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Research article

Microplastics contamination in the soil from Urban Landfill site, Dhaka, Bangladesh

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ABSTRACT

Microplastics (MP) pollution has become a matter of global concern because of its several deleterious effects on environmental health, especially on the terrestrial environment. The evidence of MP contamination in terrestrial environment is less explored compared to aquatic bodies. However, in Bangladesh despite having high possibility of MP contamination, there is lacking of available research-based evidence. Urban areas soil is subjected to act as a major environmental reservoir for MPs. Thus, this study was carried out to investigate the presence of MP contamination in constructed landfill sites near Dhaka city, Bangladesh. Ten unmixed soil samples were collected from the Aminbazar Sanitary landfill sites, from that thirty replicated samples were investigated *via* Fourier Transform Infrared Spectroscopy (FT-IR) analysis and Stereomicroscope. The range of physicochemical parameters were found in the soil samples as follows: moisture content; 15.84%–56.54%; soil pH; 5.76–6.02, electric conductivity; 0.1 μs/cm - 2.43 μs/cm, alkalinity; 6.7 ± 1.528–14.33 ± 0.577, TOC; 0.18% ± 0.02–1.09 ± 0.03. Among the ten samples, 3 samples were identified to have the presence of MP in the form of Low density polyethylene (LDPE), High density polyethylene (HDPE), and Cellulose acetate (CA) respectively. The detection limit ranged from 1 – 2000 μm. Hence, the results show that the procurement and discharge of MPs in the landfills is an overlong process. The results of this study provide an initial evidence and affirm that landfill can be a potential source of MPs. This study indicates that MPs are comparatively overlong outcome of human induced activities which can significantly cause changes in terrestrial ecosystems.

1. Introduction

Plastic pollution is omnipresent and its effects are long-term. It is a synthetic chemical which acts as an emerging pollutant because of its adverse effects on the terrestrial environment. Plastics are categorized into meso, macro and micro size plastic particles. MPs are a multifarious group of plastic particles which is less than 5 mm in length. MPs have become an exemplary indication of man-made waste and driver of environmental pollution (Galloway et al., 2017). There is striking evidence indicating that MPs might cause changes in terrestrial environment (de Souza Machado et al., 2018; Horton et al., 2017; Rillig et al., 2012; Rochman et al., 2013; Ng et al., 2018). MPs can be categorized into primary MPs and secondary MPs (Cole et al., 2011). Primary MPs are micro-sized plastic particles that used for commercial purpose. They are used as raw materials for manufacturing and pellets used in industries (Cole et al., 2011). Secondary MPs are disintegrated version of larger plastic particles used in agriculture and industries after entering in the environment. The degradation of such large plastic particles in the environment is caused by weathering process or through high temperature which then discomposed into secondary plastic particles (Rillig et al., 2012; Rillig, 2018). Two types of pollution source can be identified for the production of terrestrial MPs, which is point source and non-point source pollution (Horton et al., 2017). Point source pollution can be triggered by sewage sludge treatment where primary MPs enter into the sewage and industrial waste water, then through sewage discharge it enters into soil environment (Horton et al., 2017; Zubris and Richards, 2005). Non-point source pollution is produced mainly from different landfill, agriculture and garbage settlement. One of the significant sources of MPs in the ecosystem is the use of mulch in agriculture (Roy et al., 2011; Steinmetz et al., 2016). Landfill and other deposits of surface can produce particles which can be airborne through atmospheric displacement (Rillig et al., 2012).

Soil is a mixture of several types of gases, liquids, organic matter, minerals which can support life. Soils act as a media for multiple services such as biogeochemical cycling, carbon sequestration and biodiversity promotion (Jung et al., 2010; Schroter et al., 2005). Soil is potential

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environmental reservoir of MPs and in itself can cause many terrestrial problems. MPs can also enter waterways through the soil. For example, many beaches and coastal areas have been used as landfill and as erosion occurs due to rising sea levels (due to global warming). So, it is expected that MPs in coastal landfill can also impact the waterways (Hurley et al., 2018).

Landfill which is used for the disposal of waste in the world, can store 21–42% of the plastic waste produce globally (Nizzetto et al., 2016). So, waste dumping at landfill, industrial manufacturing, agricultural technology development all these are related to the release of primary, secondary MPs which then enter into the terrestrial environment, through material flow and flow of energy in the environment. Because of its absorption capacity, MPs not only enter the soil but also absorb organic pollutants (Beckingham and Ghosh, 2017), and also act as catalyst to incorporate the heavy metal bioavailability in soils (Hodson et al., 2017). As a result, these MPs accumulated in soil with higher concentration can be uptake by soil organisms (Huerta Lwanga et al., 2016, 2017). MP's physical and chemical properties make it more harmful to environment than larger plastic wastes (Leed and Smithson, 2019). Therefore, MPs can cause changes in soil's physical and chemical properties, which can have adverse impact on biodiversity and various soil processes such as the degradation pattern of the organic matter (Rillig et al., 2012). The major source of MP contamination is tire wear as they are quite abundant than any other plastic particles types. Degradation of such plastic particles cause the formation of fibers and fragments. The primary MPs can cause changes in the terrestrial ecosystems through entering into the environment (Ng et al., 2018). de Souza Machado et al., 2018 clearly stated that the MPs can affect the soil properties and how it can affect the plant performance. He et al. (2019) stated that MPs were found in different landfill soil samples, 99.36% MPs were originated from landfill's plastic waste fragmentation. Plastic degradation process depends on several factors such as polymer type and its age and some environmental processes like weathering processes, acidity, alkalinity and temperature (Akbay and Özdemir, 2016).

Recently, numerous research and investigation has been done to assess the MPs sources and their comparative impacts on the terrestrial environment (Auta et al., 2017; Blasing and Amelung, 2018; He et al., 2019; Ng et al., 2018; Pinto da Costa et al., 2018). Moreover, researchers are more focused on investigating the effects of MPs causing from plastic waste dumping and improper management of landfill sites (Duis and Coors, 2016). Giving attention to the MPs in the environment, researchers are also focusing on the degradation of plastic particles into lower scale, which is termed as “nanoplastics” having size range from 1 - 1000 nm. Nanoplastics are the particles that are unintentionally produced from the manufacturing and breakdown of old-MP materials, representing a colloidal behavior (Bouwmeester et al., 2015). The colloids are hetero-aggregates (clays and organic matter) with one dimension between 1 nm and 1μm. A recent study indicates that nanoplastics are releasing in the environment which may be a concerning reason because of their toxicity and contaminants absorbtion and also influencing pathogenic behavior. According to Gigault et al. (2018), PVC presence at nanoscale can be described by change in size of the particles from macro to nanoscale, because the particles dispersed in water due to buoyancy property at the macroscale, resulting in micro-scale conversion. According to the transportation pathway, these particles can incorporate to micro-organisms where this transportation can alter their buoyance property, feeding behavior and metabolism (Lagarde et al., 2016; Long et al., 2015). In the given physical and chemical conditions of the dispersion criteria, nanoplastics can incorporate with the dissolved organic matter and colloids to create stable and non-stable aggregates (Gigault et al., 2018). According to their size, their transportation, sorption, bioavailability and fate are controlled by their physicochemical properties. Because of the high surface area of nanoplastics, it can trigger the release of chemicals (monomers and additives, other environmental contaminants) in the surrounding environment (Silva et al., 2018). Which can have adverse effects on the environment and in humans, also makes it a potential source of plastic contamination in landfill as they are lower scale particles than MPs.

Both colloids and nanoplastics have potential effects on pollution, transportation pathways, nutrients, pathogenic chemistry and bioavailability, making themselves bioavailable (Lead and Wilkinson, 2006). Such techniques have been improved for the analytical, characterization and fractionation understanding. Such techniques follows as: X-ray/-fluorescence spectroscopy or electron microscopy use. Then, cross flow filtration (CFF), field-flow fractionation (FFF), centrifugation, atomic force microscopy (AFM). If no fractionation is performed, then the sample can be concentrated or diluted (Lead and Wilkinson, 2006). Though, there is a need of strong effort on addressing the proper identification and quantification criteria of nanoplastics and the effects of colloids on contaminant are not yet understood comprehensively.

Several authors depict that soil hold comparatively more MP particles than ocean (Nizzetto et al., 2016). As ocean exhibits great penetration potential. Human activities and various environmental sources are responsible for such MP contamination in the terrestrial environment (de Souza Machado et al., 2018). According to *Plastics Europe* (2016), in 2015, plastic production has been estimated with 332 million tons of plastic globally. Around 6,300 million tons of plastic waste were generated in 2015, 9% of that plastic waste were recycled, 12% were incinerated and the remaining 79% sent to landfills or discharged to the environment. It has been recorded for the past 50 years that the plastic production is about 9.1 billion tons globally, this plastic production increasing rate is 8.7% annually (Geyer et al., 2017). If actions are not taken then around 12,000 million tons of plastic waste are predicted to accumulate in landfills or in the environment by 2050.

MP presence has been reported in all types of environment worldwide, from freshwater (Free et al., 2014) to seawater (Law and Thompson, 2014), from urban to remote areas (Hirai et al., 2011) and from beach to deep-sea sediment (Claessen et al., 2013; Coppock et al., 2017). Potential negative impacts of MPs has been found out in aquatic organisms, since then concern has been given. Aquatic animals can suffer from starvation due to ingesting MPs (Cole et al., 2011). Many researchers exhibited the trophic transfer of MPs (Farrell et al., 2013; Setäläetal et al., 2014) and this trophic transfer can be a potential pathway for MP ingestion in species (Santana et al., 2018). Several toxic compounds can also discharge from MPs such as Polycyclic Aromatic Hydrocarbons (PAHs), Polybrominated Diphenyl Ethers (PBDEs), and heavy metals (Wardrop et al., 2016).

There are some complications in the extraction of small plastic particles because of the additional pollutant presence, solid matrix perplexity and various organic features (Blasing and Amelung, 2018). Several analytical methods drawn up for investigating the presence of MPs were different among different researchers (Elert et al., 2017; Zhang et al., 2018; Mai et al., 2018). The characterization of MPs and nanoplastics is challenging. Due to shortage of appropriate of methodologies, the MP contamination is not yet known entirely. Some other promising methods can be used for characterization technique such as: Raman spectroscopy, X-ray photo electron spectroscopy (XPS), Energy-disperse X-ray spectroscopy (EDS), Transmission electron microscopy (TEM), atomic force microscopy (AFM). To assess micro (nano) plastics on facial scrubs, XPS with scanning electron microscopy (SEM) has been used. Though the limitation of this technique is in the elemental information, it can't give a proper identification of polymer type. On the other hand, Raman spectroscopy give specific polymer identification information through fingerprint spectrum (Nascimento et al., 2018; Schwaferts et al., 2020). Because of the small size of MPs, produce a weak Raman spectrum. To avoid such situation, the certainty of such analysis must be increased. To provide a better molecular structure, Raman spectroscopy performs very well. The advantages of Raman spectroscopy to Infrared (IR) spectroscopy are high resolution, high spectral reach, color offsetting in identification, nanoplastics visualization, exact fingerprint spectra and low interferences from water. These good qualities make Raman spectroscopy quite unique especially in the characterization of the micro and

nanoplastics. A major concern related to Raman spectroscopy is its extremely small scattering cross section, which may produce weak signal (Schwaferts et al., 2020). So, in terms of the resolution Raman is one step ahead from IR as for the excitation the laser's short wavelength is produced (Sobhani et al., 2019). In order to visualize the small particles and enhance the Raman scattering, tip-enhanced Raman scattering (TERS) can be used. TERS has high sensitivity due to large electromagnetic field locally which create good visualization (Zhang et al., 2016). Another method is scanning near-field optical microscopy (SNOM), which can increase the resolution to the nanometer range (Zhang et al., 2016). According to Meyns et al. (2019), SNOM can be combined with IR to create high resolution visualization and identification of polymer types. Then another extraordinary method is superlens, which can increase the evanescent waves through using meta materials, also providing a high resolution visualization (Liu et al., 2017; Fang et al., 2020). Generally, below the diffraction limits, all these methods and technologies can provide high resolution spectra and optical image (Rygula et al., 2018). Yet, having these methods, the identification and characterization of micro and nanoplastics are still challenging.

According to United Nation Environment, in countries MPs can be found in tap water, which can carry disease causing organisms. Around 83% samples had plastic fibers. In Europe fibers average number were found around 4.8 in each 500 mL sample, where in US, samples of tap water contained around 94.4% of plastic fibers. In recent days, there exists some knowledge gap on the terrestrial ecosystem, as there are no standardized process available for plastic particles identification in the soil environment. As a result, it is quite difficult to determine the final fate of MPs in the soil environment accurately (de Souza Machado et al., 2018). Therefore, relevant to the present time scale and pollution management, it is logical to take in a near-viable and exacerbating MP pollution in the terrestrial environment (Geyer et al., 2017).

As, there are no such studies have been conducted on MPs findings in Bangladesh. In respect to that, particular landfill has been chosen as sampling site. Because in landfill, several waste including plastic wastes are being dumped and accumulated there for decades which can help to identify the potential MP presence because MP accumulation is an overlong process. The aim of the current study was to identify the MPs presence in the collected landfill soil, elucidation of various soil properties, mentioning the limitations and key challenges of this study and indicating more investigation is needed in order to evaluate the possible outcome of MPs pollution.

2. Material and methods

2.1. Study site

Test soils were collected from Urban Landfill site, Dhaka, Bangladesh (23° 47′ 44.75″N; 90° 17′ 59.11″E). This landfill site a waste dumping site since 2007 and it is near the Dhaka-Aricha highway and 30 km off from Dhaka city. This landfill occupies 52 acres of land including leachate pond. For sampling, the whole area was divided into five sections. Mainly, ten samples were collected from the five corresponding areas in two different depth, topsoil and 0–20 cm depth. Then those ten samples were individually placed to yield three replicates each. S-11, S-13, S-15, S-17, S-19 represent the five samples of top soil and S-12, S-14, S-16, S-18, S-20 represent the five samples of the core (0–20 cm) soil. The weight of main ten samples was 300 g each and the weight of each replicated sample was 100 g. Total thirty replicated samples were analyzed using the MP identification procedures described in the following sections.

2.2. Sample collection and preparation

Ten soil samples in two depths were collected with a distance of ninety meters successively within the field boundary. Soil samples were taken from the topsoil and (0–20 cm) depth using a soil hand auger. Samples were collected in the plastic bags (3 mm in thickness) and transported directly to the laboratory. In the laboratory, samples were picked out from the sample bags and spread over the tray and oven dried at 105 °C for 24 h. A control sample with no plastic was made to check if the plastics bags can pollute the samples compromising the analysis quality of the plastics. The dried samples were weighted and after oven

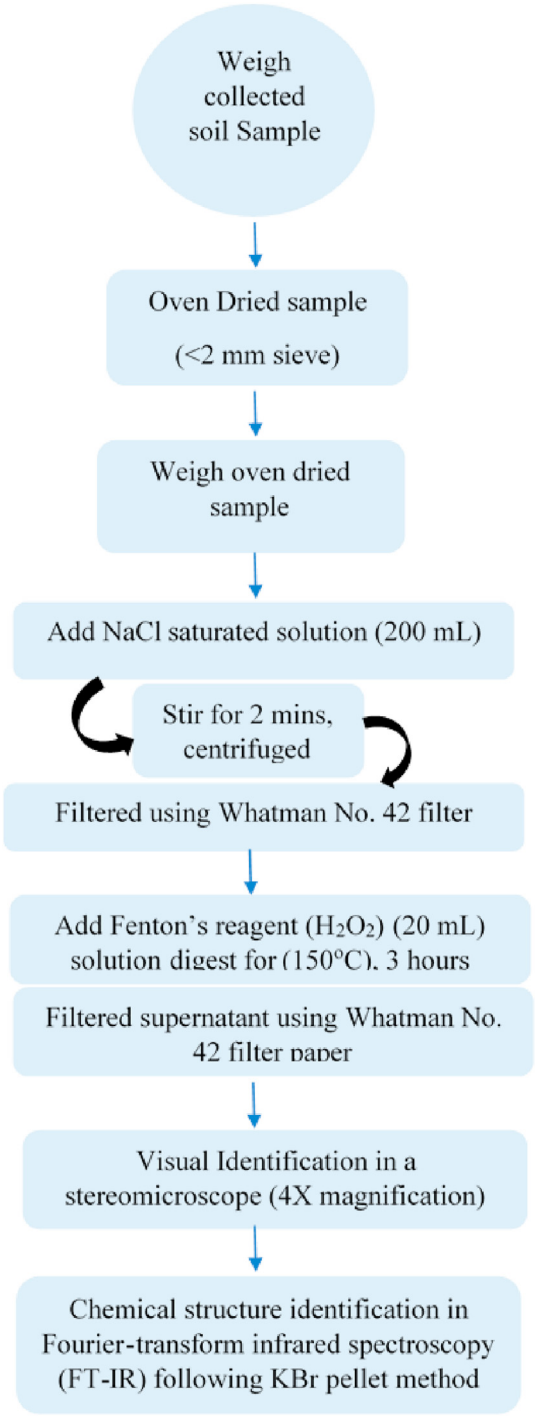

Figure 1. Diagram of the method used. Samples were dried, sieved, and weighted. Different solutions were added in sequential time steps to extract and digest sample for identification of microplastics. First sample was weighed, then a solution of NaCl was used. The samples is stirred, centrifuged and filtered. Thirdly, a solution of Fenton's reagent was used then the sample was digested and filtered for the last time. The filtered samples then inspected in stereomicroscope and FT-IR to identify plastic particles.

dry the samples were again weighted to determine moisture content. Then the samples were sieved and ignited for 3 h at 500 °C. To eliminate the plastic particles, the temperature was ensured reach that level (Anuar Sharuddin et al., 2017). Then the ignited samples were placed in shaker for almost 10 min at 180 strokes per min to promote transport. Then the main soil samples were unpacked and packed in PET jars. Because of no guarantee of certain contamination, in the field blanks were not collected. Zhang et al. (2018) suggested that soil samples should be initially pass through 2 mm sieve which is different from sediment samples.

2.3. Laboratory analysis

There is no standardized method to determine MPs in the soil samples. This study is particularly implemented following the methodology of four recent studies (Zhou et al., 2016; Corradini et al., 2019; Piehl et al., 2019; Zhang et al., 2018; Hurley et al., 2018). A comprehensive description of the methodology is shown in Figure 1.

According to de Souza Machado et al. (2019), MPs can change soil properties. To see the present soil property condition of the sample, some physico-chemical parameters were measure along with moisture content. Though more research is needed to address the correlation.

Soil moisture acts as a vector for soil nutrient which regulates soil forming processes. Soil moisture has an impact on soil temperature and weathering processes. The moisture content of freshly collected soil samples was determined by the gravimetric method. The formula of moisture content as follows:

$$\text{Percentage of moisture content} = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$$

Where, W_1 denotes weight of beaker in gram; W_2 denotes weight of wet soil + weight of beaker (g); W_3 denotes weight of oven dried soil + weight of beaker (g).

The pH of freshly collected soil samples was determined by using pH meter. The ratio of soil to water was 1:2.5. The soil and water were thoroughly stirred for an hour with glass rod and then pH of the content was measured. The pH meter was calibrated with two known buffer solution (pH 4.0 and 7.0) (Jackson, 1973).

The Electric conductivity (EC) is an essential parameter of soil. The collected samples were mixed with distilled water to determine EC, the ratio between soil and water was 1:5. The electrode of conductivity meter was provided in the content and then recorded the reading (Parveen et al., 2012).

Soil alkalinity is an important parameter of soil properties. Due to weathering and deposition of minerals soil produce sodium carbonate, results in soil alkalinity. Soil alkalinity was measured following titration method with acid-based indicator phenolphthalein. Taking 1.0 g of soil with 40 mL distill water, 5 drops of phenolphthalein, titrated with 0.01M sulfuric acid and the result recorded as parts per million as $CaCO_3$ (Jackson, 1973).

The total organic carbon is a significant parameter of soil to assess its suitability for further implications. Total organic carbon is the organic carbon measurement in the soil and other aquatic ecosystems. Percentage of TOC can help to assess the potential MP concentrated areas, though further research is needed to address this correlation (Maes et al., 2017). Wet oxidation method was followed to determine the total Organic Carbon in the collected soil samples (Khan et al., 2016). The formula follows as:

$$\text{Percentage of Organic Carbon} = \frac{(B - T) \times S \times 1.3 \times 0.003 \times 100}{weight}$$

Where, B denotes amount of mL of $FeSO_4$ solution for the blank experiment, T denotes amount of mL of $FeSO_4$ solution needed in the experiment, S denotes strength as 1N of $FeSO_4$ solution (from blank experiment) and W denotes weight of taken soil sample.

Soil organic matter of collected soil sample was measured by following the steps of total organic carbon determination process. Soil organic matter of the samples were calculated as multiplying the total organic carbon of each samples determined previously by Von Bemelen factor (1.724). Organic matter was determined by the following formula (Jackson, 1973):

Percentage of organic matter in soil sample = percentage of organic carbon × 1.724.

2.4. Density separation and identification of potential MPs

After the sieving process, density separation step can be occupied in order to remove various soil mineral phases. Extraction of MP from collected soil samples was done using Saturated NaCl solution (Besley et al., 2017). Fully saturated salt solution was used. 50 g of soil was dissolved by adding 200 mL of NaCl 5 M salt solution. Which was then stirred for 2 min and settled for 6 h. The content was filtered using

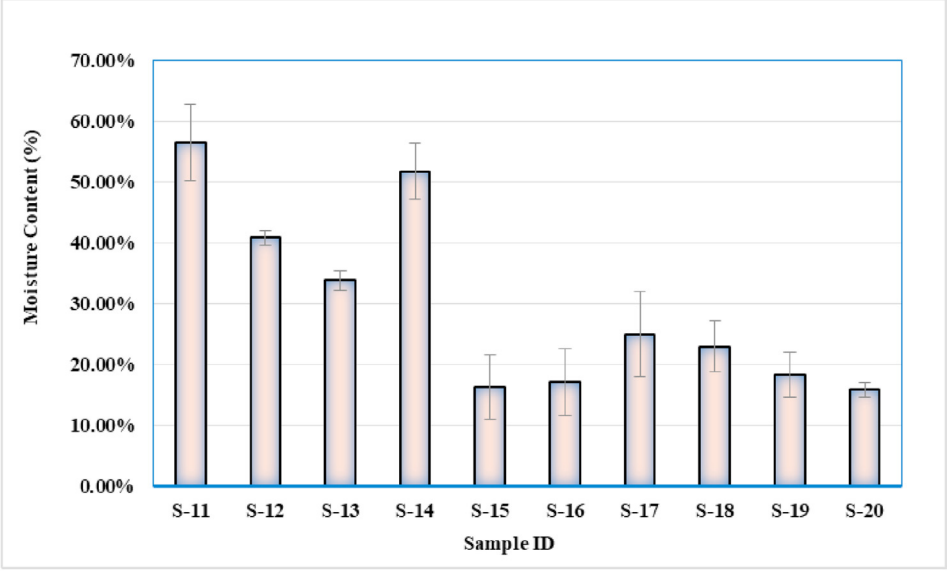

Figure 2. Moisture content values of collected soil sample. The moisture content values (mean ± standard deviation) were estimated in MS excel.

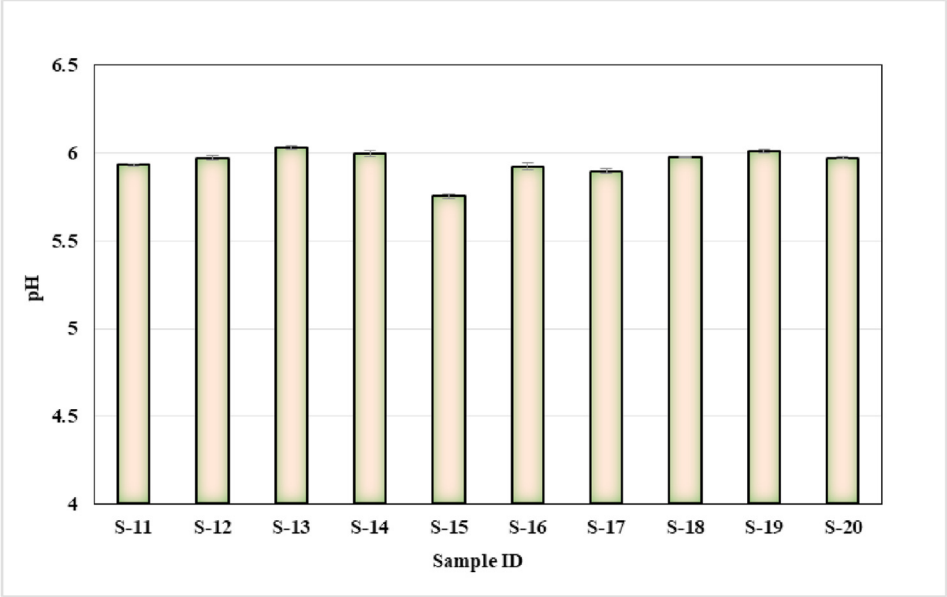

Figure 3. pH values of collected soil sample. The pH values (mean ± standard deviation) were estimated in excel. The tested soil samples pH values found between 5.76 to 6.02.

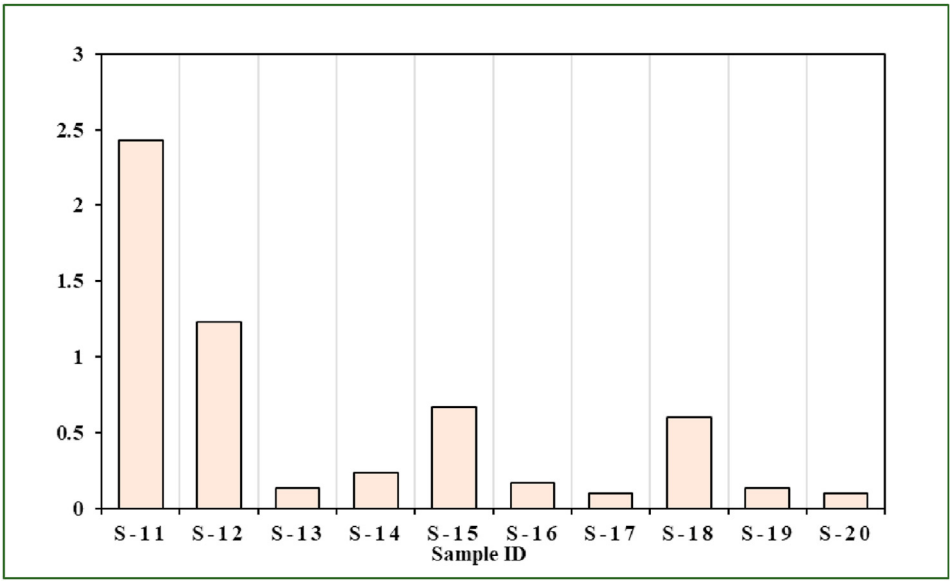

Figure 4. Electric conductivity (μS/cm) values of collected soil sample. The electric conductivity values were estimated in excel and values range from 0.1 μS/cm to 2.43 μS/cm.

Whatman No. 42 filter paper (retention >8 μm). Repeat the extraction process three times for reproducibility and validity. Filtered soil samples on filter papers then were saved in petri dishes to inspect further (Corradini et al., 2019).

An additional step of organic matter removal is needed in order to disintegrate MPs from organic matter enriched soils. Because soil organic matters densities are generally between 1.0 and 1.4 g cm−3, which alike for various plastic particles like Nylon and Polyethylene terephthalate (Blasing and Amelung, 2018). For the removal of organic matrices from soil for MPs identification, Hurley et al. (2018) have compared 10% KOH, 10 M NaOH & Fenton's reagents. According to Lusher et al. (2017), density separation using NaCl solution followed by digestion procedure using H_2O_2, resulted in 95% recovery rate for MPs having no impact on polyethylene and polystyrene, though a slight FT-IR spectra modification was appeared. Fenton's reagent was most effectively used to remove organic matters from environmental samples following oxidation process (Gray et al., 2010; Zhang et al., 2018). Then, samples were transferred into glass beaker and processed. 500 mL of sample was soaked with de-ionized water and 20 mL of Fenton's reagent was added. After the reaction stopped (gasification and bubble formed), size fractioning was done using a 2 mm sieve.

After extraction and sample purification stage, the samples were inspected using a stereomicroscope-Olympus DP22 (model U-TV0.5XC-3, SN-5M01493) at 4X. The samples collected on each filter were examined under stereomicroscope thrice. MP particles were referred to have some features such as MPs may have shiny surfaces, various sharp geometrical shapes, potent colors. Artificial fibers were referred to have potent color and bland sides (Horton et al., 2017). Plastic particles were categorized according to their shapes such as fibers, fragments (angular, smooth and solid) & films. Examined samples were photographed with Olympus

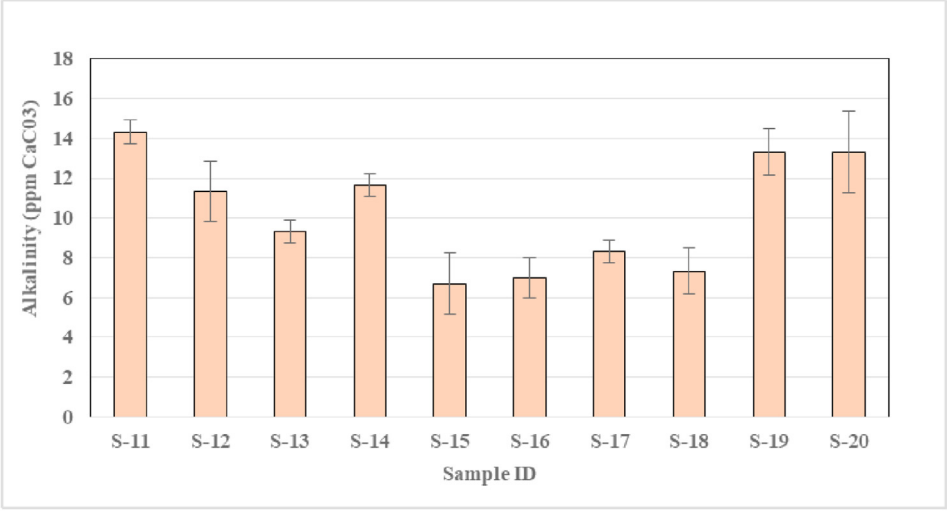

Figure 5. Soil alkalinity values of collected soil sample. The soil alkalinity values (mean ± standard deviation) were estimated in excel and the values of collected soil samples range from 6.7 ± 3.79 to 14.33 ± 0.577.

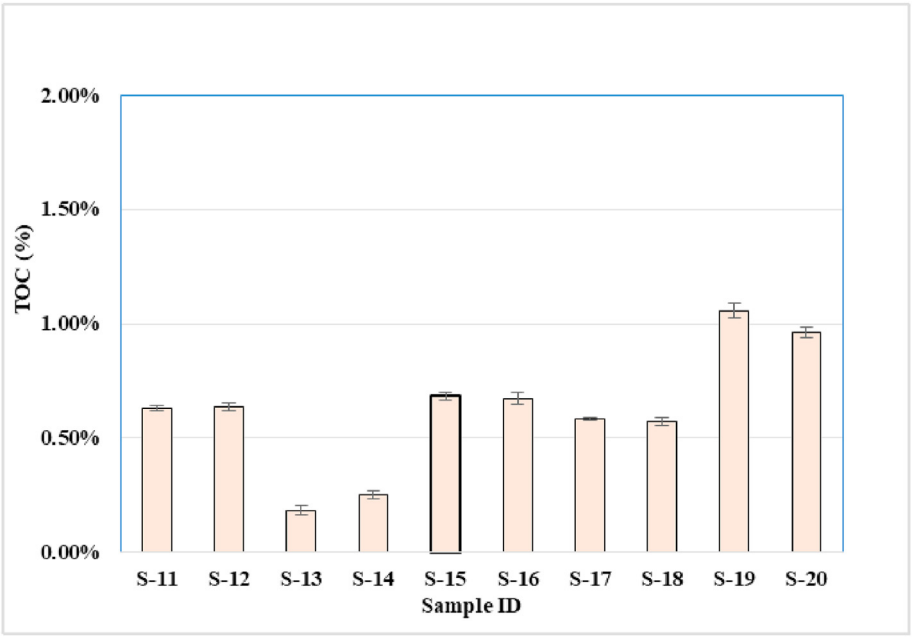

Figure 6. TOC values of collected soil sample. The TOC values (mean ± standard deviation) were estimated in excel. The TOC values of collected soil samples range from 0.18% ± 0.05–1.09% ± 0.08.

DP22 to measure the extent and length of fibers that may present. Cell lens entry software was used for this purpose. Results were reported as identifying the presence of MPs in the examined samples.

For chemical structure identification, Fourier-Transform Infrared spectroscopy (model IR Prestige-21 FTIR-ATR) was used followed by KBr Pellet Method. Grinded a small amount of processed soil sample with 200 mg fine KBr powder and then finely crushed and put into a die to form pellets. As soil is colorful, so the lesser the soil sample would be taken to form pellet, the better a good IR spectra could be achieved. A force of on an average 8 tons was applied for few minutes under a vacuum of several mm Hg in order to form nearly transparent pellets. Degassing step was performed to extract any kind of moisture and air from the KBr powder. Inadequate vacuum may cause easily broken pellets that may scatter light. A fast heating can cause oxidizing some of the KBr powder to $KBrO_3$, creating a brown stain. After drying the powder, it was stored in a desiccator. KBr pellet was then assess in IR prestige-21 to get the IR spectrum. The spectrums were evaluated in comparison with reference spectrum (Jung et al., 2018).

2.5. Statistical analysis

Every time three replications were performed in all parameters then analyzed the data. All statistical analysis including average, mean, standard deviation were estimated using Microsoft excel 2016.

3. Results and discussions

3.1. Determination of physicochemical composition of collected soil

Moisture content is an important property of soil. High moisture content has an adverse impact on permeability of soil. Moisture content also comprehensively affects soil's shear strength (Zhang et al., 2018).

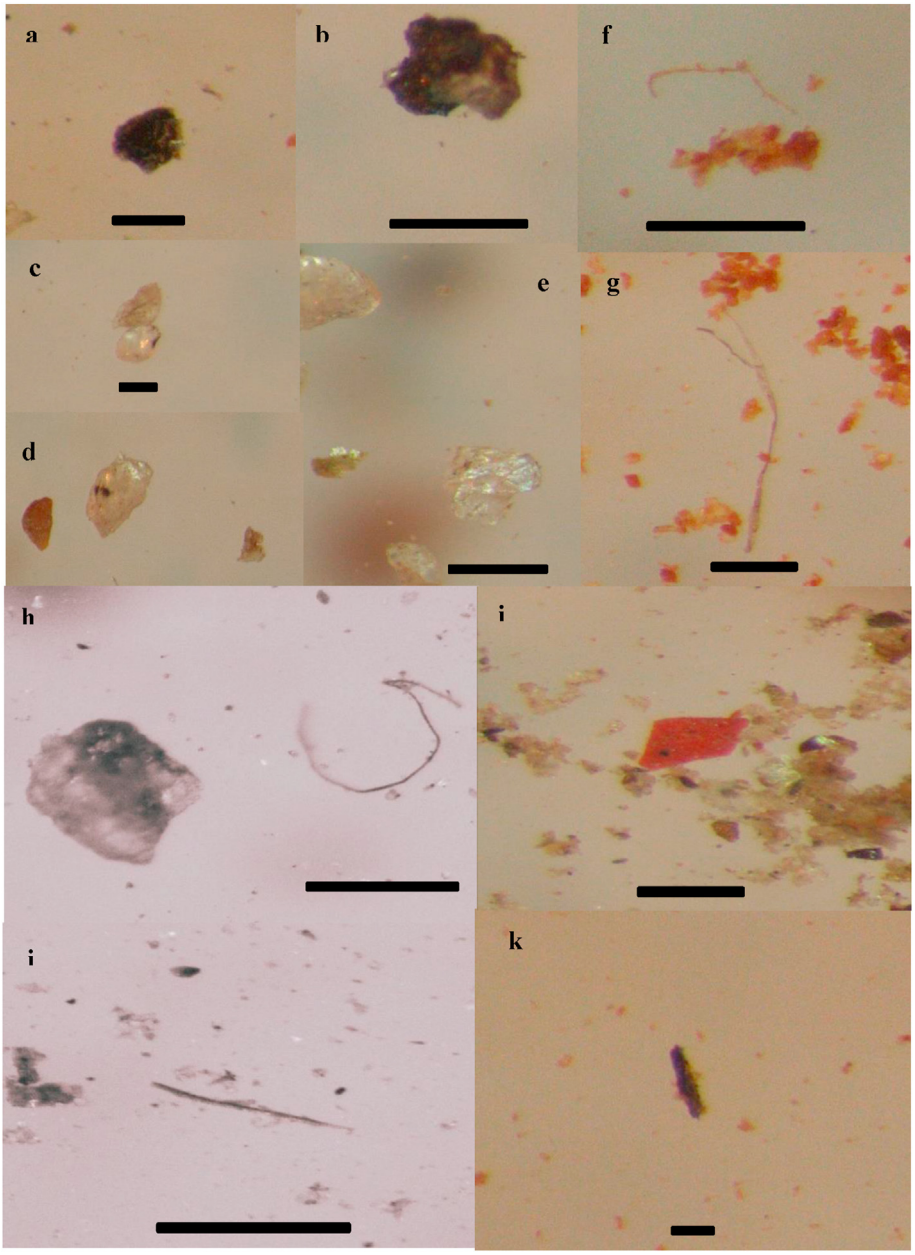

Figure 7. Pictures of microplastics debris on the investigated landfill soil. Particles were grouped into three categories: Films (a, b, c, d, e); fibers (f, g, h, i) and fragments (j, k). The black bar in each panel indicates 200 μm size.

Generally, soil moisture ranges from 10% to 45%, but under the watering situation it could be higher. The data are shown in Figure 2. The soil samples range from 15.84% to 56.54%. According to optimum level, soil moisture content of the few collected soils are higher than the optimum range that affect the soil forming processes, metabolic activities and weathering.

For the prolong effects of different practices of soil management, pH of soil is an important parameter of terrestrial environment. Soil pH affects the nutrients availability and soluble chemicals that regulates soil water. Nutrient availability in soil environment largely depend on acid and alkaline condition of the soil. The data are shown in Figure 3. Normally, the pH of the soil ranges from 7 ± 1. So, the soil is slightly acidic. According to Agriculture Victoria, if pH is close to 5.5 to 5 then it is slightly acid. It shows optimal balance of major nutrients and trace elements available in soil for plant uptake.

Soil electrical conductivity is an important indicator of environmental health. Optimum level of electric conductivity in the soil ranges from 200-1200 micro Siemens per centimeter (μs/cm). Below the level of 200 μs/cm would indicate insufficient nutrient for plant uptake and infertility in the soil. If the electric conductivity level is greater than 1200 μs/cm in the soil, it could indicate that the soil has high salinity. Thus, the level must be maintained within the range. The data are shown in Figure 4.

Soil alkalinity is a condition that arises from the deposition of minerals and salts in soil. The collected soil samples were analyzed to determine their alkalinity level to determine the soil's applicability in further investigation. The data are shown in Figure 5. The soil alkalinity value of collected soil sample ranges from 6.7 ± 1.528 to 14.33 ± 0.577. The alkalinity exceeds the optimum level which is from 6.5-7.5, thus affects the soil fertility and soil may have deficiencies of essential

nutrient, may show toxicity. Parveen et al. (2012) found that the total alkalinity observed ranged between 350-2250 mg/L that values are above the permissible limit of 200 mg/L in all the water samples in the landfill site of Nanded city, Maharashtra.

Total organic carbon (TOC) affects many physical and chemical characteristics of soils such as nutrient holding capacity which can be both cation and anion exchange capacity, soil stability, potential color of soil & nutrient cycling. High clay content enriched soil may contribute more to cation exchange. The high cation exchange capacity of soil's organic matter is majorly responsible for soil's static structure. The data are shown in Figure 6. The organic carbon is equal and slightly higher as compared with standard value of <0.5 % (Katyayan et al., 2008). The soil surveyed had between 0.32% to 1.82% organic matter. They did not represent a problem during analysis. MPs can absorb harmful substances in soil solutions and change soil physical properties, such as increasing porosity, changing aggregate structure or becoming part of soil aggregates and these changes can change microbial activity (Huerta Lwanga et al., 2017).

3.2. Visual identification of potential MPs under steriomicroscope

The filtered sample were analyzed for the presence of potential MP using steriomicroscope at 4 X and photographed by Olympus DP22. Out of thirty replicated samples, MP debris was successfully found in three (03) sample, one from top soil samples and the other two from core soil samples. According to size, the detection range was from 0.001 – 2 mm because to address the limitation of detectable size is one of the main challenge of the MP assessment. The presence of MP debris has been successfully identified in those three samples in three categories: five types of film, two types of fragments, four types of fiber MP debris were identified (Figure 7).

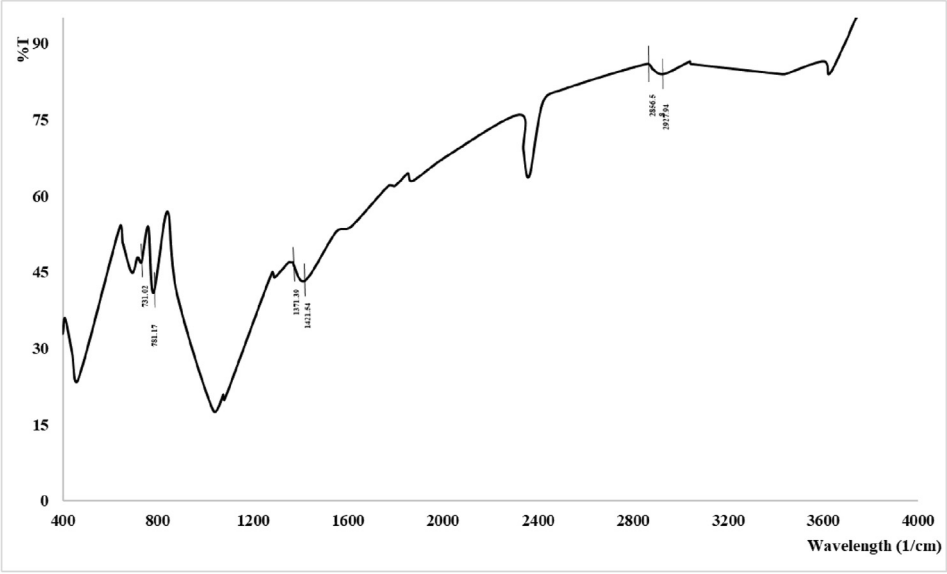

Figure 8. IR spectrum of 1st corresponding sample which shows significant absorption band (cm^{-1}) of "Low density Polyethylene (LDPE)".

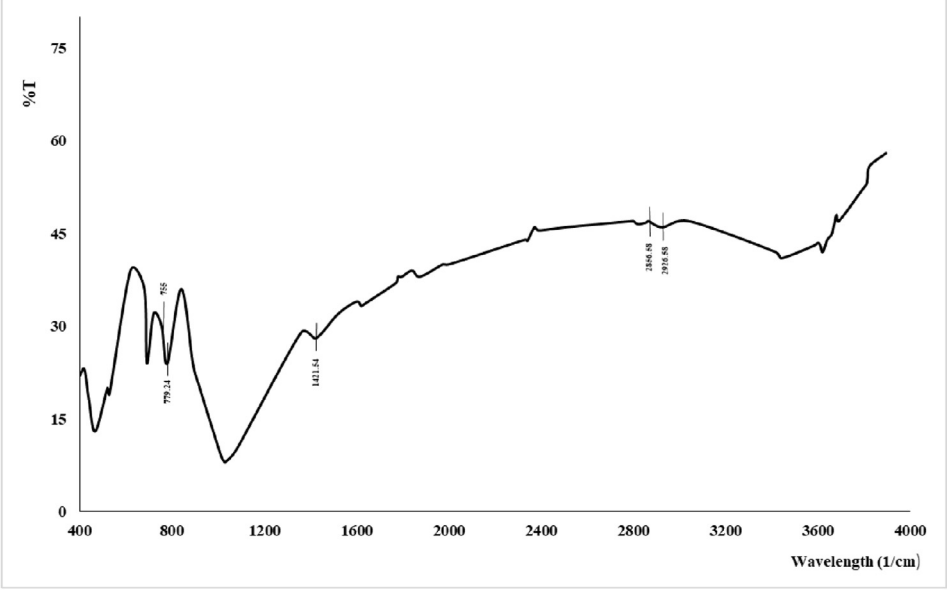

Figure 9. IR spectrum of 2nd corresponding sample which shows significant absorption band (cm^{-1}) of "High density Polyethylene (HDPE)".

3.3. Identification of presence of potential MPs using FT-IR technique

The collected soil sample were analyzed for chemical groups by using Fourier Transform Infrared spectroscopy. KBr pellet method was followed during the determination procedure. Each collected sample was replicated into three parts and used to prepare KBr pallets. The region from 1500-500 cm^{-1} in IR spectrum is called as fingerprint region, which contain all forms of complicated vibrations and bending vibrations of the molecules. This fingerprint region can be used to identify the unknown chemical compound or several other comparable compounds structure by assimilating the troughs in the spectroscopy's right sides graph. High resolution instrument is needed for precise detection of particles bonds. ±10 % resolutions can provide informative fingerprint, otherwise not informative. For plastic monomers and polymers like alkanes, alkenes which have few bands, C–H stretching absorption band is significantly remarkable for the identification purpose.

The IR spectroscopy has built in KBr standard. Out of the main ten samples, MPs were found in three replicated samples successfully. FT-IR spectrums of potential MPs appearance are identified in three (3) samples.

Figure 8 represents IR spectrum of corresponding sample showing Absorption bands (cm^{-1}) of low density Polyethylene (LDPE) (Jung et al., 2018; Asensio et al., 2009; Noda et al., 2007; Nishikida and Coates, 2003). The spectrum shows following bands in cm^{-1}: CH_2 Asymmetric C–H stretching at peak 2927.94 cm^{-1}; CH_2 Symmetric C–H stretching at peak 2856.58 cm^{-1}; CH_2 bending at peak 1421.54 cm^{-1}; CH_3 bending at peak 1371.39 cm^{-1}; CH_2 rock at peaks 731.02 cm^{-1},781.17 cm^{-1} in comparison with reference spectrum (Jung et al., 2018).

Figure 9 represents IR spectrum of corresponding sample showing Absorption bands (cm^{-1}) of high density Polyethylene (HDPE) (Jung et al., 2018; Asensio et al., 2009; Noda et al., 2007; Nishikida and Coates, 2003). The spectrum shows following bands (cm^{-1}): CH_2 Asymmetric C–H stretching at peak 2926.01 cm^{-1}; CH_2 Symmetric C–H stretching at peak 2856.58 cm^{-1}; CH_2 bending at peak 1421.54 cm^{-1}; CH_3 bending at peak 1371.39 cm^{-1}; CH_2 rock at peak 755 cm^{-1}; CH_2 rock at peak 779.24 cm^{-1} in comparison with reference spectrum (Jung et al., 2018).

Figure 10 represents IR spectrum of corresponding sample showing Absorption bands (cm^{-1}) of Cellulose acetate (CA) (Jung et al., 2018; Asensio et al., 2009; Noda et al., 2007; Nishikida and Coates, 2003). The spectrum shows following bands (cm^{-1}): C=O stretching at peak 1776.44 cm^{-1}; CH_3 bending at peak 1396.46 cm^{-1}; C–H bending 912.33 cm^{-1}; O–H Bending at peak 692.4 cm^{-1} in comparison with reference spectrum (Jung et al., 2018).

The presence of HDPE, LDPE and CA were identified in examined soil samples. The results acquired from soil samples collected from Urban landfill site depict that this landfill site could act as a potential source of MPs in later time. Many researches have been focused on identifying the MP sources in aquatic environment, but it should be realized accordingly that the terrestrial ecosystem is also facing extreme MP contamination, as plastic products are being used on larger scale worldwide (Horton et al., 2017). MP can be accumulated in the soil on higher concentration, for that reason MPs can deposit in soil for longer period, causing impacts on functions of terrestrial ecosystem and its biodiversity (Rillig et al., 2012). In current days, there are little studies on MPs circulation on soil matrices. This situation needs to be handled precisely for the indifferent soil function without any disturbance in proper action mechanism of soil and to support plant growth in farmlands.

4. Limitation, key challenges and future implications

Briefly, special attention on different soil processes must be provided in order to have a strong understanding of corresponding impacts of MP contamination on the terrestrial ecosystem (de Souza Machado et al., 2018). There is many vagueness in various prospects such as significant source, concentration level, proper analytical identification methodology, final fate of MP contamination in the soil environment (He et al., 2019). Key challenges can be addressed as,

- It is essential to establish appropriate sample collection & preparation procedure which is simple & understandable method for MPs identification in soil.
- As, there is a little data is available on terrestrial ecosystem MPss pollution. Different kinds of MPs are found everywhere, addressing them properly is a real challenge. So, the primary focus should be provided on addressing the transport and distribution pattern of MPs in soil environment.
- Data and proper equipment should be available for the successful detection.
- There is a need to put a check on plastic pollution locally first, unless in future these MPs can be more toxic for human health.
- Neverthless, the proper density separation and identification procedure of MPs in the soil environment is an imperative issue for soil

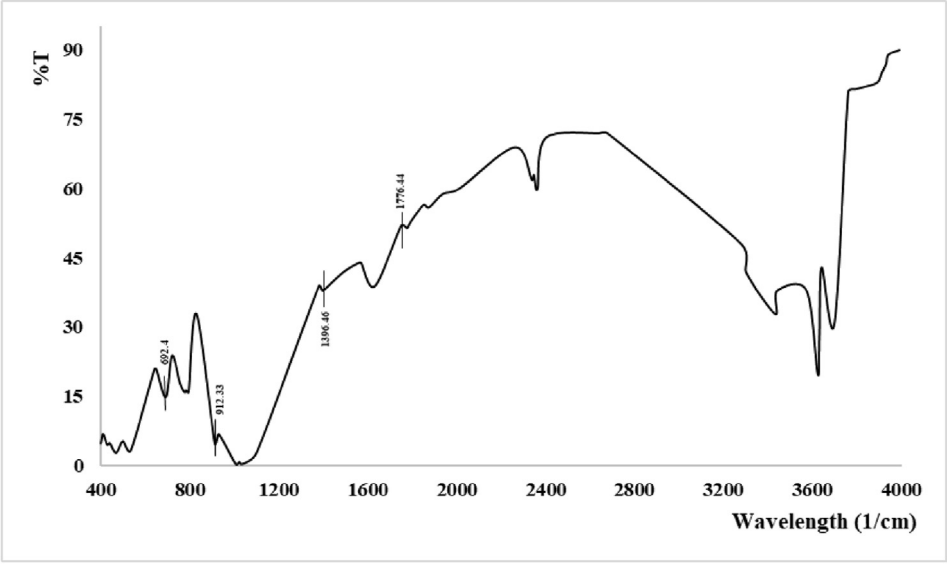

Figure 10. IR spectrum of 3rd corresponding sample which shows significant absorption band (cm^{-1}) of "Cellulose acetate (CA)".

management which should be enlightened in further research. The existing drawn up separation and detection process for freshwater, beach sediment MP particles can be followed for the MP contamination identification in the terrestrial environment.

- The composition of soil, soil structure and several geological and environmental factors and environmental conditions must be considered and investigated timely for the accurate analysis of MP accumulation pattern relevant to MP pollution effects assessment.

5. Conclusion

The study indicates some important information on the possibility of landfills as a significant source of microplastics for very first time in Bangladesh. On that context, this particular study has been done for the initial assessment on potential microplastics presence in the terrestrial ecosystems. So, more studies are required globally for establishing appropriate methodology in order to address the proper identification of plastic particle types. Results of these study may have an impact on the disposal of plastic waste and on the management of landfills. Following the methodology of four recent studies, three types of plastic has been identified from the collected ten soil samples. Therefore, there are only few studies conducted addressing microplastic contamination in soil, so the actual range of this matter has not been evaluated still. There should be more research on weathering of plastic particles and their transport processes within the soil media and it is an urgent need to address the fate of such plastic pollutants in all type of environment, particularly in terrestrial environment. Thus, it is required to develop an accurate analysis method for identifying microplastics in soil samples. This study highlights that microplastics could be accumulated in soils by the natural functioning of terrestrial ecosystems and could affect the environmental health in significant ways other than causing direct toxicity in the terrestrial ecosystem. Moreover, the landfill soils can be transferred into agricultural land. As a result, if there are significant presence of microplastics in soils that can have adverse impacts on plant growth and various soil functions. So, in Bangladesh context further assessment on microplastic pollution in terrestrial environment should be conducted for the proper analysis and solution of this microplastic contamination problem.

Declarations

Author contribution statement

Sadia Afrin: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Md. Khabir Uddin: Contributed reagents, materials, analysis tools or data.

Md. Mostafizur Rahman: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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