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Review Article

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Microplastics: A One Health priority agenda

Ripan Biswas[1]✉, Chanchal Debnath[1], Rahul Barua[1], Indranil Samanta[2]

[1]*Department of Veterinary Public Health & Epidemiology, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata 700037, India*

[2]*Department of Veterinary Microbiology, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata 700037, India*

ABSTRACT

Interdisciplinary approaches are increasingly recognized as crucial for strengthening and integrating health systems. The implementation within One Health framework needs more guidelines for successful execution. Microplastics have become a growing environmental concern, as they are collectively found in all environmental sectors. Microplastics pose risks to crops, plants, animals, wildlife and human due to the persistence and bio-accumulative properties. Microplastics are directly and indirectly associated with climate change, not only threatening food security but also leading to the novel distribution of species that may transmit new pathogens. This article focused on the ubiquitous presence of microplastics in One Health, highlighting the necessity for further research and implementation efforts.

KEYWORDS: Microplastics; One Health; Plastic

1. Introduction

Plastic waste has emerged as a significant global problem, and addressing requires the application of One Health. Plastic particle affects every nutritional level of food chain of any ecosystem and that can be even in molecular level. Human and other biotic stakeholders like animals and plants are contaminated with plastics rather it is microplastics. Thus, before understanding microplastics (MPs), we have focused the historical development of plastic since its beginning.

The term “plastic” originates from the Greek word “plastikos” which means “pliable and capable of being shaped or modeled”. After serial polymerization of different monomers and addition of additives, plastic is made[1]. Cellulose is a common and copious natural polymer found in the environment. The first semi-synthetic polymer was developed by Alexander Parkes in 1862 and he demonstrated his invention “Parkesine” at the Great International Exhibition in London. But it did not get admiration because of its high price. The history was created in the year 1869 when the pioneer, John Wesley Hyatt invented a durable, colorful, and moldable thermoplastic known as celluloid, the first commercially effective semi-synthetic plastic. This revolutionary invention inspired Leo Baekeland, who in 1907 invented Bakelite, the first fully synthetic substitute of shellac, a natural electrical insulator. Thereafter, different types of plastics in different forms have been developed for public ease and comfort. Production of plastic has been increasing. In 2022, global plastic production reached 400.3 million metric tons, marking a 1.6% increase compared to the previous year. It is forecasted that by 2050, production will rise to 1 800 million tons. Plastic managment remains inadequate, with 67.9% plastics being either burned or buried. Plastic particles are capable of move both short and long distance, facilitating

✉To whom correspondence may be addressed. E-mail: dr.ripanbiswas@gmail.com

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the transmission of pathogenic and invasive agents, as well as environmental contaminants. Currently, we are standing in the era of plastics which have become integral to our daily life, accumulating in every biotic component of ecosystem and transmitting through food chain. Microplastics detrimentally affect terrestrial animals, leading to consequences for food security and food safety, and ultimately affect human health. These heterogenic, smaller microplastic represent an ongoing threat that can be only addressed by the integrated One Health approach.

2. Classification of plastics

On the basis of chemical structure and temperature behavior, plastic can be classified into thermoplastics, thermosets and elastomers (Figure 1). To differentiate or identify different plastics, the following codes are used based on the International Standards[2] (Table 1).

3. The impacts of microplastics on environment and One Health

Plastics wreckages are characterized into Nanoplastics (1 to 1000 nm), microplastics (<5 mm), macroplastics (5-25 mm) and mesoplastics (>25 mm). In 2004, Thompson and his team from University of Plymouth in England conducted a study on plastic debris in seawater, firstly proposed the concept of MPs[3]. MPs are heterogeneous mixtures of synthetic polymer that appears in various forms, including fragments, fibers, spheroids, granules, pellets, flakes, or beads. Their sizes range from 0.1 to 5000 μm[3,4]. Their shapes can be flat, oblong, cylindrical, disk-shaped bits and sphere-shaped to ovoid with rounded ends[5, 6]. Generally, MPs are composed of polyethylene terephthalate (PET), nylon, polyvinyl chloride (PVC), and polystyrene (PS) that are normally invisible by naked eye[7]. Based on the source, Microplastics have been divided into two types: primary and secondary sources[8]. The primary sources are basically pre-production plastic pellets, industrial rubbing, exfoliants and other consumer goods. Secondary microplastics in the environment are originated from the crash of larger plastic materials, particularly marine debris.

Currently, we are in a plastic era, with global annual plastic waste production reaching approximately 350 million tons[1]. Plastics are extensively dispersed and can be transport through water, wind and even animal movement[9], expressively impacting human life. MPs have been found in water, shellfish, algae, turtles[10], fish[11], intestine of vertebrates[12], large animals[13] and even breast milk[14]. MPs have been found in many areas and settings, from marine ecosystems to far-off mountain forestry, from earthworms in the soil to forest birds and domestic animals[15]. MPs have also been detected in human food[16] and in human feces[17]. Ultraviolet radiation, waves, corrosion, and photo-oxidation in combination with bacteria breakdown the plastics into micro and nanosized particles[18]. Due to small size and low density, MPs can persist in the environment for a long time resulting into an increasing environmental hazard[19]. Thus, MPs have emerged as a major global problem which involve the disposal of these from the ecosystem. MPs are the budding crises for One Health and to combat this hazard, a transdisciplinary One Health approach is required to study the impacts of microplastics in animal, human and environmental health.

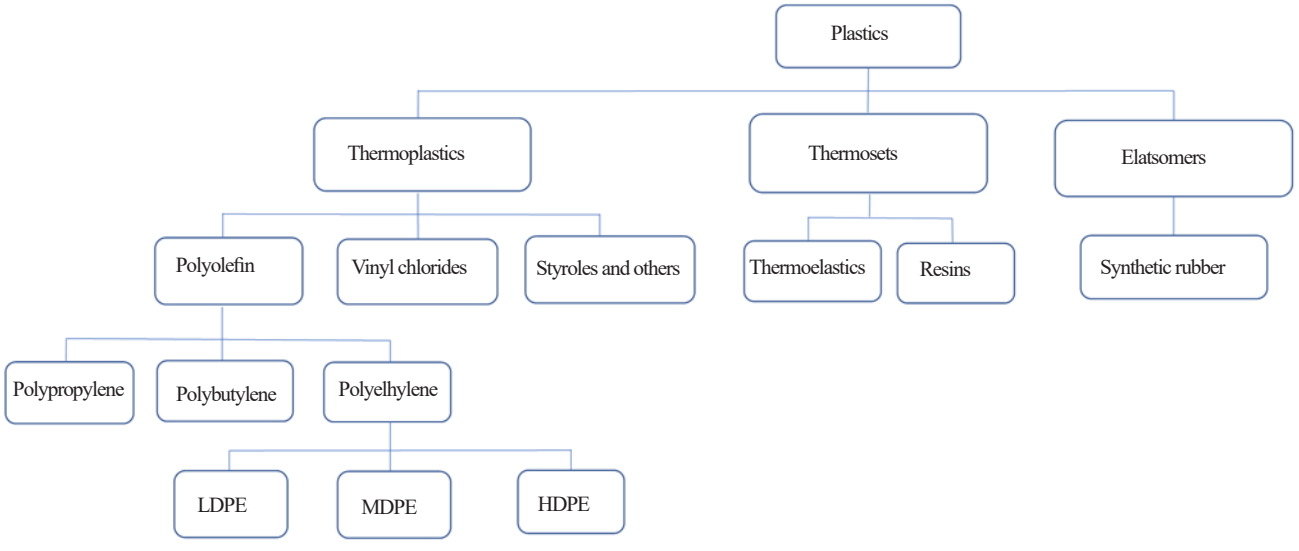


Figure 1. Classification of plastics. LDPE: Low density polyethylene; MDPE: Medium density polyethylene; HDPE: High density polyethylene.

Table 1. Types of plastics and their uses.

Type	Use
Polyethylene terephthalate (PET)	Food and drink containers, soft drink bottles, cloth fiber
High density polyethylene (HDPE)	Piping for water and drain, milk jugs, detergent bottles, nursery pots, oil containers, snowboards, boats and chairs
Polyvinyl chloride (PVC)	Plumbing products, medical tubing, pressure pipes, insulation for electrical cable, outdoor furniture, liquid detergent containers, *etc*.
Low density polyethylene (LDPE)	This polyethylene is ductile and, thus, used for shopping bags, food containers, films or bags and stretch wrap
Polypropylene (PP)	Laboratory apparatus, health devices
Polystyrene (PS)	Yoghurt pots, foodservice containers, CD cases, envelope windows, video cassettes, appliance housings
Other type of plastics	Multiple uses

4. The impacts of microplastics on food safety and animal health

MPs are potential pollutants which hamper the soil quality as a result, consequently reducing the efficiency of food production. Moreover, food safety for animals is also compromised as by MPs is a physical contaminant for food. MPs have been recognized in gastrointestinal tract of duck, such as crop[20], gizzard[20,21], intestine[21, 22]. This emerging hazard has also been acknowledged in packaged chicken[23], chicken cut on plastic board[24], eggs[25], feces[20] and manure[26]. The sources of MPs in manure are hypothecated to originate from plastic tools and apparatus (*e.g*., scrapers and water pipes), packaging materials (*e.g*., feed bags), and animal feed[26]. At the same time, MPs have also been detected in cattle milk[27, 28, 29] and cattle manure[30]. Huge quantity of MPs has been confirmed in lungs tissue of pigs[31]. In small ruminant, MPs have been found in feces of sheep[32] and chevon cut on plastic board[24]. The sweet honey is also contaminated with MPs[33]. Animals are also at high risk as they get contaminated with MPs from fishmeal, crops and drinking water. Moreover, MPs have recently been found to impact microbial communities and increase rate of gene exchange which include antibiotic and metal resistance genes[34]. Special attention must be given to food animals, as they yield food such as milk, eggs and meat, with the consequential hazard of biological intensification along the food chain.

5. The impacts of microplastics on marine ecosystem

Marine mammals, such as whales, dolphins and seals are often considered as significant indicators of health of marine ecosystem, mainly in relation to pollution[35] because of these animals are having high trophic level, long life-span and susceptible for bioaccumulation and biomagnification of aquatic chemical contaminants. The most predominant waste materials are transported to the seas by rivers, floods, and winds that pollute the ocean and seashores ecosystem. Used fishing craft, plastic bags, food containers, and plastic drinks bottles (water and cold drinks) pollute the water ecosystem[3]. MPs have been detected in edible fish due to biomagnifications, and they enter human systems[36–38] as MPs contaminated fish muscle is consumed by humans[39–43]. As fish is a major source of protein for humans, the prevalence and ecotoxicological effects of MPs in fish may impact food security[44,45]. MPs have been detected in seashores, oceans, seas, rivers, lakes/reservoirs, artificial reefs, gyres and other water bodies[46–51]. The presence of MPs has been observed in fishes, mollusks, crustaceans and microbiota living in plastic-contaminated seawater[52,53]. Moreover, MPs can embrace or adsorb additives, heavy metals, antibiotics, pesticides, and other environmental contaminants[54]. Additionally, they can host beneficial and pathogenic microorganisms that form the "plastisphere"[25, 55–58]. Therefore, the impacts of MP ingestion on the health of aquatic biota is a relevant research topic.

6. The impacts of microplastics on plant life

MPs are taken up by plants, but plants with cellulose-rich cell walls resist entry of MPs because of its high molecular weight and large size[59]. So, absorption is basically depends on two properties; a) the anatomical and physical structure of plant; b) the absorption affinity for different substances. The absorption of carbon-based nanoparticles has been documented in whole plants such as rice, maize, soybean, and Arabidopsis thaliana. Once MPs accumulate in the soil, they can be absorbed by plants and transferred along the food chain[60]. The sources and possible pathways of MPs entering the soil are various, including the application of sewage sludge and compost[20, 61], irrigation[62], plastic mulching[63], littering[64] and atmospheric depositio[65]. Particularly, urban and agricultural soils are susceptible to microplastic pollution because they are the most often exposed and accompanying to human activities[66,67]. Agricultural soil is contaminated with MPs polymers such as PS, PE, and polypropylene[68]. The use of plastic mulch is very popular in agriculture, altering the temperature of soil, reducing evapotranspiration, controlling weeds and decreasing the soil imperfection of the products. However, this plastic covering contributes to the increment of plastic residues in the soil[69, 70]. Mass tillage practice send all the plastic residues and MPs into the deep soil column where they interact with soil microbes and root of plants[60,71]. As a result, global food productivity is hampered and reduced because of affected soil microbes and root function[72]. The terrestrial ecosystem contains more microplastics than the marine ecosystem[73]. It has been reported that agricultural soil contains more MPs than the ocean[74]. Thus, MPs not only disturb the uptake of water and nutrien[75] but also accumulate PE in roots, resulting in limited photosynthetic rate and expansion of leaf may further impair development of the root, which is another indicator of nitrogen deficiency[76].

7. The impacts of microplastics on microbes

Different studies have reported that microplastics provide an ideal substrate/surface where colonization of microbes and formation biofilms in aquatic environments take place[77]. The formation of biofilms poses a significant challenge in industrial, environmental, public health and medical settings[78]. Microplastics associated microbial pathogens form biofilm on microplastics termed "Plastisphere" and their resistance against antimicrobials are gaining the attention gradually in microplastic research. Some studies have revealed that MPs are also responsible to transfer of integron, mobile genetic elements, and other genes responsible for horizontal transfer of AMR genes (ARGs) to other antimicrobial drug-sensitive strains through conjugation, transduction and transformation[79]. These microplastics associated biofilm are considered as the hotspot for ARGs. *Flavobacterium* spp. and *Chryseobacterium* spp. are the most commnoly isolated from MPs. AMR is a global health and developmental threat, necessitating crucial multisectoral action to overcome the difficulties in achieving the Sustainable Development Goals[80].

8. Conclusions

Plastics have become a part of our lives and we cannot avoid the use of plastics due to ongoing development of civilization. Thus, simply we can say that we are living in the era of plastics. However, only few reports and information are on the surface regarding microplastics. In this article, we have tried to focus the appearance of MPs in One Health stakeholders which is just the tip of the iceberg. Because of various knowledge gaps regarding MPs in food production, food safety and security, human health, animal health, environmental health, formation of biofilm and AMR, One Health approach is required to ensure a healthier ecosystem. More emphasis should be given to raising awareness about plastics and microplastics. To overcome and combat the challenges posed by microplastics, more high-quality researches need to be conducted in agriculture, soil, water, animals, humans and climate change for better understanding of the consequences on One Health components.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' contributions

Biswas R and Debnath C conceptualized and prepared the primary draft of the manuscript. Barua R and Samanta I collected data and critically reviewed the article. All authors read and approved the final manuscript.

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