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EXPERIENCE IN ESTABLISHING A LABORATORY: DEDICATED FOR SOLID WASTE IN KUET

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ABSTRACT

Nowadays, plastic-derived products have become a fundamental item for everyone resulting in environmental hazards. The proper management of huge plastic waste is a challenging issue in middle-income countries like Bangladesh. To reduce the effects of plastic, a collaborative research project entitled "Sustainable Capacity building to reduce Irreversible Pollution by Plastics-shortly SCIP Plastics Project" between Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh Bauhaus-Universität Weimar (BUW), Chittaging University of Engineering & Technology (CUET), Khulna City Corporation (KCC) and Institute for Social-Ecological Research (ISOE) have already started on 1st January 2022. In this regard, a Waste Lab was developed in the KUET campus to focus on reorganizing waste management structures as well as assessing the waste composition status as a baseline scenario. Additionally, further knowledge about the quantity, composition, and fate of the material streams will be generated. All methods for waste sorting, testing and analyses will be documented and readily available for reference. The list of sampling and analysis methods will be updated with relevant information on a regular basis. The waste laboratory will be used for sampling and analyzing procedure for waste at secondary disposal points and recycling shops, focusing on the non-recyclable fraction, emission monitoring at landfill sites, waste composition at transshipment and repacking units, analysis of jute products for plastic substitution, waste sorting, degradability testing, detection and assessment of marine pollution. The lab ensures and facilitates the completion of a study to determine acceptance and satisfaction with municipal waste management, especially plastic waste management, adequately equipped and staffed to aid and to streamline waste analyses.

***Keywords**: Waste Laboratory, Plastics, Waste Management, Establishment.*

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INTRODUCTION

Sustainable municipal solid waste management (MSWM) is a major environmental concern of the municipal authority in most of the cities in Bangladesh as the number of populations is increasing day by day. At the same time, the growing volume of waste and the presence of harmful chemicals and additives in different waste fractions lead to major environmental pollution (Ahsan, 2009). Khulna, the third largest city of Bangladesh, is one of the fastest growing commercial cities and produces about 420 to 520 ton of municipal solid wastes per day. Khulna City Corporation is mainly responsible for solid waste management, namely the organization of collection, treatment, and disposal of all municipal wastes since 1984 in Khulna City. KCC followed door to door waste collection system, where community-based organizations or dwellers were involved to deposit the MSW in secondary disposal points (SDP). Finally, the waste transfers from SDP to landfill located in Rajbandh, which is around 7 km away from Khulna city. Presently, the baseline scenario of MSWM in Khulna city are composting (4.4%), recycling (9.1%) and landfilling (86.5%) respectively of the total managed waste (M. S. Islam & Moniruzzaman, 2019). However, S. A. Islam et al. (2010) reported that, in Khulna city, due to lack of sanitation facilities lead to improper management, approximately 57% of generated solid wastes and 74% of sewage were directly discharged into the surface drain.

Altogether, the rapid increase of plastic pollution has a significant impact on the environment and without immediate action, it will continue to pollute the freshwater, ocean, and terrestrial environment. Nowadays, plastic pollution is an emerging research area among the researchers, businesses, policy makers and the general public (Chowdhury et al., 2021). The usages of plastic have changed the scenario of human behavior from domestic to industrial level to such extend that without plastic-derived products, it will be difficult to think about the ease of human life. Due to its enormous properties such as readily available, lightweight, durable, strength, cheap, low density, user-friendly designs and fabrication capabilities, plastic is widely used for different purposes around the world. As a result, annually millions of tons of plastic waste get deposited into the natural environment and pose a serious risk to marine and terrestrial biota (Shahnawaz et al., 2019). Different types of solid waste accumulated in landfill; among them plastic waste is the most hazardous waste as it degrades very slowly (Figure 1). In some cases, it will take a thousand years to decompose in the environment (Zhou et al., 2022).

Figure 1 Photographs depicting the plastic waste at landfill site (Source: SCIP Working Groups)

The production of plastic has increased at a significant rate and the amount was 1.5 million tons in 1950 whereas, in 2013, the amount was estimated at 299 million tons (+19,933%) (Li et al., 2016). Presently, only 31% of plastics was recovered and the rest of the plastic wastes accumulated into the ocean through different water bodies such as canals, rivers, etc. Hence, the concentration of micro-nano plastics (MNPs) was rising in the sea which adversely impacted marine life. Organisms in lower levels get confused and consume micro-plastics due to their minute size, resulting in food web bioavailability (Tirkey & Upadhyay, 2021). For instance, micro-plastics enter the flora and fauna, and human body via inhalation and ingestion. Micro-plastic presence in human tissues can alter the immune system or may cause some other clinical complications such as infertility, impediment in blood vessels, and abnormal behaviors.

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SOLID WASTE GENERATION IN BANGLADESH

Bangladesh is one of the most densely populated countries in the world (approximately 168.7 million) where the urban population is 39.4% (Worldometer, 2022). According to worldometer population forecasting, the urban population will be increased 47.3% by 2030 due to the advancement of industrialization and urbanization process. This will improve lifestyles, per capita income, and consequently a large volume of solid waste generation. As shown in Figure 2, the solid waste generation rate 0.32 kg/capita/day and 0.35 kg/capita/day in year 2012 and 2015, respectively. Moreover, it is estimated that the generation rate will be increased up to 0.60 kg/capita/day within year 2025 (Ashikuzzaman & Howlader, 2020). In recent years, the country has been facing severe problems in both organic and inorganic solid waste management. The population growth, poor socio-economic condition, climatic condition, lack of facilities, inappropriate technology, lack of awareness, inadequate waste management, ineffective legislation and law enforcement, and insufficient budget for waste management are some of the prime causes of improper solid waste management. At the same time, large migration of rural people to the urban area may create an ecological threat through waste generation (Mourshed et al., 2017).

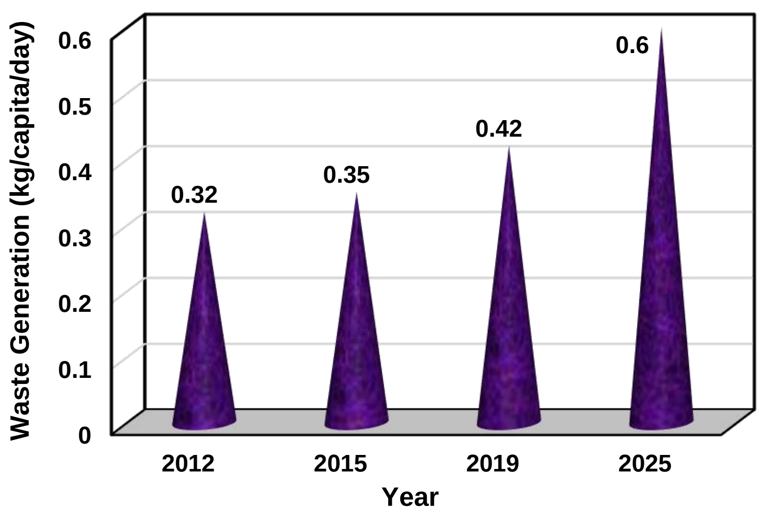

Figure 2 Waste generation rate in Bangladesh (Ashikuzzaman & Howlader, 2020)

Solid wastes can be classified into three categories: i. Combustible, ii. Non-combustible, and iii. Miscellaneous. Paper, garbage (including meats, food stuff), textile, wood, grass, straw, plastic, leather and rubber are combustible wastes; where ferrous and non-ferrous metal, glass, stone and ceramic including bones and shells are non-combustible wastes. Again, any types of material and products made of plastics; such as: wrapping film, plastic bag, plastic bottle, plastic hose, plastic string, tires etc. are included among the plastic wastes (According to Asian Institute of Technology, Environmental Engineering Division, 1991)

PLASTIC WASTE SCENARIO IN BANGLADESH

Plastic goods become widespread in Bangladesh from 1982 for every class of people and it created a threat to the environment within 5 years. Therefore, from January 2002, the Ministry of Environment and Forest, Bangladesh prohibited the private and commercial transportation, distribution, uses, and sales of single-use polythene bags with thickness less than 55 micron-meter (Mourshed et al., 2017). However, the plastic materials consumption is increasing 2-3% annually in developing countries due to rapid population and industrial growth. Since last few years, Asia is one of the leading polymer consumers in the globe and producing almost 30% of plastic debris. In a similar fashion, the plastic materials market is getting bigger in size which include more than 3000 Small Medium Enterprises (SMEs) and contributing around 1% of the national GDP in Bangladesh (Chowdhury et al., 2021).The consumption of plastic production is sharply increasing in urban areas. As shown in Figure 3, the annual plastic consumption per capita in Bangladesh was 2.07 kg and 3.5 kg during the year of 2005 and 2014, respectively. But it was found that the consumption was sharply increased up to 9.0 kg within year 2020 (The World Bank, 2021). However, the generation rate of plastic waste rises around 7.5% per year whereas the solid waste increasing rate about 5.2% per annually. Moreover, the COVID-19 pandemic has worsened the situation, it increases the single-use plastic especially in masks, wrappers, gloves, shopping bags and Personal Protective Equipment (PPE). These mismanaged plastic wastes are polluting canals, rivers, countryside, and cities. During heavy rainfall, they clogged natural water bodies or drains may cause water logging and flood.

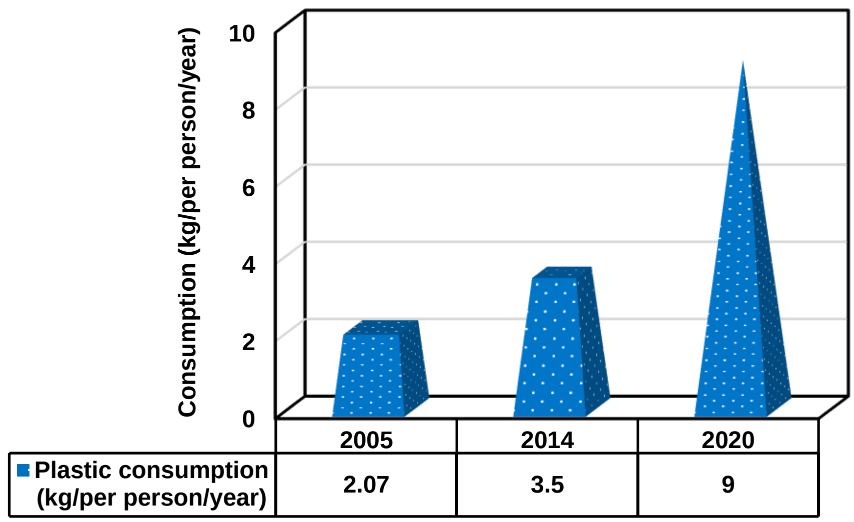

Figure 3 Plastic consumption in Bangladesh (Mourshed et al., 2017)

SCIP PLASTIC PROJECT

The SCIP-Plastics project aims at long-term avoidance of marine plastic pollution in the oceans and protection of vulnerable aquatic life and habitats. Bangladesh situated in the Bay of Bengal is, due to its location in the mostly populated delta of the world, one of the highest marine plastic polluting countries. KUET takes the interdisciplinary actors from economy, politics and society are developing an improved master plan for the reorganization of the waste management system in Khulna while additionally meeting the informal sector’s demands. The waste management chain (decentralized collection - recycling shops - landfill) is evaluated from a socio-economic point of view and activities are communicated via an inner-city awareness center. One of the core activities of the project is to establish a Knowledge Transfer Hub and Waste Lab at the KUET campus. The main objective of this hub is to bring together all Bangladeshi expertise in science and practice. Furthermore, the hub ensures the integration of the outcome into the strategies of the political partners.

DEVELOPMENT OF WASTE ANALYSING LABORATORY

The Waste Lab was set up at department of Civil Engineering, KUET to characterize and generate knowledge about the quantity, composition, and fate of the waste material streams. For example, screens, scales, drying ovens for the characterization of municipal solid waste, namely the determination of dry matter and organic content. The Head of the Waste Lab ensured that all methods used in the laboratory was documented and readily available for reference.
Sampling and analysis procedure for:

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- Waste at secondary disposal points
- Procedure for recycling shops, focusing on the non-recyclable fraction
- Emission monitoring at landfill sites
- Jute products for plastic substitution
- Waste composition at transshipment and repacking units
- Waste sorting
- Degradability testing
- Detection and assessment of marine pollution

SORTING STATION

Screening is a part of sorting process which is used to separate mixtures of materials of different sizes into two or more size fractions by means of one or more screening surfaces. The principal applications of screening devices in the process of wastes include the removal of oversized or undersized materials etc. For the separation of waste materials, two types of equipment are involved in the sorting station, such as Rotary Drum Screen and Modular Screen.

Figure 4 Rotary Drum Screen

Rotary Drum Screen

The waste samples collected are sieved through a rotary drum screen that has a square sieve opening of 120mm. The drum length is 1300mm slightly sloped and the diameter is 700mm. After putting the waste samples into the sieve, it is rotated manually and then sieved by the screen. As the screen rotates, the material to be separated and contacts the screen numerous times as it travels down the length of the screen. Small particles will fall through the holes in the screen while the oversized material will pass through the screen. According to "Solid Waste Management" (George Tchobanoglous et al.'93), the material falling through the screen is collectively known as unders, undersize and underflow; material retained by the screen is known as overs, oversize and overflow. Having passes through the trammel, the oversize wastes are then sorted manually.

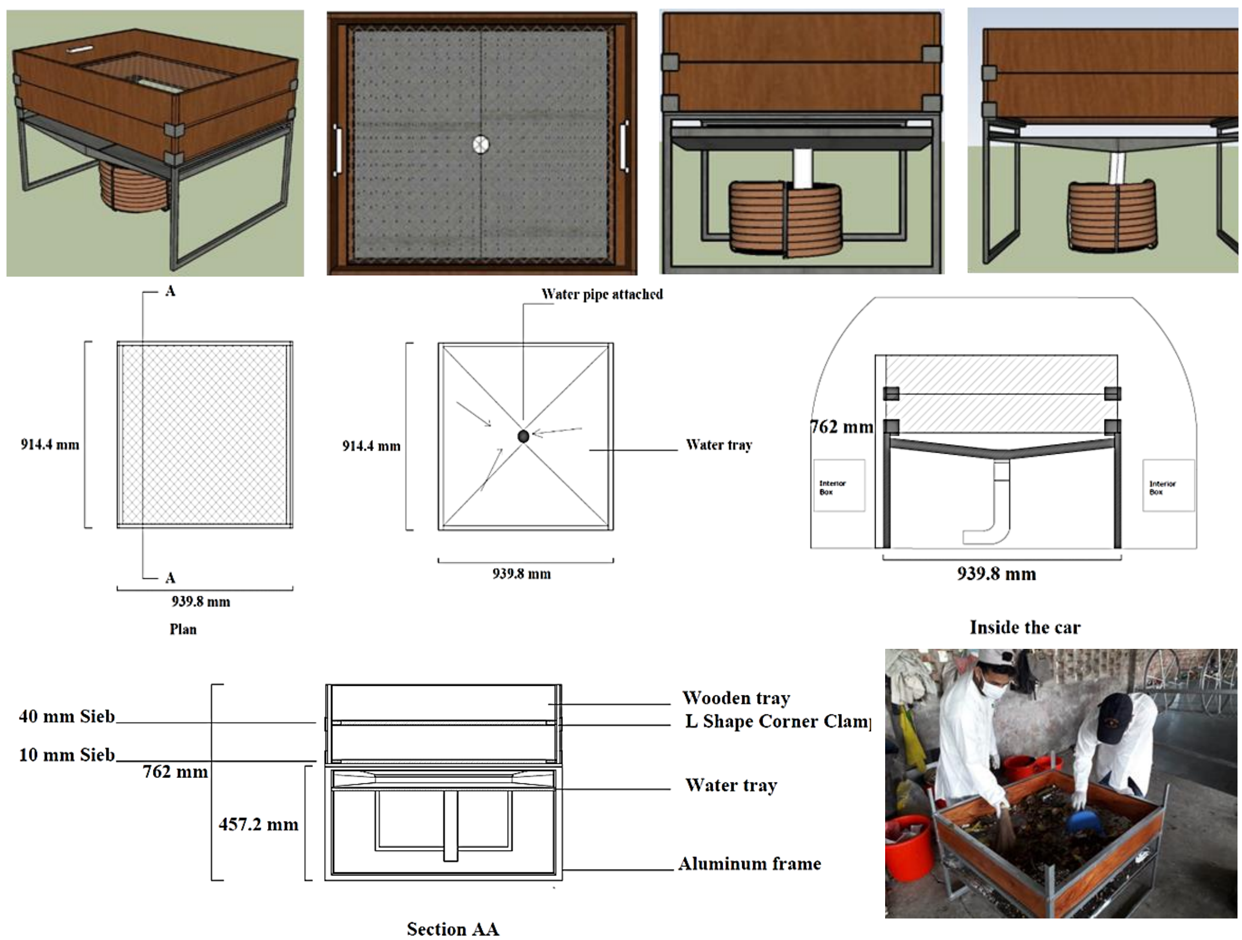


Figure 5 Individual Modular Screen

Individual Modular Screen

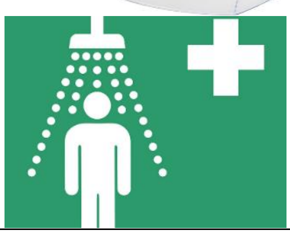
The individual Modular Screen is (914.4mm*939.8mm) in size with a height of 762mm that can easily fit into the boot of the multipurpose car on time. It contains two square sieves of 40mm and 10mm and a water pipe is attached at the center of the mildly sloped water tray so that wastewater can drain out slowly through the pipe. A water bucket or pot is kept under the pipe for collecting water. During sorting, collected wastes from each sieve were spread on clean sheets and the wastes were sorted by hand. In this study, the separated waste has been segregated according to the specified ten categories. The categories are biodegradable waste, plastics, paper & cardboard, glass, textiles & wood, electrical goods, metals, brick, concrete & stones, medical waste, dust & ashes and others.

SAFETY POLICY

The waste laboratory is committed to protect the health and safety of its researchers, faculties, employees, and visitors. Laboratory, however, sometimes involves a variety of hazardous works and some of these hazards are not encountered in an ordinarily manner, needs special precautions. Hence, the head of waste lab established some safety policies that are strictly followed by all employees, researchers, and researchers. Few basic safety policies such as unattended procedure, working alone, housekeeping, safe use of equipment and Personal Protective Equipment (PPE) are adopted to minimize risk. The following PPE as attached in Table 1 was worn when working with laboratory hazards. Laboratory procedures that require specialized personal protective equipment, such as personal fall arrest systems or arc-flash clothing, are considered high-risk procedures. Also, the use of laboratory equipment requiring highly specialized training was considered a high-risk procedure if accidental misuse of the equipment could cause injury or damage to the building. Lab-specific standard operating procedures, including training for operators, was developed.

Table 1 List of Personal Protective Equipment (PPE)

Helmet		➢ Hard hats can protect students sand staffs from impact and penetration hazards as well as from electrical shock and burn hazards.
Ear plugs		➢ There is a wide variety of hearing protection devices available. ➢ Use one according to your need in the laboratory
Face shields		➢ Face shields should be worn in addition to safety glasses or goggles whenever a splash hazard is present. ➢ Safety glasses or goggles must always be worn beneath a face shield.
Protective clothing		➢ Protective cloth must be worn while working in the laboratory. ➢ Based on the hazard and risk assessment, other body protection including chemical resistant sleeves and chemical resistant aprons may be required.
Gloves		➢ Heavy-duty gloves provide longer protection and can be reused if they are washed and air-dried after use. ➢ Inspect reusable chemical protective gloves before each use.
Boots		➢ Closed-toed shoes should be considered standard attire for laboratory work, especially if there is a risk of dropping hot liquids or laboratory materials, or if materials-handling carts are used.

Safety Glasses		➢ Safety glasses are the minimum requirement for working with hazardous material in the laboratory ➢ For use of eye protection around lasers please refer to the Laser Eye Protection Selection Guide
Safety showers		➢ In the case of hazardous chemicals encountering your skin, it's extremely important to have a way to promptly rinse off the substances. So, all laboratories should include a safety shower.

CONCLUSION

To escalate the SCIP plastic project activities along with research activities, the waste laboratory has played a big role. Both the assessment of the status as a baseline scenario and the assessment of the further development depends significantly on the ability to generate knowledge about the quantity, composition, and fate of the waste material streams. The processes are generally accompanied by a waste management laboratory for qualification purposes. Such an analytical laboratory is also considered essential for quality assurance in case of changes in the management as well as for a sustainable anchoring of the knowledge transfer hub. Within the scope of the project, a laboratory in the KUET's inventory was expanded to include these waste management issues.

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