, cellulose microbeads, PHA microspheres and Mirel Micropowder are the newer biodegradable microplastics available in the market claiming to rapidly breakdown to carbon dioxide and water in marine environments leaving no harmful solids. But the problem with many of these so-called biodegradable materials is that they only breakdown in higher temperatures than would usually be found in the environment. Also biodegradation is not a simple process as multiple mechanisms and processes are involved.

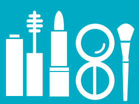
According to an article in The Guardian (O'Connor) it is unclear if the biodegradable alternatives will introduce harmful chemicals into the waterways because they may still absorb toxins in the water and introduce them into the food chain.[24] Hence more research is needed to reach to any kind of conclusion regarding the usefulness of the biodegradable plastics options.

Microbeads

Microplastics when used in personal care and cosmetic products (PCCP) as abrasives (abrasives were originally based on natural materials) majorly for improving the cleaning function or imparting color or for various other functions (see Table 1) are often termed microbeads. Microbeads are generally smaller than 1 mm in size. There are other general terms or registered trademark and product names used as well, like, microspheres, nanospheres, microcapsules, nanocapsules, etc. These plastic particulates are mostly of spherical shape but can also be amorphic. Commonly used PCCPS, like, toothpaste, cosmetics, cleansing agents, lotions, sunscreens, shaving creams and skin exfoliators contain microbeads.[25] Microplastics in leave-on lotions, make-ups, sunscreens and deodorants are much smaller in size of around micrometer to nanometer range which makes them more abundant in such products.

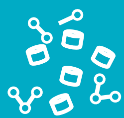
An average consumer discards
2.4 mg
of microplastics daily

Estimation shows:



680 tonnes of microbeads used annually in cosmetic products in the U.K.

A single **150 ml** cosmetic product could contain **3 million** plastic particles.



Every applications of a skin exfoliate might release **4,600 – 94,500 microbeads.**

A typical shower gel roughly contains as much plastic material as in its **packaging**.

Source: House of Commons, Environmental Audit Committee. 2016. Environmental impact of microplastics. Fourth report of session 2016-17. Available at https://publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/179/179.pdf

Source: Napper I. E., Bakir A., Rowland S. J. and Thompson R. C. 2015. "Characterisation, quantity and sorptive properties of microplastics extracted from cosmetics." Marine Pollution Bulletin 99(1-2): 178-185

Source: UNEP. 2015. Plastic in cosmetics: are we polluting the environment through our personal care?

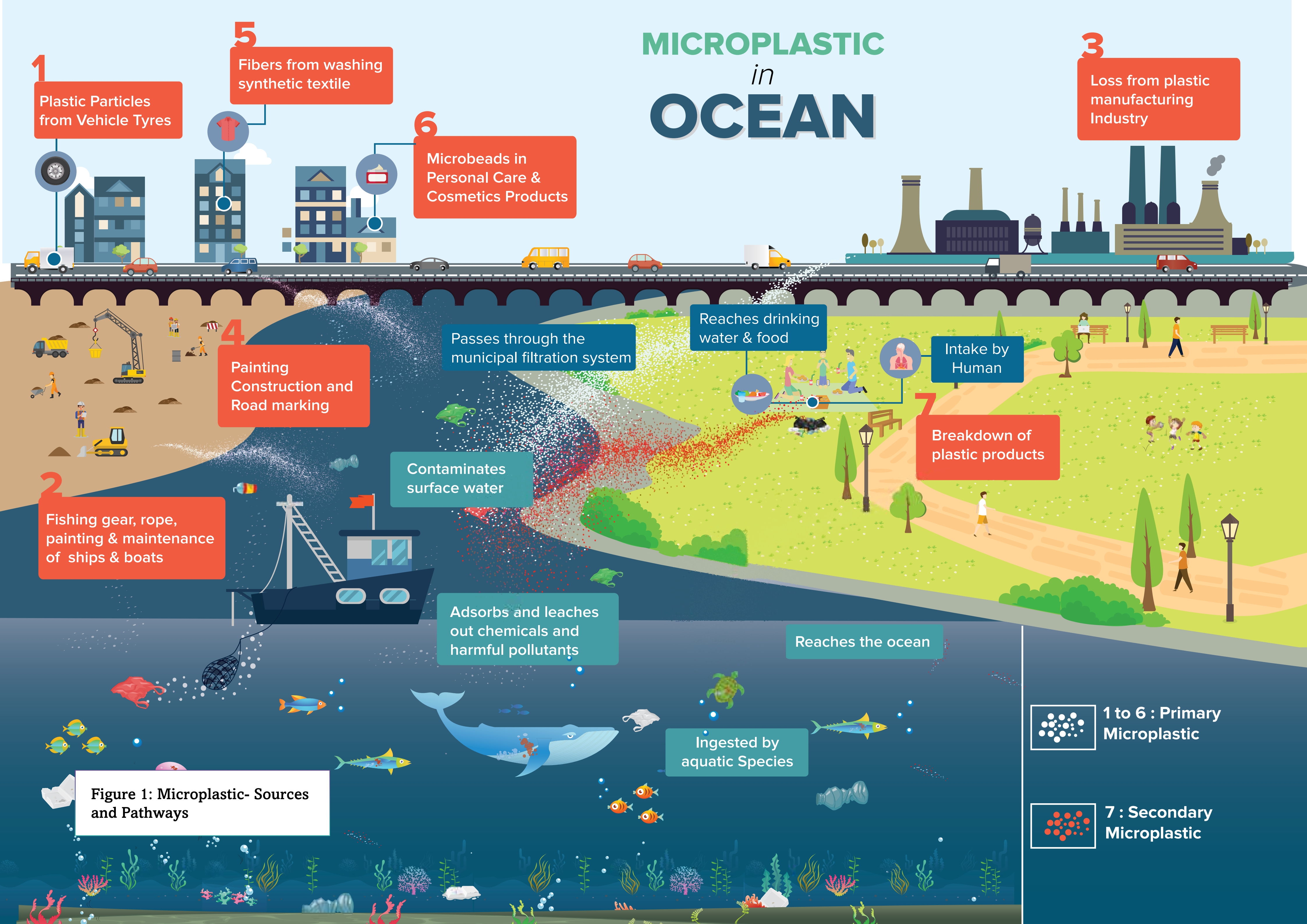
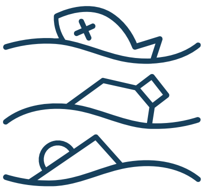


Figure 1: Microplastic- Sources and Pathways

Tracking Down the Route to Environment



About
5-14
million tones
of plastic waste enter into the oceans every year

Ever since the mass production of plastic began in the 1950s, accumulation and fragmentation of plastic debris have become a major concern for both terrestrial and aquatic environment. The poor waste management practice leads to dumping of plastic waste in the environment and their durable nature let them accumulate over long periods of time. The concerns of plastic waste are environmental, economic, social and aesthetic with complex challenges and impacts. It can even be assumed that every bit of plastic that has ever been manufactured, with the exception of which has been incinerated, still exists. While the accumulation of mega and macro-plastics are no longer uniformly increasing in the seas, it is the increased abundance and global distribution of micro-plastics which is alarming[26]. In over six decades, 8.3 billion tons of plastic is estimated to be produced of which roughly 60 percent, that is, 4.9 billion tones of plastic is now in the landfill as waste without being recycled. With the current rate of production and waste management a whopping 12 billion tones of plastic waste will be dumped in the landfill by 2050[27]. About 5 to 14 million tones of this plastic waste enter into the oceans every year[28]. Of this about 1.5 million tons accounting for 15 to 31 percent are primary microplastics released into the ocean annually as estimated by an IUCN study.[29] Not just the aquatic environment, microplastics are also detected in the air as fibrous microplastics which are mostly generated from plastic textile fibers. There are both natural and man-made textile fibers used in the textile industry. Man-made textile fibres include synthetic fibers of polypropylene, acrylic, polyamide, polyester, polyethylene, etc.[30] Of the 90 million tons of textile fibers produced worldwide in 2016, two thirds were synthetic and plastic fibers.[31]

Majority of the primary microplastics entering into the ecosystems originate from land-based activities (98%). Laundering of synthetic textiles and abrasion of tyres are the largest sources in the land. A single synthetic garment releases 1900 microplastic fibres in one laundry machine wash. Maximum release to the oceans comes from usage (49%) and maintenance (28%) of products containing microplastics while the main pathways are road runoff (66%), wastewater treatment systems (25%) and wind transfer (7%).[29] From cosmetics, especially the rinse off ones, the microbeads get washed down in the drain, they evade routine filtration systems at water treatment or sewage treatment plants and are eventually discharged to the waterways and the oceans. According to the UK parliament's environmental audit committee, a single shower can result in 100,000 plastic particles being washed down the drain[32]. Fionn Murphy (2016), in his studyof a wastewater treatment plant claiming high success rate found release of 65 million microplastics into the receiving water every day.[33]

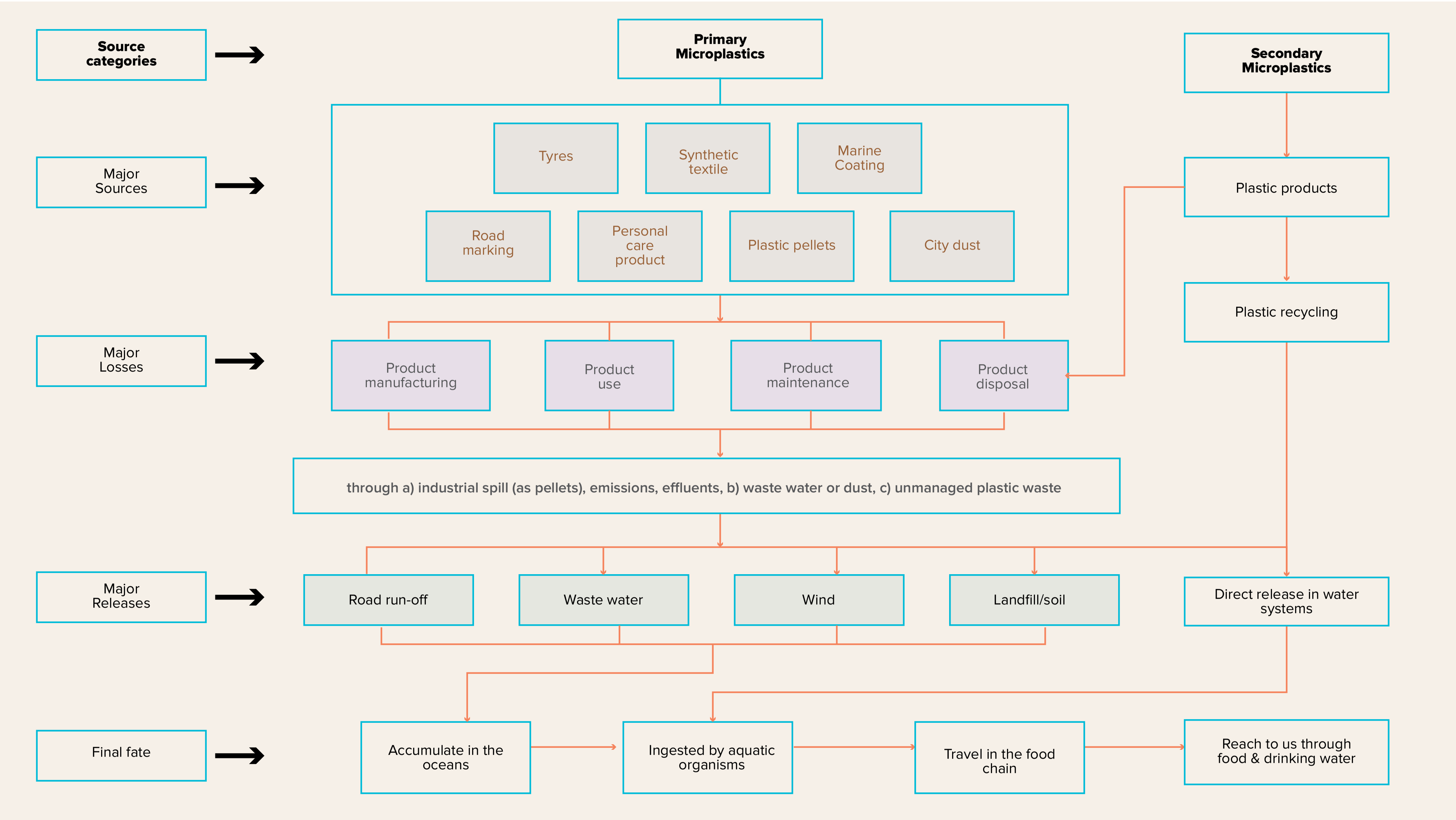
Distribution of plastic debris in oceans varies depending on the oceanic circulations, local wind, coastline geography (like, open, enclosed or semi-enclosed sea) and the waste entry points, such as, trade routes or urban areas[26]. This leads to the formation of plastic waste patches or 'hotspots' in the regions of slower currents which is seen in all the major ocean basins, viz., North Pacific, South Pacific, North Atlantic, South Atlantic and Indian Oceans[25]. These local hotspots might be permanent accumulation zones or can be transported longer distances. Plastic fragments, in form of microplastics, are found on shorelines worldwide and contribute to these debris with their numerical abundance going as high as over 80 percent of intertidal plastic debris at some locations[34]. Presence of microplastics in the remotes of Arctic Ocean, deep Arctic seafloor, Antarctic waters and in stomachs of Canadian Arctic birds are also reported by a number of studies[35].

60-90%
of marine litter is plastic-based.

Table 2: Primary Microplastics in Different Products and Pathways to the Environment[8]

Product categories	Emission pathways
Cosmetics and Personal care products: rinse off, leave on, super-absorbents	Waste water, direct human uptake, solid waste (makeup remover, disposable hygienic products)
Detergents	Waste water (solid waste)
Paints/Coatings/Inks: Building, Road, Paper making (drainage aid; coating), Laser printer inks, Domestic polishing agents (floor)	Paint spill during application (to soil, water), waste water, solid waste, direct human uptake (inhalation), formation of secondary microplastics
Industrial abrasives: blasting abrasive, abrasive media	Most likely: recovery for reuse + filter masks for workers; possible: waste water; direct human uptake (lungs)
Agriculture: Controlled release fertilisers (nutrient prills), crops; Soil enhancement (water retention); Dewatering of manure	Dissolution of polymer coating (encapsulated ingredient/fertiliser is released over time), routes to soil and ground water (not established)
Medical applications: 1. Pharmaceuticals (additive in drug formulations, controlled release, nanocapsules); 2. Dental polymers for cavity filling, sealants, dentures, abrasive in dental polish	Direct human uptake, waste water
Waste water Treatment: Flocculation agent, sewage dewatering	Through sewage onto agricultural land, further water channels
Construction: Polymer concrete, Fibre reinforced concrete (PP, Nylon, PET) Insulation (EPS)	During construction: emission into water, soil; after demolition of buildings into environment (water, soil)
Others: Furniture / soft toys (e.g. expanded Polystyrene beads), nappies, Adhesives and sealants, Oil and Gas (Drilling fluids, flocculant)	Solid waste, Unintentional releases in the marine (or terrestrial) environment (for oil & gas)

Figure 2: Distribution Pathways of Microplastics in the Environment



Source of information: IUCN[29]

Impacts of Microplastics – an unsustainable affair

63000

microplastic particles float on average in every square kilometer of the world's oceans

Plastic waste is a growing concern and evidence is mounting in recent times that the chemical building blocks that make plastics so versatile also make the material a problem. Its production, use and disposal contribute to an array of environmental and health problems. This extends to microplastics as well, although the potential impact of microplastics on environment and human health remains to be a pretty fresh topic of global concern till date. The focus is mainly on two aspects. First, when microplastics are discharged into water bodies, they may gradually accumulate and may be consumed by aquatic organisms as food. Second, microplastics could hardly be further degraded in or be removed from the natural environment once entered into waters or the sea. If toxic substances attach to or build up on their surfaces, the microplastics may impact the entire ecosystem or even human beings when they pass up the food chain. Scientists worldwide are still exploring and studying the issue, and have yet to fully understand the environmental fate of microplastics, as well as their environmental and ecological impact.

Environmental impacts

The longevity of plastics has proved to be a boon in many cases but it is also the reason for an emerging threat for environment as it does not degrade for thousands of years. Plastics travelling in any route, un-recycled, have the chance to end up in the oceans, potentially in the form of microplastics in long term.

Environmental accumulation of plastic fragments was first reported indirectly in 1960s while examining the gut contents of Laysan Albatross, a sea bird. The contents included plastic caps, polyethylene bag, broken plastic pieces and toys, etc.[36] Since then the presence and increased abundance of plastic fragments in the oceans worldwide have been widely reported by a number of studies, making them global pollutants. According to an estimation study carried out in 2014, about 63000 microplastic particles float on average in every square kilometer of the world's oceans with regional variations[37]. The impacts of microplastics on environment have several layers including the risks associated with these tiny particles, the damage it causes to the marine lives and the anthropogenic impacts that they bear. It is a challenge to several sustainable development goals including that of achieving sustainable cities owing to its socio-economic impacts.

- Impacts of the microplastics accumulation in environment depends largely on their distribution in space, like for example, between the geographic regions (temperate, tropical, polar) or open and enclosed seas or different ecological levels of aquatic bodies (surface, water column and benthic) or between the coastal habitats (salt marsh, mangrove, coral reef, mussel bed, etc.).[1] Microplastics deposited on the seafloor sediments can pose additional risk to that ecosystem due to the colonization by organisms, adherence to phytoplankton and aggregation with organic debris and other small particles eventually enhancing the settling[35].

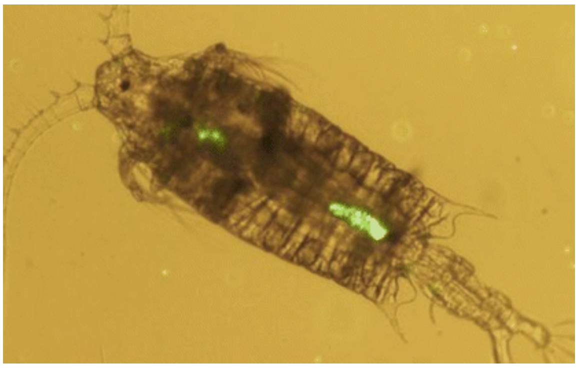
- Ecological impacts: A large variety of marine or aquatic biota, including marine invertebrates, e.g., zooplankton, mussels, sea cucumbers, fish, marine mammals and the fish-eating birds ingest microplastics – reported from all oceanic regions.[1] Ingestion of microplastics by zooplanktons and several other smaller biota lead to their introduction to the base of the food web triggering a bio-accumulation within the organisms and bio-magnification successively at the higher levels in a food chain[38]. Intracellular uptake of microplastics, retention in the guts after ingestion for several days, translocation to circulatory system and retention in the tissue have been reported for several aquatic organisms making them available for consumption by higher organisms[39,40]. The threat of microplastics can also be as severe as modifying the population structure of organisms, including bacteria and viruses by negatively affecting photosynthesis of primary producers, growth of secondary producers and thereby reducing productivity of the whole ecosystem[1].
- Chemical impacts: The large surface area, reactivity, intrinsic toxicity of the polymers and adsorbed contaminants pose the chemical risk of microplastic exposures to environment. Plastic additives, by-products, monomers and the hydrophobic contaminants as well as metals carried by these particles exert eco-toxicological impacts[41]. Dietary uptake has proven to be the majority mechanism of POPs exposure for fish and shellfish[42]. The POPs get transferred subsequently from food to organisms after ingestion and thus contribute to most of the contaminant burden. Leaching of metals from the carrier microplastics to the gut of ingesting organism or to surrounding water is also observed.[1]
- Even when not ingested, microplastics can provide surface for laying eggs of marine insects or colonization of microbes which are different than those normally found in seawater leading to potential ecological consequences[25].
- Occurrence of fibrous microplastics in the atmosphere is rarely studied. Though it has been suggested by a few studies but there is a lack of evidential studies[43]. They were found in atmospheric fallout[44], indoor air, outdoor air and dust fall in urban and sub-urban areas indicating their contribution towards the already alarming air pollution levels[45].

Impacts of microplastics on wildlife

The biological impact of microplastics on different life-forms, particularly the marine populations, is still an emerging field of research. Their adverse effects can potentially come from both the external physical obstruction or damage of organs due to physical harm and the toxicity and damage related to internal exposure. For most of the organisms both the impact and magnitude of external exposure is lower than the exposure through ingestion[1].

Microplastic exists in the ocean along with the smallest forms of marine plants (Phytoplankton) and animals (Zooplankton). These planktons measure a few microns to millimeter in size which is almost similar to that of microplastics. They also form the base of the marine food chains. Therefore, these microplastics are available along with the food source for a wide range of marine flora and fauna. Studies say that some of the zooplanktons, like daphnia also ingest and accumulate microplastics of 1.7-30.6μm size (Fig3)[46]. Daphnia is an aquatic organism which is very sensitive to changes in the environment surrounding them, like toxins, pollution and it acts as a major component of food chain[47]. A downfall of daphnia or any other plankton could mean severe threats to

Figure 3: Zooplankton with ingested microplastic in the marine ecosystem



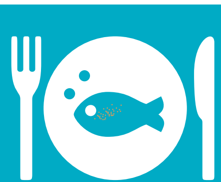
Sourced from DOI: 10.1021/es400663f

the whole marine food chains as that would lead to a decline in the food source. A number of marine organisms including oysters, clams, scallops, manta rays, whale sharks, krills etc widely feed on these planktons which filter their food from the surrounding waters[48].

Ingested microplastics can lead to starvation of the organism caused by physical impacts, such as, blockage in the digestive tract, damaged stomach lining and lessen feeding capacity[49]. It has also found to be impairing digestion, altering feeding behaviour, reducing reproductive efficiency, delaying larval development, altering the cell oxygen levels and reducing energy levels.[50] When oysters intake micro plastics, their ability to reproduce is almost halved.[51] Accumulation of these particles in their gut even reduces the life span of the organism by making them weak and prone to diseases.[52,53]

Microplastics were found to have retention time of at least 14 days while studied for crabs before they are excreted from the body to outside environment (as compared to a normal digestion periods of 2 days).[54] These plastic particles often just do not remain limited to the gut of a fish but also get dissimilated to the adjoining tissues. Various experiments with a range of marine species show that microplastics are able to translocate from stomach to other organs such as liver and hepatopancreas.[55,56] It has been experimentally studied that after ingestion, microplastics could move from the gut to the circulatory system and be retained in the tissues of marine mussels – a species consumed by human[39]. One serving of edible oyster mussels is likely to have 50 microplastic particles[57].

Microplastic fragments in the ocean also act as substrates for the growth of algae, and also smell similar to the food that fishes eat.[58] According to a study conducted by National Oceanic and Atmospheric Administration (NOAA), California, it was found that Anchovy fishes prefer to eat the microplastic particles camouflaged with algae rather than clean microplastic fragment. These fishes usually feed on small krills, planktons in the ocean and they are one of the important preys for whales, sea lions, seals and even humans.[59] Young fishes seem to be getting addicted to eating plastic in a similar way as teenagers prefer junk food.[60] Consumption of microplastics was found to be down regulating gene expressions in male and female fishes leading to their behavioural changes and impairments and non-viability of the species. With and without pollutant adsorption plastics in these microscopic forms can also cause stress in liver and single cell necrosis as determined in Japanese medaka.[61]



A plate of sea food could be giving humans more plastic than protein!

Plastic debris accumulates pollutants such as PCBs (polychlorinated biphenyls) up to **100,000** to **1,000,000 times** the levels found in seawater.

- National Oceanic Atmosphere Association, 2011

The chemical contaminated microplastics containing additives like triclosan, BPA, plasticizers, stabilizers, flame retardants and fillers and known endocrine disruptors, like, phthalates, alkyl phenols, poly-brominated diphenyl ethers pose further hazardous health impacts.[62,63,64] Endocrine hormones are required to perform metabolism and reproductive development. EDCs mimic and disrupt the normal functioning and synthesis of the endocrine hormones in the body. These harmful chemicals are released inside the body of the organisms which feeds on them. Studies show impaired reproduction in fishes fed with polyethylene (PE) due to the additives present in the microplastics. The impact was due to the impaired synthesis of reproduction hormones essential for the formation of egg.[65]

Microplastics pollution thus poses one of the most long-term threats to aquatic life as their effects take time to manifest. Their presence detected in across sea species and their impact established on reproduction and digestion poses the risk of a decline in sea food sources.

Socioeconomic impacts of microplastics

Plastic havoc is of the public knowledge, yet the economic and social impacts of microplastics are still in the prediction stage. Marine debris is one of the factors with potential to dwindle the benefits of marine ecosystem. Marine system is a major source for livelihood for people living in and around the coastal areas and provide host of services like food and non-food resources (medicines, ornaments and other raw materials), tourism/recreation, fisheries and agriculture. The system also has many intangible services and contributes towards earth's climate and water cycle regulation, air purification, forests development, water quality maintenance, coastal erosion prevention, etc.[66] Sadly, the world's oceans are now acting as the sinks for plastics including the dangers of tiny primary and secondary microplastics and no research have been carried out to estimate the direct socio-economic impacts of microplastics.[1]

Although the issue is at a nascent stage, Microplastics, impacting marine biodiversity, directly affects the coastal communities owing to their loss of income. Fisheries and aquaculture are directly impacted from for example damage to fishing vessel due to entanglement, contamination of the catch with plastic debris and indirect impacts include loss of target species, lowered rate of commercial fish species as they are reported to be ingesting microplastics[25].

Tourism is another livelihood sector getting affected greatly from the consequences of visible presence of marine litters and the resulting reduced recreational activities discouraging the tourists and thereby lowering the revenues from tourism and increasing the cost of beach cleanup. This particularly affects the local and regional economy[25]. Significant decline in tourist numbers and associated revenues due to plastics were reported from the islands of Hawaii and Maldives.[67] Effects on the marine food-chain can, by extension, pose potential risks to human health through the consumption of sea food which may further lead to socio-economic costs[1]. Though the impact of microplastics on soil is never studied but there are citations suggesting their negative impact on coastal agriculture due to reduced soil productivity. Increased potential of harmful microbial colonization and their longer survival on the microplastic concentrates in marine coastal ecosystems could impact the water quality of the coastal areas, spread pathogenic diseases and thereby, affect human health, agriculture and tourism.[68]

A Socio-Economic Costs Model based study for Microplastics (SECMMPs) carried out to understand the potential impacts of microplastic debris on aquaculture sector in two seas (Channel and France Manche region) in the UK projects the costs to cleanups and tourism for this region to range between £1.5 million to £499 million per year in 2010-2100.[69] As reported in the study, just the absence of microplastics in the oceans and seas could have saved approximately 250 million pounds combined from aquaculture, tourism and clean-ups actions.

Health impacts

Global researches have focused mostly on understanding the effects of microplastics on marine or aquatic ecosystems. But the role of microplastics as a **health concern for terrestrial species or land dwellers – though of major concern – yet is less researched.**[70] Assessing these concerns are as important as of the aquatic organisms as many of these terrestrial organisms like birds, reptiles and humans consume aquatic organisms, which constantly feed on microplastic debris along with their diet. Fishes and other aquatic animals are even referred as 'passive samplers' of POPs in the bird's stomach.[71]

Major routes of microplastics exposures to humans are contaminated food and drinking water. Oral ingestion followed by uptake of inert particles across the gut is the most widely studied pathway for microplastics to enter the human body. After the ingestion, particle size plays an important role in determining their fate inside the body. They can get mixed with the blood lumen (persorption), translocate from the gut to other body fluids or even get absorbed across the gut depending on their size.[72]

A study through various oceanic expeditions and oceanic models found that 93000 to 236000 metric tons of microplastics have been accumulated in the ocean already.[73] This high amount of microplastics in the ocean along with the fact that it is consumed by aquatic organisms might make sea food no longer fit for human consumption.

Potential harm

Majority of the health implications of plastic polymers are attributed to the plastic additives which can leach from the polymers into water, air, food or body tissues owing to their low molecular weight.[74] A hazard ranking study found Polyurethane (PUR foam), Polyacrylamide (PAN with co-monomers) and Polyvinylchloride (PVC plasticised) having the highest hazard potential to health risks in terms of the harmfulness of the additives they carry.[75] Leaching of chemicals from ingested microplastics inside the human body and tissue can thus be a long-term source of chemicals like, phthalates, bisphenol, triclosan or brominated flame retardants.[76] These plastic additives or leached chemicals from plastic polymers are found to have hormone disrupting ability,[77] exhibit estrogenic activity (EA) leading to early puberty in females (mammals), reduced sperm counts, altered functions of reproductive organs, obesity, altered sex-specific behaviours, and increased rates of some breast, ovarian, testicular, and prostate cancers.[78,79,80,81,82,83,84] Fetal, newborn, and juvenile mammals are especially sensitive to very low (sometimes picomolar to nanomolar) doses of chemicals having EA.[85] UN report, Frontiers has confirmed that the presence of microplastic in foodstuffs could potentially increase direct exposure of plastic-associated chemicals to humans and marine organisms. Potential adverse effects, at high enough concentrations, may include immune-toxicological responses, reproductive disruption, anomalous embryonic development, endocrine disruption, and altered gene expression.[86,87,88,89]

Studies show that plastic particles can cause lung and gut injury, and especially very fine particles can cross cell membranes, the blood-brain barrier and the human placenta. Observed effects include oxidative stress, cell damage, inflammation, and impairment of energy allocation functions.[90]

The use of primary microplastic containing products can also be harmful for human beings. Microplastics from daily use toothpaste can get stuck in the gum and trap bacteria leading to gingivitis. Over time that infection can also move from the gum into the bone holding the teeth resulting into bleeding from the gum and eventual teeth weakening (periodontal disease).[91] While washing the face, microbeads (used in facial care products) can cause tiny rips in the skin letting in the bacteria and pollutants contributing to skin ageing and dark spots. Microbeads can also get stuck in the eye. Usually these get blinked away, but sometimes granules can be lodged under the eyelid and injure the cornea which is the most sensitive part of the body as it has 50,000 nerve endings.[92] Microplastics suspended in the air could even be breathed in with the risk of a noxious effect on the lungs similar to car fumes.[93] Once inhaled, they might induce lesions in respiratory system even at low concentrations to susceptible individuals.[94]

Recorded Occurrence of microplastics in India

Microplastics, as a whole, are a rarely studied issue in India. However, in the counted studies, the presence of microplastics was detected in inland surface water bodies, river waters and along the coastline indicating the spread of these tiny toxin careers and recognizing the need to probe further on their contamination.

Back in 2013, in a study conducted to analyse the plastic debris on Mumbai beaches, small plastics were found to be numerically predominant with 41.85 percent of microplastics.[95] Among the recent studies, microplastics were found in several beaches along the Goa coast with an abundance of polyethylene and polypropylene. Also, south-west monsoon was observed to be the driving force for transportation and deposition of microplastic particles on these beaches.[96] In a study in Chennai coast, polyethylene and polypropylene were again found dominant as microplastics. Interestingly this pre- and post flood analysis observed a tripling of microplastics post-flood indicating their source to be the inland rivers.[97] Occurrence of microplastics was also reported in the beaches of the remote island of Tinnakkara located in Lakshadweep archipelago.[98] Microplastics were found extensively distributed in a Ramsar site in Kerala (Vembanad Lake) with low density polyethylene as the dominant type.[99]

According to an IUCN 2017 study, India and South Asia region of the 7 global regions (North America, South America, Europe & Central Asia, Africa & Middle East, East Asia & Oceania, China) considered, has the highest release of primary microplastics into the world oceans amounting to 274 KTons. High population and technological inefficiency makes India and South Asia the worst in this case. Also, the release of primary microplastics from textile and cosmetics in this region is highest across the globe[29].

When in many parts of the world the concern for primary microplastics are recognized owing to their unmanageability and initiatives were taken forward for restrictions in many cases, India still sits silent on the issue. Though primary microplastics come from a number of sources, but those used in PCCPs are easily replaceable or can be eliminated. In fact, most of the international brands are in the process of phasing out microplastics from their PCCP products in countries which have banned them.[100] But their status in India is unknown.

Global Initiatives

A resolution has been passed in its Environment Assembly in 2017 urging the phasing-out of primary microplastic particles in personal care products, industrial abrasives and printing products.

Microplastic is slowly becoming one of the most pressing issues being discussed globally, amidst the growing concern of its harmful impacts. There have been a few global initiatives which contributed for making the path to this discussion.

United Nations Sustainable Development Goal (SDG) 14

In 2015, United Nations has adopted 17 Sustainable Development Goals aiming to transform the world to a better place for living. Goal 14 called for efforts to **'conserve and sustainably use the oceans, seas and marine resources'** as the first of its targets set for 'preventing and significantly reducing marine pollution of all kinds, in particular from land-based activities, including marine debris' by 2025. Recognized also by the UN is the fact that marine plastic pollution including microplastic abundance, contamination and ingestion throughout the food chains is the major concern. Realising the need of international agreements in solving the problem, an Ocean Conference was held in the UN headquarterwith 193 member countries for voluntary commitments for implementation of SDG 14. The outcome document, 'Our ocean, our future: call for action' lists down, i) reduction of plastics and microplastics pollution and ii) implementing long-term and robust strategies to reduce the use of plastics and microplastics among the others as the actions to be taken up on urgent basis by the countries.

A resolution has also been passed in its Environment Assembly in 2017 urging the phasing-out of primary microplastic particles in personal care products, industrial abrasives and printing products. This resolution is the first concerted action requiring involvement of national and local

UN Actions in brief

- Adoption of SDG 14: Life below water, 2015
- Voluntary commitment by 193 member countries to strategise reduction of microplastics, Ocean Conference June, 2017
- Non-binding resolution urging phasing out of primary mcroplastics, UNEA, December, 2017

governments, private sector, non-governmental organsations and citizens.

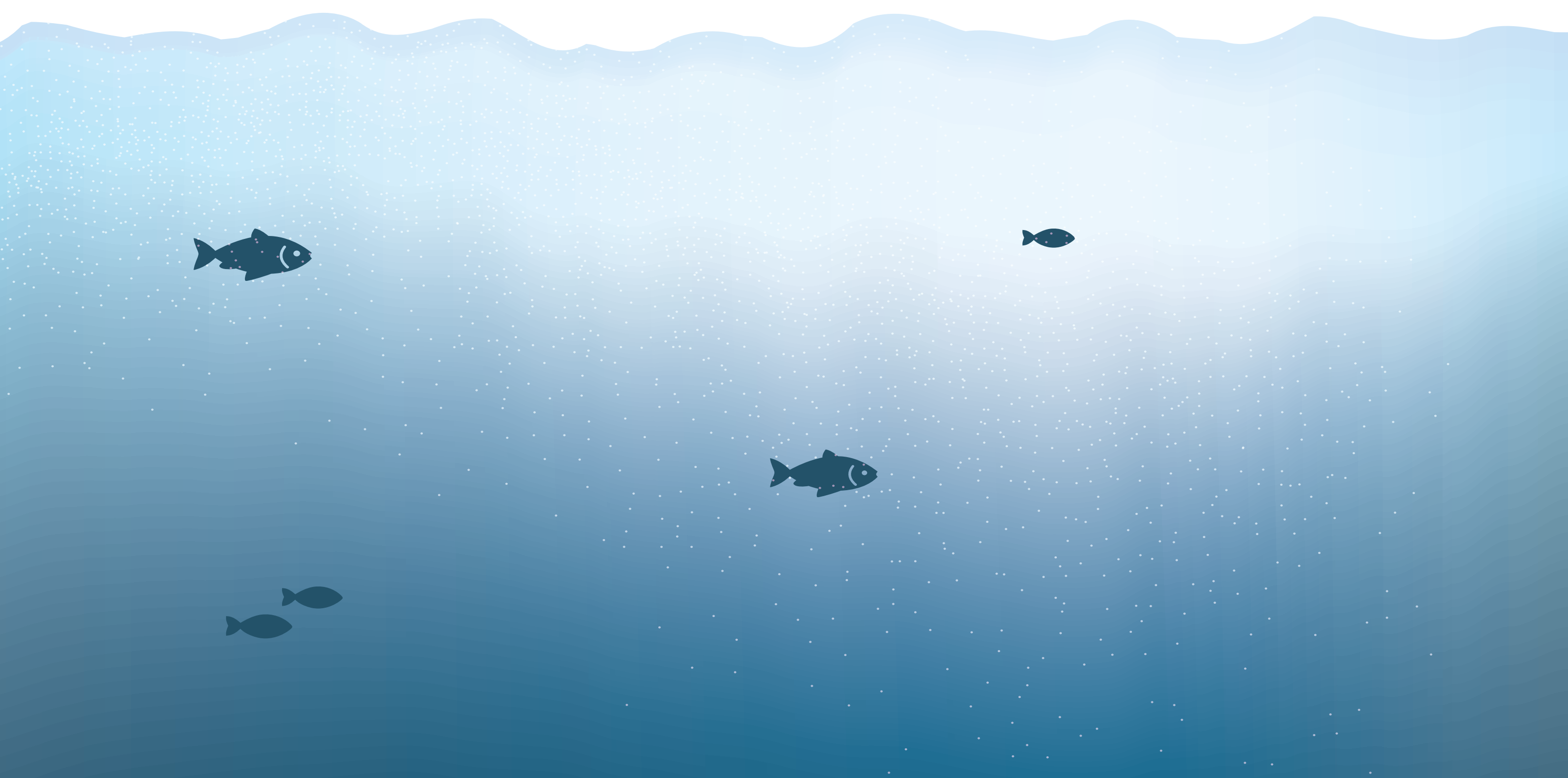
Beat the Microbead

'Beat the Microbead' is an international campaign against microplastic ingredients used in personal care products. Launched in 2012 by the Plastic Soup Foundation and the North Sea Foundation, it campaigns to prevent plastic microbeads from cosmetics to end up in sea or in real term advocates for a ban on use on microbeads in cosmetics. The campaign has 92 NGO partners from 38 countries. As part of the campaign, the initiative has also introduced a smartphone application which helps consumers identify products containing plastic microbeads. The App scans product barcodes from a number of brands and manufacturers and detects the presence of microplastics depending on the declaration or status of the companies/brands on the use of microplastics in their products. In 2013, UNEP partnered with the initiating Foundations committing to upscale the geographic reach/scope of the campaign by upgrading the data base and promoting the App. The App has been translated to several languages for increasing accessibility and is currently available in English, Spanish, Greek, Polish, Deutsch, French, Norwegian and Portuguese. The campaign also lists out productswith respect to its microplastic constituents on its website. Recent introduction to the campaign is the 'Look for the Zero' logo, which can be used by companies and brands to declare their products free of microplastic ingredients through.

Clean Seas Campaign

The Clean Seas campaign (#CleanSeas) was launched by the UN Environment in January 2017 as a war against ocean plastic. It aims to engage governments, general public, civil society and the private sector. The campaign goals are to have industrial plastics management improved, non-recoverable plastics (e.g. microplastics in cosmetics) phased out, and single-use plastic significantly reduced within the next five years. The key strategies adopted are, a) education and engagement of citizens, b) collaboration with governments and private sector, c) replication and scaling up of the efforts around the world. This UN Environment campaign connects stakeholders across the systems to transform individual and institutional practices, standards and policies to reduce the harm. Nearly 40 countries have joined the campaign which aims to achieve a global ban on microbeads in personal care and cosmetic products and a drastic reduction in the production and use of single-use plastic by 2022.

"Unless we take action, our oceans will contain more plastic than fish by 2050." – UN Environment



Microplastics in Cosmetics: Microbeads

Plastic ingredients, mostly termed 'microbeads' are widespread in personal care and cosmetic products

Plastic ingredients, mostly termed 'microbeads' are widespread in personal care and cosmetic products (PCCPs). They are mostly thermoset and thermoplast plastic materials which are solid phase, such as polyethelene, polypropylene, polyurethanes, some silicone polymers, etc. These synthetic non-degradable polymers serve an array of purposes in PCCPs which include exfoliation, film formation, acting as a sorbent for delivering active ingredients, skin conditioning and a lot more. While some of these microbeads in the PCCPs are clearly visible, others are as small as in micro- or nanometer range[2]. PCCP microplastics are similar to any primary or secondary microplastics in terms of their properties or behavior- and have an affinity for adsorbing a majority of the toxic chemicals they come in contact with.. Phthalate esters, of which diethyl phthalate (DEP) is the most common, are used as additives to PCCP microplastics.[101]

According to a survey conducted by Cosmetics Europe, a total of 4360 tonnes of microplastic beads were used in cosmetics in the year 2012 only across the two European Union countries, Norway and Switzerland. One can imagine the number of such beads being used globally! Polyethylene beads only represent 93 percent of this amount.[102]

The concerns of microbeads ingredients in cosmetic products are notable as they are, in many cases direct 'down-the-drain' products. Once a product containing microbeads is washed off a person's hands or face, the cleaning agents plus the microbeads are rinsed down the drain and enter wastewater systems. Most wastewater is processed through a wastewater treatment plant, and the ability of a wastewater treatment plant to capture microbeads depends upon its specific treatment capabilities. Because of their small size and buoyancy, many microbeads escape capture by wastewater treatment plants. Subsequently, microbeads in the treated water are discharged to rivers, lakes, or oceans, where they accumulate and persist.

Table 3: Selected examples of solid-phase, water-insoluble plastic ingredients currently applied as particulates in personal care and cosmetics products[2]

Polymer	Examples of functions in PCCP formulations
Nylon-12 (polyamide-12))	Bulking, viscosity controlling, opacifying (e.g. wrinkle creams
Nylon-6	Bulking agent, viscosity controlling
Poly(butylene terephthalate)	Film formation, viscosity controlling
Poly(ethylene isoterephthalate)	Bulking agent
Poly(ethylene terephthalate)	Adhesive, film formation, hair fixative; viscosity controlling, aesthetic agent, (e.g. glitters in bubble bath, makeup)
Poly(methyl methylacrylate)	Sorbent for delivery of active ingredients
Poly(pentaerythrityl terephthalate)	Film formation
Poly(propylene terephthalate)	Emulsion stabilizing, skin conditioning
Polyethylene	Abrasive, film forming, viscosity controlling, binder for powders
Polypropylene	Bulking agent, viscosity increasing agent
Polystyrene	Film formation
Polytetrafluoroethylene (Teflon)	Bulking agent, slip modifier, binding agent, skin conditioner
Polyurethane	Film formation (e.g. facial masks, sunscreen, mascara)
Polyacrylate	Viscosity controlling
Acrylates copolymer	Binder, hair fixative, film formation, suspending agent
Allyl stearate/vinyl acetate copolymers	Film formation, hair fixative
Ethylene/propylene/styrene copolymer	Viscosity controlling
Ethylene/methylacrylate copolymer	Film formation
Ethylene/acrylate copolymer	Film formation in waterproof sunscreen, gellant (e.g. lipstick, stick products, handcreams)
Butylene/ethylene/styrene copolymer	Viscosity controlling
Styrene acrylates copolymer)	Aesthetic, coloured microspheres (e.g. makeup
Trimethylsiloxysilicate (silicone resin)	Film formation (e.g. colour cosmetics, skin care, sun care)

Note: some polymers that make up the plastic materials may be available in various forms, as dispersions in solvents, or as partially water soluble polymer forms. The functions can be many, provided are examples.

Market sources of microbeads

Microbeads, (also called microspheres), as mentioned above, are used mainly in personnel care products, industrial sector, paints and coatings, and in medical technology. Global microsphere market was estimated to be USD 3.98 billion in 2016 and it is projected to reach USD 6.68 billion by the year 2022[103]. Some of the major vendors of microspheres are Sigmund Lindner GmbH (Germany), Matsumoto Yushi-Seiyaku Company (Japan), Momentive Performance Materials Inc. (U.S.), Trelleborg AB (Sweden), Luminex Corporation (U.S.), Chase Corporation (U.S.), AkzoNobel N.V. (Netherlands), Cospheric (U.S), Microbeads AS (Norway) and the R.J. Marshall Company (US based company), 3M (U.S.), Potters Industries LLC (U.S.) and Mo-Sci Corporation (U.S.)[104]. In India polyethylene microsphere is supplied by Triveni Chemicals, (Vapi) Gujarat.

Legal Status
and alternatives

Considering the environmental impact a number of countries have moved for issuing legal restrictions or bans on microbeads

Plastics – the indispensables of modern world – are finally accumulated in the environment either through the loopholes of waste management or directly as a result of ignorance. Since the material is non-biodegradable, the plastic litter gets degraded into small particles or microplastics and exists. Inadequate waste management is often blamed for the plastics to escape from the system and dumped into the environment, either in the landfill or into the oceans through water channels. What is majorly overlooked, until recently, is the contribution of primary microplastics, those tiny plastic particles finding their way directly – even after treatment – into the water, soil and air. Worldwide research and scientific evidences indicate synthetic plastic microbeads as serious concern to the environment. They are dispersed widely across the globe, found across the food chains, particularly in the aquatic habitat, can cause bioaccumulation of hazardous chemicals and stays in the environment for indefinite period.

Concerning the environmental impact a number of countries have moved for issuing legal restrictions or bans on microbeads in cosmetic products. A non-binding resolution addressing microplastics was passed during the recent UN Environment Assembly (3rd) in Nairobi in 2017 with nearly 200 nations supporting the cause. Reducing or phasing out of the use of microbeads has also been recommended in the background report of the assembly[105].

Below listed is some of the country specific initiatives.

US: The US has banned manufacture or interstate trade of products containing microplastics by 2017 and rinsing-off of microbeads containing cosmetics from 2018 through the *Microbead-Free Waters Act 2015*.[106] This act was introduced as an amendment to the Federal Food, Drug, and Cosmetic Act.

Canada: Through the *Microbeads in Toiletries Regulations* under the *Canadian Environmental Protection Act, 1999*, the Canadian Government has defined microbeads as toxic substances and put a ban on manufacture and import of toiletries containing microbeads (came into force from January 2018), sale of such toiletries by 2018. The same regulation bans manufacture or import of natural health products or non-prescription drugs' containing microplastics by 2018 and sale by 2019 within the country.[107]

***Europe*:** Though widely discussed and proposed by a number of member countries, EU does not have any regional legislation on banning microbeads in cosmetics as of now. Some of the member countries, like, Sweden, Finland, France, Iceland, Ireland, Luxemburg and Norway have planned national ban on rinse-off cosmetics containing microbeads. The Italian parliament adopted a proposal on 19 December,2017 to ban microbeads scrub particles in cosmetics as of 2020. France has published a decree in 2017 aiming to ban solid plastic particles in rinse-off exfoliating and cleaning cosmetics in 2018. A law proposal for banning the use of microplastics in care products in Italy has been approved unanimously in Italian Parliament.

Plastic microbeads can no longer be used in cosmetics and personal care products in the UK from January 2018. The ban initially bars the manufacture of such products and a ban on sales will follow in July. The ban is stronger here as it does not only include 'rinse off products'.

Asia: South Korea had also notified the World Trade Organisation (WTO) with 'Proposed Amendments to the Regulation on Safety Standards etc of Cosmetics' earlier in 2016 with a proposed ban on the use of microbeads in cosmetics. Taiwan plans to ban cosmetics containing microbeads from 2018 with measures following footsteps of the United State and UK.

Japan, China and India still does not show any move towards ending of the use of microbeads in cosmetics which of course is the easiest way to reduce microplastic pollution immediately.

Oceania: New Zealand has also brought out a legislation to prohibit use of microbeads in wash-off products, their selling and manufacture across the country which is to come to effect from 1 July 2018. Federal Govt. of Australia called for a voluntary phasing out of microbeads from cosmetics and plan for a stricter stance through imposing ban.

India: Amidst the global concern, India has done little. The only action has been through an individual citizen's initiative. A concerned citizen knocked the door of National Green Tribunal, filling a plea asking for banning of microbeads in cosmetics. The case was also seeking that fines/penalties be imposed on defaulting companies causing environmental pollution by the use/ manufacture/ import/ sale of various cosmetic/personal care products containing microbeads/microplastics. The NGT issued a directive for getting the cosmetics analysed. After this the microbeads were classified by the Bureau of Indian Standards (BIS) in India as 'not recognized as safe' for use in cosmetic products. There has been no action post that. As of now there is no directive from the tribunal as well as notification from the government on banning or restrictions of microbeads in India.

In an exemplary initiative by the Government of Maharashtra, manufacture, usage, storage, distribution, wholesale or retail sale, import and transportation of all kinds of plastic bags (with or without handle), single use disposable items made of plastic and thermocol — dish, cups, plates, glasses, fork, bowls, forks, spoons, straw, containers, non-woven polypropylene bags, pouches to store liquid, plastic to wrap or store products and packaging of food items are banned in the state through the Maharashtra Plastic and Thermocol Products (Manufacture, Usage, Sale, Transport, Handling and Storage) Notification, 2018 under the Maharashtra Non-Biodegradable Garbage (Control) Act, 2006. They are also planning to ban the use of microplastics in cosmetics soon.

Cosmetics microplastics are a tiny contribution to marine microplastic pollution, i.e, **0.1% to 4.1%**. But stopping that would reduce a load of **2400 – 8600 tonnes** of plastics annually from our oceans!

Source: UK Parliament. 2017. Microbeads and microplastics in cosmetic and personal care products. Hirst D. and Bennett O. Briefing paper No. 7510. House of Commons Library, UK Parliament.

A number of companies also are either discontinuing or phasing out of the use of microbeads in their products in EU, like, Colgate-Palmolive (phased out in 2014), Unilever and Boots (in 2015), Johnson and Johnson (phasing out started in 2015), BDF Beirsdorf and L'Oreal (total group phase out by 2017) but there is no information available for the products of these companies in India.

Table 4: An overview of the worldwide banning status of microbeads

Country	Legal status/ regulation	Year of imple-mentation	Prohibitions (proposed/implemented) on	Definitions
United States	'Microbead-Free Waters Act of 2015' as amendment to the 'Federal Food, Drug, and Cosmetic Act'	Dec, 2015	Manufacture or the introduction or delivery for introduction into interstate commerce of a rinse-off cosmetic including toothpaste that contains intentionally-added plastic microbeads Effective dates • Manufacturing from July 1, 2017 • Introduction or delivery for introduction from July 1, 2018 • Manufacturing of nonprescription drug from July 1, 2018 • Introduction or delivery for introduction of nonprescription drug from July 1, 2019	Plastic microbead: "Any solid plastic particle that is less than five millimeters in size and is intended to be used to exfoliate or cleanse the human body or any part thereof"
Canada	'Microbeads in Toiletries Regulations' under the 'Canadian Environmental Protection Act, 1999'	To come into force on January 1, 2018, or the day they are registered if after that.	• Manufacture or import any toiletries that contain plastic microbeads • Manufacture or import of toiletries that are also natural health products or non-prescriptin drugs on or after July 1, 2018 • Selling of any toiletries containing microeads on or after July 1, 2018 • Selling of toiletries that are also natural health products or non-prescriptin drugs on or after July 1, 2019	Microbeads: "Plastic microbeads that are ≤ 5 mm in size" as defined in the 'Toxic substances list: schedule 1 of CEPA 1999'. Toiletries: "Any personal hair, skin, teeth or mouth care products for cleansing or hygiene, including exfoliants and any of those products that is also anatural health productor a non-prescription drug"
European Union	No regional legislation in place. Individual countries planned for national bans but no such concrete moves other than UK, France & Italy			
UK	The Environmental Protection (Microbeads) (England) Regulations 2017 under the 'Department for Environment, Food and Rural Affairs'.	Notified World Trade Organisation (WTO) Proposed date of adoption: not determined	Prohibit the use of microbeads as an ingredient in the manufacture of rinse-off personal care products and the sale of any such products containing microbeads Proposed date of entry into force for prohibition: • Manufacture on January 1, 2018 • Sale on June 30, 2018	Microbead: "Any water-insoluble solid plastic particle of less than or equal to 5mm in any dimension" Rinse-off personal care product: "Any substance, or mixture of substances, manufactured for the purpose of being applied to any relevant human body part in the course of any personal care treatment, by an application which entails at its completion the prompt and specific removal of the product (or any residue of the product) by washing or rinsing with water, rather than leaving it to wear off or wash off, or be absorbed or shed, in the course of time"
France	French decree	published in March, 2017	Prohibition on rinsed cosmetic products used for exfoliation or cleaning purposes or wadded sticks for household use with plastic stem for placing them in the market • Rinsed cosmetic products on January 1, 2018 • Household sticky sticks with a plastic shank on January 1, 2020	

Country	Legal status/ regulation	Year of imple-mentation	Prohibitions (proposed/implemented) on	Definitions
New Zealand	'Waste Minimisation (Microbeads) Regulations 2017' under 'Waste Minimisation Act 2008'	To come into force from July 7, 2018	• Prohibited wash-off products containing microbeads for 1 or more of the purposes: i. exfoliation of all or part of a person's body ii. cleaning of all or part of a person's body iii. abrasive cleaning of any area, surface, or thing iv. visual appearance of the product, But, does not include a medical device or medicine. • Selling and manufacturing of prohibited wash-off products is not allowed in New Zealand • Contravention is offensive and liable on conviction to a fine not exceeding $100,000	Microbead: water-insoluble plastic particle that is less than 5 mm at its widest point
Australia	Currently, depends on voluntary phasing out of microbeads by the companies by 2017. No banning implied as of now but can go for a ban in law if phasing out is not achieved nationally.			
South Korea	'Proposed Amendments to the "Regulation on Safety Standards etc of Cosmetics" under the The Korean Ministry of Food and Drug Safety (MFDS)	Notified WTO (October, 2016). Date of adoption and entry into force not determined.	Proposes to ban the use of microbeads in cosmetics	Microbeads: less than or equal to 5mm in size
Taiwan	Environmental Protection Administraion (EPA) preannounced a draft of the Restrictions on the Manufacture, Import and Sale of Cosmetics and Personal Care Products Including Toothpaste that Contain Plastic Microbeads			
China	No action taken			
Japan	No action taken			
India	Microbeads are notified by Bureau of Indian Standard (BIS) as 'not recognized as safe' for use in cosmetic products. No other phasing out either voluntary or through legislation is in place.			

Alternatives to Microplastics in Cosmetics[8,108,109]

Microbeads in the cosmetics came replacing originally used natural or less harmful alternatives. Though there is not one alternative to all applications but different potential alternatives are already introduced for different applications depending on their characteristics. In response to the phasing out commitments, a number of international companies have quoted alternatives which will be used in the products to achieve their commitments. The cosmetic groups claimed that they were replacing synthetic materials with a number of environmentally friendly natural bead alternatives, including those made from beeswax, rice bran wax, jojoba waxes, starches derived from corn, tapioca and carnauba, seaweed, clay and other natural compounds. Natural ingredients, such as pumice stone or walnut shells were also being used in some products, depending on the function.

Current Study Framework

18 Products from 16 major consumer brands were tested

The cosmetic industry in India is expected to grow with an annual compound rate of 25 percent by 2025 and most likely to be placed among the top 5 global markets by revenue.[110] International brands along with the Indian products are found in almost every shelf of the cosmetic stores across the country. The rising awareness of beauty products, changes in consumption patterns and lifestyles and improved purchasing power have boosted the industry. Cosmetics, which were at a point, seen primarily targeted at women, now have a huge market with men too and is also a big driver for potential growth. The cosmetics product range has also widened in recent times and products like face wash, body wash, scrubs which were a rarity even a couple of decades back, are now regularly found in Indian households.

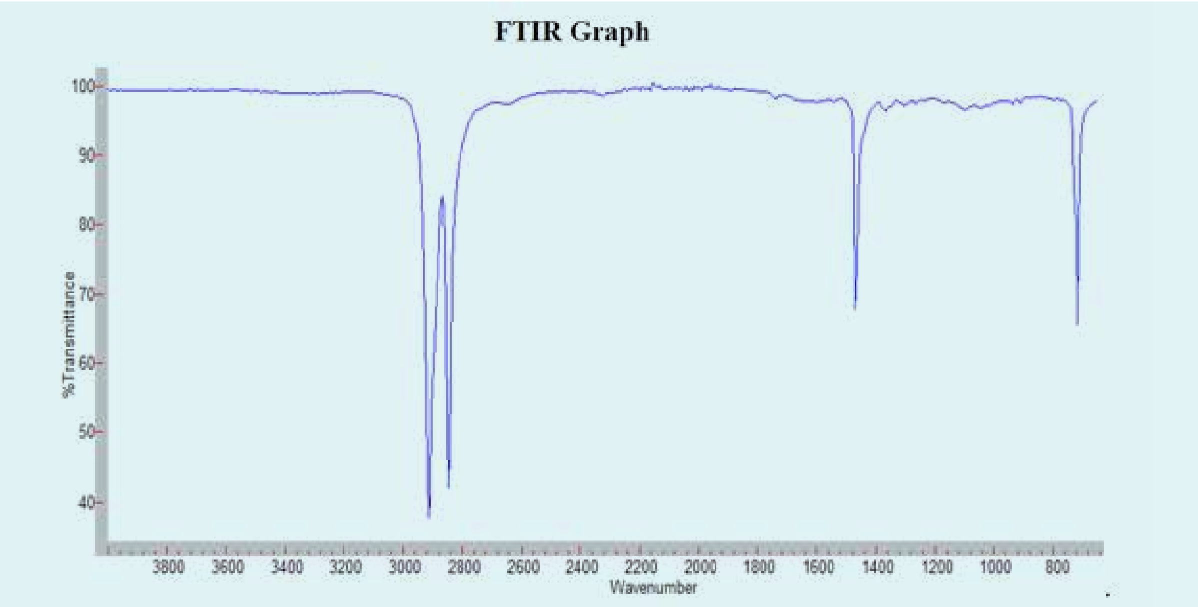
The wide penetration of cosmetics and mushrooming of smaller companies, along with national and international brands also means there is a growing need to regulate the content carefully. With no regulatory framework in place for microbeads in the country, many of these products in Indian market are likely to contain this pollutant.

Objective

Considering the concerns and importance of the source identification and removal of primary microplastics, Toxics Link has initiated a primary study in a first of its kind in India. The study is framed to identify the occurrence of microplastics in the personal care and cosmetic products (PCCP) available in India.

Methodology

- PCCP products of both rinse-off and leave-on categories were randomly collected from departmental stores in New Delhi. Face wash, face scrub,



body wash and face mask were among the rinse-off products and body lotion, sunscreen lotion, BB cream and baby lotion were the leave-on lotions. Major international and national, including herbal brands were covered while selecting the products.

- Total 18 products covering 16 major consumer brands were collected to test for microbeads.
- Products were labelled with sample numbers and transferred to glass bottles with metal caps. The sample holder glass bottles were also labelled with the corresponding sample numbers. The glass bottles were selected to avoid and prevent any further plastic contamination.
- The samples were analysed (in an external laboratory) for identification of microplastics through: a) Visual analysis: Samples were observed for presence of visible particles, b) semi-quantitative analysis using 0.45 micron filter paper c) Stereomicroscopic analysis and d) FTIR analysis using Cary 630 Fourier Transform Infrared Spectroscopy (FTIR). The objective of the FTIR analyses was to identify the polymer origin. Samples were directly exposed to FTIR and the obtained spectrum ranges were analysed by comparing to the reference spectra of known materials.

Limitations

Since the issue of Microplastics is at a nascent stage in India, there were many challenges in the course of the study.

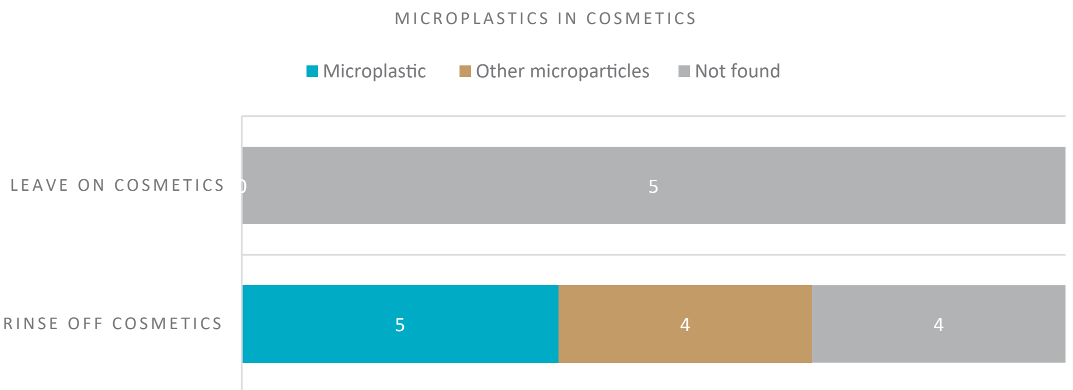
- Lack of existing research in India on microplastic- There have been only limited number of studies in water bodies or oceans for assessing microplastics. But there is significant body of work done internationally hence those were extensively referred to in the study report.
- There is no information available on use of microbeads in cosmetics sold in Indian market.
- Non- availability of an accredited laboratory in India for testing microbeads in cosmetics was a major challenge. Attempt was made to develop a protocol, based on available international research and use a certified lab to follow the process.

Results & Discussion

A large number of rinse-off products were found to have microplastics

Analysis of microplastics is complex as they even vary by definitions in terms of their size, composition or solubility according to different agencies/sources. Many polymers are recognised as microplastics in international studies, but their chain lengths are not defined. The chemical nature and solubility of these polymers can get altered with variation in chain length and composition. Retention of their plastic characteristics in both cases are not widely discussed or established. Like for example, polyethylene-glycol (PEG), acrylate copolymer, silicone resin are listed as microplastic ingredients in PCCP products by 'Beat the Microbead' campaign referring to UNEP 2015 and TAUW report.[111] But the UNEP 2015 report describes only polyethylenes with 700 carbon chain are waxy, water insoluble and solid particles, hence, are microplastics. It also says, polyethylene alkane chains with less than 20 carbons are liquids or gases and water soluble and PEG with the ethylene oxide polymer chain lengthened to 20,000 results into solid material (PEG-2M).[29] But which chain length of PEG can be considered as microplastics is not clear. There are water dispersable polymers as well in the PCCPs termed as 'microgels' in a study by Gruber, 1999.[112]

In the current study, 6 face wash, 3 body wash, 3 face scrubs from different brands, 1 face mask and 5 varieties of leave-on lotions were analysed for detecting the presence of microplastics (water insoluble) of more than 0.45 micron size. Large numbers of particles, especially granular material were observed with naked eye. The



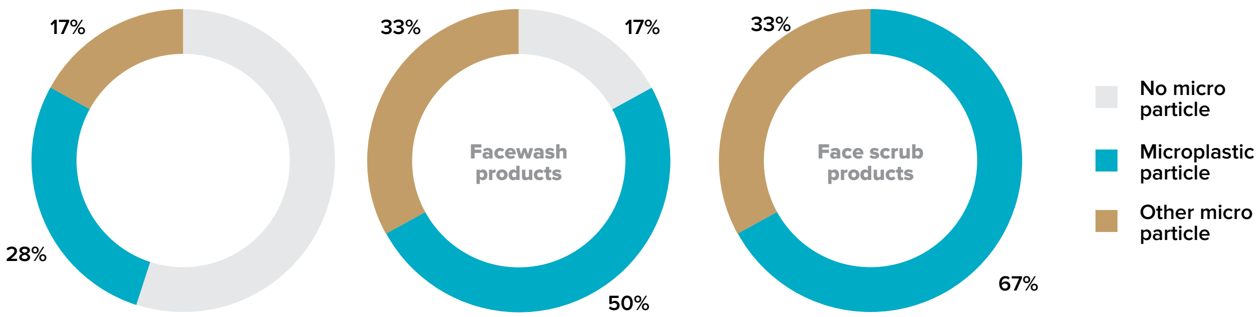
Stereomicroscopic examination as well as filtration indicated presence of micro particles in 9 out of the 18 samples tested. The findings indicated presence of microplastics in most of the rinse off cosmetics. Interestingly, none of the leave-on products were detected with microplastics or even microparticles.

Presence of insoluble micro particles in majority of the rinse off products does raise an alarm. These are designed to be disposed of with no possibility of recovery or recycling. Out of the 12 rinse off products included in the study, 5 of them were found to have microplastic. Since these are direct body to drain products, the beads from these products get directly into the water system and through the water channel reach the larger water bodies.

Table 5: Assessment of Microplastics in Selected Personal Care & Cosmetics Products from Indian Market

Sample No.	Product Sample No.	Polymer Ingredients in the product as listed in packaging	Stereomicroscopic Analysis	Type of particle detected in FTIR	Remark
1	Face Wash 1	Acrylates Copolymer, Microcrystalline wax beads,	Micro particles were observed in the sample	Polyethylene (PE)	Presence of micro plastic particles
2	Face Wash 2	PEG-7 Glyceryl Cocoate, PEG-40 Hydrogenated Castor Oil, Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer	Micro particles were observed in the sample	cellulose	absence of micro plastic particles
3	Face Wash 3	Acrylates Copolymer	Micro particles were observed in the sample	Viton	absence of micro plastic particles
4	Face Wash 4	Acrylates Copolymer, PPG 9, Polysorbate 20	Not observed	NA	absence of micro plastic particles
5	Face Wash 5	Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer,	Micro particles were observed in the sample	polyethylene	Presence of micro plastic particles
6	Face Wash 6	Acrylates Copolymer, Acrylates/Ammonium Methacrylate Copolymer	Micro particles were observed in the sample	polyolefin	presence of micro plastic particles
7	Body Wash 1	PPG-9, Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer, Styrene/Acrylates Copolymer	Micro particles were observed in the sample	Viton	absence of micro plastic particles
8	Body Wash 2	Acrylates Crosspolymer-4, Polyquaternium-7 (copolymer of acrylmide)	Not observed	NA	absence of micro plastic particles
9	Body Wash 3	Acrylates Copolymer, PEG-40 Hydrogenated Castor Oil, PEG-7 Glyceryl Cocoate	Not observed	NA	absence of micro plastic particles
10	Body Lotion 1	Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer	Not observed	NA	absence of micro plastic particles
11	Sun Screen 1	Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer, PEG 100 Stearate	Not observed	NA	absence of micro plastic particles
12	Face Scrub 1	Polyethelene beads	Micro particles were observed in the sample	Polyethylene (PE)	Presence of micro plastic particles
13	Face Scrub 2	Acrylates Copolymer, Polysorbate 20, Polyquaternium-7	Micro particles were observed in the sample	cellulose	absence of micro plastic particles
14	Face Scrub 3	Acrylates/C-10-C-30 Alkyl Acrylate Crosspolymer	Micro particles were observed in the sample	Polyethylene (PE)	Presence of micro plastic particles

Sample No.	Product Sample No.	Polymer Ingredients in the product as listed in packaging	Stereomicroscopic Analysis	Type of particle detected in FTIR	Remark
15	Facial mask 1	Polyethelene Glycol 1500	Not observed	NA	absence of micro plastic particles
16	Baby Lotion 1	Polysorbate 20	Not observed	NA	absence of micro plastic particles
17	Anti-aging 1	PEG 100	Not observed	NA	absence of micro plastic particles
18	BB Cream 1	Methacrylate Crosspolymer	Not observed	NA	absence of micro plastic particles



Looking at further details, microparticles were observed in 5 of the 6 face wash samples of which 3 were identified as plastic particles (polyethylene & polyolefin). The remaining 2 samples were detected with cellulose and viton (synthetic rubber). All 3 face scrub samples showed presence of micro particles, out of which 2 were identified with plastic particles and one had cellulose. Though none of the body wash samples were found to have microplastics, one sample contained micro particles of viton. The brands found to have microplastics in their products are all internationally acclaimed and that includes one herbal brand too.

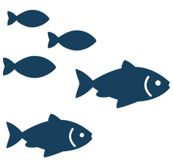
Though the topic of research for this particular study is microplastic, it is interesting to observe that there are other non- soluble microparticles being used in cosmetic products. It will be crucial to also look at the behavior and impact of particles like viton and cellulose which were detected in the samples. Though the intent of the study was also to quantify microbeads, the current protocol was not suited for the same and will need further improvement.

This is an indicative study to establish the presence of microplastics in cosmetics available in Indian industry. The intent is also to initiate discussion on the necessity of using them and understanding its impact on environment. The study had both financial and resource accessibility challenge leading to a restriction of testing only representative samples. It surely opens up the need for probing into a number of other products available in the market and suspected of having microbeads (e.g., toothpaste, detergents and a lot more brands of the same products) as well as defining the protocol for microbeads analysis.

Some major findings

- Different categories of rinse-off and leave-on cosmetic products of varied leading brands were tested for microplastics. 28% of all the tested products contains microplastics.
- 38% of the rinse-off products are detected with microplastics which include international and even herbal brands. None of the live-on products are found to have microplastics.
- 31% have micro particles other than microplastics.
- 50% of the facewash products and 67% of the facial scrubs are found to contain microplastics
- Predominating microplastic detected in the product samples is polyethylene.

Conclusion and initial recommendations



Fish species that humans harvest for food have been known to eat micro-plastic particles at an alarming rate and the toxins absorbed in those plastics transfer to the fish tissue.

Plastic debris persistent nature and toxic effects makes this issue one of the world's foremost environmental concerns. The negative externalities caused by the profusion of plastic litter are an example of failure that comes with exorbitant social and environmental costs. All of these problems are indicator of the modern-day linear system of production, transport, consumption and disposal of largely unsustainably designed goods around the globe. The tiny plastic debris or microplastics are one major component.

The indiscriminate presence of microplastics in the environment and its rate of increase are already posing a big challenge globally. Unfortunately, though it's a man-made problem, its impact is across all livings beings and our planet. Unless we work towards arresting this effluence, we are looking at a catastrophe, as microplastics have the ability to upset the entire ecosystem. Despite a growing body of work on plastic debris and a heightened global awareness of its global impact, remedial efforts to combat this pollution have been constrained by a lack of research and knowledge surrounding the original sources of the waste matter.

Apart from further investigation and research, the need of the hour is take conscious steps towards reducing microplastic generation to prevent further spread. Even for stopping further contribution, it would need source identification, assessing the alternatives, restricting production, import and use, leak proofing of the plastic waste management system and a number of actions at global and local level.

A study ranks India as the 12th biggest contributor to plastic marine debris calculating its un-captured plastic waste.[113] The country being the global host to 'Beat Plastic Pollution' – the 2018 UN World Environment Day theme – is yet to wake up on the issue of microplastics apart from some isolated studies. Recent studies showing presence of microplastics in tap water and bottled water (including collected from India) should certainly be reason for alarms bell to ring. The need to further study this issue and understand the source and points of arrest are essential.

Primary microplastics are a significant source of marine plastic and the greatest contributors are unintentional sources.[29] Rising population and living standard is going to increase this primary source contribution unless action is taken.

Unilever statement on their website

"We stopped using plastic scrub beads in 2014 in response to concerns about the build-up of microplastics in oceans and lakes. We had formerly used them in some of our exfoliating products. We now use alternative exfoliating ingredients, enabling people to feel confident that the Unilever face and body washes they use do not contribute to the accumulation of microplastics in the world's oceans."

The cosmetic and personal care product industry uses intentionally manufactured microplastic in products that are designed to be disposed into municipal sewer systems without regard to our ability to recover, recycle, or otherwise prevent the tiny plastic beads from entering the environment. Hence, a life cycle approach with environment friendly designs, technological innovations, behavioural change and policy solutions with measured indicators, set targets and monitored progress is needed to manage the menace of primary microplastics like this.

Though drawing an appropriate strategy for curbing microplastic pollution from all sources is difficult at one go, but elimination of an avoidable source like PCCPs with alternative ingredients could well be discussed immediately and taken forward in the country. A legislative ban on the intentional use of synthetic plastic microbeads in all personal care products is of immediate requirement. Fortunately, plastic is not an essential ingredient in cosmetics and personal care products and several major producers have already committed to replacing plastic abrasives with natural alternatives to address this new source of pollution. Many companies around the world that produce cosmetics and personal care products have made some level of commitment to phase out microbeads in their products. This clearly shows that its possible to do.

Phasing out of microbeads in PCCPs or primary microplastics in any products is also linked to people's choices for alternative products. Hence, more research, public debates and discussions, media campaigns and policy framing are required to bring in the topic on public knowledge. There is also need to look at our waste treatment facilities and understand if there are possibilities of capturing and removing these tiny beads from reaching the water bodies.

This will be the first small step towards reducing microplastics pollution. Tackling the multitude of sources of marine plastics requires a holistic approach that addresses the problem at its source. The need is to drive new thinking around the way we design, produce, consume and dispose of plastics. This Toxics Link study concludes with a hope to set off the discussion of addressing primary microplastics while considering the plastic waste management.

"Avoid products with microbeads

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