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Assessing Plastic Waste in Marine Environment using Foreign Ships from Chattogram Port

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Abstract

Plastic disposal in the landfill is found detrimental to the environment. Increasing plastics with the expansion of foreign ship-generated wastes end up in landfill in the absence of a proper plastic management system following the 3R approach. The projection of the amount of plastic waste is needed to counteract this fallible waste management of plastics. The objective of this study is to estimate the projected amount of foreign ship-generated plastic waste in Chattogram Port. The study considers the current plastic waste amount per ship and the number of ships for the projected period. The number of ships is projected based on the ship handling by the Chattogram Port in the last 11 years. It has been anticipated that approximately 10,500 foreign ships need to be handled by the Chattogram Port in the year 2050 which are to generate 552 metric tons of plastic waste. A huge amount of these non-biodegradable plastic wastes will end up in the landfill which will be a burden for the landfill unless an immediate shift to an effective management system. Based on this result, the Port Authority and other stakeholders involved can plan a feasible waste management to implement in the port for plastic waste.

Keywords: *Chattogram Port; Plastic Waste; Ananda Bazar Landfill; Foreign Ship; Waste Management*

1 Introduction

Plastic disposal at the end of the life cycle has impacts on the environment due to its non-biodegradability. For instance, a plastic bottle can take as long as nearly 450 years to decompose (World Economic Forum, 2018). In warm water of the ocean of the South Asian region, these wastes reduce oxygen from the seawater by dissolving and consuming oxygen (Abeysekera, 1991). In the landfill, plastics work as vectors and vehicles of pollutants. Plastic degrades and releases harmful volatile organic compounds in the landfill. Additionally, due to large surface area, microplastics adsorb pollutants, which can be transported via leachate and gases generated in landfill (Wojnowska-Baryła et al., 2022). Plastic wastes have various land-based sources such as households, industries as well as water-based sources such as ships. Within the marine environment, shipping-caused pollution is alarming due to the large ship sizes and higher ship density in the confined shipping routes. Various categories of ships produce different quantities of waste. Generally, each crew member on commercial ships generates 1.5 kg of garbage per person per day, while on passenger ships, it is roughly 2 kg (ISO, 2017; PAME, 2017).

Plastic waste management in ports varies based on the individual port authority's followed plan, policy, and regulations. Different countries are entitled to different global and regional agreements that have been taken for the waste management of ships to protect the marine environment (Mamun, 2000). The International Convention for the Prevention of Pollution from Ships (MARPOL) is the most important and immediately relevant treaty for preventing operational pollution from ships (IMO, 2019). According to the discharge provision of the MARPOL Convention, discharge of garbage especially plastics from ships into the marine environment is prohibited. The convention addresses six different categories of pollutants, whereas Annex V focuses on garbage and solid wastes (IMO, 2017; ISO, 2017). Bangladesh is one of the countries to sign MARPOL Annex V, however, pollution from vessels is a common scenario in Bangladesh due to unregulated operation of vessels and lax

enforcement of laws (Karim, 2009). To implement the MARPOL Convention, the Department of Shipping in Bangladesh drafted a national legislation named Marine Environment Conservation Act (MEC Act) in 2004 (Dewan, 2023). According to the MEC Act, the port authorities themselves or with the assistance of private parties provide reception facilities to the ships (Draft Bangladesh Marine Environment Conservation Act, 2004). Chattogram Port, the largest seaport in Bangladesh, provides reception facilities to the ships through vendors. The Garbage Cleaning Vendors use Chittagong Municipality's landfills to dispose of the ships' garbage.

A significant amount of plastic waste due to its flexible and versatile usage is due in the future. It aligns with the port business as well due to the increase in transshipment. Chattogram Port has to deal with a high amount of ship waste where plastics cover a significant portion. According to Det Norske Veritas Industri Norge AS (1993), a ship that was handled by the port of Chittagong in the fiscal year 1998-1999, generates 27 kg of garbage daily. Chattogram Port, the 58th busiest container port in the world as of 2020, deals with 80% of the export and import of Bangladesh (Mahmud & Rossette, 2007; Munim et al., 2014). The number of ships is increasing with the increasing amount of cargo handling. Moreover, the higher turnover time of the ships in this port results in a high amount of plastic waste (Mahmud & Rossette, 2007). While, as per convention and the port's solid management system, the quantification of solids from a ship is recorded, the end-of-life cycle of the plastic is still lacking behind. Due to the absence of a proper quantification model and 3R policies, the management scheme cannot be designed properly, thus in turn putting a huge pressure on the environment. A proper scientific estimation of plastic waste from foreign ships is needed to address a total master plan for plastic pollution reduction at ports.

The objective of this study is to estimate the amount of foreign ship-generated plastic waste for the year 2050 that is to be handled by Chattogram Port. This study projects the number of ships for the specified year based on linear regression. The plastic waste generated on average in a foreign ship is based on the three-monthly data of the fiscal year 2021-2022 that is submitted to the Department of Shipping by the Harbour and Marine Department. The projected amount of plastic waste generated by foreign ships will end up in landfill, which will vastly impact the environment.

2 Study Area

Bangladesh has a 710 km long coastline along with a marine area (exclusive economic zone) of 40,000 sq. miles (Alam, 1998, 2006; Rashid, 2004). Bangladesh has two seaports, Chittagong and Mongla. Besides, several small ports are active along the coast for cabotage and fishing vessels. (Mamun, 2000). Chattogram Port is located 11 kilometers away from the Bay of Bengal in the Karnafuli River estuary (CPA, 2020). Chattogram Port handles nearly about 4000 ships as of 2021, which is gradually increasing.

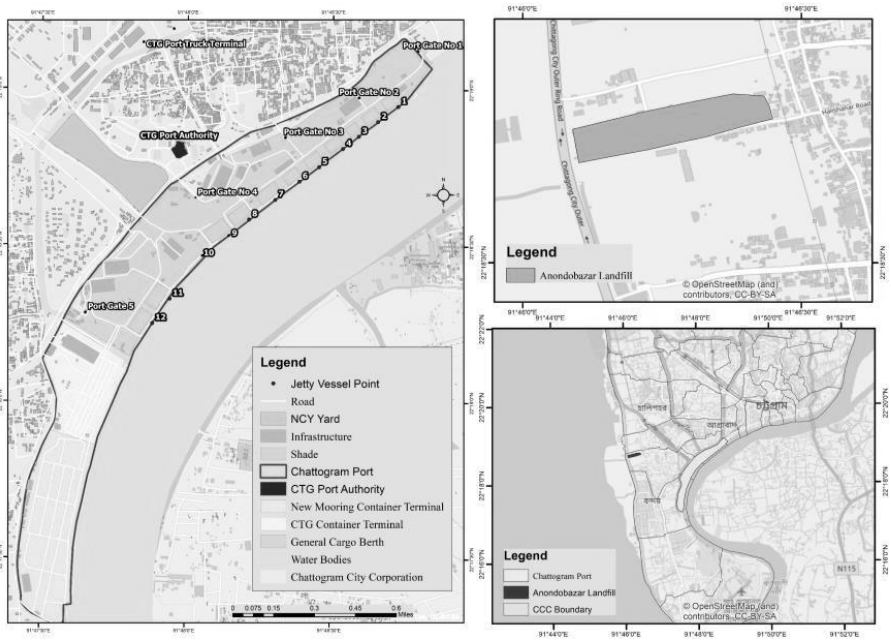

Figure 1. Location of Chattogram Port and the landfill that is used for waste disposal

Chattogram Port has 19 jetty berths including two designated container berths, a few agency-built specialized berths, and four river mooring berths (CPA, 2022). The wastes of Chattogram Port are mainly handled by third parties who are assigned by Port Authority through contracts. The assigned third party mainly uses Chittagong City Corporation's landfill by taking the authority's permission. Ananda Bazar is at Halishahar, the mid-western part of the city, where the Chattogram Port's wastes are dumped. Ananda Bazar and Arefin Nagar are the two landfill sites of Chittagong City Corporation (CCC) (Ali Ashraf et al., 2021). Both are not designed as sanitary landfills.

2 Methodology

The paper is based on the secondary data of Foreign ships of Chattogram Port. For visualizing the overall waste management system of Chattogram Port, a field interview was conducted among port officials and stakeholders. Secondary data on cargo and ship handling, and generated foreign ship waste were collected from Chittagong Port Authority. From the current annual ship handling data of Chattogram port, a linear equation has been identified. The number of foreign ships for the year 2050 is projected based on the linear equation. In addition, the paper estimates the average plastic waste data generated in a foreign ship for the year 2021-2022. The paper assumes that the same amount of plastic waste will be generated in a foreign ship in the year 2050. Based on the assumption and projected number of foreign ships, the total amount of generated plastic waste in the foreign ships has been calculated that will be handled by Chattogram Port in the year 2050.

3 Results

3.1 Cargoes and Ships handled by Chattogram Port

Figure 2 presents the total amount of cargo and number of ships handled by Chattogram Port in each year from 2011 to 2022. The amount of cargo handled increased by almost 200% between the years 2011 and 2022 from 40,901,309 M.ton to 118,174,160 M.ton. Within that period, the number of foreign ships also rises from 2265 to 4231. The contribution from ships to the total cargo handling is seen to increase proportionately. An equation has been found based on a linear regression on the number of ships data, which is shown as Equation 1. Taking foreign ships into consideration, the estimated linear regression value is found to be 0.9604%. Though linear estimation is crude, the smooth trend can be taken forward as an indicator for the projection.

$$y = 217.04x + 1886.6 \quad (1)$$

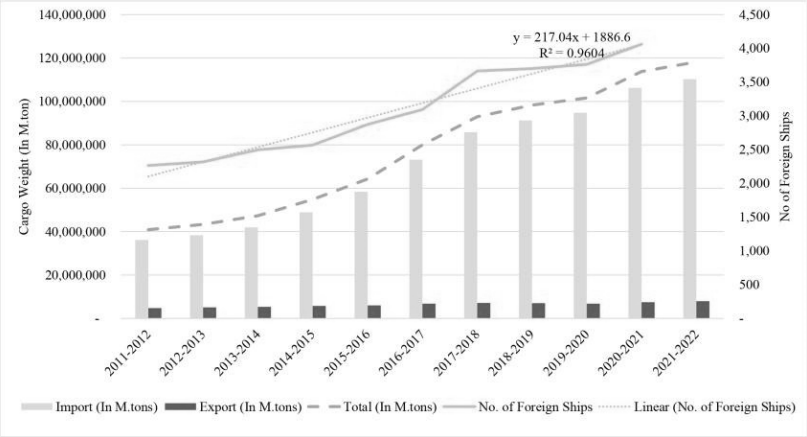

Figure 2. Cargo and Ship Handling of Chattogram Port in the past 11 years (Source: CPA, 2016, 2021)

3.2 Waste Management System of Chattogram Port

The detailed waste collection process of foreign ships is described in Figure 3. The Chittagong Port Authority (CPA) provides four different types of licenses to vendors for different services on the ships. The holders of garbage cleaning licenses are typically responsible for the collection of wastes from the ships and disposal of wastes to the landfill. Whenever any ship intends to enter the Chattogram Port area, they inform the shipping company if they will use the reception facilities before their arrival. For receiving the reception facilities of garbage cleaning, the shipping company informs the shipping agent of the availability of vendors. The shipping agent contacts vendors. Vendors submit quotations for waste collection and if chosen, take permission from Customs and Traffic Department for waste collection. Subsequently, the vendor collects all the waste after the

arrival of the ship in the Chattogram Port area. Moreover, the vendor should provide a report to the port authority containing the amount of the waste according to MARPOL Annex V.

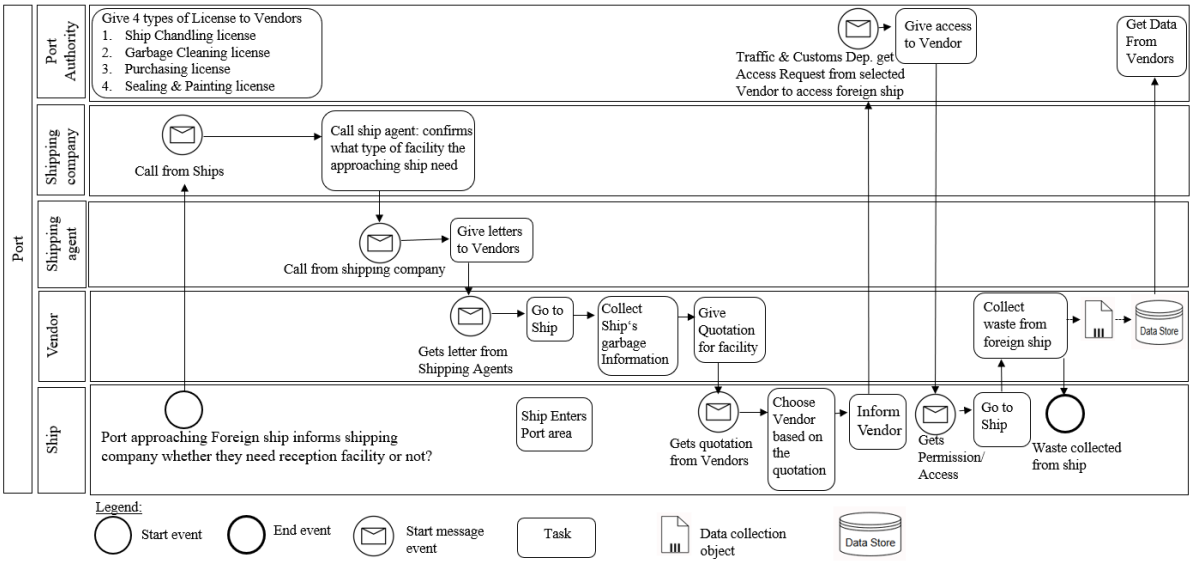

Figure 3. Administrative Process for Waste collection of foreign ships

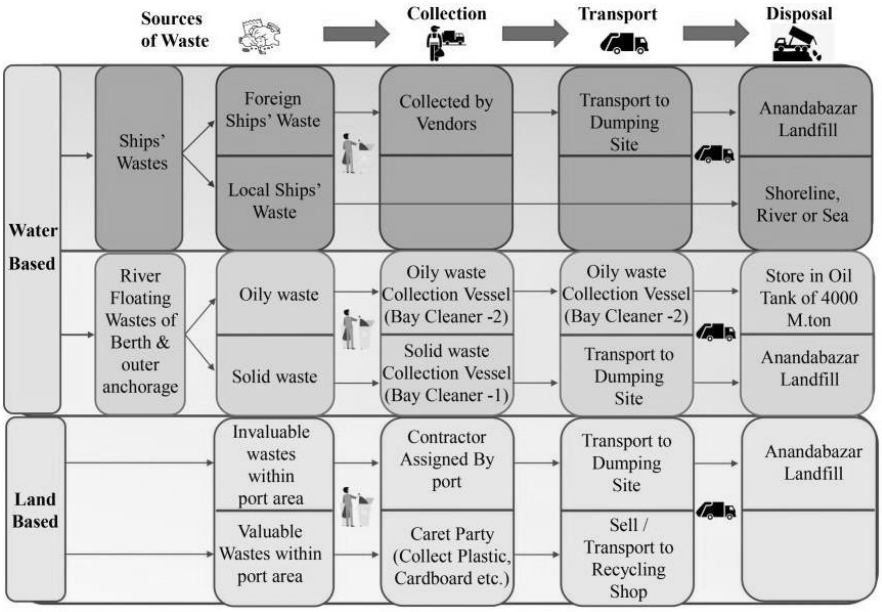

Figure 4. Overall Waste Management System in Chattogram Port

Figure 4 represents the overall flow of the port's wastes. Waste is generated at Chattogram Port from various sources, mainly land-based and water-based sources, including shipping operations, cargo handling, ship maintenance and repair, port facilities, and the activities of port users. CPA's waste management consists of handling different types of waste generated within the port area, including solid waste, hazardous waste, and wastewater. Ship-generated waste, floating wastes in berths and outer anchorage areas, and waste within port-restricted areas and office areas are the sources. According to Figure 4, foreign ships' waste is collected by the CPA's nominated vendors. They collect the waste from the mother vessel as per demand and transport all waste to the Anandabazar landfill, which is situated in the Halishahar area. All international ships store waste following MARPOL Annex V, whereas, most of the local ships directly dump their waste into the river, sea, or near the shoreline. Another water-based waste source is shown in Figure 4, which is the area of the berth and outer anchorage, which mainly creates oily and solid waste. The CPA has two facilities to manage this oily and solid waste: Bay Cleaner 1 and Bay Cleaner 2. The bay cleaner 1 (solid waste collection vessel) collects the river's floating solid waste from the berth and outer anchorage area and transfers it to Anandabazar landfill. The port-

restricted area, office area, and other areas within the port are prime sources of land-based waste. The port authority assigns some contractors to collect these wastes. The invaluable wastes that cannot be recycled or sold are dumped in landfills, and recyclable products such as plastics and cardboard are sold to recycling shops.

3.3 Solid Waste Composition of Foreign Ships

Figure 5 displays the total percentages of the solid wastes collected from foreign ships from October 2021 to September 2022. This data is made from the trimonthly waste collection report of one year provided by CPA. Domestic and food wastes are the leading category of waste which together stands for 55% by weight of the total waste collected from foreign ships, while plastic waste is found 17% by weight, reflecting a substantial contribution. All plastic waste along with other wastes are ended up in the Anandabazar Landfill by the vendors.

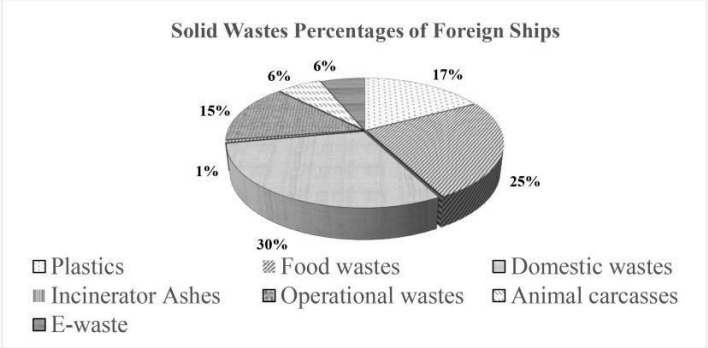

Figure 5. Solid waste composition of Foreign Ship based on the collected waste data during the months between October 2021 to September 2022 (Source: CPA, 2022b)

Table 1. Maximum and Minimum Solid Wastes Amount Per Ship in Three months based on the collected waste data and Yearly Average Solid Wastes Amount Per Ship estimated for the months between October 2021 to September 2022.

Waste Types of Foreign Ships	Amount of Wastes (in kg)			
	Minimum	Maximum	Mean	Std. Deviation
Plastic	36.40	72.91	52.24	17.94
Food waste	41.00	106.18	74.36	36.37
Domestic waste	76.00	117.09	90.86	19.51
Incinerator Ashes	.00	2.08	1.52	1.01
Operational wastes	31.31	66.49	45.10	16.68
Animal carcasses	8.40	33.16	18.63	11.16
E-waste	8.80	40.20	18.40	14.86

The trimonthly maximum and minimum weight of solid wastes and the yearly average weight of solid wastes generated per foreign ship are presented in Table 1. The estimated value of this waste is only for the foreign ships that took the reception facilities from the port authority. It is seen that in a period of one year, a ship can produce approximately 52.24 kg of plastic waste due to ship activities, crew members, and other sectors. Food and domestic waste produced in one ship are also significant contributors to the total waste which are 74.36 kg and 90.86 kg.

3.4 Projected Plastic Waste

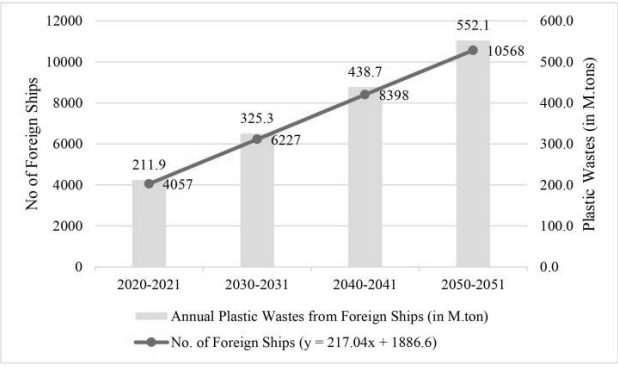

Figure 6. Projected amount of plastic waste based on the total number of foreign ships in a year.

Using Equation 1, the projected number of ships for the fiscal year 2050-2051 is calculated, which is 10568 (Figure 6). Based on the data of Table 1 and the projected number of ships, the projected amount of plastic waste is 552.1 M.ton for the fiscal year 2050-2051. It is seen that the volume increased almost 2.5 times in the year 2050 from the year 2020, which amounted to a huge plastic waste that requires a land area. These plastic wastes will end up in the landfill that act as vector of pollutants and leach out from the landfill. Moreover, the slow disintegration to microplastics via chemical and biological reactions increases the surface area to adsorb and spread pollutants.

4 Conclusions

From the projected number of foreign ships, the study estimates the projected amount of plastic waste. The amount of annual plastic waste from ships will be 552.1 Metric tons for the year 2050-2051 where the projected number of foreign ships is 10,568. Even though the development of Bay Terminal and Patenga Container Terminal will increase the number of foreign ships, it is not considered in this study. In the absence of proper waste management at Chattogram Port, all the waste including plastics will end up in the landfill. The total solid waste for the year 2050-2051 will be too big for the existing landfill of CCC. As plastics is 17% of the total solid waste, these non-biodegradable plastic wastes will be vulnerable to landfill disposal. The projected amount of plastic waste will help port authorities to take necessary steps to implement proper waste management, which will create a plastic life-cycle of reduction, reuse, and recycling.

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