CROSS-BORDER COMPARISON OF WASTE MANAGEMENT PRACTICE: A STUDY OF FOREIGN SHIPS AND LOCAL VESSELS AT MONGLA PORT AREA

S. Roksana*[1], Q.H. Bari[2], I.M. Rafizul[3], .M. Hossain[4], E. Kraft[5], T. Haupt[6] and M. Rahaman[7]

[1] Department of Civil Engineering, KUET, Bangladesh (roksanasumi2@gmail.com)
[2] Department of Civil Engineering, KUET, Bangladesh (qhbari@ce.kuet.ac.bd)
[3] Department of Civil Engineering, KUET, Bangladesh (imrafizul@ce.kuet.ac.bd)
[4] Department of Civil Engineering, KUET, Bangladesh (meherab.hossain@scip.kuet.ac.bd)
[5] Faculty of Civil Engineering, Bauhaus-Universität Weimar (BUW), Germany (eckhard.kraft@uni-weimar.de)
[6] Faculty of Civil Engineering, Bauhaus-Universität Weimar (BUW), Germany (thomas.haupt@uni-weimar.de)
[7] Mongla Port Authority, Mongla, Bagerhat, Bangladesh (khan.motiur06@gmail.com

***Corresponding Author**

ABSTRACT

Effective waste management in the maritime industry is crucial for mitigating environmental impacts and promoting sustainability. This study compares waste management practices between foreign ships and local vessels visiting the Mongla Port area in Khulna, Bangladesh. The assessment involved ten foreign ships and 100 local vessels, utilizing surveys and on-site visits to reveal distinct waste management strategies. Waste bins were distributed on local vessels and collected from 25 local vessels and three foreign ships. The collected waste was analyzed using a sieve and modular screen methods. Data on waste collection by ship chandlers from foreign ships were obtained through the Mongla Port Authority. Findings indicated that foreign ships demonstrated efficient waste management, with only 38 foreign ships relying on ship chandlers for waste collection, while 96.5% to 97.67% accessed waste facilities from other ports like Chittagong. Compliance with MARPOL Annex regulations was consistent among foreign ships. In contrast, local vessels from Bangladesh lacked regulatory frameworks for waste management. Practices varied, with some vessels implementing waste segregation while others lacked proper separation methods. Several local vessels engaged in plastic waste recycling, but inconsistent reporting hindered the assessment. Despite lower plastic waste generation rates on local vessels (4.13 gm/capita/day) compared to foreign ships (154 gm/capita/day), their waste disposal practices raised environmental concerns. This comparative analysis underscores the need for enhanced waste management infrastructure and practices among local vessels. Urgent interventions are essential to promote environmental preservation and sustainability in the maritime industry. The BIWTA and all the corresponding officials, port authorities, and crew members of local ships must take the necessary steps to make waste management sustainable and environmentally friendly.

Keywords: *Foreign ships, Local vessels, Waste management, MARPOL ANNEX V*

1. INTRODUCTION

As society evolves, numerous forms of transportation, cars, innovations, and so on negatively influence the environment, impacting humans, animals, birds, plants, trees, aquatic life, etc. These determinantal effects can be caused physically, chemically, or biologically, known as pollution (Titiksha, 2017). One of the significant reasons pollution is occurring is the increase in solid waste; about 2.24 billion tons of waste are generated yearly due to population growth, and the number may increase to 3.4 billion tons by 2050 (Ardiansyah et al., 2022). Solid plastic waste from land-based sources that enter the ocean is between 4.8 and 12.7 million tons (Jambeck et al., 2015). The sources of this solid waste are households, industries, markets or commercial places, ships, and tourist ships (Abdel-Shafy & Mansour, 2018). If appropriately managed, the waste from these sources ends up in landfills and secondary disposal points. If it is not managed correctly, the waste ends up in rivers, seas, and oceans, which leads to environmental and marine pollution. Previous studies mainly focused on municipal solid waste management systems considering households, streets, industries, etc. (Bari et al., 2012; Buenrostro et al., 2001; Nidia Rinasti et al., 2022). Maritime transportation is a vital global transportation network component for international trade(Alderson et al., 2020; Fratila (Adam) et al., 2021). These vessels transport people, products, and machinery from one nation to another. Waste is produced throughout these voyages, and these ships are obligated by the International Maritime Organization (IMO) to separate and handle their garbage appropriately before disposal. (IMO, 1973, 1978, 2018; IMO (2018MEPC.1-Circ.834-Rev.1, n.d.). Bangladesh is a riverine country where most goods are transported via foreign ships and vessels (Roksana et al., 2023). It has the two largest seaports, Chittagong and Mongla Seaport, and other minor ports. According to Das et al. (2023), each crew member on commercial ships generates 1.5 kg of garbage per person per day, while on passenger ships, the quantity of waste generated per person per day is roughly 2 kg. Per year, about 1000 to 1500 foreign ships and 8400 to 12000 local ships per year (Roksana et al., 2023) call to Mongla Port.

The study centers on the Mongla Port Area, surrounded by major rivers, the Indian border, and the Bay of Bengal. The increasing importance of Mongla Port is primarily due to the surge in marine traffic and capacity constraints at the Chittagong Port. The Bangladeshi government has initiated development projects to enhance port performance and infrastructure. Still, this influx of marine traffic poses a risk of introducing marine plastic debris into the Pussur River. This could lead to an increase in microplastic concentration, potentially disrupting the natural balance of the river and impacting the surrounding ecosystem. The study aims to shed light on waste management practices. Thus, this study compares waste management practices among foreign ships and local vessels at Mongla Port Area.

2. METHODOLOGY

The study's methodology was developed using a thorough review of relevant literature, meticulous identification of the study area, and the development of a sturdy research framework. The subsequent subsections detail the selected study area and the data collection and analysis methods.

2.1 Study Area

Mongla is an Upazila in Bangladesh's Bagerhat District of the Khulna Division, located at coordinates 22.4833°N 89.6083°E (Hossain et al., 2016). The study's specific focus is the Mongla Port Area, which is located inside the borders of Mongla Upazila. Figure 1 illustrates the geographic range of this study area, which is between latitudes 22.4892º and 22.4676º N and longitudes 89.586º and 89.6076º E. It is included in Mongla Port Municipality's Ward No. 04, which is situated in Bagerhat, Khulna, Bangladesh. Moreover, this area is situated on the Pasur River's eastern bank (Nawar et al., 2023). The study region is bordered by the largest mangrove forest, "Sundarbans," to the west of the Indian border and the south by the Bay of Bengal (Amin et al., 1970). The second-largest port, Mongla Port, is a crucial gateway to the southwest. The growth in maritime traffic and the capacity problems at Chittagong Port have significantly boosted the significance of Mongla Port. Consequently, the government of Bangladesh has initiated several development projects to enhance port infrastructure and performance. Mongla Port receives between 1000 and 1500 international ships and 8,400 and 12,000

local vessels yearly (Roksana et al., 2023). There is a chance that this significant increase in marine activity will introduce pollutants into the Paur River. Particularly concerning is the prospect that this marine debris will degrade into smaller particles, increasing the river's microplastics. An increase of this magnitude could negatively influence the ecology, potentially disturbing the river's natural balance and affecting the delicate web of life, including the surrounding forest and its accompanying food chains (Hitchcock, 2022).

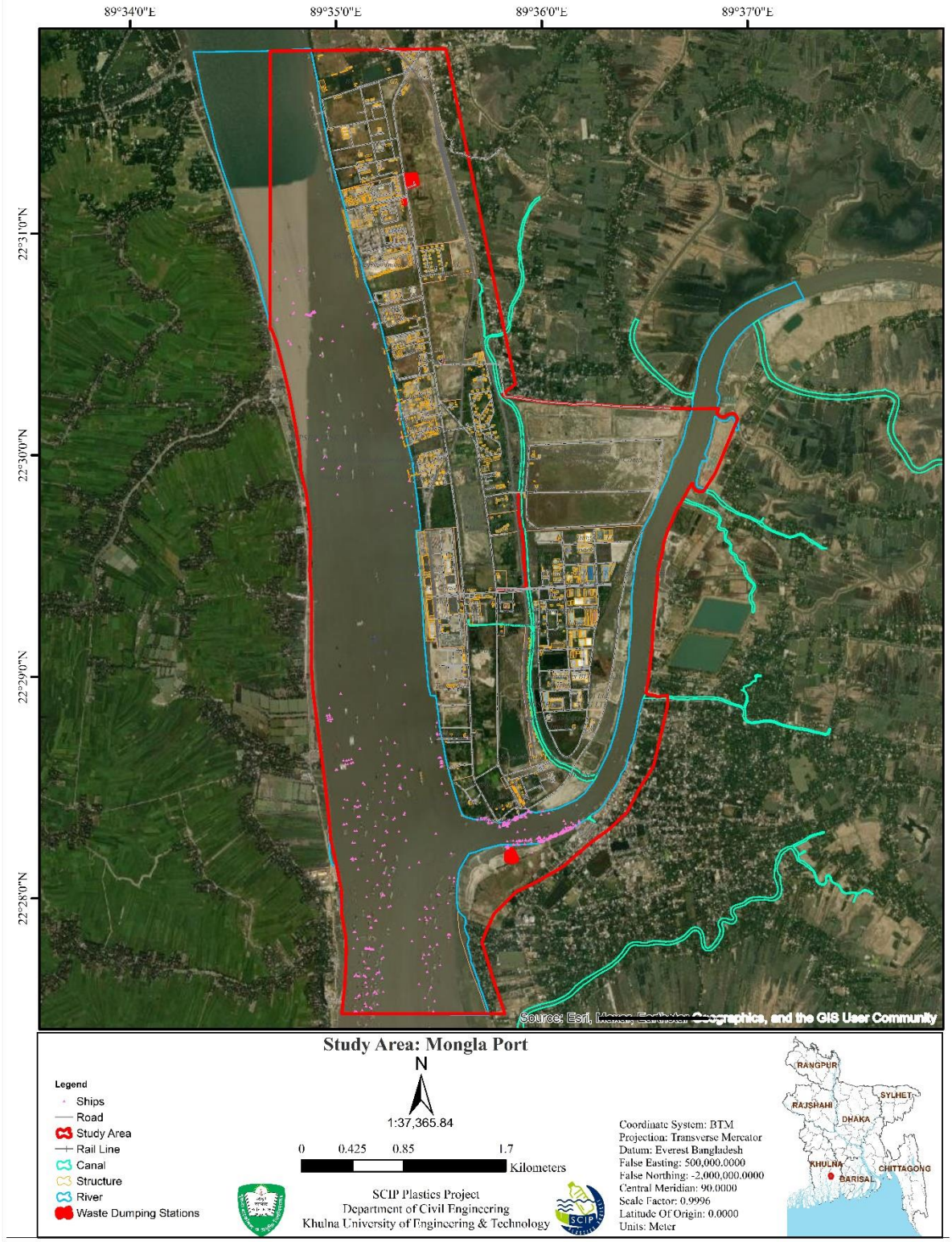

Figure 1: Map of the Study Area

The study was conducted based on the methodology shown in Figure 2. First, the study area was selected, and permission from Mongla Port Authority was taken. Mongla Port being a restricted area, permission was taken from the Port Authority to access the port area; thus, a significant meeting was held in September 2022 at Mongla Port. The meeting was held between the renowned Chairman of Mongla Port, the high-ranking officials from the Mongla Port Authority, and the SCIP Plastics Project representatives. During the meeting, the Mongla Port Authority granted the SCIP Plastics Team entry, recognizing the significance of their project.

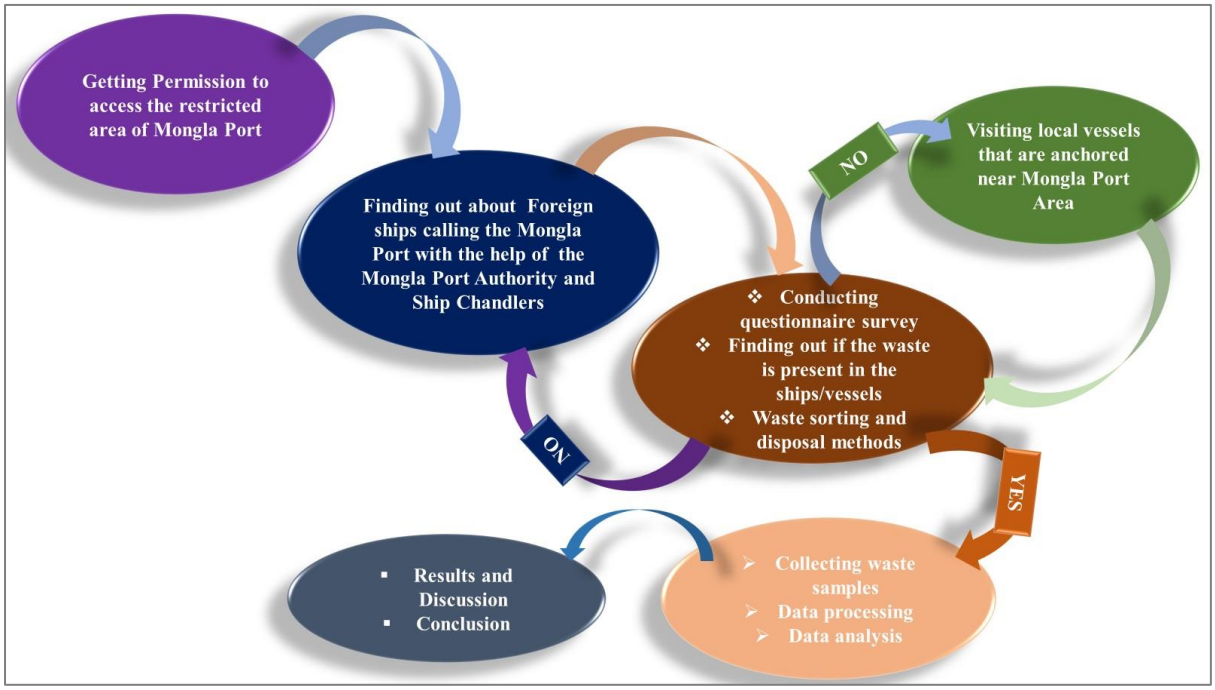

Figure 2: Methodology of the study

Figure 3: Providing Bins to the Local Vessels and Conducting the Questionnaire Survey

2.2 Data Collection

Figure 1 shows the entire methodology of the study. According to the methodology, foreign ships and local vessels were visited, and a questionnaire was conducted with the crew members. Pictures were taken of their waste management system. A total of 10 foreign ships and about 100 local vessels were visited. From these local vessels willing to assist with the study, waste bins were given to collect waste from them. As for foreign ships, secondary data was collected from the Mongla Port Authority. From 3 foreign ships, waste was collected with the help of ship chandlers. Figure 3 shows the bin-providing and questionnaire survey scenarios and the waste samples collected from the local vessels.

2.3 Waste Sorting and Weighting

Plastic waste was collected from 25 local vessels and three foreign ships and weighed on-site before being transported to the SCIP Plastics project waste lab. The waste was separated using a rotatory drum sieve and a modular screen with sieve widths of 120 mm, 40 mm, and 10 mm. Following sieving, the plastic debris that passed through and did not pass through the screens was manually sorted and weighed, as shown in Figure 4.

Figure 4: Waste composition according to their types

3. RESULTS AND DISCUSSION

3.1 Waste Generation Rate

Various scenarios have been observed on foreign ships. Data obtained from the Mongla Port Authority revealed that approximately 38 ships provided waste to Chandlers within a year. During this period, the total annual waste generated amounted to 111.8×10^4L, with plastic waste accounting for an annual volume of 3.6×10^4L. It was found that each foreign ship generates approximately 8.6 L/day of waste and about 2.6 L/day of plastic waste. The primary data found that the average plastic waste generation rate was calculated at 2580 gm/day on a per-ship basis. The local vessels' waste generation rate per ship is less than that of foreign ships. Figure 5 shows that the average plastic waste generation rate was calculated at 4.13 grams/capita/day, resulting in an average of approximately 40.65 grams of plastic waste generated per local vessel. In comparison, the average overall waste generation was 6.51 grams per day per capita, resulting in an average of approximately 62.75 grams of waste generated per local vessel.

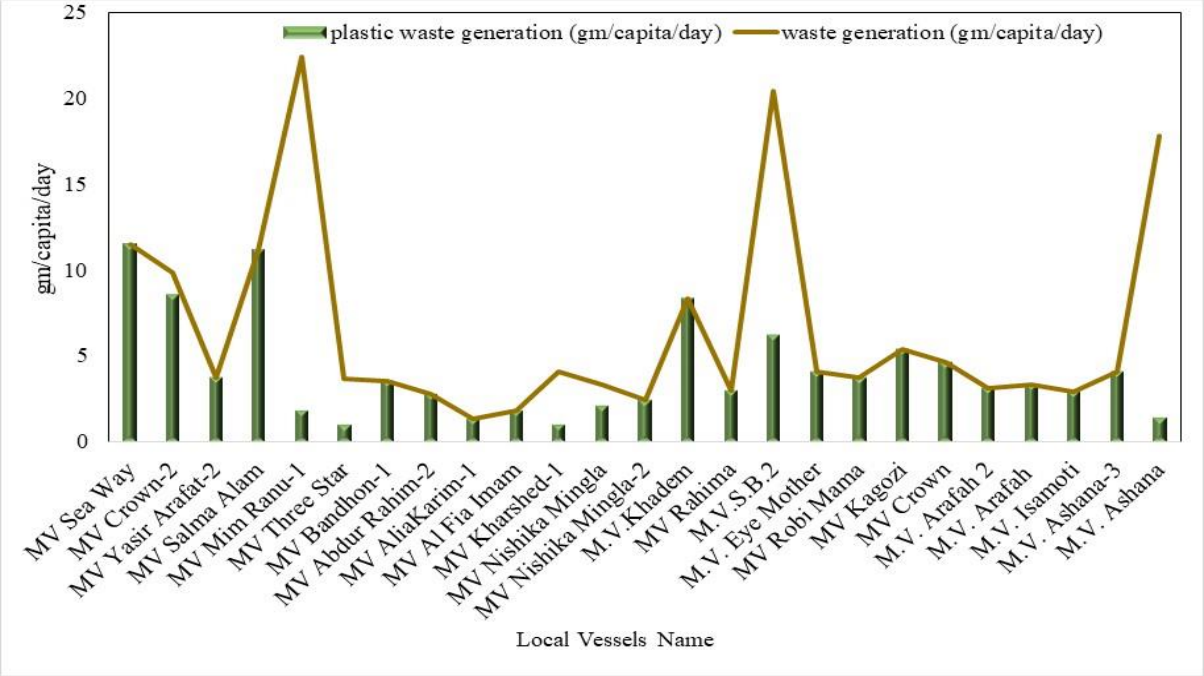

Figure 5: Per capita waste generation of local vessel

3.2 Local Vessels Waste Management Practice

Based on the questionnaire survey, the local Vessel Characteristics and Operational Dynamics at Mongla Port were found, as shown in Table 1. It states that all the local vessels originated in Bangladesh. Their voyage path varies based on the ship agent's or company's instruction. Also, depending on the instruction, their duration at Mongla Port was found to be a maximum of 10 days and a minimum of 2 to 3 days. In some cases, it is one day. Their voyage path to Mongla Port was at least 15 days to a maximum of 4 months. The number of crew members varied from one vessel to another, which was 6, 9,10, and 12. It was found that some ships separated food waste and plastic waste, while others did not. Their waste separation system involved categorizing "food waste, including polythene bags, food wrappers, etc.," and plastic waste was specified as "plastic bottles." Some vessels reused plastic polythene bags and bottles before disposing of them in the river or nearby shore. Additionally, some vessels sold plastic bottles to the "faraway," who approached them in a small boat. They stored their waste in bins, paint buckets, polythene bags, etc. Regarding waste disposal, the most commonly mentioned method was dumping the waste into nearby rivers or landfill areas. Specific disposal practices varied, with some vessels indicating regular dumping intervals or daily waste disposal. It should be noted that some vessels did not provide detailed information about their waste management and disposal systems.

Table 1: Local vessel characteristics and operational dynamics at Mongla Port

Origin	Voyage Paths	Duration of Their stay at Mongla Port Area	Arrival Times At Mongla Port	Crew Number	Vessels Type	Goods carries
Bangladesh	India Noapara Dhaka Barishal etc.	1 to 10 days	15 to 20 days, 1 to 1.5 months, and 2 to 4 months	6 to 12	Cargo	Fly ash, Coal Fertilizer, Slag Lime, Clinker Snad, etc.

3.3 Foreign Ship Waste Management Practice

Foreign vessels strictly adhered to comprehensive rules and regulations, ensuring meticulous waste management by MARPOL Annex V guidelines. On these ships, waste materials were systematically stored in designated bins strategically positioned on the deck, with each bin being distinguished by specific symbols labeled from A to K, representing distinct waste categories; as depicted in Figure 6, these symbols aligned with the corresponding MARPOL Annex categories, signifying diverse types of waste. For instance, 'A' signified Plastics, 'B' denoted Food Waste, 'C' was reserved for Domestic Waste, 'D' designated Cooking Oil, 'E' represented Incinerator Ashes, 'F' pertained to Operational Wastes, 'G' was allocated for Animal Carcasses, 'H' signified Fishing Gear, 'I' related to E-Waste, and 'J' covered Cargo Residues classified as non-Hazardous Material (HME). The final symbol, 'K,' was reserved for Cargo Residues categorized as Hazardous Material (HME). These symbols simplified the waste sorting and disposal procedures aboard the vessels.

The waste from foreign ships at Mongla Port is collected by ship chandlers appointed by the shipping company. The company either bids or subcontracts these chandlers. Ship chandlers collect waste and perform repair works, painting, unloading cargoes, and other tasks for the ships. When they collect the waste, they provide certificates to the ships, indicating the amount of waste received. This provides a clear record for other ports, confirming that the foreign ship did not dump waste into the river. After collecting waste from the ships, ship chandlers dump it into the Mongla Port Municipality landfill. They approach the ship with a boat to collect the waste, as shown in Figure 6. It was also found that if their waste bins get full and there is no nearby port, according to MARPOL 73/78 rules, they can dump their food waste and incineration ash outside the territorial boundary. Each crew member's room has separate small waste bins, as seen in Figure 6, as does the kitchen.

Figure 6: Foreign Ships Waste Management in Designated Bins as per MARPOL Annex V, With Collection and Certification by Ship Chandler

They dispose of their waste according to these bins. The waste is then kept in designated larger bins on the ship decks. Big foreign ships typically have 20 to 30 crew members and come from different places around the world, carrying cargoes, vehicles, machinery, etc. Their voyage paths can vary from 15 days to 2 months.

The waste composition of thirty-eight foreign ships is shown in Figure 7, as well as the diverse waste types generated on these ships and their corresponding categorizations. Notably, plastic waste emerged as the predominant category among foreign vessels, accounting for a significant volume of 36.01 m^3. Following plastic waste, the second dominant category was domestic waste, comprising 29.74 m^3, with food waste ranking as the third dominant category at 22.67 m^3. Other notable categories included

Incinerator ashes at 18.8 m^3, Operational wastes at 5.74 m^3, Cooking Oil at 2.67 m^3, E-waste at 2.23 m^3, Fishing gear at 0.6 m^3, and Animal carcasses at 0.5 m^3. These findings were based on data collected by the Mongla Port Authority.

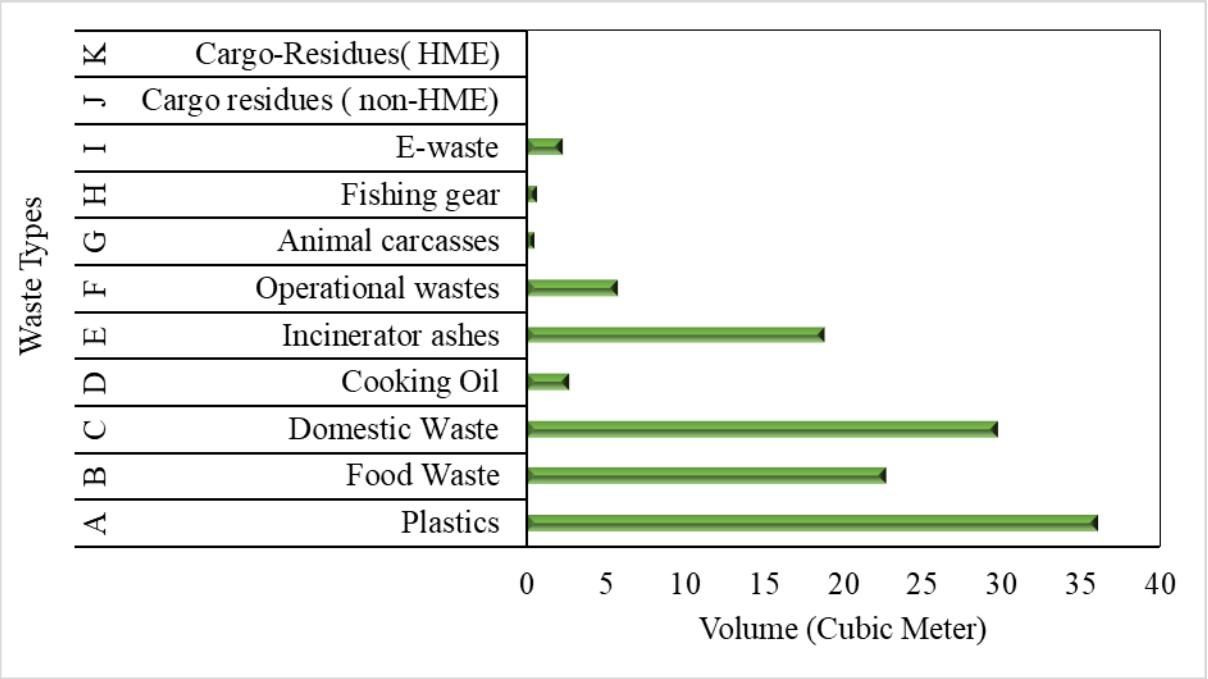

Figure 7: Waste Composition Analysis According to MARPOL ANNEX V

3.4 Comparison Between Foreign Ship and Local Vessels Waste Management Practice

The waste management practices in foreign ships and local vessels coming to Mongla Port showed some differences. It was seen that goods carried by foreign ships were vehicles, machinery, and containers, whereas local vessels carried fertilizer, coal, slag, etc. The waste generated by foreign ships was higher than that of local vessels. About 154 gm/capita/day of plastic waste was generated by foreign ships, whereas local vessels generated 4.13 gm/capita/day of plastic waste. This variation happened because the crew member numbers differed in both vessels. Foreign ships had a maximum crew member of about 30 persons, whereas local vessels had a maximum of 12 crew members. Also, local vessels dump their waste daily, whereas foreign ship waste disposal happens when they find a port on their voyage path. So, some foreign ships dispose of waste 5 to 10 days later. The cargo waste produced in local vessels was considered goods because it remained clinker, lime, coal, etc.; after delivering them, about 500 gm can be found at the local vessel hatch. Which later can be sold; fly ash reaming was disposed of in the water. As for foreign ships' cargo residue waste, maintenance waste, etc, waste was kept in designated bins to be disposed of at the port. The operational waste at local vessels was oil, and the amount was negligible. As for waste sorting, foreign ships follow the IMO 73/78 rule; thus, they sort their waste according to MARPOL ANNEX V, which indicates a proper management system. As for local vessels, there were no proper rules or guidelines for their waste management. Because there is no proper place to dispose of waste, they dump it into rivers. It was also seen that ship chandlers collected foreign ships' waste and disposed of it at the Mongla Port Municipality landfill. However, there was no collector to gather waste from local vessels.

3.5 Recommendation for Local Vessels Waste Management

The study underlines the vital need for local vessels to use standardized waste management practices that comply with international standards. The crew of the local vessel must adhere to current waste management standards and sorting processes. Waste must be disposed of in designated places, such as landfills. This good management should be maintained, and an awareness campaign to educate crew members about environmental and marine contamination is required. Port officials, ship agents, local vessel operating firms, the government of Bangladesh, and the Bangladesh Inland Water Transport

Authority (BIWTA) can work together to implement this awareness program. It will employ efficient garbage collection and disposal procedures to reduce marine operations' environmental impact in the Mongla port zone.

4. CONCLUSIONS

A detailed analysis of waste management processes at Mongla Port reveals considerable cross-border discrepancies between foreign and local vessels. Waste generation rates, disposal methods, and general practices demonstrate a significant disparity, which is highlighted below:

1. The waste generation rate analysis revealed data from Mongla Port Authority, showing that one foreign ship generates an average of 8.6 L/day of mixed waste and 2.6 L/day of plastic waste. In contrast, local vessels exhibited lower waste generation rates per ship, with an average plastic waste generation rate of 4.13 grams/capita/day and an overall waste generation rate of 6.51 grams/capita/day.
2. Survey findings reveal that local vessels lack standardized waste management practices, leading to varied disposal methods, while foreign ships systematically sort and store waste in designated bins. Foreign ships sort waste according to IMO 73/78 and MARPOL Annex V, while local vessels lack proper waste management guidelines. Ship chandlers collect foreign ships' waste and dispose of it at the Mongla Port Municipality landfill, but no collectors gather waste from local vessels.
3. The difference in waste generation rates between vessels is due to crew size and disposal frequency, with foreign ships disposing of waste quickly. In contrast, local vessels regularly dispose of waste in rivers.

The study reveals that local vessels' existing waste management practices are below the standard. The BIWTA and all the corresponding officials, port authorities, and crew members of local ships must take the necessary steps to make waste management sustainable and environmentally friendly.

ACKNOWLEDGMENTS

The SCIP Plastics project on which this publication is based was funded by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety under grant no. 67MM0004. The responsibility for the content of this publication lies with the author.

REFERENCES

Abdel-Shafy, H. I., & Mansour, M. S. M. (2018). Solid waste: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(4), 1275–1290. https://doi.org/10.1016/j.ejpe.2018.07.003

Alderson, D. L., Funk, D., & Gera, R. (2020). Analysis of the global maritime transportation system as a layered network. *Journal of Transportation Security*, 13(3–4), 291–325. https://doi.org/10.1007/s12198-019-00204-z

Amin, M. N., Ali, M. Y., & Salequzzaman, M. (1970). Identification and impact analysis of invasive species: A case study in the Mongla Sea Port Area of Bagerhat District of Bangladesh. Daffodil International University *Journal of Science and Technology*, 4(1), 35–41. https://doi.org/10.3329/diujst.v4i1.4353

Ardiansyah, Damar, A., Hariyadi, S., & MacHfud. (2022). Current Source and Distribution Pattern of Plastic Waste Leakage in the Estuary of Jakarta Bay. IOP Conference Series: Earth and Environmental Science, 950(1). https://doi.org/10.1088/1755-1315/950/1/012057

Bari, Q. H., Mahbub Hassan, K., & Haque, R. (2012). Scenario of solid waste reuse in Khulna city of Bangladesh. Waste Management, 32(12), 2526–2534. https://doi.org/10.1016/j.wasman.2012.07.001

Buenrostro, O., Bocco, G., & Cram, S. (2001). Classification of sources of municipal solid wastes in developing countries. Resources, Conservation and Recycling, 32(1), 29–41. https://doi.org/10.1016/S0921-3449(00)00094-X

Das, N., Das, T., Pal, S. K., Zuthi, M. F. R., Kraft, E., Haupt, T., & Kuehlewindt, S. (2023). Assessing Plastic Waste in Marine Environment using Foreign Ships from Chattogram Port. In Architecture and Civil Engineering.

Fratila (Adam), A., Gavril (Moldovan), I. A., Nita, S. C., & Hrebenciuc, A. (2021). The Importance of Maritime Transport for Economic Growth in the European Union: A Panel Data Analysis. Sustainability, 13(14), 7961. https://doi.org/10.3390/su13147961

Hitchcock, J. N. (2022). Microplastics can alter phytoplankton community composition. Science of The Total Environment, 819, 153074. https://doi.org/10.1016/j.scitotenv.2022.153074

Hossain, M. F., Islam, M. A., Al-Mamun, A., Hossain, F., Islam, M. A., Al-Mamun, A., Naher, K., Khan, R., Das, S., Tamim, U., Hossain, S. M., Nahid, F., & Islam, M. A. (2016). Assessment of Trace Contaminants in Sediments of the Poshur River Nearby Mongla Port of Bangladesh Heavy metal contamination and risk assessment of river sediments and soils View project Assessment of Trace Contaminants in Sediments of the Poshur River Nearby Mongla Port of Bangladesh. In *Nuclear Science and Applications* (Vol. 25, Issue 2). https://www.researchgate.net/publication/319164927

IMO. (1973). International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78).

IMO. (1978). International Convention for Preventing Pollution from Ships, 1973, as modified by the Protocol of 1978. https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships

IMO. (2018). Consolidated Guidance for Port Reception Facility Providers And Users. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/MEPC.1-Circ.834-Rev.1.pdf

IMO (2018MEPC.1-Circ.834-Rev.1. (n.d.).

Nawar, N., Rahman, Md. M., Chowdhury, F. N., Marzia, S., Ali, M. M., Akbor, Md. A., Siddique, Md. A. B., Khatun, Mst. A., Shahjalal, Md., Huque, R., & Malafaia, G. (2023). Characterization of microplastic pollution in the Pasur River of the Sundarbans ecosystem (Bangladesh) with emphasis on water, sediments, and fish. Science of The Total Environment, 868, 161704. https://doi.org/10.1016/j.scitotenv.2023.161704

Nidia Rinasti, A., Faisal Ibrahim, I., Gunasekara, K., & Winijkul, E. (2022). Fate of Non-Recyclable Plastic Wastes: Material Flow Analysis, Leakage Hotspot Modelling, and Management Strategies. https://doi.org/10.21203/rs.3.rs-1611355/v2

Roksana, S., Bari, Q. H., Rafew, S. M., Rafizul, I. M., Kraft, E., Susanne, K., & Rahman, M. (2023). Development of A Qualitative Material Flow Analysis for Ship-Generated Waste at Mongla Port: The Role of SCIP Plastics Project. In M. Alamgir, S.M.T. Islam, & J. A. Saju (Eds.), *Proceedings of the Waste Safe 2023 – 8th International Conference on Integrated Solid Waste and Faecal Sludge Management*. https://wastesafe.info/wastesafe-2023-papers-list/

Roksana, S., Bari, Q. H., Rafizul, I. M., Hossain, M., Kraft, E., Haupt, T., & Rahman, M. (2023). A Study on Marine Plastic Debris from Local Ship in Mongla Port Area. In Architecture and Civil Engineering.

Titiksha. (2017). Biodegradable Pollutants and Non-Biodegradable Pollutants