



## **WASTE MANAGEMENT OF A MARITIME PORT: THE CASE OF MONGLA PORT**

**M. R. H. Khondoker<sup>1\*</sup> and K. R. Hasan<sup>2</sup>**

<sup>1\*</sup>Dept. of Naval Architecture and Marine Engineering, Military Institute of Science and Technology, Dhaka, Bangladesh, Email: [mr9hasan@gmail.com](mailto:mr9hasan@gmail.com)

<sup>2</sup>Dept. of Port and Shipping Management, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka, Bangladesh, Email: [kraselhasan@gmail.com](mailto:kraselhasan@gmail.com)

### **Abstract:**

*During voyage of a ship from one port to another, different types of wastes are generated because of day to day operation of the ship and livelihood of the crews, which fall under the scope of international convention for the prevention of pollution from ships, MARPOL 73/78. It is seen that almost 1000 nos. of ships are calling in to Mongla port every year which is gradually increasing day by day. However, there is no waste management system in the port now. IMO has recognized that provisions of proper wastes collection vessel as well as oil spill management vessel and reception facilities are crucial for effective MARPOL implementation in the maritime port. In view of the same, the feasibility of the establishment of a standard and modern waste management system for Mongla port has been studied. First of all, amount of different types of wastes sourced from the shipping operation during voyage to the port of Mongla has been estimated following standard procedure and to facilitate the necessary services to incoming ships, a proposal has been made to procure waste collection vessel, oil spill collection vessel and port reception and treatment facilities by Mongla Port Authority (MPA) along with other necessary vessels and equipment. The procurement, operation and maintenance costs as well as revenue to be collected from the incoming ships for wastes quantities, alternative uses of the vessels and facilities and earnings from selling of the product of the treatment have been examined. It is found from the study that the investment is technically and economically viable.*

**Keywords:** Waste, oil spill, collection, reception, management, treatment, etc.

### **1. Introduction**

Mongla port is the second largest port in Bangladesh and the gateway for the south-western part of Bangladesh. The geometric growth of Bangladesh shares in the maritime trade along with the limitation of accommodating more ships by Chittagong port, has revived the opportunity of Mongla port once again. Furthermore, the capital dredging at the Passur channel and the construction of the Padma Bridge added fuel in the container and cargo handling possibility of Mongla port. Numbers of development activities for the enhancement of port facilities as well as performance undertaken by the government of Bangladesh has brought forward significant impact on the importance of the port in coming years. Rampal power plant, Mongla EPZ, Special Economic Zone including the revival of the Jute industries mostly based on the greater Khulna region, Southern part of Bangladesh, is impossible without the use of Mongla port. Under the regional cooperation in respect of providing connectivity to Nepal and Bhutan with the utilization of the Mongla port is also in serious consideration by concerned authorities.

In the study report entitled “Bangladesh: Port and Logistics Efficiency Improvement” conducted by ADB, a projection of the utilization of port facilities have been conducted where it is shown that even though in case of the maritime trade, the share of Chittagong port is 90% and Mongla is 10% at present, however, it would be likely 50% share of Chittagong and 40% that of Mongla in 2040 (ADB, 2011). It is pertinent to mention that in this report only the extension possibilities of Chittagong port have been considered rather than the construction of Deep-sea port or Payra port. However, this report justifies the future possibilities and demand of Mongla port.

On the other hand, the recent cargo and container handling statistics of Mongla port—shows an average growth in all aspects of handling of ships, cargo and containers (MPA, 2020), which justifies the further development of the port.

In view of the above to improve the performance of the port and to meet the increasing demand, different projects for development of the port have been undertaken (MPA, 2020). However, port activities have impact on the coastal zone as ports need to handle a large amount of ships generated wastes (Butt, 2007) and (Svaetichin and Inkinen, 2017). Therefore, ports should have reception facilities for ship generated waste which has been mandated under international convention MARPOL 73/78 of International Maritime Organization (IMO, 1973/78). On the other hand, the location of Mongla Port is highly environmentally sensitive as the vessels needs to cross the UNESCO world heritage Sundarban. Therefore, the port authority needs to consider the waste reception matter with due significance and reduce the environmental vulnerability. As a result, procurement of different watercrafts for carrying out the mandated responsibilities of Mongla port as an international maritime port under IMO guidelines is considered. This will ensure providing of the required marine services to incoming and outgoing vessels in the Mongla port. Waste collection and management as well as oil spill management are the most essential support services of a maritime port which is mandatory according to IMO requirement and still lacks in Mongla port.

In order to facilitate the necessary services to incoming ships in connection with collection, store and treat different kinds of wastes generated in the ships, waste collection vessel and reception facilities along with ancillary support vessels and equipment have to be procured and established in Mongla port without any delay. Consequently, necessary amenities including procurement of oil spill recovery vessels and other ancillary facilities to be procured for recovery of spilled oil in port water as soon as any incident occurs. This paper aims to examine the technical and economic feasibility of establishing a waste management facility in Mongla port. The findings reveal that the establishment and management of waste management facility in Mongla port is technically and economically viable and therefore, the port authority can implement the most essential service and fulfill the IMO mandatory requirements.

## **2. Methodology**

The study starts with the collection of data on different types of ships calling in Mongla port and estimation of the number of days spent in the voyage as well as at the port area. Using the above information and standard procedure (DNV, 1993), the quantities of different types of wastes delivered by different incoming ships have been estimated. On the basis of the estimated waste types and quantities, the preliminary design, particulars and capacity of the necessary vessels, plants and other facilities can be assessed, which has been elaborated later on. The following data are directly or indirectly related to the vessels, equipment, facilities and infrastructures to be proposed for the waste management services and have been examined as well.

Different relevant factors, their relation and influence in designing the necessary vessels, equipment and accessories as well as port reception facilities are shown in Fig. 1 and described below:

### **Port Characteristics:**

- Port layout;
- environmental data;
- berths and equipment;
- commodity flows;
- Information on companies or other organizations in the Mongla area which could possibly receive and process certain wastes, such as:
  - Garbage collection and treatment companies;
  - Oil refineries;
  - Terminals for petroleum products and other products;
  - Chemical plants
  - Ship repair and/or recycling yards;
  - Tank cleaning companies.
- Space requirements for the facilities (also for possible extension);
- Existing or available and required technical manpower and labour; and
- Laboratory facilities needed to be used for testing samples of the wastes.

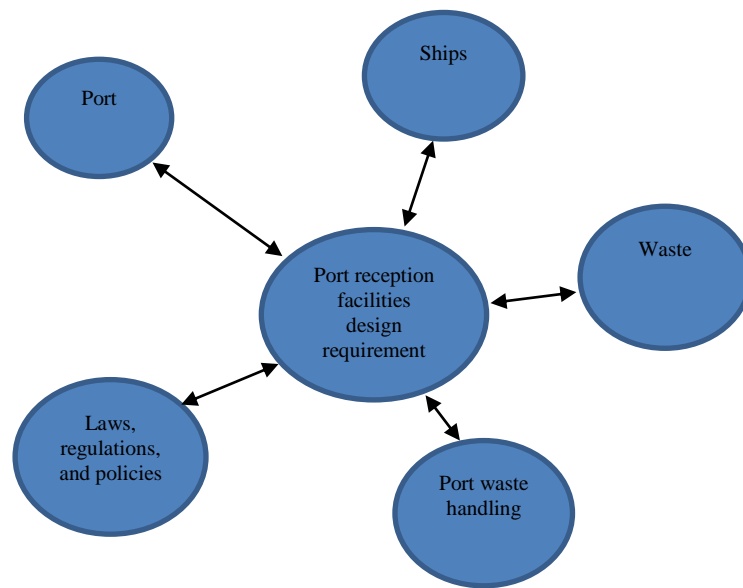


Fig. 1: The methodological framework showing the influence of different factors on the port reception facility design

**Ship Characteristics:**

- Present shipping traffic and ships' characteristics at Mongla port (including pleasure boats, commercial fishing vessels and other non-commercial vessels);
- Future trends in shipping traffic and ships' characteristics at Mongla port (including the categories mentioned in the previous point); and
- Ship requirements of Mongla port for access to reception facilities including size limitations.

**Waste Characteristics:**

- Types and quantities of wastes received at present at Mongla port and estimates of the waste streams that could be discharged in Mongla port; and
- Types and amounts of waste generated by ships calling at Mongla port.

**Port Waste-Handling Characteristics:**

- Needed facilities for the reception and treatment of wastes from ships (including location of facilities, access, security, visibility, signs, lighting, etc.); and
- Needed facilities for the reception and treatment of wastes from local industrial activity.

**Applicable Laws, Regulations and Policies:**

- Port and other regulations regarding the prevention and combating of port pollution and the receipt of wastes from ships at Mongla port (incl. existing fee systems, e.g. implemented in port dues); and
- Waste management strategy which is applied in the country, if there is any.

**3. Category of Waste under MARPOL 73/78 requiring Port Reception**

Wastes could be defined as substances or objects disposed or to be disposed or are required to be disposed in accordance with the provisions of national and international legislations. Ship waste is all wastes (Delft, 2017), non-hazardous and hazardous that has occurred during ship navigation, as well as the wastes being transported by cargo vessels. In general, ship waste includes solid waste, liquid waste, oily and non-oily waters and contaminated waste waters. The wastes generated by the shipping operation are internationally categorized by different annexes of MARPOL 73/78 as shown in Table 1, where the provision of reception facilities has also been discussed (Djadjev, 2015).

According to MARPOL 73/78 these wastes must be collected by the port reception facilities all around the world. The port reception facility must be able to receive dirty oil and other contaminants, and also provide quick and efficient services. Therefore, port reception facilities (IMO, 2014) are places those international shipping ports must provide to collect residues, oily mixtures and garbage generated from ocean-going vessels which is mandated by MARPOL 73/78 that the states party to this convention have to have such facilities at their ports.

Table 1: Category of Waste under MARPOL 73/78 requiring Port Reception

Sl. No.	Category of Waste	Detailed types of waste under each category	Relevant Annex of MARPOL 73/78
1.	Waste oils and their mixtures	Sludge, Bilge water, others viz. oily waste waters originate from engine rooms and machinery spaces, e.g. pump rooms	Annex I
2.	Sewage	Sewage, drainage and other wastes from any form of toilets and urinals, drainage from spaces containing living animals, other wastewaters for example a mix of sewage and grey water.	Annex IV
3.	Solid Waste	From watercraft this waste is similar in composition to domestic waste, residues of any type of ship cargo in ship warehouses or tanks occurred after debarking, cleaning or washing of ship warehouses, deck or tanks, including the excess and spilled cargo during embarking/ debarking operations	Annex V

#### 4. Port Reception Facilities at Mongla Port

Bangladesh, being a party to the MARPOL, needs to implement port reception facilities (Davis et al, 1990). Port reception facilities have not yet been installed according to MARPOL guideline at any of the maritime as well as inland ports of the country. The Chittagong port, the largest maritime port of the country, has established an Environmental Management Unit (EMU), which is not a complete facility for the waste collection, management and treatment of the ship generated wastes. However, it could not be started using of the same due to different limitations. Mongla being the second maritime port of the country is gradually gaining some market share as the port at Chittagong is already at its optimum level of operation. The gradual increase in the number of ships handling for the last ten years provides a clear picture of the raising importance of the port. Moreover, the port has managed to attract special kinds of cargo as it is trying to develop as an industrial port by establishing a number of privately owned LNG terminals within the port limit.

It is seen that the number of ships calling the port is increasing gradually and other than the bulk carriers specialized ships which are LNG and Roll on-roll off (RO-RO) are calling the port (MPA, 2020). The bulkers are also carrying specific cargo mostly clinker for the cement factories established at the port area. However, for receiving the wastes, like Chittagong Port, Mongla Port has established local mechanism by appointment of some vendors through licensing by the port authority. The vendors collect the wastes generated by the shipping operation with their own facilities. But this is not fully workable for a port like Mongla, the geographical location of which is extremely vulnerable. The port is situated around 130 km inside from the sea on a river named Passur which has crossed the largest mangrove forest of the world and this is a world heritage site as well. Therefore, any sort of maritime pollution is comparatively more environment costly at this port area.

#### 5. Estimation of the Quantity of Ship Generated Waste

To quantify the amount of waste, standard procedure (DNV, 1993) is there. However, access of the required data is quite difficult to obtain as none of the port here have maintained any such record of ship generated wastes. Therefore, the available data on the size, number and category of ships calling the port for the last three years have been taken into consideration to predict the ship calls in next three years based on the growth rate of each category of ships in last three years as shown in Table 2. It is pertinent to mention here that the highest available draft at the port channel is 8 meter; therefore vessels calling the ports on average are of size 15000 Deadweight Tonnage (DWT).

Table 2: Prediction of different numbers of ships calling in Mongla Port in different years (2019 to 2021)

Category	2019	2020	2021
LPG	260	286	314
Container	58	64	71
Car	40	44	48
Oil Tanker	20	22	24
G. Cargo	81	90	98
Bulk	459	505	555
	917	1009	1110

Source: Mongla Port Authority

In order to quantify the amount of waste that could be generated at the Mongla port area, the other required information is the number of days spent in the voyage as well as at the port area, which has been shown in Table 3. The average turnaround time at Mongla port is 5 (five) days. On the other hand the average voyage time has been estimated considering the originating port, the port from where most of the ships are calling at Mongla. From the consultation with the traffic department, it is understood that around 60% of the total vessels calls to the Chittagong port before calling at the Mongla port and other 20% vessels originate from Singapore. The rest of the vessel calls from different parts of the world, however, not very far from the Arabian Gulf or Far Eastern ports. Therefore, the vessels calling the port at Chittagong would obviously deliver their garbage there and bring a little for Mongla, whereas the rest would directly deliver the waste at Mongla. The average voyage day to Mongla from Chittagong is less than one day, whereas from Singapore it is 7 days and from Arabian Gulf it is around 14 days considering a speed of 10 nautical miles. The vessels calling to Chittagong before calling Mongla also mostly visit from the ports at Singapore, Far East as well as the Middle Eastern regions. Therefore, these ships are also spending an average time at sea of around 7 to 8 days and at the port of Chittagong on an average 10 days because most of them are bulk carriers and since the Chittagong port is facing severe congestion now in case of bulker it needs to wait more compared to container carriers.

Table 3: Calculation of Average Voyage Duration

Originating Port	Transit Port	Days at Sea	Days at Port	Total Days	Percentage of Ships
Singapore/ Far East/ Middle East	Chittagong	8	10 days at CP & 5 days at MP	23	60%
Singapore	No	10	5	15	20%
Other	No	14	5	19	20%

Average Voyage days = 13.70 (assuming 50% vessel will deliver wastes at CP) = 14 days

Average Stay at Port = 5 days

Therefore, an average day for each voyage could be considered as 14 days for the calculation of the total amount of waste generated at Mongla. The above information and data have been used to estimate the amount of waste generated and delivered by each ship calling at Mongla port and this is the most critical part of this study. As mentioned previously the best suggested procedure is to conduct a survey calling the port, but the scope of this study is not permitting such a lengthy process due to paucity of time. As a result, the average amount of different types of wastes generated by different types of ships calling at Mongla from the existing literature has been taken into consideration (DNV, 1993). Table 4 provides an average estimation of each category of waste that could be generated by ships calling at Mongla Port. Therefore, an average day for each voyage could be considered 14 days for the calculation of the total amount of waste generated by different ships calling at Mongla.

Table 4: Annual Amount of Ship Generated Waste

Garbage				
Domestic Waste				
Number of Ships (Nb)	Average duration of voyage and stay at the port (Tb)	Average daily domestic garbage generation rate (Qb) - (2 kg/person & day)	Average number of persons on board (Pb) -(person/vessel)	Total Quantity of Domestic Garbage
1110	14 days	2 kg	15 nos.	466200 kg
Maintenance Waste				
Number of Ships (N)	Average stay at the port (T)	Average quantity of maintenance solid wastes generated daily from a typical vessel (M) - (11 kg/vessel-day)		Quantity of Maintenance Waste Gm = NXTXM
1110	5 days	11 kg		61050 kg
Cargo Associate Waste				
Types of Ships	Cb=Quantity of break bulk cargo X waste generation factor (1/123) - kg/week	Cd=Quantity of dry bulk cargo X waste generation factor (1/10,000) - kg/week	Cc=Quantity of container cargo X waste generation factor (1/25000) - kg/week	Total Cargo Associated Waste Gc=Cb+Cd+Cc
Bulker -555 Container-70 General Cargo-98	44800 kg	4019 kg	57 kg	48875 kg
Total Garbage				576125 kg/ 576.00 ton
Oily Waste				
Number of Ship (Nb)	Average duration of voyage and stay at the port (Tb)	Oil Sludge (0.5 ton) & Waste Oil (0.08 ton)	Oily bilge (1.0 ton)	Total Oily Waste
1110	14 days	7770 ton & 1243 ton	15540 ton	24553 ton
Sewage				
Number of Ship (Nb)	Average duration of voyage and stay at the port (Tb)	Average daily Sewage generation rate (Sb) - (0.01 ton/person & day)	Average number of persons on board (Pb) -(person/vessel)	Quantity of Sewage = NbXTbXSbXPb
1110	14 days	0.01 ton	15 nos.	2331 ton
Amount of Possible Waste Annually (Garbage + Oily Waste + Sewage)				27,460 ton

Therefore, the estimated amount of wastes sourced from the shipping operation at the port of Mongla could be 27460 ton per year as seen in Table 4.

## 6. Vessel, Equipment and Facilities for Waste and Spilled Oil Management

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments throughout the years. The Convention includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations and currently, contains six technical Annexes as mentioned before in Table 1. Governments are required to ensure the provision of adequate reception facilities at ports and terminals for the reception of different types of ship generated wastes under MARPOL 73/78 Annex I, IV, V (Djadjev, 2015).

In view of the above, to facilitate the necessary services to incoming ships in connection with collection, store and treat different kinds of wastes generated in the ships, initiative is necessary to procure waste collection vessel by Mongla Port Authority. The procurement should also include other necessary vessels and equipment like self-propelled barge, dumb barge and service tug for collection of wastes from incoming ships and fork lifts, pick up van, dump truck, mobile crane, yard and workshop cleaning equipment, etc. Moreover, in order to facilitate emergency oil spill recovery in the port area and the vicinity two numbers of oil spill recovery vessels and other accessories including oil boom, skimmers, etc. needs to be procured. The procurement will result in the formation of a complete oil recovery fleet along with the existing one similar oil recovery vessel.

### 6.1 MARPOL waste collection vessel

The requirements of MARPOL Waste Collection Vessel (See Fig. 2) or MARPOL 73/78 to collect wastes from other ships includes Passenger, Cruiser Ships, Cargo Vessels and Oil/Chemical Tankers round the clock and time saving while waiting at anchorage, during bunkering or just for disposing of waste.

Features will be as follows:

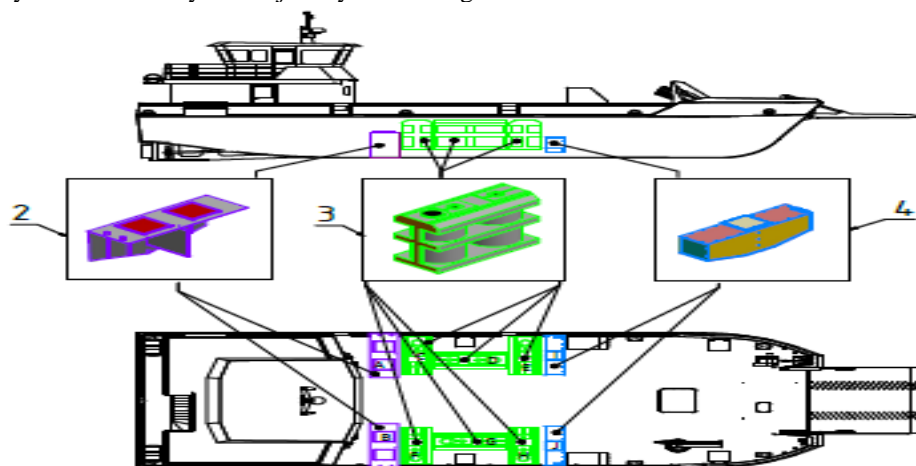
- MARPOL Waste Collection Vessel should be based on a robust structure.
- MARPOL Waste Collection Vessel should have suitable engine configuration.
- Hydraulic knuckle or any similar crane to assist in handling operations.
- Debris / Garbage reception and storage containers.
- Oily water reception (sludge, slop, bilge, sewage, dirty ballast water and oily waste liquid) facilities.
- Sewage Treatment Systems and Oily Water Separator Systems may be provided.
- Fire Fighting equipment and facilities.
- Accommodation with cabin for the crew, WC & Bathroom or a workshop can be provided.

#### *Oil Spill Response Skimming System*

The centerline OSR Skimming System should be a high-capacity advancing system that is effective in rivers and fast flowing waters. The system should be installed between the hulls of a catamaran and are designed for quick, easy and safe deployment. The system should allow the skimmer to be adapted to any channel width and installed on new or existing vessels.

#### *Garbage Compactor System*

The MARPOL vessel should have a Garbage Compactor system that can be loaded on the main deck of the vessel. The garbage compactor should be fitted with a stationary container, which is easy to handle for all vehicles. They should be ready to use just by connecting to an electrical outlet.



(1-Garbage Press, 2-Fuel tanks, 3-Oily waste/slop/bilge water & Black Water tanks and 4-Fresh Water tanks  
Fig. 2: Layout plan of a typical Waste Collection Vessel (Source: www.lamor.com)

## 6.2 Reception facility

An international standard Port Reception Facility (PRF) has also to be established at the Mongla Port to recycle oily bilge water, slop-oil waste, to treat the sewerage water streams and also to take care of solid waste coming from the incoming ships, according to MARPOL regulation (Env. Board, 2018). The design concept of the PRF should be ‘Treatment at Source’ method using Modular concept (EUROPEAID, 2009)]. The other vessels, equipment, machinery and items are of standard practice and as required by Mongla Port Authority.

Standard Requirement to ensure adequate port waste reception facilities;

- The port authority shall ensure the availability of waste reception facilities adequate to meet the needs of ships normally using the port without causing undue delay to ships.
- “adequate” means capable of receiving the types and quantities of prescribed wastes from ships normally using the port taking into account the operational needs of the users of the port, its size and geographical location, the types of ships calling there.
- the powers of the port authority to ensure the availability of adequate waste reception facilities may include power to join with any other person in providing them and references in these Regulations to the provision of such facilities by the port authority may be construed accordingly and any such power may also include power to arrange for the provision of such reception facilities by any other person.

Since the adoption of MARPOL, global environmental and societal awareness has grown and developed, this development has introduced new concepts on how to manage operations in an environmentally sensitive and responsible way. Many shipping companies and port authorities have implemented environmental management systems which ensure that their operations are conducted in an environmentally sound manner (Rashmi, 2005). Frequently, environmental objectives are set in order to facilitate the ongoing improvement, year on year, in terms of a company's environmental impact. Coupled with this is a growing desire to incorporate the principles of sustainability alongside that of corporate and social responsibility.

‘Keeping the seas and oceans’ clean should be seen as the overriding obligation for the use and provision of PRFs (IAOGP, 2015). MARPOL includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations. The basis for providing and using PRFs is incorporated in the Annexes of MARPOL and implementing laws and regulations of State Parties. The Port Reception Facility (PRF) shall be consisting of the following Units:

- Reception, Classification & Storage Unit
- Stop-Oil Treatment Unit
- Water Treatment Unit
- Solid Waste Treatment Unit
- Sewerage/Waste Water Treatment Unit

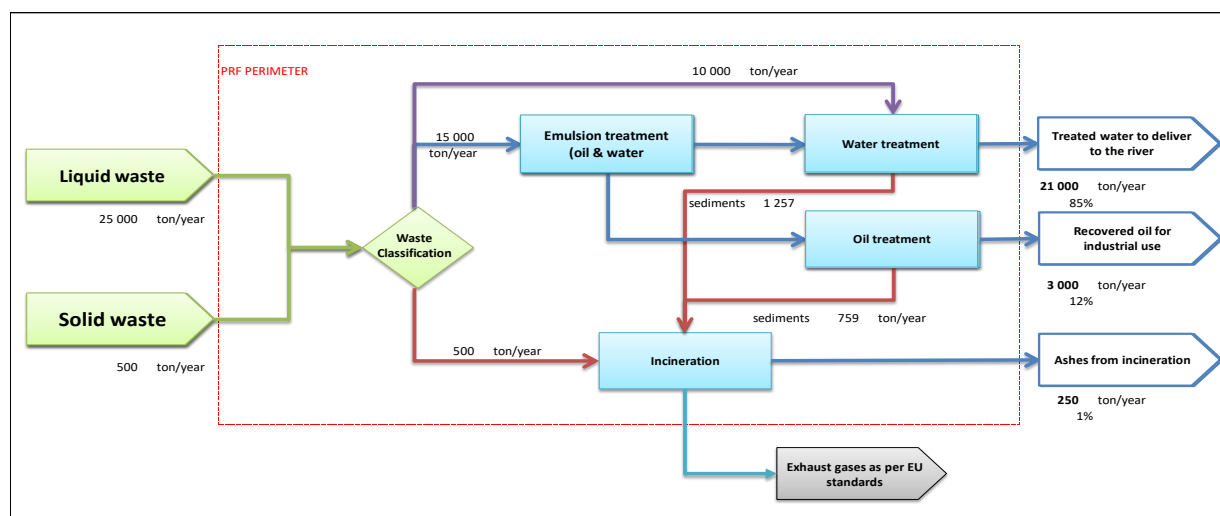


Fig. 3: Flow Chart of the treatment procedure in a standard Port Reception and Treatment Facility (Source: www.ngrp.com)



It is seen from the flow chart of treatment procedure as shown in Fig. 3 that the oily bilge water and other oily waste will be treated for producing industrial oil (15-20% of the original) and about 10% solid sludge (Ali et al, 2017). The waste oil will result in about 80% of the industrial fuel and about 10% sludge. Both the industrial and oil sludge can be sold out. The sewerage will be treated to remove sludge from wastewater and the solid sludge (6-8%) will be disposed of in landfill or in city corporation dump center. The sewerage will be treated to remove sludge from wastewater and the solid sludge (6-8%) can be used as fertilizer or disposed of in landfill. The compacted solid garbage (1/6 times) will be separated in different groups and will be sold or dump in a dumping center. However, among the solid wastes food and bio-waste need to be treated to avoid any biological risk.

There is possibility of electricity generation form solid wastes. However, this costs about US \$ 0.127 per kwhr. Moreover, less than 2.5 ton/day good quality municipal waste (4900 kcal/kg, containing mainly cooking wastes) is not feasible for electricity generation. Therefore, in terms of costs and quantity of garbage it is not feasible to install a power plant for generation of electricity from solid wastes in Mongla port.

### 6.3 Oil spill recovery vessel

Oil Spill Recovery ship is designed to support oil spill clean-up operations by oil recovery, boom deployment and/or dispersant application. The ship can be equipped with fixed installations and/or mobile equipment for the removal of oil from the sea surface and its retention on board, carriage and subsequent unloading. Boom deployment vessels install floating barriers (booms) to control spilled oil. They frequently feature reels for stowage of boom. Dispersant application vessels are fitted with pumps and distribution systems.

## 7. Financial and Economic Analysis

In case of a new procurement, financial and economic viability can be judged on the following parameters:

- Total estimated cost of the procurement
- Financing in terms of its capital structure, debt to equity ratio, etc.
- Projected cash flow and profitability

The financial and economic viability of should provide the following information:

- Full details of the assets to be financed and how to liquidate those assets
- Rate of conversion to cash-liquidity
- Funding potential and repayment terms
- Sensitivity in the repayments capability

Table 5: Estimated Procurement Cost of the Proposed Port Reception Facility and Other Vessel and Equipment

Sl.	Items	Qty	Unit Cost (US \$ in '000')	Total Cost (US \$ in '000')
1	Waste Collection Vessel	1	9,235.29	9,235.29
2	Port Reception facilities	1	11,270.59	11,270.59
3	Oil Recovery Vessel	2	2,920.59	5,841.18
4	Boom, Skimmers & other ancillary Equipment	1	1,764.71	1,764.71
5	Service tug boat	1	2,352.94	2,352.94
6	Dumb barge & Mooring Pontoon	3	333.33	1,000.00
7	Self-propelled barge	1	1,470.59	1,470.59
8	Dump Truck, Forklift, Pick up & Crane	4	160.29	641.18
9	Workshop & yard Cleaning equipment	2	345.41	690.82
10	Sub-station, Generator, LED, etc.	3	127.45	382.35
11	Jetty, shed, burn house, etc.	3	974.51	2,923.53
12	Miscellaneous, CD, Vat & Contingency	LS		14,073.88
13	Total			51,647.06

Every waste or oil spill management skim presents unique conditions with respect to location, site constraints, collection system, treatment procedure and necessary equipment considerations. Also, market conditions of the machinery and equipment price and other accessory price can greatly affect the costing. By considering both

historical costs as well as current cost estimating methods, an attempt has been made to account for the range of potential costs. However, no estimates can be considered final until complete environmental management plan, construction and installation plans and detail specifications of all the components have been prepared (IMO, 2019). At the planning stage, these unit costs, as well as complete procurement costs derived from them, evaluated appropriately are shown in Table 5. Thus these generalized costs are appropriate for comparison of alternative approaches for providing necessary services, but additional detail should be provided for site-specific construction estimates.

In view of the above, the procurement costs, annual operating costs, manpower costs, repair and maintenance costs of the selected service ships and reception facilities as in Table 5 have been furnished in Table 6. It is to be mentioned that operation costs have been estimated from the fuel, lubeoil and manpower costs and maintenance cost has been assumed as 1% of the procurement cost for each year.

Table 6: Estimated Annual Operation and Maintenance Costs

Sl No.	Item	Total Cost (US \$ in '000')
1	Procurement Cost	1,012.78
2	Annual Operation Cost	234.71
3	Annual Manpower Cost	487.32
4	Annual Repair & Maintenance Cost	1,734.81

It is to be mentioned that the proposition is rather different from the other investment project. The same might generate some direct income subject to the policy of the port but it would create several indirect benefits most significantly the money spent for environmental protection. 'Cost' is probably the greatest fear for the ports when considering the establishment of waste reception facilities. Two elements of costs have to be considered, the capital and the operational cost. Government involvement is essential to arrange initial funding in the form of grant or assistance from own source or under bilateral technical co-operation from foreign countries. For the recovery of operational cost two principles are followed, namely "polluter pays" and "shared costs" principles. The first one follows the recovery from polluters that is the ships, while the latter is usually based on government compensation. From a commercial point of view, the "shared costs" idea is not a true cost recovery rather it is a non-cost recovery system (Carpenter and McGill, 2001). For real cost recovery, the "polluter pays" idea is widely practised both nationally and internationally. But its application for port reception facilities will cause a portion of the cost to be ultimately borne by the society in the form of increased freight.

In order to carry out the above mentioned financial and economic analysis, the revenue as estimated from the existing data and prevailing market value (Port of Chennai, 2020) have been furnished in Table 7.

Table 7: Estimated Annual Earnings from and Maintenance Costs

Sl No.	Item	Revenue (US \$ in '000')
1	Earnings from the Alternative Use of Vessels and Shore Equipment	570.00
2	Earnings from the Wastes Quantities Collected from Incoming Ships	1,850.53
3	Earnings from the End Products of the Reception Facility	1,574.18
<b>4</b>	<b>Total Earnings</b>	<b>3,994.71</b>

For the purpose of charging the cost to ships three different systems are used, namely, Direct charge system, No-special fee system and Free of charge system. Among the three methods, the second method seems more practical and to implement this method a portion of the earning shown in Table 7 needs to ensure through increasing the port dues or other form of mechanism. Here the direct operating earnings of the equipment, which is the significant part, are being considered as the earning of the waste reception facilities and that have to be collected directly from the ships as per ton of wastes received (Carpenter and McGill, 2001) and the quantity of residue or end product after treatment in reception facilities. However, alternatively the necessary revenue and the expenses to operate the vessels and other facilities can indirectly be reimbursed increasing the general port

dues based on the total revenue as depicted in this report. Financial aspects of procurement of the vessels and reception facilities include examining the procurement costs, operation and maintenance costs of various types of components including probable output of the vessels and facilitating more revenue earning providing adequate and efficient services to incoming and outgoing ships to the port.

Economic feasibility assessment has been carried out to determine the positive economic benefits of the procurement of the waste collection and oil spill management vessels and other facilities to the organization that the proposed vessels, equipment and system will provide. It will also include quantification and identification of all the benefits expected. For this particular case, it is anticipated that procurement of the vessels would enhance the port revenue by 2.5% as it would facilitate the vessels to discharge with all the waste generated during shipping operation and facilitate them for sustainable shipping. It would encourage the owners to call the port even with a reduction in freight as this is associated with the green and sustainable image of the owner as well, which would enhance more shipping activities at the port area resulting more port dues. Moreover, the environment and ecology of the Sundarban area will remain safe and preserved, any deterioration of which is immeasurable. Both the financial and economic assessment typically involves a cost/ benefit analysis, determination of Net Present Value, Internal Rate of Return, etc. and the results of the analysis are presented in Table 8.

Table 8: Financial and Economic Indices

Sl No.	Name of Item	Financial	Economic
1	Benefit Cost Ratio	1.01	1.29
2	Net Present Value (US \$ in '000')	406.81	14745.10
3	Internal Rate of Return	12.11%	15.37%

The financial analysis reveals that the proposed procurement of waste and oil spill management ships and facilities will be a feasible concern for Mongla Port. The b/c ratios are also satisfactory and the proposition will have sufficient liquidity to pay the capital repayment. The break-even analysis shows sound position and survivability of the project in sensitive market situation for the same cases. The project is capable to afford a maximum financial cost of capital of 12.11% and economic cost of 15.37% as indicated by Internal Rate of Return (IRR). The project will be contributive to National Economy throughout the facilitation of smooth services of maritime transport throughout the country, especially, cheaper cost of services for export and import for south-western part of the country and will open door for regional cooperation in respect of providing connectivity to Nepal and Bhutan. In view of the above facts it is found that the proposition is technically sound, financially feasible and economically viable.

## 8. Conclusion and Recommendation

Bangladesh is a party of MARPOL convention; thus, port reception facility is mandatory for all ports of Bangladesh. Assessing the requirements of the procurement of waste collection vessel, oil spill recovery vessel and setting up the reception facilities including ancillary vessels and equipment at Mongla port, the overall framework and detail planning has been formulated in this study. The study includes review of the waste management aspect and planning in the maritime port, review of international and national guidelines and legislation, assessment of ship generated waste types and quantities to be handled by Mongla port, necessary vessels, equipment and facilities to be procured by MPA to handle ship generated wastes, and technical and economic viability of the procurement of the same. In view of the same following conclusions can be made;

- The financial and economic analysis reveals that the proposed procurement will be a feasible concern if the targeted income can be generated adequately.
- The IRR and B/C ratios are satisfactory and the proposed procurement will have sufficient liquidity to pay the capital repayment.
- The break-even analysis shows sound position and survivability of the proposed procurement in sensitive market situation for the same cases.
- The proposed procurement is capable to afford a maximum financial cost of capital of 12.11% and economic cost of capital of 15.37% as indicated by Internal Rate of Return (IRR).
- The proposed procurement will be contributive to National Economy throughout the facilitation of smooth services of maritime transport throughout the country, especially, environment friendly and cheaper cost of services for export and import for south-western part of the country and will open door for regional cooperation in respect of providing connectivity to Nepal and Bhutan.

- In view of the above facts it is found that the proposed procurement of waste and oil spill management facilities is technically sound, financially feasible and economically viable.

Following recommendations can also be made in view of the above study;

- To attract the users, port should take some initiative such as port will reward 'environment friendly ships' by reducing port dues, like 'green award' in port of Rotterdam.
- Recycling of garbage waste can be one best solution to process the waste. It also helps the port in earning by selling the products and will eliminate the possibility of further environment pollution after dumping it.
- IMO can share some portion of infrastructure and operational cost for the developing country. It will help not only Bangladesh also other developing countries, who cannot establish PRF due to cost involvement. On the other hand, because of this sharing the charges will be low and shipping company won't face any difficulty to pay this charges.

## Reference

- ADB (1991): Bangladesh: port and logistics efficiency improvement, section 2: summary and recommendation for Mongla port, Technical Assistance Consultant's Report, Project Number: 3946.
- Ali, M. A., Abu-Hassan, M. A., Ibrahim, R. R. K., Zaini, M. A. A., Karim, B. I. A., Hussein, A. S., Su, S. M., and Halim, M. A. I.M. (2017): Characterization of petroleum sludge from refinery industry biological waste water treatment unit, Preprints, Biomedical and Chemical Engineering. <https://doi.org/10.20944/preprints201708.0033.v1>
- Butt N (2007): The Impact of cruise ships generated waste on the home ports and ports of call: a case study of southampton, Marine Policy 31 (2007) 591-598. <https://doi.org/10.1016/j.marpol.2007.03.002>
- Carpenter, A. and McGill, S. (2001): Charging for port reception facilities in north sea ports: putting theory into practice, Marine Pollution Bulletin 42(4):257-66, [https://doi.org/10.1016/S0025-326X\(00\)00223-X](https://doi.org/10.1016/S0025-326X(00)00223-X)
- Davis, J. D., Knight, S. M., IMO Staff and Others (1990): Environmental considerations for port and harbor developments, World Bank Technical paper Number 126, Transport and Environment Series, The World Bank, Washington D.C., USA,
- Delft, C. E. (2017): The management of ship-generated waste on-board ships, EMSA/OP/02/2016, European Maritime Safety Agency.
- DNV (1993): Mottak av avfall fra skip (Reception of waste from ships). Technical Report commissioned by the Norwegian Maritime Directorate, Det Norske Veritas Industri Norge AS.
- Djadjev, I. (2015): Complying with MARPOL 73/78, Research Gate. <https://www.researchgate.net/publication/277708775>
- Environmental Board, Port of Tallinn, Estonia (2018): Ship-generated waste and cargo residues reception and handling plan, No. 8-2/18/10581-6, 2018
- IMO (1973 & 1978): International convention for the prevention of pollution from ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78).
- IMO (2014): Revision of the IMO comprehensive manual on port reception facilities-inadequacy of reception facilities, Marine Environment Protection Committee, 67th session Agenda item 11, MEPC 67/11.
- IMO (2019): Merchant Shipping (MARPOL Annex I - Prevention of pollution by oil) order, Statutory Document No. 2019/0239.
- International Association of Oil & Gas Producers (IAOGP) (2015): At-sea containment and recovery- Good practice guidelines for incident management and emergency response personnel, IOGP Report 522.
- MPA(2020): Mongla Port Authority (MPA) official website. <http://www.mpa.gov.bd/>
- Port of Chennai (2020): Port reception facilities as per MARPOL-charges for collection of wastes and garbage from ships, Port of Chennai, India.
- Rashmi, S. P. (2005): Environmental management plan for port and harbour projects- Article in Clean Technologies and Environmental Policy, <https://www.researchgate.net/publication/225963315>
- Svaetichin, I. and Inkinen, T. (2017): Port waste management in the baltic sea area: a four port study on the legal requirements, Processes and Collaboration, Sustainability 2017, 9, 699; <https://doi.org/10.3390/su9050699>
- The European Union's Fare Program (2019): Port reception facility study service, Contract No.: 2006-0505-020301 Identification No.: EUROPEAID/125614/D/SER/HR, Final Report.