# Identification of Microplastics in Contaminated Urban Informal Landfill Soil With Removal Methods

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***Abstract*— Microplastics (MPs) of size 1µm-500µm (small MPs, and >500µm – 5mm (MP) are currently found in all the environmental attributes (air, water and soil). The pervasiveness of microplastics in land ecosystems has increased because 70-75% of plastic waste littering. The global plastic production is increasing at a rate of 5-6% per year at present. In this work we report identification of microplastics in the soil of urban informal landfill/ municipal solid waste dumpsite in Mysore city contaminated by MPs. The extraction of microplastics was done by density separation by NaCl method which is ecofriendly and non-toxic; followed by Organic matter digestion by Fenton's reagent. The identification of Microplastics was done by Scanning Electron Microscopy and Electron Dispersive Spectroscopy for analytics. Additionally, Fourier Transform Spectroscopy was also conducted for some particles which determined the type of plastic particles fragmented into Microplastics due to various factors. Physiological parameters like Moisture content and pH of the collected soil samples were determined and the results ranged between 4.4% - 52.9% and 5.95 – 7.74 respectively. The amount of microplastics found was around 370-410 particles/kg of informal landfill soil, most of which were fragments of large plastic particles followed by MP fibers. Some methods available for MP removal are also reported in this paper.**

***Keywords—Microplastics, Soil pollution, Plastic pollution, landfill, open dump, environment, soil, terrestrial ecosystem.***

## I. INTRODUCTION

Worldwide, microplastics (MPs) in soil and water are a multifarious group of plastic particles identified to be <5mm in size. MPs are of prime concern because of its non-biodegradability, persistence, heat, accumulation, alteration in soil micro biota, subsidence of food chain and food webs. Because of the complexity in the chemical nature of soil, a suitable and efficient method for standardising MP analysis in the matrix of soil is not yet determined [1]. Long term accumulation of plastic fragments can severely affect soil quality [2], and the disintegrated MP fibres/fragments slowly find their path into ground water through soil pores. Invitro studies have shown the potential effects of Microplastics on human-derived cells [3]. Animals have shown to ingest MPs [4] and when humans ingest animals, microplastics enter the human peristaltic system, and as a result with ~11000 plastic particles are annually consumed [5]. Identification, remediation and removal of microplastics should be viewed as a serious issue in a developing country like India, and so we propose to take up this novel work - the feasibility studies on identification and characterization, and removal of microplastics from soil.

Urban soil and agriculture lands are prone to MP pollution/contamination. Potential pathways are littering, surface run-off, atmospheric deposition, wastewater irrigation, soil amendments through sludge/fecal sludge as compost, or open non-engineered landfills in urban areas. MP pollution causes induced stress on the land soil causing physiochemical changes to the micro-soil ecosystem with impacts on the soil structure and its chemical composition. Heat island is a common issue because of extreme MP littering. The micro dust airborne in urban area carry MPs to the recipients.

In the Indian scenario, no policies are yet framed to deal with controlled use of plastics and urban litter control. Not being aware of the grave consequences of microplastics, humans and animals have been taking in microplastics through any of the three, or all the three routes of exposure. Novel innovations to analyse MPs in environmental attributes is necessary to find apt and reliable solutions to challenging problem of MPs in a complex soil matrix.

Identification, remediation and removal of microplastics should be viewed as a serious issue in a developing country like India. Hence, in this study we aim to determine the level of contamination of soil by microplastics in urban informal municipal landfill site.

## II. MATERIALS AND METHODS

### *A. Study area and sampling site*

Mysore city is the third largest city in the Indian state of Karnataka, located 146 kilometers southwest of Bangalore, it stretches across an area of 155 $km^2$ at the base of the sacred Chamundi Hills. In 2011, the Indian census determined that Mysore had a population of 920,550. Currently, the gross population is ~11 lakh and an added population equivalent (PEQ) of ~3 lakh totaling to 14 lakh human population with an average of 0.6kg of solid waste generated, the total waste each day would account to ~$7.8x10^5$ kg/d. The urban informal landfill site is located in Mysore (12°16' 43.97" N; 76°39' 37.90" E; 732m elevation) which has a total of 65 wards, generating more than 600 tons of waste per day as on 2022. This informal landfill site is functional from past 20 years and occupies a total area of 287 acres as shown in Fig 1.a. it is presumed that the plastic content approximates 4% by weight of the total MSW. i.e., 31200 kg/d.


**Fig. 1. a.** Spot marked in aqua color - baseline soil sampling site; Boundaries marked in green color-Major sampling was done within this boundary as shown in Fig.1. b


**Fig.1. b.** 7 Sampling locations as marked in red location pin.

Fig .1. Informal municipal solid waste landfill site of Mysore
Source: Google Earth

*B. Soil sample collection*

Grab soil samples was collected from the local open urban informal landfill site of Mysore city. The soil was then classified as per standard operating methods. MP contaminated soil of approximately 1 kg of wet soil was collected using a metal trowel and hand auger just below the top soil surface and between 0 to 10cms depth [6]. A total of seven soil samples and one baseline soil sample were taken from different locations on the solid waste dumpsite, as shown in Fig.1.b and 1.a, respectively. The samples were collected in aluminium foil to ensure absolute zero contamination. The samples were then brought to a laboratory for further analysis.

*C. Soil sample analysis*

i) Moisture Content

- The moisture content in the soil serves as a vector for the soil nutrients that regulates the soil forming process. The amount of soil moisture can affect the temperature and weathering processes of the soil. Gravimetric measurements were used to determine the moisture content of fresh soil samples.
- The collected samples were dried for 24hrs in hot air oven at constant temperature of 100°C. Once the samples were dried, calculation of Moisture content was done. Fig.2. shows the Moisture content obtained for samples collected at different locations.
  Percentage of moisture content = $\frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$
- $W_1$ is the crucible weight in grams; $W_2$ is the weight of wet soil + weight of crucible in grams; $W_3$ is the weight of oven dried soil + weight of crucible in grams

ii) pH of the samples

pH of the freshly collected MP contaminated soil samples was noted by using a pH meter. The sample was prepared taking a soil-water ratio of 1:2.5. the soil-water mix was homogenized by stirring and then allowed to stay under quiescent condition for about an hour. The pH meter was calibrated before measuring the pH [7].

*D. Homogenization of samples*

The analysis and extraction of MPs from the soil sample can become a tedious process if homogenization of samples is not done. Sieve plate considered was 2mm sieve for homogenization of samples. The dried samples were passed through the sieve plate to differentiate into coarse and fine soil samples [8].

*E. Density separation*

- Density separation was done by NaCl method as specified by [9]. The Density of NaCl is 1.2 g/cm$^3$, and hence particles whose density is lower than that of NaCl will be afloat of the supernatant. PET and PVC were exempted as their densities were more than that of NaCl viz, 1.34-1.58 g/cm$^3$ and 1.16-1.35g/cm$^3$ respectively.
- Saturated NaCl solution was added to 100g of dried soil sample. This mixture was left overnight for allowing settling of the denser particles.
- MPs and other organic debris with density < NaCl were afloat on supernatant.
- The supernatant was then transferred to another container to carryout further treatment.

*F. Digestion of Organic matter (OM)*

- Supernatant obtained after density separation was subjected to thenext step of digesting organic matter digestion step.
- The laboratory procedure as described by [10] was followed. Here, the supernatant was treated by 30% $H_2O_2$ and Fe(II) Solution- Fenton's reagent.
- The mixture was then kept over a hot plate at 250-400rpm and temperature not exceeding 75°C for 20min. This can be an optional step if the soil sample is abundant in organic matter.

*G. Vacuum Filtration*

- The organic matter digested supernatant was then subject to Vacuum filtration for further analysis.
- It was filtered onto cellulose membrane of pore size 0.45µm.

- This membrane on which the particles were collected was then allowed to dry for 24hrs at ambient room temperature.

### H. Identification of Microplastics

The membrane was then chemically examined for confirming the composition of the MPs [11]. To characterize MPs, an optical microscopy was used for pre-screening MPs from contaminated soil samples. Then, the selected samples were taken to the scanning electron microscope (SEM) attached with an energy dispersive X-ray spectrometer (EDS) for analysis. The data SEM provides morphology, while EDS provides qualitative information of the basic elements and spatial distribution in the sample scanned. The combined use SEM and EDS gives full information about the elemental composition of MPs that may be additional information on the inorganic additives they contained [12]. FTIR spectra analysis was additionally done for specifically extracted micro particles [13].

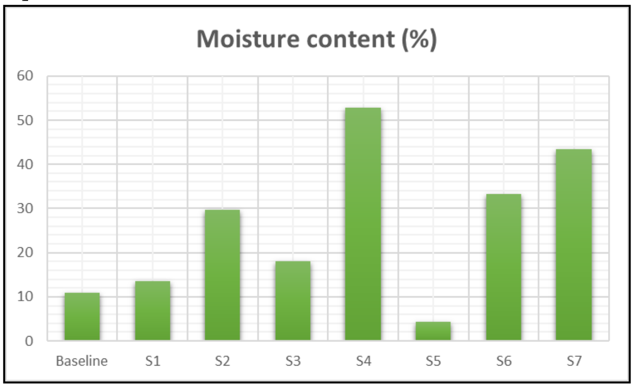


Fig.2. Moisture content (%) values of the samples

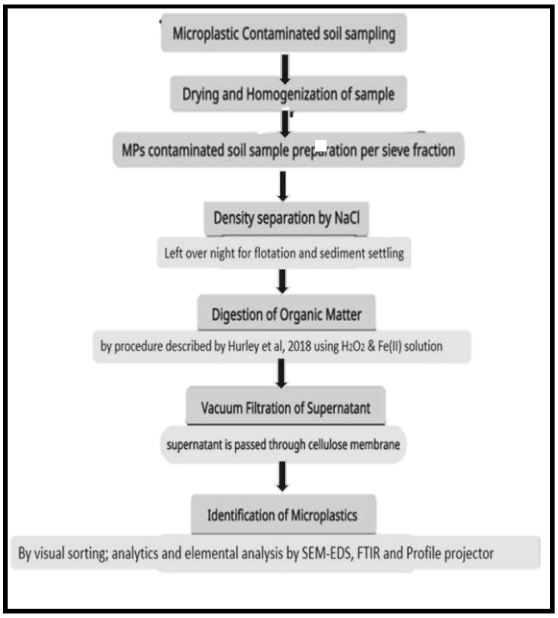


Fig.3. Methodology for extraction of Microplastics from contaminated soil samples

## III. RESULTS AND DISCUSSION

### A. Physiochemical components of Soil samples

In general, commonly the moisture content (MC) in soil ranges from 10-45%. However, under watering conditions, it can be little higher. The moisture data in the soil is shown in Figure 2. The moisture content in the soil samples range from 4.4% - 52.9%. Considering the soil MC optimum, the soil MC of the collected samples were higher compared to the optimum value which affect the soil forming process, metabolic activities of soil biota and weathering condition.

The pH of soil affects the availability of nutrients and few soluble chemicals that regulate soil. An important parameter of terrestrial ecosystem is the pH of soil for long-term effects of different soil management practices. The nutrient availability in the soil environment at large depends on the acid and the alkaline conditions of the soil. The pH of the samples ranged from 5.95 – 7.74.

### B. Abundance of Microplastics

From the 7 soil samples analyzed, the average MP particles ranged from around 370-410 particles/kg of landfill soil. The baseline sample did not show considerable amount of microplastics. Fig.4. shows the SEM image of one such plastic particle found with size ~ 0.5mm.

Fig. 5 shows the FTIR spectra of the MP particle. The particles found between the 2mm to 1µm were considered. The spectrum illustrates the following bands $CH_2$ rock C–H stretch at the peak 717.39 $cm^{-1}$; C–H stretch at the peak 2950.55 $cm^{-1}$; C-H stretch at the peak 2915.84 $cm^{-1}$; C-H stretch at the peak 2838.70 $cm^{-1}$; $CH_2$ rock, C-$CH_3$ stretch at the peak 840.81 $cm^{-1}$. The MP particle is found to be Polypropylene in comparison with reference spectrum [14]. Amongst the MP particles found, fragments were the dominant type of MPs. It was inferred that MPs from such informal landfill can act as a primary source of microplastics to the terrestrial ecosystem.


Fig. 4. SEM image of MP particle found to be of size ~0.5mm

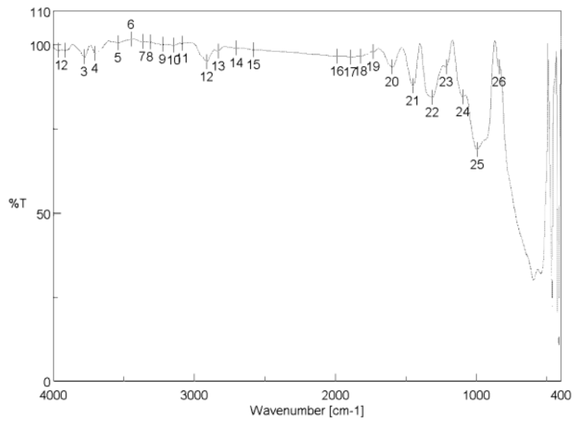


Fig. 5. FTIR spectra of extracted Microplastic particle from the soil sample

### C. *Microplastic Removal methods*

There is a number of analytical techniques that are employed to mitigating MPs; and two of them are briefly discussed.

i) Removal using dynamic membranes

One of the studies conducted by [15] focused on the use of dynamic membranes to remove MPs efficiently from synthetic wastewater. In this study, influent flux and particles concentration were investigated to see how it impacts the pollutant removal of dynamic membranes during filtration of synthetic wastewater on a diatomite system with 90µm of supporting mesh. Microplastics were effectively filtered out in less than 20 minutes reducing the turbidity value from 195 NTU to <1NTU in the treated effluent. Microplastics concentrations and fluxes associated with higher influents are conducive to dynamic membrane formation.

ii) Removal by Membrane bioreactors

The use of membrane technologies has been successful in removing microplastics from polluted aquatic environments. It has been shown that membrane bioreactors are superior to simple dynamic membranes for removing micro sized plastic particles [16;17]. In a study [17], researchers examined methods for removing MPs from wastewater treatment plant effluent using an advanced tertiary treatment technology. These included membrane bioreactors (MBR), disk filters, rapid sand filtration (RSF), and dissolved air flotation (DAF). The findings showed that the MBR eliminated 99.9% of microplastics, from 6.9 to 0.005 MP particles per litre. The researchers also showed RSF and DAF with membrane bioreactor eliminated MPs of any size, even small particles smaller than 20 to 100 µm. Furthermore, the removal efficiency was independent of the shape of the microplastics; particularly, textile fibres, which dominated both the influents and the effluents during the treatment, which were successfully removed. In addition to being able to successfully treat a variety of complex industrial wastewaters, membrane bioreactors are ideally suited to remove contaminants such as polymeric debris or microplastics [18]. Based on porous membranes and combined biological processes, [19] investigated the purification capability of a coupled system.
Removing microplastics effectively for a membrane depends on several factors, including its durability, influent flux, microplastics size, and concentration. By using porous membranes and biological processes, it may be possible to increase the removal efficiency by 99.9%.

## IV. CONCLUSION

In this study, we have inferred that urban informal landfill could be a significant source of microplastics. Microplastics are generated as a result of weathering plastic trash in an informal MSW landfill. The results of this study showed possible impacts on landfill management and the disposal of plastic wastes. In order to meet the challenge of addressing the fate of the polymer plastic pollutants in all types of environments, specifically in the terrestrial ecosystem, more research is needed addressing the fate, transport and effects of plastic particles in soil and aquatic media. More attention should be focused on the release of microplastics from informal landfills. As this study shows, microplastics can accumulate in the top soils, ecological functioning of the associated ecosystems can go impaired irreversibly over time. It is important to assess the environmental impacts of microplastics released from informal landfills and to develop measures to counter the effects of microplastics from these unplanned urban/semi-urban landfills.

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