Evaluation of waste management activities within the scope of sustainable environmental management at Tatvan Van Lake Ferry directorate Turkiye

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Abstract

With the development of technology in the 21st Century, changes have also occurred in the transportation sector. In recent years, transportation by ships at full capacity has increased the volume of maritime trade, causing unavoidable pollution in the seas. Today, maritime transportation is safe and encompasses various services and activities. Pollution caused by marine vessels is a significant concern for all over the world. In addition to this fuel costs were high because maritime transportation relied on simple, low-capacity vessels. The new vehicles used today pose a problem due to their low capacity. This article aims to identify the types and amounts of waste from new ships at the Tatvan Van Lake Ferry Pier and to develop strategies for transporting this waste to land within the framework of sustainable environmental management. The study suggests building a waste reception facility in the city to manage the waste generated by maritime activities.

Keywords: environmental management, waste management, lake Van, Bitlis, maritime transportation.

Avaliação das atividades de gestão de resíduos no âmbito da gestão ambiental sustentável na diretoria Tatvan Van Lake Ferry, Turquia

Resumo

Com o desenvolvimento da tecnologia no Século 21, mudanças também ocorreram no setor de transportes. Nos últimos anos, o transporte por navios em plena capacidade aumentou o volume do comércio marítimo, causando poluição inevitável nos mares. Hoje, o transporte marítimo é seguro e engloba diversos serviços e atividades. A poluição causada por embarcações marítimas é uma preocupação significativa em todo o mundo. Além disso, os custos de combustível eram elevados porque o transporte marítimo dependia de embarcações simples e de baixa capacidade. Os novos veículos utilizados hoje representam um problema devido à sua baixa capacidade. Este artigo tem como objetivo identificar os tipos e quantidades de resíduos provenientes de novos navios no cais de *Ferry Tatvan Van Lake* e desenvolver estratégias para transportar esses resíduos para terra no âmbito da gestão ambiental sustentável. O estudo sugere a construção de um centro de recepção de resíduos na cidade para gerir os resíduos gerados pelas atividades marítimas.

Palavras-chave: gestão ambiental, gestão de resíduos, lago Van, Bitlis, transporte marítimo.

1. Introduction

The concept of sustainability; In the Our Common Future report published by the United Nations in 1983, it was

defined as leaving a world with sustainable economic, ecological, and social conditions to future generations (Thia-eng, 1999; Gedik, 2020; Zhang et al., 2021; Arslan et al., 2022). The Sustainable Development Goals were adopted by the United Nations in 2015 as a universal call to action to end poverty, address climate change, and ensure that all people enjoy peace and prosperity by 2030. The United Nations aims to solve the main problems faced by people in the world by determining 17 interconnected main targets and 232 indicators to achieve sustainable development goals, including Turkiye.

Turkiye continues to work to achieve these goals by 2030 (Global Goals,2023). Life Below Water, the 14th Goal of the United Nations Sustainable Development Goals; He talks about the importance of the seas as follows: Seas provide us with access to main natural resources, especially food, medicine, biofuel, and other products. It ensures that waste and pollution are cleared by nature and acts as a buffer against the severity of storms. Protecting the health of the seas means reducing the effects of climate change and facilitating adaptation (Global Goals, 2015).

The development of technology and population growth have also caused changes in the transportation sector. Sea transportation has become preferred especially in recent years (Darbra et al., 2015; Dursun, 2018). As the volume of maritime trade in the world increases, marine pollution caused by ships also increases. In recent years, solutions have been sought to prevent pollution through both international regulations and local practices. Precautions are taken to determine waste types and effective solutions are tried to be produced for possible new pollution sources (Keskin, 2016).

Transportation in Turkey is carried out mainly through highways. Our country, which is surrounded by sea on three sides, is trying to catch up with other countries in maritime transportation. Geopolitically, Turkiye is in an important position at the crossroads of Europe and Asia. This crossing point is also at the center of important waterways. However, despite this, our country has not yet been able to use this locational advantage in terms of sea routes. Long-haul ships generally do not use our ports. Although our country is a transit center, this advantage has not been utilized sufficiently until today (Bulut, 2007).

Tatvan, international transportation and transit transportation in the region where maritime transportation is carried out in a narrow basin, has also led to the development of Tatvan Port. Ships built and operating in the 1970s have carried out maritime transportation in the region for many years. With changing needs, international transportation has gained importance and many loads have begun to be transported. Considering the socio-economic structure of the region, the aid coal provided to the citizens by the public is transported to the region via railway and transferred from Tatvan to Van by sea transportation (Yılmaz; Günay, 2021).

Old marine vessels were simpler and had a narrower capacity, their power capacity was low, and their fuel costs were quite high. Again, the resulting wastes posed a problem because the tank volume capacities of the ships were low. In this article, the types and amounts of waste from new ships at the Tatvan Van Lake Ferry Pier were determined, and a study was conducted to determine environment-friendly land transfer and disposal alternatives.

2. Theme review

2.1 Seas pollution and pollution from ships in terms of environmental management

Since the second half of the 20th century, large-scale maritime accidents have resulted in catastrophic environmental pollution, some of which are irreversible. The Torrey Canyon (1967), Amoco Cadiz (1976), Exxon Valdez (1989), Sea Empress (1996), Erika (1999), Prestige (2002), and Tasman Spirit (2003) accidents are examples of catastrophic maritime accidents. The loss of life, property, and ecological balance caused by sea pollution necessitates a series of measures (Aşan, 2022). Marine pollution, in its simplest definition, refers to the deterioration of water quality, obstruction of activities such as fishing, threats to human and environmental health, and harmful environmental effects caused by the direct or indirect release of matter and energy from various activities into the marine ecosystem (Efe et al., 2022).

Pollutant sources that cause marine pollution can be categorized into three main groups: land-based sources, pollution caused by ships, and other sources (Tuçev, 2020). Marine pollution has been a significant environmental issue for many years in our country, which is surrounded by seas on three sides. The main factor causing this pollution is the discharge from ships. Ship bilge water, ballast water, and solid waste from ships cause serious environmental pollution when released into the marine environment.

A factor is defined as pollution if it negatively affects the marine ecosystem. To define any factor as pollution, it must negatively affect the marine ecosystem (Özdemir, 2012). Marine pollution is primarily caused by two

components: terrestrial pollutants with high pollution potential and ships. Ship-related marine pollution occurs as either accidental pollution or routine pollution (Peng et al., 2020). Routine pollution occurs when ships violate international rules and discharge wastewater, such as bilge, ballast, and domestic wastewater, into the sea. Accidental pollution is the pollution that occurs as a result of accidents of tankers and ships carrying hazardous wastes (Küçük; Topçu, 2012). Shipping is a cyclical industry that responds to global supply and demand. The cruise ship market has shown rapid growth in recent years. The world's merchant fleet consists of 46,222 ships. Although cruise ships represent less than 1% of this fleet, they are responsible for 25% of the waste produced by commercial ships (Alpay, 2015).

The number of passengers increased from 3.7 million in 1990 to 27.2 million in 2018, with an annual growth rate of around 7.1% (Snasches et al, 2020). The aim is to reduce and recycle garbage from ships and domestic solid waste from the port by the zero-waste approach proposed by the Turkish Ministry of Environment and Urbanization (MoEU). The main types of garbage from ships and solid waste from operations include paper/cardboard, composite wastes, plastic waste, glass waste, packaging materials, vegetable waste oils, and waste batteries (Zero Waste, 2020). Research indicates that plastics are the most common type of waste. Since different types of plastic cannot be disposed of in the same way, their use should be minimized, particularly single-use plastics, within the scope of zero waste planning (Green University, 2020).

2.2 National and international conventions on marine pollution

Environmental and social impacts as a result of decreasing resources as a result of increasing temperatures in the last century have revealed the need to take many sustainable measures for waste from ships. (Tuğdemir et al., 2016). Table 1 shows the International Maritime Organization (IMO) conventions to which Turkey is included.

The diversity of legislation on the subject makes the management of ship waste quite complex. Within the scope of the study to be carried out, the types and amounts of wastes generated as a result of the shipping activities carried out here will be determined through the examination to be carried out at the Van Lake Ferry Directorate, the regulations and locations of these wastes will be determined, the wastes will be grouped, the disposal methods of these wastes will be determined, and the waste management of the port will be revealed.

Table 1. International maritime organization (IMO) conventions on the environment.

Contact Name	Explanation
MARPOL 73/78	International convention for the prevention of pollution of the seas by ships
CLC 92	Legal liability arising from oil pollution damages
IOPC-FUND 92	Convention establishing an international compensation fund for oil pollution damage
LDC-1972	Agreement to prevent marine pollution by waste
OPRC-990	Convention on cooperation and combating pollution from oil
OILPOL-1954	Convention to prevent pollution of the seas by oil
Barselona Covention	Mediterranean Region pollution protection convention
Bükreş Convention	Convention on the protection of the Black Sea Region against pollution

Source: Authors, 2024.

3. Materials and Methods

In this research, fieldwork was conducted at the Van Lake Ferry Pier to detect ship-generated waste, considering environmental sustainability principles. The study aimed to identify deficiencies in the environmental management practices of ship waste in Türkiye and to reveal factors affecting these practices. Environmental management practices are essential for ensuring environmental sustainability and creating environmental awareness. As part of the field study, samples were taken from domestic wastewater and bilge water released by the activities of the Sultan Alparslan which is one of two equivalent ferries operated in Van Lake. These samples, accumulated in the ships' waste depots, were analyzed. Sampling and analyses were conducted by accredited environmental analysis companies. Based on the analysis results, the wastes were characterized, and disposal solution alternatives were evaluated.

3.1 Measured Parameters and Analysis Methods

Within the scope of the study, the parameters analyzed, and analysis methods used in domestic wastewater released as a result of the activities of the ship are given in (Table 2), and the parameters and analysis methods measured for bilge water are given in (Table 3 and 4).

Table 2. Analyzed parameters and analysis methods for wastewater from domestic use.

Parameter	Method
Biological Oxygen Need	SM5210 D
Chemical Oxygen Requirement	TS 2789
Suspended Solids (SS)	TS EN 872
pH	TS ISO 10523

Source: Authors, 2024.

Table 3. Metals and analysis methods analyzed for bilge water.

Parameter	Method
Arsenic(As)	
Cadmium (Cd)	
Crom (Cr)	EPA 6020 B
Lead (Pb)	

Source: Authors, 2024.

Table 4. Other analyzed parameters and analysis methods for bilge water.

Parameter	Method
Chloride (Cl^-)	EPA 5050 /SM 4110 B
Total halogens	-
Polychlorinated biphenyls (PCB)	En 12766 2000-33
Polychlorinated biphenyls (PCB)	ASTM D 92

Source: Authors, 2024.

3.3 Characteristics of the existing ships at the ferry pier and the amount of waste from the ships

Two locally made train-ferry ships serve in the port examined within the scope of the study. Both ships have the same project and have equivalent features. The characteristics of the ships are given in (Table 5). The ships' fuel

is supplied from two 500-ton diesel tanks in the port. There is an underground line leading from the tanks to the ships, and the ships are filled with fuel through this line. The view of the fuel tanks used in the port is given in. When the ships operate at full capacity, it is planned to make an average of 2 voyages per week and 8 voyages per month. The waste tanks available on ships are designed to last 6 months if the ship operates at full capacity. The waste generated during the ship's voyages as planned is discharged every 6 months when the ship docks at the port. However, since the ships have not yet been operated at full capacity and new operations have begun, the tanks have not yet been filled during the thesis study.

Table 5. General Features of Sultan Alparslan and İdris-i Bitlis-i Ships.

General features	Ship Size	6900 Groston (GRT)
	Main machine power	6400 kW
	Type of fuel used	Motorin
	Personal number	18
Waste tank capacity of the ship	Synsite tank volume	19,92 m^3
	Waste Tank Volume	88,6 m^3
	Waste oil tank volume	8,37 m^3

Source: Authors, 2024.

The ship's fuel is supplied from two 500-ton diesel tanks located in the port. There is an underground line leading from the tanks to the ships, and the ships are filled with fuel through this line. The view of the fuel tanks used in the port is shown in (Figure 1).

Figure 1. Fuel tanks are located at the port. Source: Authors, 2024.

3.4 Ship waste management and Tatvan Van lake ferry example

There are 4 types of tanks to collect waste generated on ships. These; is a wastewater, saline, oil, and sludge tanks. Mineral oils used for lubrication in ships' engines are called waste oil after use. There is a constant oil consumption (in the form of loss/leakage) due to the operation of the ship. After the waste oils from the ship pass through the separator on the ship, sediment, and mud remain at the bottom of the separator. This waste is described as sludge and is stored in the sludge tank on the ship.

It is used in the same way as the diesel used for ships, by passing it through a separator. After the ships dock, the contents of the waste oil tank are emptied into the bilge tank on land. Leakage from the ship's machinery and auxiliary machinery subtanks, which may contain oil, is called bilge and is stored in the bilge tank available on

the ship. Since there is no waste reception facility in the facility, both waste oils and bilge are pumped into the bilge tank in the port. That's why bilge and waste oils mix. After waiting in the bilge tank, phase separation occurs and the oil phase at the bottom is filled into barrels and given free of charge to companies that have a disposal license from the Ministry of Environment and Urbanization for the recycling/disposal of waste oils (Yılmaz et al., 2009).

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3.5 Annual amounts of waste generated on ships and characterization of sewage

To characterize the wastewater originating from ships, samples were taken and analyzed from the wastewater accumulated in the ship's sewage tank on 29.09.2020. The analysis results of domestic wastewater and comparison with the limit values given in the Turkish Water Pollution Control Regulation (SKKY) are given in (Table 6).

When the analysis results of the sample taken are examined, it is seen that the pollution level in the raw wastewater is low and does not require any treatment. However, the ships are not yet operating at full capacity. The planned number of passengers on the ship's voyages could not be reached. The infirmary and canteen that should serve on the ship are not yet operational. In this context, the characterization needs to be repeated as soon as the ship reaches full capacity for passenger transportation. However, treating the sewage collected on ships through a package treatment unit to be established in the port after the voyage seems to be the most appropriate solution to the issue. Although there is already a package treatment unit in the port structure, this unit was placed and put into operation in the port in 2012, not for the treatment of sewage originating from ships, but for the treatment of wastewater resulting from administrative buildings, lodgings, and workshop activities in the port.

The incoming wastewater is first passed through a coarse screen before entering the package treatment unit. Here, the water separated from coarse solids (< 20 mm) is taken into a 100 m3 preliminary sedimentation tank. Solids that can settle in the sedimentation tank are separated from the wastewater and settle at the bottom of the tank. Thus, damage to the pump and diffuser systems in the system is prevented. The mud accumulated on the pool bottom is removed with a sewer truck approximately once every 4 months. In this process, wastewater is taken into a 100 m^3 balancing tank. Here, the homogenized wastewater is fed to the 100 m^3 Arsimak brand package treatment system with the help of a pump. Package purification works with the logic of a sequential batch reactor (SBR). In the system; The aeration, settling, and discharge phases are carried out sequentially in additional compartments. The resulting sludge is mineralized over time and kept at a minimum level in the biomass system (Arsimak, 2020).

Table 6. Analysis results of the sample taken from the wastewater tank.

Parameters	Unit	Analysis result	SKKY Composite Sample 24 hours
Suspended Solids		28	45
Biochemical Oxygen Need	mg/L	33.2	45
Chemical Oxygen Requirement	mg/L	73.7	120
pH	-	7.08	6-9

Source: Authors, 2024.

Within the scope of the study, a 24-hour composite sample was taken from the treatment discharge (between 28-29.09.2020) to determine the treatment efficiency of the package treatment. The analysis results obtained, and the results of the previous analysis conducted on 06.06.2017 are given in (Table 7). When the analysis results are examined, it becomes clear that there has been a significant decrease in the treatment efficiency of the facility in terms of COD and BOD compared to 2017. This situation is believed to be due to inadequate maintenance of the facility and insufficient organic load in the incoming water.

Therefore, regular maintenance of the facility is essential. Currently, the amount of wastewater arriving at the facility is low. It is believed that the package treatment system will work more efficiently by processing the wastewater from ships at the end of their voyages. The current capacity of the package treatment unit is 100 m^3/day, and it seems feasible to purify the expected 1.3 m^3 of wastewater per voyage (250 m^3/year for 192 trips/year) in this system. This will ensure that sewage is disposed of by the provisions of MARPOL 73/78 Currently, there is no oil separator in the system, so one needs to be added.

Table 7. Domestic Wastewater Treatment plant effluent analysis table.

Parameters	Unit	Analysis result (2017)	Analysis result (2020)	SKKY Composite Sample 24 hours
AKM		11	36.40	45
BOİ	mg/L	13.13	60	45
KOİ		60	112.78	120
pH	-	8.10	7.70	9-9

Source: Authors, 2024.

3.6 Characterization of bilge water and waste oils from ships

Bilge water and waste oils in the facility are currently taken into the same tank. In this context, a sample was taken from this tank on 08.09.2020 and analyzed. Analysis results of the sample taken, its comparison with the previous analysis conducted in 2017, and the comparison of the results with the limit values of the Waste Oil Control Regulation (AYKY) are given in (Table 8).

When the existing waste oil categories in the AYKY regulation are examined;

1st Category Waste Oil: Pollutants such as PCBs, total halogens, and heavy metals in the waste oils in this category remain below the limit values given for the 1st category in (Table 8). Waste oils in this category can be recycled through regeneration and refining. These oils also can be used for energy recovery.

2nd Category Waste Oil: Waste oils in this category are suitable for energy recovery in facilities licensed by the MoEU. However, it is possible to recover industrial waste oils whose chloride, total halogen, and PCB parameters do not exceeded the limits for regeneration and refining.

3rd Category Waste Oil: Heavy metals in the waste oils in this category are above the limit values given in Table 8. Chloride and total halogens are above 2000 ppm, and PCB is above 50 ppm. These are waste oils whose regeneration and refining are not suitable, whose use as fuel poses a risk to human and environmental health, and

which must be treated harmlessly by incinerating in licensed waste incineration facilities.

When the analysis results are examined, it is understood that the sample taken in 2017 has the character of category 1 waste oil. The sample taken in 2020 is a category 2 waste oil in terms of the Cl parameter. Additionally, the flash point has decreased, and the incineration characteristic has become more difficult. It is thought that this situation is due to the increase in the water content of the waste. As a result, the application of mixing bilge and waste oil spoils the waste character and makes disposal more difficult. Since the water content of bilge water waste varies, it deteriorates the character of the waste. This situation also makes the disposal of waste difficult. For this reason, it is recommended not to mix these wastes in the new facility.

Table 8. Waste oil control regulation (AYKY).

Parameter	Unit	Analysis Result (2017)	Analysis Result (2020)	AYKY Limit Values Categories		
				1st	2nd	3rd
As	ppm	<1.25	<2	<5	5	>5
Cd		<1.25	<0.5	<2	2	>2
Cl		90.77	348	200	2000	>2000
Cr		<6.25	3.4	<10	10	>10
Pb		<6.25	2.53	<100	100	<100
PCB		<1	<0.1	10	50	>50
Flash Point	T ^{0}C	>70	202	min 38	min 38	

Source: Authors, 2024.

3.7 Garbage from ships and domestic solid waste from the port

It aims to reduce and recycle garbage from ships and domestic solid waste from the port by the zero-waste approach put forward by the MoEU. Among the garbage from ships and solid waste from operations, the main ones are; paper/cardboard and composite wastes, plastics, glasses, packaging materials, waste vegetable oils, and waste batteries. Wood waste, which is within the scope of zero waste, is not found among ship garbage and operational waste. Within the scope of zero-waste in the enterprise and on the ship, the necessary boxes for separate collection of waste must be placed as soon as possible.

4. Results and Discussion

Pollution from shipping is a significant threat to Lake Van. Because of Lake Van is a closed basin it is especially sensitive to such pollution. Preventing pollution from transportation activities on the lake is crucial to protecting this ecosystem. This study examined the wastes generated by the Sultan Alparslan Ship and Idris-i Bitlis-i ships operating in the Tatvan Van Lake Ferry Enterprise, as well as alternatives for their disposal. Both national and international legislation mandate the construction of a Waste Reception Facility at the port where ships dock. According to the 'Regulation on Waste Removal from Ships and Control of Waste, a facility must be built with separate units for storing bilge water, domestic wastewater, sludge, waste oil, and garbage, and also include wastewater treatment units. Sewage, sludge, and waste oil must be collected, treated separately, and properly disposed of. Mixing these wastes negatively affects their recyclability and quality.

The existing biological package treatment unit at the port should be regularly checked and monitored to ensure efficient operation. Currently, while the package treatment unit receives low volumes of water it can treat, the facility does not meet discharge limits. In recent years, Türkiye has emphasized implementing zero-waste practices, which involve reducing waste production through sustainable environmental management and efficient use of resources, both on ships and in port operations. Legally, a Waste Reception Facility must be constructed at the Van Lake Ferry site by MARPOL 73/78, specifically the article on 'Management of Ship-Generated Wastes and Domestic Wastewater. The facility should include liquid tanks for storing different types of liquid waste, a package biological treatment unit for sewage, and sufficient waste containers for solid waste.

Wastes collected from ships should be filtered first. Solids larger than 5 mm should be removed with a coarse filter and then sent to licensed companies for disposal. Pipelines must be installed to transport petroleum-derived wastes, such as sludge, bilge water, and waste oil, to the tanks. The free water phase separated from bilge water in the tanks should be visually inspected and discharged through the designated free water line. Bilge water should be pumped to the decanter where it will be separated from water and solids in a cold process. The separated solid material should be sent to a licensed recovery or disposal facility. The collected water should be sent by gravity to the package wastewater treatment plant through the designated line. In the planned Waste Reception Facility, sludge, bilge, and waste oil should be collected from ships using appropriate methods as per the 'Petroleum-Derived Liquid Wastes' regulation under MARPOL Annex I, with each type of waste stored separately in designated tanks.

5. Conclusions

In accordance with MARPOL 73/78, as examined in the research on ship waste management. According to the article 'Management of Ship-Borne Waste and Domestic Wastewater,' it is a legal requirement to build a Waste Reception Facility at the Lake Van ferry site. The essential features of the facility are summarized as follows: it must include liquid tanks for storing different types of liquid waste, a biological treatment unit for sewage, and sufficient containers for solid waste.

• The new facility should be constructed in the port's designated area, with an auxiliary system to transport waste from the port to the Waste Reception Facility. Lines must be installed to transport petroleum-derived wastes, such as sludge, bilge water, and waste oil, to the tanks.

• Wastes collected from ships should be filtered first. Solids larger than 5 mm should be removed using a coarse filter and then sent to licensed companies for disposal.

• The free water that forms while bilge water is stored should be inspected and then discharged through the free water line through valves.

•Bilge water should be pumped to the decanter, where it will be separated from water and solids through a cold process.

• The separated solid material should be sent to a licensed recovery or disposal facility. The collected water should be sent by gravity to the package wastewater treatment plant through the designated line.

• Bilge water, once separated from solids, should be pumped to the preheating tank.

• Preheated bilge water should be controlled and removed if free water has formed in the tank due to heating.

• The heated bilge water should be transferred to the heated mixing tank and its temperature raised above 70 °C.

• The water should then be pumped to the separator, where it will be separated into water, bilge oil, and sludge.

• The sludge should be pumped into a heated tank designed for sludge formation at the facility.

• The sludge collected from ships should go through the same processing stages and be dewatered.

• Oil with a maximum of 8% water content should be categorized and stored in appropriate tanks. The results of category analyses will determine whether it should be sent to licensed recovery or disposal facilities.

6. Availability of data and materials

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8. Authors' Contributions

Yunus Urfan: conceptualization, methodology study design, and research. *Sevgi Akkoy*: validation, writing, methodology, investigation, writing, and scientific reading. submission and publication. *Edip Avşar*: coordination

of the article, submission, publication methodology, and data collection.

9. Conflicts of Interest

The authors declare no conflict of interest.

10. Ethics Approval

Not applicable.

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