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Microplastics: Sources and Solutions

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Abstract:

Microplastics does not belong to a specific type of plastic that pollute environment but any kind of plastic whose fragment's length is less than 5 mm according to the National Oceanic and Atmospheric Administration. Microplastics (MPs) have a diameter of less than 5 mm, whereas Nanoplastics (NPs) have a diameter varying from 1 to 100 to 1000 nm. They invisibly mix with the ecosystem from a variety of sources like cosmetics, soaps, clothing and various industrial process. In this paper, the various sources and the solutions for tackling the emission of microplastics arepresented.

I INTRODUCTION

The emergence of industrialization saw many new inventions amongst which plastics play a minimal yet detrimental one. Although derived synthetically from petrochemicals, some variants are manufactured from renewable materials. Due to cheap production costs and the ease of available raw resources, it has easily replaced traditional materials such as leather, metal, glass, ceramic and wood. The consumption of plastics cannot be restricted to one particular sector; From single use, house-hold plastics to those used in industries, they are nearly omnipresent. What is more concerning is the level of microplastics circulating in the ecosystem. Microplastics are by definition small sized plastic particles (5.00 mm in diameter or less) that could have either released from microfibers from textile and cosmetic industries or from the degradation of larger plastic wastages found in the environment[1]. The latter is found to be a major pollutant in marine and aquatic ecosystems. However, what makes them a case of concern is the collateral damage they bring about in the environment. Since most of them take a long time to degrade and might take even a century or more, they form one of the hazardous pollutants on earth. Additionally, as chemical toxins, they pose a threat to both for marine fauna and human life by entering the food chain. More research is needed in studying the cause, distribution and the effect of micro and nanoplastics since our knowledge is very fragmented.

However plastics are an important raw material which, however, poses a danger to world water system due to its prevalence and longevity of the environment. Microplastics refer to the plastic particles with diameter of more or less 5mm.

Microplastics are divided in to two types according to textile industries, as Primary microplastics and Secondary microplastics

Primary microplastics are particles that are manufactured for a purpose like cosmetics and other valuable products or as raw materials for the plastic industry. Many European countries have banned the addition of fibres in to plastics.

Secondary microplastics are released from other cosmetic products during the use of it. Those products contains plastic products, car tyres and other costlier cosmetic materials

According to Finnish Environment Institute, there is no elaborated information about emissions of microplastics at various operations and manufacturing sectors.

II SOURCES OF MICROPLASTICS

Emission of microplastics can be attributed to few different sources and the major ones are,

(a) Sewage treatment plants

In most of the developed and few developing countries, wastewater management system poses a huge source of microplastic contamination. The treated sewage effluents contain a significant amount of these pollutants meaning such sewage treatment plants are not successful in filtering out microplastics. In 2018, Paul Kay and group [3]figured that the concentration of microplastics aregreater in the downstream of several of these treatment plants in northern England.

(b) Car and truck tyres

Since the advent of transportation vehicles, wear and tear from the automobiles on the road present one of the major causes of microplastics. The composition of tyres are usually made from the combination of natural and synthetic rubbers along with sulphur through the process of vulcanization. The friction created when the tyre hits the road results in emission of microplastics although the quantity depends on the road, climate and the quality of the tyre. In the Netherlands, the roads paved using asphalt concrete tend to capture the microplastics released from the

tyres, thereby highly reducing the emission. A study published in [2] have estimated wear and tear of tyre and cause microplastic emission for different countries in the measurement of per capita per year. Scandinavian and Asian countries have an average of 0.23 to 1.9 kg/year but 4.7 kg/year alone for the USA.

(c) Cosmetic industry

Since the 1960s, microplastics have been used in cosmetic industry in the form of polyethylene and acrylates copolymer. The former is used in the production of microbeads, small and solid plastic beads that are used in exfoliation, smoothening and polishing of the skin. Current awareness programs in the cosmetic sector while focusing on banning the microbeads, leave out the usage of acrylates copolymers as they are used in combination with other monomers making it difficult to regulate[5].Cosmetic products which are used to clean the body of human beings, fragrance which change the view, body smell to protect and keep in good condition. This results in equality of products which are uncommon interms of composition. The groups mainly include skin products and cleaning of hair such as gels, fragrance shampoos, and soaps. Decorative products like lipstick and makeup products with certain protective functions. Fig.1 shows the microplastics on sand causing soil pollution.

Fig.1. Microplastics on sand

Cosmetic products and their ingredients are regulated on unique way throughout the EU since 1976. In the current situation are the EC cosmetics regulation 1223/2009 considering the consumer safety and Reach regulation 1907/2006 considering the environmental impact. The current debate considering the microplastic in marine area has caused some impact regarding existing regulatory instruments to environment satisfaction, where micro plastics cause direct harm or in negative contribution to the plastic accumulation in the environment. Here a summary of some issues with a emphasis on composition and safety of the product and their uses in cosmetic industry are provided.Plastic ingredients used in cosmetic products are not common ingredients, by which their use is limited to a select number of new functional uses in niche products. They are used in body and face cleansing products if they have special peeling effect. Skin cleansing products are used to remove heavy duty soiling in an industrial environment. The plastic ingredients used in scrubbing functions are called microbeads. In past, few toothpastes are made of plastic microbeads. Microbeads are comprised of polyethylene, polyurethane, Ethylene-Vinyl Acetate co-polymer(EVA). The advantages of scrubbing and exfoliating functionality microbeads are soft peeling effect, good skin tolerance, chemically inert, odourless, non-sensitive and non-irritating. The technical advantages of plastic microbeads are:

- Good performance and fine adjustability of particle size and roughness.
- Surface is very smooth and there is no cutting angles and edges.
- Simple to handle.
- Physical and chemical properties are very favourable.
- Microbiologically not complicated.
- Doesnot block the drain.
- Cleaning effect of the product is improved.
- There is no negative influence on product stability.

(d) Textile

A study published in Environmental Science and Technology[3] states that a considerable amount of these micro polymers come from clothing fibers such as polyethylene, nylon, spandex and acrylics released from washing machines. Textile is one of the top five major industries that let out microplastics into the ocean. The study has also found out that shredding of clothes while washing and drying is the main cause of fiber release. Currently there are varied estimates of such microfibres released from similar garments ranging from 120 to 728,000. With the increase of synthetic and polymer-based cloth manufacturing, this estimate is expected to rise sharply.

Up to 7,00,000microfibres will come and mix into the oceans when a textile product used for clothing is washed, where they are consumed by sea life and become involved in the food cycle, resulting in a food that is eaten by human beings[7].

It is also energy intensive that generates 1.2 billion tons of CO2 equivalent to (CO_2 e) in 2015. The latest study that affects the carbon cycle to wash their clothes at minimum temperature using bags to capture the sea animals.

Need to build existing industry initiatives on the way clothing is produced, right down to the fibres that are used. Fabrics should be designed not to shed microfibers when they are washed, and industry needs to look at how efficiencies can be made in cutting that sees 60 billion m^2 of cut material disposed of in floors every year.

The industry is one of many with emissions of air, water and a large amount of water produced for landfill and incineration. This is because, in order to start creating a fashion industry, it is necessary to showcase all those areas by producing solutions that range from higher efficiency in machinery and water use to new materials with reduced shedding.

It has been assumed that there are 20 new clothing made per capita each year and that consumers are 60 per cent more than in 2000.

Priority Areas of Action:

The government in collaboration with fashion industries, should invest in starters which provide

some funds for development of more environment friendly fibres.

They also have to work with fashion industry and producers to initiate a simple framework to stop 'greenwashing', or false claims.

They must also support the production of mechanical and chemical fibre recycling technologies, those which are able to separate the blended fibres.

(e) Fishing industry

Apart from the aforementioned sources, a significant amount of microplastics are produced from fishing industries that uses fishing gear, nylon net and plastic monofilaments. Marine debris that are left out in the open ocean pose a serious threat to aquaculture and marine organisms, apart from the land fillings that eventually end up in oceans[6].

Additionally, manufacturing sites that manufacture plastics can also release micro and nanoplastics into the atmosphere which when inhaled can cause health problems. Fig.2 shows the data of marine microplastic debris in a pictorial form.

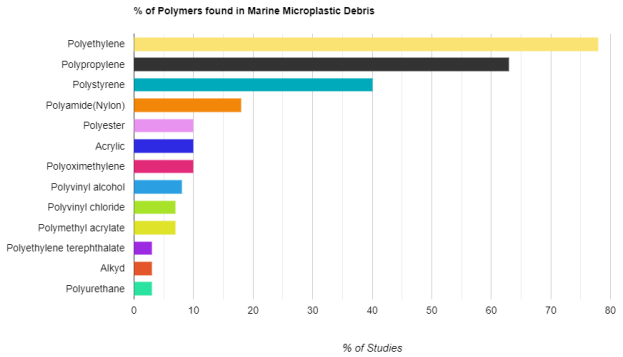

Fig2. Data of marine Microplastic Debris

Credit: Amanda Montañez; Source: "Sources, Fate and Effects of Microplastics in the Marine Environment: A Global Assessment," edited by Peter J. Kershaw,(IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), GESAMP Reports and Studies, No. 90; 2015

In humans the risk of ingestion of microplastics is reduced by gastrointestinal tract removal in most species of seafood consumed.

However, most species of bivalves and several species of small fish are consumed whole microplastics.

A worst case assumption of exposure to microplastics after consumption of mussels(225g) leads to 7 micro grams ingestion of plastics.

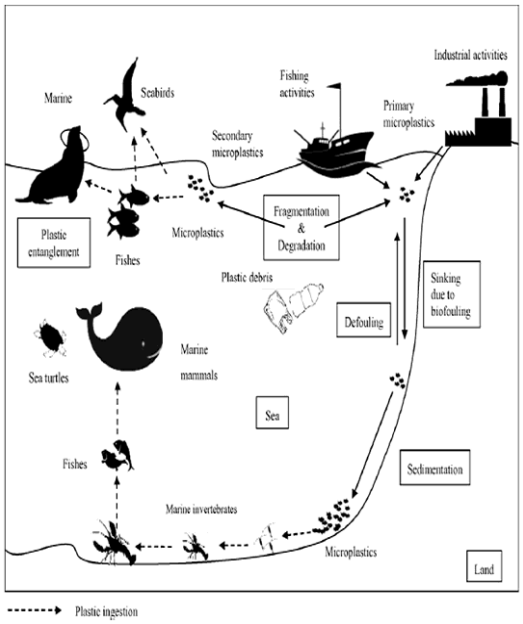

Fig 3. Microplastics cycle affecting marine

Microplastics contamination of aquatic animals will continue to increase in future and at present there are significant knowledge gaps on the occurance in aquatic environments and organisms of smaller sized microplastics(less than 150 micrometer)

Currently there are no methods available for the observation of nanoplastics in marine environments and organisms.

III MICROPLASTICS AS GLOBAL THREAT

In the past five decades, we have let plastics and by products to permeate the entire planet's ecosystem thereby risking every organism and its well-being. From lands to oceans, they are transported as far as uninhabited places where they wash up in the shores. Researches clearly suggests that these millimeter sized particles are ingested by a wide range of marine beings starting from planktons to huge fishes, thus ending up in the human food chain. And ingestion of which does not pass without harming effects; it can result in organ damage and even emit harmful chemicals such as hormone disrupting bisphenol to pesticides,that can compromise immune function and lastly, reproduction [6]. The microplastics ending up in landfills and agricultural lands can disrupt the fertility of the soil where the food is grown hence altering the microbial community.

IV ALTERNATIVE FOR MICROPLASTICS

Producers of cosmetic products have announced on a basis of volunteering and they are not dependent on each other that they will not continue in future the regular usage of micro beads to clean the products using water and replace them by other choice of alternative substances. This was also used to find from talks to GERMAN authorities by the Federal Ministry of environment(BMU & BMUB)

Cosmetics Europe,21.10.2015: in view of the public they are considering over plastics wastes in the marine area and given the additional availability of

materials. Cosmetics Europe approves the membership to discontinue washing cosmetics products placed in the market as of 2020.

Use of chemical products and the solid particles used to split them into layers and cleaning that are not decompose in the marine environment .many producers are working on a reinvention of the products have met this requirement possible choice materials are given below.

a) Possible alternatives

Sand and other mineral substances such as wood flour,walnut shells,waxes,cellulose.

b) Benefits

Natural and Decomposable

c) Disadvantages

Possibly high wearing, settling down of products under tube caps(sand), Range is limited.

Current discussions with the environmental authorities shows that decomposability must also consider for other choice of substances.

d)Reformulation

Safety of marine environment(existence of skin tolerance,Compatibility of the environment, Stability, Price and efficiency are to be considered for reformulation.

V SOLUTION

All that is needed is sound research in detecting the level of microplastics, their source and distribution pathways in order to foresee the problems, create protocols to eliminate the pollutants at an early stage. For example, creating methods to intervene at the upstream of water bodies such as lakes, rivers and waste treatment plants in filtering out microplastics could stop them from merging at the ocean. Regarding the transportation sector, it is better to follow the Netherlands' system of open asphalt concrete and laying down the roads to capture the wear and tear. The law has to be made strict regarding the production and consumption of synthetic cloths, which can easily be replaced by natural fibers. Cosmetic industriesinfewcountries are already banning the usage of microbeads, and others should follow it.

Individuals and groups that are mostly involved in environmental process and clean-ups come from non-governmental organizations although government agencies allocate funds to scientific communities to work and report on plastic pollutions. However, recently the United Nations Environmental Programme (UNEP) has set up Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) that regularly gather to report on the state of scientific evidence regarding the issue and to pass the information back to the UNEP.

A recent study by Eriksen et al [8] has laid down four major ways to tackle the microplastics problem.

1) Identify and quantify terrestrial microplastic sources
2) Zero waste strategies
3) Pursue policy driven EPR
4) Develop novel business solutions

Hopefully, creating awareness in the society along with properly placed guidelines from the government can help in addressing the pollution issue.

VI CONCLUSION

Plastics are ubiquitous in our everyday lives. However, a substantial amount of plastic waste is released into the environment, either directly or by insufficient reuse or recycling. Plastic waste decomposition produces micro- or nano-sized plastic particles, which are referred to as micro- or nanoplastics. According to the analysis, micro or nanoplastics can be present in both aquatic and terrestrial habitats around the world, and they can be consumed and stored by animals in the food chain. Micro or nanoplastics have been shown to have detrimental health effects on marine and freshwater species. Microplastics have been discovered in human stool samples in recent research, meaning that humans are exposed to microplastics by diet and/or drinking water.The effect of micro or nanoplastics on human health, on the other hand, has received little attention. MNPs can release plastic additives and/or adsorb other environmental chemicals, many of which have been shown to have endocrine disrupting and other toxic effects. In conclusion, further research is required to develop a thorough understanding of micro or nanoplastics pollution risks, as well as a framework for subsequent pollution management and control.

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