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A study on microplastic contamination in selected riverbank soil sample

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ABSTRACT

Abstract: The increasing use of plastic and improper disposal practices have led to microplastic contamination in various ecosystems, especially freshwater bodies. This study aims to investigate the occurrence, distribution, and characterization of microplastics in the sediment samples collected from riverbanks of nine different freshwater sites, Karnataka, India. Samples were collected from 10cm depth to assess vertical distribution and potential accumulation trends. The extraction process involved drying, sieving, density separation using NaCl solution, organic matter removal via wet peroxide oxidation, and microscopic visual sorting to quantify microplastic particles. The results revealed widespread presence of microplastics across all sites, with highest abundance found in Kabini River (Nanjangud) and the lowest in Kabini River (Sargur) and Cauvery River (KR Pete). Microplastic particles were primarily in fibrous, filament, fragment and film -like forms, varying in length and color. The findings suggest that human activities such as tourism, agriculture, domestic discharge, and religious rituals significantly contribute to microplastic pollution. The study underscores the effectiveness of simple, cost-efficient methods for microplastic extraction and highlights the critical need for standardized sampling protocols. Moreover, it emphasizes the importance of regular monitoring of riverbank sediments and promotes awareness towards plastic pollution in freshwater systems to aid in conservation and pollution mitigation strategies.

1. Introduction

Plastic production has increased rapidly since the start of large-scale plastic manufacturing in the1950s due to its versatility, low cost, and durability. Global plastics production doubled from 2000 to 2019 to reach 460 million tons with only 9% recycled, 12% incinerated, and the remaining left in the environment or landfills. Global studies on plastic production and transportation estimated that the annual river sourced contribution of plastic waste to oceans ranged from 0.41 to more than 8 million tons per year (Geyer et al., 2017; Meijer et al., 2021).

Plastics can be flexible, inexpensive, lightweight, robust and waterproof and act as insulators. They Are not biodegradable, but some are biodegradable and can be decomposed by hydrolysis or by the action of Microbes or in the occurrence of ultraviolet (UV) light. They can be classified as microplastics (1× 10－3 m to<5× 10－3m), Microplastics (5× 10－3 m to<25× 10－3 m) and macro plastics (⩾25× 10－3 m). The use of plastic is increasing with the increase in the population and is regularly used in different types of industries like packaging, electrical, sports, automotive, construction, cosmetics, water treatment plants, etc. Plastics are of two types: thermoset and thermoplastics. Thermoset plastics cannot be recycled, for example, Polyurethane (used inpillows, insulating foams, building insulation, etc.); some polyesters; epoxy resins and some acrylic resins (Bhardwaj et al., 2024).

Some plastics comprise prooxidants that encourage fragmentation and have the potential to form microplastics. Microplastics have largely been an overlooked part of plastic pollution. Microplastics are naturally Hydrophobic and can go into the freshwater environment through treated and untreated sewage effluent of, surface run-of, air deposition, industrial effluent and tainted plastic trash. They are in synthetic clothing, cosmetics and even plastic shopping bags. They have been reported in food, air, beer and tap water. They have been pervasive in the environment for an extensive time and can be swallowed by biota due to their utility, stability and degradation resistance (Hartmann et al., 2019). Microplastics can enter tap and bottled water from the water distribution systems. They are present in dust particles and may be a source of air pollution. They differ in size, type, color and density and their physical appearances are strongly related to their fate, toxicity and source (Bhutto & You 2022). The length of these particles is smaller than 5×10–3 m. If the length is less than 1× 10–6 m then they are termed Nano plastics. They have been categorized into six groups: fragments, pellets, microbeads, fibers, films and foam (Anderson et al., 2017).

Microplastic pollution is a complex environmental issue with multiple mechanisms contributing to its presence in water bodies. Microplastics are distributed in the water column, and the distribution is dependent on their properties, such as size, shape, density and adsorption of chemicals. The distribution of microplastics is also dependent on environmental conditions such as water density, wind, currents and waves. Polymeric elements from cleaning and cosmetic goods, feedstocks used in the production of plastic goods and plastic powders used for air blasting are the principal sources of microplastics (Jiang 2018). According to Morritt et al., (2014). Drinking water production, distribution and wastewater effluent, atmospheric deposition, industrial effluent and run-off from land-based sources are the different major sources of microplastics in freshwater environments (Cesa et al., 2017).

The use of plastics is a major threat to the freshwater environment (Sarijan et al., 2021). The existence of micro-plastics in freshwater environments is harmful to the health of organisms. This threat exists due to the size, surface characteristics and adsorption of chemicals on the surface of microplastics. The health impacts, fate and transport of microplastics are not being studied thoroughly yet. However, the presence of microplastics in bottled water, tap water and the digestive system of the various invertebrates of freshwater have been reported (Kosuth et al., 2018). Microplastics with low density ($<1.0\times103$ kg/m^3) keep floating on the water surface and are consumed by filter-feeding invertebrates (e.g. Daphnia magna) and carnivorous fish (e.g. Culter dabryi and Culter alburnus) while microplastics with high density ($>1.0\times10^3$ kg/m^3) may suspend in the water column and are consumed by omnivorous fish (e.g. Sinibrama Wui). After exposure to polyvinylchloride or polyethylene, the immune system of fish can be destroyed due to oxidative stress in the leukocytes. Local human activities are the major causes of the accumulation of microplastics in the muscles of fish (Akhbarizadeh et al., 2018). Reduced growth, variation in oxygen (O2) consumption, a limited feeding capability, a decreased lifespan and amplified antioxidant-related enzyme action have been reported after the ingestion of microplastics (Windsor et al.,2019). Due to the low feeding capacity of food, less energy is produced to carry out life functions resulting in reproductive and neurological toxicity. Microplastics affect aquatic organisms for several generations due to their slow degradation and stability and affect the photodegradation of organic mixtures and the poisonousness of metal ions. (Akhbarizadeh et al., 2018).

2. Materials and Methodology

Soil samples were collected from riverbank of nine different locations of five riverbanks, viz., Cauvery River (Site 1-Srirangapattana, Site 2- Bannur, Site 3- KR Nagara, Site 4- Kannambadi), Kabini river (Site 5-Nanjangud, Site 6-Sargur), Hemavati River (Site 7-Holenarsipura), Lakshmanatheertha (Site 8-Hunsur), Lokapavani river (Site 9-KR Pete).

Sample collection

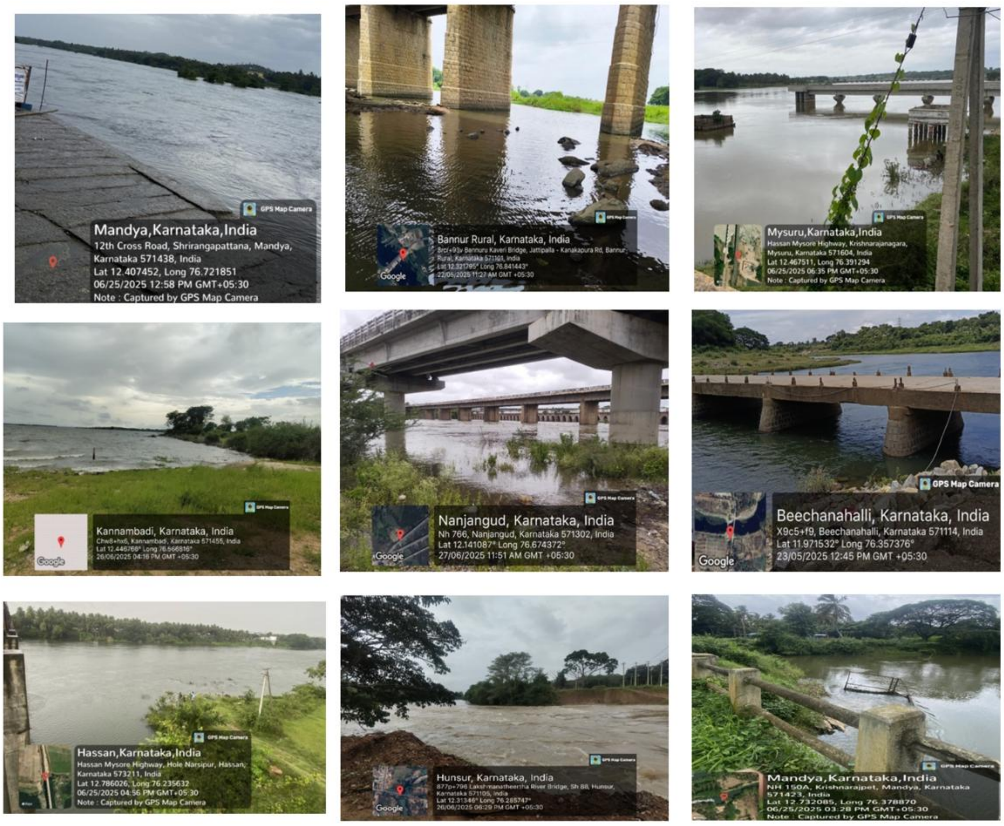


Plate 1: Sites of collection of soil samples from different riverbanks (Sites1-9)

The Riverbank soil samples were collected from 10cm depth vertically and were brought to the laboratory for analysis.

Sample analysis

1) Drying the Riverbank soil sample:

A clean and dry 1000-mL beaker was weighed and labelled appropriately. 250 g of wet sample was transferred to the beaker and covered using Aluminum foil. Dried in a drying oven at 90°C overnight or until sample dryness.

2) Sieving

The sample was poured through 1cm and 0.5cm, allow particles smaller than 0.5cm (5mm). Any visible material > 0.5cm was removed with forceps. Ensured that all solids are transferred to the beaker.

3) Density Separation

300 mL of aqueous NaCl (d=1.6 g/mL) solution was added to the dried soils in the beaker containing sieved samples. The sand-water mixture was vigorously stirred in the beaker for several minutes with a spatula to float out the microplastics. All floating solids in the beaker were transferred to the custom 0.3 cm sieve. A clean and dry 500-ml beaker to the nearest 0.1 mg was labelled. The solids collected on the 0.3cm sieve transferred into tared 500-mL beaker using spatula and minimal rinsing with a squirt bottle containing distilled water. The beaker and solids were dried in a drying oven at 90° C for 24 hours or longer to sample dryness.

4) Wet Peroxide Oxidation (WPO):

20 mL of aqueous 0.05 M Fe (II) solution was added to the beaker containing collected solids. 20 mL of 30% hydrogen peroxide was added. Allowed the mixture to stand on lab bench at room temperature for five minutes prior to proceeding to the next step. A Stir bar was added to the beaker and covered with a watch-glass or Aluminum foil. Sample was allowed to heat at 75° C on a hotplate. As soon as gas bubbles are observed at the surface, beaker was removed from the hotplate and allowed to cool until boiling Subsides. If natural organic material is visible, another 20 mL of 30% hydrogen peroxide Was added. Repeated until no natural organic material is visible. Mixture was allowed to heat to 75° C until the salt dissolves and then allowed to cool room temperature.

5) Filtration

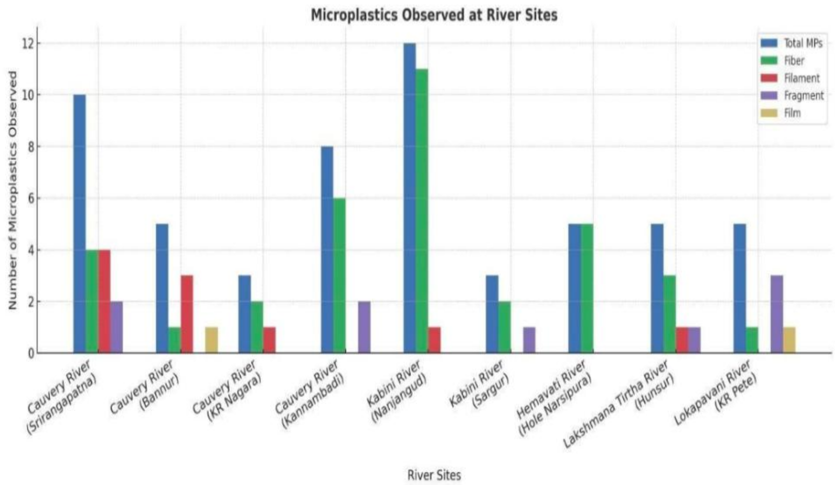
WPO solution was transferred funnel with Whatman Grade 1 filter paper. WPO beaker was rinsed with distilled water to transfer all remaining solids to the conical flask. Solids were allowed to settle. The filter paper was allowed to dry by keeping it in the incubator and scrapped. Again, WPO step was repeated and the now the sample (the filtrate) was used to analyze the microplastic present.

6) Quantification

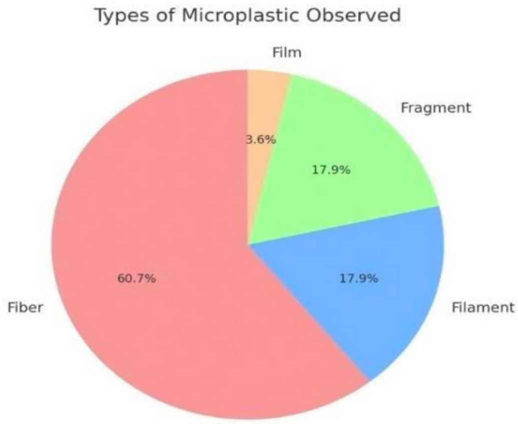
Visual sorting – The 2ml of sample (filtrate) was taken on a clean slide for inspection for any microplastics and counted manually under Stereomicroscope under 40x magnification. The microplastics observed were photographed to identify the type and color.

3. **Result**

Microplastics were found at every site sampled, but abundance varied among sites. Samples from Kabini river (Nanjangud) had the highest count of 12 microplastic pieces, whereas samples from Kabini river (Sargur) and Cauvery River (KR Nagara) had the lowest counts with 3 pieces and in sample from other sites the microplastics ranged from 4 to 10 pieces. Different shapes of microplastics were observed from the samples including fibers, Fragments, filaments & Films. Fibers(thread-like) materials were the most common types of microplastics observed in many samples. At Srirangapattana, a total of 10 microplastic particles were Observed in 2ml final filtrate comprising 4 fibers, 4 filaments, and 2 fragments. Bannur Showed the presence of 5 microplastics, including 1 fiber, 3 filaments, and 1 film. KR Nagara exhibited 3 microplastics, consisting of 2 fibers and 1 filament. At Kannambadi, 8 microplastics were detected, which included 6 fibers and 2 fragments. In the Kabini River, two sites were analyzed. At Nanjangud, the highest count was observed, totaling 12 microplastics with 11 fibers and 1 filament. At Sargur, 3 microplastics were found, Including 1 fiber and 2 fragments. In the Kabini River, two sites were analyzed. The Hemavati River at Holenarsipura presented 5 microplastic particles, all of which were Fibers. Similarly, in the Lakshmanatheertha River at Hunsur, 5 microplastics were Identified, comprising 3 fibers, 1 filament, and 1 fragment. Lastly, in the Lokapavani River at KR Pete, 5 microplastics were recorded, made up of 1 fiber, 3 fragments, and 1 film. Microplastics observed had variety of colors, including transparent, brown, blue, green, pink, yellow, black and purple.



Graph 1: Abundance of Microplastics observed in different riverbank soil samples

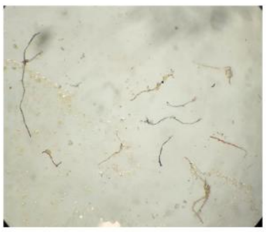


Graph-2: Types of microplastics observed in different riverbank soil

MPs detected in Cauvery riverbank Soil sample (Srirangaptna)

MPs detected in Cauvery riverbank Soil sample (Bannur)

MPs detected in Cauvery riverbank Soil sample (KR Nagara)



MPs detected in Kabini riverbank Soil sample (Nanjangud)

MPs detected in Hemavati riverbank Soil sample (Hole Narsipura)

MPs detected in Lakshmanatirta riverbank Soil sample (Hunsur)

Discussion

1. Abundance and Anthropogenic Influence on Microplastic Distribution

Our study identified microplastics (MPs) in all nine freshwater riverbank locations sampled across southern Karnataka, India, from a depth of 10 cm. This consistent presence, irrespective of the urban or rural status of the sites, affirms that microplastic contamination is now pervasive across both highly impacted and moderately impacted environments. The highest number of MPs (12) was observed at Kabini River (Nanjangud), a semi-urban area with religious, residential, and commercial activity. In contrast, lower counts (3 MPs) at Kabini (Sargur) and Cauvery (KR Nagara) reflect reduced anthropogenic interference.

Our findings align with Talbot and Chang (2022), who concluded in their global review that urbanization, land-use intensity, and proximity to wastewater treatment plants are the primary predictors of microplastic load. Sites such as Srirangapattana and Nanjangud are close to bridges, pilgrimage centers, and residential zones—consistent with the elevated microplastic levels documented in river systems downstream of cities worldwide (Fiore et al., 2022; Blair et al., 2019). Importantly, microplastics were consistently retrieved at a depth of 10 cm, suggesting long- term deposition and possible reworking through fluvial action. According to Hossain et al. (2022), sedimentation and burial of MPs in riverbanks may result from repeated monsoonal floods and sediment redistribution, further supporting the persistent nature of microplastic contamination in depositional zones.

Types of Microplastics and Inferred Sources

The composition of microplastics in our samples was dominated by fibers (60.7%), followed by filaments (17.9%), fragments (17.9%), and films (3.6%). These proportions mirror those reported by Blair et al., (2019), who found that fibers comprised over 85% of total microplastics in Scottish freshwater sediment samples. Fiore et al., (2022) similarly noted fiber dominance in sediment along the Italian Po River, emphasizing their ubiquitous presence in river environments. Fibers are widely associated with synthetic textile shedding during laundry cycles. As explained by Klein et al., (2018), fibers often bypass conventional filtration systems and enter natural waterways via domestic wastewater. Even in the absence of nearby wastewater treatment plants in our study sites, informal grey water discharge and sewage seepage could explain the high fiber content. Filaments likely originate from fishing gear, synthetic ropes, or netting, especially in regions where local livelihoods include fishing or boating. The presence of fragments—irregular, angular particles—is consistent with the breakdown of larger plastic debris, such as packaging material, plastic containers, and disposable products. Klein et al., (2018) highlight this as a classic sign of secondary microplastic formation due to environmental weathering. Films, although the least common, were observed in Bannur and KR Pete, and may have originated from agricultural plastic mulch, food wrappers, or carry bags. Campanale et al., (2020) noted that films, being lightweight and flat, are easily transported by wind or water and may degrade faster due to greater surface area exposure.

3. Morphology and Shape-Related Implications

The shapes and physical properties of microplastics affects their transport behavior, retention in sediments and bioavailability to aquatic organisms. Fibers, due to their flexibility and elongated form, tend to entangle with fine sediment particles and organic matter, facilitating their retention in the soil matrix. Our observation that microplastics were found at 10 cm depth, often in fine sediment, is supported by Blair et al., (2019), who reported preferential fiber accumulation in sediments. Fragments, although denser and often irregular, can also be deposited in sediment through biofouling or aggregation, especially during periods of reduced water flow or in areas with vegetative cover. Klein et al., (2018) suggest that plastic particles, despite being buoyant initially, may become waterlogged, encrusted, or weighed down by silt and microbial films, increasing their deposition potential. In our samples, films appeared less frequently, possibly due to higher mobility and susceptibility to photodegradation, as noted by Campanale et al., (2020). The absence of primary MPs (e.g., beads or pellets) in our samples is also in line with findings from Blair et al., (2019) and Hossain et al. (2022), who observed secondary microplastics as the dominant type in riverbank sediment due to local waste mismanagement rather than industrial inputs.

4. Colour Diversity and Source Implications

The microplastics recorded in our study exhibited a wide range of colors, including transparent, blue, black, green, pink, yellow, and purple. Such chromatic diversity reflects multiple consumer and industrial sources. Colored fibers—particularly blue and black—may derive from synthetic clothing and fishing gear. Transparent and white fragments and films likely originate from food packaging and single-use plastics. According to Blair et al., (2019), colored MPs are more visible under microscopic observation, which can lead to detection bias; however, the high diversity in color in our samples indicates a genuine range of sources, including both domestic and commercial plastic products. Hossain et al.,

(2022) also identified color variety as indicative of local plastic use patterns, especially in urban and semi-urban contexts.

The colors of MPs can influence their ecological impact. As noted by Klein et al., (2018), brightly colored particles may be mistaken for food by aquatic organisms, increasing ingestion risks. The presence of such colors in our riverbank sediment, even at considerable depth, poses a latent ecological threat to benthic fauna. The widespread presence of microplastics in riverbank soil samples analyzed has serious environmental and ecological implications. Riverbanks represent critical buffer zones between terrestrial and aquatic ecosystems.

References

1. Fiore, L., Serranti, S., Mazziotti, C., Riccardi, E., Benzi, M., & Bonifazi, G. (2022). Classification and distribution of freshwater microplastics along the Italian Po River by hyperspectral imaging. Environmental Science and Pollution Research, 29(35), 48588– 48606. https://doi.org/10.1007/s11356-022-18501-x.
2. Hossain, M. S., Siddika, A., Saifullah, A. S. M., Sheikh, M. S., & Uddin, M. J. (2022). Abundance and distribution of microplastics in surface water and sediment of two selected rivers in Bangladesh. Environmental Engineering and Management Journal, 21(6), 1047–1058. https://doi.org/10.30638/eemj.2022.094
3. C. Jiang, Yin, L., Wen, X., Du, C., Wu, L., Long, Y., Liu, Y., Ma, Y., Yin, Q., Zhou, Z., & Pan, H. (2018). Microplastics in sediment and surface water of West Dongting Lake and South Dongting Lake: Abundance, source and composition. International Journal of Environmental Research and Public Health, 15(10), 2164. https://doi.org/10.3390/ijerph15102164
4. D. Morritt, Stefanoudis, P. V., Pearce, D., Crimmen, O. A., & Clark, P. F. (2014). Plastic in the Thames: A river runs through it. Marine Pollution Bulletin, 78(1– 2), 196–200. https://doi.org/10.1016/j.marpolbul.2013.10.035
5. F. Cesa, Turra, A., & Baruqe-Ramos, J. (2017). Synthetic fibers as microplastics in the marine environment: A review from textile perspective with a focus on domestic washings. Science of The Total Environment, 598, 1116–1129. https://doi.org/10.1016/j.scitotenv.2017.04.172
6. F. Windsor, McGivern, A., Barton, D. N., & Barton, D. N. (2019). Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. Science of The Total Environment, 667, 133–144.https://doi.org/10.1016/j.scitotenv.2019.133465
7. L. Meijer, van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances, 7(18), eaaz5803. https://doi.org/10.1126/sciadv.aaz5803
8. L. Bhardwaj, K., Rath, P., Yadav, P., & Gupta, U. (2024). Microplastic contamination, an emerging threat to the freshwater environment: A systematic review. Environmental Systems Research, 13(8). https://doi.org/10.1186/s40068-02400338-7
9. M. Kosuth, Mason, S. A., & Wattenberg, E. V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. PLOS ONE, 13(4), e0194970. https://doi.org/10.1371/journal.pone.0194970
10. R. Akhbarizadeh, Keshavarzi, B., Moore, F., & Sillanpää, M. (2018). Microplastics in freshwater systems: A review of occurrence, fate, and removal technologies. Science of The Total Environment, 643, 1583–1594. https://doi.org/10.1016/j.scitotenv.2018.01.Windsor
11. N. Hartmann, Hüffer, T., Thompson, R. C., Hassellöv, M., Verschoor, A., Daugaard, A. E., Rist, S., Karlsson, T., Brennholt, N., Cole, M., Herrling, M. P., Hess, M. C., Ivleva, N. P., Lusher, A. L., & Wagner, M. (2019). Are we speaking the same language? Recommendations for a definition and categorization framework for plastic debris. Environmental Science & Technology, 53(3), 1039–1047.https://doi.org/10.1021/acs.est.8b05297.
12. P. Anderson, Warrack, S., Langen, V., Challis, J. K., Hanson, M. L., & Rennie,M. D. (2017). Microplastic contamination in Lake Winnipeg, Canada. Environmental Pollution, 225, 223–231. https://doi.org/10.1016/j.envpol.2017.03.054.
13. R. Blair, Waldron, S., Phoenix, V. R., & Gauchotte-Lindsay, C. (2019). Microscopy and elemental analysis characterisation of microplastics in soil of a freshwater urban river in Scotland, UK. Environmental Science and Pollution Research, 26(12),12491-12504 https://doi.org/10.1007/s11356-019-04678-1
14. R. Geyer, Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782. https://doi.org/10.1126/sciadv.1700782
15. R. Talbot & Chang, H. (2022). Microplastics in freshwater: A global review of factors affecting spatial and temporal variations. Environmental Pollution, 292, 118393. https://doi.org/10.1016/j.envpol.2021.118393
16. S. Bhutto & You, X. (2022). Spatial distribution of microplastics in Chinese freshwater ecosystem and impacts on food webs. Environmental Pollution, 293, 118494. https://doi.org/10.1016/j.envpol.2021.118494

17. S. Klein, Dimzon, I. K., Eubeler, J., & Knepper, T. P. (2018). Analysis, occurrence, and degradation of microplastics in the aqueous environment. In M. Wagner & S. Lambert (Eds.), Freshwater Microplastics: Emerging Environmental Contaminants? (pp. 51–67). Springer. https://doi.org/10.1007/978-3-319-61615-5_3