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Microplastics in waters of Bhoj Wetland: implication and solution

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Abstract

The aim of the present investigation was to find out the presence of microplastics in Bhoj Wetland, a Ramsar site in Central India. The water samples were collected during September, 2023 to November, 2024. The wet peroxide oxidation (WPO) and density separation method were used to assess the microplastics in surface water sample. The samples were examined under microscope and photography was done. Microplastics were visually classified on the basis of colour and shape. The results showed that highest amount of microplastics was found at Talliya Road (LL) 19.65% and Masjid Lal Imli (UL) 19.28% water samples while the central zone (controls) of both the lakes showed lowest concentrations 1.3% in UL and 0.38% in LL respectively. The fiber and fragment type particles were the most prevalent as identified during investigation in Bhoj Wetland. The presence of MPs in Bhoj wetland was due to tourists carrying packaged food, plastics as packaging material and various types of anthropogenic activity. Thus, it is necessary to put pause on anthropogenic activities near the water bodies and pay attention to public awareness, ecotourism, sustainable lifestyle and stringent laws and regulations, if required, to reduce the usage of plastics.

Keywords: Microplastics, Bhoj wetland, Ramsar site, water quality

Introduction

Microplastics (MPs) are tiny pieces of plastic that are less than 5 mm in size. Microplastics were initially discovered in the environment in the 1970s (Carpenter and Smith, 1972 and Wong *et al*., 1974). Microplastics have been widely found in the land, freshwater, and marine environments and, in animals and humans in recent years. The concern for microplastics contamination is growing, and it is the second significant scientific concern in the subject of ecology and environment. The publications regarding microplastics pollution have been rapidly growing in recent years, particularly since, 2014. Furthermore, varieties of animal *viz*., small fish, crustaceans, coastal crabs, filter-feeding bivalves ingest microplastics present in water. Microplastics can go up to the food chain from the basic trophic level, such as phytoplankton and zooplankton, to the fish and to the humans at top trophic level (He *et al.*, 2018).

The plastics enter the aquatic ecosystem via surface runoff from the terrestrial ecosystem that undergo mechanical abrasion, degradation, oxidation and gradually break into minute particles >5mm and are termed as macroplastics and particles <5 mm are microplastics. These microplastics are not easily detectable and distinguishable from the water. They enter food chain *via* zooplankton to fish and to man.

Microplastics are also divided into two type *viz.*, primary and secondary microplastics. The primary microplastics are purposefully included in consumer and industry-related products such cosmetics, pharmaceuticals, paints, pesticides, nappies, and detergents (Duis and Coors, 2016). Further, there are physical, chemical, and biological variables that can cause the breakdown of bigger polymers, such as tyre debris, which can result in the unintentional formation of microplastics, these microplastics are referred to as secondary microplastics (Andrady, 2017). There are five main categories of microplastics fibers, fragment, foam, pellets, and films (Anderson *et al*., 2017). Polymer is an inexpensive, strong, lightweight, and pliable material. It can be applied to almost any number of situations (Boucher and Friot, 2017). According to their chemical composition, microplastics can also be divided into six groups, as polyethylene, polystyrene, polypropylene, polyurethane, polyvinyl chloride, and polyethylene terephthalate (He *et al.*, 2018).

These particles are believed to enter the food chain and may ultimately be consumed by humans, as some evidence of tropic transfer has been reported. As a result, a lot of study has been done on the possibility of microplastic contamination in fisheries and aquaculture products. Other food commodities such as table salt, sugar, honey, beer, water, edible fruits and vegetables have also been reported to contain microplastics (Gamarro and Costanzo, 2022).

When these microplastics get into the environment, especially aquatic ecosystems, they cause risk to ecosystems and other life forms. They also contribute to environmental contamination and human health. Regulatory actions, product restrictions, and technological advancements targeted at creating substitute materials and production techniques are all part of the effort to lessen the release of primary microplastics into the environment (Cole *et al.*, 2011).

MPs contain organic and inorganic contaminants, including heavy metals. Their harmful effects cannot be neglected. These MPs increase the chance of toxicity by acting as vectors for both organic and inorganic hazardous contaminants. These MPs absorbed and released heavy metals through living organs, including the digestive tract, where adsorption is facilitated by a low pH environment (Khalid *et al.*, 2021).

The impact of microplastics on environmental condition, human health consequence, damaged gill function, decreased feeding intensity, immune suppression, impaired reproducibility, fish weight, season, pattern of development, degree of stomach fullness, sexual category, size range, and physical condition are also being affected (Hassan *et al.*, 2022).

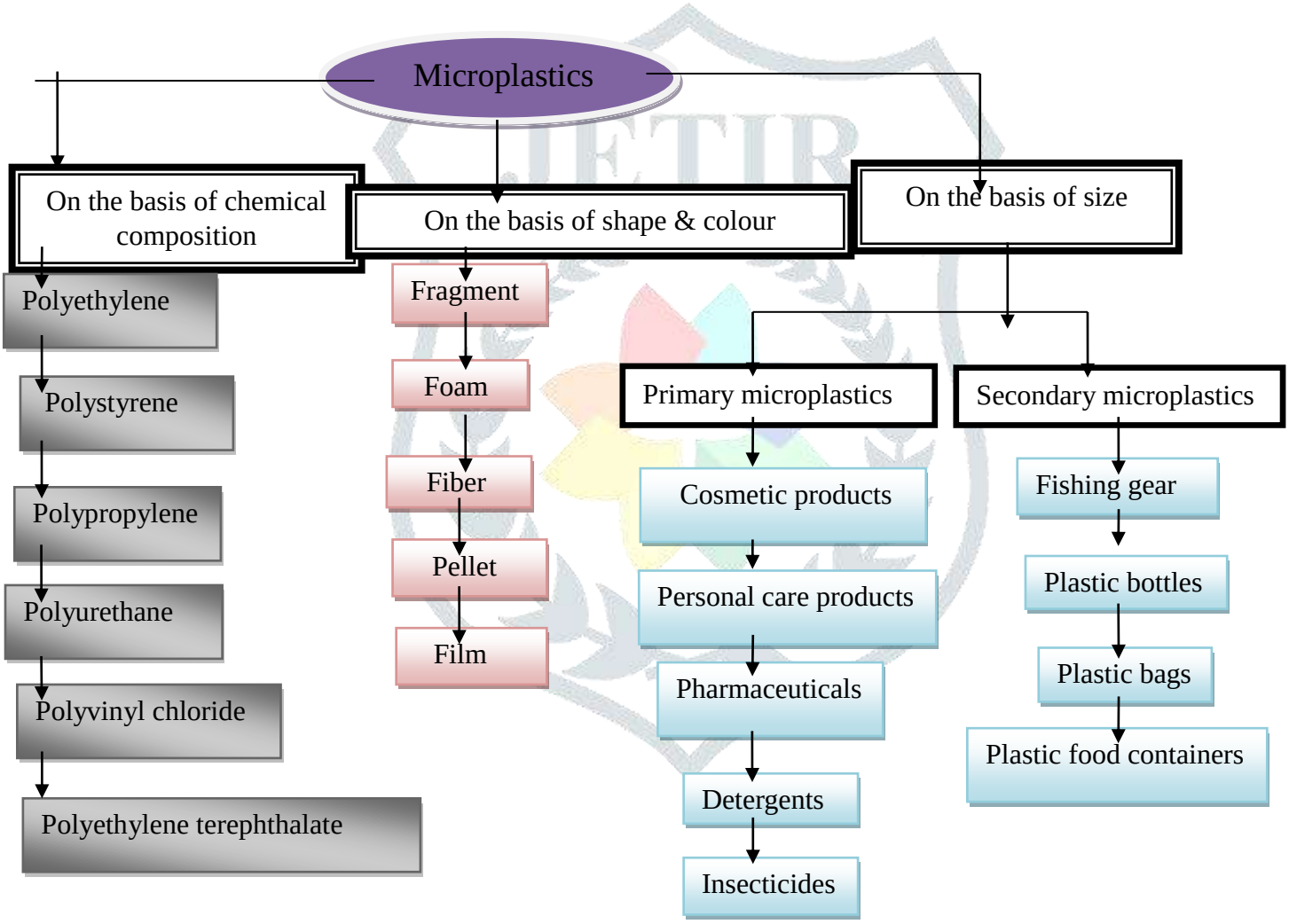

Fig.1 Types of microplastics based on chemical composition, shape, colour and size (Osman *et al.*, 2023)

Material and Methods

Study area

The present study was conducted in Bhoj wetland which is comprised of two lakes; Upper Lake and Lower Lake. They altogether designated as Ramsar site in 2002 which makes it imperative to study presence of microplastics in water as many species including fishes and migratory birds finds their food and habitat in Bhoj wetland. The microplastics may reach their body *via* digestive tract and enter the food chain.

The Lower Lake is situated to the east of Upper Lake and is the separated by an earthen dam. Because the two lakes are sloped, the Upper Lake's lowest level is slightly lower than the Lower Lake's maximum level. At its downstream the Lower Lake is situated.

The surface area of Upper Lake is 36 square kilometres and catchment area is 361 square kilometres and depth of approx. 8 meters. It is also known as Bada Talab in local population and is located between 23°12' - 23°16' N and 77°18' - 77°23' E. The Upper Lake is the

major source of drinking water for the population of Bhopal city. It is also one of the major excursion sites for the visitors, which forms major source of microplastics in Upper Lake. It is home to a wide variety of wildlife, including migratory and resident birds, insects, reptiles, amphibians, macrophytes, phytoplankton, and zooplankton.

The lower lake is geographically located between 23° 12' 0" and 77° 18' 0". The Lower Lake is contaminated due to sewage across the city is dumped in it. Water has become contaminated by soap, caustic soda, detergents, and other chemicals as a result of the proliferation of washing bays and laundry houses nearby and is important to analyze sample for microplastics in water and human waste as well.

During the study, five sampling sites were selected in Upper Lake (UL) and four sites were selected in Lower Lake (LL) for the collection of water sample to analyze presence of microplastics in water of Bhoj Wetland. The details of sampling sites are given below in Table 1.

Table 1 Sampling sites for assessment of microplastics in Bhoj Wetland

SN	Name of Site	Geographical location	Anthropogenic activity details
	Upper Lake (UL)		
1	Boat Club	23.243032° and 77.381372°	Excursion, hotels, café, boating
2	Van Vihar	23.241752° and 77.375708°	Agriculture, fishing
3	Masjid Lal Imli	23.255251° and 77.397038°	Fishing, sewage
4	Sheetal Das ki Bagiya	23.250697° and 77.39547°	Religious offerings, washing of clothes
5	Central Zone (control)	23.249486° and 77.341203°	No anthropogenic activity, maximum depth
	Lower Lake (LL)		
6	Sultania Road	23.254306° and 77.40913°	Religious offerings
7	Talliya Road	23.253672° and 77.408705°	Fishing, sewage
8	Jahagirabad	23.245193° and 77.407977°	Sewage
9	Central zone (control)	23.248338° and 77.406961°	No anthropogenic activity, maximum depth

Fig.2 Map showing study area

Methodology

A total of 9 samples (n=9) were collected from September, 2023 to November, 2024. The plankton net was deployed thrice and fixed at a position for 1 hour and then removed from the water body and rinsed many times with lake water. The collected material was placed directly into a 250 ml glass jar from the net. The sample is placed in hot air oven for 24 hrs.

Sample preparatory steps

For the digestion of organic material, the water samples using hydrogen peroxide (30%) and 30 ml of Fenton's reagent (an acidic solution of Ferrous sulphate) is taken in beaker and kept on water bath at 75 °C until the digestion of the organic content is done. After digestion, MPs were separated using a high NaCl density solution (Briggs *et al.*, 2019).

Identification and classification of MPs

After drying, the solid material was collected on filter paper and examined under microscope for microplastics and photographs were taken. Hot needle test was performed on each sample to determine the nature of plastic particles. The MPs were classified based on their morphology (fragments, fibers, foams, films) and colour (black, white, transparent, blue, yellow, red, green, and other hues) (Bilal *et al.*, 2022).

Quality assurance and control for sample analysis

All the precautionary measures were taken to avoid equipment and laboratories contamination. To prevent cross-contamination, a specific area of the lab was utilized for MPs samples. The non-plastic packaging materials, such as wood, glass or aluminum containers were used while handling samples. To prevent airborne contamination microplastic samples were holds on sterile surface under laminar flow and covered with clean lids. All equipment were sterilized before use. The non-plastic brushes and non-shedding wipes were used to clean the equipment. To prevent the shedding of synthetic materials that could contaminate samples wear gloves, face masks, and non-synthetic lab coats made of natural fibers (like cotton). Before handling any samples or equipment, thoroughly wash hands to prevent the contamination. To avoid exposure to synthetic particles in the air, samples should be kept in hygienic, non-plastic containers (such as glass) with lids. Minimize the exposure time of the samples to the open air or in areas where microplastic samples can be contaminated from any synthetic fibers, polyester clothes or carpeting.

Results and discussion

The processes *viz.*, chemical degradation and mechanical abrasion are important factors in the breakdown of plastics into microplastics entering into the air, soil and water (Zhang *et al.*, 2020). During the study, the highest concentration 19.65% of MPs was observed in Talliya Road (LL) and 19.28% in Masjid Lal Imli (UL) during summer while the central zone (controls) of both the lakes showed lowest concentrations 1.3% and 0.3% in UL and LL respectively during monsoon ascribed to the dilution factor. Talliya Road (LL) and Masjid Lal Imli (UL) of Bhoj wetland water contains domestic waste which forms the source for MPs *viz.*, synthetic fibers from fabrics like polyester, nylon, and acrylic (Bilal *et al.*, 2022). Furthermore, microbeads are microscopic plastic particles used in many cosmetic products including toothpaste that contribute to microplastics contamination in lakes (Anderson *et al.*, 2017).

As discussed earlier, these lakes are prominent tourist sites for the local population and tourists. The sites like Sheetal Das ki Bagiya (UL) and Sultania Road are visited for religious offerings and fishing respectively whilst Boat Club (UL) is known for excursion. During the study, the percentage of MPs in Sheetal Das ki Bagiya (UL) is 18.7% in summer, 11.45% in Boat Club and 16.7% in Sultania Road (LL) accredited to packaged food items, plastic wrappers, plastic bags, disposables and other plastic wastes that are left behind by the visitors which contributes to microplastic in the lake (Napper *et al.*, 2020).

Jehagirabad (LL) reported 8.6% MPs from fishing nets and plastic wastes that is being discarded into the lake by fisherman and the local people (Jin *et al.*, 2022). The results showed that like marine ecosystem, the freshwater aquatic ecosystems are also getting affected by MPs due to plastic bags, plastic packaging material, plastic in cosmetics, and anthropogenic activities. These plastics reach freshwater ecosystem *via* tourist who visits these serene water bodies and carry plastic (Bilal *et al.*, 2022). The plastic reach water bodies and as time proceeds they start degrading in the water as microplastics (Napper *et al.*, 2020; Jin *et al.*, 2022).

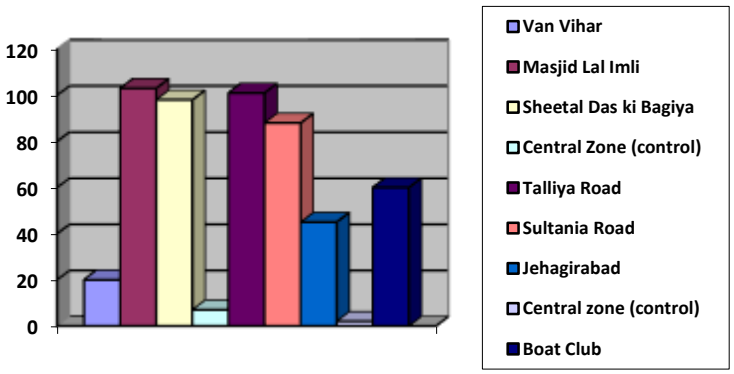

Fig.3 Graphical presentation of MPs in Bhoj Wetland

Physical characteristics of the detected MPs

In order to evaluate the microplastics pollution status in Bhoj Wetland, the physical characteristic (shape and colour of the microplastics) of the identified MPs were examined as per prescribed classification (Saad *et al.*, 2024).

Color

During the present investigation, black, red and white were the most common colors, making upto 42%, 21%, and 23% respectively of the total MPs. The minor percentages of other colours, such as yellow, brown were also noted which made 14% of the total MPs recorded during the study (Saad *et al.*, 2024).

Shape

During the present study, MPs were identified under stereomicroscope and categorized on the basis of their physical appearance. The round particles were categorized as pellets; irregular particles as fragments and; particles with a slender, elongated look as fibers (Saad *et al.*, 2024). During the investigation, fibers dominated comprised of 52% followed by fragments 28.62%, film 10.3% and foam 8.9%. MPs of different shapes have different periods of retention and cause various physical injuries which can have different toxicological effects animal body (Gray and Weinstein, 2017).

In the present investigation, the higher percentages of fibers were reported from Masjid Lal Imli (UL) and lowest percentage was in central zone (LL). The higher percentages of fragments were reported from Talliya Road (LL) and lowest percentage was in central zone (LL). The higher percentages of film were reported from Boat Club and lowest percentage was in Central Zone of Upper Lake and Lower Lake. The higher percentages of foam were reported from Boat Club and lowest percentage was in Central Zone of Upper Lake and Lower Lake.

During the survey, the fibers dominate the urban atmosphere due to the growing amount of synthetic fiber generated from clothing, upholstery, or carpet which gets deposited into water body by washing, cleaning and household drainage (McCormick *et al.*, 2016; McGoran *et al.*, 2017). The fibers infiltrate aquatic habitats through aerosols produced by atmospheric precipitation and improper sewage and textile-related product disposal (Collard *et al.*, 2019). Fiber and fragment are mostly reported microplastics in freshwater bodies (Jian *et al.*, 2020; Scherer *et al.*, 2020; Zhang *et al.*, 2019; Mason *et al.*, 2016).

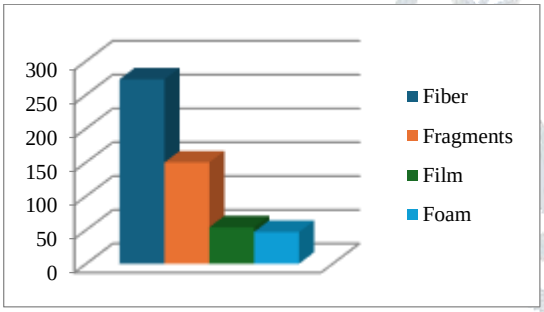

Fig.4 Graphical presentation of MPs on the basis of shape

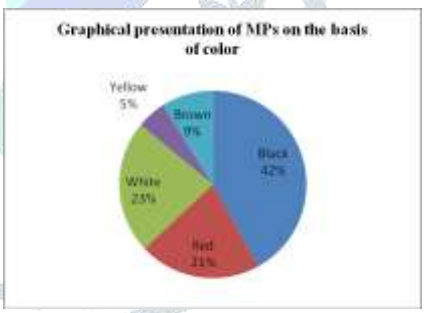

Fig.5 Graphical presentation of MPs on the basis of color

Conclusion

It was concluded that the fibers were found in significant amounts in the total samples based on MP types in Bhoj wetland. An increased MPs pollution is caused by the massive influx of tourists. The mass awareness plays an important role in reducing formation of microplastic caused due to tourism. It is highly recommended to launch an awareness initiative to inform visitors and the local population about the impacts of plastics on lakes and to administer rules strictly. As compare to other months, April (summer) had noticeably higher abundance of microplastics and lower in September (monsoon) during the study. The quantities of microplastics in water bodies are diluted by increased rainfall during the rainy season (Wang *et al* 2021). The dry season on the other hand results in less dilution and higher relative concentrations of microplastics in water bodies (Wu *et al.*, 2020; Wicaksono *et al.*, 2021).

During the investigation, any pellet-type microplastics were not reported from any of the sites. Many variables, including location, environmental influences, and analytical limitations, could be the cause for its absence. However, the study suggests that MPs in Bhoj wetland are from the domestic waste and anthropogenic pressure near the site and, industrial or cosmetic items are not manufactured in the catchment area of the Bhoj Wetland. The detailed research on size, type of MPs and how microplastics entering sediments and fish biodiversity of Bhoj Wetland is ongoing and will be published in next articles.

(a) (b) (c) (d) (e)

Fig.6 Microscopic images of identified MPs as fiber (a, b, c, d) and fragment (e)

References

Anderson, S. F., Kelley, K., & Maxwell, S. E. (2017). Sample-size planning for more accurate statistical power: A method adjusting sample effect sizes for publication bias and uncertainty. Psychological science, 28(11), 1547-1562.

Andrady, A. L. (2017). The plastic in microplastics: A review. Marine pollution bulletin, 119(1), 12-22.

Bilal, M., Ul Hassan, H., Siddique, M. A. M., Khan, W., Gabol, K., Ullah, I., ... & Arai, T. (2022). Microplastics in the surface water and gastrointestinal tract of Salmo trutta from the Mahodand Lake, Kalam Swat in Pakistan. Toxics, 11(1), 3.

Briggs, E., de Moura, E. A., Furusawa, H. A., Cotrim, M. E., Oguzie, E. E., & Lugao, A. B. (2019). Microplastics: a novel method for surface water sampling and sample extraction in Elechi Creek, Rivers State, Nigeria. In Characterization of Minerals, Metals, and Materials 2019 (pp. 269-281). Springer International Publishing.

Carpenter, E. J., & Smith Jr, K. L. (1972). Plastics on the Sargasso Sea surface. Science, 175(4027), 1240-1241.dui.

Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. *Marine pollution bulletin*, *62*(12): 2588-2597.

Collard, F., Gasperi, J., Gabrielsen, G. W., & Tassin, B. (2019). Plastic particle ingestion by wild freshwater fish: a critical review. Environmental Science & Technology, 53(22), 12974-12988.

Duis, K., & Coors, A. (2016). Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. Environmental Sciences Europe, 28(1), 2.

Garrido Gamarro, E., and Constanzo, V. (2022). Microplastics in food commodities: A food safety review on human exposure through dietary source.

Gray, A. D., & Weinstein, J. E. (2017). Size-and shape-dependent effects of microplastic particles on adult daggerblade grass shrimp (Palaemonetes pugio). Environmental toxicology and chemistry, 36(11), 3074-3080.

He, D., Luo, Y., Lu, S., Liu, M., Song, Y., & Lei, L. (2018). Microplastics in soils: Analytical methods, pollution characteristics and ecological risks. TrAC Trends in Analytical Chemistry, 109, 163-172.

Jin, T., Tang, J., Lyu, H., Wang, L., Gillmore, A. B., & Schaeffer, S. M. (2022). Activities of microplastics (MPs) in agricultural soil: a review of MPs pollution from the perspective of agricultural ecosystems. Journal of Agricultural and Food Chemistry, 70(14), 4182-4201.

Khalid, N., Aqeel, M., Noman, A., Khan, S. M., & Akhter, N. (2021). Interactions and effects of microplastics with heavy metals in aquatic and terrestrial environments. Environmental Pollution, 290, 118104.

McCormick, A. R., Hoellein, T. J., London, M. G., Hittie, J., Scott, J. W., & Kelly, J. J. (2016). Microplastic in surface waters of urban rivers: concentration, sources, and associated bacterial assemblages. Ecosphere, 7(11), e01556.

McGoran, A. R., Clark, P. F., & Morritt, D. J. E. P. (2017). Presence of microplastic in the digestive tracts of European flounder, Platichthys flesus, and European smelt, Osmerus eperlanus, from the River Thames. Environmental Pollution, 220, 744-751.

Osman, A. I., Hosny, M., Eltaweil, A. S., Omar, S., Elgarahy, A. M., Farghali, M., ... & Akinyede, K. A. (2023). Microplastic sources, formation, toxicity and remediation: a review. *Environmental Chemistry Letters*, *21*(4), 2129-2169.

Saad, D., Ndlovu, M., Ramaremisa, G., Tutu, H., & Sillanpää, M. (2024). Characteristics of microplastics in sediment of the Vaal River, South Africa: implications on bioavailability and toxicity. International Journal of Environmental Science and Technology, 21(1), 43-50.

Wang, G., Lu, J., Li, W., Ning, J., Zhou, L., Tong, Y., ... & Xiayihazi, N. (2021). Seasonal variation and risk assessment of microplastics in surface water of the Manas River Basin, China. Ecotoxicology and environmental safety, 208, 111477.

Wicaksono, E. A., Werorilangi, S., Galloway, T. S., & Tahir, A. (2021). Distribution and seasonal variation of microplastics in tallo river, makassar, eastern indonesia. Toxics, 9(6), 129.

Wong, C. S., Green, D. R., & Cretney, W. J. (1974). Quantitative tar and plastic waste distributions in the Pacific Ocean. Nature, 247(5435), 30-3

Wu, P., Tang, Y., Dang, M., Wang, S., Jin, H., Liu, Y., ... & Cai, Z. (2020). Spatial-temporal distribution of microplastics in surface water and sediments of Maozhou River within Guangdong-Hong Kong-Macao Greater Bay Area. Science of the total environment, 717, 135187.

Zhang, Y., Kang, S., Allen, S., Allen, D., Gao, T., & Sillanpää, M. (2020). Atmospheric microplastics: A review on current status and perspectives. Earth-Science Reviews, 203, 103118.

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