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Research Article

Port waste reception facilities in iron-steel industry: A case study from Türkiye

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ABSTRACT

Maritime transport is one of the traditional alternatives for moving heavy loads around the world. Providing long ranges with high capacity and low costs are regarded to be the most important superficies of the marine transport. However, similar to the other transporting facilities some environmental impacts arise from shipping and port operations. Waste reception facilities are essential in order to minimize and manage the environmental impacts on marine ecosystems. This work aims to evaluate the practices at a waste reception plant serving for iron and steel industry. In the study, the maximum waste amounts were determined individually for all types of vessels handled at the port. The calculated quantities of ship sewage, solid waste, bilge, sludge, and waste oil were approximately 17483, 59, 616, 1715, and 123 m^3/month, respectively. The actual and calculated amounts of ship-sourced solid waste were found to be 607 and 708 m^3/year, respectively. The closer values indicate that the current disposal facility is sufficient for the management of solid wastes. On the other hand, a significant difference was found between the actual and calculated data for liquid waste. The present situation and ways to improve the overall efficiency of the plant were evaluated in detail within the study.

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INTRODUCTION

The development of industry has become inevitable to meet the needs of the rapidly growing world. Increasing manufacturing activity requires rapid and economical transportation of raw materials and products on a global scale [1]. This demand makes maritime transport attractive as it offers the advantage of once transporting large volumes at a low cost. [2]. Maritime transport is crucial to the global economy as more than 90% of all trade goods worldwide are transported by ship [3].

Despite the economic benefits of maritime transport, it causes some environmental problems similar to other transport activities. Air pollution sourced from ship traffics and marine pollution caused by the hazardous wastes released from the ships are among the main environmental problems related to maritime transport [4,5]. The quality of the aquatic ecosystem is significantly degraded by routine operations and accidents during maritime transport.

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Routine operations that cause marine pollution can be listed as the release of bilge water, dirty ballast, or warehouse/tank washing waters containing oily chemicals and also blasting and painting operations [6,7]. Accidents in maritime transport are another factor causing widespread environmental damage [8]. In the Exxon Valdez accident that occurred in 1989, millions of tons of oil were released into the sea due to physical factors such as wind, heat currents, and wind stress. The spilled oil has caused serious long-term environmental problems in a wide area [9–11]. It is observed that PAH and heavy metal contamination emitted from ports have carcinogenic and detrimental effects on living beings [12,13].

Since the environmental impacts caused by shipping are an international problem, international conventions are also needed for solution-oriented measures. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) [14], which was amended by a protocol in 1978, addresses introduce the importance of waste management onboard vessels and the reception of waste in ports.

Based on the requirements in MARPOL 73/78 [14], Directive 2000/59/EC [15] was adopted by the European Community in 2000 in order to regulate port reception facilities for ship-generated waste and cargo residues [15,16] MARPOL classifies pollutants from ships as follows:

- Oil and Petroleum Derivative Wastes (bilge wastes, dirty ballast water, sludge, waste oil, solid sludge wastes) (MARPOL Annex-I)
- Hazardous Liquid Substances Transported in Bulk (MARPOL Annex-II)
- Hazardous Substances Carried Packaged at Sea (MARPOL Annex-III)
- Wastewater (MARPOL Annex-IV)
- Garbage Waste (including cargo residues) (MARPOL Annex-V)
- Air Pollution from Ships (MARPOL Annex-VI)

The environmental impacts of shipping can be reduced by the ports by offering services such as the acceptance of ship-generated wastes and environmentally safe cleaning operations.

Since Türkiye, with its two straits, is a transshipment point for global maritime traffic, pollution from ships becomes more important for the country [15]. Therefore, Türkiye is a party to many conventions including MARPOL. In Türkiye, “Regulation on Waste Collection and Control of Wastes from Ships” was published in consideration of European Parliament Directive 2000/59/EC [15], which contains regulations on “Port Reception Facility for Wastes from Ships” [17]. Additionally, the term “waste reception plant” which defines the enterprises where ship-sourced waste is accepted and stored for a certain period was first used in the Regulation on Receiving Waste from Ships and Control of Wastes in 2010 [18].

The efficient operation of waste reception facilities ensures sustainable waste management in ports that are active participants in the maritime transport chain. In addition to the international agreements signed to reduce the risk of pollution in port areas, the concept of “green ports” is also developing to raise awareness and effectively manage social responsibility [19]. It is aimed to reach an integrated quality management system in port facilities employing a green port approach which is based on the volunteering principle. To this end, many ports serving different industrial organizations around the world have developed strategies within the framework of these approaches [20]. At this stage, the most important key factors are the geographical and physical conditions of the relevant port, as well as the characteristics of the sectors to be serviced such as raw material requirements and production potential.

Among the various heavy industry branches, the iron and steel sector exhibits a high potential, both in terms of the amount of raw material used and the production volume, and the supply of raw materials and shipment of products require international trade. In the iron and steel sector, which is highly dependent on foreign countries, especially in terms of raw material needs, there is a great demand for iron ore and coke coal (approximately 3.000.000 tons annually), more than 90% of which is supplied from abroad [21]. Therefore, maritime transportation stands out for this sector considering the competitive approach in the free market economy. For such facilities, more than 1000 ships come to the relevant port per year. Prevention and minimization of environmental risks can only be achieved by implementing waste management plans. In the iron and steel industry, which is highly dependent on, especially for raw materials, there is a large demand for iron ore and coking coal (about 3,000,000 tons annually), more than 90% of which is supplied from abroad

Waste reception plants in the ports exhibit various qualifications and capacities concerning the number, general properties and loading capacities of the served vessels. The major aim of this study was to analyze ship waste flows of a port serving for an iron and steel enterprise in the western Black Sea Region of Türkiye. In this way, the management of ship-originated waste and effective utilization of waste reception plants can be achieved.

MATERIALS AND METHODS

Features of the Studied Harbor

In the study, the waste management plan is created for a harbor serving iron and steel production companies. Features of the harbor dock are given in Table 1. In the port, there are 8 different docks (4 cargo, 2 evacuations, 1 Ro-Ro, and 1 train ferry dock) designed considering the properties of the served ships. The investigated harbor has the capacity to serve 2 ships simultaneously depending on the constraints of dock and load type.

Table 1. Features of the harbor docks

Dock	Dock length (m)	Dock depth (m)	Max. tonnage of the approached ship (DWT)
General cargo dock-1	295	14	40.000
General cargo dock-2	300	14	60.000
General cargo dock-3	170	6.5	3.000
General cargo dock-4	150	10	15.000
Evacuation dock-1	405	10.5	60.000
Evacuation dock-2	350	20	200.000
Train ferry dock	25-11.2	10	10.000
Ro-Ro dock	23	14	20.000

Depending on the requirement of the iron and steel company, anthracite coal, ore, Ferro Manganese, Ferro silica, Ferro silica manganese, scrap, imported plates, imported coils, cased glass, ingots zinc, manganese, metallurgical coke, pellets, petro coke, platform material, rolled sheet, siliceous sand slab, and sulfuric acid are brought to the port by ships and discharged. Materials such as pipe profile, steel pipe, slag, coke powder, sheet, roll sheet, bagged cement, bagged feldspar, bagged salt, tar and benzoyl are carried out by loading ships in the port.

The relevant port has no permission license for petroleum-carrying tankers. However, for the fuel purchases of the vessels served, fuel tankers come to the port and ship refueling is carried out from ship to ship.

Except for sulfuric acid evacuation, and loading of benzoyl and tar, any material that is defined as waste according to MARPOL Annex-II is not discharged or loaded. Therefore, vessels carrying any substance specified as waste according to MARPOL Annex-II are not accepted to the port.

Waste Management Practices in the Port

Integrated waste management is the selection and implementation of the appropriate method, technology and management programs including all substances and production resources that constitute the composition of the waste generated in the enterprise in which planning will be carried out. The main purpose of waste management in ports is to prevent sea pollution by controlling all kinds of wastes accumulated during loading/unloading operations and the arrival of the ship to the port and to ensure sustainable waste management in marine transportation. Ports may not obtain proper information about the ships that are granted exemptions as they have different agreements with waste contractors. The number of ships that are exempted from this obligation exhibit variation between countries [16]. So, it is obligatory to determine the properties and waste generation potentials of the ships being served in order to develop waste management plans for the ports.

In this study, integrated waste management planning for the related port facility has been realized in 2 main stages:

1. Calculation of waste types and amounts generated by the serviced ships
2. Determination of quality and capacity of the waste reception facility required for the management of the accepted wastes

Table 2. Types and properties of the wastes accepted to the waste reception facility.

Oily wastes (MARPOL73/78-An.I)	Cargo residue (MARPOL73/78-An.II)	Wastewater (MARPOL73/78-An.IV)	Garbage (MARPOL73/78-An IV)
Bilge water	Washing water containing harmful cargo residues	Wastewater	Plastics
Sludge	Ballast water containing harmful cargo residues		Food wastes
Used oil wastes			Domestic wastes
Tank cleaning water			Cooking oil
			Incinerator ash
			Operational waste
			Cargo residues
			Animal carcass(es)
			Fishing gear
			Paper
			Rags
			Glass
			Metal
			Bottles

This study was focused on ship-generated waste, a portion of the overall wastes generated in ports, cargo vessels, chemical tankers and ro-ro ships (no passenger). According to MARPOL 73/78 [14], it is possible to classify the wastes sourced from the ships that will be accepted to the waste reception facility as oily wastes, cargo wastes, wastewater and garbage (Table 2).

The amounts of daily accepted solid and liquid wastes were calculated by considering the average amount of waste received in the case of 2 approaching ships. The scheduling of the waste reception service is planned according to the the berthing periods.

Bulk cargoes coming to the ships are discharged to the stock areas. Since the cargo tanks are not washed in the port, the wastewater generated from the washing of cargo tanks is not included in the calculations.

After the loading of sulfuric acid, tar, and benzene, which are brought by the chemical tanker, the wastes are received in the transfer pump and hoses into IBC tanks. MARPOL Annex-II must be marked on IBC Tanks and the content should be returned to the process in case of waste formation. Since no material other than the cargo types handled at the port is received and no residual load has occurred so far, waste generation due to loading-unloading operations has not been calculated.

Parameters such as the period of the travel, the average fuel consumption of the ship, the number of employees, and the time spent in the port were considered while calculating the incoming ship-sourced waste types such as bilge water, sludge, waste oil, wastewater, and domestic solid wastes. By defining the type, it was intended to manage all kinds of accepted wastes in an environmentally friendly manner, quantity, and capacity of the required units and equipment.

Calculation of Generated Lıquıd and Solid Waste Amounts

Maximum waste generation amounts and vessel capacities were taken into consideration during calculating monthly waste generations. The formulas used in the calculations have been presented below:

$$BW = A * G * J \tag{1}$$

$$SLG = B * G * J \tag{2}$$

$$WO = C * G * J \tag{3}$$

$$WWSS = D * G * J \tag{4}$$

$$WWSD = E * G * (H + 1) * J \tag{5}$$

$$SW = F * G * (H + 1) * J \tag{6}$$

Where;

BW: Bilgewater (m^3/month), SLG: Sludge (m^3/month), WO: Waste oil (m^3/month), WWSD: Wastewater source-domestic (m^3/month), WWSS: Wastewater source-ship (m^3/month), SW: Solid waste (kg/month), A: Maximum bilge water generation per ship (m^3/day), B: Maximum sludge generation per ship (m^3/day), C: Maximum waste oil generation per ship (m^3/day), D: Maximum wastewater generation per ship (m^3/day), E: Wastewater generation per staff (0.15 m^3/person.day), F: Waste generation per staff (4.5 kg/person.day), G: Number of staff, H: Journey period (day), I: Maximum duration of stay in port (day), J: Number of ships served in the port (monthly)

Chemical tankers come to the port only for the purpose of transferring the tar produced at the iron and steel plant, and in the case of tar waste formation, these wastes are returned to the process. In the case of waste generation during the transportation of sulfuric acid, it is not acceptable to the port.

Chemical tankers are not cleaned in the port. Bilge water with an oil content of less than 15 ppm can be discharged to the sea. Therefore, half of the amount that may be occurred during the journey is included in the calculation of bilge water. Since there is no special protection measure for the wastewater originating from the ship, it can be discharged to the seas. The ships coming from a long distance (1794 nautical miles) can discharge half of it before entering the Mediterranean Sea. All in all, the quantities of general liquid and solid waste were calculated by (through) considering this information.

RESULTS AND DISCUSSION

It is necessary to calculate the amounts of ship-sourced wastes (bilge, sludge, waste oil, wastewater, and domestic solid wastes) in order to create a waste management plan for the port. For this reason, it is obligatory to determine the types, characteristics and amounts of the wastes which are generated during the journey and while berthing in the port.

Properties and Waste Generation Potentials of the Ships Served in the Port

Information about the types and properties of the ships which are served in the port are summarized in Table 3. As seen from the table, ships of varying sizes between 3,000 DWT and 170,000 DWT arrive at the port and these vessels remain in the port for 1-2 days depending on the amount of their load.

Table 3. The characteristics of the ships served in the port

Vessel type	Number of ships (monthly)	Max. Size	
		GRT	DWT
Cargo	36	50.000	80.000
Bulk cargo	18	100.000	170.000
Chemical tanker	1	15.000	25.000
Ro-Ro	2	6.000	5.500

Table 4. Parameters used to calculate the waste generation potential of ships using the port

Ship type served	GRT	Maximum waste generation calculations for ships (m³/day)					Number of staff	Journey period (day)	Max. duration of stay in port (day)	Max travel speed (Knots)	Cruising distance (nautical mile)	Average fuel consumption (ton/day)
		MARPOL Annex I		MARPOL Annex IV		MARPOL Annex V						
		Bilge water	Sludge	Used ship Oil	Wastewater	Solid waste						
Cargo	0-15.000	1.5	2.74	0.1	3	1	15	2	1	10.1	577	27.4
	> 15.000	2.0	6.85	0.2	25	3	20	5	2	12.1	1277	68.5
Bulk cargo	0-15.000	1.5	4.52	0.1	3	1	15	2	1	11.4	577	45.2
	>15.000	2.0	5.03	0.2	25	3	20	24	2	11.9	7194	50.3
Chemical tanker	>15.000	2.0	1.60	0.2	3	1	20	1	2	11.7	319	16
Ro-Ro	0-15.000	1.0	5.42	0.1	3	1	8	1	1	14.2	333	54.2

Marine traffic without control and management of ship-generated wastes is considered to be the major source of contamination in the Black Sea [22]. Operating waste reception plants with maximum disposal capacities will undoubtedly contribute to the prevention of marine pollution in the region.

The number of ships using the port is of great importance to calculate the amount of waste that may come to the facility. As seen in Table 3, mostly cargo-type ships with higher tonnages and waste generation potentials are being served in the port. In order to calculate the number of waste factors such as the average number of personnel on ships, the duration of the sea journey and the estimated fuel consumption rates of the ships should be known. The speed of the ship and travel distance are considered to be the most significant parameters affecting fuel consumption during the journey [23]. Sludge generation potentials of the ships have been calculated considering the fuel consumption values. The relevant data are presented in Table 4 for this study.

Monthly maximum waste amounts calculated for different types of ships served in the port are given in Table 5. Among the vessels served at the port, the highest waste generation is due to cargo and bulk cargo vessels. Approximately 20000 m^3 of liquid waste (bilge water, sludge, waste oil and wastewater from personnel and ships) and 59 m^3 of domestic solid waste are generated monthly. Although these calculations are made considering maximum waste formation, the existing waste reception facility is sufficient. In order to achieve gradual capacity increment in the reception plant, actual amounts of waste received from the ships are also discussed within the study.

The annual amounts of solid and liquid wastes taken from the port are given in Table 6. As seen from the table, food wastes constitute the major fraction of the solid waste composition with a 45% ratio. Managing ship-generated food waste is a complex subject affected by several factors. Odor, health and hygiene problems may occur due to the prolonged presence of untreated organic waste on board ships. Furthermore, storage or processing of organic waste on board is a challenging task as there is a lack of available space. Greenpeace organization estimated that approximately 6.4 million tons of garbage are discharged into oceans each year during ship voyages [24]. So, it is necessary to manage ship-sourced organic wastes with efficient cooperation between ships and waste reception plants [25]. Results of this study showed that a total of 606.69 m^3/year solid wastes (the sum of food wastes, plastics, papers and cargo residues) were accepted to the waste reception plant. This value indicates that 86% of the calculated solid waste amount has been disposed of in the port and it can be concluded that the present waste reception plant has a contributing role in preventing ship-sourced marine pollution.

The actual amounts of liquid waste delivered by the ships appear to be considerably lower than the calculated amounts. It is observed that a very little portion of the maximum waste generation potential has been released to the

Table 5. Monthly maximum waste amounts for different types of ships

	Cargo	Bulk Cargo	Chemical Tanker	Ro-Ro	Total
Bilge Water (m³)	180	432	2	2	616.00
Sludge (m³)	616.5	1086.48	1.6	10.84	1715.42
Waste Oil (m³)	36	86.4	0.2	0.2	122.80
Waste Water (Domestic) (m³)	756	1404	9	4.8	2173.8
Waste Water (Ship) (m³)	4500	10800	3	6	15309
Solid Wastes (kg)	22680	42420	270	144	65514 (~59 m³)

waste reception facility. This result may be explained by two probable reasons:

- Another port may service the vessels for acceptance of the wastes
  and/or
- The vessels may discharge their wastes into the open sea.

Grey water is generally discharged into the sea directly, whereas black water (sewage) requires proper treatment either onboard or onshore to respect strict MARPOL regulations [26]. The absence of stringent regulations about discharge to seawater complicates the tracking of ship-sourced wastes.

Evaluation of the Quality and Capacity of the Waste Reception Plant

There are different waste management strategies applied for solid (recyclable waste, garbage waste and hazardous waste) and liquid (bilge water, sludge, waste oil and wastewater) ship-sourced wastes accepted to the waste reception plant.

The steps of waste management practices applied for liquid wastes are presented in Figure 1. Transport vehicles and sewage trucks are used for the collection and transport of wastewater, oily waste, sludge, and bilge. A mobile wastewater tank is used for the transport of wastewater from the ships to the treatment plant. Sludge, bilge water and waste oil are stored in the tanks and containers after the dewatering process that is operated with hot steam (max. 800 °C) exposure and transported to the licensed disposal facilities together with ship-sourced solid wastes. Efficient separation of waste oil-water and performing an appropriate dewatering process increase treatment and recovery efficiencies in waste reception facilities [27]. The wastewater coming from the dewatering process is treated in chemical treatments plant belonging to the iron and steel company.

Table 6. Annual amounts of waste received at to waste reception plant

Marpol Ek –I			Marpol Ek-V							Marpol Ek-IV
Sludge m^3	**Bilge water m^3**	**Waste oil m^3**	**Plastics m^3**	**Food wastes m^3**	**Paper m^3**	**Cooking oil m^3**	**Incinerator ash m^3**	**Operational wastes m^3**	**Cargo residues m^3**	**Waste water m^3**
353.94	237.2	10.76	183.27	273.58	99.74	66.42	54.53	72.41	50.1	18

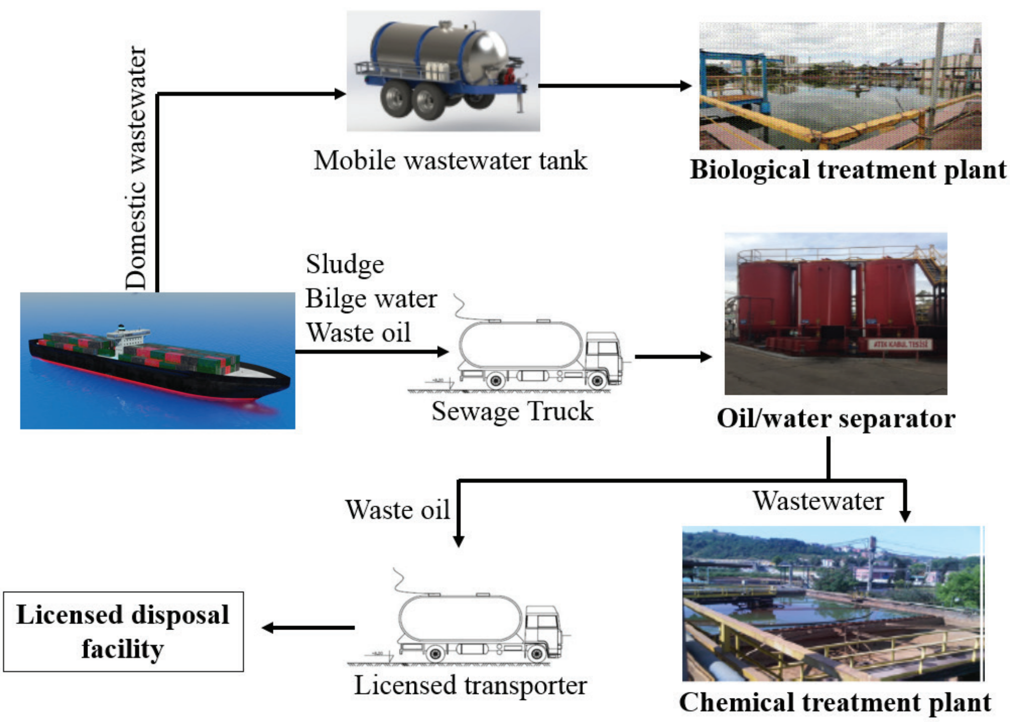

Figure 1. Management of liquid wastes in the studied waste reception plant.

Similarly, ship-sourced domestic wastewater is treated in the biological treatment plant of the company. Using microalgae can also be evaluated as a promising alternative for the treatment of ship-sourced domestic wastewater before discharge to marine ecosystems [28,29].

The process diagram for the management of solid wastes is presented in Figure 2. As seen in the scheme, the recyclable wastes are collected at the temporary storage site and sent to the licensed disposal facility. Domestic wastes such as cargo and food waste are disposed of in municipal storage facilities. Tar / benzoyl and scrap cargo residues are recycled in the iron and steel plant.

In order to achieve efficient waste management, ports and their nominated waste disposal contractors should ensure acceptance and beneficial utilization of recovered and recyclable wastes. Also, the usage of local facilities should be encouraged to prevent transport by land and additional environmental loading [30]. In recent years, investments have been made in waste reception facilities in many ports. However, the appropriateness and sufficiency of present plants have still carried uncertainties. In order to achieve successful management strategies factors such as the type of the served ships, the size and geographical location of the port should be taken into account in the design and operation of reception plants [16].

The concept and capacity of the waste reception plants are created considering maximum waste generation conditions. Calculated values for wastewater coming from the dewatering process and wastes that are transported to the disposal plant are presented in Table 7. During calculations process efficiencies of the dewatering process are accepted

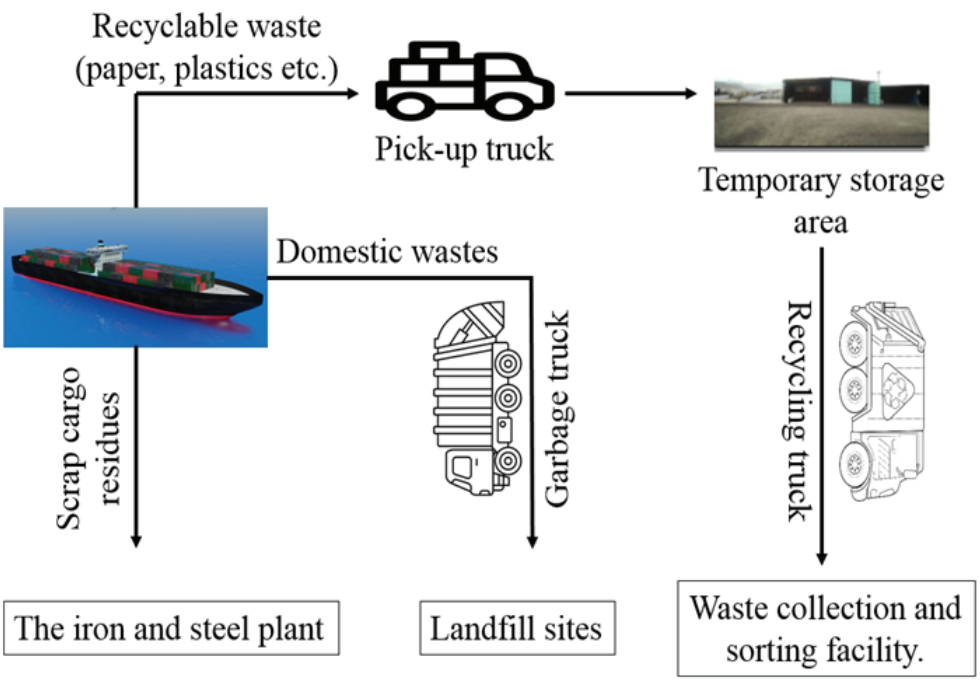

Figure 2. Management of solid wastes in the studied waste reception plant.

Table 7. Generation rates for ship-sourced wastes and utilized disposal methods

	Waste generation rate (m³/day)	Recycling and disposal of waste (m³/day)	The flow rate of chemically treated wastewater (m³/day)	The flow rate of biologically treated wastewater (m³/day)
Bilge water	20.53	2.05	18.48	-
Sludge	57.17	45.74	11.43	-
Waste oil	4.09	3.68	0.41	-
Wastewater	582.76	-	-	582.76
Solid waste	1.97	1.97	-	-
Total	666.52	53.44	30.32	582.76

Table 8. Units of the waste reception facility

Units of the Waste Reception Plant	Capacity	Quantity
Wastewater transport vehicle	10 m^3	2
Oil transport vehicle		
Sewage truck for sludge	10 m^3	2
Sewage truck for bilge		
Water		
Garbage truck	11 m^3	2
Wastewater tank	10 m^3	1
Sludge tank	50 m^3	2
Bilge water tank	50 m^3	2
Ship waste oil tank	50 m^3	1
Solid waste container	15 m^3	41
Chemical treatment unit	493 m^3/hour	1
Biological treatment unit	250 m^3/hour	1

to be 10%, 80% and 90% respectively for bilge wastewaters, sludge, and waste oil.

Performed calculations showed that the present conditions of the investigated waste reception plant exhibit enough capacity to accept all serviced vessels even if the case maximum waste generation. Investigated waste reception plant consists of the units given in Table 8.

When the waste management process in the port is evaluated holistically, it is seen that the capacity of the existing waste reception facility meets the need. In order to control and minimize the relevant pollution economically, all port authorities and waste reception facilities should work in a common and coordinated platform.

CONCLUSION

Ports are responsible for all ship-generated waste and cargo residue management procedures in accordance with Directive 2000/59/ EC. Sustainable port waste management can be achieved through an efficient operating waste reception facility. In this study, efficiency of a waste reception plant at a port serving iron and steel industry was evaluated in terms of quality and capacity.

The port examined in this study generally serves high-tonnage cargo and bulk cargo ships, chemical tankers, and Ro-Ro vessels. Calculations considering the maximum waste generation potential of all ships types served at the port indicates that bulk cargo vessel have the highest waste generation potential and totally 20000 m^3/month liquid waste and 59 m^3/month domestic solid waste should be managed at the port. There is a significant difference between the calculated maximum amounts of wastewater that can be generated on ships and the actual values obtained from the waste reception facility inventories. This difference can be explained by discharge into the open seas due to the lack of special protection measures.

Approximately, 607 m^3/year of solid waste was accepted to the waste reception plant while 45 % of the solid waste originating from ships was food waste. Disposal ratio of 86 % achieved for ship-generated solid wastes indicates the important role of waste reception plant by means of waste management. Currently, household solid waste is transferred from ships to licensed storage facilities. Separation and reuse of these wastes may provide economic raw material alternatives for various sectors.

In the investigated waste reception plant, the separated bilge, sludge, and used oil are transferred to licensed disposal facilities. It is considered that liquid waste with high oil content can be used as an alternative fuel in the iron and steel industry which has a high energy demand. These wastes can improve the calorific value of the main fuel source. Technical evaluations and examinations are recommended for the beneficial utilization of these oily wastes.

The overall results of the study concluded that the port waste reception facility consisting of waste transport vehicles, sewage trucks, mobile wastewater tank, oil separator, biological and chemical treatment plants has enough capacity to accept all the served vessels even in case of maximum waste generation. However, in order to control and minimize marine pollution all port authorities and waste reception facilities should work on a common and coordinated platform.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] Deniz C, Kilic A, Cıvkaroglu G. Estimation of shipping emissions in Candarli Gulf, Turkey. Environ Monit Assess 2010;171:219-228. [CrossRef]

[2] Stopka O, Kampf R. Determining the most suitable layout of space for the loading units' handling in the maritime port. Transport. 2018;33:280-290. [CrossRef]

[3] Abelando M, Bobinac M, Fiore JC. Assessment of the efficiency of controls to prevent biologic invasions at the San Lorenzo Port, Argentina. 2020. [CrossRef]
[4] Iduk U, Samson N. Effects and Solutions of Marine Pollution from Ships in Nigerian Waterways. Int J Sci Eng Res 2015;6:81-90.
[5] Florin N, Roman I, Cotorcea A. Air pollution from the maritime Transport in the Romanian Black Sea Coast. Cercet Mar 2017:260-266.
[6] Alam MW, Xiangmin X. Marine pollution prevention in Bangladesh: A way forward for ımplement comprehensive national legal framework. Thalassas Int J Maritime Sci 2019;35:17-27. [CrossRef]
[7] Küçük YK. The impact of ballast water management convention on combating invasive species in Turkey (Black Sea). World Marit Univ Diss 2019:1125.
[8] Tangahu BV, Titah HS, Purwanti IF, Arliyani I, Wardhani WK, Hidayat K, et al. Anticipation methods for management of ship oil spills on the sea. J Mater Cycles Waste Manag 2022;24:1718-1726. [CrossRef]
[9] Barron MG, Vivian DN, Heintz RA, Yim UH. Long-term ecological impacts from oil spills: Comparison of exxon valdez, hebei spirit, and deepwater horizon. Environ Sci Technol 2020;54:6456-6467. [CrossRef]
[10] Peterson CH, Rice SD, Short JW, Esler D, Bodkin JL, Ballachey BE, et al. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 2003;302:2082-2086. [CrossRef]
[11] Hassanzadeh S, Hajrasouliha O, Rezaei Latifi A, Nohegar A. The Impact of Physical Processes on Oil Pollution Diffusion in the Persian Gulf. Environ Forensics. 2013;14:312-323. [CrossRef]
[12] Donateo A, Gregoris E, Gambaro A, Merico E, Giua R, Nocioni A, et al. Contribution of harbour activities and ship traffic to PM2.5, particle number concentrations and PAHs in a port city of the Mediterranean Sea (Italy). Environ Sci Pollut Res 2014;21:9415-9429. [CrossRef]
[13] Xie S, Jiang W, Sun Y, Yu K, Feng C, Han Y, et al. Interannual variation and sources identification of heavy metals in seawater near shipping lanes: Evidence from a coral record from the northern South China Sea. Sci Total Environ. 2023;854:158755. [CrossRef]
[14] International Maritime Organization (IMO). International Convention for the Prevention of Pollution from Ships (MARPOL), 1978.
[15] European Parliament and Council. Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, 2000.
[16] Wilewska-Bien M, Anderberg S. Reception of sewage in the Baltic Sea - The port's role in the sustainable management of ship wastes. Mar Policy. 2018;93:207-213. [CrossRef]
[17] Republic of Turkey. Regulation on waste collection and control of wastes from ships, 2004.
[18] Dashan ES, Apaydin O. An investigation on waste amount from ships in Istanbul. Glob Nest J 2013;15:49-56. [CrossRef]
[19] Hua C, Chen J, Wan Z, Xu L, Bai Y, Zheng T, et al. Evaluation and governance of green development practice of port: A sea port case of China. J Clean Prod 2020;249:119434. [CrossRef]
[20] Suykens F, Van De Voorde E. A quarter a century of port management in Europe: objectives and tools. Marit Policy Manag 1998;25:251-261. [CrossRef]
[21] Aksoy C. Iron-steel factory harbours and sustainable waste management [Master Thesis]. Kocaeli: Kocaeli University; 2019. [Turkish]
[22] Ulniković VP, Vukić M, Jančić-Heinemann R, Antonović D. Ship waste quantities prediction model for the port of Belgrade. Chem Ind Chem Eng Q 2011;17:239-248. [CrossRef]
[23] Bialystocki N, Konovessis D. On the estimation of ship's fuel consumption and speed curve: A statistical approach. J Ocean Eng Sci 2016;1:157-166. [CrossRef]
[24] To NT, Kato T. Solid waste generated from ships: a case study on ship-waste composition and garbage delivery attitudes at Haiphong ports, Vietnam. J Mater Cycles Waste Manag 2017;19:988. [CrossRef]
[25] Vaneeckhaute C, Darveau O. Current state and potential valorisation of ship-generated organic waste in Quebec, Canada. Waste Manag 2020;118:62-67. [CrossRef]
[26] Vaneeckhaute C, Fazli A. Management of ship-generated food waste and sewage on the Baltic Sea: A review. Waste Manag 2020;102:12-20. [CrossRef]
[27] Özdoğan N, Albahnasawi AM, Ağır H, Arslan S, Gunaydin O, Gürbulak E, et al. Demulsifying of waste oils in a port reception facility by ultrasound with a new coagulant: techno-economic evaluation. Energy Sources, Part A Recover Util Environ Eff 2021:1-15. [CrossRef]
[28] Singh V, Mishra V. Enhanced biomass production and nutrient removal efficiency from urban wastewater by chlorella pyrenoidosa in batch bioreactor system: Optimization and model simulation. Desalin Water Treat 2020;197:52-66. [CrossRef]
[29] Singh V, Mishra V. Evaluation of the effects of input variables on the growth of two microalgae classes during wastewater treatment. Water Res 2022;213:118165. [CrossRef]
[30] Butt N. The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton. Mar Policy. 2007;31:591-598. [CrossRef]