ENVIRONMENTAL SCIENCE ARCHIVES
ISSN: 2583-5092
Volume II Issue 2, 2023

www.envsciarch.com

REVIEW PAPER OPEN ACCESS

Impact of Microplastic Pollution on Human Health

Pamil Tayal, Shantanu Mandal, Pawani Pandey, Nipun Kumar Verma

Department of Botany, Sri Venkateswara College, University of Delhi, New Delhi -110021
Correspondence for materials should be addressed to PT (email: pamiltayal@svc.ac.in)

Received: 2023/07/11
Accepted: 2023/08/30
Published: 2023/09/02

Abstract

Besides visible plastic pollution, there is also a microplastic threat. Microplastics are ultrasmall plastic items, smaller than 5 mm in size. The presence of microplastics in aquatic ecosystems is increasing at an exponential rate posing a direct or indirect threat to all biodiversity on the planet This paper highlights the Indian scenario of microplastic pollution in comparison with developed regions of the globe while primarily focusing on impacts on human health. Microplastic particles are not metabolised by living organisms and thus they keep bioaccumulating. These tiny plastics also sorb a wide plethora of chemical substances that may have severe effects on life forms. Pathogenic bacteria may also adhere to microplastics affecting health. Exposure to microplastics has become impossible to avoid as these tiny plastics can enter through food, cosmetics and even via air. Besides bioaccumulating microplastics have been proven to interfere with cellular processes and normal physiological functioning of the human body. Very few papers have been published to date highlighting this issue, more research needs to be done on sources, distribution patterns and effects of microplastics on the ecosystem and humans.

Keywords: Microplastic pollution; Marine plastics; Aquatic ecosystems; Bioaccumulation; Biomagnification; Human health

Introduction

Plastics are a set of materials (predominantly synthetic) that use polymers having long carbon skeletons such as polyethene, polypropylene, polystyrene etc. as their main constituent (Woodford, 2022). Plastic entities having a size of 1µm – 5mm are classified as MPs (NOAA, 2021). Based on origin, MPs are further divided into primary and secondary MPs. Plastic particles that are less than 5mm, when released into the environment are called primary MPs. 1.5 million tonnes of primary MPs are released annually into the world's oceans (Boucher and Friot, 2017). Secondary MPs are predominantly generated via photodegradation by UV radiation (in parallel with the action of oxidative degradation and physical weathering agents like heat, wind and hydraulic forces) acting on larger plastic pieces. (NEA, 2014; GESAMP, 2015, Andrady et al., 1996) (Figure 1).

Almost all of the plastic produced to date persists in our environment (UNEP). Surface MPs form great garbage patches in the oceans wherein MPs with heavier densities sink into world oceans (Evers, 2022). Among various sources of MPs, plastic fibres and tyre abrasions are classified as the biggest sources of their genesis; while mismanagement and improper dumping of plastic waste is the biggest cause of MP pollution. Industries account for 23% of MPs released in the oceans whereas, the rest 77% comes from individual household activities. (Boucher and Friot, 2017). In India, fibres from synthetic textile industries and household activities are primary causal agents for water bodies pollution; which are directly dumped in bigger water bodies without wastewater treatment. As a result, primary MPs completely dominate over secondary MPs. However, in other developed regions like Europe and US, the majority of households' water released is well connected to wastewater treatment plants (WWTPs) at the first stage which filters out a lot of MPs. (Boucher and Friot, 2017). Automobile tyres erode due to friction during use, releasing primary MPs on the road, places where roads with heavy traffic are very close to water bodies, these tire MPs easily enter water bodies through wind or rain.

There are 641 vehicles per capita in the European Union (ACEA, 2022). Samples from Lake Kallavesi, Finland mention tire abrasion as a major source of MPs in the lake (Uurasjärvi et al., 2020). The Thames River basin in the UK also shows high MP concentrations due to tire abrasions and erosion of road markings (Horton et al., 2017).

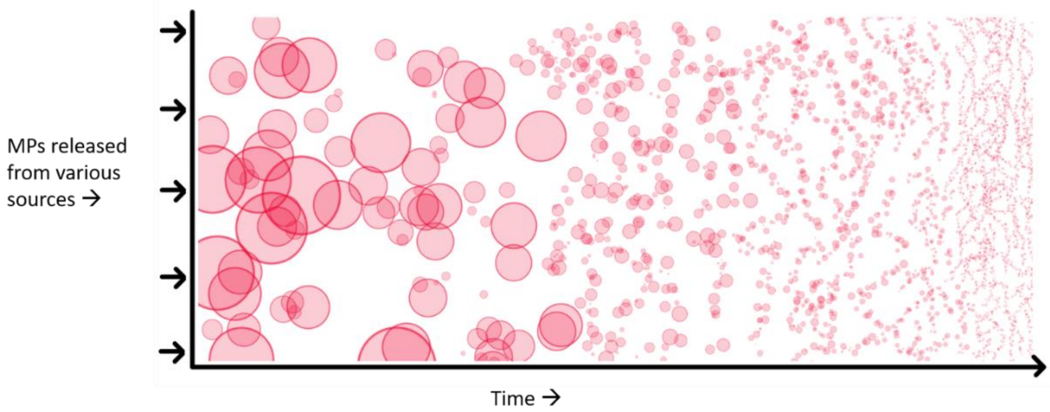

Figure 1. **Fate of MPs in the environment.** Primary and secondary MPs undergo breakdown into smaller entities due to photodegradation assisted with physical weathering agents therefore number of particles increases. The total mass of MPs in the environment would decrease with time due to their breakdown into monomers or other nano substances that no longer could be considered microplastics (Hale et al., 2020).

Furthermore, urbanization, industrialization and tourism all across the globe show a directly proportionate relationship with MPs. These areas act as hotspots for MP pollution. Fishing nets and ropes also wear and tear on use significantly contribute to primary MPs in European lakes. Erosion of waste dumps is also responsible for releasing plastics into water bodies. (Uurasjärvi et al., 2020). A high concentration of MPs in an area may not always be a result of that area itself being located near an MP emitting source. Some places also act as sinks for MPs. Ocean currents deposit MPs at Lambra beach, Spain (which is very far from any human settlement), making it one of the most polluted European beaches (Herrara et al., 2018; Martinez et al., 2009). A significant contribution to the number of MPs in seas and oceans is made by rivers drain MPs that they collect in their course upstream.

A lot of MPs are now trapped in arctic ice, this will directly be released into oceans as the ice melts due to global warming (Obbard, 2014). As secondary MPs are formed by the degradation of large plastic pieces, increasing temperature will speed up this weathering. Increasing ocean temperatures due to global warming will further accelerate the MPs concentration in the world oceans. A 2017 IUCN report on MPs points out that as a region South Asia is the biggest contributor (18.3%) to MPs in water bodies, whereas Europe owes 14.1% of all (Boucher and Friot, 2017). An EU citizen annually generates 54.4 kg of plastic waste per capita; this is way higher than the Indian population which barely touches the 20kg mark apiece (Calma, 2020). Germany is the largest producer of plastic waste in Europe (6.68 million tons of plastic waste in 2016), compared to India generates 26.33 million tons, the highest in Asia; nearly half of all the plastic waste generated by India (12.99 million tons in 2021) ends up as marine plastic waste (World Population Review, 2022). Among South Asian countries, water bodies surrounding the Maldives have the highest concentration of MPs (Neill, 2020). Plastics include a wide range of polymers having a large diversity in their properties and uses. Polypropylene (PP) is used as a packaging material., in electronics and automotive parts. Polyethene terephthalate (PET) is used in making containers for food and beverages and has wide applications in synthetic textiles. Polyethene (PE) is a low-density plastic that has applications in packing films, grocery bags, squeeze bottles, toys and a lot more. There exists a significant variation in the relative abundance of the type of plastic polymers constituting the MPs in associated water bodies around different regions of the world (Hamid et al., 2018; Cera, 2020). Keeping the concern of rising MPs in mind, the present work focuses on the impacts of MPs on human health and is framed to highlight the current status and future estimations of MPs' problems in India and worldwide by exploring common points of entry and their detrimental impacts in various forms on the human body.

Impacts of MPs

The impacts of MPs pollution have been elucidated in the form of Figure 2. MPs sorb a variety of substances: MPs can absorb extremely harmful hydrophobic organic chemical substances such as endocrine disrupting chemicals, POPs, organochlorine pesticides, persistent bio-accumulative toxins (PBTs), and many aromatic hydrocarbons (often potential carcinogens), in addition to these MPs can also sorb metals from water bodies (Thompson et al., 2009; Cole et al., 2011; Rochman et al., 2013). They, therefore, act as carriers for pollutants to enter aquatic organisms (Zarfl and Matthies, 2010). In addition to the base polymer, additives (like polybrominated diphenyl ethers, bisphenol A, Butylated hydroxytoluene, and organometallic compounds having tin or arsenic) are added during the manufacturing of plastics to achieve desired properties like colour, stabilizers prevent reaction with certain compounds, flexibility, increased shelf life, thermal resistance, resistance to oxidative damage etc. These additives can result in hormonal imbalance in organisms, along with impacts on mortality, reproductive abnormalities, and neurological development depending on the concentration of chemicals engulfed by the organisms (Barnes et al., 2009; Lithner et al., 2009).

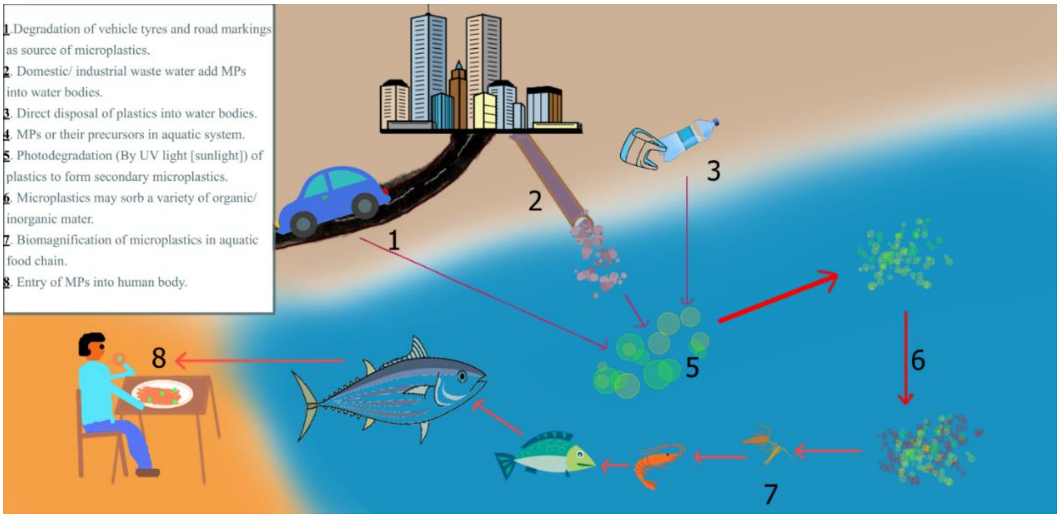

Figure 2. Entry of microplastics into aquatic ecosystem and humans

PBTs, POPs, plastic additives/ monomers and heavy metals are bioaccumulated in the food chain. MPs worsen their bioaccumulation as the organisms at low trophic levels pile up very high concentrations of bio-accumulants, these will further concentrate over higher trophic levels (Rochman et al., 2013; Teuten et al., 2009). These substances are not metabolized and have the potential to interfere with the cellular and physiological functions of an organism.

Impacts of MPs on human health

Sources of MPs in the human body: Human beings acquire the highest trophic levels in the ecosystem, therefore the transfer of MPs through food (seafood especially) is a very common means of exposure to MPs (Smith et al., 2018). Coloured MPs are also present in packaged milk (Muniasamy, 2020). PET is the most common MP found in branded table salt (Yang et al., 2015). Tap waters in many parts of the world have MPs (IUCN, 2021). 82% of taps in New Delhi (India) supply water contaminated with MP fibres (Kosuth Mary et al., 2018) (Figure 3).

Plastics are used in the formulation of many daily use personal care products; A lot of cosmetic items contain MPs intentionally added to them as emulsifying agents, viscosity regulators, opacifiers, excipients, binders and many more applications depending on polymer type (Leslie, 2014). Microbeads in facial products can cause cornea damage by sticking in the eye, tiny skin rips, and bacterial infections (Mahesh and Mukherjee, 2018). Plastic containers used for storing food and beverages also degrade (in negligible amounts) to release MPs. Analysis of bottled water across the world shows PP, the material used to make bottle caps happens to be the major MP constituent and PET was also found to be present significantly in bottled water (Tyree and Morrison, 2018). Suspended MPs can directly enter our bodies simply by inhalation and can persist in our lungs resulting in increased risks of respiratory irritation, interstitial lung disease, tumours and inflammation (Gasperi et al., 2018; Borm et al., 2000; Warheit et al., 2001; Greim et al., 2001). If the concentration of POPs associated with MPs is less relative to the gut wall, it results in the movement of POPs from tissues to MP particles (Kelly et al., 2004). This concept has medical applications in drug delivery.

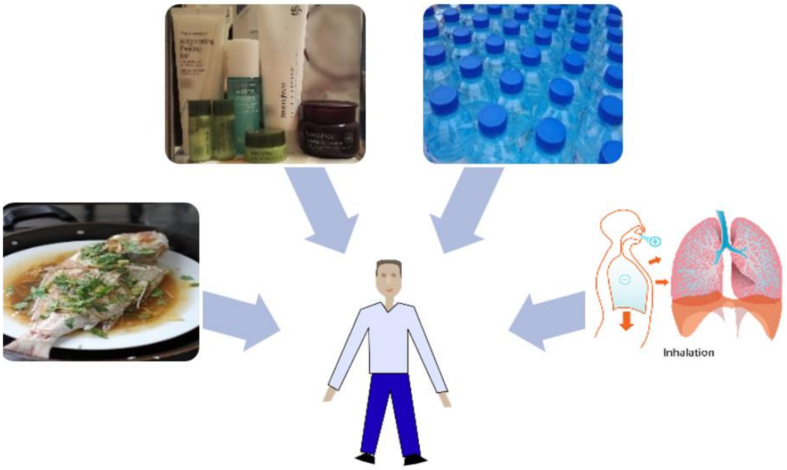

Figure 3. Common entry sources of MPs in humans. MPs can enter our body via food, cosmetics, plastic containers or air

Threats due to things commonly associated with MPs: MPs sorb a wide variety of metals, organic and inorganic compounds hence the entry of these substances is inevitable, these substances can potentially interfere with cellular and physiological functions in human beings including behavioural changes, immune disorders and organ damage in case of high concentrations (GESAMP, 2015; Holmes et al., 2012; IUCN, 2021). The consumption of microplastics by organisms is positively correlated with concentration of PCBs in fat tissues as PCBs are commonly found in plastics, also no such correlation in birds was found between microplastic ingestion and bio-accumulants that are not associated with microplastics such as DDT, dieldrin, DDE and OCs (Ryan et al., 1988). MPs in water bodies often have biofilms on their surface which might contain toxin-producing microbes, if these plastispheres are ingested directly they can cause serious infections and other problems (Zettler et al., 2013; Kettner et al., 2019). Studies on *Pfiesteria piscicida* (potentially toxin-producing plankton) show a fifty-fold density increase of this plankton in the MP particles with respect to the surrounding seawater (Berlin, 2019). Many opportunistic human pathogens are also found adhered to aquatic MPs that manifest as a threat to human health (Wagner et al., 2014; Snoussi et al., 2008).

Effects of MPs on a cellular level

The method of cellular intake of MPs varies according to the size of the particles; Clathrin-coated pits for small particles (<200 nm) and phagocytosis for larger particles (up to 40 µm) (GESAMP, 2015). Ultrafine MPs (<10 µm) can cause an increase in pro-inflammatory cytokine interleukin 1 (IL-1) gene (critical role in immune response [activates monocytes and neutrophils]) expression in cells, and an increase in cytosolic calcium ion concentration due to calcium influx across plasma membrane because calcium is involved in transcription pathway of pro-inflammatory cytokine protein Tumour Necrosis Factor-alpha (TNFα); MP induced calcium changes may be significant in causing pro-inflammatory gene expression, such as chemokines (Brown et al. 2004). Plastic particles are found to accumulate in lysosomes which coincides with the breakdown of the lysosomal membrane and the release of degrading enzymes into the cytoplasm causing cell death (Rank et al., 2007; Fröhlich, 2012) (Figure 4).

Effects of MPs entering the digestive tract

Gut epithelium cells can uptake MPs (von Moos et al., 2012). MPs entering into gut are very likely to cause abrasion of lining tissues of the gut. Translocation of smaller MPs across gut epithelium in disguise of nutrients results in their entry into the circulatory system (Browne et al., 2008; Hussain et al., 2001). Experiments on aquatic animals show that MPs trigger immune response cells (macrophages and leucocytes) (Veneman et al., 2017; Hoher et al., 2012). After entering into bloodstream, they create risks of physical damage to internal tissues and chocking of narrow ducts, arteries (100µm - 10mm in diameter) and capillaries (3-4 µm generally). Nanoplastics can cross biological membranes therefore they often interfere with cellular functions and cell organelles (Berntsen et al., 2010; Fröhlich et al., 2009). Wick et al. (2010) using fluorescent PS nano-beads demonstrated that MPs (<240nm) can span through the placental membrane.

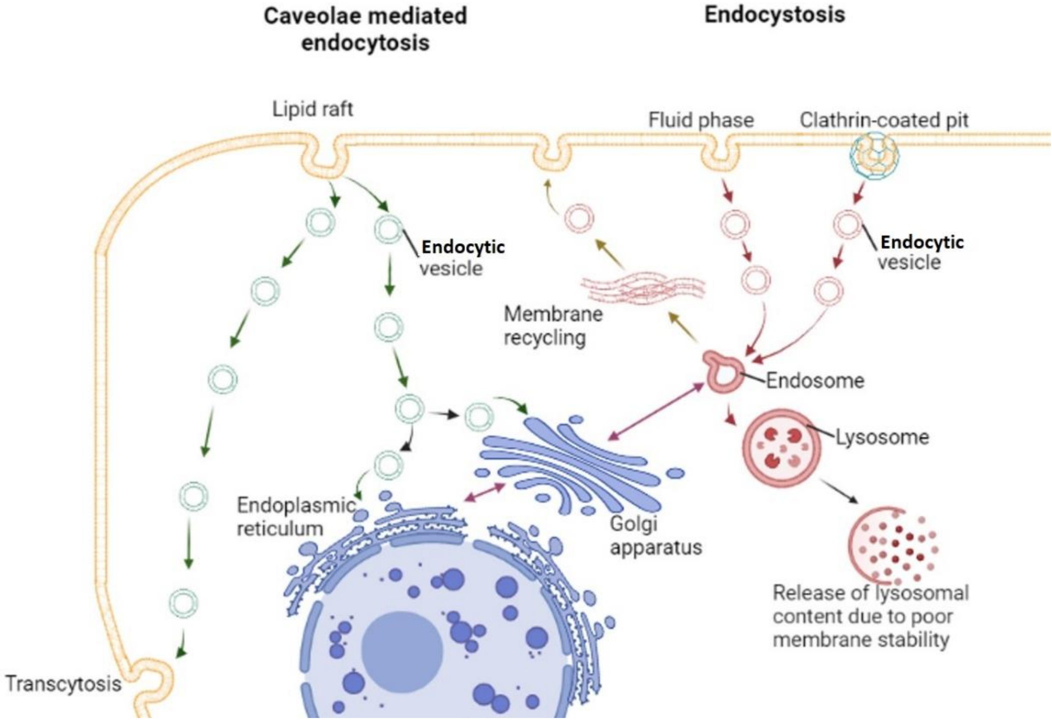

Figure 4. Cellular entry pathway of MPs. Cellular accumulation of microplastics into ER or Golgi body is brought by endocytic vesicles (green) that alongside acting as carriers for various substances, also intake small MPs in disguise during endocytosis (caveolae-mediated). MPs inside some of such vesicles are passed through the cell without getting accumulated. Vesicles (Red) formed by non-caveolae-mediated endocytosis (might involve Clathrin protein receptors) can lead to deposition of MPs into lysosomes (Shin and Abrahim, 2001; van der Goot and Gruenberg, 2002; Moore, 2006)

Potential effects on physiology, development and reproduction

Not much research has been done on the effects of MPs in human beings, but studies on mice (under very high concentrations of PE and PS MPs as compared to what human beings are exposed to) conclude MPs are responsible for small intestine inflammation and reducing reproductive ability hence producing lesser and smaller off springs (Li et al. 2020; Park et al. 2020; Jin et al., 2021). Sussarellu et al. (2016) suggested in a similar study on oysters that this resulted because of an energy shift away from reproduction and toward structural growth, due to feeding changes triggered by MP exposure. MPs have detrimental effects on white adipose tissue differentiation which is hypothesised to result in type II diabetes (Egusquiza and Blumberg, 2020; Danforth, 2000). Mice exposed to 1000 µg/L PS MPs show a significant increase in hepatic total bile acids (TBA) as a result of upregulation in two bile acid synthesis genes CYP7a1 and ABCb11 (Jin et al., 2019). MPs and plastic additives are hypothesized to increase obesity in humans (Kannan and Vimalkumar, 2021).

Conclusion

Conclusions about immune responses and physiological changes due to MPs are based on studies on mice (model organisms for the human system) administered with extremely high doses of MPs under lab conditions. Exposure and accumulation of MPs via food, water and air surely is a true phenomenon but the concentrations of MPs are not too high in the environment currently as to show direct visible effects and extremely few detailed analyses have been done on human health concerning MPs. No confirmed death/severe illness to date in humans can be solely blamed on MPs. As in, MPs are proven to act as vector particles for many human disease-causing bacteria, but this contributes negligibly as compared to other modes of pathogen entry in humans. As of now, it is not possible to draw a heat map of the world showing the health effects of MPs on humans as very few papers have been published on the effects of MPs on human health worldwide and more research needs to be done. However, as of now, effects can be correlated theoretically with the concentration of MPs in the environment (soil/ sediments/ water bodies/sea salt etc.) and organisms (like fishes). This will become a major concern in upcoming years if MP levels keep on increasing exponentially and start showing severe effects on human health.

Abbreviations

MPs - Microplastic(s)
POPs - Persistent organic particles
IUCN- International Union for Conservation of Nature
PS- Polystyrene
PCB- Polychlorinated biphenyls

References

ACEA - European Automobile Manufacturers' Association (2022) Report - Vehicles in use, Europe 2022. [online] Available at: https://www.acea.auto/publication/report-vehicles-in-use-europe-2022/

Andrady A, Pegram and Searle (1996) Wavelength sensitivity of enhanced photodegradable polyethylenes, ECO, and LDPE/MX. Journal of Applied Polymer Science, 62(9): 1457-1463.

Barnes, Galgani, Thompson R and Barlaz M (2009) . Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526): 1985-1998.

Berntsen P, Park C, Rothen-Rutishauser B, et al. (2010) Biomechanical effects of environmental and engineered particles on human airway smooth muscle cells. Journal of The Royal Society Interface, 7(suppl_3)

Borm P, Höhr D, Steinfartz Y, Zeitträger I and Albrecet C (2000) Chronic Inflammation and Tumor Formation in Rats After Intratracheal Instillation of High Doses of Coal Dusts, Titanium Dioxides, and Quartz. Inhalation Toxicology, 12(sup3):225-231.

Boucher J and Friot D (2017) Primary Microplastics in the Oceans: A Global Evaluation of Sources. IUCN, Gland, 43 p. https://doi.org/10.2305/IUCN.CH.2017.01.en

Brown D, Donaldson K and Stone V (2004) Effects of PM10 in human peripheral blood monocytes and J774 macrophages. Respiratory Research, 5(1) https://doi.org/10.1186/1465-9921-5-29

Browne MA, Dissanayake A, Galloway TS, Lowe DM and Thompson RC (2008) Ingested microscopic plastic translocates to the circulatory system of the mussel, Mytilus edulis (L.) Environmental Science and Technology 42(13): 5026-5031 https://doi.org/10.1021/es800249a

Calma J (2020) The US is one of the world's biggest sources of plastic pollution. [online] The Verge. Available at: https://www.theverge.com/2020/10/30/21542109/plastic-waste-united-states-ocean-pollution-study

Cera A, Cesarini G and Scalici M (2020) Microplastics in Freshwater: What Is the News from the World? Diversity, 12(7), p.276. https://doi.org/10.3390/d12070276

Cole M, Lindeque P, Halsband C and Galloway T (2011) Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin, 62(12):2588-2597.

Danforth E (2000) Failure of adipocyte differentiation causes type II diabetes mellitus? Nature Genetics, 26(1):13. https://doi.org/10.1038/79111

Egusquiza R and Blumberg B (2020) Environmental Obesogens and Their Impact on Susceptibility to Obesity: New Mechanisms and Chemicals. Endocrinology 161(3) https://doi.org/10.1210/endocr/bqaa024

Evers J, Emdash (2022) Great Pacific Garbage Patch. [online] Education.nationalgeographic.org. Available at: https://education.nationalgeographic.org/resource/great-pacific-garbage-patch

Forschungsverbund Berlin (2019) Microorganisms on microplastics. Science Daily. www.sciencedaily.com/releases/2019/06/190605121655.htm

Fröhlich E (2012) The role of surface charge in cellular uptake and cytotoxicity of medical nanoparticles. International Journal of Nanomedicine, 5577.

Fröhlich E, Samberger C, Kueznik T, Absenger M, Roblegg E, Zimmer A and Pieber T (2009) Cytotoxicity of nanoparticles independent from oxidative stress. The Journal of Toxicological Sciences, 34(4):363-375.

Gasperi J, Wright S, Dris R, et al. (2018) Microplastics in air: Are we breathing it in? Current Opinion in Environmental Science and; Health, 1, pp.1-5.

GESAMP (2015) Sources, fate and effects of MPs in the marine environment: a global assessment (Kershaw, P. J., ed.) (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) Reproductive Studies, GESAMP No. 90: 96.

Greim H, Borm P, Schins R, Donaldson K, Driscoll K, Hartwig A, Kuempel E, Oberdörster G and Speit G (2001) Toxicity of fibers and particles—report of the workshop held in Munich, Germany, 26–27 OCTOBER 2000. Inhalation Toxicology, 13(9):737-754.

Leslie HA (2014) Review of Microplastics in Cosmetics - Scientific background on a potential source of plastic particulate marine litter to support decision-making. IVM Institute for Environmental Studies.

Hale R, Seeley M, La Guardia M, Mai L and Zeng E (2020) A Global Perspective on Microplastics. Journal of Geophysical Research: Oceans, 125(1) https://doi.org/10.1029/2018JC014719

Herrera A, Asensio M, Martínez I, Santana A, Packard T and Gómez M (2018) Microplastic and tar pollution on three Canary Islands beaches: An annual study. Marine Pollution Bulletin, 129(2):494-502.

Höher N, Köhler A, Strand J and Broeg K (2012) Effects of various pollutant mixtures on immune responses of the blue mussel (Mytilus edulis) collected at a salinity gradient in Danish coastal waters. Marine Environmental Research 75:35-44.

Holmes L, Turner A and Thompson R (2012) Adsorption of trace metals to plastic resin pellets in the marine environment. Environmental Pollution 160:42-48.

Horton A, Svendsen C, Williams R, Spurgeon D and Lahive E (2017) Large microplastic particles in sediments of tributaries of the River Thames, UK – Abundance, sources and methods for effective quantification. Marine Pollution Bulletin, 114(1):218-226. https://doi.org/10.1016/j.marpolbul.2016.09.004

Hussain N, Jaitley V and Florence AT (2001) Recent advances in the understanding of uptake of microparticulates across the gastrointestinal lymphatics. Advanced Drug Delivery Reviews 50(1-2):107-142.

IUCN (2021) Marine plastic pollution. [online] Available at: https://www.iucn.org/resources/marine-plastic-pollution

Jin H, Ma T, Sha X, et al. (2021) Polystyrene microplastics induced male reproductive toxicity in mice. Journal of Hazardous Materials, 401:123430. https://doi.org/10.1016/j.jhazmat.2020.123430

Jin Y, Lu L, Tu W, Luo T and Fu Z (2019) Impacts of polystyrene microplastic on the gut barrier, microbiota and metabolism of mice. Science of The Total Environment 649: 308-317. https://doi.org/10.1016/j.scitotenv.2018.08.353

Kannan K and Vimalkumar K (2021) A Review of Human Exposure to Microplastics and Insights Into Microplastics as Obesogens. Frontiers in Endocrinology 12. https://doi.org/10.3389/fendo.2021.724989

Kelly B, Gobas F and McLachlan M (2004) Intestinal absorption and biomagnification of organic contaminants in fish, wildlife, and humans. Environmental Toxicology and Chemistry 23(10): 2324. https://doi.org/10.1897/03-545

Kettner M, Oberbeckmann S, Labrenz M and Grossart H (2019) The Eukaryotic Life on Microplastics in Brackish Ecosystems. Frontiers in Microbiology 10. https://doi.org/10.3389/fmicb.2019.00538

Kosuth M, Mason S and Wattenberg E (2018) Anthropogenic contamination of tap water, beer, and sea salt. PLOS ONE 13(4): e0194970. https://doi.org/10.1371/journal.pone.0194970

Kutralam-Muniasamy G, Pérez-Guevara F, Elizalde-Martínez I and Shruti V (2020) Branded milks – Are they immune from microplastics contamination? Science of The Total Environment 714: 136823. https://doi.org/10.1016/j.scitotenv.2020.136823

Li B, Ding Y, Cheng X, et al. (2020) Polyethylene microplastics affect the distribution of gut microbiota and inflammation development in mice. Chemosphere 244: 125492. https://doi.org/10.1016/j.chemosphere.2019.125492

Lithner D, Damberg J, Dave G and Larsson Å (2009) Leachates from plastic consumer products – Screening for toxicity with Daphnia magna. Chemosphere 74(9): 1195-1200. 10.1016/j.chemosphere.2008.11.022

Mahesh P, Mukherjee M (2018) Microplastics: The most widespread and persistent hazards of plastic. Toxics Link. Factsheet number 56. http://toxicslink.org/Publication/factsheet-56-on-microplastics.

Martinez E, Maamaatuaiahutapu K and Taillandier V (2009) Floating marine debris surface drift: Convergence and accumulation toward the South Pacific subtropical gyre. Marine Pollution Bulletin 58(9): 1347-1355. https://doi.org/10.1016/j.marpolbul.2009.04.022

Moore M (2006) Do nanoparticles present ecotoxicological risks for the health of the aquatic environment? Environment International 32(8): 967-976. https://doi.org/10.1016/j.envint.2006.06.014

NEA (2014) Sources of microplastics to the marine environment. Norwegian Environment Agency. https://www.miljodirektoratetno/publikasjoner/2015/februar/sources-of-microplastic-pollution-to-the-marine-environment/

Neill P (2020) Maldives has highest levels of microplastics in the world. [online] Environment Journal. Available at: https://environmentjournal.online/articles/maldives-has-highest-levels-of-microplastics-in-the-world/

Obbard R, Sadri S, Wong Y, Khitun A, Baker I and Thompson R (2014) Global warming releases microplastic legacy frozen in Arctic Sea ice. Earth's Future 2(6): 315-320. https://doi:10.1002/2014ef000240

Oceanservice.noaa.gov. (2021) What are microplastics? [online] Available at: https://oceanservice.noaa.gov/facts/microplastics.html

Park E, Han J, Park E, et al. (2020) Repeated-oral dose toxicity of polyethylene microplastics and the possible implications on reproduction and development of the next generation. Toxicology Letters 324: 75-85. https://doi.org/10.1016/j.toxlet2020.01.008

Rank J, Lehtonen K, Strand J and Laursen M (2007) DNA damage, acetylcholinesterase activity and lysosomal stability in native and transplanted mussels (Mytilus edulis) in areas close to coastal chemical dumping sites in Denmark. Aquatic Toxicology 84(1): 50-61.

Rochman C, Hoh E, Kurobe T and Teh S (2013) Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports 3(1). https://doi.org/10.1038/srep03263

Ryan P, Connell A and Gardner B (1988) Plastic ingestion and PCBs in seabirds: Is there a relationship? Marine Pollution Bulletin 19(4): 174-176. https://doi.org/10.1016/0025-326X(88)90674-1

Shahul Hamid F, Bhatti M, et al. (2018) Worldwide distribution and abundance of microplastic: How dire is the situation? Waste Management & Research: The Journal for a Sustainable Circular Economy 36(10): 873-897.

Shin J and Abraham S (2001) Caveolae-Not Just Craters in the Cellular Landscape. Science 293(5534): 1447-1448. https://doi.org/10.1126/science.1061079

Smith M, Love D, Rochman C and Neff R (2018) Microplastics in Seafood and the Implications for Human Health. Current Environmental Health Reports 5(3): 375-386. https://doi.org/10.1007/s40572-018-0206-z

Snoussi M, Noumi E, Usai D, Sechi L, Zanetti S and Bakhrouf A (2008) Distribution of some virulence related-properties of Vibrio alginolyticus strains isolated from Mediterranean seawater (Bay of Khenis, Tunisia): investigation of eight Vibrio cholerae virulence genes. World Journal of Microbiology and Biotechnology 24(10): 2133-2141.

Sussarellu R, Suquet M, Thomas Y, et al. (2016) Oyster reproduction is affected by exposure to polystyrene microplastics. Proceedings of the National Academy of Sciences 113(9): 2430-2435. https://doi.org/10.1073/pnas.1519019113

Teuten E, Saquing J, Knappe D, et al. (2009) Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526): 2027-2045.

Thompson R, Moore C, vom Saal F and Swan S (2009) Plastics, the environment and human health: current consensus and future trends. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526): 2153-2166.

Tyree C and Morrison D (2018) Plus, Plastic Text — Orb Media. [online] Orb Media. Available at: https://orbmedia.org/plus-plastic-text

Unep.org. n.d. Visual Feature | Beat Plastic Pollution. [online] Available at: https://www.unep.org/interactives/beat-plastic-pollution/

Uurasjärvi E, Hartikainen S, Setälä O, Lehtiniemi M and Koistinen A (2020) Microplastic concentrations, size distribution, and polymer types in the surface waters of a northern European lake. Water Environment Research 92(1): 149-156. https://doi.org/10.1002/wer.1229

van der Goot F and Gruenberg J (2002) Oiling the wheels of the endocytic pathway. Trends in Cell Biology 12(7): 296-299. https://doi.org/10.1016/S0962-8924(02)02307-3

Veneman W, Spaink H, Brun N, Bosker T and Vijver M (2017) Pathway analysis of systemic transcriptome responses to injected polystyrene particles in zebrafish larvae. Aquatic Toxicology 190: 112-120. https://doi.org/10.1016/j.aquatox.2017.06.014

von Moos N, Burkhardt-Holm P and Köhler A (2012) Uptake and Effects of Microplastics on Cells and Tissue of the Blue Mussel Mytilus edulis L. after an Experimental Exposure. Environmental Science &amp Technology 46(20): 11327-11335. https://doi.org/10.1021/es302332w

Wagner M, Scherer C, Alvarez-Muñoz D, et al. (2014) Microplastics in freshwater ecosystems: what we know and what we need to know. Environmental Sciences Europe 26(1). https://doi.org/10.1186/s12302-014-0012-7

Warheit D, Hart G, Hesterberg T, et al. (2001) Potential Pulmonary Effects of Man-Made Organic Fiber (MMOF) Dusts. Critical Reviews in Toxicology 31(6): 697-736.

Wick P, Malek A, Manser P, et al. (2010) Barrier Capacity of Human Placenta for Nanosized Materials. Environmental Health Perspectives 118(3): 432-436. https://doi.org/10.1289/ehp.0901200

Woodford C (2022) Plastics. Explain that Stuff website. https://www.explainthatstuff.com/plastics.html

World Population Review (2022) Plastic Pollution by Country (2022) World Population Review website. https://worldpopulationreview.com/country-rankings/plastic-pollution-by-country

Yang D, Shi H, Li L, Li J, Jabeen K and Kolandhasamy P (2015) Microplastic Pollution in Table Salts from China. Environmental Science & Technology 49(22): 13622-13627. https://doi.org/10.1021/acs.est.5b03163

Zarfl C and Matthies M (2010) Are marine plastic particles transport vectors for organic pollutants to the Arctic? Marine Pollution Bulletin 60(10): 1810-1814.

Zettler E, Mincer T and Amaral-Zettler L (2013) Life in the "Plastisphere": Microbial Communities on Plastic Marine Debris. Environmental Science & Technology 47(13): 7137-7146. https://doi.org/10.1021/es401288x

Author Contributions

PT, SM, PP and NKV conceived the concept, wrote and approved the manuscript.

Acknowledgements

We would like to thank the head of the institute, Prof. C. Sheela Reddy, Head and Principal., Sri Venkateswara College, University of Delhi for providing the opportunity and facilities to work under SRI-VIPRA program. The authors are highly thankful to Dr. Tabassum Afshan for her valuable guidance and meaningful discussions from time to time during the study.

Funding

There is no funding source for the present study.

Availability of data and materials

Not applicable.

Competing interest

The authors declare no competing interests.

Ethics approval

Not applicable.

Citation: Tayal P, Mandal S, Pandey P and Verma NK (2023) Impact of Microplastic Pollution on Human Health. Environ Sci Arch 2(2): 195-204.