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Research Article

Prevalence of Microplastic Pollution in Freshwater Ecosystem: A Case Study of Thal Canal

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Abstract: Microplastic pollution in the aquatic ecosystems is a hot global debate due to wide spread effects on human life and environment. This study aims to identify microplastic pollution presence in the Main Line (ML) Thal canal, its distributaries and provide an overall estimation of microplastics concentration in surface water of Thal Canal. Six major sampling points at ML canal and distributaries were assessed for microplastic prevalence out of which five locations showed microplastic contamination. Size, structure and type of microplastic were assessed using light microscopy and FTIR. The study provided baseline information about the prevalence of microplastics in Thal Canal and evaluated their categories according to their size, color and type of polymers. Microplastics concentration in the canal ranged from 6.4 ± 0.5 to 8.8 ± 0.5 particles/m^3. Films, mostly transparent in coloration, were the most prominent microplastic type appeared in this study. Polyethylene with 55% presence was the most prevalent type of microplastics found in the canal and the distributaries. This study provides a better understanding of the extent of microplastic pollution assessment in Thal canal with equal emphasis on Microplastic presence in distributaries which may be beneficial in identifying the introduction of microplastics at sources.

Keywords: Microplastic, Sampling, Thal Canal, Assessment, Characterization.

1. INTRODUCTION

Synthetic products of petroleum made up of repeating macro molecules having high molecular weight are known as plastic. There are more than 200 families of plastics [1]. These are more durable, convenient and due to their increasing demand, unchecked proliferation and skyrocketing production is causing their accumulation in the environment. Macro and microplastic have a very smaller boundary to separate that is the size of microplastic < 5 mm [2]. Microplastic (MP) itself has two categories depending upon the origin. Primary microplastics come as pellets and used as feedstock of plastic industry or abrasive. Secondary microplastic are broken fragments of larger plastic materials [2].

Since 1970, plastic pollution in the marine environment is being studied. The freshwater system is least understood, but is getting attention with every passing day. In oceanic ecosystem, microplastics are present in surface water column, near shores and in deep sea sediments [3]. Microplastics can be tossed to thousands of miles away with the tides and oceanic currents [4]. Microplastics due to their resemblance in size with planktons and food of marine fish can be ingested by these marine biotas. Thus, transfer of these pollutants in upper food chain is also a debating arena [1, 4].

Freshwaters may amass a large number of microplastic particles and fibers; yet freshwater microplastics have received less attention than those in seawaters. Microplastics can be found in such fresh waters as sources (such as wastewater plants), transfer media (such as rivers), and sinks (such as isolated lakes), which may differ from those found in seawaters due to huge changes in amount [5]. In the fresh water ecosystem, microplastic addition is a terrestrial factor influenced by roads, agriculture

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plastics, atmospheric dust and industrial effluents [6]. In freshwater ecosystem, microplastics are mostly present on the surface forming a layer or in deposited sediments form, and are settled at the very bottom. Microplastics serve as the vessels for the pollutants adhesive to their micro surface and also as transporter of invasive species to the remote areas, creating threat to native fauna and flora [7]. The micro spores adhesive to microplastics, survive longer time than in the aquatic environment and transferred successfully. Aquatic biota like fish engulf these plastics, which often cause digestive tract damage and decline to the population. These are often transferred from lower trophic levels to the upper trophic levels causing toxic effects due to toxic pollutants adhesive to their surface [4].

Microplastic on the surface of water also form a microlayer which put different undescribed effects to the aquatic environment, their accumulation increases as sediments deposition, slow degrading material and causing pollution by leaching of toxic compounds [8, 9]. Therefore, the canal irrigation water has no exception from microplastic pollution, as it comes from fresh water bodies, i.e., rivers. Microplastic pollution is causing severe harm to food crops decreasing their yield. Pesticides and fertilizers adhesion to microplastic reduces their bioavailability and causes environmental pollution. Possible sources of microplastic pollution in canal water could be due to (i) fragments of plastic debris present in the environment, (ii) runoff and deposition from the surroundings, and (iii) from agricultural practices. Therefore, major source includes fragmentation of intentionally or unintentionally discarded plastic debris. Canal water sampled near urban areas contained many types of suspended riverine particles and different types of microplastics similar to those in wastewater and sludge [10, 11].

The unavailability of data about microplastic pollution in canal irrigation water is presenting a gap of knowledge for global understanding. This comparatively new research area would get benefit from more quality assurance/quality control design, as there is a current dearth of data relevant to reference materials, proficient testing and training. The skyrocketing production, increased usage and insufficient waste management of plastics are causing microplastic introduction in freshwater environments globally. Most of documented work about microplastic pollution in aquatic ecosystems is about marine environment. The indication of inflow mechanism and pointing out sources is as important as the assessment of microplastics concentrations in freshwater. The objective of current research was the provision of first hand quantitative and qualitative data of micro plastic contamination in Thal canal irrigation water and creating a base line data for future studies.

2. MATERIALS AND METHODS

Assessment of micro plastics in Thal Canal was conducted to check their prevalence and distribution. Their size, color and types were analyzed to see their physical and chemical characteristics. Sampling site is the Main Line Thal Canal and its different distributaries. Thal canal originates from Indus River at the location of Jinnah Barrage in Kalabagh, district Mianwali. The coordinates for its origin point are 32.916069° N at longitude and 71.527647°E latitude. Sampling was done from the major distributaries located in the Bhakkar District. The schematic map of irrigation network showing Thal Canal is presented in Figure 1.

2.1. Phase 1: Walk Through Survey and Sample Site Selection

Thal canal is the main sources of irrigation water in Thal region distributing water from the Indus river system to quench the thirst of Thal desert. The supply of 8000 cusec water to three lac acre cultivated land is made possible by different distributaries originating from ML Thal canal at different head-works. Therefore, walk through surveys in the Bhakkar district's main areas provided the insight to select the correct sampling site. It was kept in focus that the site was easily accessible, less turbulent and fragile to MPs contamination by being in public reach or at the prime vicinity of population, roads, farms and agriculturally active areas. For data collection, six sampling points were selected.

2.2. Phase 2: Sample Collection from Surface Water of Thal Canal and its Distributaries

The sampling started at tail and moved towards the head area in Bhakkar district. The Trawl was

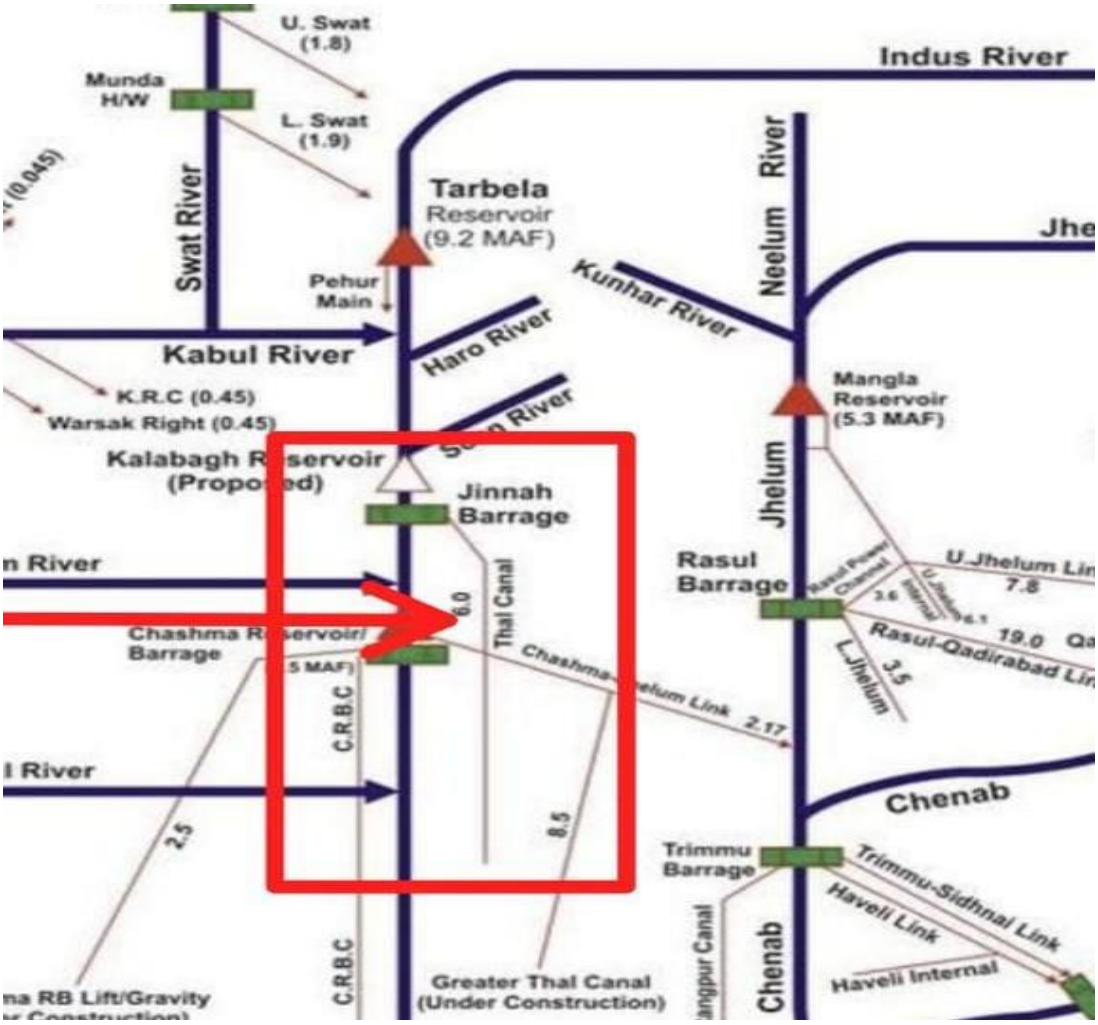

Fig. 1. Schematic map of irrigation network showing Thal Canal.

manufactured according to equipment specifications for sampling [12]. The location of sites is presented with coordinates given in the Table 1.

Samples of microplastic were collected by using microplastic-sampling protocols [12]. Samples from surface of canal water was acquired by using manta trawl (Table 2) with mesh size ~330 µm. From each site, at least 2-3 samples were collected during 5-15 minutes of water flow for every sample collection. Microplastics collected in the trawl net were washed from outside and collected on a standard sieve with mesh sized 2 mm to get the concise sample. The larger particles were manually segregated from the main sample. Table 2 depicted the specifications of trawl.

Sediments sample collection was done by metal spatula and sieve. Wet sieving was performed to remove clay and get clean and categorized sample.

Table 1. Sampling points coordinates.

S. No.	Sampling Site	No. of Samples	Coordinates (Latitude, Longitude)	
1	Firdous Head (main line Canal)	3	31.57064	71.135295
2	Khokhar disty (Distributary)	3	31.568358	71.133897
3	Thalla Sarein (ML Canal)	3	31.925071	71.231438
4	Hukam Minor (Distributary)	3	31.931255	71.227804
5	Tinda Section (ML Canal)	3	31.956893	71.233641
6	FG Kallurkot	3	32.12025	71.31067

Table 2. Manta Trawl specifications.

Trawl frame part	Length	Width	Height
Wings	23 inches each side	5 inches	2 inches
Aperture	20 inches	7 inches (From inlet towards outlet)	11 inches inlet 6 inches outlet
Meshing Net	95 inches (2.4 meters)	Fixed to aperture box	Fixed to aperture box
Towing ropes	8 meters	-	-

The material on the sieve was photographed and documented, while the material on the larger sieve was rinsed until the filtrate is practically transparent and free of clay [12]. These samples were transferred to jars rinsed with distilled water covered with aluminum foil and placed for drying in oven for 24 hours at 65 °C.

2.3. PHASE 3: Manual Sorting and Sample Preparation

The samples collected from all sampling sites were transferred to lab in air tight jars. Every sample was placed into a wash basin for removing contamination and sorting the larger particles, gravel and dregs from smaller particles. This was done in sieve washing and the gravel and solid non plastic materials were discarded.

2.4. PHASE 4: Lab Processing and Analysis: Sample digestion

The next step was to remove organic matter and non-plastic materials stuck with plastic particles, which were accomplished by digesting both the water and sediment samples. The washed, purified, sorted sample after drying in oven for 24 hours was settled for digestion. The sample in jar was shifted to a beaker in the presence of 20 ml distilled water and digestion chemical (Fenton reagent) [12]. It comprises of 30% hydrogen peroxide (H_2O_2) in the presence of 0.05 M Fe (II) solution. The beaker was covered with aluminum foil and placed on magnetic hot plate at 65 °C temperature.

In the whole digestion process the gas bubbles in the beaker were observed and the process continued until the bubbles stopped appearing in the beaker. It was the sign of digested sample, free of organic and non-plastic materials. The whole process took 53 minutes to complete and removal of bubbles. The digested material was then left to be cooled at room temperature and allowed to settle down.

2.4.1. Density separation

Following digestion, a homogeneous solution containing various types of suspended particles was utilized for density separation, with low-density materials being separated from high-density particles. The saturated solution of NaCl was used for density based separation of microplastics according to the method of Wang et al. [13] with some little changes. NaCl weighing 337 g was dissolved in 1 L of distilled water to prepare a saline solution. The NaCl method has a good separation rate and been used widely to separate microplastics and other materials [13-16].

The homogenized sample was properly shifted into a clean 500 ml glass beaker (washed with deionized water). After that, 500 ml of the NaCl filtered solution was introduced and stirred with rod for 2 to 5 minutes. The sample was left for settling for 5 hours. In a 150 ml beaker, the suspension was decanted carefully. With this process, the lower density microplastics floated into the upper water, and the higher density non-plastic particles sank to the bottom, thus recovering the micro plastics in the supernatant.

2.5. Counting and Morphological Identification of Microplastics

The oven dried sample placed for counting of particle type by their size, color and appearance. The pictorial representation of separated Microplastics is shown in Figure 2. All collected samples were observed for their size, structure, color and type under light microscopy and FTIR spectroscopy

Fig. 2. Pictorial representation of separated Microplastics.

technique. Microplastics were also divided into five categories depending on their morphology (fibres, sheets, pieces, foams, and beads).

3. RESULTS AND DISCUSSION

The present study was intended towards the estimation of microplastic pollution in Thal Canal and highlighting the sources contributing to this pollution by assessing the microplastic inputs and identifying the potential contributors to the microplastic contamination.

3.1. Counting and Morphological Identification

Altogether, microplastic detected had the size range of 0.045 to 5 mm as previous studies reported [17-19] with 74.5% falling in the range of under 0.33 mm and 25.5% within 0.33 to 5 mm range (Figure 3), larger than 5 mm plastic particles were discarded [20]. The majority of the detected microplastic fractions consisted of finer proportions. The high proportions of secondary finer particles point out to the degradation of large plastic fragments [21] which provide endorsement to our previous statement of biotic and abiotic breakdown of plastic to smaller fractions that results in underestimation of microplastics. These smaller and finer plastic proportions together with other apparent features (color and shape) may tempt and persuade aquatic biota and resulted in plastic ingestion [22-26].

The most abundant type of microplastic in our results was transparent extending to 60% (Figure 4), which may points out the transparent plastics' extensive use for packaging of food and other materials, and single use shopping bags. The remaining proportion of identified microplastics comprised of colored particles majorly blue, green and white that may be linked to packaging material, cleaning products, bottles, cosmetics, and clothing [27]. In modern times, single use plastic goods have become an integral part of our daily lives which started the competition of making products more alluring through coloring [25, 28] not considering the prospects of toxic effects [24, 29, 30]. Though lack of evidence exists but coloration may spoil the polymer characteristics [31], the weathering of plastics may give rise to microplastic pollutions in both terrestrial and aquatic environment [21].

According to results by shape the most identified plastics were irregular hard fragments (Figure 5), which originate mostly as a result of weathering of larger plastic waste [32]. Second most found shape on the list was fibers and could have been the result of sewage and garbage from household in the vicinity of canal, air deposition

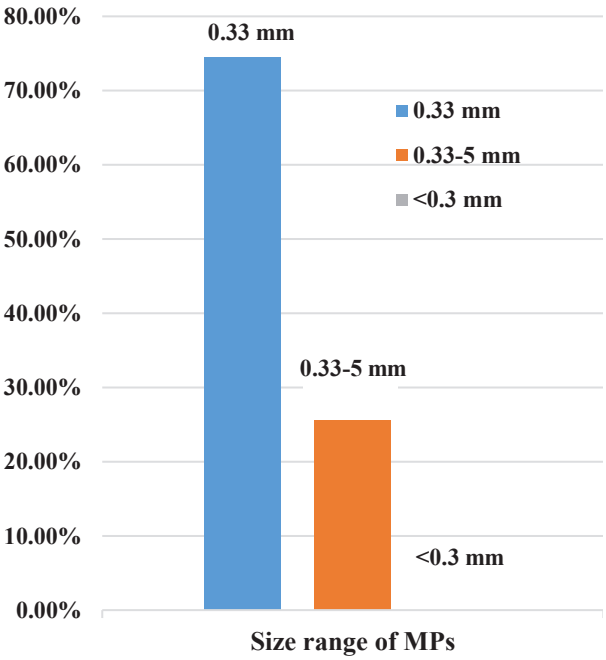

Fig. 3. Size range percentile of collected microplastics.

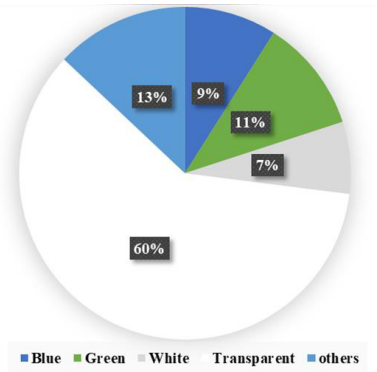

Fig. 4. Percentage distribution of Microplastic by color.

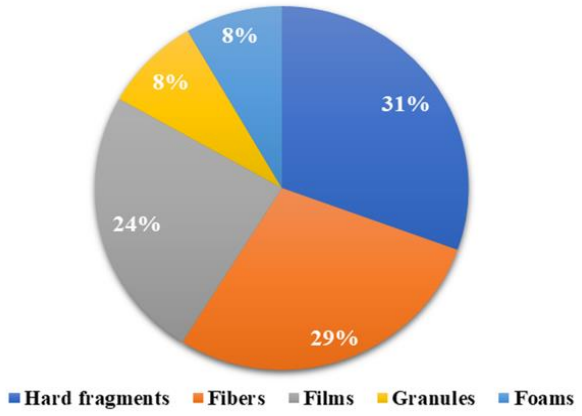

Fig. 5. Microplastic percentage by morphological

from roads and nearby farms or disintegrated fertilizer and seed bags [25, 33, 34]. Films were also the major contributor in the list and this could also be the result of breakdown of larger plastic waste. Small numbers of granules were also present in the samples, which pointed towards cleaning products and cosmetics as their source [34], while presence of foams in the samples might have a source origin from the packaging and building materials [30].

3.2. Categorization of Polymers

In our analysis, we identified total four types of polymers (Table 3). The predominant type of microplastic identified was Polyethylene in Thal Canal and its distributaries which is coherent with previous studies on freshwater ecosystem [35, 36]. Total 95 particles of varying shape, color and sizes were carefully selected as representative of each sampling visit's visually identical 50 fractions [25, 37]. Polyethylene (PE) was most recognized type among the selected particles as followed by polypropylene (PP) and polystyrene (PS) which is testimony to the previous literature and the fact that PE, PP and PS are single-use types of plastics largely produced [30, 38-41].

3.3. FTIR Spectrum of Identified Polymers

Each peak showing in Figure 6 at specific frequency range in the absorption spectra tells about the specific compound class and chemical group. The first two sharp peaks show the frequency range of compounds of alkane which are polypropylene. The second peak is medium peak and the frequency

Table 3. Polymer types of Microplastic.

	Polyethylene (PE)	Polyester (P)	Polystyrene (PS)	Polypropylene (PP)
Granules	8			
Fibers	13	9		5
Films	17		1	5
Foams			8	
Hard fragment	20			7
Percentage (%)	62	10	10	18

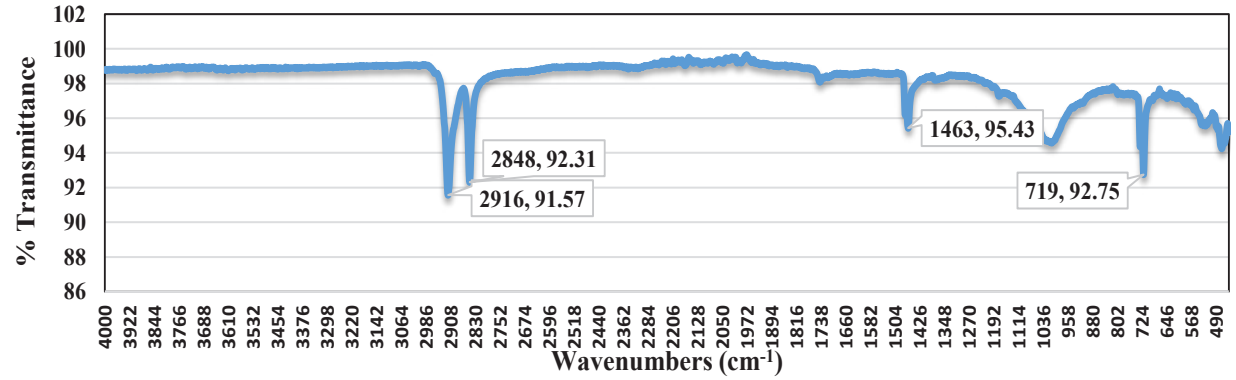

Fig. 6. FTIR spectra of MPs sample.

range represents the Methylene group, those of polyethylene plastic which are often referred as engineering plastic. The third and last peak is a medium peak and falls in the frequency range of Benzene derivative compounds group which are polystyrene compounds mostly synthetic rubber and food packaging materials.

4. CONCLUSIONS

The study assessed the microplastic pollution prevalence and abundances in Thal Canal and its distributaries. Consistent with our assumption, the Canal's surface water was found contaminated with microplastics. The concentrations of microplastics were between 6.4 ± 0.5 to 8.8 ± 0.5 particles/m³. Household dumping and sewage waste along the distributaries and main line canal proved to be the primary sources of pollution. In distributaries, microplastics were abundant at the points closer to the high population areas. Polyethylene was found as the dominant type of microplastic, almost 55% of the total microplastics collected from the canal. The dominant microplastics in the canal were fine sized microplastics, which together with the prevalence of secondary microplastics, indicated about the possible breakdown of the larger plastic waste. The major characteristics of sampled microplastics were films and transparent nature. Subjected to polymer identification, polyethylene and polypropylene dominated the mega proportion of microplastics. This preliminary study can notify policymakers for being concerned about microplastic pollution and articulating a suitable microplastic controlling and management system. Further studies should be conducted on the Thal Canal and its distributaries to evaluate the microplastic concentration in the outflow water. Similar studies must be conducted for soil and crops in the Thal region mostly irrigated by Thal Canal water to predict the effect of microplastic on these areas of concern as well.

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6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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