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Preliminary studies on the microplastic pollution in Dal lake, Kashmir (first report)

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Abstract. We provide the first study on the occurrence of microplastics in Dal lake, Kashmir, India. Microplastics act as catastrophe that trigger many environmental problems. The key origins of microplastics are larger plastics, which split into smaller plastics after UV light disintegration. There is relatively little work carried out on the existence of microplastics. The present work has been undertaken on the occurrence of microplastics at four pre-selected sites (surface water) in Dal lake, Kashmir. The samples were taken to the laboratory to dissolve organic matter by using H_2O_2 (6%). To speed up the organic digestion; the treated mixture was heated on a hot plate at 70°C. The mixture was then subjected to density separation. The supernatant obtained was observed under the microscope (10X) and measurements were taken. At site-I, the microplastics ranged from 2-3 mm, site-II 5-6 mm, site-III 3-4 mm, site-IV 4-5 mm in thickness, indicating the presence of microplastics in the lake. The presence of microplastics indicated that the lake has undergone an anthropogenic change over a period of time. Our research highlights the value of enhancing the quality of the drainage system and sewage disposal. This work can be helpful to recognize successful microplastic control management techniques and possible threats associated with the Dal lake. So far, no such data on the presence of microplastics in Kashmir lakes is available.

Keywords: Dal lake; microplastic pollution; microplastics; Kashmir; first report; sewage

1. Introduction

Microplastics, made from hydrocarbons, very petite, flotsam and jetsam of plastic, are the most polluting plastics, which are barely visible to the naked eye. Microplastics are microscopic fragments, less than five millimeters in length or much smaller (National Oceanic and Atmospheric Administration) than that. Generally, the key sources of microplastics are larger plastics that undergo photodegradation with the aid of UV rays, resulting in smaller plastic pieces.

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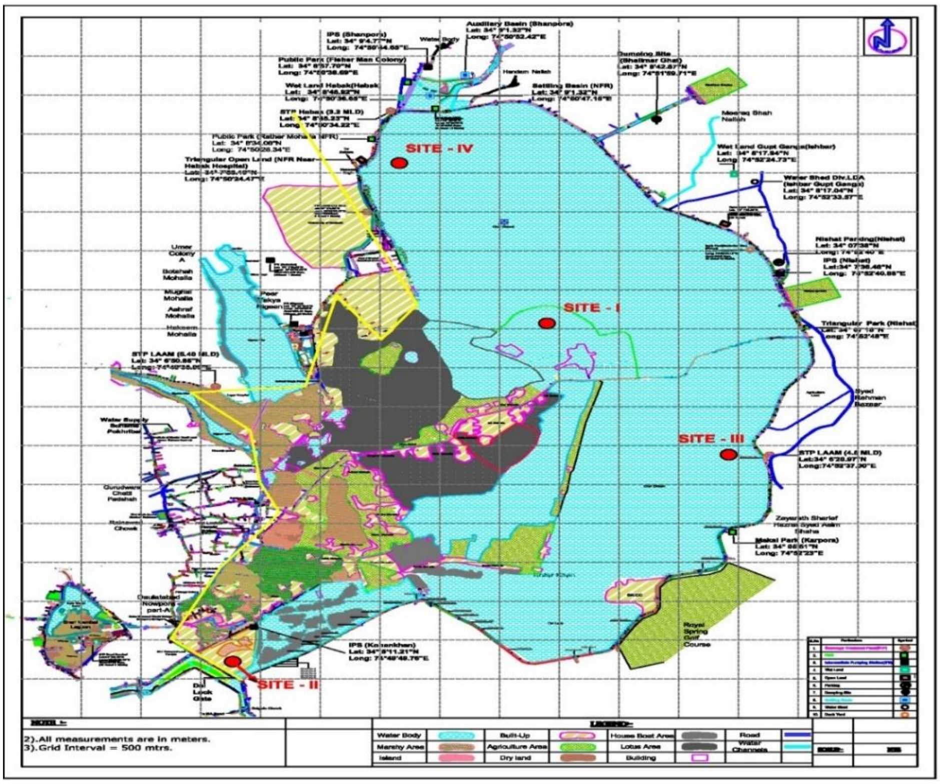

Fig. 1 Map of Dal lake showing the selected sampling sites

Owing to the rise in the production of plastics, the quantity of microplastics in the lakes has increased most over the years. Microplastics are also contributed from the waste water treatment plants. India alone produces approximately 26000 tons of plastic waste per day (CPCB 2015). There are currently more than 10,000 tons of plastic waste uncollected. In due course of time, uncollected plastic waste winds up in the natural world, like water bodies. The Jammu and Kashmir lies between latitude 32° 17’N to 36° 58’N and longitude 73° 26’E to 80° 30’E, the northernmost portion of the Indian Union. The Kashmir valley is a lacustrine basin that rises between the smaller and the larger Himalayas in the mountainous depression. A wide variety of fresh water sources, such as lakes, reservoirs, wetlands, springs, streams and waterways abound. Numerous but varying freshwater habitats are of considerable aesthetic, environmental, socio-economic and ecological importance. There are encouraging signs that these freshwater bodies have been used to the maximum degree in Kashmir for their resources. Like other water sources, the Dal lake has been exploited in a variety of ways by humans and the level of anthropogenic pressure is continuously rising. The Dal lake and its surroundings have a large communities of people who reside in houseboats and surrounding human settlements in the Dal lake. Increased invasion of human settlements in the lake catchment area facilitates greater dumping of household garbage, waste and sewage waste, resulting in pollution of the lake. Unregulated tourist flow and infrastructure growth have also resulted in the accumulation of waste, including plastic waste. According to the report conducted by CPCB in 2015, the production of plastic waste in Srinagar is approximately 28.14 tons per day.

Table 1 Status of sewage waste water treatment located at the periphery of Dal lake

S.No.	Status (2018-2019)	STP-1	STP-2
1	Waste water treated per month	134 LD	225 LD
2	Waste water generated per month	144.7 LD	228.1 LD
3	No. of households connected to sewerage network	5%	10%

Plastic bottles, chips and polythene bags scattered around lakes and waterways are popular sights. Around 9000 metric tons of waste was dumped every year in the Dal lake by house boats alone. Around 18.2% of phosphorus and 25% of inorganic nitrogen join the lake water. About 80,000 tons of silt is deposited annually in the lake (Jeelani *et al*. 2016). All wastes are drained directly or indirectly into the lake. The key sources of microplastics in Dal lake are plastic bottles and plastic wrappers which, when disintegrated by UV light, break into small particles. Waste including plastics enters the lake from different channels and ends up floating in Dal lake, making room for microplastics. Effluents from several peripheral plants are also dumped straight into the lake water without or little treatment. Such effluents contain plastic and are also combined with several chemicals found in soaps and detergents (Boucher and Friot 2017). Sewage treatment plants designed for the treatment of waste water from nearby areas in the lake catchment also discharge their processed waters into Dal lake might be contributing microplastics to the water. Studies on contamination of micro-plastic water sources have also been reported (Cole *et al*. 2011, Free *et al*. 2014). The literature survey finds contradictory amounts of contribution from microplastic depending on the degree of human impact (Cole *et al*. 2011, Dris *et al*. 2015).

Till date, no work on microplastic presence has been reported on the Kashmir lakes, including the Dal lake. This is the key objective of the present research, which was conducted to carry out preliminary studies on the occurrence of microplastic pollution in Dal lake. In order to clarify the extent of danger posed by the plastic to the ecosystem of the lake, the present study investigated the physico-chemical parameters and the presence of microplastic waste so that potential steps may be taken to preserve the ecology of the natural lake. The sources of microplastics in the lake were identified which highlight the importance of improving the sewage treatment facilities and possible threats associated with it. This work would be the first to provide baseline data which will be helpful in understanding the planning and control of polluting factors.

2. Methods

2.1 Selection of sites

In the Dal lake, four sampling sites were chosen, reflecting various environmental characteristics (Fig. 1). The site-I chosen in the lake was taken as a reference site as this area is least impacted by human interference. As compared to the other lake areas, this site had cleaner water. Site-II was chosen from the area infested with prolific macrophytic growth and this site receives wastes from the human population in the surrounding. This site is the outlet of the lake. Site-III is situated on the eastern side of the lake, near STP (LAAM). Site-IV, which receives treated waste water from STP-1 and 2 (Table 1), is situated on the western side of the lake. A total of 12 samples (3 from each site) were collected from surface waters in the spring (March-May)

Table 2 Physico-chemical parameters and their ranges (2019)

Parameters	Concentration ranges	SI units
Water temperature	0.3-8.2	$^{\circ}$C
pH	7.1-8.3	-
Dissolved oxygen	0.8-10.1	mg/l
Alkalinity	42-113.5	mg/l
Conductivity	100-245	mg/l
Calcium	17.6-47.5	mg/l
Magnesium	2.4-22.4	mg/l
Chloride	14.2-40.9	mg/l
Total phosphate	120-351	μg/l

and winter (November-February) seasons.

2.2 Collection of samples and analysis

Sampling was performed during the spring and winter months of 2019 and 2020, respectively. A total of 12 surface water samples (3 from each site) were taken once a month for physico-chemical analysis in one-liter polyethylene bottles from the four lake sites following standard methods of analysis (Baird *et al*. 2017). The samples collected for the study of microplastics were taken from the respective sites by scooping with 64 nm mesh plankton net. In order to separate the larger debris, the samples were then sieved through a 300 μ mesh. The samples were first sprayed with distilled water in a squirt bottle after sieving, then moved to the beaker and 6% hydrogen peroxide (H_2O_2) was used to digest the sample's organic debris. The mixture of sample and hydrogen peroxide was heated to 70°C over a hot plate in order to accelerate acid digestion following Masura *et al*. (2015). After full acid digestion, the solution was filtered into Whatman filter paper using a separator, and the solution was retained until all the water was drained through the filter paper. The filter paper was then air-dried in the oven to prevent airborne pollutants. The supernatant was then transferred to Sedgwick rafter cell and was observed under a compound microscope at 10X magnification and the microscopic fields were counted for the presence of fine threads and other microplastics that were seen shining. By measuring the grid size of the Sedgwick rafter, the size of the MPs was calculated and the number of such grids filled by microplastics was calculated as well. The basic technique of NOAA was adopted for this analysis.

3. Results and discussion

3.1 Physico-chemical features

The physico-chemical features at the investigated sites of the Dal lake are summarized in Table 2. The temperature ranged from 0.03-8.3°C where normal seasonal pattern has been observed, with maximum values in spring and low values in winter. The pH values ranged from 7.1 to 8.3, suggesting that the lake was somewhat on the alkaline side. The conductivity values ranged from

Fig. 2 Photo plate no. 2 showing macroplastics flowing in Dal lake water at investigated sites

Table 3 The percent by weight of macroplastic recorded at the peripheries of the Dal lake

S. No.	Plastic type (year 2019)	Percentage by weight
1	Plastic bottles	40%
2	Plastic bags (coloured)	24%
3	Plastic wrappers	6%
4	Miscellaneous (all plastic material mix which cannot be segregated)	4%
5	Foam plastics (plates, cups, glasses, etc)	8%
6	Transparent plastic bags	4%
7	Broken plastic buckets, plastic flooring, plastic strings, other plastic utensils, etc	4%
8	Plastic unknown (debris)	10%

100-245 μS cm^{-1}. The water of the lake can be classified as beta-mesotrophic on the basis of the classification provided by Olsen (1950). The range of dissolved oxygen in the investigated lake varied from 0.8 to 10.1 mg/l. During cooler months, maximum dissolved oxygen was observed. The concentration of calcium varied from 17.6 to 47.5 mg/l and the concentration of magnesium varied from 2.4 to 22.4 mg/l suggesting that the lake water was rich in nutrients with the progression indicator as Ca > Mg. The alkalinity ranged from 42 to 113.5 mg/l indicating that the water was fairly hard (Moyle 1946). The lake is rich (14.2 to 40.9 mg/l) in chloride content, suggesting the presence of human feaces and organic water waste (Thresh 1944). The overall amount of phosphorus fluctuated from 120 to 351 μ/l. Overall the lake's water is alkaline, fairly hard and high in nutrients.

3.2 Microplastics

Due to the absence of existing waste management schemes, as demonstrated by the pre-

Table 4 Size and abundance range of microplastics recorded in Dal lake

Site	Spring season (2019)	Winter season (2019)
	Size/abundance range	Size/abundance range
Site-I	3 mm (5-31%)	2 mm (9-38%)
Site-II	6 mm (12-70%)	5 mm (10-65%)
Site-III	4 mm (20-56%)	3 mm (17-57%)
Site-IV	5 mm (20-60%)	4 mm (20-56%)

dominance of plastics, the existing preliminary work on microplastic in Dal lake, is likely to result (Fig. 2). This research reveals that the water for this new emerging microplastic waste serves as a sink. This is also in line with the studies undertaken by Browne *et al*. (2013), Cole *et al*. (2011), Rochman (2015) suggesting that the presence of microplastic contaminants could also be a threat to the lake's aquatic fauna. In the Dal lake, the water was dominated by plastic particles and fibers under examination. These microplastic particles are likely the result of fragmentation and degradation of plastic household debris, such as poly bags, poly bottles, wrappers, which dominated the peripheries and surface water of the lake (Free *et al*. 2014) (Table 3).

3.3 Seasonal variation

The temperature of the lake water remained low during the winter months and reduced UV exposure may also have resulted in less microplastic fragmentation (Table 4). Another explanation for less fragmentation of microplastics in the Dal lake may be the moderate water temperature throughout the year. The elevated microplastic density at the sites collecting STP waste (site-III, IV) and domestic waste (site-III) means that the microplastics come from the residential community as well as from the untreated waste water entering the lake.

The surface water of the lake is extensively covered with extreme growth of floating macrophytes such as *Azolla* sp and *Salvinia* sp. The Dal lake, the catchment basin and the shallow water source are fed by Telbal Nallah on the western side of the lake. The plastic waste produced in the lake catchment area is transferred to the lake and deposited in the lake water. The watercourse that feeds Dal Lake serves as an important carrier for the transport of plastic waste. Sewer connectivity to sewage systems is not 100 percent (Table 1). Around the same time, the efficiencies of water treatment plants in the retention of sewage influent microplastics are under the scanner. This is the single most influential element in stopping microplastics from accessing the aquatic ecosystem, the Dal lake. It is clear from our study that, the STPs neither cater for 100 percent communication nor are they capable of preventing microplastics from accessing the lake water. The outskirts of Dal lake are surrounded by black topped highways, and the cars are driving along these roads. Particles of tyre and road wear are also a strong cause of microplastics entering the lake water. Verschoor *et al*. (2016) argued that tyre and road wear particles are undeniably the main land contributor of microplastics to surface water. Our analysis is the first attempt to confirm the existence of microplastic loads in Dal lake, no data is available.

3.4 Comparison with other studies

In comparison, the latest concentration assessment methodologies in lake waters are

Fig. 3 Photo plate no.1 showing presence of microplastics and fiber threads in water samples at selected sites

considerably very poor (uncertain). This implies that it is not yet feasible to provide detailed validation. We may, therefore, approximate the findings with the available data and, through this inquiry, represent the observation. At site-II, where all the lake water accumulates and joins the Jhelum river through a gate (Fig. 3), greater microplastic abundance has been observed. At site-I, where lake water receives less waste compared to other locations, the lowest abundance was reported. This location is situated in the middle of the lake and as opposed to other locations; the peripheries at this site are remote. The total microplastic presence is seen as site-I < site-III < site-IV < site-II. The variability of microplastics in the lake under investigation may be used in the fresh water environment as a measure of microplastic contamination in Kashmir. Small streams that feed Dal lake are important carriers for plastic waste transportation. Riverine outputs by Lebreton *et al*. (2017) have been shown to be a significant source of microplastics. Microplastic pollution in surface water was observed to be more in urban areas, according to Zhang *et al*. (2016) and is confirmed by the present study, as Dal lake is an urban lake.

In particular, fewer concentrations of microplastics were detected in lake water relative to the percentage of plastics observed at the periphery of the lake (Tables 2 and 3). As microplastics are less soluble in water and may be decomposed through weathering (Weinstein *et al*. 2016), sunk to the bottom (Long *et al*. 2015), swallowed by aquatic species (Vendel *et al*. 2017) and transferred through flow (Isobe *et al*. 2014) and cling to macrophytes, lower microscopic fields occupied by microplastics at various sites of the present investigation can be correlated with lower microscopic fields. The excess of fibers in the present study may be due to the fact that the sinking of floating microplastics can be another explanation for small microscopic fields. The presence of microplastic particles included fibers, irregular items and threads were reported from studies conducted worldwide. Di and Wang (2018), Peng *et al*. (2017) and Xiong *et al*. (2018) have had similar opinions.

4. Conclusions

In India, data on the presence of microplastics is deficient. No data or literature on the presence of microplastics in Kashmir Lakes was available, which attracts more global focus nowadays.

• Our research is the first Kashmir study on the occurrence of microplastics in Dal lake waters. The lake serves many people as a means of income, whether they are fishermen, tourist guides or owners of Shikara boats.

• The flora and fauna are in danger of death due to the existence of microplastics, which would in turn be a major loss to the survival of the populations dependent on Dal lake.

Therefore, based on the studies carried out during this investigation, it is concluded that by government and NGO management steps should be taken to prevent the death of the existing fresh water ecosystem.

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Compliance of ethical standards

This research article does not contain any studies involving human participants performed by any of the authors.

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