Research Article

Systematic Study on Global Patterns of Pollution, Toxicity and Remediation of Microparticles

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Abstract

Microfibers and microplastics are the emerging pollutants that were being studied by several researchers over an extended period of time. Pollutants are detected in urban, rural and even at the remote parts of the world. Microfiber pollution is mostly explored in the marine environment, recent studies have brought light into the terrestrial as well as the eco toxicological effect of the food chain, and humans. Several identification and quantification methods were being given by the researchers, but the main problem is several researchers have several quantification methods and metric which makes it difficult for understanding the actual quantum of the problem. To mitigate the problem consumer awareness and change in the urban habits can be a step forward. The present review paper is a structured study on the microfiber pollution, toxicity effects and bioaccumulation/ Eco toxicological effects, identification methods and remedies to control the pollution from further spread.

Keywords: Microfibers, Microplastics, Marine pollution, Synthetic fibers

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Introduction

Microparticles consist of both microplastics and microfibers which are <5mm. Microplastics and microfibers have drawn more attention during the present years; but this problem has been reported since the 1990s (Shomura and Godfrey, 1990) with several researchers working on this problem to date. Microparticles have more surface area and buoyancy due to which they attract or react with the surrounding materials causing the increment of the toxicity, plastics are highly related to their specific gravity. Synthetic microfibers or plastics were mainly made up of non-biodegradable materials which include synthetic polymers like polyester (PE), Polyethylene terephthalate (PET), polypropylene (PP), polyamide, nylon, acrylic, spandex (De Falco et al., 2019; Hacker et al., 2019), major producing countries are China (50 Mt), India (8.4Mt), Europe (5Mt), USA (3.2Mt), Taiwan (2.8Mt), Indonesia (2.3Mt), South Korea (2Mt), Thailand (1.5Mt), and Japan (1.3Mt) [1].

Microparticles can be mainly divided into two types; primary source where microfibers were made industrially for specific end uses, secondary microfibers, or microplastics which are fibrillated or made into smaller pieces due to several factors and are mixing up with the surrounding environment. Secondary microparticles are the main cause of pollution and toxicity which was being researched. Several sources of these microparticles were given in the **Table 1**. Huge number of microfibers and microplastics are being released into terrestrial and aquatic/ marine environments contaminating the habitats. One of the major problems being noticed is that as these fibers are so small and buoyant these can be easily carried away into several directions with wind currents, rainfalls, and oceanic currents. Investigation on oceanic surface water for microplastics [2] found out that before and during the rainy season sediment accumulation was found to be higher. On conducting a similar study, [3] results stated that the beaches of Fernando de Noronha Island which have no fishing activity or plastic industry has showed a whooping level of contamination with plastic debris which was brought about by wind currents or by water currents.

In the present review paper, microfiber contamination is addressed with emphasis on pollution caused, toxicity effects, and identification and remediation effects.

Marine microfiber pollution

Fishing is considered to be one of the most contaminating activities in relation to plastic microfibers and debris. Plastic fishing gears and nets were found to be the main reason as fishing nets were reported to be sunken in the ocean or lost or damaged which were then left behind in the fishing area. In 1975, the amount of plastic net deposition was 135,400 tons, whereas in 2010 it reached a figure of 640,000 tons [4]. Fishing nets were mostly made up of mono-

filament nylon and these sunken fish nets results in ghost fishing or trapping of small fishes and sea horses and other organisms choking them to death or depriving them from free movement. In a study carried out, results showed that 504 fishes which were collected from the English Channel have 36.5% of synthetic polymers and 68.3% of fibers in their gastrointestinal tract [3].

Table 1 Sources of microparticles pollution

S. No	Sources	Microfibers Released in Million tons (Mt)	References
1	Domestic laundering	13	[8]
2	Abrasion of tires	4	[2]
3	Cosmetic industries	8	[1]
4	Waste water treatment plants	227	[8]
5	Fishing nets	0.64	[3]
6	Textile industries	0.00022-0.0011	[2]
7	Illegal land filling	0.00015	[9]

Another fascinating source of microfiber pollution is from domestic laundry, [8] conducted studies on shorelines of 18 sites covering six continents including poles and equator and results show that the domestic laundry water which is directly released into sewage is a major polluting activity because the discharged water consists of fragmented polyester which is similar to the samples found in the waste water treatment plants and marine sediments. Metrics show that 78% of polyester and 22% of acrylic fibers found on the shores were similar to the textiles of human consumption. It showed the positive relationship with the microplastics and microfiber abundance with the human population density.

Terrestrial microfiber pollution

Soil is one of the most fundamental aspects of the terrestrial ecosystem. Terrestrial microfibers contamination is the less explored area as the quantification methods can be very tedious and prone to contamination and less possibility for quantification. Investigation report presented at “the ocean conference” in the year 2007, stated that a city with one lakh inhabitants can surprisingly release about 9110 kgs of synthetic microfibers into the surrounding environment. Landfills and fast fashion have made its way into the urban lifestyle and the microfibers released through these landfills compose of 90% synthetics and are easily travelled over from the source to other secluded areas. These synthetic fibers can be present in the soil upto 100s of years. A study conducted even quantified the rate of fibers present in the indoor environments as 1586 to 11,130 fibers per m^2 with and abundance of 0.3 to 1.5 m^{-3} in the city of Paris. **Figure 1** gives and in detailed explanation on the size, shape, colour and the components of the microfibers present in the terrestrial environment.

Apart from the garments and fabrics, there are several other sources for microfiber pollution which are creating a noticeable emission which includes abraded car tiers, tooth brushes, plastic water bottles, drinking straws etc.

Location	Size (mm)	Shape			Components	References
		Fibers	Fragments	Foams/ Granules		
Dongguan, China	200- 700	80%	-	-	Cellulous (73%), PE (14%), PP (9%), PS (4%)	Cai et.al., 2017
Shanghai, China	23- 500	67%	30%	3%	PET, PE, PES, PAN, PAA, Rayon	Liu K et.al., 2019
Yantai, China	< 500	95%	-	-	-	Zhou et.al., 2017
Tehran metropolis, Iran	250- 500	30%	-	65%	-	Dehghani et.al., 2017
Asaluyeh Country, Iran	2- 100	-	-	-	-	Abbasi et.al., 2019
Paris, France	200- 1400	-	-	-	-	Dris et.al., 2016
Hamburg, Germany	<63	-	-	-	PE (48%), EVAC, PTPFE, PAV	Klein and Discher, 2019
	300- 5000	10%	90%	-		
Pyrenees mountains	<300	-	-	-	PS, PE	Allen et.al., 2019
	<50	-	68%	-		
	50- 150	-	-	-		
Supraglacial debris of Alpine glacier	-	-	-	-	Polyester, PA, PE, PP	Ambosini et.al., 2019

Figure 1 Abundance of microfibers in the terrestrial environment [10]

Toxicity/ eco toxicological effect

The growth in the researches in the field of microfiber contamination have reached a level where researchers have identified the eco toxicological effects of these tiny particles on the terrestrial and aquatic organisms. Exposure rates

can be dated back since the last 50 years and have a potential to cause carcinogenic effect on the ingesting organism. Microfibers are been reported in the sea salt which is obtained from the contaminated sea regions, and table salt which is a refined version of the sea salt, drinking water, industrial drinks, sugar, which are a direct human consumption source [9, 10].

Aquatic animals which are being exposed to these tiny microparticles misinterpret these particles as food and consumes leaving them with several health disorders like decreased life span, reduced food consumption, reduction in the number of offspring's generated etc. risk is more seen in the juvenile aquatic animals where non-selective feeding habits can lead to increase in the amount of micro waste up-takement. Mussels fed by polyvinylchloride were further fed to the fish and crabs, analysis showed the transfer of the microparticles to predators, thus put forth the theory of Eco toxicological effect or transfer in the food web. When researched about the health risk of humans due to microplastics ingestion [3]. Global estimates prove that humans may directly or indirectly were ingesting about 0.1 – 5 grams of microplastics weekly through various pathways. Some of the most recognized paths include drinking water, sea salt, beer, honey, sugar and sea food in the form of direct ingestion; atmospheric dust which is contaminated with textile fibers, tyre dust were the contamination pathways for inhalation (estimates indicates human lungs might be exposed to 26– 130 microplastics daily), and several health problems which are related to the microparticles ingestion; which includes breast cancer, blood infection, respiratory disorders, kidney and liver disturbance, gastric desorption and genital defects.

Identification methods

Microfibers are typically very small with dimensions ranging from millimeters to micrometers. Microscopic analysis is the age old method of practice for the identification of the smaller objects using this technique SEM (scanning electron microscopy) was found to be useful for identifying the surface morphology of the trapped fibers. Several other microscopy includes fluorescent microscopy, stereo microscopy (which will be useful to capture images), optical microscopy, phase contrast microscopy, x-ray diffraction, bright field microscopy. FTIR (Fourier transform infrared), µFTIR where the fibers or microparticles are identified using a spectral range or peaks by exciting the molecules of the sample and raman spectroscopy is one of the simplest techniques used to figure out the composition of the polymer in a faster way were found to be the recent advancements in the analysis of the synthetic fibers. This microscopy can detect upto 1mm and even less.

Remediation for control

As far the researches concerning microfiber pollution from the domestic laundry several innovative solutions like lint filters are available in the market to trap the lint which is being generated. The trappers have varying capacities and built, but the real problem is whether the lint trapped is being disposed of in a solid waste or being washed out to remove the fibers which is a total failure for the intended purpose [4-7]. Enhancing the consumer knowledge regarding the harmful effects will provide a way to minimize the pollution extent.

Recent innovations include the drones which were developed to eat up the debris through traps and nets connected to an autonomous device. The ocean clean up array is another innovative technology which is taking advantage of the ocean gyres and oceanic currents to clean up the debris. Manta trawls which are attached to the boats and ships which will collect the debris while moving, in later days these were not found to be effective due to the increased cost and less coverage areas. Several beach cleaning campaigns were taken up by the non-governmental organizations and the individuals have restored beaches from the harmful plastics. But the main remediation problem is that if clean-up is undertaken will that sustain become unpolluted, no because the sources are continuing to pump their debris in this direction.

Consumer awareness and consumer behavior are the crucial aspects when related to the aspects of pollution. Promoting the usage of bio-degradable material instead of non-biodegradable materials or standard materials, reduce the usage of plastic and reusing and recycling of the materials which are possible. In addition to those industries should get back to recycling of the materials, keeping in priority.

Conclusion

To conclude, microparticles both microfibers and microplastics are pollutants which are been spread in the environment from the past decades, but due to the increase in the level and intensity of the pollution researchers have been exploring different ways to communicate and mitigate the problem. Fishing nets, garments laundry, textile industry, abrasion of tiers, increased usage of the plastic particles and other non-biodegradable materials without proper care are the leading causes for the enhancement of the problem. Due to the several reasons the microfibers

have even reached into the food chain and food web which resulted in several health-related problems as well as produce the eco toxicological effect. Researches around the world have provided an increased trend in the microparticles pollution, but the most important aspect is the consumer behavior and enhancing the consumer awareness to mitigate the problem within the beginning stage. Mitigating microparticles pollution is a collective effort, when consumers feel responsible for environment around us the consciousness behavior will make a huge difference in reducing the contamination.

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