Assessment of Microplastic Pollution along the Bhairab River, Jashore Municipality, Bangladesh

By

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This Thesis Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science (B. Sc.) in Environmental Science and Disaster Management (ESDM)

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APPROVAL

The thesis report titled "**Assessment of Microplastic Pollution along the Bhairab River, Jashore Municipality, Bangladesh**" was submitted to the Department of Environmental Science and Disaster Management by Sanzida Mollik. It has been accepted as the partial fulfillment of the requirement for the degree of Bachelor of Science (B.Sc.) in Environmental Science and Disaster Management (ESDM). There was a presentation on regards to this thesis which took place on 28th February.

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DECLARATION

I hereby state that I have carried out this work under the supervision of **Dr. Mahfuza Parveen, Associate Professor of the Department of Environmental Science and Disaster Management (ESDM),** Daffodil International University, I declare that no research project has been presented to other parties or any aspect of this research project for any degree.

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DEDICATION

Almighty Allah & Beloved Parents

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Finally, I am thankful to my parents for supporting my research interest and I would not have been able to complete my thesis without their support and encouragement.

Abastract

Plastic waste problem has become a burning issue at present in many countries and its solution to environment friendly manner has become an urgent need for attaining the sustainable development goals. Bhairab River belongs to the south-western part of Bangladesh consisting of a distributary of the Ganges. The study was conducted surrounding Bhairab River under Jashore Municipality where soil and water samples were collected besides the highly plastic contaminated Bhairab River. Plastic contaminated five rural and five urban points with two control samples were used for the study. Among these plastic categories, micropelletesin the mid rang size fractions (0.25-0.7mm) were the predominant types of plastics noticed in the specified sampling site clearly. Most of the samples, dark colored pellets were found here suspected that suspended pellets seemed to be the polyethylene based micro plastics. However, SEM-EDX analysis performed here showed that suspended pellets were primarily metallic. Fibres were the second most common types of micro plastics identified visually with different colors such as black, dark blue, red etc. Microfibers with similar characteristics were found in freshwater ecosystem with <2mm identified visually. In FTIR analysis, in most of the water sample, strong halo compounds were found together with N-H stretching with primary amine was found. Apart from the soil samples, most of the samples showed similar transmittance compared with the control samples but rest of the samples, aliphatic amine, conjugated alkene and primary amine were found. In SEM analysis, urban soil samples showed structural deformation because more plastic fragments were responsible for deformation of soil samples but in rural samples, structural deformation were not found here compared with the soil samples. In EDX analysis,

compare with the control samples, in most of the urban soil samples, carbon was present at the highest rate than the rural soil samples. Whereas, chromium, cobalt, lead were found at the highest rate in most of the urban soil samples. At the end, it can be concluded that recycling would be the only sustainable options to reduce this huge plastic pollution therefore more research regarding the plastic waste management is dying need.

Keywords: Plastic Pollution, Plastics packaging (Low Density Polyethylene), Fourier Transform Infrared Spectroscopy, Scanning Electron Microscope, Energy Dispersive X-Ray, Microscopic analysis.

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Chapter 1

Introduction

1.1 Background:

Millions of tons of plastic are produced each year, facilitating all aspects of people's lives. Rivers play a crucial role in transporting land-based plastic waste to the ocean, with the Ganges reported as the second largest contributing river of plastic pollution globally. To better quantify global plastic pollution transport and effectively reduce the sources and risks imposed, a clear understanding of the origin, transport, fate, and effects of riverine plastic debris is important. In this paper, we discuss the current state of knowledge of plastic pollution in aquatic systems in Jashore and evaluate existing research gaps. Bangladesh has been recognized as an internationally significant nation in the plastic pollution crisis, but this paper identifies a major disconnect in knowledge, understanding and capacity to understand and address this critical environmental and public health issue.

The 21st century is facing a serious situation in waste management, especially Plastic waste. Plastic has many advantages but with it comes with many problems too. The word plastic means any material which is made of synthetic or organic compound which has malleable properties. The major features which play a big role in the usage of plastic are malleable, durable, light weight, impervious to water and low cost. According to associations of plastic manufacturers in Europe, about 20 types of plastics are used worldwide. Few of the highly used plastics are high-density polyethylene (PE), low-density and linear low-density polyethylene (HDPE/LDPE), polypropylene (PP), polystyrene (PS), polyvinylchloride (PVC), polyethylene terephthalate (PET), and Polyurethane (PUR) resins; and polyester, polyamide, and acrylic (PP&A) fibers. Plastic has diversified uses and consumed by a number of sectors worldwide. The principal consumer of plastics is packaging industry (consumes almost 36% of the total world plastic production).

The current state of the water bodies and rivers of Bangladesh have become a growing concern due to the continuous disposal of untreated wastewater from various industries, urban and agrochemical outflows. Both surface water and groundwater sources are polluted with different contaminants, which include toxic trace metals, coliforms, as well as other organic and inorganic pollutants**(Hasan, Shahriar and Jim, 2019)**. Additionally, around 4000 to 4500 tons of solid waste is created every day and more than 50% of this waste is discarded into low lying land or into freshwater**(Arefin and Mallik, 2017)**. Among different types of solid waste, mismanaged plastic has been identified as one of the major pollutants, with Bangladesh ranked 10th in the top 20 mismanaged plastic waste producing countries in the world **(Kibria, 2017)**.

Globally, plastic pollution is a rapidly growing area of concern and has received increased research attention**(Blettler *et al.*, 2018)**, particularly as the negative impacts of this waste on people and the environment are becoming better understood**(Baak, Provencher and Mallory, 2020)**. Based on their size, plastic pollutants can be divided into macroplastics (>5 mm), mesoplastics (≤5 to >1 mm), microplastics (≤1 mm to >0.1 μm), and nanoplastics (≤0.1 μm)**(Lambert, Sinclair and Boxall, 2014)**.

The current levels of plastic production, use/disposal patterns, low recovery rate, and demographic data all point to increasing accumulation of plastic waste**(Dahlbo *et al.*, 2018)**. While plastics are both persistent and recyclable materials, less than 5% are reclaimed **(Lambert and Wagner, 2016)** and 4.8–12.7 million tons of plastic waste entered the ocean in 2010 **(Jambeck *et al.*, 2015)**. Projected over one hundred years, the degradation cycle of plastics waste predicts severe environmental problems as surface embrittled plastics are micro cracked by microbial-mediated and weathering conditions and mechanisms, such as ultraviolet (UV) light and hydrolysis, and are progressively broken down into the small fragments and particles known as microplastics**(Cole *et al.*, 2011)**. In a word, microplastics have become a global environmental issue and have aroused widespread concern about health risks. As the number of researches regarding microplastics in soil has considerably increased in recent years, it is important to examine the interactions between soil and microplastics, and identify research gaps and directions. Studying many papers related my topic I have been seen many places of soil and water test for micro plastics; but still now in my study area of Jashore did not work here about micro plastics and that's why I believe that my work is new in that case and I choose this place as my study area for my thesis work purpose and from that place I assume my work is different.

1.2 Objectives of the study

1. To identify the diversity of plastic waste production in urban and rural areas beside the Bhairab River.
2. To identify & quantify microplastics using microscopic analysis.
3. To identify the polymer identification behavior towards the microplastic wastes using FTIR analysis.
4. To assess the metal composition among the plastic waste using EDX analysis in combination of SEM.

Chapter 2

Literature Review

2.1 General:

We know water and soil quality deals with the physical, chemical and biological characteristics in relation to all environmental properties. The soil of Bangladesh is prone to pollution from several types of wastes such as municipal wastes of plastics, hospitals and clinics wastes, industrial plastics wastes and many more. Bangladesh has one of the largest river networks in the world, with approximately 700 rivers and watercourses, including tributaries, which have a total length of an estimated 24,140 km (Chowdhury, 2012; Rahman and Yunus, 2016). This chapter is about the discussion of some basic information and background of the Bhairab river, it's soil features, and it's drainage system; including summary of previous literature on this topic.

2.2 Plastic pollution:

Globally, plastic pollution is a rapidly growing area and has received increasing research interest, especially as the negative impacts of this waste on humans on the environment become increasingly common which is clearly understood (Blettler et al., 2018). Based on their size, plastic pollutants can be divided into macroplastics (>5 mm), mesoplastics (≤5 to >1 mm), microplastics (≤1 mm to >0.1 μm), and nanoplastics (≤0.1 μm) (Lambert et al., 2014). The presence of plastic debris in the river water and in the soil has becoming a well-research topic but in general, above ground of river in the environment is much less concern. Most recently, a global study showed more than 3,000 microplastic related papers have been published, with about 40% of those studies focused on freshwater ecosystems, though that number has been increasing significantly in the last two years (Szymańska and Obolewski, 2020).

2.3Microplastic (<5 mm)

Microplastic pollution has been detected worldwide in various soils. In studies of most agricultural soils, the sampling depth varies from 0–10 to 0–30 cm, a range that falls within the tilling layer. The sampling depth of other soils is shallower, less than 5 cm. For example, soil samples were collected from the top 2 cm and 5 cm of the profiles in coastal and floodplain soils, respectively (Scheurer & Bigalke, 2018; Zhou et al., 2018). Many studies have reported microplastic pollution by its number concentration, which stemmed from the initial studies of microplastic pollution in marine and freshwater systems (Ivar do Sul & Costa, 2014; Zhang, Shi, et al., 2018). The simulation of concentration is also more easily implemented in the laboratory, and therefore it is conducive to the study of microplastics under environmentally relevant conditions. We know that without any agricultural plastic application, although microplastics smaller than 1 mm were excluded in the latter measurement, which might have led to an underestimation of the microplastic concentration. Polyethylene (PE) and polypropylene (PP) are the dominant types of microplastics in the studies reviewed, likely due to the fact that PE and PP are the most demanded plastics in the world (Andrady & Neal, 2009). It is important to study the physical structure and surface properties of microplastic in order to facilitate a comprehensive understanding of factors affecting the environmental fate of microplastics in soil. Some studies characterized microplastics only through a microscope, which is not suitable for microplastics in environmental samples, because it is difficult for the naked eye to determine accurately whether it is plastics or other environmental components; spectroscopic methods such as Raman and Fourier-transform infrared spectroscopy (FTIR) should be used to verify the particle composition, showing the dominant composition of microplastics as much as possible (Vollertsen & Hansen, 2017).

2.4 Mesoplastic (5–25 mm) and Macroplastic (> 25 mm)

Several studies have reported the co-existence of mesoplastics with microplastics in farmland and floodplain soils (Liu, Lu, et al., 2018; Piehl et al., 2018; Scheurer & Bigalke, 2018). Due to the larger size of mesoplastic, there is a lower number concentration but higher mass concentration of mesoplastics than microplastics. For example, a floodplain soil was detected with a lower number (0–89 vs. 0–593 particles) but greater mass (0–55.5 vs. 0–295.3 mg) of mesoplastics in one-kilogram soil compared with microplastics (Scheurer & Bigalke, 2018). Mesoplastics may have a similar (but not identical) polymer composition to microplastics, but it is not rigorous to conclude that microplastics are derived from mesoplastics. More factors should be considered as well. But in the river side area there also fallen down meso and macroplastics which also affects in soil very worsely but unfortunately there have no action to change in there, with a positive way.

2.5 Previous studies:

- ❖ Authors of (Xu *et al.*, 2020) have worked out about “Microplastics in the soil environment find out it’s Occurrence, risks, interactions” as well as highlighted perspectives for future research on microplastics in soil. This paper of -Microplastics in the soil environment: Occurrence, risks, interactions and fate highlighted that microplastic pollution is a great issue overall the whole world that be founded from the marine environment, aquatic environment, terrestrial environment is estimated to receive annually 4–23 times more plastic wastes(as per2019 report). This paper summarized the observed effects of microplastic pollution on soil ecosystems as well as sorption and transport behaviors of microplastics in such environments in the surroundings. Microplastic pollution has been detected in various types of soils including agricultural/farmland, home garden, coastal, industrial, and floodplain soils. Micro plastics affect soil physical and chemical properties, microbial and enzyme activities, and plant growth, and these are also claim unfavorable of eco-toxicological effects for soil fauna. These effects also depend on the concentration, size, and shape of micro plastics as well as soil texture. Here broadly included issue of micro plastic pollution; it's finely defined plastics category including macroplastic, microplastics, nanoplastics. It look-out first identified the microplastics pollution in soil and then many of them showed interest and it's increasing number of studies focused on this important topic as soil and environmental scientists alike have realized its gravity. This paper-" Micro plastic in soil environment: occurrence, risks, interactions and fate covered the current progress of the study of microplastic pollution in soils, including such subjects as pollution status, environmental risks, interactions with toxic chemicals, and transport throughout soil; and the other side it also find out the lacking of pollution data for microplastics in soil.

❖ Authors of (Chowdhury *et al.*, 2021) have worked the current state of knowledge of plastic pollution in aquatic systems in Bangladesh and evaluate existing research gaps as well as reviewed scientific publications on plastic pollution in the freshwater and marine environment in Bangladesh and identified key research themes. The impact of plastic pollution on the environment is a rapidly emerging area of interest for researchers, policy makers, businesses and the general public, garnering significant attention worldwide (Nielsen et al., 2020). Bangladesh has been recognized as an internationally significant nation in the plastic pollution crisis, but this paper identifies a major disconnect in knowledge, understanding and capacity to understand and address this critical environmental and public health issue. Plastic Pollution is mainly caused by land based sources, for example, industrial waste and effluents, solid waste and sewage disposal and inadequate sanitation facilities (Hasan et al., 2019). In addition, lack of awareness among the communities, continuous reduction of water flows in the river from upstream due to water abstraction by dams, silt deposition, river erosion, industrialization and untreated waste from industries are also responsible for aquatic pollution (Hossain et al., 2005). The current state of the water bodies and rivers of Bangladesh have become a growing concern due to the continuous disposal of untreated wastewater from various industries, urban and agrochemical outflows (Al-Razee et al., 2016; Ali et al., 2016; Islam et al., 2015). In addition, in the Bhairab river in Jashore here also similar to become micro plastic pollution in river water is continuous disposal of untreated wastewater from various places mostly responsible is house water drainage system and many types of shops and hospitals also.

- Authors of (Rolf *et al.*, 2022) have Research on microplastics which has shown a particular interest in the Rhine, one of Europe's largest and most heavily altered rivers. A global issue is the presence of microplastics (plastic particles smaller than 5 mm) in our environment(Dris et al., 2020). The word "microplastics" refers to a broad category of heterogeneous particles with a variety of intrinsic features that affect their mobility, such as varied polymer kinds, sizes, forms, densities, environmental aging, or biofouling (Rochman et al., 2019; Laforsch et al., 2021; Millican and Agarwal, 2021). The goal of this research is to look at the abundance and vertical distribution of microplastics in Rhine floodplain soil. The author had related the amount of microplastics to changes in flooding frequency driven by the Rhine's water level and the local topography, soil characteristics, vegetation cover, and indicators of earthworm associated bioturbation to illustrate our hypothesis of how local topography and flood frequency could influence the abundance of microplastics in floodplains. For the purpose of conducting a microplastic investigation, they therefore collected soil samples along three transects in a Rhine floodplain that had not yet been affected by agriculture. In fact,they modeled several flooding scenarios at the three analyzed transects to establish the interaction between local topography and flood frequency.
- Authors of (Guo *et al.*, 2020)Recent research has focused on the detection, occurrence, characterization and toxicity of microplastics in marine and freshwater ecosystems; However, our understanding of the ecological impact of microplastics in terrestrial ecosystems is still limited compared to aquatic ecosystems. Here we have documented, investigated the sources and migrations of microplastics in the soil, negative impacts on soil health and function, nutrient transfer through the food chain. This study of research aims to fill gaps in knowledge, elucidate the ecological impacts of microplastics in soil, and suggest future studies on microplastic pollution and soil toxicity. In addition, this paper focuses on limiting microplastics in soil and providing management and remedial measures to reduce the risks posed by microplastic contamination. This paper covered microplastic distribution in soils from four countries- Australia, Switzerland, SE Mexico and China; they assimilated and analysed sources of data, found out sources of soil microplastics,

migrated of micro plastics in soil, elaborately discussed effects of microplastics in soil; Impact on soil and make relation between soil health and it's function, soil contamination sources- trophic transfer of microplastics in terrestrial food chains; Effects of microplastics on soil animals, plants; how to get prevent micro plastics in soil then finally future research recommendations and conclusions.

- Authors of(Karim *et al.*, 2020)here they have documented that microplastics are emerging environmental pollutants that have attracted great scientific attention in recent years. These trace elements are common in both terrestrial and aquatic environments and constitute a harmful threat to ecosystems and biodiversity. By critically reviewing previously published scientific literature, this review briefly describes the characteristics, occurrence and potential toxic effects of microplastics on the biota. terrestrial and underwater. The paper also focuses on some innovative approaches to sustainably remediate macrophages as well as microplastics. As the concept of microplastic pollution is still a stub in Bangladesh, this summary provides an overview of the current scenario of microplastic pollution and some recommendations for future research in the context of Bangladesh. which researchers may find useful for those who are new to the field.
- (Thomas *et al.*, 2020) worked on this paper is focusing on plastic debris prediction using classification levels in microplastics with specific sample of soil organic matter, it's density and nicely observe sample treatment and digest portion. The methods in this paper include soil-focused microplastic analyses from aquatic research without acknowledging the complex nature of soil approach. Most importantly, the number of samples per sites have been taken which extent the investigated area with coverage the spatial variation like as three subplots and for each subplot they have taken one composite sample consisting of 15-50 subsamples ha^-1.According to actual size of microplastic, Liu et al. [45], Huang et al. [62], and Zhou et al. [63] included all fractions below 5 mm in order that large microplastics may cover smaller particles and lead to systematic depreciation during spectroscopic analysis. The sample preparation of this paper included the segments of Drying, Homogenization, Sieving and Sorting, Dispersion of Soil Aggregates, Density Separation and many others. The suggestions for best practice soil sample preparation in the research manuscript is focusing on the preparation method for microplastic analysis of soil samples. It can be elevated to multiple soil types datasets from multiple locations or regions. The sampling of soils particle size is polymer types that is validated by a realistic, well-characterized soil matrix and it can be escalated.

- ❖ (Wang *et al.*, 2022) worked on microplastic soil, abundance uses and it's ecological risks including environmental risks as well as factors. The methods in this paper include accumulation of microplastics in the soil but having much more lacking, they found out no kit with specific grade for sampling techniques and it's extraction methods, analytical procedures also expression units for soil microplastics. Additionally, they focused on the analysis of the environmental risks which be founded from the accumulation of microplastics in soil those were interacting with metals and organic pollutants. Significantly, they found a large research gaps which be situated in the interaction between microplastics and pollutants in the soil and it's mechanism of entire pollution. This paper worked on many portions like as distribution characteristics of microplastic in soil, occurrence of microplastics detected in the soil compartment,human activities, Soil and Plastic Physicochemical Properties and so on. Zhang et al. [99] have found that between of two different beaches released several types of microplastics which can affect the diversity of soil microorganisms; on the other hand Lee et al.[109] have conducted adsorption experiments on 14 different hydrophobic organic pollutants which consuming polyethylene and many more types of microplastics like polyethylene, polypropylene, and polystyrene micro plastics even discovered that adsorption of the surfaces where microplastics fell down they are- Cd, Zn, Ni, Pb and other heavy metals presence but did not specified those metals. Finally, Zhou et al.[61] found out the heavy metals including Cd, Cr, Pb, Ag, Cu, Sb, Hg, Fe, and Mn. Ding et al.[66] (2020) reported that the adsorption capacity of polystyrene was improved with increasing aging degree. They also added that if microplastics find their way into the soil, they interact with other pollutants and in that case, the slow decomposition process of microplastics can diffuse or discharge these adsorbed toxic chemicals into the environment or into the underlying soil along with groundwater. Even they emphasized that at the presence of microplastics pollutants which pose a greater risks to the environment.
- ❖ (Sultan *et al.*, 2023) worked on Mangrove estuary of micro plastics presence in fish muscles. This paper also related to demersal and benthic species which are more contaminated in the Mangrove estuarine and find out their health impacts that also high lighten concerning in Bangladesh's Sundarban mangrove estuarine zone. This paper output the plastics growth rate between 1950 and 2016. In February 2022, 20 different species of fish and shellfish were identified to it's species level, their total body length and weight were measured precisely.

- (Wang *et al.*, no date) studies mainly seasonal abundance of micro plastics variation of summer and winter in river water. At the present time, for the accumulation of plastic products in the environment is at risk (Derraik, 2002; Thompson et al., 2009). Cincinelli et al. (2019) found that annual global plastic production could reach 33 billion tons by 2050. Nor and Obbard,2014- they also added that people are much depend on plastic products because of lower prices and for that it's becoming big issues in the environment and the reasons are- poor disposal of plastic waste and low recycling rate creating large amounts of plastic accumulation in the environment. At the COVID-19 time also produced huge plastic products such as plastic-based personal protective equipment in medical sites and other sectors. In this study, they collected samples in two different seasons and showed the differences between them. Microplastics extraction also showed using the density separation method; then identified the micro plastics and then studied using scanning electron microscopy combined with an energy spectrometer (SEM/EDS) to determine the surface properties of microplastics and the types of heavy metals in sediments; they also analyzed of heavy metal elements and finally discussed spatial and seasonal distribution of microplastics elaborately.
- (Vianello, 2020) studies about specifically microplastic analysis using FTIR spectroscopy. This paper finely describes about plastics terribly using and it's badly impacts in our daily environments as well as our wildlife, and finally us the humans. The preparation of samples for microplastic analysis is an important and complex step, as it strongly influences the results of subsequent analyses, but currently, standardized operating protocols are being developed but having some lacking. Microplastics often have a very low concentration compared to the matrix containing them. Therefore, it is essential to extract the MPs from the matrix and concentrate them before include them in the analysis, while effectively reducing the matrix effect, which can cause strong interference during the analysis. Although in the sampling time, when dealing with different substrates, several common procedures and techniques are used to extract and purify microplastics from organic and inorganic substrates, adding several visual classification under the microscope, sieving, filtration, density separation, chemical oxidation, etc. (Hidalgo-Ruz et al., 2012; Rocha-Santos and Duarte, 2014; GESAMP, 2015; Duis and Coors, 2016).

Chapter 3

Materials & Methods

3.1. Selection of the study area

Jashore belongs to the main district of undivided Bengal which is an increasing center of south-western Bangladesh (Fig. 1). There are eight (8) upazila in Jashore district. These are: Abhaynagar, Bagherpara, Chaugachha, Jashore Sadar, Jhikargacha, Keshabpur, Manirampur and Sharsha (BBS, 2012). Jashore was the present study area where soil and water samples were collected from surrounding the Bhairab River in Jashore municipality where five rural and five urban points with two control samples were used for the study. Bhairab river belongs to the south-western part of Bangladseh consisting of a distributary of the Ganges. The origin of Bhairab river is from the Tengamari border of Meherpur districts and passes through the Khulna city dividing it into two parts such as the Khulna-Ichamati and the Kobadak. The Khulna-Ichamati forms a boundary between Bangladesh and India. The towns of Khulna and Jashore are situated on the bank of the river. The river is approximately 160 kilometres (100 mi) long and 91 metres (300 ft) wide. Its average depth is 1.2 to 1.5 metres (4 to 5 ft) and with minimal water flow (Rob and Abdur, 2012; Geology of the Khulna City, 2010).

Figure 1: Taken photos during field work

Table 1: Sector-wise plastic waste production and consumption pattern globally in 2018(Source: R.P. Mishra et al., 2018)

Globally Plastic waste production in the year 2018		Globally plastic waste consumption in the year 2018	
Sector-wise Production	**Percentage (%)**	**Sector-wise Consumption**	**Percentage (%)**
Packaging	46.0	Packaging	35.0
Textile	14.9	Building and construction	16.0
Consumer products	12.1	Textiles	14.8
Transportation	5.6	Consumer products	10.3
Building and construction	4.3	Transportation	6.6
Electrical and electronics	4.2	Electric and Electronic	4.3
Industrial machinery	0.4	Industrial machinery	0.6
Other	12.5	Other	11.6

Country-wise ranking of plastic waste generation per persons per day (Source: Hossain et al., 2020)

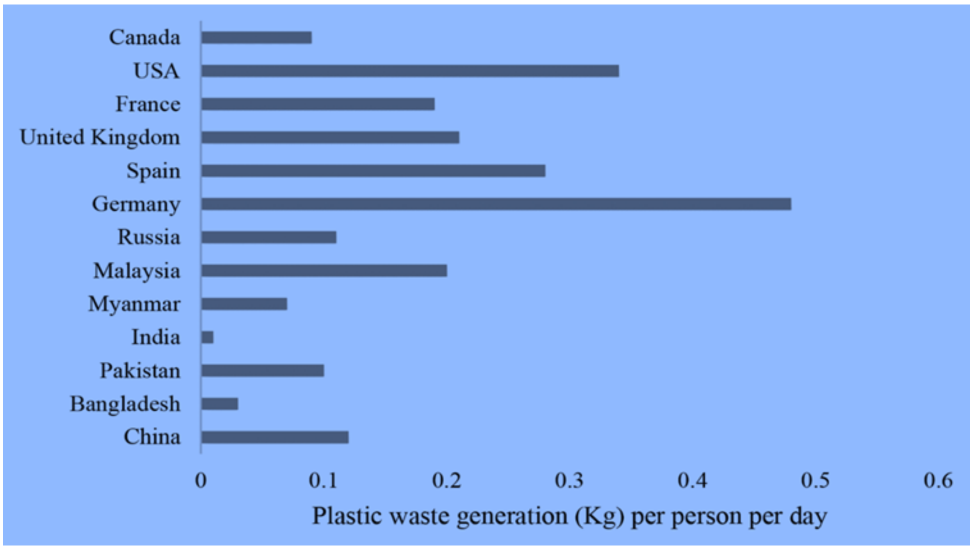


Figure 2: Plastic waste utilization pattern in different countries

Table 2: Commercially available plastics and their applications (Shilpa et al., 2022).

Group	Criteria	Typical application	Recycling code
PET (Polyethylene Terephthalate)	Lightweight and durable, transparent, and resists to breakage	Used in bottled water, soft drink, sports drink, oil and food packaging	1
HDPE (High Density Polyethylene)	Strong and rigid type of plastic	Used in shampoo bottles, liquid soap bottles, detergent bottles	2
Poly Vinyl Chloride	Hard plastics	Electric cable, glass cleaning bottles, water pipes, tray for sweets, food wrappings	3
LDPE (Low density polyethylene	It is formed in high temperature, hard and strong	storage boxes, and toy, bread bags, shopping bags, frozen food bags, dry cleaning bags, plastic sheet, packaging films and sheetings.	4
Polypropylene	It is easily formed in high temperature, flexible, hard, and resistant to fat.	Used for food containers, plant pots, drug bottle caps, and straws.	5
Polystyrene	It is easily formed in high temperatures and is very stiff at room temperature.	Used in plastic tools, plastic cups, grocery store meat trays, egg cartons, fresh produce containers	6

3.2. Collection of samples

Five urban points were selected besides the hospital sites of Bhairab Rivers where water and soil samples were collected. While collecting the samples from rural areas, the most important thing is to keep it mind that the selected sites should be far from the residential and urban activities. The control soil and water samples were collected from agricultural field far from the hospital sites and pure intact water samples were taken to find out the difference from the urban and rural samples.

For this study, soil and water samples were collected from rural and urban areas to find out the micro plastics detection and variation between the rural and urban areas. The location maps of the urban and rural areas are shown in Figure 2.

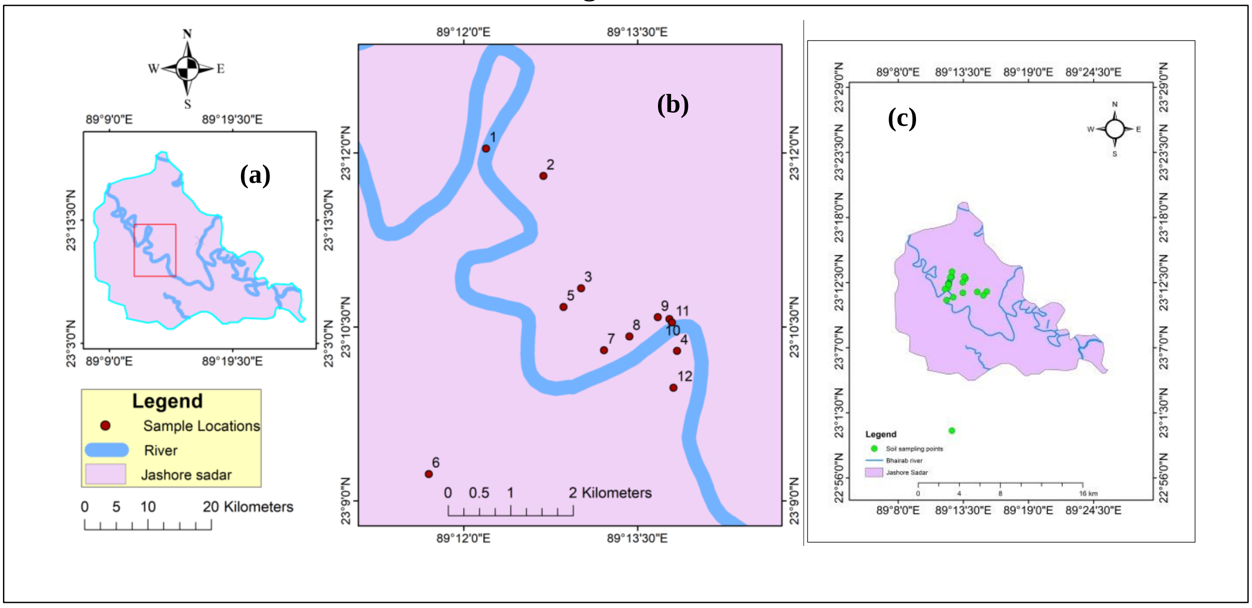


Figure 3: Map of the study area. a) Map of Jashore Sadar Upazilla; b) Map of water sampling points in urban areas besides the Bhairab River; and c) Map of soil sampling points in rural areas (The pictures were taken on Google arc map)

Figure 4: Taken photos of the study area

3.3. Soil samples processing

Soil samples were collected from ten sites and then dried. Soil sample was sieved and meshed properly with mortal to form powder form. Then 10g soil was used and kept in beaker to add 50 ml NaCl solution to mix homogeneous suspension and repeat it for three times. Homogeneous suspension kept overnight for deposition of unwanted sludge and organic matter. Then filtration process was applied with the filter paper and after proper filtration process is end up the filter paper was dried properly to detect the micro plastic particles on the filter paper.

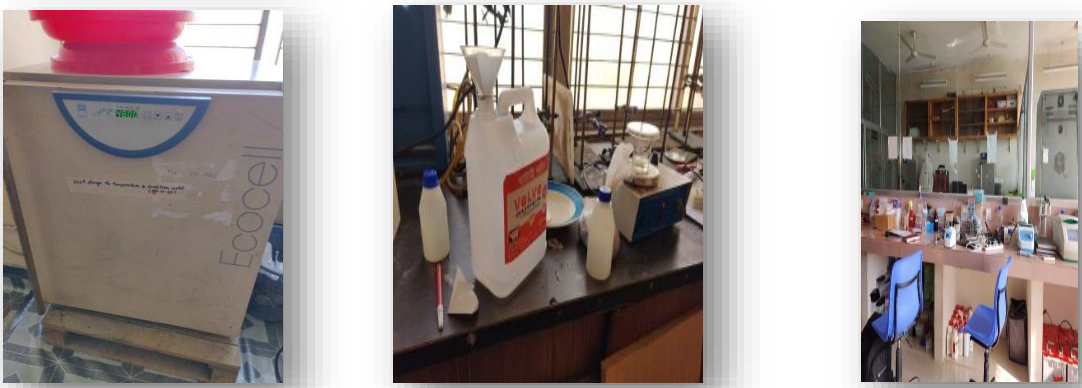


Figure 5: Taken photos during lab work

3.4 Water sample processing

Plastic waste carrying water samples were collected from the Bhairab River using a boat with manta net for a period of 30 min. Before collection of water samples, excessive amount of plastic waste dumping sites were selected for getting the plastic debris in a supplied water sample. After collection of water samples, 50 ml falcon tubes were used to sterile the collected sample and kept at 4^0C during transportation. The collected contaminated samples were rinsed with sterile freshwater to remove microorganisms not attached to the biofilm and filtered using a filter paper to remove unwanted debris. The filtered paper containing plastic debris were dried properly and used to visual analysis for detection of micro plastics in the supplied samples.

3.5. Physical Characterization

3.5.1. Micro plastics detection

The detection of micro plastics on soil and water samples is not very easy process. Analysis of micro plastics can be divided into two parts such as physical and chemical analysis. For detection of physical analysis, first of all, microscopic analysis is done to count the micro plastics on the supplied samples with 4X resolution. Through this visual analysis, the micro plastics can be easily identified with the common features such as size, shape and color (Crawford and Quinn, 2016; Prata et al., 2019). These microfibers, pellets and microfragments were counted by oppo phone using Primostar Microscope; ZEISS company.

3.5.2. SEM measurements

To get clear idea about the surface morphology of plastic particles, SEM analysis is a powerful tool to get the proper idea of the surface structure that may be corroded, roughness, and so on. Plastic surface biofilm formation depends on specific factors such as surface roughness, plastic hydrophilic surface properties, and the properties of substratum also the bulk liquid as well as on cell surface properties (Nauendrofr et al., 2016). A model using FESEM (Field Emission Scanning Electron Microscope) ZEISS Sigma 300, Quorum 150nRS plus was used to analyses the surface fracture of plastic particles on soil samples. Before SEM analysis, filtered soil samples were cut into small size about 0.5 mm using sterile scissors and air dried in oven and kept in sterial basket with proper label for identification. The observations were conducted at magnification of 5KX and 10KX in a low vacuum mode.

3.5.3. EDX analysis

Energy dispersive X-ray (EDX) analysis is *a method of elemental detection via the collection of characteristic X-rays induced by electron beam radiation*. EDX can show the metal composition of the plastics particles. EDX analysis was done using Bruker Nano GmbH XFlash Detector 630M to observe the carbon peak in Genome Centre of Microbiology department in Jashore Univerity of Science and Technology.

3.6. Chemical Characterization

For chemical composition analysis of plastic particles, Fourier transform infrared (FTIR) spectroscopy provides efficient and reliable functional group changes of the plastic particles.

3.6.1 FTIR measurements

Fourier Transform Infrared Spectroscopy is a useful tool for determination of the formation of new or disappearance of existing functional groups. FTIR test was conducted in CSIRL (Central for Sophisticated Instrument Research Laboratory in Chemical Engineering department using FTIR instruments. Prior to FTIR test, filtered both soil and water samples were cut at a size of 1.5×2 cm suitable for FTIR sample holder.

Chapter 4

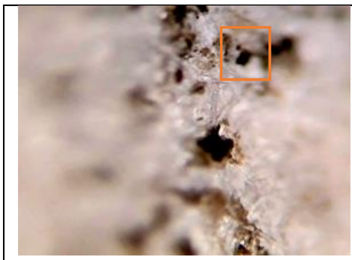
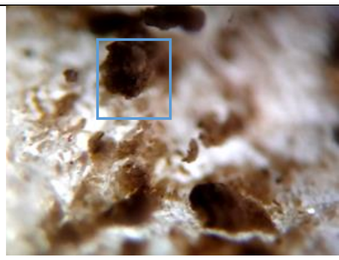
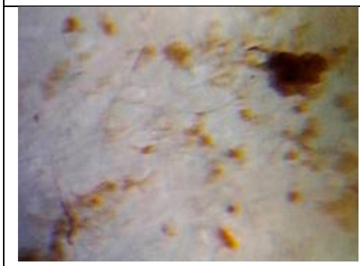
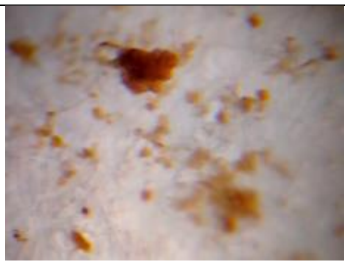
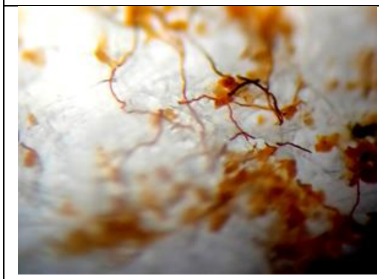
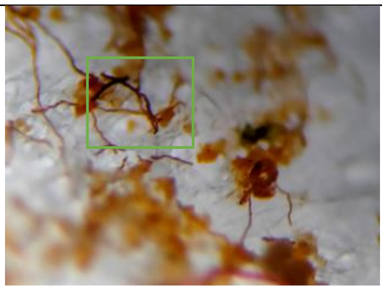
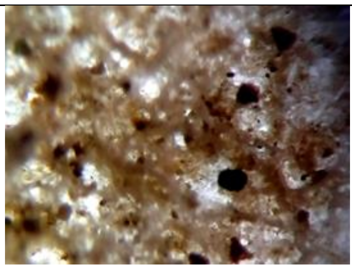
Result & Discussion

Table 3: Micro-plastic counts in soil and water samples surrounding Bhairab River

Identification stage	Sampling point	Micro-plastic counts			
		Pellets	Fibers	Fragments	Total
	Water samples				
Visual observation	WC	4	1	3	8
	WU1	20	0	5	25
	WU2	4	3	6	13
	WU3	18	20	1	39
	WU4	23	8	6	37
	WU5	8	6	0	14
	WR6	20	10	2	32
	WR7	10	10	3	23
	WR8	13	15	5	33
	WR9	14	3	6	23
	Soil Samples				
	SC	20	0	6	26
	SU1	30	4	6	40
	SU2	6	0	9	15
	SU3	20	4	6	30
	SU4	20	4	8	32
	SU5	8	2	2	12
	SR6	4	4	12	20
	SR7	12	10	6	28
	SR8	20	0	8	28
	SR9	14	2	10	26

N.B: WC = Control of water sample; WU= Water sample of urban area; WR = Water sample of rural area; SC = Control of soil sample; SW = Soil sample of urban area; and SR = Soil sample of rural area.

4.1. Identification of micro-plastics through physical observation (Microscopic identification)

 WC (Pellets)	 WU1 (fragment)	 WU2 (fragment)
 WU3(Fragment, Fibre)	 WU4 (fragment, film)	 WU5 (fragment, fibre, film)
 WR6 (Fragment, fibre, film)	 WR7 (Fragment, fibre, film)	 WR8 (Fragment, fibre, film)
 WR9 (Fragment, film)		
		

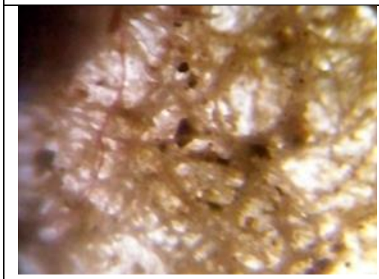
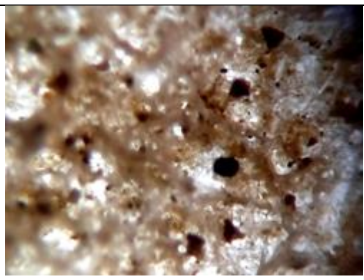
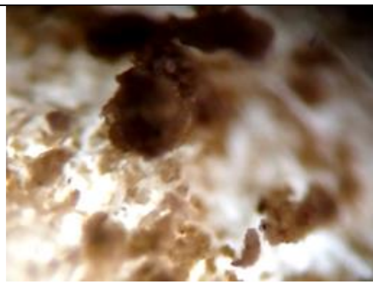
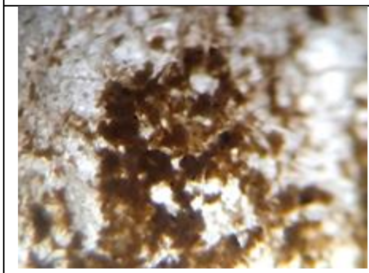
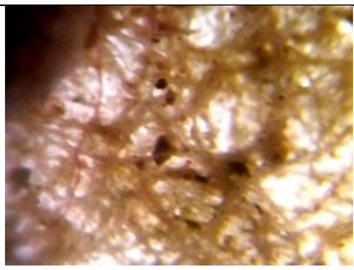
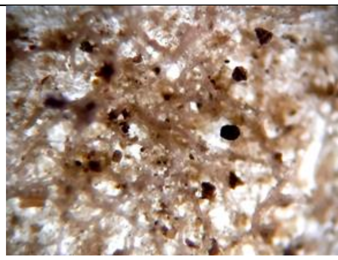
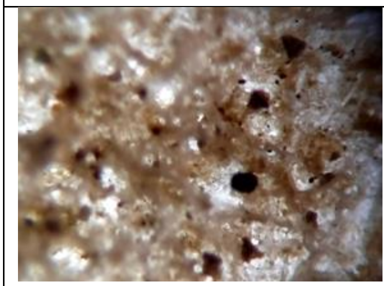
SC (Fragment)	SU1 (Fragment, film)	SU2 (Fragment)
 SU3 (Fragment, fibre)	 SU4 (Fragment, film)	 SU5 (Fragment)
 SR6 (Fragment)	 SR7 (Fragment, Fibre)	 SR8 (Fragment, fibre, film)
 SR9 (fragment, film)		

Figure 6: Microscopic detection of micro-plastics counts based on shape, size and color (Using Primo star Microscope; ZEISS company).

4.2. Micro plastic categories

4. 2.1 Micropelletes:

In urban water and soil samples besides the Bhairab River, Micropelletes were the predominant types of plastics noticed the specified sampling site clearly (Fig. 3). Previous studies showed that pellets could be identified clearly with dark-colored visually (Castaneda et al., 2014). Most of the samples, dark colored pellets were found here suspected that suspended pellets seemed to be the polyethylene based micro plastics. However, SEM-EDX analysis performed here showed that suspended pellets were primarily metallic. Micro pellets were present in the mid range particle size fractions (0.25-0.7mm) in range.

4.2.2 Microfibers:

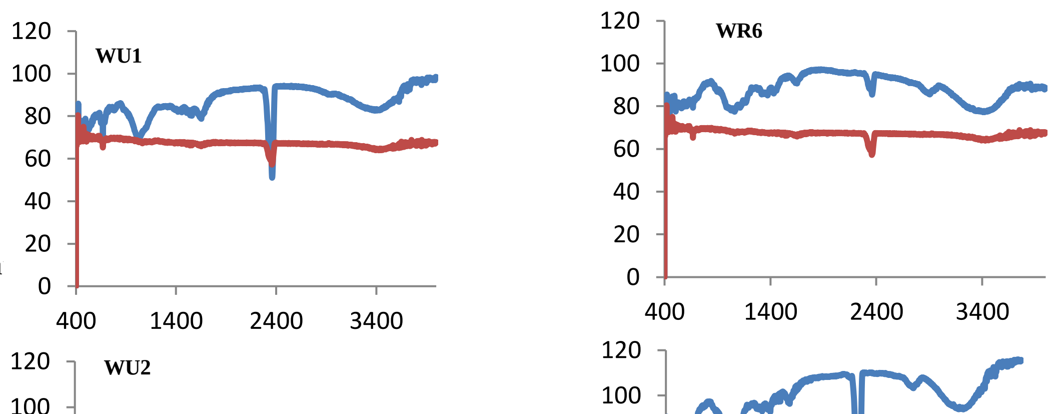
Fibres were the second most common types of micro plastics identified visually with different colors such as black, dark blue, red etc. Microfibers with similar characteristics were found in freshwater ecosystem with <2mm identified visually. In the studies, microfibers were found in most of the rural soil and water samples because environmental factors such as wind may be responsible to translocate the microfibers type's micro plastics. Previous studies showed that most of the microfibers were found in the lower range fractions between <0.090 to <0.063mm (Blair et al., 2019).

4.2.3 Micro fragments:

Micro fragments or flake like pieces were found from the broken off larger pieces that have uneven edges and shapes. Micro fragments were found higher in rural samples than the urban samples. Suspected MP fragments were observed in suspended and settled material and consisted mainly of dark color to brown color pieces (Fig.3).

4.3 FTIR analysis of water samples

©Da



WR7

WU3 WR8

WU4 WR9

WU5 WC

Figure 7: FTIR analysis of water samples

In W1 samples, in 500 spectrums strong C-I stretching with halo compound was found whereas in control samples halo compound was not found. In 690 spectrums, C-Br stretching with strong halo compound was found. In 1000 spectrum, C=C bending with strong alkene group was found but was absence in control sample. In 1710 spectrum, C=O stretching with strong conjugated aldehyde group was found but absence in control sample.

In W2 samples, in 3400 spectrum, medium N-H stretching with aliphatic primary amine found but absent in control samples. In 2900 spectrum, medium C-H stretching with alkane group found but in control samples, this functional group was not found. In 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. But in 1400 spectrum, strong C-F stretching with fluoro compound was found. In 700 spectrum, strong C=C bending with aromatic amine was found but absent in control samples. But in 600 spectrums, strong C-I stretching with halo compound was found.

In W3 samples, in 3400 spectrum, medium N-H stretching with aliphatic primary amine found but absent in control samples. In 2900 spectrum, medium C-H stretching with alkane group found but in control samples, this functional group was not found. In 2349 spectrum, strong CO_2 group with O=C=O stretching was found but broad spectrum was found in control samples. In 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. In 1085 spectrum, C-O stretching with strong aliphatic ether was found but in 600 spectrums, strong C-I stretching with halo compound was found.

In W4, 3350 spectrum, N-H stretching with medium secondary amine was found but absent in control samples. In 2900 spectrum, medium C-H stretching with alkane group found but in control samples, this functional group was not found. But in 2400 spectrum, no functional group was found in both control and W4 samples. In 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. In 1070 spectrum, S=O stretching with strong sulfide group was found.

But compare with the control sample with control samples, no changes were observed on both the sample.

In W6 samples,in 3500 spectrum, N-H stretching with medium primary amine was present. But in 2800 spectrum, N-H stretching with strong broad amine salt was present but was absent in control sample. In 2349 spectrum, strong CO_2 group with O=C=O stretching was found in both the W6 and control samples. In 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples.

In W7 samples, 3400 spectrum, N-H stretching with medium aliphatic primary amine was found but absent in control samples. In 2900 spectrum, medium C-H stretching with alkane group found but in control samples, this functional group was not found. In 2349 spectrum, strong CO_2 group with O=C=O stretching was found in both the W7 and control samples. In

1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. In 850 spectrums, C-Cl stretching with strong halo compound was found. In 600 spectrums, in 600 spectrums, strong C-I stretching with halo compound was found.

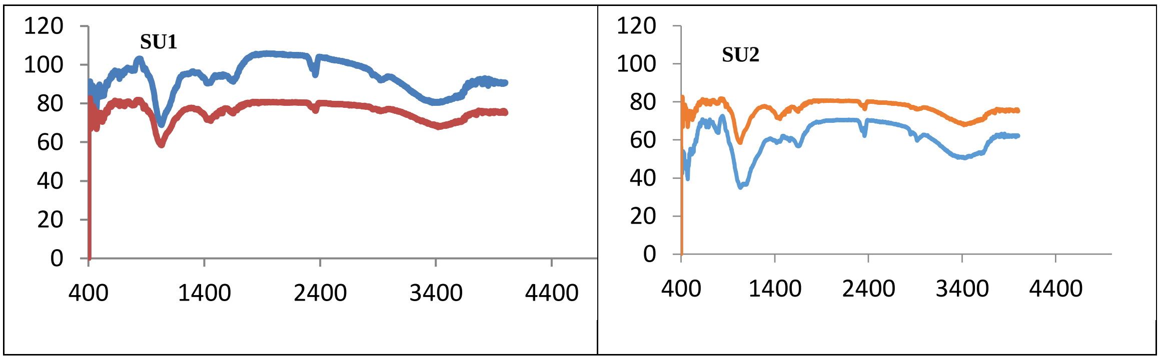
In W8 samples, no observable change was found in both the control and supplied sample.

In W9 samples, 3550 spectrum, N-H stretching with medium primary amine was present. In 2800 spectrum, N-H stretching with strong broad amine salt was found but in 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. But in 1205 spectrum, C-O stretching with strong vinyl group was found. In 850 spectrums, C-Cl stretching with strong halo compound was found.

4.4 FTIR analysis of soil samples:

In both the soil sample of S1, S2, S3, S5, S6 and S8 samples none of the change has been found between the control and the supplied sample. Both these samples, transmittance found same compare to the control sample.

But in case of S4 samples, in 3400 spectrum, N-H stretching with medium primary amine was present**. 2200 spectrum,** In 1600 spectrum, medium C=C stretching with conjugated alkene was found but absent in control samples. **1500, 1100** and 850 spectrum, C-Cl stretching with strong halo compound was found. In S7 sample, in 3400 spectrum, N-H stretching with medium sharp aliphatic primary amine was found but broad aliphatic primary amine was also present in control samples.



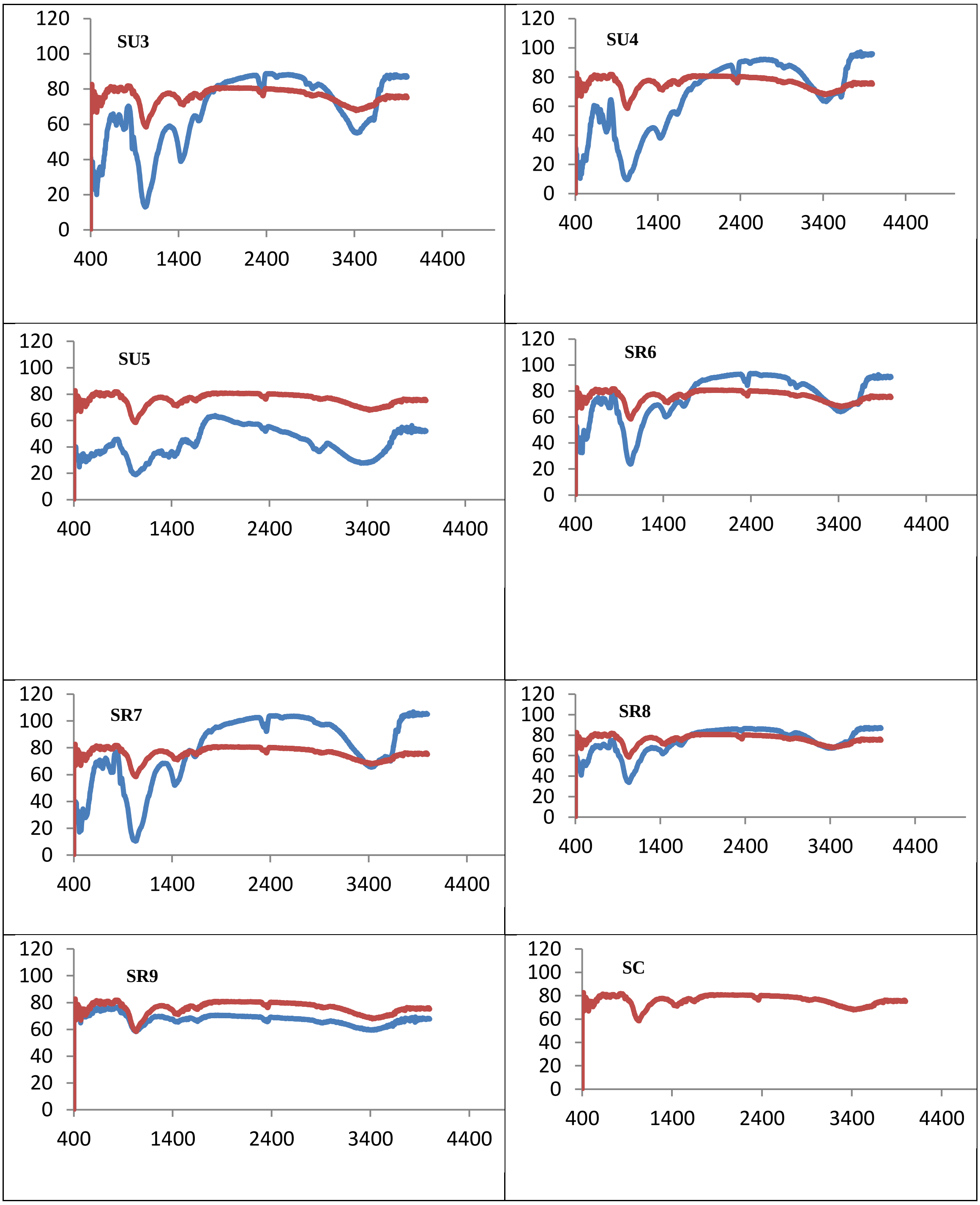


Figure 8: FTIR analysis of soil samples

4.5. SEM-EDX analysis

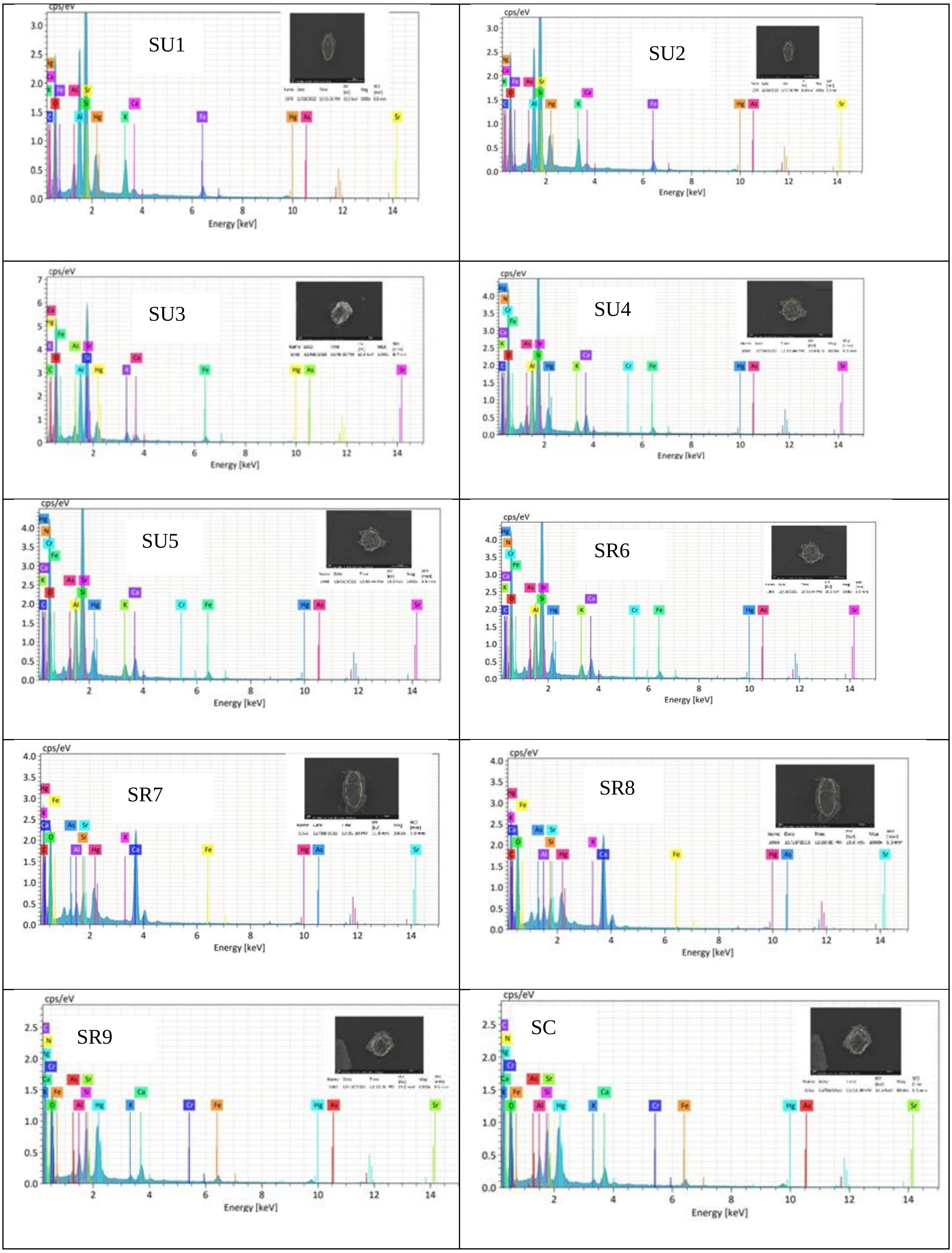


Figure 9: EDX analysis of soil samples

Table 4: Energy Dispersive X-Ray Analysis (EDX) of soil sample of Bhairab river

Sample Name	C	O	Ca	Cr	Mn	Co	Ni	As	Pb	Cd	Hg
S1	69.3	22.1	3.74	0.13	0.16	0.52	0.28	0.08	3.7	-	-
S2	84.1	3.2	0.73	-	0.02	-	-	0.11	11.8	-	-
S3	79.3	4.9	-	-	0.21	-	0.20	0.19	15.1	-	-
S4	56.9	27.5	-	-	0.13	0.38	-	-	-	0.08	12.2
S5	77.6	5.1	2.6	0.16	0.05	0.11	0.01	0.28	-	0.01	14.1
S6	61.3	25.4	-	0.11	0.27	-	0.09	-	-	0.02	12.8
S7	42.3	35.5	-	-	0.03	0.16	0.32	0.59	-	0.14	18.4
S8	57.4	25.9	-	0.10	0.03	0.33	0.30	-	-	0.12	15.9
S9	59.5	18.6	0.66	0.01	0.22	-	0.55	0.12	-	0.12	20.2
SC	80.9	5.9	0.31	-	0.01	-	0.07	0.60	-	0.03	12.1

During SEM-EDX analysis, Fibres exhibited a strong carbon peak and Oxygen showed smaller carbon peak (Fig. SR9). But in control sample, in SC showed the similar trend such as strong carbon peak and smaller Oxygen peak. The fibers were present because of the movement of the airborne fibres by atmospheric fallout.

Suspended flake like fragment with medium to high carbon signal and high oxygen peak was observed in most of the sample unlike SR9 and SC samples. Most of the samples showed medium carbon signals but exhibited additional elemental signals such Si, Hg etc. Some samples showed strong carbon signal may indicate high density plastic fragments are present for instance polyvinyl chloride come from construction activities, hospital activities. Fragments can come from the breakdown of larger pieces from non-point pollution such as rainwater runoff to road drainage, hospital sewage water, landfill sites, riverbank erosions and floodplains (Kataoka et al., 2019).

From the SEM analysis, all urban soil samples were compared with the control samples showed that micro plastics such as pellets, fibres and fragments are found here. These micro plastics are responsible for broken off the soil structure. But in rural soil samples, these soil structures are degraded at a lower stage than the urban samples.

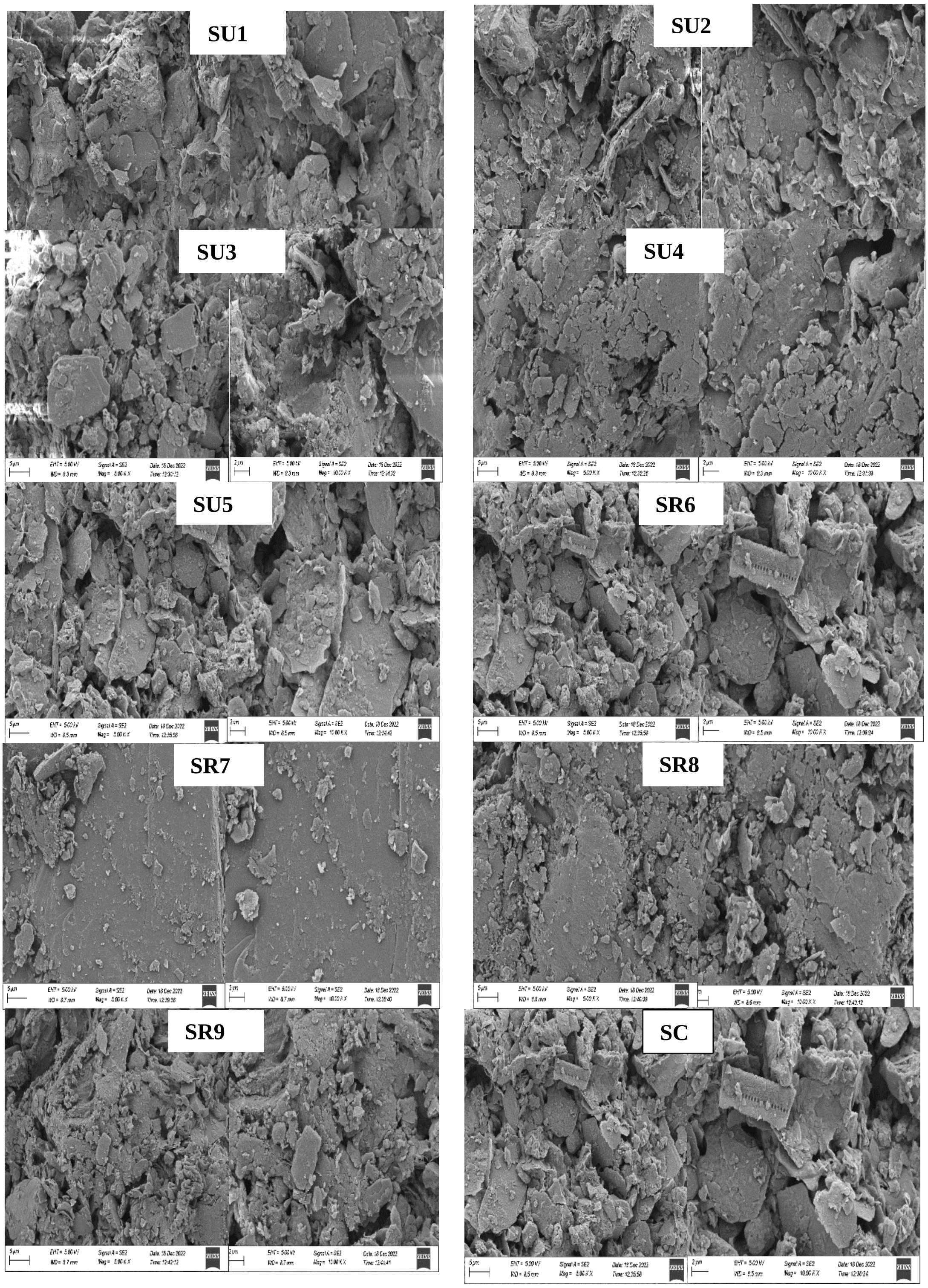


Figure 10: SEM analysis of soil samples

In urban soil samples surrounding Bhairab rivers were contaminated with different types of plastic wastes therefore structural deformation were found in urban samples at the highest rate than the rural soil samples. Whereas in rural samples, Bhairab river found not very contaminated with plastic wastes for this soil samples contain less plastic debris and structural deformation were very be negligible.

Chapter 5

Conclusions

Conclusions

Globally, plastic pollution is a rapidly growing area and has received increasing research interest, especially as the negative impacts of this waste on humans on the environment become increasingly common which is clearly understood. Microplastics were found at the highest rate in both the urban water and rural soil samples. Among these plastic categories, micropelletesin the mid rang size fractions (0.25-0.7mm) were the predominant types of plastics noticed in the specified sampling site clearly. Most of the samples, dark colored pellets were found here suspected that suspended pellets seemed to be the polyethylene based micro plastics. However, SEM-EDX analysis performed here showed that suspended pellets were primarily metallic. Fibres were the second most common types of micro plastics identified visually with different colors such as black, dark blue, red etc. Microfibers with similar characteristics were found in freshwater ecosystem with <2mm identified visually. In FTIR analysis, in most of the water sample, strong halo compounds were found together with N-H stretching with primary amine was found. Apart from the soil samples, most of the samples showed similar transmittance compared with the control samples but rest of the samples, aliphatic amine, conjugated alkene and primary amine were found. In SEM analysis, urban soil samples showed structural deformation because more plastic fragments were responsible for deformation of soil samples but in rural samples, structural deformation were not found here compared with the soil samples. In EDX analysis, compare with the control samples, in most of the urban soil samples, carbon was present at the highest rate than the rural soil samples. Whereas, chromium, cobalt, lead were found at the highest rate in most of the urban soil samples.

Chapter 6

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Appendix

Survey Data Of Hospitals

Hospital name	Establish year	Patient capacity	Waste management strategy-- Bin types		
			yellow	green or black	red
1)City Hospital		per day admit patient num 2(average) bed+cabin=18+12=30	blood,fuge,discarded sample,tumer,histoctomy parts	general waste remain parts of foods	sensitive wastes, acute materials, syringe, needle, injection(ample), plastic waste, chips packets, drinkable bottles
2) Jashore Adunik Hospital	2017	per day 10 patients (average) bed facility->general bed+cabin= 15+7=22	plastics materials	general wastes	glassware and sharp danger stuffs
3) Jashore eye & laser center		15 patients per day average	hazardous wastes- cotton, gauge, bandages, pathological wastes	general wastes- plastics syringes, saline bags, food wastes	acute wastes- blades, needle, glasses
4) Medilab hospital	2021	admit patients 3-5 persons per day average bed capacity-20 beds	pathological wastes	plastics and general wastes	sharp stuffs
5)IBN Sina Hospital & Diagnostic Center	2016	Bed number-30 Indoor capacity-(12-15) patients admit per day	Infected waste	Plastic and general waste- paper, boxes daily used waste	Sharp waste- syringe, needle, knife etc. and various unused glass waste, ampoule, vial.

		Outdoor capacity-average 1200-1500 patients per day		like tissue, poly bags	
6)Labaid Diagnostic, Jashore	2017	Outdoor patients average 250-300 per day	Infected waste	Plastic and general waste- paper, boxes daily used waste like tissue, poly bags	Sharp waste- syringe, needle, knife etc. and various unused glass waste, ampoule, vial.
7) Central Hospital & Diagnostic Centre	2012	patient capacity Indoor-5 patients admit per day average outdoor- 10-15 patients average	Plastic waste	General waste	Hazardous waste
8) Queen’s Hospital Pvt. Ltd	2005	Bed capacity-general bed+cabin=40+60=100 patient capacity- Indoor->average 100 Outdoor-> average 1000 per day	Infected waste	Plastic and general waste- paper, boxes daily used waste like tissue, poly bags	Sharp waste- syringe, needle, knife etc. and various unused glass waste, ampoule, vial.
9)Bandhon Hospital & Diagnostic Center	2019	Bed Capacity-20 Indoor 10-12 patients admit per day .Outdoor 15-16 patient average	Infected waste	General waste such as waste food/food rubbish, peel or fruits	Sharp waste such as syringe, needle, knife etc. and various unused glass waste.

Hospital name	Location	Latitude	Longitude	Waste Collection facility	Waste Water Treatment Facility
1)City Hospital	Ghop,Central road,Jessore	23.170455	89.210229	General Waste Collected by City Corporation Medical Waste Collected by Prism	No Water treated
2) Jashore Adunik Hospital	Ghop central road	23.170455	89.210229	Collected By City Corporation	No treatment plant
3) Jashore eye & laser center	Ghop central road	23.169743	89.210157	Collected by Prism	No treatment plant
4) Medilab hospital	Ghop central road	23.169555	89.209911	Collected by Prism	No treatment plant
5)IBN Sina Hospital & Diagnostic Center	Beside of 250 Bedded General Hospital,Main Road,Doratana Jessore			Collected by Prism	
6)Labaid Diagnostic, Jashore	Holding#498/2,Jail Road, Ghop,Jessore-7400			General waste- City Corporation	Wastewater Treatment Plant

				Medical waste- Prism	
7) Central Hospital & Diagnostic Centre	High Court Road,Jessore	23.168242	89.210229	Collected by Prism	No treatment Plant
8) Queen’s Hospital Pvt. Ltd	Jail Road,Jessore	23.168557	89.214551	General waste-City Corporation Medical waste-Prism	Human waste- Septic tank Sewage sludge-Wastewater Treatment plant
9)Bandhon Hospital & Diagnostic Center	96Jail Road,Jessore	23.168557	89.214551	Collected by Prism	Sewage & Human waste-Septic tank


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