Journal of Advanced Zoology

ISSN: 0253-7214

Volume 45 Special Issue 02 Year 2023 Page 1141:1145

UNDERSTANDING THE TOXICITY AND CONTAMINATION OF MP IN THE WATER OF THE KRISHNA RIVER – A REVIEW

Laxmi R[1], N Venu[2], Rahul Singh[3]*

[1,2] Department of Zoology, University Pg College, Palamuru University, Mahabubnagar 509001
*. [3]*School of Bioengineering and Biosciences, Lovely Professional University, Phagwara, Punjab, India*

**Corresponding author's E-mail: rahulsingh.mlkzoology@gmail.com*

Article History

Received: 11 February 2023
Revised: 21 August 2023
Accepted: 29 September 2023

Abstract

Tiny plastic fragments known as "microplastics" are extremely dangerous to society. Microplastics contaminate rivers because of their sluggish degradation. It became clear that plastic pollution would pose a health risk when more plastic trash started to accumulate in the natural world. Since plastics are long-lasting, incorrectly disposed of plastic items might be detected in the environment for a very long period. Plastic pollution has an impact on human health, animals, and aquatic life. Marine life, including fish, birds, and turtles, can become entangled in plastic debris and swallow it, which can cause severe harm or even death. Since these environments act as accumulation zones, it has been established that plastic litter negatively affects plant species like mangrove forest trees and the wildlife that lives there. Religious offerings, cultural celebrations, and untreated sewage water are the primary contributors of microplastic pollution. Sewage water from nearby settlements finds its way into the river. The disposal of garbage is one of the main human activities contributing to the microplastic burden in the Krishna River. These substances are now just tiny particles.

Keywords: *Micro plastics; Plastic litter; plastic contamination; Krishna River; material disposal*

1. Introduction

Plastic is a petroleum-based material that has changed the world forever. The 1940s and 1950s saw the start of commercial plastic production (Hahladakis et al., 2018).1. Following then, plastic production skyrocketed due to the breadth of its advantages. Plastic is used extensively in everyday life as well as in scientific, technological, and industrial applications because of its durability and inexpensive cost. 8300 million metric tonnes of virgin plastic have been produced up to this point. If current trends continue, there will be around 12000 million metric tonnes of plastic waste in landfills and natural places by 2050. (Colleagues Geyer, 2017). Plastic polymers include polyethylene mine, polyvinyl chloride, polypropylene, polyamide, polystyrene, high-density polyethylene, low-density polyethylene, and various other plastics. Although plastic polymers aren't utilized in their purest form, they are normally harmless. Polymers are combined with additives or monomeric constituents to enhance the material's properties (Deanin, 1975).

The three types of additives are: preventing plastic from deteriorating and aging during processing or use (light stabilizers, heat stabilizers, or antioxidants); facilitating processing (lubricants, mold-release agents, or blowing agents); and giving plastics desirable qualities. (Optical brighteners, impact modifiers, flame retardants, fillers, dyes, pigments, antistatic agents, nucleating agents, and plasticizers) (Pelzi et al., 2018).

The three types of additives are: preventing plastic from deteriorating and aging during processing or use (light stabilizers, heat stabilizers, or antioxidants); facilitating processing (lubricants, mold-release agents, or blowing agents); and giving plastics desirable qualities. Because plastic degrades so quickly, it is widely acknowledged as a serious environmental issue (Wang et al., 2016). Plastics are more likely to fragment than to deteriorate, which causes the substance to get smaller. Gigault et al. (2018) state that when plastic particles are as small as 25 mm, they are classified as mesoplastic (5-25 mm), large microplastic (1-5 mm), small microplastic (20μm1 mm), and nanoplastic (1-1000 nm). Primary and secondary microplastics are the two types that exist. Two examples of primary microplastics that are manufactured on purpose are pellets and microbeads. When large plastics break down and fragment, secondary microplastics are produced (Wen et al., 2018). Secondary plastic is more prone to fragmentation when exposed to extreme weathering conditions and elevated UV levels (Horton et al., 2017). Because microplastics can bioaccumulate more readily as they get smaller, this makes them a particular cause for concern (Wagner et al., 2014). Because of their small size, microplastics and the organic contaminants they contain are susceptible to ingestion by living things. Planktons, fish, birds, and even mammals are among the many species that might ingest these particles, which then accumulate throughout the food chain (Batel et al., 2016). The marine environment has been the focus of the majority of scientific studies on microplastics. Nonetheless, freshwater, terrestrial, and human health issues have been the subject of recent research (Pico et al., 2018, Blasing et al., 2017, Rist et al., 2018).

Owing to their strong adsorption ability, microplastics have the ability to carry or gather other hazardous substances that are added to them during production, making it easier for these substances to enter a variety of species. Because of how microplastics interact with other contaminants in the environment and expose those chemicals to living things, microplastics in the environment are a major cause for concern. Consequently, animals are harmed chemically and physically when they swallow microplastic. After the Ganga, Godavari, and Brahmaputra, the Krishna River ranks fourth in India in terms of water inputs and river basin area. The river spans approximately 1,288 kilometers, or 800 miles. Another name for the river is Krishnaveni. It is one of the main irrigation sources for Telangana, Karnataka, and Maharashtra. The district of Mahbubnagar occupies 2,737.00 square kilometers (1,056.76 sq mi). The district is traversed by the Tungabhadra and the Krishna River. A merger occurs at Sangameswaram. It has been shown that one of the main sources of microplastic pollution is the Krishna River. Religious offerings, cultural celebrations, and untreated sewage water are the primary contributors of microplastic pollution. Sewage water from nearby settlements finds its way into the river. The disposal of garbage is one of the main human activities contributing to the microplastic burden in the Krishna River. These substances are now just tiny particles. The majority of the mechanism underlying metal adsorption on microplastic remains unclear due to its great variability and complexity (Brennecke et al., 2016). Therefore, an attempt should be made to understand the intricate combination of contaminants associated with this item. In order to define microplastic's ecological significance as numerous stressors, research on interactions between microplastic and other pollutants in freshwater is essential.

The Krishna River in Mahabubnagar District is renowned for the variety, richness, and spread of its fish population. Fish from the Krishna River have been identified as belonging to 109 species. Order Cypriniformes dominated in terms of percentage composition and species richness, with 61 species. It was followed by Siluriformes with 26 species, Perciformes with 13 species, Synbranchiformes with 4 species, Beloniformes with 3 species, Osteoglossiformes with 1 species, and Anguilliformes with 1 species apiece. One of the eight most invasive fish taxa in the world, Cyprinus carpio, is also one of the freshwater fish species that causes the greatest ecological harm. Numerous characteristics, such as its early sexual development and broad adaptability to a variety of environments, add to its invasive nature.

Ground water

Worldwide, there is a significant risk that MP pollutants will contaminate water supplies. Sadly, the current literature analysis only contained two investigations into the presence of MPs in Indian groundwater (Ganesan et al. 2019; Selvam et al. 2020a). The current research indicates that a few of the primary factors contributing to MP contamination in groundwater throughout India are tourism-related activities, discharges of industrial and residential wastewater, fragmentation of poorly managed plastic litter, and riverine leaching. Groundwater samples were collected and processed using a variety of techniques in order to test for MP contamination. For the Ganesan et al. (2019) experiment, samples were promptly collected in glass bottles, and MP isolation was performed in the lab by filtering the samples. In contrast, on-site filtration using stainless steel sieves with a 50 m mesh size was selected in a different investigation by Selvam et al. (2020a) following sample collection with a Teflon pump. The next step in the MP extraction process was wet peroxide oxidation, which was followed by filtration of the oxidized solution. Then, utilizing a stereomicroscope on filters, the existence and identity of MP were investigated. The same study looked into the adsorption capacities of PP, PVC, PA, CE, and PE against the heavy metals Mn, As, Cd, Zn, Cr, Cu, and Pb. MPs composed of PP and PE polymers have been found to be capable of adsorbing significant amounts of metals, even at very low concentrations. This raises serious concerns if any aquatic life consumes these MPs.

Freshwater Systems:
Notwithstanding the fact that freshwater serves as a source of potable water, little is currently known about the pervasive and dangerous environmental stressor known as microplastic pollution (MP) in the world's oceans. India has not given this field enough attention, the literature review states, even though research in it is steadily advancing globally (Sruthy and Ramasamy 2017; Sarkar et al. 2019; Ganesan et al. 2019; Gopinath et al. 2020; Manikanda Bharath et al. 2020; NPC 2020; Amrutha and Warrier 2020; Ram and Kumar 2020; Selvam et al. 2020a). This raises the need to assess the MP pollution of freshwater systems in India. A detailed study of freshwater ecosystems will help the researchers better understand the sources, fate, and associated toxicity of these MPs in aquatic settings. The majority of research on MP in Indian freshwater systems has focused on the surface water and sediment in lakes and rivers. The scenario of MP pollution in Indian rivers, lakes, and groundwater is explained in the next three subsections, which are based on changes in the prevalence of MP in freshwater systems in India.

Lake
Bengtsson and Herschy (2012) estimate that 90% of the fresh surface water on Earth is found in lakes. However, these resources are now directly vulnerable to heavy metals, eutrophication, and other forms of contamination due to growing human activity. MPs, an emerging contaminant, are a relatively new type of pollution that these water bodies are now dealing with. According to recent studies on the presence of MPs in Indian lakes, one important source of these synthetic polymers is the fragmentation of macroplastic debris (Sruthy and Ramasamy 2017; Ganesan et al. 2019; Gopinath et al. 2020; 2020). Bharath Manikanda and others. Leakage of primary MPs from industry or personal care products, MP movement in rivers, precipitation-induced runoff, and dry deposition are possible additional contributory factors. The MP experiments were focused on the sediment and surface water sections of Indian lakes. Vembanad Lake's aquatic life may also be threatened by microplastic contamination. For fish and marine invertebrates, ingesting MPs has been shown to have detrimental physiological effects (Browne et al., 2013; Cole et al., 2013; Rochman et al., 2013a, b; Rochman, 2015). Despite reports of MP consumption by fish and freshwater invertebrates (Imhof et al., 2013; Sanchez et al., 2014), nothing is known about the harmful effects of MPs (Wagner et al., 2014; Anderson et al., 2016). When MP are consumed by zooplankton and benthic animals, it can have more detrimental effects since it can contaminate the remaining food chain (Green, 2016; Lonnstedt and Eklov, 2016). The black clam, Villorita cyprinoides, and other clam species, including Paphia malabarica and Sunetta scripta, are abundant in Vembanad Lake. Every year, 31,650 tons of clams are harvested from the lake (Kripa et al., 2004) for local consumption. Prawns, crabs, and fish are also common foods in the area, therefore eating plastics and their byproducts may have negative health effects. Due to the large number of water birds that frequent this lake, MPs may be transported from the lake to terrestrial habitats by bird scat.

Rivers:
According to Wagner et al. (2014), rivers and other recognized land transit pathways account for an astounding 80% of all plastic rubbish found in marine ecosystems. The Ganges, Brahmaputra, and Meghna rivers are estimated to discharge one to three billion MPs into the Bay of Bengal daily, citing a recent study by Napper et al. (2021). Nevertheless, some MPs from rivers do accumulate in their sediments, which can act as a significant MP sink, even though they may not all reach the oceans (Sruthy and Ramasamy 2017; He et al. 2020). There is an issue with global river water contamination.

Microplastic Hazard
They found that polyvinyl chloride, polypropylene, polyethylene, polyamides, and polyformaldehyde could absorb lead, copper, and cadmium; additionally, they found that these heavy metals had a higher absorbance on PVC and PP particles than on PA, PE, and POM. Xu et al. (2021) found that mixed exposure was associated with microplastic concentration in survival, body length, and heart rate, even

though they did not find any fatal consequences in their mixed toxicity test utilizing zebrafish (Danio rerio) and microplastics. This may be supported by research by Lu et al. (2018), which discovered that microplastics increase cadmium accumulation in zebrafish liver, gut, and gills and cause oxidative damage and inflammation. Yang et al. (2020) have showed that Chlorella pyrenoidosa displays antagonistic behavior when coupled with microplastics and nonylphenol. It's crucial to remember that prolonged exposure to smaller-sized plastics may exacerbate their effects on algal development, even if the consequences of combined toxicity can vary. Stock et al. conducted in vivo research on mice and in vitro experiments using human cells (2019). Oxidative stress response in male mice indicated an effect on intestinal immune cells. However, no histological lesions were discovered. Experiments using cells have shown that they are capable of absorbing small particles.

The study did discover that mammal health was not significantly harmed by oral exposure to microplastics. Wang et al. (2020) investigated the effects of microplastics on human Caco-2 cells and discovered that nanoscale microplastics may increase cytotoxicity. It was found that the division, integrity, and survival of cell membranes were all impacted by bisphenol A (BPA). Pop et al. (2021) concluded that BPA affected water microorganisms' levels of chlorophyll either directly or indirectly. Bhatnagar and Anastopoulos (2016) claim that BPA was a notable unprocessed chemical that was used as an endocrine disruptor. Wang and Qian (2021) claim that phthalates negatively affect the endocrine system and other organ functions, especially those connected to the reproductive system, pregnancy, and the growth and development of children. Because there are so few experimental studies on the metabolism of microplastics in the human body, care must be used when interpreting the results. Additionally, a ton of research studies on toxicity have been released recently.

These research investigate the harmful effects of microplastics using cell lines and species.Numerous studies have been conducted recently on the danger of microplastics in ecosystems. Adam et al. (2019) determined the predicted-no-effect concentration (PNEC) as the fifth percentile of the probabilistic species sensitivity distribution based on 53 values from 14 freshwater species. They found that ecological risks cannot be totally eliminated in Asia, where 0.4% of the RCR values were above 1. Besseling et al. (2019) report that preliminary risk assessments were carried out for every species of freshwater, estuary water, and seawater. After 168 toxicity data from 66 studies were analyzed, the HC5 (Hazardous Concentration for 5% of the Species) value in this study was determined to be 2.0 ng/L.

Conclusion

Because plastic takes a long time to decompose, contamination from plastic has led to environmental degradation on a global scale as plastic production has increased. As a result, microplastic pollution is growing in importance on a global scale, yet researchers are still lacking in tools for monitoring, toxicity, analysis, and removal. Thus, the distribution, toxicity, analysis technique, and removal technologies of microplastics were studied in this research, and the findings were summarized as follows. High-contamination microplastics were identified as PET, PU, PS, PVC, PP, PE, and PA. . Microplastics are contaminated by a variety of sources, including road runoff, industrial and agricultural wastewater, litter, sewage treatment plants, household personal goods, decomposing atmosphere, and fishing trash. Eventually, these pollutants find their way into the ocean, where they contaminate marine life and are eventually consumed by humans. . Microplastic contamination is becoming more and more widespread worldwide, showing up in rivers, seas, drinking water, sewage water, soil, and other places. In conclusion, microplastics will soon become a major issue. . Plastics like PS, PVC, PP, and others may still pose health risks to people even though their toxicity has not received much attention. Consequently, a number of studies are looking at the possibility of microplastics.

References:

De Sá, Luís Carlos et al. 2018. “Studies of the Effects of Microplastics on Aquatic Organisms: What Do We Know and Where Should We Focus Our Efforts in the Future?” Science of The Total Environment 645: 1029–39.

Deanin, R. D. 1975. “Additives in Plastics.” Environmental Health Perspectives 11: 35–39.

Gong, Xiaomin et al. 2023. “Micro- and Nano-Plastics Pollution and Its Potential Remediation Pathway by Phytoremediation.” Planta 257(2): 35.

Hahladakis, John N., and Eleni Iacovidou. 2018. “Closing the Loop on Plastic Packaging Materials: What Is Quality and How Does It Affect Their Circularity?” Science of The Total Environment 630: 1394–1400.

Horton, Alice A. et al. 2017. “Microplastics in Freshwater and Terrestrial Environments: Evaluating the Current Understanding to Identify the Knowledge Gaps and Future Research Priorities.” Science of The Total Environment 586: 127–41.

Horton, Alice A., and Simon J. Dixon. 2018. “Microplastics: An Introduction to Environmental Transport Processes.” WIREs Water 5(2): e1268.

James, Keziya et al. 2022. “Microplastics in the Environment and in Commercially Significant Fishes of Mud Banks, an Ephemeral Ecosystem Formed along the Southwest Coast of India.” Environmental Research 204: 112351.

Jiang, Jia-Qian. 2018. “Occurrence of Microplastics and Its Pollution in the Environment: A Review.” Sustainable Production and Consumption 13: 16–23.

Jovanović, Boris. 2017. “Ingestion of Microplastics by Fish and Its Potential Consequences from a Physical Perspective: Potential Consequences of Fish Ingestion of Microplastic.” Integrated Environmental Assessment and Management 13(3): 510–15.

Kidder, G. W., and C. W. Montgomery. 1975. “Oxygenation of Frog Gastric Mucosa in Vitro.” The American Journal of Physiology 229(6): 1510–13.

Laxmi R, Venu Naganulu. 2023. “Microplastic Contamination: A Case Study in the Freshwater of Krishna River.” https://zenodo.org/record/7809089 (October 3, 2023).

Li, Xianxu et al. 2022. “Ecotoxicological Response of Zebrafish Liver (Danio Rerio) Induced by Di-(2-Ethylhexyl) Phthalate.” Ecological Indicators 143: 109388.

Lu, Kai, Ruxia Qiao, Hao An, and Yan Zhang. 2018. “Influence of Microplastics on the Accumulation and Chronic Toxic Effects of Cadmium in Zebrafish (Danio Rerio).” Chemosphere 202: 514–20.

Napper, Imogen E. et al. 2021. “The Abundance and Characteristics of Microplastics in Surface Water in the Transboundary Ganges River.” Environmental Pollution 274: 116348.

Pannetier, Pauline et al. 2020. “Environmental Samples of Microplastics Induce Significant Toxic Effects in Fish Larvae.” Environment International 134: 105047.

Shen, Maocai et al. 2019. “Can Biotechnology Strategies Effectively Manage Environmental (Micro)Plastics?” Science of The Total Environment 697: 134200.

Vaid, Mansi, Komal Mehra, and Anshu Gupta. 2021. “Microplastics as Contaminants in Indian Environment: A Review.” Environmental Science and Pollution Research 28(48): 68025–52.

Van Cauwenberghe, Lisbeth, and Colin R. Janssen. 2014. “Microplastics in Bivalves Cultured for Human Consumption.” Environmental Pollution 193: 65–70.

Vermaire, Jesse C. et al. 2017. “Microplastic Abundance and Distribution in the Open Water and Sediment of the Ottawa River, Canada, and Its Tributaries” ed. Daniel E. Schindler. FACETS 2(1): 301–14.

Wang, Jundong et al. 2016. “The Behaviors of Microplastics in the Marine Environment.” Marine Environmental Resea.