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BASELINE ASSESSMENT OF MICROPLASTICS IN THE SEDIMENTS OF KOLAVAI LAKE

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ABSTRACT
The assessment of microplastics in freshwater systems has drawn more attention in recent years. Microplastic pollution in developing countries is still underestimated. The sampling, analysis, and observation procedures employed in developed countries cannot be fully applied in developing nations due to disparities in infrastructure and economic capability between countries, necessitating particular adaptations. The current study uses a modified methodology to evaluate the microplastics in the bottom sediments at 10 distinct sites of Kolavai Lake using a PVC pipe sampler. The average microplastic concentration was 120 particles per kg sediment. Fibres outnumbered fragments (66% to 81%) in all 10 stations of the lake. The high concentrations of microplastics in the regions were strongly linked with anthropogenic activity, demonstrating the impending need to identify the sources of microplastics.

Keywords: *Microplastics, freshwater, lake, sediment, litter*

INTRODUCTION
Plastics have been widely used since its introduction in the late 19^{th} century (Ryan, 2015). In 2014, the production of plastic increased to 311 million tonnes (MT) due to their applicability in a wide range of fields and low production cost (PlasticsEurope, 2015). Photodegradation, oxidation, physical and chemical processes can lead to the breakdown of larger plastic debris to smaller particles (Karthik *et al*., 2018). In the absence of efficient management and removal mechanisms of plastic waste, microplastics (<5mm) have rapidly become ubiquitous due to their widespread industrial, medicinal, municipal and commercial applications (Wright *et al*., 2013). As a result, microplastics, the emerging pollutants of all ecosystems (Daily and Hoffman, 2020). The density of microplastics is a crucial factor in their accumulation in sediments. The denser the microplastics are compared to water, the more efficiently they deposit in sediments (Welden and Lusher, 2017). The other factors including wind, surface runoff, velocity, and biofouling also equally affect the deposition of microplastics in the lake sediments (Yang *et al*., 2022). Microplastics have biomagnification impacts on the aquatic food web due to their high surface-to-volume ratio and smaller size (Pathan *et al*., 2020). Besides being hazardous, microplastics can also adsorb other toxic substances and get colonised by pathogenic microorganisms (Rochman *et al*., 2013). Following ingestion, microplastics may cause an organism to become inflamed or to block its digestive tract, leading to reduced nutrient absorption and starvation (Lusher *et al*., 2017).

Sediments can act as sink for microplastics making them available to organisms that thrive and feed in the demersal zone. Plastic pollution poses a significant risk to benthic fauna due to their inability to distinguish between MPs and food particles (Iannilli *et al*., 2019). MPs are widely studied in marine environments, while freshwater systems are least studied (Vaughan *et al*., 2017). However, in recent times, the microplastics pollution of freshwater environments is gaining attention. In India, most of the studies on freshwater systems so far conducted focus on large water bodies in urban locations (Gopinath *et al*., 2020). However, no published data exist for microplastics in sub-urban and rural lakes of TamilNadu. Here, we present data demonstrating the abundance and spatial distribution of microplastics in the sediments of a suburban lake in Chengalpattu.

MATERIALS AND METHODS

Sampling

Sampling locations (10 stations -B1 to B10) in Kolavai Lake were selected to provide a representative coverage of the underwater sediments. Benthic lake sediment was collected with a coring PVC pipe with 50 cm length and 6 cm diameter. Another PVC pipe of 5 cm diameter was used to push the sample out on a stainless-steel tray. The top 10 cm was sectioned and composited into a 500-mL glass bottle and stored for further analysis (Pradit *et al*., 2022).

Extraction of plastics

For the extraction of microplastics from freshwater or marine sediments, there is no clear standard procedure. However the majority of marine studies employ a size-and-density separation combination (Karthik *et al*., 2018). Each sediment sample was dried at 60°C in an oven to obtain dry weight. 30-50 g of each benthic sample was sieved using stacked 5 mm, 300 µm, 100 µm and 37 µm sieves. Subsets of the respective samples were taken as duplicate samples. The sediment retained on the 5 mm sieve was examined for plastic particles. The isolated plastics were kept in glass petri dishes and allowed to dry for further analysis. The sediment collected on each of the sieves was subjected to density separation using sodium chloride solution (d=1.2g/cm^3) separately. The process was followed by wet peroxide oxidation (30% hydrogen peroxide) to digest organic matter. After digestion, the samples were filtered through Whatman filters (Cellulose nitrate, 0.45 µm pore size, and 47 mm diameter). The filters were then transferred to glass petri dishes and dried in shade for further analysis.

Identification of plastics

To identify the microplastics, the filter papers were observed under stereomicroscope. As the filters were completely dry, there was no bias in the light reflection from the microscope. Using the method described by Free *et al*., (2014) the microplastics were recognised by their shape. The microplastics were also classified based on their colours and sizes (Karthik *et al*., 2018). The visual identification was followed by FTIR analysis.

Quality control

To avoid potential contamination during sampling to laboratory analysis, nitrile gloves and laboratory cotton coats were used. To avoid contamination, filters were immediately kept in a petri dish and covered until further examination. Air blanks were conducted to check for potential contamination. To find out airborne contamination, filter paper was first examined under a stereomicroscope; and then kept open on a petri dish in the working environment for 24 h. Field blanks were also conducted in selected sampling locations.

PVC core tube used was individually inspected prior to sampling. Visual evidence for potential contamination from these tubes was not apparent, but additional blank samples were not collected to verify this observation. Given that only one of all the sample particles analysed by FTIR were found to be PVC, it was considered unlikely that the core tube introduced contamination of PVC particles. And also, the colour of the PVC tube was analysed for checking cross-contamination.

RESULTS AND DISCUSSION

The distribution of microplastics in lake sediments was mostly expressed as items/kg. In the present study, the microplastics were found in every duplicate sediment sample of the sampling sites with mean density of 120 particles per kg. The presence of microplastics is closely related to anthropogenic activities such as dumping of waste along the shore of the lake (Gopinath *et al*., 2020). The weathering of larger plastic debris can lead to increased microplastic content (Vaughan *et al*., 2017). The current study focuses on the various sizes of microplastics, taking into account the consequences of different microplastic size classes in the aquatic food chain. The microplastics of size >0.3 mm were dominant with 88.2% followed by the sizes 0.1-0.3 mm (7.7%) and <0.1 mm (4.1%). The various shapes of the microplastics influence their bioavailability (Barboza *et al*., 2020). The high percentage of microplastics in the shape of fibres (75.5%) may be related to fishing activities and domestic wastewater entering the lake (Sathish *et al*., 2020).

Similar to the shape and size parameters, the colour of the microplastics also plays an important role in ingestion by aquatic organisms. Microplastics can be mistaken for prey due to their colour resemblance (Barboza *et al*., 2020). The dominant colour found in the study was blue (33%), followed by red (27%). A significant difference was found within the colours of the microplastics in the sediment samples of Kolavai Lake (One way-ANOVA, $p<0.05$). But no significant difference was found with the colour distribution of microplastics among the sampling sites (One way ANOVA, $p>0.05$).

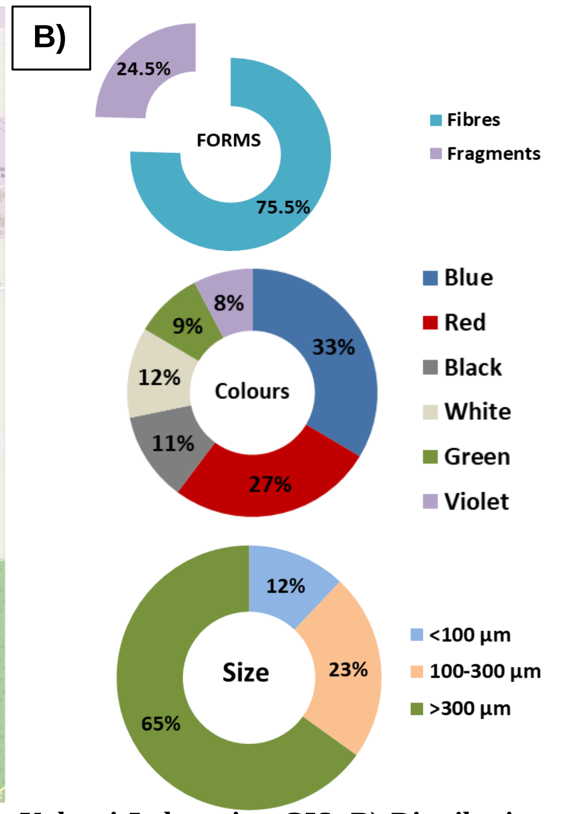

Figure 1: A) Ten benthic sampling sites fixed along the Kolavai Lake using GIS. B) Distribution of microplastics in various forms, colours and sizes.

Few representatives for microplastics of each colour and texture were selected for FTIR analysis. Polyethylene (63%) and polypropylene (31%) dominated the plastic polymers recovered. Polyethylene is the widely used polymer in developing countries especially in Asia due to its versatile application (Yang *et al*., 2022). Chronic exposure to weathered polyethylene causes oxidative injury and weakened filter activity in *Perna viridis* (Hariharan *et al*., 2020).

Microplastics have adverse effects on the aquatic organisms from microalgae to commercial fishes (Zhang *et al*., 2017; Nikki *et al*., 2021). Ingestion of microplastics lead to formation of ROS, which causes reproductive failure (Jeong and Choi, 2019), these microplastics could be sites for adsorption and desorption of hydrophobic Endocrine Disrupting Chemicals which could cause feminisation in fishes (Lu *et al*., 2020). Through consumable aquatic organisms, microplastics could enter the digestive system of humans an affect the public health (Neves *et al*., 2015). The toxicity is high when the adsorbed substances are released into the organisms after ingestion (Al-Thawadi, 2020). It is unclear if MPs can pass the gut epithelium or if they stay in the gut lumen after consumption. While MPs up to 10 micrometres may be recognised by Peyer's patch cells of the ileum, gut cells can absorb particles as small as a few micrometres (Cox *et al*., 2019). Plastic particles of size greater than 0.2 microns in the blood are cleared by bile and expelled by faeces, whilst those in the lymph are taken from the lymph into the gut through splenic filtration (Rist *et al*., 2018; Carbery *et al*., 2018).

Kolavai Lake which is one of the largest freshwater systems of Chengalpattu district with an aerial area of 894 hectares. The lake borders a municipal town, Chengalpattu, and 11 villages including, Amanapakkam, Chengalpattu, Pulipakkam, Paranur, Malayampakkam, Hanumanthai, Terukkupattu, Esenkaranai, Kunnavakkam, Pattaravakkam, Ilanthopu, and Thenur. For years, fishing has been carried out at this lake. Both fish that are native to the lake and new species that the government has brought reside there. Some of the native fish species include rohu (*Labeo rohita*), and mirigla (*Cirrhinus mrigala*), although the government has also introduced silver fish, catla (*Catla catla*), and Tilapia (Raghavan, 2004). The lake also shows abundance in zooplankton density (unpublished data).

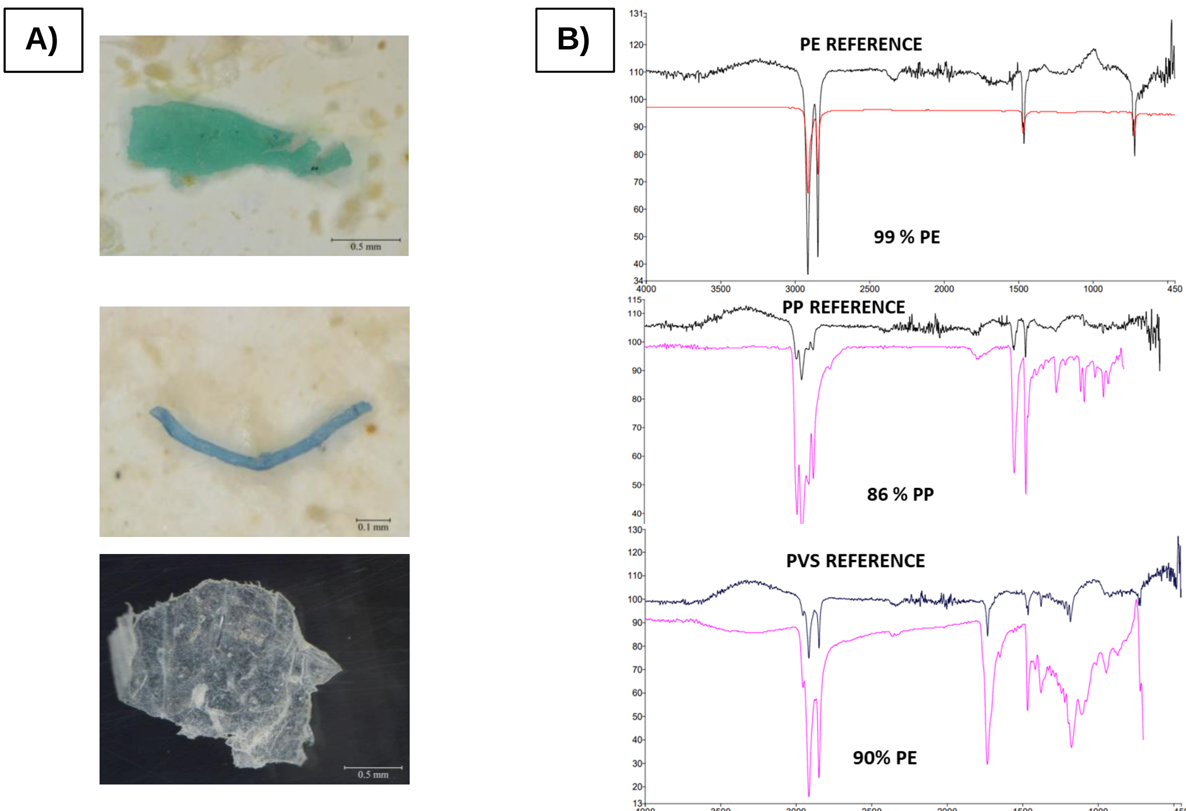

Figure 2: A) Microplastics extracted from the sediment samples, B) FTIR analysis of microplastics recovered from the sediments of Kolavai Lake.

This richness in biodiversity of the lake can get affected by increased microplastic pollution. The sources of microplastics in the environment are strongly linked to the degradation of meso- and macroplastics (Egessa *et al*., 2020). This research establishes the foundation for future research on the contamination of microplastics in lake sediments and the requirement to identify the sources of microplastics in freshwater systems.

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