Toxics Link
for a toxics-free world

Dirty Cleanser

Assessment of Microplastics in Cosmetics

About Toxics Link

Toxics Link is an Indian environmental research and advocacy organisation 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

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Abbreviations

AIM	Advanced imaging and microscopy
EVOH	Ethylene vinyl alcohol
MPs	Microplastics
µ-FTIR	Micro-Fourier transform infrared spectroscopy
PCCP	Personal care and cosmetics products
PCPs	Personal care products
POPs	Persistent organic pollutants
PET	Polyethylene terephthalate
PE	Polyethylene
PCBs	Polychlorinated biphenyls
PAHs	Polyaromatic hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PHA	Polyhydroxyalkanoate
PAM	Polyacrylamide
PP	Polypropylene
WWTPs	Wastewater treatment plants
Polystyrene	PS
Poly methyl methacrylate	PMMA

Indian PCCPs

(Facewash, Bodywash, and Scrub)

contain 14 different types of polymer

Particle size was in the range of

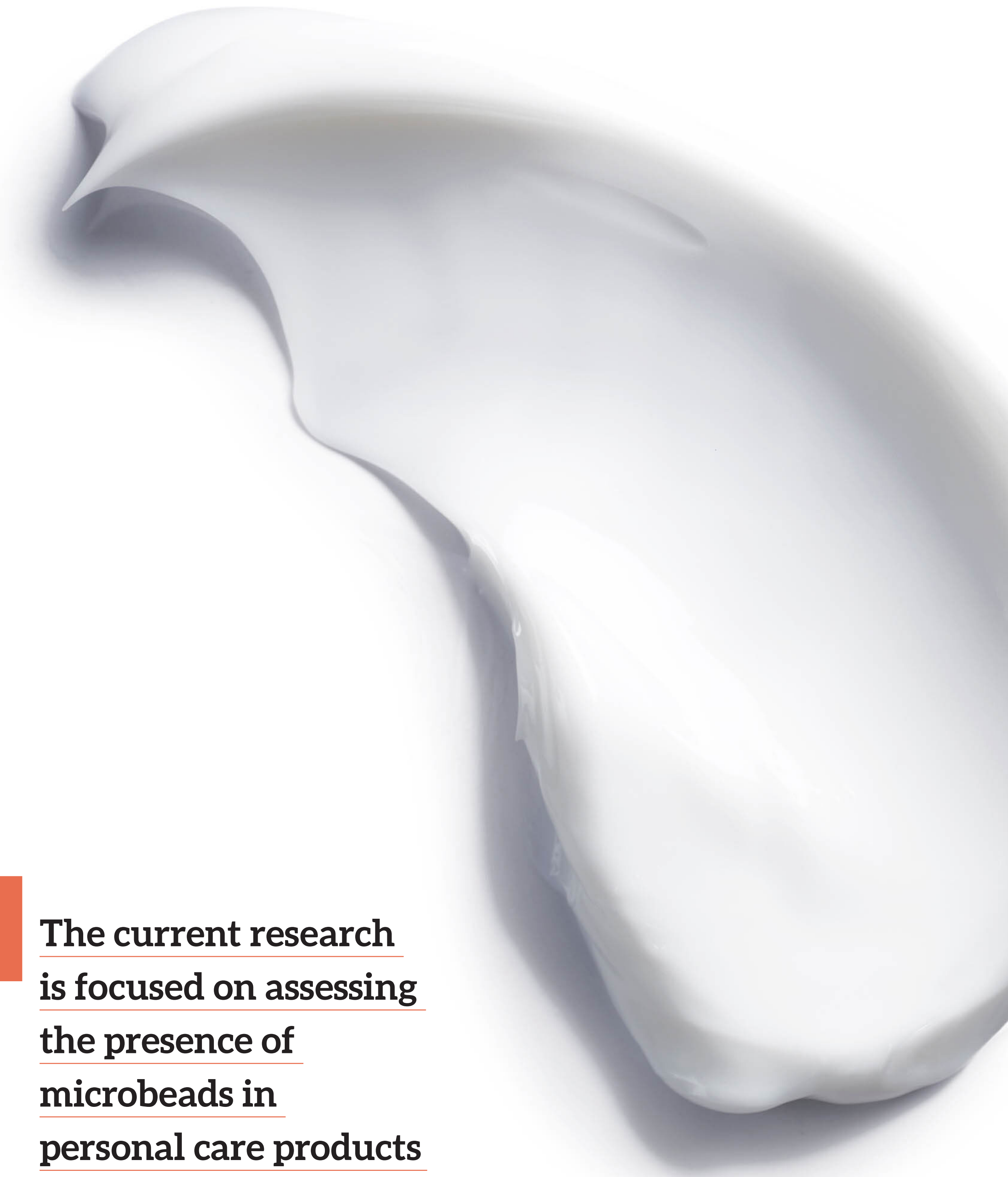
32.55 - 130.92 µm

for facewash, scrub and bodywash

Between

60 and 4,312 Microbeads

could be released from an exfoliant in a single use (5ml per use)



The current research is focused on assessing the presence of microbeads in personal care products and cosmetics in India.

Introduction

Environmental pollution from plastics is one of the most deliberated topics by the scientific community, governments and civil society organisations today. Though plastic waste pollution has caught the attention of governments and the public, not much is still known about microplastics in these quarters. This is in spite of the fact that microplastics or tiny plastic particles have contaminated the whole planet, from Arctic snow and mountain soils to the rivers and deepest oceans. According to the UN, there are as many as 51 trillion microplastics particles in the seas, 500 times more than the stars in our galaxy. They have been found in food and drinks, including beer, salt, honey and tap water.

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51 trillion microplastics particles in the seas, 500 times more than the stars in our galaxy.

The non-biodegradability of plastic is a known characteristic; it does not decompose but breaks down into smaller pieces. The plastic waste and debris floating around the ocean or on land are exposed to the elements of harsh solar radiation and constant abrasion from the action of wind and water waves. Over time, these elements break down the plastics into smaller chunks of debris, and the cycle goes on till the remaining debris becomes microscopic. While environmental action is the most common way that microplastics are formed, the other relevant means comes from intentional human production and the use of small plastic beads.

These small plastic beads or microbeads are solid particles, composed of mixtures of specific polymers and functional additives and are less than 5 mm in diameter. Microbeads, a relatively cheap ingredient, are added to a range of products, including rinse-off cosmetics, personal care and cleaning products. This is included as an abrasive or exfoliant, a bulking agent, to prolong shelf-life of the products, or for the controlled release of active ingredients.

Microbeads, being plastic, do not degrade or dissolve in water. They go down the drain and are not captured by most wastewater treatment systems from where it reaches our rivers, lakes, and oceans. These tiny plastics persist in the environment, causing massive damage to marine life, the environment and human health. This is due to their composition, ability to adsorb toxins and potential to move up the marine food chain.

Since microplastics have begun catching the attention of researchers, environmentalists and governments globally, there have been some efforts to address the concerns, especially on intentionally added microbeads. Microbeads in cosmetics have been banned in many countries, and some global brands have also phased it out voluntarily.

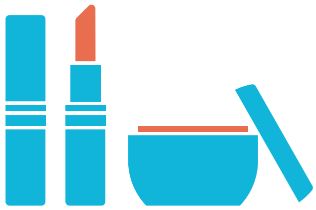
India, though, has not yet banned microbeads and there has been little research on assessing microbead usage in personal care products and cosmetics.

The current research is focused on assessing the presence of microbeads in personal care products and cosmetics in India, because the public domain has limited information on this.

MICROPLASTICS

Microplastics are a source of terrestrial and aquatic contamination and may be found in soils[1], surface waters[2], lagoons, estuaries, coastal shorelines, regions of the sea, Arctic freshwater, ice and the ocean[3]. Based on size, residue of plastics can be divided into nano (<0.1μm), micro (5mm to 0.1μm), meso (5mm to 25mm), and macro (>25mm).Microplastics can also be found in different shapes such as fibres, fragments, foam, flakes and shaft[4]. Both size and shape dictate the fate and degradation of microplastics in the environment.

Based on origin, microplastics can be divided into two categories -- primary and secondary. Synthetically manufactured plastic pellets, beads, nurdles, fibres, and powders for commercial purposes are considered to be primary microplastics.



For example, cosmetic formulations may contain

0.5–5% primary microplastics, and a single-use may release approximately 4,500–94,500 microbeads.

1. Huang, Y., Liu, Q., Jia, W., Yan, C., & Wang, J. (2020). Agricultural plastic mulching as a source of microplastics in the terrestrial environment. Environmental Pollution, 260, 114096.
2. Fischer, E. K., Paglialonga, L., Czech, E., &Tamminga, M. (2016). Microplastics pollution in lakes and lake shoreline sediments–a case study on Lake Bolsena and Lake Chiusi (central Italy). Environmental pollution, 213, 648-657.
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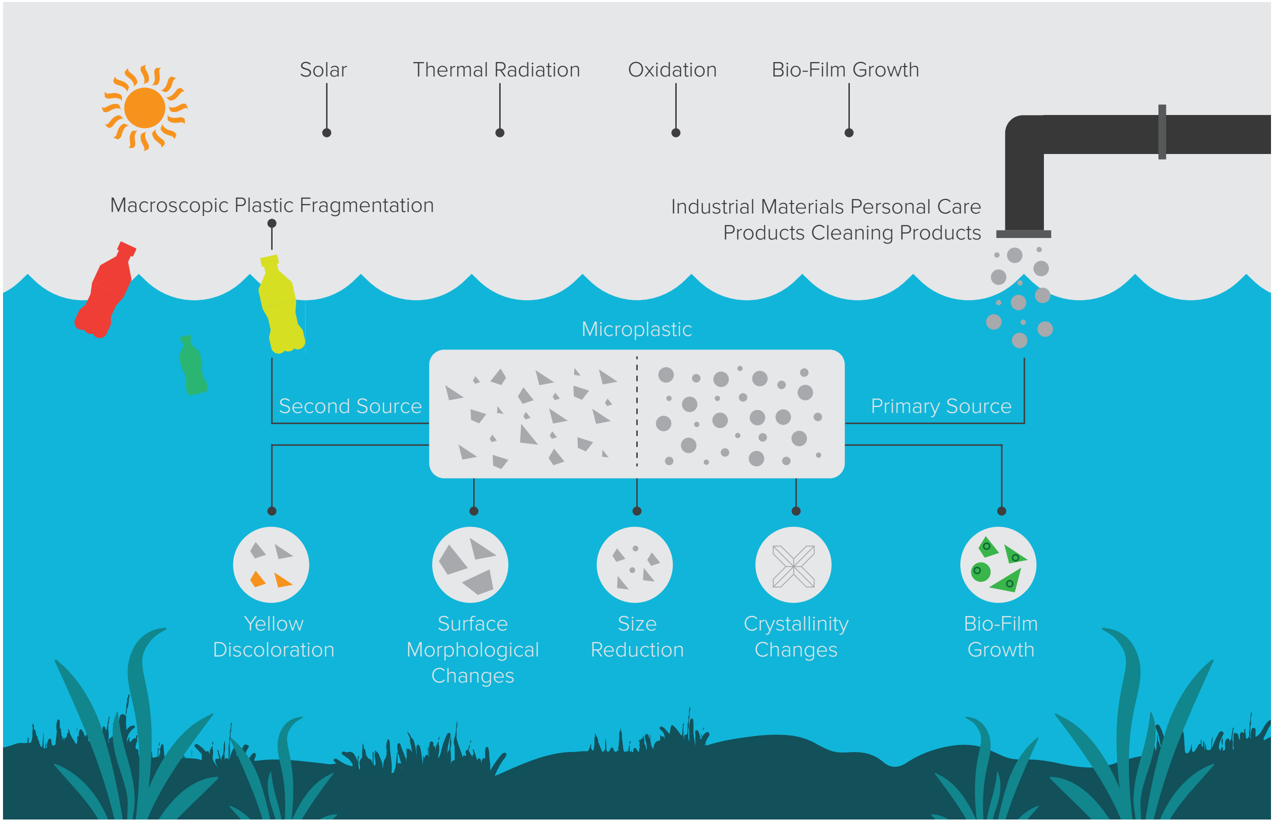
These are widely used as feedstock for plastic production (e.g., resin pellets) or appliance manufacturing, textile fibres in clothing (e.g., acrylic fibres), industrial abrasives (e.g., air blasting), and exfoliants incorporated in personal care and cosmetic products (PCCPs) (such as cleansing products, make-up cosmetics, shower gel, facial cleanser, hand sanitiser, soap, toothpaste, shaving cream, bubble bath, sunscreen and shampoo[5]). For example, cosmetic formulations may contain 0.5–5% primary microplastics, and a single-use may release approximately 4,500–94,500 microbeads[6].

Secondary microplastics are the breakdown products of bigger plastic particles from fishing gears, ships, aquaculture and recreational activities. The process of breaking down plastic trash might be physical, chemical or biological over time, due to the loss of structural integrity[7]. The formation of microplatics in the ocean is greatly influenced by a combination of environmental factors such as (1) solar ultra-violet radiation that facilitates oxidative degradation of polymers and causes it to lose mechanical strength, (2) mechanical abrasion such as wind, wave, ocean current, animal bite, human activity that can break the polymer further into smaller fragments. This process is called 'weathering' and tends to occur in decreasing order of plastics float in water, in the mid-water column and in the sediment.

Figure 1: Source of primary and secondary microplastics



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Microplastics in cosmetics

PLASTIC INGREDIENTS IN PERSONAL CARE AND COSMETIC PRODUCTS

Plastic materials have been applied as ingredients in PCCPs for several decades, with early patents dating from the 1960s. It remain a focus of innovation in new PCCPs[8]. Synthetic polymer materials are mixed with a variety of chemicals ('additives') in order to achieve an end-product plastic material with properties that are appropriate for the function. The plastic materials applied as ingredients in PCCP formulations discussed here include two main categories of plastics typically made from petroleum carbon sources: thermoplastics (e.g., polyethylene, polypropylene, polystyrene, polytetrafluoroethylene [Teflon], poly{methyl methylacrylate} and polyamide), and thermoset plastics (e.g., polyester and polyurethanes). Silicone is the other type of plastic relevant to the PCCP plastics discussion.

Cosmetic products contain microplastics for various functions such as skin exfoliation, illumination of the skin and cleansing, silky feeling (microbeads), opacity control, smoothness and viscosity control[9]. Microplastics are intentionally added in both rinse-off and leave-on cosmetics. 'Rinse-off products' are personal care products that are washed or rinsed off with water after cleaning skin and hair. Examples of rinse-off cosmetics with microplastics are products for hair and body bleaching, hair colouring and nourishing, shampoos, shower gels, soaps, scrubs, body wash, face wash, etc. Although 95% of rinse-off products have only one microplastics ingredient, some even have two[10].

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'Leave-on'products' are cosmetic products that are intended for prolonged contact with skin, hair or mucous membranes. The leave-on product category includes a vast number of different product categories, such as skincare and make-up (mascara, foundation, eye shadow, lipstick, nail varnish, eye pencils, lip care, etc.). For instance, mascara may contain microplastics fibres, and eye shadows may contain glitter in the form of microplastics particles[11]. Glitter is a primary microplastics consisting of metalisedpolyethylene terephthalate (PET)[11] and is used decoratively in cosmetics.

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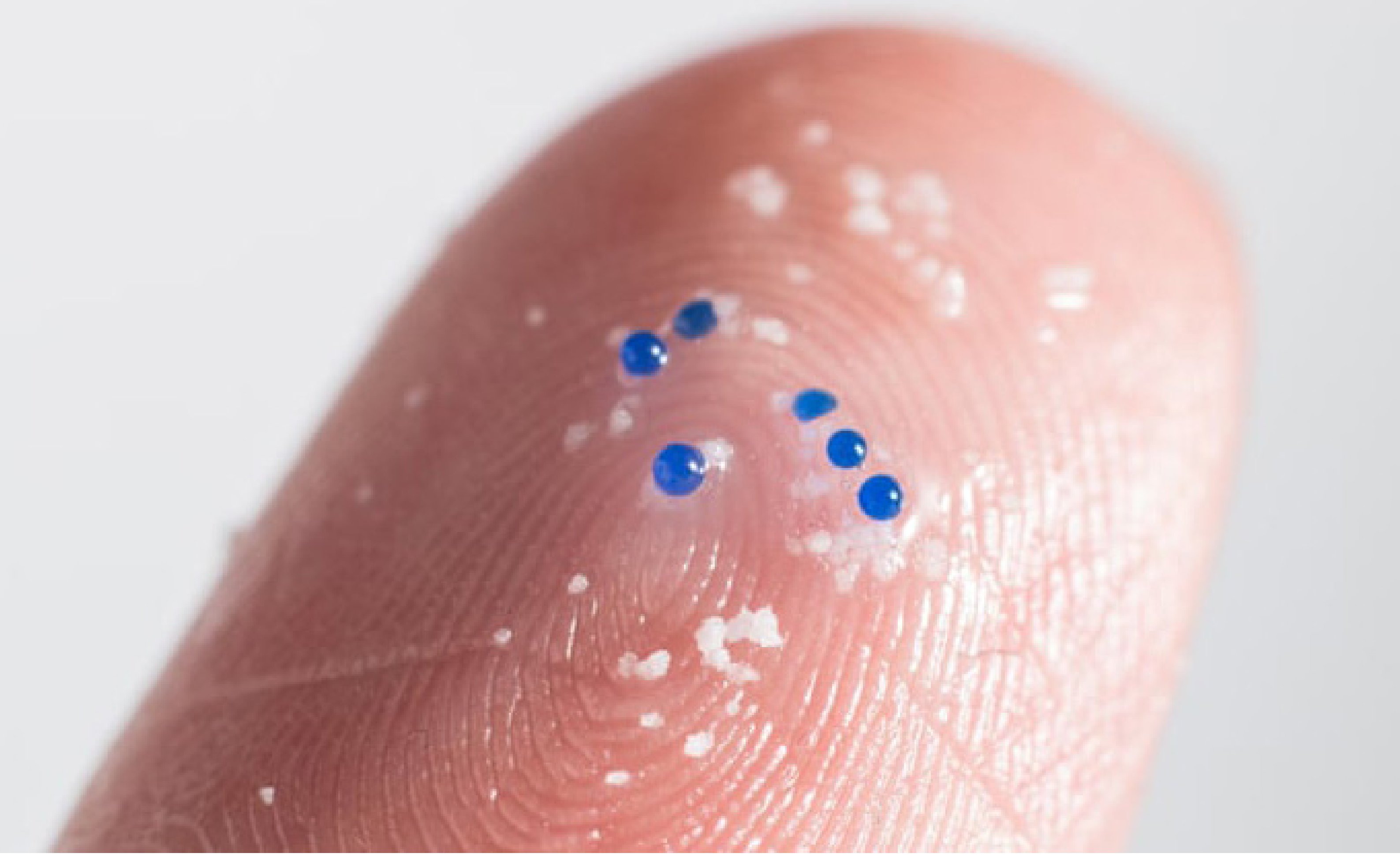
11. Yurtsever, M., 2019a. Glitters as a source of primary microplastics: an approach to environmental responsibility and ethics. J. Agric. Environ. Ethics 32, 459–478.

Glitter is used more widely in cosmetic products than microbeads but, surprisingly, it has not received much attention from scientists who specialise in the study of environmental contamination by microplastics. This is mainly because glitter sinks in sediments and most studies take samples of microplastics from the surface. Leave-on cosmetics, consisting of 4 to 6 polymers[12], have more complex formulae than the rinse-off variety.

Both rinse-off and leave-on cosmetics' formulations may also contain microplastics as encapsulators for fragrances[13].



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Microbeads in cosmetics

Microbeads, with their current function as cleaning or exfoliating agents in cosmetics,

were patented in 1972 and were rarely used until the early 1990s

Microbeads, with their current function as cleaning or exfoliating agents in cosmetics, were patented in 1972[14] and were rarely used until the early 1990s[15], when cosmetic manufacturers began replacing the most popular inorganic peeling ingredients of the time, such as aluminium oxide or other natural materials such as millet or pumice peels, with synthetic polymeric beads[16]. Before the invention of microbeads, natural abrasive products such as cocoa beans, ground almonds, ground apricots, sea salt and ground pumice were used[17]. The cosmetics industry prefers plastic microbeads over natural alternatives. They are considered to have several advantages over inorganic ingredients used in the past. Plastic microbeads are less rough and cheaper, offer smoother exfoliation, are easier to wash off without blocking drainage, are of lower density, are highly compatible with other compounds in the product and do not cause damage to the containers. On the consumer side, microbeads succeeded commercially as they left a cleaner and softer skin feeling[18] compared to natural ingredients. Furthermore, microbeads also impart decorative characteristics to cosmetics products; for example, spherical and blue microbeads impart colour in toothpaste. In fact, spherical coloured beads are used mainly for decoration and not abrasion[19].

Microbeads in cosmetics can be of different sizes. Smaller microbeads are mainly used in facial cleansers, where a mild abrasion is desirable, while the larger ones are added in body scrubs where intense abrasion is necessary[20]. In a toothpaste, where even milder cleansing is needed, the size of microbeads is up to 100 times smaller than those used in other cosmetics[21]. The quantity of microbeads can vary from 0.05 to 12% of the final product[22,23].

14. Beach, W., 1972. Skin cleaner. US3645904A.
15. Zitko, V., Hanlon, M., 1991. Another source of pollution by plastics: skin cleaners with plastic scrubbers. Mar. Pollut. Bull.
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NANOPLASTICS IN COSMETICS

In recent times, multinational cosmetics companies have invested millions of dollars in nanotechnology[24], mainly to improve the intradermal transport of active substances and use them as natural UV absorbent filters in sunscreen products[25]. Nanoparticles (particles sizing range from 1 to 100nm) in cosmetics are mainly of inorganic forms like TiO_2, ZnO and silica. Nanoscale plastics (nanoplastics) are intentionally added to cosmetics, mainly in the form of nanocapsules[25]. There is no intended use of solid polymeric nanoparticles in rinse-off cosmetic products for exfoliation or cleansing as they would be too small to provide the desired properties. Hernandez et al[26] reported that scrubs contained nanoparticles of PE. The nanoparticles were not intentionally added but were created probably from the breakdown of microplastic beads during the stirring and the preparation of the formula. It should be noted that nanoplastics are a relatively new area of research. There is not even a universally accepted definition to date[27], although some researchers treat nanoplastics as a lower size of microplastics.

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Table 1: Examples of microplastics currently used as particulates in personal care and cosmetics products (PCCPs)[18]

S.No	Polymer name	Functions in PCCP formulations
1	Acrylates copolymer	Binder, hair fixative, film formation, suspending agent
2	Allyl stearate/vinyl acetate copolymers	Film formation, hair fixative
3	Butylene/ethylene/styrene copolymer	Viscosity controlling
4	Ethylene/propylene/styrene copolymer	Viscosity controlling
5	Ethylene/methylacrylate copolymer	Film formation
6	Ethylene/acrylate copolymer	Film formation in waterproof sunscreen, gellant (e.g. lipstick, stick products, hand creams)
7	Nylon-12 (polyamide-12)	Bulking, viscosity controlling, opacifying (e.g. wrinkle creams)
8	Nylon-6	Bulking agent, viscosity controlling
9	Poly (butylene terephthalate)	Film formation, viscosity controlling
10	Poly (ethylene isoterephthalate)	Bulking agent
11	Poly (ethylene terephthalate)	Adhesive, film formation, hair fixative; viscosity controlling, aesthetic agent, (e.g., glitters in bubble bath, make-up)
12	Poly (methyl methylacrylate)	Sorbent for delivery of active ingredients
13	Poly (pentaerythrityl terephthalate)	Film formation
14	Poly (propylene terephthalate)	Emulsion stabilising, skin conditioning
15	Polyethylene	Abrasive, film forming, viscosity controlling, binder for powders
16	Polypropylene	Bulking agent, viscosity increasing agent
17	Polystyrene	Film formation
18	Polytetrafluoroethylene (Teflon)	Bulking agent, slip modifier, binding agent, skin conditioner
19	Polyurethane	Film formation (e.g.. facial masks, sunscreen, mascara)
20	Polyacrylate	Viscosity controlling
21	Styrene acrylates copolymer	Aesthetic, coloured microspheres (e.g., makeup)
22	Trimethylsiloxysilicate (silicone resin)	Film formation (e.g., colour cosmetics, skincare, suncare)

MAJOR EMISSION PATHWAYS TO OCEANS

Worldwide release estimation

Microplastics from PCPs have been identified in the environment all around the world. However, the information in this regard is limited. To obtain a large picture of the contribution of PCPs to the current microplastics pollution, microplastics release in different countries has been estimated, based on their emissions per capita via consumption of PCPs and the population[28]. Another 2012 study[29] estimated that an average consumer (5ml per person) in the UK could release 4,594 to 94,500 microbeads. A Chinese study[34] estimated that 10,000 to 1,00,000 microbeads were rinsed off in Hong Kong in a single use..

28. Sun, Q., Ren, S. Y., & Ni, H. G. (2020). Incidence of microplastics in personal care products: An appreciable part of plastic pollution. Science of the Total Environment, 742, 140218.
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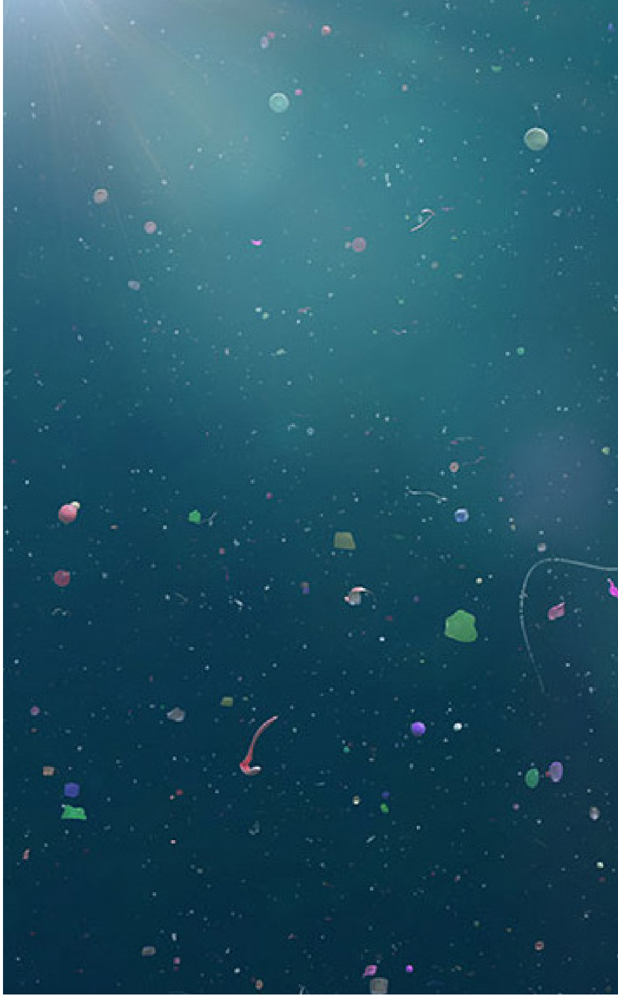
In the USA, the annual emission of microplastics (PE) from consumption of PCPs was estimated to be 282 tonnes in 2015[30] and the per capita use of polyethylene beads in PCPs was 2.4mg/day. Data obtained from the Cosmetics Europe survey shows that the per capita use of microplastics in PCPs was 12 mg/day — almost four times greater than that of USA. The annual emission of microplastics from the consumption of PCPs in Europe was 3,215 tonnes.

According to a study done in 2015 in China, ~39 tonnes of microplastics are released into the environment every year from the consumption of shower gel alone[31]. The release from facial cleansers is 307 tonnes[34]. Therefore, the annual emission of microplastics from PCP consumption in China is not less than 346 tonnes, as there might be also other microplastics containing PCPs. Hence, the sum of annual emissions of microplastics from PCPs in Europe, the USA and China was 3,843 tonnes in 2015. The world's three largest economies comprise 33% of the global population[29]. Overall, approximately 1,500 tonnes/year of microplastics from PCPs escape from wastewater treatment plants (WWTPs) and enter the global aquatic environment[29]. The same study reported that, according to the PCP consumption and microplastics levels, the mass emission of global PCP-derived microplastics reach up to 1.2×10^4 tonnes/year. Up to (3.00×10^5) tonnes of PCP-derived microplastics have accumulated in the environment over the last 50 years (1970–2019)[29].

When we use these personal care products in houses, parlours, etc., microbeads present in PCCP enter the environment primarily through sewage. Roughly any microplastics contained in rinse-off cosmetics end up in the drainage system, while the corresponding proportion for leave-on cosmetics ranges between 15% and 90%, depending on the use of the cosmetic[32]. In particular, >50% of glitter in leave-on cosmetics ends up in sewage[33].

Microplastics in personal care and cosmetics products get washed directly into household drains and transported to WWTP. These microplastics can pass through WWTPs to oceans due to their small size. The specific size of screens to remove the microparticles in WWTPs are not fully effective. WWTPs have been identified as one of the potential contributors for microplastics into the marine environment. Cheung and Fok[34] suggested that WWTPs contributed over 80% of microplastics to the aquatic environment due to incomplete removal. The remaining ~20% can be attributed to direct emissions (~18.2% from cities and ~0.5% from rural areas)[35]. Many studies have indicated that traditional WWTP technologies may not completely remove microplastics[36].



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30. Worldometers (2019). Available online at: http://www.worldometers.info/world population/world-population-projections/ (Accessed February 20, 2019).
31. Lei, K., Qiao, F., Liu, Q., Wei, Z., Qi, H., Cui, S., & An, L. (2017). Microplastics releasing from personal care and cosmetic products in China. Marine pollution bulletin, 123(1-2), 122-126.
32. European Chemicals Agency Annex XV Restriction Report. Proposal for a Restriction. Substance Name(s): Intentionally Added Microplastics. Ver 1.2. Helsinki, Finland..
33. Yurtsever, M. (2019). Glitters as a source of primary microplastics: an approach to environmental responsibility and ethics. *Journal of Agricultural and Environmental Ethics*, *32*(3), 459-478.
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Rivers connect land to sea and present an essential pathway of microplastics waste generated inland to reach the marine environment.

The conditions are heightened in a countries where sewage is still discharged directly into the waterbodies without treatment. For example, in Antarctica, 52% of the 71 research stations have no wastewater treatment system[37]; likewise, in China, nearly half the population (approximately 45% in 2014) lives in rural areas without sewage pipe networks (the sewage treatment rate is only 4%[38]). Hence, plastic particles from personal care products (PCPs) are directly released to the surface water and further into the ocean.

Moreover, 87% of the microplastics retained in WWTPs end up in biologically active sludge, which is used as a fertiliser. A certain proportion of the sludge, too, which is difficult to calculate, is released into the aquatic environment through aquifers[35]. The portion of microplastics intercepted by the WWTPs enter the sewage sludge, which is approximately 1,000 plastic particles per kilogram of dry sludge ($1.00 \times 103–4.95 \times 10^5$ particles/kg)[39]. Presently, disposal technologies for sludge mainly include agricultural use, composting, landfills and incineration[40]. For example, the amount of sludge being incinerated in Scotland is 35% of the total sludge produced in 2016[41], with 47% in Canada in 2001[42], 55% in Korea and Japan in 2004 & 2013 [43,44], and up to 99% in the Netherlands in 2001[45]. In Europe, over a third of the total sewage sludge generated is currently being applied on agricultural fields as fertiliser, called 'biosolids', around 40% is being landfilled, and 12% is used for forestry, land reclamation, etc.,[46]. In addition, many developed countries have dumped sludge directly into the sea over the last two decades[47]. This situation has improved in recent years, but it is still a common practice in some parts of the world.

Sewage generation from urban centres in India is estimated at approximately 72,368 MLD, as reported in Table 2. There are 1,631 STPs (including proposed STPs) with a total capacity of 36,668 MLD covering 35 States/UTs. Out of 1,631 STPs, 1,093 STPs are operational, 102 are non-operational, 274 are under construction and 162 STPs are proposed for construction[50]. As per the Central Pollution Control Board (CPCB), only 38% sewage is being treated in the STP, which means that 62% sewage is left untreated. Though STPs may be able to capture some proportion of microplastics, some amount of plastic microbeads in untreated sewage will remain undetected and will not be captured.

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Table 2: State-wise sewage generation and treatment capacity of urban centres-India [48]

States / UTs	Sewage generation (in MLD)	Installed capacity (in MLD)	Proposed capacity (in MLD)	Total treatment capacity (in MLD) including planned / proposed	Operational treatment capacity (in MLD)
Andaman & Nicobar Islands	23	0	0	0	0
Andhra Pradesh	2,882	833	20	853	443
Arunachal-Pradesh	62	0	0	0	0
Assam	809	0	0	0	0
Bihar	2,276	10	621	631	0
Chandigarh	188	293	0	293	271
Chhattisgarh	1,203	73	0	73	73
Dadra & Nagar Haveli	67	24	0	24	24
Goa	176	66	38	104	44
Gujarat	5,013	3,378	0	3,378	3,358
Haryana	1,816	1,880	0	1,880	1,880
Himachal Pradesh	116	136	19	155	99
Jammu & Kashmir	665	218	4	222	93
Jharkhand	1,510	22	617	639	22
Karnataka	4,458	2712	0	2,712	1,922
Kerala	4,256	120	0	120	114
Lakshadweep	13	0	0	0	0
Madhya Pradesh	3,646	1,839	85	1,924	684
Maharashtra	9,107	6,890	2,929	9,819	6,366
Manipur	168	0	0	0	0
Meghalaya	112	0	0	0	0
Mizoram	103	10	0	10	0
Nagaland	135	0	0	0	0
NCT of Delhi	3,330	2,896	0	2,896	2,715
Orissa	1,282	378	0	378	55
Pondicherry	161	56	3	59	56
Punjab	1,889	1,781	0	1,781	1,601
Rajasthan	3,185	1,086	109	1,195	783
Sikkim	52	20	10	30	18
Tamil Nadu	64,21	1,492	0	1,492	1,492
Telangana	2,660	901	0	901	842
Tripura	237	8	0	8	8
UttarPradesh	8,263	3,374	0	3,374	3,224
Uttarakhand	627	448	67	515	345
West Bengal	5,457	897	305	1202	337
Total	**72,368**	**31,841**	**4827**	**36,668**	**26,869**

48. National Inventory of Sewage Treatment Plants, CPCB, March 2021

All the disposal methods of sewage sludge also impact the environment. Agricultural use, composting and landfills cause microplastics pollution. Namely, the ecological risk of microplastics is transferred from aquatic systems to terrestrial ecosystems through the food chain cycle. For incineration, potentially toxic substances will be emitted to the ambient environment[49]. Obviously, with these disposal approaches, environmental stress originating from microplastics utilisation shows little sign of abating. Even if microbeads are totally prohibited around the world by 2020, microplastics that have already been released into the environment will remain for a long time and demand our full attention.

Effects of microbeads on aquatic organisms

Globally, concerns about the impacts of these microplastics on marine and freshwater ecosystems have been raised. Microplastics, once released into the environment, persist for a long time before getting fully decomposed and re-enters the bio-geochemical cycles. Microplastics have been shown to induce negative impacts on the health of various marine organisms. The possibilities of microplastics getting transferred in the food chain and biomagnification of toxins present in microplastics are also predicted, which may directly induce toxicity in human beings through seafood. Microbeads used in cosmetics are responsible for a significant proportion of the human-made solid waste in aquatic environments and hence impacts the marine life.

From the scientific literature, the effects seen are either primarily driven by physical effects (i.e., effects resulting from blockages, external/internal attachment, etc.) and/or it may be due to the presence of residual chemicals (chemicals present when the microbeads are synthesised) and/or adsorb pollutants (e.g., persistent organic pollutants or POPs), pesticides, etc., which are adsorbed in later life-cycle stages). Where physical effects are the primary driver for effects, no significant differences were seen between freshwater and marine organisms.

49. Batistella, L., Silva, V., Suzin, R. C., Virmond, E., Althoff, C. A., Moreira, R. F., & José, H. J. (2015). Gaseous emissions from sewage sludge combustion in a moving bed combustor. *Waste Management*, *46*, 430-439.

The types of effects are summarised below:

- **Uptake:** Microbeads are readily taken up by a variety of organisms, including fish, mussels and several types of zooplankton[50] and, in many cases, organisms removed microbeads over time through faeces.
- **Translocation:** Microbeads translocation from the gastrointestinal tract into the organism has also been confirmed; for example, Rosenkranz et al,[51] found rapid uptake and depuration of microbeads in Daphnia magna but also found the presence of microbeads in the Daphnia lipid storage droplets. In addition, Von Moos et al.[52] found that microbeads can also be internalised from tissues into cells by measuring the presence of microbeads in the intestine, lumina of the digestive gland and digestive epithelial cells of blue mussels.
- **Food-web transfer:** Setala et al[53], reported that microbeads could transfer across food webs by feeding microbead-containing zooplankton to mysid shrimp and confirming the presence of beads after 3 hours of incubation.
- **Long-term impact:** There is limited information on the long-term effects of microbeads. A multigenerational study in copepods conducted by Lee et al[54] found that 0.5 µm polystyrene microbeads caused mortality of nauplii and copepodites in the first generation at a concentration of 12.5 µg/mL and in the second generation at 1.25 µg/mL. In the same study, the developmental delay was measured at 25 µg/mL for 0.5µm microbeads.
- **Direct effects:** A study conducted by Nobre[55] noted direct effects in a 24-hour study on the embryonic development (likely from residual chemicals in the microbead during production) of sea urchins exposed to as-produced and beach-sourced microbeads (20% by volume microbeads). In a 9-day study by Cole et al,[56] in copepods, the impedance of feeding behaviour led to decreased reproductive output. Similar findings have been shown recently in Hyalellaazteca with decreased body growth and reproduction due to feeding impedance. For spherical polyethylene and fibres microbeads. Another study accessing the impacts on feeding behaviour by Carlos de Sa [57] indicated a colour-specific uptake where red and black microbeads significantly impeded feeding behaviour relative to white microbeads.
- **Cellular and sub-cellular effects:** A research study was conducted by Rochman et al[58] on pollutant adsorption in Japanese medaka and found that microbeads with and without pollutant adsorption caused stress in the liver as determined by glycogen depletion, fatty vacuolation, and single cell necrosis. In a follow-up study by the same authors (2014) in the same organisms, and following 2-month exposure from plain and pollutant-modified microbeads, there was altered gene expression in male fish (from pollutant-modified microbeads) and female fish (from both modified and unmodified microbeads)[57.] Results of the follow-up study concluded that the capability of inducing an endocrine-disrupting effect both from modified and unmodified microbeads. However, it is unclear in this study whether the effects from the unmodified microbeads were from only the particle and/or residual chemicals from manufacturing.

50. Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., & Laforsch, C. (2017). Spatial and temporal variation of macro-, meso-and microplastics abundance on a remote coral island of the Maldives, Indian Ocean. *Marine Pollution Bulletin*, *116*(1-2), 340-347.
51. Rosenkranz, P., Chaudhry, Q., Stone, V., & Fernandes, T. F. (2009). A comparison of nanoparticle and fine particle uptake by Daphnia magna. *Environmental Toxicology and Chemistry: An International Journal*, *28*(10), 2142-2149.
52. Von Moos, N., Burkhardt-Holm, P., & Koȟler, A. (2012). Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure. *Environmental science & technology*, *46*(20), 11327-11335.
53. Setälä, O., Fleming-Lehtinen, V., & Lehtiniemi, M. (2014). Ingestion and transfer of microplastics in the planktonic food web. *Environmental pollution*, *185*, 77-83.
54. Song, Y. K., Hong, S. H., Jang, M., Han, G. M., Rani, M., Lee, J., & Shim, W. J. (2015). A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples. *Marine pollution bulletin*, *93*(1-2), 202-209.
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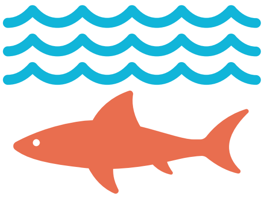
58. Rochman, C. M., Hoh, E., Kurobe, T., Teh, S. J. (2013). Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Scientific reports*, *3*

- **Transport of pollutants:** Multiple studies have shown that microbeads can adsorb pollutants from the environment and desorb them in the organism. For example, Rochman et al[58] exposed Japanese medaka to microbeads modified with polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and flame retardants (PBDEs), and found an increase of pollutants in all cases inside the fish relative to concentrations in the test media. In another study in lugworms by Brown et al[59], it was found that although microbeads adsorb and desorb pollutants (including nonylphenol, phenanthrene, triclosan, and PBDE-47), silica particles (sand) were found to release higher concentrations in the gut tissue, suggesting that more information is needed to understand the significance of microbead transportation of pollutants versus naturally available particulate matter in organisms. Recent work has shown that microbeads extracted from cosmetics have similar potential to adsorb and hence transport chemicals to that previously demonstrated for microbeads and secondary microplastics[60].

According to the United Nations, at least 800 species worldwide are affected by marine debris, and as much as 80% of that litter is plastic. According to The Living Planet Report 2014, the Living Planet Index (LPI) for marine population, which measures trends in 5,829 populations of 1,234 mammal, bird, reptile and fish species, showed a decline of 49 per cent between 1970 and 2012.



According to the United Nations,

at least 800 species worldwide are affected by marine debris, and as much as 80% of that litter is plastic.

Effect of microplastics on humans

Humans are susceptible to microplastics exposure via multiple sources, such as through the consumption of seafood and terrestrial food, drinking water and via inhalation[61]. Microplastics can be ingested indirectly through our food chain due to the genuine prey-predator relationship[62] and it may lead to higher accumulation of microplastics in organisms at the top of the food chain. Microplastics are also present in the salt derived from seawater as well as in sugar and honey[63]. The primary uptake is believed to take place by the ingestion of a wide variety of marine animals, including fish (mackerel, cod and tuna), molluscs (squid and octopus), and those found in coastal lagoons such as bivalves (mussels and oysters) and crustaceans (prawns)[61].

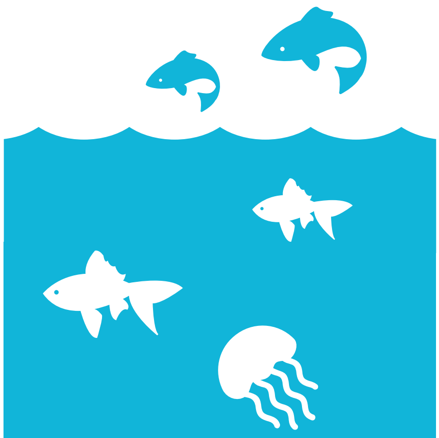
Since microplastics are considered to be a complex and diverse suite of contaminants[64], including such substances such as PAHs, PCBs, phthalates, bisphenols, hormones and pharmaceuticals, they can transfer contaminants, thus exposing humans to the physical and chemical toxicities of microplastics. Most investigations have studied trophic transfer and bioaccumulation of POPs, though the studies on PPCP compounds, endocrine-disrupting chemicals, and metals are scarce[65].

59. Browne, M. A., Niven, S. J., Galloway, T. S., Rowland, S. J., Thompson, R. C. (2013). Microplastics moves pollutants and additives to worms, reducing functions linked to health and biodiversity. *Current Biology*, *23*(23), 2388-2392
60. Napper, I. E. Thompson, R. C. (2015). Characterisation, Quantity and Sorptive Properties of Microplastics Extracted From Cosmetics. Marine Pollution Bulletin (in press). CHECK FONT
61. Barboza, L. G. A., Vethaak, A. D., Lavorante, B. R., Lundebye, A. K., &Guilhermino, L. (2018). Marine microplastics debris: An emerging issue for food security, food safety and human health. *Marine pollution bulletin*, *133*, 336-348.
62. Liebezeit, G., &Liebezeit, E. (2014). Synthetic particles as contaminants in German beers. *Food Additives & Contaminants: Part A*, *31*(9), 1574-1578.
63. Seth, C. K., &Shriwastav, A. (2018). Contamination of Indian sea salts with microplastics and a potential prevention strategy. *Environmental Science and Pollution Research*, *25*(30), 30122-30131.
64. Rochman, C. M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., & Hung, C. (2019). Rethinking microplastics as a diverse contaminant suite. *Environmental toxicology and chemistry*, *38*(4), 703-711.
65. EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain) Statement on the presence of microplastics and nanoplastics in food, with particular focus on seafood EFSA J., 14 (6) (2016), pp. 4501-4531

Humans are exposed to these chemicals either by the direct ingestion of microplastics or by secondary sources such as the consumption of organisms that bioaccumulated these contaminants by consuming contaminated prey[66]. The bioaccumulation of these contaminants in the human body can result in skin irritation, respiratory problems, cardiovascular diseases, digestive problems and reproductive issues.

Sustainable Development Goals (SDGs)

The issues related to marine plastics are being addressed internationally by the UN and by individual countries at national, subnational and supranational levels, including regional levels. At the global level, the issue of marine plastics has been recognised in the UN SDGs under Goal 14, which is to: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Specifically, in target 14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution. Since microplastics is a huge marine polluter, this SDG is directly linked to microplastics pollution. But microplastics also is indirectly linked to many other SDGs as mentioned in following page.



Sustainable Development Goal 14: Life below water

It calls upon states to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris, by 2025.

66. Carbery, M., O'Connor, W., & Palanisami, T. (2018). Trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health. *Environment international*, *115*, 400-409.

Table 3: SDGs and Microplastics[67]

Goal	(Micro)plastic challenges to implementing UN SDGs
1 NO POVERTY	Negative impacts on ecosystem services and economic impacts on communities.
2 ZERO HUNGER	Presence of (micro)plastics in food packaging, agricultural soils, fruits and vegetables, fish and shellfish posing potential risks to human health through ingestion.
3 GOOD HEALTH AND WELL-BEING	Presence of (micro)plastics in humans and fetus via ingestion, inhalation, and dermal exposure of microplastics in packed food products, foodstuff, and air.
6 CLEAN WATER AND SANITATION	Presence of (micro)plastics in drinking water and treated wastewater effluent.
7 AFFORDABLE AND CLEAN ENERGY	Incineration of (micro)plastic waste used in waste-to-energy systems contributes to greenhouse gas emissions, release of atmospheric pollution, and is unsustainable.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Innovation is required for sustainable bio-based alternatives to fossil fuel–based plastics to help contributing to a circular economy.
10 REDUCED INEQUALITIES	Exports of plastic waste from developed to developing countries have been considered waste pollution transfer.
11 SUSTAINABLE CITIES AND COMMUNITIES	Indiscriminate disposal of plastics in countries with inadequate waste management systems is choking critical urban infrastructure.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Unsustainable global plastic production and plastic waste mismanagement.
13 CLIMATE ACTION	Greenhouse gases are emitted at every step of the plastic life cycle, from production to transportation to waste disposal.
14 LIFE BELOW WATER	Extraordinary efforts are required to reduce emissions of (micro)plastics to marine and freshwater ecosystems.
15 LIFE ON LAND	Mismanagement of (micro)plastic waste causing widespread terrestrial pollution of (micro)plastics in landfills, urban and rural areas, protected areas, and agricultural soils.

67. Tony R. Walker, (Micro)plastics and the UN Sustainable Development Goals, Current Opinion in Green and Sustainable Chemistry, Volume 30, 2021,

Objective and methodology

Microplastics have assumed critical proportion, mainly because of the widespread distribution as well as its possibility to impact the environment and the living beings. Though there is a need to reduce microplastics pollution from both primary as well as secondary sources, in applications like PCCP, it is easier because most of the times, these are not essential ingredients and are intentionally added to products. Despite worldwide attention devoted to the ocean plastics crisis, in India, there has been no action till date to restrict use of microbeads in PCCPs. There has been only one limited study to determine use of these non-biodegradable beads in personal care products, hence it is difficult to assess the criticality.

To address this gap, Toxics Link has conducted a primary study to access the presence of microbeads in PCCPs. This is further to an earlier small assessment done by the organisation. The primary goal of this study is to assess the presence of microbeads in PCCPs and also to understand the possibility of pushing the stakeholders to minimise its usage. This is in line with the SDG goals, mainly Sustainable Development Goal 14: Life below water. It calls upon states to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris, by 2025.

Objective — Assessment of microplastics in Indian personal care and cosmetics products.

Objectives in details

- Characterisation and identification of microbeads in PCCPs
- To identify the harmful effects of plastic microbeads to human life
- To promote the awareness on impact of single-use plastic and microplastics in the marine environment.

MATERIAL AND METHODOLOGIES

Thirty-five personal care cosmetic products were selected to assess the presence of plastic microbeads and also to quantity and identify the type of polymer present in the samples.

Nineteen face washes, 7 facial scrubs, and 9 body washes were included in the samples, which included most popular brands available in India presently as shown in Figure 2.

Figure 2: Cosmetics samples; (A) face wash samples (F1-F19), (B) scrubs samples (S1-S7); body wash (B1-B9)

S.	Sample Name	Denoted as
1	Lakme Blush & Glow Strawberry Blast Face Wash	Lakme Facewash
2	Himalaya Oil Clear Lemon Face Wash	Himalaya Facewash
3	Clean & Clear Morning Energy Aqua Splash, Blue,	Clean & Clear Facewash
4	Garnier Men Oil Clear Clay D-Tox Deep Cleansing Icy Face Wash	Garnier Facewash
5	Garnier Bright Complete BRIGHTENING DUO ACTION Face Wash	Garnier Bright Facewash
6	POND'S Pure Detox Face Wash 100 g, Daily Exfoliating & Brightening Cleanser, Deep Cleans Oily Skin - With Activated Charcoal for Fresh, Glowing Skin	POND'S Facewash
7	Nivea Refreshing Face Wash with Vitamin E and Hydra IQ	Nivea Facewash
8	Pears Fresh Renewal Gentle Ultra Mild Daily Cleansing Facewash, Ph Balanced, 100% Soap Free, With Exfoliating Beads, Cooling	Pears Facewash
9	Everyuth Naturals Moisturizing Fruit Face Wash	Everyuth Facewash
10	Lotus Herbals WhiteGlow 3-In-1 Deep Cleansing Skin Whitening Facial Foam, face wash, for all skin types	Lotus Facewash
11	Fair and Handsome Instant Radiance Face Wash	Fair and Handsome Facewash
12	Patanjali Herbal Facial Foam	Patanjali Facewash
13	L'Oreal Paris Men Expert White Activ Oil Control Charcoal Foam	L'Oreal Facewash
14	Neutrogena Deep Clean Foaming Cleanser For Normal To Oily Skin	Neutrogena Facewash
15	Lever Ayush Natural Saffron Face Wash	Ayush Facewash
16	Kaya Youth Oxy-Infusion Face Wash,Boosts Skin Oxygen,Instantly Brightens skin,Gives youthful glowing skin,Developed by Dermatologists	Kaya Youth Facewash
17	Mamaearth Charcoal Face Wash with Activated Charcoal & Coffee for Oil Control	Mamaearth Facewash
18	Aroma Magic Face Wash - White Tea & Chamomile	Aroma Facewash
19	Glow & Lovely Insta Glow Multivitamins Face Wash - For Bright Skin	Glow & Lovely Facewash
20	NIVEA Men Body Wash, Pure Impact with Purifying Micro Particles, Shower Gel for Body, Face & Hair	NIVEA Bodywash
21	Palmolive Feel the Massage Body Wash for Women, Exfoliating Shower Gel with 100% Natural Thermal Minerals - pH Balanced, No Parabens, No Silicones	Palmolive Bodywash
22	Fiama Shower Gel Peach & Avocado, Body Wash with Skin Conditioners for Soft Moisturised Skin	Fiama Bodywash
23	Adidas Team Force 3in1 Body, Hair And Face Shower Gel For Men	Adidas Bodywash
24	Patanjali Shower Gel	Patanjali Bodywash
25	Dove Gentle Exfoliating Nourishing Body Wash	Dove bodywash
26	Liril Lemon & Tea Tree Body Wash 250 ml, Refreshing Liquid Shower Gel for Bathing - For Men & Women	Liril bodywash
27	Pears Naturale Detoxifying Aloe Vera Body Wash 250 ml, 100% Natural Ingredients, Liquid Shower Gel with Olive Oil for Glowing Skin - Paraben Free	Pears Bodywash
28	Lux Soft Touch Body Wash with French Rose and Almond Oil	Lux Bodywash
29	VLCC Rose Face Scrub	VLCC Scrub
30	Neutrogena Deep Clean Scrub Blackhead Eliminating Daily Scrub For Face	Neutrogena Scrub
31	Clean & Clear Blackhead Clearing Daily Scrub	Clean & Clear Scrub
32	NIVEA Women Face Wash, Skin Refining Scrub with Vitamin E	NIVEA Scrub
33	FABEYA Biocare Natural Activated Charcoal Face and Body Scrub	FABEYA Scrub
34	Mamaearth Charcoal Face Scrub for Oily and Normal skin, with Charcoal and Walnut for Deep Exfoliation	Mamaearth Scrub
35	Nykaa Wanderlust Body Scrub - Sicilian Sweet Pea	Nykaa Scrub

A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Clean & Clear
MORNING ENERGY
Himalaya
everyuth
kaya youth
FAIR AND HANDSOME
LOTUS HERBALS
WHITEGLOW
NIVEA
FACE WASH
GARNIER MEN
OilClear
LAKMÉ
POND'S
mamaearth
Charcoal Face Wash
L'ORÉAL MEN EXPERT
WHITE ACTIV
Pears
GARNIER
Light Complete
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Neutrogena
deep clean
Glow & Lovely

B


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VLCC
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Neutrogena
deep clean
adidas
smooth
fiama
NIVEA MEN
PURE IMPACT
NIVEA
Clean & Clear
Pears
PALMOLIVE
MASSAGE
mamaearth
Charcoal Face Scrub
Liril
LUX
Dove

Microplastics (microbeads) extraction

Briefly, 20g of each sample was added to a 500-ml beaker with 400 ml of MiliQwater (water that has been purified using resin filters and deionised to a high degree by a water purification system) in triplicate. MQ water was boiled prior to addition of the sample. The solution was stirred (670 rpm) on a hot plate at 75°C to achieve a heterogeneous solution. It was then stirred properly to achieve a heterogeneous solution. Vigorous sample agitation was avoided during extraction to prevent foaming. The solution was allowed to settle for ≥1 h to precipitate[74]. Next, the solution was filtered through Whatman filter paper by using vacuum filtration pump. Filtration was facilitated by gently rinsing the beaker with MQ water to ensure complete transfer of the sample. After settling for >1 h in the scintillation vial, the excess alcohol was carefully removed using a Pasteur pipette and the vials were placed in an oven at 80°C overnight to evaporate any residual liquid. Samples were then weighed to quantify the mass of plastic particles captured on each sieve size.

Figure 3: Filtration of samples

Identification and quantification of microplastics

Materials on the filter papers were observed under a Nikon SMZ18 stereozoom microscope with attached Nikon DS-F2.5 camera and 1X (0.75 – 13.5 zoom) for plastics resembling particles based on their size, colour, shape and structure. The NIS-Elements D 5.20.00 software was used for quantification and identification of microplastics-slike particles. The microbeads were photographed and its size, colour and shape were noted. Finally, microbeads were selected from each sample for further identification of polymer type by μ-FTIR instrument.

Estimation of microbeads

Total number of beads was calculated by following formula:

$$\text{Number of Beads per 20g} = \frac{\text{Weight of Beads per 20g}}{\text{Weight of one Bead (g)}}$$

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 were 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 air-borne contamination. The test spectra obtained was compared with the known library spectra for the reference.

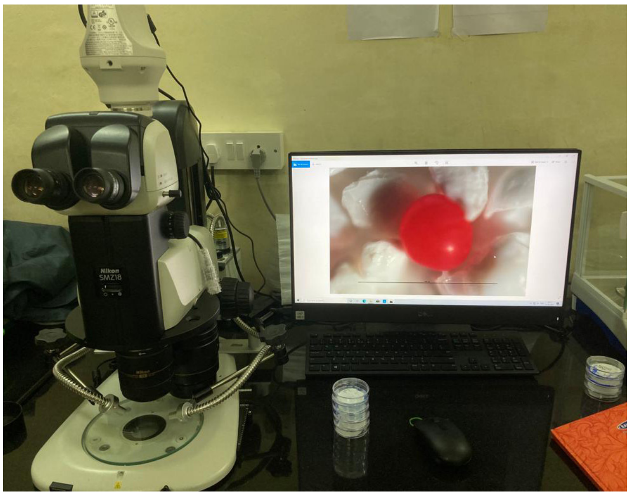


Figure 4: Nikon SMZ18 stereozoom microscope

Figure 5: FTIR-AIM

Calibration procedure before sample analysis

Figure 6: Background scan before analysis of MP samples in FTIR(IR Tracer- 100)

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

The samples were analysed 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 16cm^{-1}. μ- FTIR analysis of MPs in AIM viewer software for the polymer detection.

Here the samples are analysed for the polymer identification using AIM software.

- Selection of the aperture for the selected MP particle and a background scan is run which is followed by sample scan of the selected aperture.
- The spectra are produced for the selected 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 matching spectra with their respective scores; thus we chose the highest matching score for our final results.

Figure 7:
Ethylene /Vinyl acetate copolymer

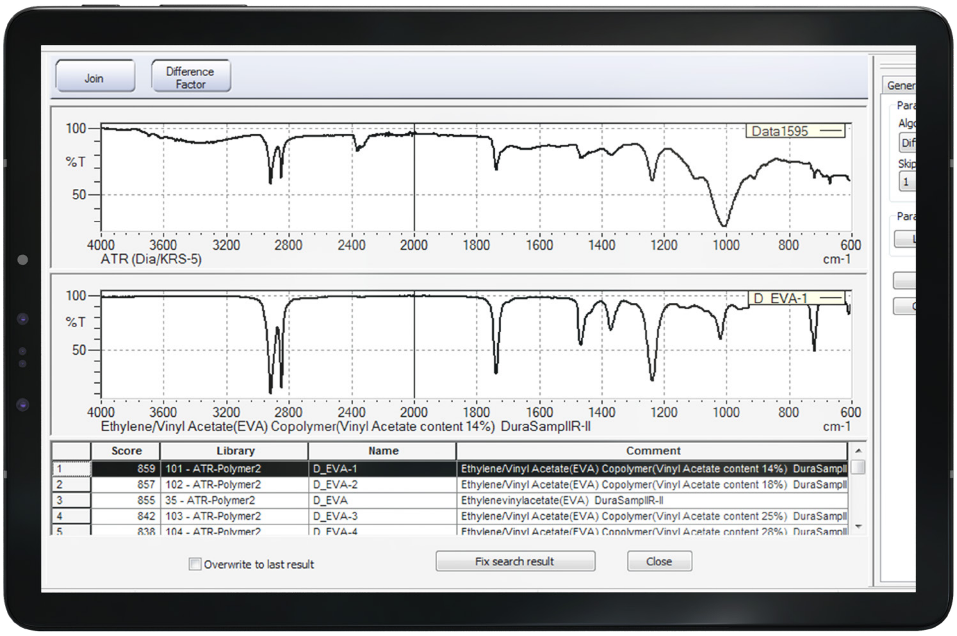


Figure 8:
Poly acrylic acid

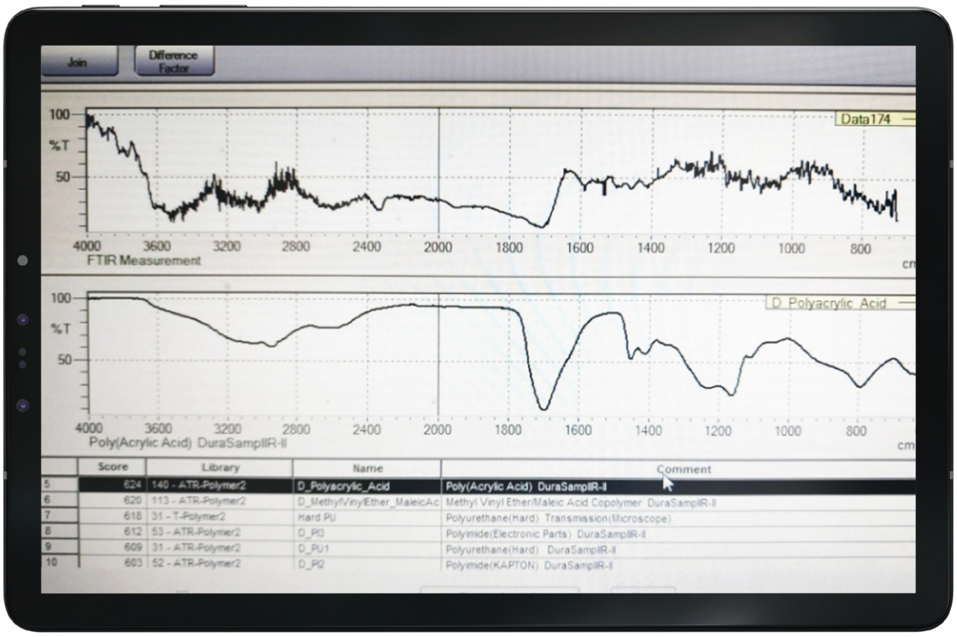
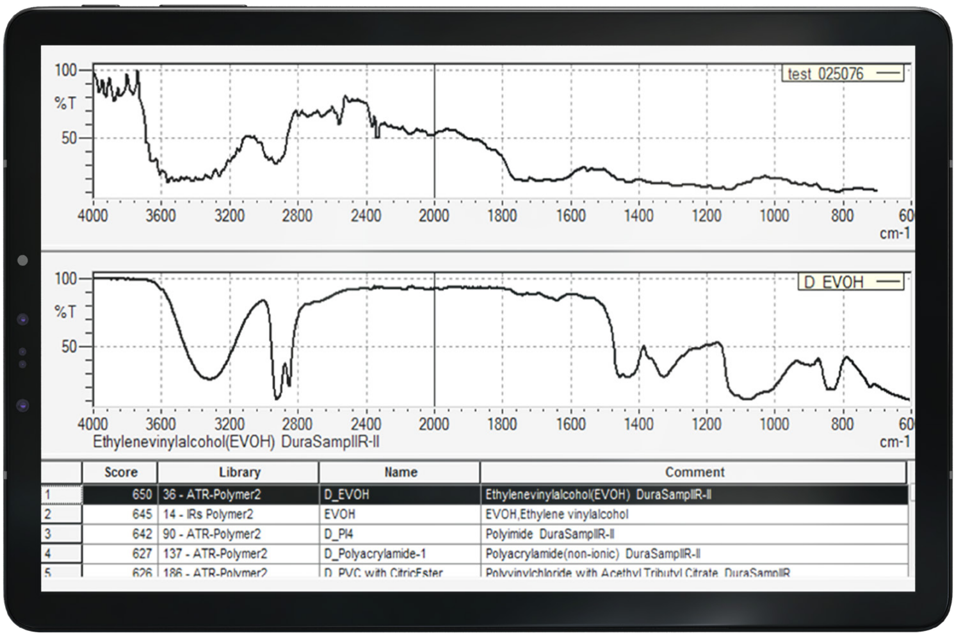


Figure 9: Ethylene vinyl alcohol



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.[68,69] Glassware were rinsed thoroughly twice with distilled/deionised water before using for experiment and white cotton lab coat and mask worn during the experiment was of non-polymer in nature. Whole experimental set-up was done in sterile area. Furthermore, filter papers were not exposed to air and were kept under a clean air laminar flow hood and maintained in clean petridishes. Glass lids were used while observing under microscope to avoid contamination. Moreover, non-existence of any airborne microfibre was confirmed in three replicate of blank filter paper to eliminate the probability of contamination by air.

It is observed between the mid infrared regions

Nineteen face washes, 7 facial scrubs, and 9 body washes were sampled, which included most popular brands available in India

68. 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
69. Wesch, C., Elert, A. M., Wörner, M., Braun, U., Klein, R., & Paulus, M. (2017). Assuring quality in microplastics monitoring: About the value of clean-air devices as essentials for verified data. Scientific Reports, 7(1), 1-8

Result and discussion

PRESENCE OF PLASTIC MICROBEADS IN PCCPs

A total of 35 samples from personal care and cosmetics products (face wash, scrub, and body wash) were analysed to assess microbeads presence. Out of 35 samples, 20 were detected with presence of polymers. Among the 20 samples with polymers, 14 have microplastics beads as shown in Figure 10. In total, 16 samples were found to have microbeads but two contained non-polymer beads.

Interestingly, polymers in non-microplastics beads format were found only in face wash samples. It was also interesting to note that some samples contained both plastic as well as non-plastic beads. The material of the non plastic beads, however, could not be identified as this was beyond the scope of this study. Samples F6, S3, B1 and B9 contained both plastic as well non plastic beads.

Figure 10: Presence of microplastics beads in tested PCCPs

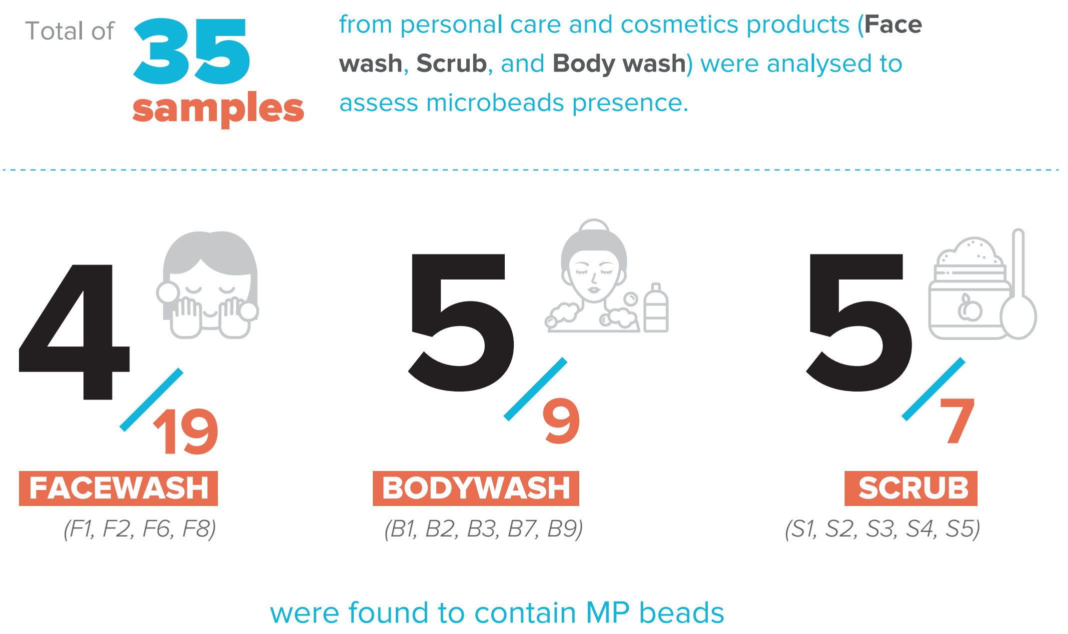
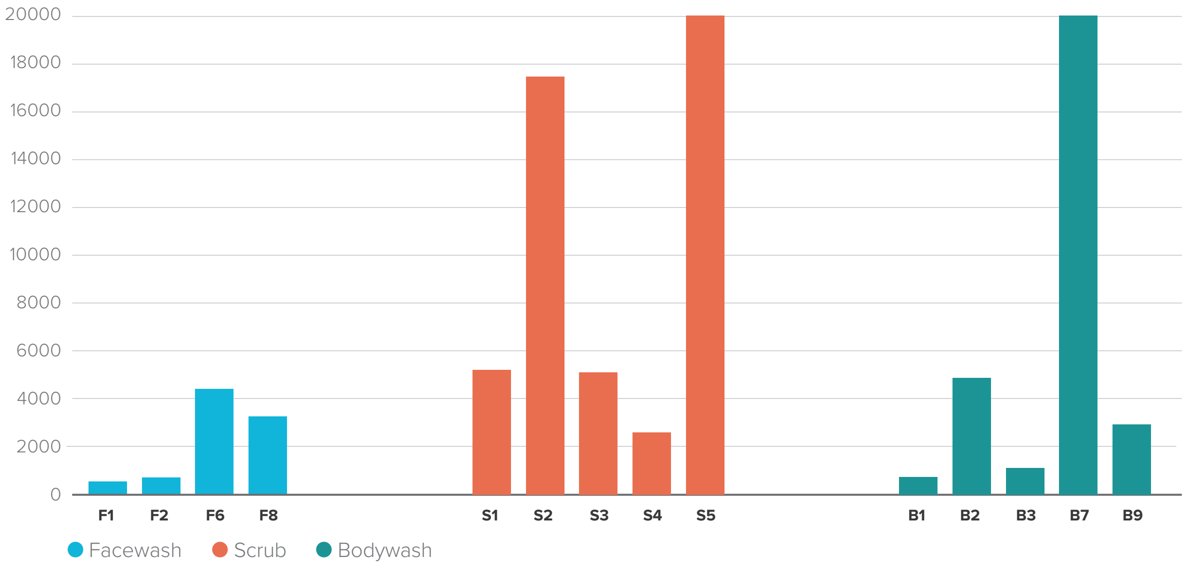


Figure 11: Material identified in PCCP samples

Sample ID	Name	Polymer in other forms	MP beads	Non-polymer beads
F1	Clean & Clear Aqua splash face wash		Acrilonitrile film	
F2	Himalayan oil clear lemon face wash		PE	
F3	Everyuth naturals moisturising fruit face wash			
F4	Nivea refreshing face wash	Poly acrylic acid		
F5	Garnier men oil clear deep cleansing icy face wash			
F6	Lakme Blush & Glow Strawberry Gel Facewash		Lanoline	●
F7	Aroma Magic Neem and tea tree face wash			
F8	Pears Fresh Renewal facewash		Acrilonitrile/ Butadiene/ Styrene	
F9	Garnier Skin naturals face wash	Polyvinyl alcohol		
F10	Kaya youth Oxy- Infusion facewash			
F11	Fair and Handsome face wash	Polyimide		
F12	Ponds pure white face wash			
F13	Mama earth charcoal face wash			
F14	Lever Ayush face wash			
F15	Neutrogena deep clean	Polyvinyl alcohol		
F16	Lotus herbal facial			
F17	L'Oreal Men Expert	EVOH		
F18	Patanjali Herbal Facial			
F19	Fair and Lovely cream	Poly acrylic acid		
S1	VLCC Natural Sciences Rose Face Scrub		Poly Butyl methacrylate + PAM	
S2	Neutrogena deep clean scrub		Ethylene/ Propylene copolymer	
S3	Nivea skin refining scrub		PAM	●
S4	Clean and clear blackhead clearing daily scrub		PP	
S5	Nykaa body scrub		LDPE	
S6	Mama earth charcoal face scrub			●
S7	FABEYA Biocare Natural Science of skincare face and body scrub			●
B1	Adidas Smooth shower gel for women		Ethylene/ Vinyl acetate copolymer	●
B2	Fiama shower gel		LDPE	
B3	Nivea Men shower gel		PE/ Poly acrylic acid	
B4	Pears naturale body wash			
B5	Liril body wash			
B6	Patanjali Soundarya shower gel			
B7	Palmolive aroma moments shower gel		PAM	
B8	Lux soft touch body wash			
B9	Dove Gentle exfoliating Nourishing body wash		Ethylene/ Vinyl acetate copolymer	●

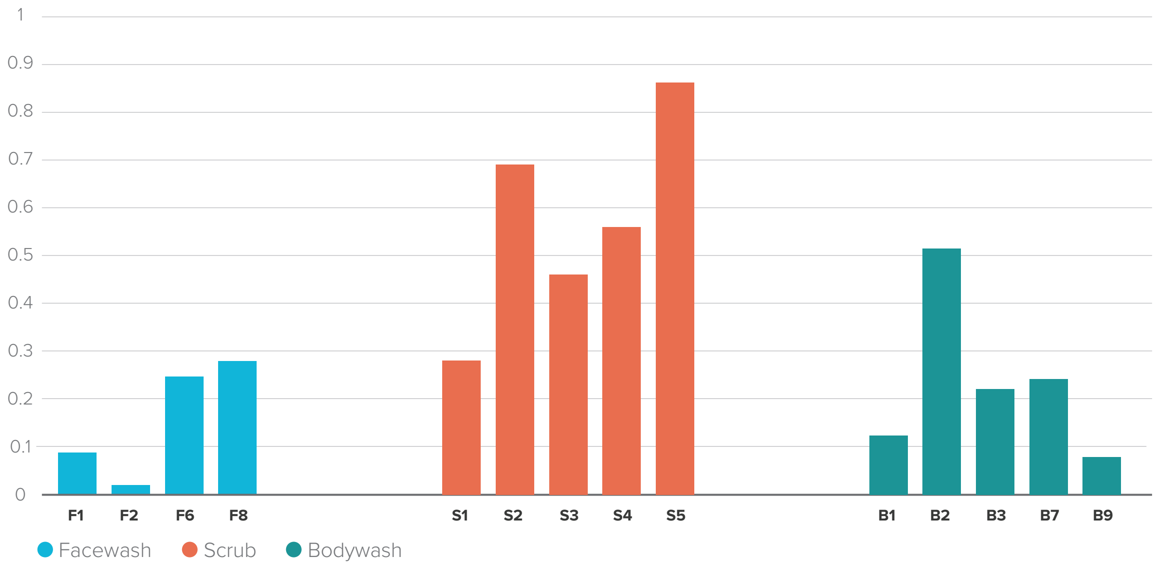
Among all types of PCCPs tested (face wash, scrub and body wash), the highest number of microplastics beads were detected in NEUTROGENA SCRUB (S2) with 17,250 microbeads per 20g, followed by VLCC FACE SCRUB (S1) with 5,510 beads per 20g and FIAMA SHOWER GEL (B2) with 4,727 micrbeads per 20g, as shown in Figure 12 . The three lowest numbers were found in CLEAN & CLEAR FACE WASH (F1) with 238 per 20g, HIMALAYAN FACE WASH (F2) with 316 per 20g and ADIDAS SHOWER GEL (B1) with 882 per 20g.

Figure 12: Number of polymer beads extracted per 20g of sample in face wash, body wash and scrub. (UC: uncountable)



The three maximum weight of the beads extracted per 20g of the samples were 0.85g in NYKAA BODY SCRUB (S5) followed by 0.69g in NEUTROGENA SCRUB (S2) and 0.54g in CLEAN & CLEAR SCRUB (S4). In contrast, lowest weight of 0.012g per 20g in HIMALAYAN FACE WASH (F2), 0.087g per 20g in CLEAN & CLEAR FACE WASH (F1) and 0.09g per 20g was obtained for DOVE BODY WASH (B9) sample as reported in Figure 13. Microbeads may appear insignificant in terms of weight. However, considering the minuscule particle sizes, the quantity of microbeads emitted could be huge. As a result, microbead emissions could increase the density of microplastics in the aquatic environment dramatically.

Figure 13: Weight of both polymer and non-polymer microbeads in all samples



The results were further analysed to check category wise microplastics occurrence.

Face wash

Out of 19 face wash samples included in the study, plastic polymers were found in 10 samples. Among them, four samples, namely F1, F2, F6 & F8, have microplastics or plastic microbeads, and six other samples revealed the presence of polymers in other forms. One of the samples, LAKME FACEWASH (F6), contained both polymer and non-polymer microbeads.

Among the sample detected with microbeads, as can be seen from Figure 11, the highest number of beads, i.e., 4,258 beads per 20g, were found in LAKME FACEWASH (F6). The lowest number of beads was detected in CLEAN & CLEAR AQUA FACE-WASH (F1) with 238 per 20g of sample. The largest recorded abundance and mass of microplastics measured in PCPs globally is 31,10,000 particles/g for facial cleansers from Slovenia[70].

Among face washes, the maximum microbead weight of 0.27g/20g was estimated in PEARS FACEWASH (F8), while the lowest weight 0.01296g/20g were found in HIMALAYAN FACE WASH (F2) as shown in Figure 13.

70. Chang, M. (2015). Reducing microplastics from facial exfoliating cleansers in wastewater through treatment versus consumer product decisions. Marine pollution bulletin, 101(1), 330-333.

Table 4: **Microplastics extracted from different face wash samples**

Sample ID	Name	Polymer in other forms	MP beads	Non-polymer beads	Characteristics of bead	Weight of beads per 20 g	Colour of beads	No. of beads per 20g	Size
F1	Clean & Clear face wash		Acrilonitrile film		Spherical	0.087	red	238	37.55 - 130.92
			Acrilonitrile film				green		
F2	Himalayan face wash		PE		Spherical	0.01296	blue	316	
F3	Everyuth face wash		Absence			Absence	Absence	Absence	
F4	Nivea face wash	Poly acrylic acid	Absence			-	-	-	
F5	Garnier face wash		Absence		Absence	Absence	Absence	Absence	
F6	Lakme Facewash		Absence	Presence	Spherical	0.24	red	4528	
			Lanoline		Spherical		white		
F7	Aroma Magic face wash		Absence		Absence	Absence	Absence	Absence	
F8	Pears facewash		Acrilonitrile/ Butadiene/ Styrene		Distorted	0.27	blue	3293	
F9	Garnier face wash	Polyvinyl alcohol			Absence	Absence	Absence	Absence	
F10	Kaya youth facewash		Absence		Absence	Absence	- Absence	Absence	
F11	Fair and Handsome face wash	Polyimide			Absence	Absence	Absence	Absence	
F12	Ponds face wash		Absence		Absence	Absence	Absence	Absence	
F13	Mama earth face wash		Absence		Absence	Absence	Absence	Absence	
F14	Lever face wash		Absence		Absence	Absence	Absence	Absence	
F15	Neutrogena facewash	Polyvinyl alcohol	Absence		Absence	Absence	Absence	Absence	
F16	Lotus herbal facial		Absence		Absence	Absence	Absence	Absence	
F17	L'Oreal facewash	EVOH	Absence		Absence	Absence	Absence	Absence	
F18	Patanjali facewash		Absence		Absence	Absence	Absence	Absence	
F19	Fair and Lovely facewash	Poly acrylic acid	Absence		Absence	Absence	Absence	Absence	

Scrub samples

In the case of scrub samples, all seven tested contain beads. Among these, 5 samples, namely S1, S2, S3, S4 & S5, revealed the presence of polymer. Among the five samples which contain plastic microbeads, one, NIVEA SCRUB (S3), contains both polymer and non-polymer microbeads. Samples S6 and S7 contained non-polymer microbeads.

Among the scrub samples, the highest number of beads was detected in SCRUB (S2) with 17,250 per 20g of beads, whereas minimum number of beads was found in CLEAN & CLEAR SCRUB (S4) with 2,288 microbeads as illustrated in Figure 12. Though NYKAA BODY SCRUB (S5), MAMA EARTH FACE SCRUB (S6), and FABEYA FACE AND BODY SCRUB (S7) were found to have microbeads, the numbers could not be counted, either because of the distortion or because of the tiny size.

Among all the scrub samples, NYKAA BODY SCRUB (S5) showed the maximum weight of 0.85g per 20g whereas VLCC FACE SCRUB (S1) showed the lowest weight of 0.27g per 20g as shown in Figure 13.

Table 5: Microplastics extracted from different scrub samples

Sample ID	Name	Polymer in other forms	MP Beads	Non-polymer beads	Characteristics of bead	Weight of beads per 20 g	Colour of beads	No. of beads per 20g	Size
S1	VLCC Face Scrub		Poly Butyl methacrylate		Spherical	0.27	Red	5510	32.55 - 91.01
			PAM				White		
S2	Neutrogena scrub		Ethylene/ Propylene copolymer		Spherical	0.69	Orange	17250	
S3	Nivea scrub			Presence	Spherical	0.45	White	3516	
			PAM				Blue		
S4	Clean and clear scrub		PP		Spherical	0.54	Green	2288	
S5	Nykaa body scrub		LDPE		Distorted	0.85	White	UC	
S6	Mama face scrub			Presence	Distorted	0.69	Brown	UC	
S7	FABEYA face and body scrub			Presence	Spherical	0.45	Brown	UC	

*UC= Uncountable

Body wash

Out of the 9 samples tested, microplastics beads were found in 5, namely B1, B2, B3, B7, B9. Two samples, DOVE BODY WASH (B9) and ADIDAS SHOWER GEL (B1), also contained beads not made of polymer or non-polymer microbeads. The highest number of 4,727 microbeads per 20g were found in Fiama shower gel (B2) while the lowest number of 882 microbeads were found in ADIDAS SHOWER GEL (B1) as shown in Figure 12. Though PALMOLIVE SHOWER GEL (B7) was also detected with microbeads, it could not be counted due to thei small particle size as shown in Table 6. The highest microbeads of 0.52g per 20g were found in FIAMA SHOWER GEL (B2), whereas the lowest weight of 0.09g per 20g was \in DOVE BODY WASH (B9).

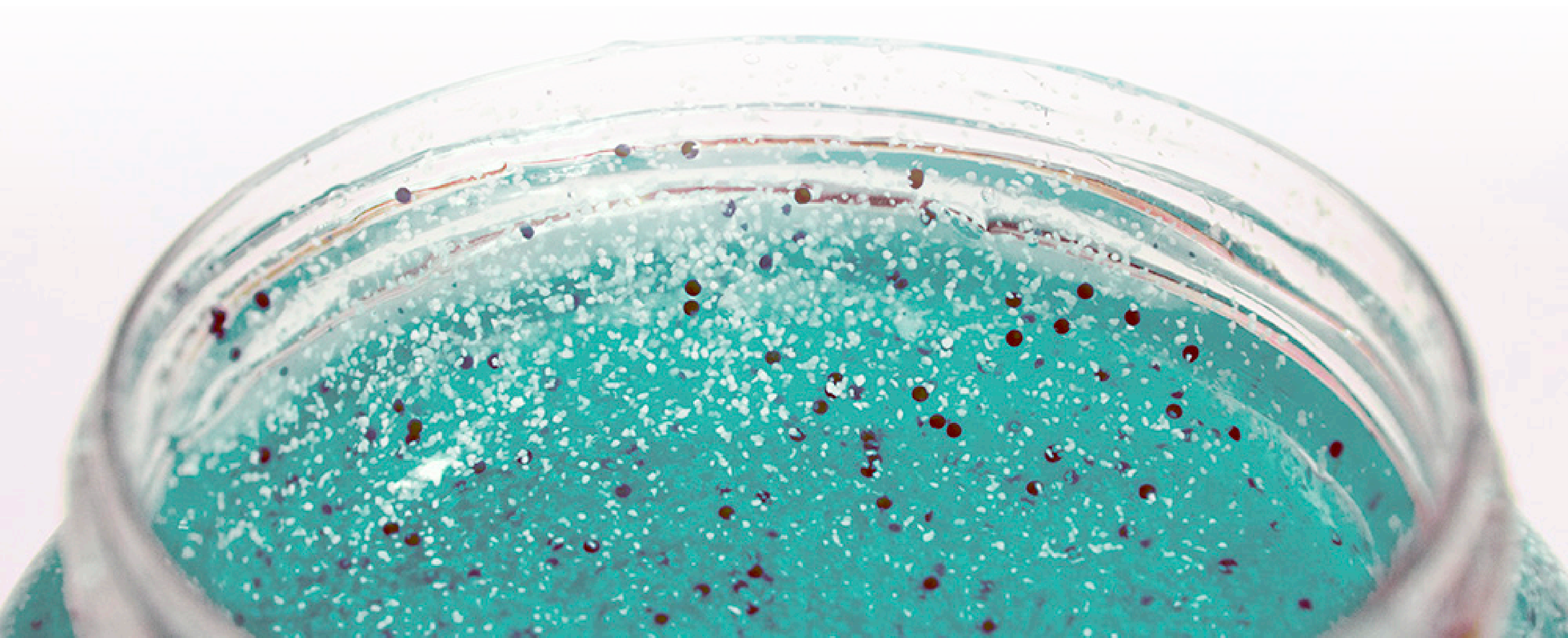
Table 6: Microplastics extracted from different samples of body wash

Sample ID	Name	Polymer in other forms	MP beads	Non-polymer beads	Characteristics of bead	Weight of beads per 20 g	Colour of beads	No. of beads per 20g	Size
B1	Adidas shower gel		Ethylene/ Vinyl acetate copolymer		distorted	0.12	Red	882	74.88-130.11
				Presence			White		
B2	Fiama shower gel		LDPE		Spherical	0.52	Red	4727	
B3	Nivea shower gel		PE		Spherical	0.21	White	1382	
			Poly acrylic acid				light blue		
B4	Pears body wash				Absence	Absence	Absence	Absence	
B5	Liril body wash				Absence	Absence	Absence	Absence	
B6	Patanjali shower gel				Absence	Absence	Absence	Absence	
B7	Palmolive shower gel		PAM		Spherical	0.22	Trans-parent	UC	
B8	Lux body wash				Absence	Absence	Absence	Absence	
B9	Dove body wash		Ethylene/ Vinyl acetate copolymer		Spherical	0.09	blue	2368	
				Presence			white		

*UC= Uncountable

Table 7: Highest and lowest microbeads in PCCPs, by weight and numbers

PCCP type	Maximum weight of microbeads (per 20g)	Lowest weight of microbeads (per 20g)	Highest number of microbeads (per 20g)	Lowest number of microbeads (per 20g)
FACE WASH	0.27g in F8	0.012g in F2	4,528 in F6	238 in F1
SCRUBS	0.85g in S5	0.27 in S1	17,250 in S2	2,288 in S4
BODY WASH	0.52g in B2	0.09g in B9	4,727 in B2	882 in B1



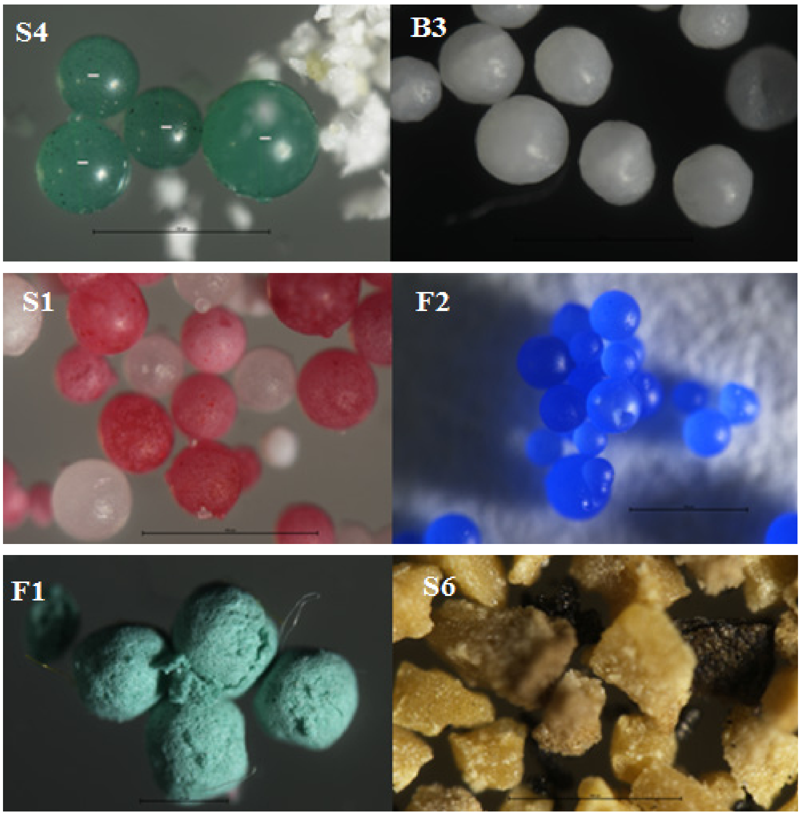


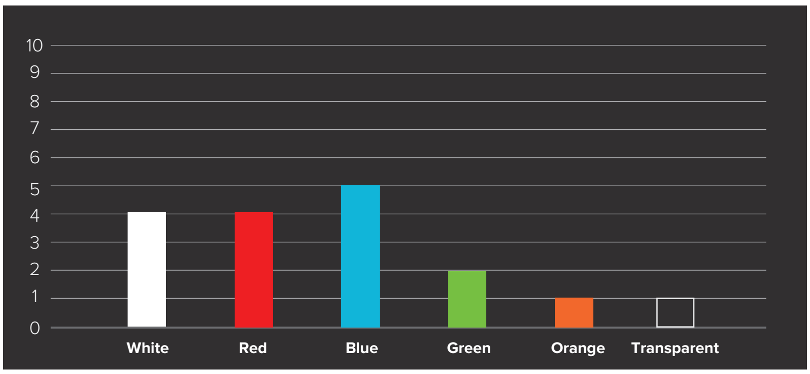
Figure 14: Stereozoom images of microbeads

CHARACTERISATION AND IDENTIFICATION OF MP BEADS

Colours, shape and size in microplastics beads

Six different colours (blue, red, white, green, orange and transparent) of MP beads were identified in the samples as reported in Figure 15. Blue was the most commonly detected colour in the MP beads, followed by red and white.

Figure 15: Colour of the beads detected in PCCPs



Though most PCCP samples contained only one colour of microplastics beads, there were a few samples with more than one colour. Sample F1 contained red and green colour microplastics, S1 contained red and white beads and B3 contained white and light blue microplastics.

If we look at different PCCP categaories, face wash samples were detected with microplastics beads of red, green, blue and white. One sample, CLEAN & CLEAR

In all the PCCPs samples, microbeads were found in the size range of

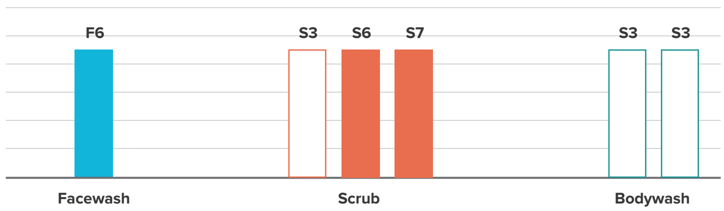
32.55 -130.92 µm.

It was also observed that the smaller the size of microbeads, the higher the number.

FACE WASH (F1), contained two different colours plastic microbeads (red and green). Though F6, Lakme Blush & Glow Strawberry Gel Facewash contained two colours of beads (red and white), the red ones were not plastic beads. In the five scrub samples detected with microplastics beads, five different coloured microbeads (white, red, orange, blue and green) were noted. The white microbeads are most dominant in this category of PCCPs. VLCC FACE SCRUB (S1) contained microplastics beads of two different colours. NIVEA SCRUB (S3) had white and blue beads but the white beads were non-polymer. S6 and S7 also had non-polymer beads of brown colour, likely to be a natural material such as walnuts.

Body wash samples reported four different colours, namely red, white, blue and transparent. NIVEA SHOWER GEL (B3) had white and light-bluebeads. ADIDAS SHOWER GEL (B1) and DOVE BODY WASH (B9) also had beads of two different colours but one of them was non-polymer.

Figure 16: Colour of the Non MP beads found in tested PCCPs-



The size range of all microbeads were measured using stereoscopic analysis. In all the PCCPs samples, microbeads were found in the size range of 32.55 -130.92 µm as reported in tables 4, 5 and 6. It was also observed that the smaller the size of microbeads, the higher the number.

The size of microbeads is crucial when it comes to the capturing ability of WWTPs. Microparticles (microbeads) are removed/retained by screens in WWTPs, preventing them from escaping with the effluents. Usually, the smaller size of microbeads has a higher probability of passing through the screen and entering the marine ecosystem via effluents. As a result of consumer use, microplastics present in cosmetics such as face wash, scrubs and body wash will routinely be washed into sewers[36].

Microplastics detected in the samples were mostly in spherical shapes as shown in tables 4, 5 and 6. Some beads were distorted --- both polymer and non-polymer.

Composition

FTIR analysis was successfully carried out for 35 PCCPs samples (19 face washes, 7 scrubs and 9 body washes) to identify the polymers present in these products. Altogether 20 samples were identified with polymers --- 10 face washes (F1, F2, F4, F6, F8, F9, F11, F15, F17, and F19), 5 scrubs (S1, S2, S3, S4, and S5), and 5 body washes (B1, B2, B3, B7, and B9).

Fourteen different type of polymers, namely acrilonitrile film, polyethylene, poly acrylic, acrilonitrile/butadiene/styrene, polyvinyl alcohol, polyimide, poly butyl methacrylate, PAM, lanoline, ethylene/propylene copolymer, polypropylene, LDPE, ethylene/vinyl acetate coploymer, and EVOH were detected in these 20 samples. Six samples show the presence of polymers though not in the microbead form. These are also a point of concern, because the polymer present in the sample might be nanoplastic or some other larger plastic form, which can go through the drains to reach larger water-bodies and the ocean and, over time, may break down into microplastics.

Polyacrylic acid and PAM was most abundant among the all the polymer present in PCCPs. The most common polymer in the microbeads identified was PAM acrilonitrile film, ethylene and LDPE.

Alternatives of microplastics beads

The use of microplastics in cosmetics has emerged as a major environmental concern. The option of removing the accumulated plastic load from the ocean is time-consuming, costly and unviable. Moreover, this operation will simultaneously remove the usually abundant microscopic yet significant planktons and other flora and fauna from the food chain, which may disrupt the entire marine ecosystem[71]. Thus, the only option is to minimise and, if possible, cease the entry of plastic in the lakes, rivers, seas and ocean.

A safer substitute is required to replace these environmentally hazardous constituents. Many personal care product companies are voluntarily phasing out the use of microplastics. Natural exfoliating materials, including pumice, oatmeal, walnut husks, salt, whole oats, almond shell and jojoba beads, maybe the potential candidates to replace non-biodegradable microbeads. But the irregular shape and high price limit the application of natural exfoliating materials in personal care products. Biodegradable polymers seem to be a promising alternative to petroleum-based polymer; for instance, polylactic acid (PLA), poly (ε -caprolactone) (PCL), and polyhydroxylalkanoates (PHAs) have been used to fabricate microbeads in various studies[72].

The biodegradable polyhydroxyalkanoate (PHA) microbeads[73] were suggested as a possible alternative to traditional microbeads. Being soluble, PHAs minimise the potential threats of microplastics beads in the environment. PHAs can biodegrade in either aerobic or anaerobic environments. It has also been demonstrated that the faster biodegradation rate of PHAs compared to other traditional synthetic polymers. Havens et al[74] have applied for a patent on the method for reducing marine pollution using PHA microbeads. They have claimed that the described method by incorporating PHA microbeads into personal care formulations such as exfoliants, cosmetics and toothpaste would reduce aquatic pollution significantly.

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73. Celmo C, Addison M. (2015). Biodegradable microbead alternative for cosmetics. Fifteenth Annual Freshman Engineering Conference, University of Pittsburgh, the USA, Paper #5187
74. Havens KJ, Bilkovic DM, Stanhope DM, Angstadt KT. (2013). Method for reducing marine pollution using polyhydroxyalkanoate microbeads. US Patent, US 20140026916 A1

Table 8: Current and future state bans on microbeads

Country	Banned or future ban	Definition	Usage	Exceptions	Law or regulation name
Taiwan	23/08/2016	Solid plastic particles used for exfoliation or cleaning of the body wherein the scope of particles diameter is smaller than 5mm	Cosmetics used for washing hair, bathing, face-washing, and soap B;. Facial scrub. C. Toothpaste	Non-biodegradable plastic is included in the ban	Huan-Shu-Fei-Tzu No. 1060059207
South Korea	01/07/2017	Plastic solid plastic<5mm in size	NA	NA	Ministry of Food and Drug Safety Notice No. 2019-352
United Kingdom	England 01/01/2018 Scotland 19/06/2018 Wales 30/06/2018 N Ireland 11/03/2019	Any water-insoluble solid plastic particle of less than or equal to 5mm in any dimension	Personal care products: cleaning, protecting or perfuming a relevant human body part (epidermis, hair, nails, lips, teeth), maintaining mucous membranes of the oral cavity or restoring its condition or changing its appearance		
New Zealand	07/06/2018	Water-insoluble plastic particle that is <5mm at its widest point	Wash-off product for: (i) exfoliation, (ii) cleaning of all or part of a person's body, (iii) abrasive cleaning of any area, surface, or thing, and (iv) visual appearance of the product	Water soluble plastic particles, medical device or medicine	Waste Minimisation (Microbeads) Regulations 2017
USA	01/07/2018	Any solid plastic particle that is less than five millimeters in size	Intended to be used to exfoliate or cleanse the human body or any part thereof (the term'rinse-off cosmetic' includes toothpaste)	Biodegradable plastic	Microbead-Free Waters Act of 2015
Ireland	14/06/2019	A solid plastic particle that (a) is not water soluble, and (b) at its widest dimension is not >5 mm in extent	Cosmetic product Cleansing product	Water soluble particles	Microbeads (Prohibition) Act 2019
Canada	01/07/2019	Plastic microbeads that are ≤5mm in size	Toiletries Toothpastes	Prescription drugs Transit products through Canada	Registration SOR_2017-111 - Microbeads in toiletries

Italy	01/01/2020	Solid plastic particles, insoluble in water, measuring 5mm or less, intentionally added to cosmetic products	Rinse-off cosmetic products with exfoliating or cleansing action and detergents	Water soluble particles	LEGGE 27 dicembre 2017, n. 205
Denmark	01/01/2020 until EU ban	Intentionally added microplastics	Rinse-off cosmetics Possibly leave-on cosmetics	N/A	Plastik uden spild—Regeringens Plastikhandlingsplan
China	31/12/2020 production 31/12/2022 sale	N/A	Daily chemical products containing plastic microbeads	N/A	Order No. 29 of the National Development and Reform Commission of the People's Republic of China
Brazil	Pending	Any solid plastic particle less than 5mm in size	To clean, lighten, burn or exfoliate the body or any of its parts	Biodegradable plastic	Projeto De Lei N° De 2016

In 2014, the European Commission published a new directive

2014/893/EU, which prohibits rinse-off cosmetics that contain microplastics to bear the Ecolabel sign, which is awarded to products with minimum environmental impact.

REGULATIONS ON BANNING THE USE OF MICROBEADS

Illinois was the first US state to enact legislation banning the manufacture and sale of products containing microbeads in 2014. The ban resulted from the reports of microplastics pollution in the Great Lakes[75] and North Shore Channel, Chicago [76].

The Dutch government was the first official body to suggest a Europe-wide ban on microbeads in 2013 and simultaneously stressed the need to inform the public[77]. In 2014, the European Commission published a new directive 2014/893/EU, which prohibits rinse-off cosmetics that contain microplastics to bear the Ecolabel sign, which is awarded to products with minimum environmental impact[78,79]. Motivated by the European Commission;s decision, Austria, Belgium, Netherlands, Luxembourg and Sweden, requested a Europe ban on microbeads in personal care products in a common statement[84].

The Canadian House of Commons unanimously voted to include microbeads in the toxic substances list under the Canadian Environmental Protection Act of 1999[80].

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76. McCormick A, Hoellein TJ, Mason SA, Schluep J, Kelly JJ. (2014). Microplastics is an abundant and distinct microbial habitat in an urban river. Environ Sci Technol, 48(20), 11863–11871
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(On 25 March, 2015, the Canadian Ministry of Environment and Climate Change analysed 130 scientific papers and as of June 2016 '...*Plastic microbeads that are ≤ 5 mm in size*...' were added as number 133 on the toxic substances list (CEPA. Canadian Environmental Protection Act, 2019; Environment Canada, 2015). Even though they were considered toxic, they were not banned. Only after the vote of the US act, Canada was forced to harmonise[81], as both countries share regulation for fresh and maritime waters. The microbeads in toiletries regulations, which were enacted in June 2017, made it illegal to manufacture, import or sell toiletries containing microbeads in Canada as of July 1, 2018, unless they were natural health products or non-prescription drugs, for which the prohibition took effect on July 1, 2019[81].

On the 30 October, 2019, China issued a new guidance for Chinese industries prohibiting the production of household chemical products containing plastic microbeads as of the 31 December, 2020, and a complete sale ban as of the 31 December, 2022[82].

Indian BIS standard 4707 deals with 'Classification of cosmetics raw materials and adjuncts'. These standards for cosmetics are not mandatory unless these have been included under the Rules. Part I of 4707 deals with dyes, colours and pigments, whereas Part 2 (Fourth Revision) contains 'List of Raw Materials Generally not Recognized as Safe for Use in Cosmetics'. This Indian Standard (Part 2) (Fourth Revision) was adopted by the Bureau of Indian Standards in 2017. Under this there are two Annexures -

- Annex A - List Of Substances Which Must Not Form Part Of The Composition Of Cosmetic Products
- Annex B - List Of Substances Which Cosmetic Products Must Not Contain Except Subject To Restrictions And Condition Laid Down

The BIS standards are not very clear on restrictions on usage of plastic microbeads in cosmetics.

Apart from the USA, Canada and China, New Zealand[83] and South Korea[84,85] are the only non-European countries, alongside the Taiwan province[87], that have already banned the use of microbeads in rinse-off cosmetics reported in Table 8. Iceland has signed a commitment to ban microbeads in PCCPs on 26 December, 2019[81].

Though none of the annexures mention microbeads or plastic beads, there are some polymers listed in them. Annex A, for example, contains:

- **628.** Aromatic hydrocarbons, C20-28, polycyclic, mixed coal-tar pitch-polyethylene polypropylene pyrolysis derived (CAS No. 101794-74-5), if they contain > 0.005 percent w/w benzo[a]pyrene
- **629.** Aromatic hydrocarbons, C20-28, polycyclic, mixed coal-tar pitch-polyethylene pyrolysis-derived (CAS No. 101794-75-6), if they contain > 0.005 percent w/w benzo[a]pyrene

81. B. Ólafsdóttir, Minister addresses the United Nations Conference on the Sea 5th of June
82. China''s National Development and Reform Commission, 2019. Guidance Catalogue for Industrial Structure Adjustment, 2019 edition. Ministry of Industry and Information Technology of the People's Republic of China, Beijing, China.
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84. Republic of South Korea, 2017. Proposed amendments to the "Regulation on Quasi-drug Approval, Notification and Review" (7 pages, in Korean).
85. United Nations Environmental Programme (UNEP), 2018. Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations.

- **630.** Aromatic hydrocarbons, C20-28, polycyclic, mixed coal-tar pitch-polystyrene pyrolysis-derived (CAS No. 101794-76-7), if they contain > 0.005 percent w/w benzo[a]pyrene

Annex B contains

Serial No.	Substance	Restrictions			Condition of use and warnings to be printed on the label
		Field of application and/or use	Maximum authorised concentration of the finished cosmetic product	Other limitations and requirements	
67	**Polyacrylamides**	• Body care leave on products • Other cosmetic products		• Maximum residual acrylamide content 0.1 mg/kg • Maximum residual acrylamide content 0.5 mg/kg	

Under the Cosmetics Rules 2020, Government of India incorporated Annex A of BIS standard 4707 (Part 2), making it mandatory, but the polymers mentioned in this part of the standard are not outright banned but not allowed to be used only if they are derived through a particular process. This certainly leaves a lot of gap. Annex B, which includes polyacrylamides with concentration limits, are not included in Cosmetics Rules.

The current standard as covered in the regulation lacks clarity amd makes it ambiguous about complete ban of use of microbeads in cosmetics in India.

CONCLUSION AND RECOMMENDATIONS

Microplastics particles in the marine environment and its impact on the entire habitat, especially on the marine species, has been a growing concern the world over. Though reduction of plastic waste, which is the main source for secondary microplastics, is now being discussed extensively, there is also need for focusing on primary microplastics. Its usage is mostly unnecessary and can easily be eliminated.

Emerging knowledge on plastic applications in PCCPs and the micro- and nano-sized plastic particle toxicity to both humans and other life forms is now coming forward. Though, in this current report we have looked at rinse-off face or body washes and scrubs, plastic ingredients encompass far more than just the exfoliating plastic beads of scrubs and shower gels. The global PCCP market is huge and the plastic applications in it is also sizeable.

In our current study, out of the 35 samples tested, 20 (10 face washes, 5 scrubs and 5 body washes) were detected with presence of polymers. Fourteen different type of polymers namely, acrilonitrile film, polyethylene, poly acrylic, acrilonitrile/butadiene/styrene, polyvinyl alcohol, polyimide, poly butyl methacrylate, PAM, lanoline, ethylene/propylene copolymer, polypropylene, LDPE, ethylene/vinyl acetate coploymer, and EVOH were detected in these 20 samples. Among the 20 samples with polymers, 14 have microplastics (MP) beads.

Even though the remaining six did not have microbeads, from the perspective of plastic pollution, the presence of polymer puts these in a similar category as the other 14. In term of numbers, among all types of PCCPs tested, the maximum number of microbeads per 20g identified was 17,250 and the lowest being 238 per 20g. In all the PCCP samples, microbeads were found in the size range of 32.55 -130.92 μm.

It was interesting to note that we found microplastics in most major brands, some of them multinational. Products of a major international brand such as Nivea were detected to have PAM microbeads in Nivea skin refining scrub and PE and Poly acrylic acid microbeads in Nivea Men shower gel. Even the company's face wash contained polymer, though not in form of microbeads. Nivea global claims to have removed microplastics from their products[86]. Another major international giant Unilever's Dove brand product was also detected with microbeads. Dove Gentle exfoliating Nourishing body wash contained ethylene/ vinyl acetate copolymer in the form of beads. Other brands of Unilever, namely Pears and Lakme face washes, also contained microbeads. Unilever claims to have stopped using plastic scrub beads in 2014 in response to concerns about the build-up of microplastics in oceans and lake[87]. According to Colgate-Palmolive, as of year-end 2014, they stopped using microbeads[88]. But our testing found PAM microbeads in Palmolive Aroma Moments shower gel. Adidas also have put out a statement on their global website that microbeads have been removed from all our shower gels[89], but the Adidas Smooth shower gel for women we tested contained ethylene/ vinyl acetate copolymer microbeads. Face wash from Clean & Clear as well as Neutrogena from Johnson & Johnson were also found to have microbeads[90]. The study findings are also important as many of these brands have presence in countries where use of plastic microbeads has been banned, which would mean that these brands or companies are making products without plastic microbeads in other countries but in India, they continue to use these polluing beads.

In term of numbers, among all types of PCCPs tested

The maximum number of microbeads per 20g identified was 17,250 and the lowest being 238 per 20g

Scrubs of Indian brands such VLCC and Nykaa also contained plastic microbeads. Though we did not look at the market share of these particular brands, most of these are popular brands and do hold a large market share.

Despite the lack of direct evidence, it can be concluded with some confidence that the great majority of microbeads present in these tested personal care products will be released to the environment. Microbeads or microplastics are often not captured even when wastewater treatment facilities are available as the sizes vary and the WWTPs are not designed to capture really small particles. Current sewage treatment facilities are not designed to remove micro- and nano-sized particles.

Even though the sizes and number of particles of polymers (apart from plastic microbeads) detected in the PCCPs have not been measured, it is unlikely that these will be too large in size and hence these may also go past the WWTPs. The study was also not designed to test nano particles and it is possible that some of the PCCPs contained those. It is even more unlikely that nano particles will be captured during treatment.

Once these microbeads and other polymers from the PCCP micro- and nano-plastics enter the marine environment, they merge with secondary MPs and add to marine pollution. Their small size also makes them accessible to a wide range of marine organisms, and may facilitate the transfer of pollutants. Though research is relatively new, till now there has been no permanent effective removal method to eliminate these particles once emitted into the environment.

Though in global context there have been several studies to assess the presence of plastic microbeads in PCCPs, our current findings fills the knowledge gap in the field of plastic microbead contamination in marine environment in the Indian context.

86. https://www.beiersdorf.com/beiersdorf-live/career-blog/blog-overview/2016/01/2016-01-07-bye-bye-microbeads
87. https://www.unilever.com/brands/Our-products-and-ingredients/Your-ingredient-questions-answered/Plastic-scrub-beads.html
88. https://www.colgatepalmolive.com/en-us/sustainability/our-sustainability-policies/ingredient-safety, accessed on 27th October, 2021
89. https://www.adidas.com/us/blog/361051-the-oceans-death-by-plastic
90. https://sustainablebrands.com/read/behavior-change/johnson-johnson-p-g-tohalt-use-of-microbeads-in-beauty-products

Given the large amounts of plastic particles recorded here, as well as current concerns about microplastics accumulating in the ocean, it is critical to to bring this information into public domain and also see if there could be triggers or drivers to push manufacturers to remove microplastics from their products. There are alternatives to using plastics as exfoliating particles, therefore, microplastics emissions can be avoided, which will help reduce primary microplastics pollution.

This study looked at 35 PCCPs samples but it is important to look at the wide range of such products available in the market, especially local products. Also, it is important to look at other range of products like make-up cosmetics that have been tested globally and tested with microbeads. Further research is also needed to understand better the implications of usage and release of nano- and micro-sized plastics from PCCPs on humans and marine ecosystem, especially with ingestion and chemical transfer through the food chain. There is a need for further probe into the health impact resulting from plastic exposure and associated additives in PCCPs, such as phthalates, in human beings as well.

Given the potential risks of microplastics, a precautionary approach can be recommended with a phase-out and eventual ban on the usage of plastic microbeads in PCCPs. The current findings can be used to inform scientific communities, regulatory organisations and the general public, and also push companies to phase out the usage of microplastics in India. The detection clearly suggests that the companies or brands have made little effort to voluntarily phase out plastic microbeads from their products. Hence, there is probably a need to push for regulatory measures focusing on cleaner production and including environmental considerations at the product design stage. It was also important to note that there are products in each category (face wash, scrub and body wash) which do not contain plastics. Alternatives are available and are being used by many companies.

KEY RECOMMENDATIONS

Plastic pollution has been on global agenda and the concerns emanating from marine pollution is now becoming clearer. Though efforts are being made to clean up or recycle plastic so that there is minimum litter and hence lesser contamination, there is not much change being pushed in the space of replacing or redesigning. It is clear that microbeads in PCCPs are not essential component and can be either eliminated or replaced by cleaner subsitutes. Some of the measures which can help are-

- Further studies are required to better understand the occurernce of microbeads in PCCPs in India;
- In-depth studies have to be taken up to understand microplastics pollution and its impacts on ecosystem and human beings;
- Regulatory agencies need to progressively phase out rinse-off PCCPs containing microbeads in India, reducing their emission and potential impact at source;
- Creating policy intervention to discourage use of plastics and promote natural materials usage in PCCPs;
- The standards as promulgated by the standard making Bodies must be clear and unambiguous. It should not allow for any gaps in interpretation. Representation of scientific experts on the subject in the committee may be beneficial.
- There is also need to look at the current waste water treatment plants and how to improve its efficiency in capturing microplastics.
- Strengthening labelling systems so that consumers make informed choices.
- There is a need to enhance public understanding of microbead-related subjects and the impact of microplastics pollution; the rise of public awareness on environmental microplastics can stimulate innovation to reduce the use and consumption of plastics, minimise their input into the environment.
- Facilitate consumers in choosing microbead-free products, shaping greener lifestyles; creation of mobile applications and websites to inform and provide choices.

It is important that these measures are initiated at the earliest so that Indian PCCPs become plastic free.

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