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A STUDY ON MICROPLASTICS: THE INVINCIBLE ENVIRONMENTAL POLLUTANTS

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ABSTRACT

The study focuses on what microplastics are, how these substances entered the ecosystem and what its adverse effects are. Microplastics are the remnants of macroplastics and mesoplastics. These particles are let into the environment by disintegration of the synthetic polymeric compound, plastic. Microplastics are wide–ranging; these are found not only on soil but, on water, in air, in the human placenta, in many marine animals, these particles enter the food web also, thus, they have become a risk for food safety. According to studies, Microplastic pollution is increasing day by day, which is an alarming situation. Owing to its circumstances, it is of the essence to understand the impacts of microplastics not only in our surroundings but in the trophic levels also. The study reports the harm caused by microplastics to the human body and how can we cope with this emerging pollutant.

KEY WORDS : Microplastics, Aquatic environment, Cadmium and Mercury uptake, Placenta, Extruded Polystyrene.

INTRODUCTION

Microplastics (MPs / MP) are predominant in the nature and the food chain of man (Frias and Nash, 2019). These are parts and parcel of the typical man-made polymer layout in the microscale, the typical range being 1µm-5mm, though an accord on size is yet to determine. These have been recognised in the marine as well as the freshwater bodies yet, strenuous research has been more predominant on marine water bodies. They have invaded our food web, growing as an evident menace to food security. Potable water is regarded to be a medium aiding in transfer of MPs to our bodies (Danopoulos *et al.*, 2020).

Plastic debris is ubiquitous on Earth (Rochman, 2018), under human influence, these have been found in the terrestrial ecosystems such as agro-systems. From the agricultural farmland soil sampled from Southeast Germany, it was quantified after an FTIR (Fourier-transform Infrared) analysis that, the plastic (macro and micro) contamination was 206 macroplastic pieces/hectare and 0.34 ± 0.36 microplastic/kg dry weight of soil, also, the polymer detected often was Polyethylene with Polystyrene and Polypropylene summing up the next (Piehl *et al.*, 2018). According to Geyer and colleagues' estimation, 8.3 billion metric ton of pure plastics were generated till 2017 and if this progresses, by 2050 12 billion ton of plastic waste will pile up on Earth. Various researchers have examined and affirmed that MPs not only served as vectors for uptake and toxicity of organic pollutants, it also adsorbed these compounds onto its surface.

It is figured from this study that MPs act as carriers of heavy metals; cadmium, mercury and so on (Yong *et al.*, 2020). Furthermore, it was appraised that the yield of plastic textile fibres shot up to > 6% / year, hitting 60 million metric ton. When these fibres break down, it leads to fabrication of fibrous plastic particles and have been identified in atmospheric fallouts as well as in closed (indoor) and open (outdoor) environment. Global production of plastics increases by 3% every year. The study found that merchandised use of prime – diameter (1 – 5 µm) plastic fibres led to environmental pollution. It was found that > 90 million metric ton of these fibres were brought forth globally (Gasperi *et al.*

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2018). MPs broke into the freshwater medium by runoff from surfaces and wastewater effluents (W.H.O Report, 2019). Other ways by which MPs paves its way into a water body includes mechanical or photo – oxidative disintegration of larger plastic debris (Masura *et al.*, 2015). There are many ways by which MPs enter into the environment, to name a few; Wastewater treatment plants, fishing, shipping, cosmetic industries.

There are 2 forms of MPs – Primary MPs, they are man-made, meant for industrial usage and are intended to be micro sized. For example, MP scrubbers used for exfoliation. Secondary Microplastics, are related to smaller pieces of larger plastic debris as a result of its breakdown, degradation is caused by subjecting it to sunlight, UV light and so on (Cole *et al.,* 2011).

The objective of this study is to calculate the fate of MPs in future as well as interpret the harm they cause to human placenta and to spread awareness regarding ill-effects of plastics [MPs].

MATERIALS AND METHODS

The following methodologies were adopted by the authors, most commonly, for analysis of the samples, FTIR Spectroscopy, Raman Spectroscopy were used and for collection of samples, trawl nets were used. (Kedzierski *et al.,* 2020; Ragusa *et al.,* 2020; Peterson 2020; Karami *et al.,* 2017; Iñiguez *et al.,* 2017; Danopoulos *et al.,* 2020; W.H.O Report, 2019).

RESULTS AND DISCUSSION

As per (The Market Analysis Report, 2020), the micro plastic pollution is anticipated to advance annually by a growth rate of ~ 3.2% from 2020 to 2027 (Suaria *et al.*, 2016) stated that, when micro plastics bound itself to any toxic agent(s) from its neighbouring aquatic environment, it not only became the habitat to varied microbial communities but, it also served itself as a vector of different toxic additives.

Microplastics in the freshwater environment

The key factors affecting the shifting and scattering of MPs are dependent on their traits such as densities, shapes, sizes. The density of common consumer plastics are from 0.85 – 1.41 g/cm^3 (Eerkes-Medrano, Thompson and Aldridge, 2015). Now, the density of MPs is responsible for the formation of biofilms in the water column. The study suggests that limited approach is available to trace the sources and movement of MPs in this area (SAPEA, 2019). Besides runoff from croplands, wastewater effluents too contribute to carrying MPs to freshwaters (Horton *et al.,* 2017; FWR, 2017; WE and RF, 2017). According to a study, 65 million MPs were let into the discharge from Sewage Treatment Plants (Murphy *et al.,* 2016). Further studies could reveal the fact that the tally of MPs in freshwaters ranged between 0 – 10^3 particles/L also, many forms of MPs were identified – filament, fragments, foam, spheres (W.H.O Report, Koelman *et al.,* 2019).

Microplastics in the drinking water bodies

In tap water analysis, six samples were studies and explored (Mintenig, 2018; Pivokonsky, 2018; Shruti, 2020; Strand, 2018; Tong, 2020; Zhang, 2020). The tap water to be scrutinised was available to the consumers by means of a public service. It was estimated that 24% - 100% samples contained MPs and the MP content in these samples ranged 0 – 1247 MPs/L, fragments dominated the presence of fibres (Danopoulos *et al.*, 2020).

In bottle water analysis, which included six samples, (Kankanige, 2020; Strand 2018) the percentage of samples loaded with MPs extended from 92% to 100%, the shapes pointed out quite often were fragments and films. As per an organised study, in raw water, the richest polymer type was PVC (Poly Vinyl Chloride) – 46% of MPs, PEST (Polyester) – 34% of MPs following the next. It was realised that in raw waters, particle sizes varied from 11µm - 530µm, (11 = lower size limit). In addition to this, smaller the particle size, more was its number – 1% - > 500µm, 21% - 100-500µm, 16% - 50-100µm, 63% - 11-50µm. Amongst shapes of MPs, fibres ranged 0-11% of MPs. In filled and capped water bottles, smaller the size of particles appeared to be, their size variations appeared quite often – 11µm - 50µm = 60-93%, 50µm - 100µm = 6-23%, 100µm - 500µm = 1-25%, >500µm = no detection. (Weisser *et al.,* 2021).

Apropos of the study conducted by (Mintenig *et al.,* 2019), plastics can be an element in the manufacturing of some treatment-plant module and distribution networks. Abrasion of these constituents may lead to MP contamination in potable water. Further, Oßmann and Schymanski *et al.,* 2018 (W.H.O Report, 2019) reported that when the form given to the bottles and its caps itself is made of plastic, it is clear-cut that these itself become the "birthplace" of MPs in drinking water. A study was conducted using Nile Red (NR) for the discernment of MPs in 11 world-wide sourced brands of bottle water. For analysis, in all, 259 individual bottles from 11 brands, were sorted into 27 lots and assessed for MPs, which were subdivided into two size batches – NR and FTIR, asserted MP particles which are more than 100µm and NR labelled, affirmed MP particles which are 6.5µm - 100µm. The results were measured in MPP/L. It was reported that for NR and FTIR, the average density was 4.15 MPP/L with a variation from 0-14 MPP/L, in case of NR marked particles, average density was 23.5 MPP/L and spanned over 7-47 MPP/L. Futhermore, when an average was calculated across the brands, the highest average density recorded was 930 MPP/L and 807 MPP/L of the brands Nestle Pure Life and Gerolsteiner and the lowest average density recorded was 30.0 MPP/L and 63.1 MPP/L of the brands San Pellegrino and Minalba. Simultaneously, this study also reported that Polypropylene was noticed more frequently {54%} than Nylon {16%}. Besides this, few shapes {of MPs} were also observed quite often – Fragments {66%}, Fibres {13%}, Films {12%} (Mason *et al.*, 2018).

(Ali and Golden, 2019) concluded that on an average, 378 MPP/L was found in tap water collected from private residences' kitchen sinks and 84 MPP/L was found when collected from public spaces. The size varied from more than 2.5µm-3mm.

Microplastics traced in the water bodies in India

According to the studies of (Veerasingam *et al.*, 2020), plentiful MPs were present along India's Eastern Coast when compared with the Western Coast. It was also reported that the Andaman and Nicobar Islands had more microplastic content i.e, 973.3 ± 76.59 items/kg than Chennai i.e., 439 172 items/kg and the Ganga river i.e., 409.86 items/kg along India's Eastern Coast. However, from the Western Coast, the presence of microplastics were higher in samples collected from Mumbai i.e, 220 50 items/kg.

Microplastics in marine water bodies and salt

According to the study guided by (Cole *et al.*, 2011), intense weather; for e.g. hurricanes, worsened the relocation of these debris from the land to the sea. Mediterranean sea is the 6th area in the world amassing thalassic clutter (Cozar *et al.*, 2015) as it is geographically delimited by 3 continents with overgrown population (WWF, 2018). Numerous factors which promotes efflux of micro plastics in the Mediterranean Sea are – Shipping, Fishing, Industrial and Touristic so on. Also, per capita solid waste generated from the Mediterranean basin is ~ 208-760 kg/year, described, (Alessi and Carlo, 2018). Not only this, plastic contamination was predominated by many millimetre-sized plastic fragments (Suaria *et al.*, 2016; van der Hal *et al.*, 2017; Schirinzi *et al.*, 2019).

(Chubarenko *et al.*, 2018) mentioned that those plastics sank which had higher density (1.02 g/cm^{3}m) than sea water, rest all (low-density polymers) floated. Corresponding to the findings of (Bayo *et al.*, 2018), the supreme form detected in the Mediterranean Sea was Polyethylene, it prevailed in 2 forms, HDPE (high-density polyethylene) and LDPE (low-density polyethylene) along with Polycaprolactone flooding in the off-shore water in this region (UNEP, 2015) and its marine heap showed 66% of MPs consisting of Polyethylene, Polystyrene, Polypropylene [low densities] (de Haan *et al.*, 2019). Plastic debris was found at a depth of 900-3000m (Ramirez-Llodra *et al.*, 2013).

Many species of fishes [*Spondyliosoma cantharus and Phycis phycis*], mussels, oysters, *Chelonia mydas* and even *Arenicola marina,* were tested positive for the presence of MPs (Lusher and Avio *et al.*, 2017, Wright *et al.*, 2013 and Sonmez, 2018). It is shown that plastic litter proved to stress the coral reefs in this region by causing discolouration, transience and breathlessness of the corals (Galgani *et al.*, 2018).

It is astounding that the hadal sediments of the Marian Trench contains MPs ranging from 200-2200 pieces/L. From the examination, 11 types of polymers were sorted out from the samples of the Mariana Trench. In the hadal bottom waters, PET (Polyethylene Terephthalate) was in abundance (19%) (Dasgupta *et al.*, 2018).

It is deciphered from the study that the inter-tidal zone of Sub-Antarctic Island of South Georgia showed the presence of MPs; Barnes *et al.*, 2009; Van Cauwenberghe *et al.*, 2013; Isobe *et al.* 2016 (Waller *et al.*, 2017). From the Western Antarctic Peninsula, 22 particles l^{-1} MPs were found (Waller *et al.*, 2017).

PET accommodated 83.3% of the analysed fibres after analysed using FTIR Spectroscopy. Plentiful PET in salt may be due to its high density (1.30 g/m^3) which causes it to settle with the salt during crystallisation (Maria, Juan, Andres; 2017). In another study, it was found that, the recurrent polymers were; Polypropylene 40%, Polyethylene 33.3%. The occurrence of these polymers may be because of their low densities; Polypropylene (0.90-

0.91 g/cm^3), Polyethylene (0.91-0.96 g/cm^3), which enables them to float on the surface of water (Karami *et al.,* 2017).

Microplastics found in soft drinks and meat

Research carried on 9 popular soft drinks' brands in Grand Forks, found that, all the brands passed the test for MP contamination, with the concentration varying from 77 MPP/L to 256 MPP/L, average being 159 MPP/L. The variation in size was noted as from 3µm-1.2mm. It was deduced that smaller-sized particles (>3µm-100µm) were copious (avg. 113 MPP/L). The investigation had reported the shapes of MPs found - fragments; 58.7%, fibres; 32.2%, filaments; 6.2%, films; 1.9% (Ali and Golden, 2019).

When extruded polystyrene (XPS) are used to manufacture wrappers for covering and wrapping food (meat), there are chances of it being trapped between the meats. The amount of fibres distinguished on the superficial side of the packaged food was 134 fibres/Kg and 221 fibres/Kg. However, from inside the packaging 18 fibres/Kg and 164 fibres/Kg were found (Kedzierski *et al.,* 2020).

Microplastics found in placenta and agricultural soil

It was reported for the first time that MPs were present in human placental samples. After an investigation, it was found that in all, 12 MP fragments; denoted as #1 -#12 were recognised of 4 women; 5 MPs in the foetus area, 4 from the mother's section, 3 from chorioamnio membrane. The MP particles #2, #10, #11 contained polypropylene. #1, #3 - #9 and #12 were the MPs which were smeared on paints, adhesives, cosmetics and few personal care products (Ragusa *et al.,* 2020).

The extent to which MPs has affected the agroecosystems, is yet to be surveyed. A study was conducted in a cropland in Middle Franconia, Southeast Germany; an expanse of 0.5 hectare was chosen as the study area. The MP particle found was arranged as- Polyethylene (67.90%; 55 particles) > Polystyrene (13.5%; 11 particles) > Polypropylene (9.88%; 8 particles) along with PVC; 4.94%, PET; 2.47%, Polymethyl methacrylate 1.24%, majority was white in colour (62.50%) (Piehl *et al.,* 2018). Dr. Mary Beth Kirkham, Kansas State University, concluded from her experiment on wheat plants, exposed to Cd and contaminated with micro plastics that, the plastics acted as vector for absorption of Cd. She added that particulate plastic clogged the soil pores thereby, arresting aeration of the soil, leading to the death of the roots.

An investigation, carried out by Esperanza Huerta Lwanga, inferred that when earthworms devoured MPs, they died as these particles excoriated their digestive tracts which caused difficulty in absorbing nutrients (Peterson, 2020).

CONCLUSION

It is concluded from this study that, plastics, are extremely flexible, thus, can be moulded to any form, hence, it has been easy for this synthetic material to minimise the use of the conventional materials used in the packaging like; paper, glass and metal. They are less expensive, more durable, corrosion resistant, bio-inert, versatile, has properties that acts like a barrier for oxygen or moisture (Brennecke, 2015). But, as the recycling of these products have been reduced and as there is an increase in the utilisation of single-use plastics, plastic pollution is magnifying (Sharma *et al.,* 2021). According to (Bucci, 2020, Wright, 2017 and Gerdes 2019), health effects triggered by MPs may be due to their – physical characteristics, chemistry of the polymers, the solvents used in the procedures of production as well as how these particles absorb chemicals in nature.

When MPs are orally ingested, it can lead to mild intestinal irritation and inflammation (WHO Report 2019). In few species, bioaccumulation of chemical additives with MP uptake was found (Miller *et al.* 2020). Pleural mesotheliomas are generally related with fibres above 8µm in length and < 0.25µm in diameter. Fibres can also settle in the alveoli, alveolar ducts, terminal bronchioles, the severity of tissue damage depends on inhaled dose over time. This may further lead to secondary genotoxicity due to the formation of ROS (Reactive Oxygen Species), increased production of ROS can cause oxidative stress thereby, leading to not only chronic inflammation and pathogenesis of lung diseases, but, oxidative stress along with age-dependent reduction in the activity of antioxidants together with mitochondrial dysfunction can cause testicular malfunction and sperm damage; cumbering male fertility. Submission to plasticiser BPA (Bisphenol A), affects spermatogenesis, modifies steroid biosynthesis and prompts germ cell and Sertoli cell apoptosis and so on (Gasperi *et al.,* 2018).

When microplastics gets accumulated in the tissues, it may activate local immune reactions.

Microplastics may also reach the placenta through the blood stream from the mother's respiratory system and the alimentary canal via M-cell mediated endocytosis. It is agreed that these particles may remodel many cell synchronising channels in the placenta; for e.g. immunity operations in the course of gestation, growth-factor signalling throughout and after implantation etc. these ill-effects can potentially lead to unfavourable gestational outcomes along with preeclampsia and foetal growth constraint (Ragusa *et al.,* 2021).

The MPs, break into and run through the human body via the food chain, principally through the aquatic medium; by ingurgitating its biota. Ones these particles enter our body, they interface with the bio-macromolecules and bring on reactions detrimental to our body. Therefore, it is suggested that we reduce if not completely stop usage of plastics. We need to switch over to the age-old conventional methods used in packaging, other eco-friendly materials used in producing products helpful in our daily lives to minimise and uproot the harmful effects caused by plastics. Furthermore, there needs to be more research performed in this area to know what plastics, especially MPs are doing to the environment.

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