



Analysis of Sewage Treatment Plant Management for the Prevention of Marine Environmental Pollution

Haerani Asri¹, Subehana Rachman², Eva Susanti³, Nurwahidah⁴

^{1,2,3,4} Politeknik Ilmu Pelayaran Makassar
haeranasri25316@gmail.com

Abstract. The primary contributor to marine pollution is the sewage generated on board ships. This waste poses significant environmental risks when discharged into the sea without undergoing appropriate treatment processes. Marpol 73/78 mandates the treatment of human waste in accordance with established standard procedures. These sewage treatment systems must be properly maintained and operated. Consequently, it is imperative to ensure the cooperation and awareness of the crew in implementing these regulations as stipulated. This investigation employed a qualitative descriptive methodology, with data collected through observations conducted in 2023. The research methodology encompassed direct observation of the subject matter and interviews with crew members. The analysis was performed with reference to relevant regulations and literature. The findings of the study indicated that the sewage management plan did not adhere to the processing procedures and disposal distance requirements as specified by the Marpol 73/78 standard.

Keywords: Pollution, Sewage Management Plan, Maritime Environment.

1 Introduction

In carrying out activities onboard, especially regarding the waste handling process, sometimes things happen that are not in accordance with the desired procedures. This happens because of the crew's lack of understanding of the issue. Thus, good management is expected to overcome problems that can cause marine pollution. Handling waste that is not in accordance with the procedures will have a negative impact on the marine environment and cause marine biota and marine ecosystems to die and become extinct. This calls for a comprehensive framework that outlines strategies and procedures to manage waste generated onboard in a systematic and environmentally responsible manner. (Sukirno, Nurwahidah, et al., 2023)

One of the factors that cause pollution in marine environments is sewage. This waste is dangerous if it is not treated prior to disposal. In this case, all ships are required to have a sewage treatment plant in accordance with the standards set by Marpol 73/78 to treat sewage waste before overboard, and the sewage treatment plant must be properly maintained and operated to ensure the well-being and ecological balance of marine ecosystems that can be significantly affected by marine pollution. (Rachman et al. 2023)

To facilitate shipping and prevent pollution of the marine environment from ship waste, cooperation and awareness among ship crews are needed. All crew members using toilets are not allowed to dispose of non-biodegradable items and substances that may interfere with sewage treatment. If there are interfering substances, the waste treatment device cannot function properly. Referring to international and national regulations, every crew member is required to know and comply with the entire process of waste disposal on board, which is greatly influenced by adherence to clear and strict regulatory standards. Successful implementation also depends on the crew's training and awareness. In addition, the effectiveness of GMP on motor vessels depends on the availability of adequate infrastructure and resources (Welem Ada, 2023).

Under these regulations, biodegradable waste can be discharged into the sea within three miles of the shore, while non-degradable waste must be disposed of beyond 12 miles. As sea transportation continues to grow in importance due to its cost-effectiveness in moving goods, the increasing number of ships operating at sea has raised concerns. The main issue lies in the disposal of solid and gaseous waste, which, due to its non-biodegradable nature, takes a long time to decompose and contributes significantly to ocean pollution. This growing environmental impact highlights the need for stricter waste management practices in maritime operations.

Marine pollution from wastewater is a significant concern, and to address this issue, the International Maritime Organization (IMO) established Marpol 1973/1978, Annex IV, which outlines 18 regulations for the prevention of sewage pollution. As part of these regulations, crew members are required to undergo systematic training in the management and treatment of wastewater on board. This ensures that the crew possesses the necessary knowledge and skills to handle wastewater responsibly and comply with regulations regarding the discharge of residual wastewater. By adhering to these guidelines, ships can contribute to maintaining a clean marine environment. For instance, the PSV Surf Perdana, when operating and discharging wastewater into the septic tank, faced a problem where the tank could not be effectively used for the compressor discharge process. The aerobic bacteria did not recycle properly, leading to their accumulation on the tank's floor, which can pose environmental risks if released during transportation or in the maritime environment. This highlights the need for better management practices to prevent such issues and ensure compliance with wastewater regulations.

Regulators are needed to protect the maritime environment, and shipping companies have clear regulatory requirements, training, public awareness campaigns, access to appropriate infrastructure and resources, and effective guidance and enforcement. (Al-Irsyad, 2020).

2 Literature Review

Munadjad Danusaputro (1980:29) defines marine pollution as unnatural or destructive changes to the sea's natural state caused by both extraterrestrial and human activities. These foreign substances can include various forms of waste, such as industrial waste,

municipal waste, fuel waste, biodegradable waste, and used cold water, all of which contribute to the degradation of marine ecosystems.

Mohtar Kusumaatmadja (1997:43) states that marine pollution refers to changes in the marine environment caused by humans, either directly or indirectly, through the introduction of materials or energy into the sea. This can lead to the disruption of marine ecosystems and harm to marine life.

Danusaputro (1994:24), marine pollution, negative changes, or degradation of marine quality caused by the presence of foreign substances due to human activities, namely, industrial waste, municipal waste, fuel, recycled waste, hot water, and used air conditioners.

According to the Makassar Polytechnic Marine Business, marine pollution is the introduction of organisms, energy, and/or other substances into the water through human activities, which reduces the quality of seawater to a point where it can no longer fulfill its natural functions.

Marine pollution is the introduction of harmful substances or energy into the sea due to human activities, which harms the marine environment. According to Indonesian law (Government Regulation No. 19 of 1999), this pollution reduces seawater quality, making the environment unsuitable. UNCLOS 1982 also defines marine pollution as both human-made and natural causes that negatively affect the sea.

Waste, particularly biological waste like human feces, contains harmful substances that can damage the environment. Improper disposal of untreated waste can disrupt the marine ecosystem, degrading water quality and harming coastal areas, ports, and docks. This leads to physical pollution such as foul odors, water turbidity, and the spread of diseases.

To prevent marine pollution, waste treatment is conducted periodically by supplying oxygen ($3.5-9.5 \text{ kg/cm}^2$) to support aerobic bacteria, ensuring they remain active. This process helps treat waste effectively, allowing it to be disposed of in accordance with government regulations, free from harmful substances, and safe to discharge into the sea without causing environmental harm.

Article 226, paragraph 1, mandates the government to prevent environmental pollution and ensure maritime environmental protection. Paragraph 2 outlines the implementation through (a) pollution prevention and control from ship operations, and (b) pollution prevention and control from port activities.

Article 229, paragraph 1, prohibits vessels from discharging waste, ballast water, excrement, garbage, and hazardous or toxic chemicals into the water.

Article 239, paragraph 1, states that waste disposal in waters can only be done at designated locations set by the minister, which must meet specific requirements.

The sewage system is where wastewater (sewage) is discharged from the toilet through the planned accommodation before it is discharged to the upper floor (O/B) or shore connection. The existence of pre-stays in untreated wastewater treatment is prohibited by law, and the applicable international regulations for sewage discharge are determined by the continent. As a result, all ships must have a standardized drainage system i.e.:

1. The chemical method, the basic method used for the storage of solid waste, is applied in the permitted area at the shore collection point.
2. Biological methods and the treatment of discharge to the shore are permitted by law.

According to Fauzan et al. (2015), wastewater treatment plants are onboard devices that require a gradual start-up and shutdown process:

1. Starting a sewage treatment plant
 - a. If any maintenance is performed on the wastewater treatment plant, the openings are closed before starting the wastewater treatment plant.
 - b. The septic tank was then filled with clean water.
 - c. At this stage, there are no aerobic bacteria in the chamber, but wastewater begins to enter the toilet, which increases the efficiency and rate. Pre-level plant bio-packs are added to the system as more specific numbers are released in the manual.
 - d. If the bio-pack is not implemented, the system will take five to seven days to function properly, but if the bio-pack operates for only 24 h.
 - e. Turning on the air compressor or starting the air compressor according to the manual, usually 0.3-0.4 bar.
 - f. The water shutoff valve was opened and the water supply valve was closed when the tank was outside the designated water area (water restricted).
 - g. The installation is checked regularly, and the flow is controlled through a clear plastic.
 - h. Sediment samples that were difficult to decompose and contained chlorine.
2. Stopping of sewage treatment plants.
 - a. For the shutoff system, the shutoff valve is closed at the sewer plant, the shutoff valve is closed, and water flows directly from the top.
 - b. Three rooms in the plant were cleaned: an air purification chamber, a sediment chamber, and a chlorine chamber. If the chamber is not empty, anaerobic bacteria that produce H₂S gas will grow.
 - c. If aspiration was performed, hydrogen sulfide gas H₂S was checked with the help of a dragon tube by lifting the sample continuously from the self-contained system with a mask and gloves.
 - d. If the vessel is dry-docked, the throttle valve should be connected to the edge of the installation.

Ships are allowed to discharge untreated wastewater at a distance of 3 miles from the nearest land, or disinfected wastewater at more than 12 miles from shore, in compliance with approved regulations. The discharge should not create floating liquids or alter the surrounding water quality. If the sewage is stored in tanks and discharged from a location where organisms cannot emerge, the ship must be moving at a speed of not less than 4 knots. The discharge rate must be approved by the administration, following the standards set by the International Maritime Organization.

3 Research Methods

Qualitative research involves gathering data through oral and written information, with the quality assessment methods focused on analyzing and comparing the data. Questionnaires and interviews were conducted with respondents, including individuals, pairs, or organizations, using statements and questions designed to capture relevant insights. The respondents were crew members of the PSV Surf Perdana, each with responsibilities linked to the research focus, ensuring accurate and pertinent data. This data was then used to identify issues, develop solutions, and perform a thorough analysis to draw meaningful conclusions using descriptive methods.

4 Research Results

Preventing marine pollution requires raising awareness and understanding of the importance of protecting the marine environment, as it is vital for marine life, ecosystems, and human survival. Failure to address pollution can threaten and endanger the sustainability of these systems. Efforts to control marine pollution are strengthened by organizations dedicated to regulating and enforcing laws and regulations related to pollution caused by ships. Increased awareness and proper management of marine pollution are essential in ensuring a healthier, more sustainable marine environment.

Seawater pollution from ships includes various types of waste such as liquid waste, grease, food processing waste, solid waste, raw materials, and both organic and inorganic waste. Handling sewage from ships involves biological treatment methods, most commonly using extended aeration processes in sewage treatment plants. These plants oxygenate the liquid through air bubbles or surface agitation, allowing bacteria to thrive and break down the waste, producing harmless sludge.

The disposal of sewage in confined waters, particularly in harbors or during docking, is strictly prohibited unless it meets specific discharge water quality standards. The management of sewage on ships has evolved due to international regulations, with a clear emphasis on preventing pollution in sensitive marine areas like harbors.

Table 1. Observations on Ship Voyage Routes in 2023

Data	Observation	Waters
January	<i>Operational system supporting the Sewage Management Plan</i>	Batam
February		Tanjung Priok
March		Letung Anambas
April		Bintuni
Mei		Sorong
Juni		Singapura
July		South China Sea

Data processed, 2023

On January 31, 2023, PSV Surf Perdana was operational and attempted to discharge wastewater into the septic tank. However, the discharge process was impeded due to compressor motor malfunctions resulting from a dysfunctional discharge system. Additionally, the implementation of sewage management protocols continues to be hindered by procedural errors.

Ship sewage and its constituents are contaminants that contribute to marine pollution and originate from:

1. Sewage and other wastes from toilets, urination sites, and defecation channels.
2. Wastewater from medical rooms (dispensaries, sick rooms, etc.), sinks, basins, and drains located within such rooms.
3. Wastewater from rooms containing live animals.
4. Wastewater is a mixture of these three elements.

The causes of the prohibition of the discharge of ship sewage into the sea, especially in restricted or enclosed waters, among others.

1. Pollution causes clean seawater to become contaminated and dark in color, and when subjected to propeller agitation, it emits an unpleasant odor.
2. In substantial quantities, sewage pollution can induce various diseases due to the presence of pathogenic bacteria. In minimal concentrations of sewage, the dissolved oxygen content in the water facilitates the biochemical processes that decompose the sewage into elemental components and carbon dioxide.

For the collection of interview data based on field requirements, respondents were randomly selected and involved in the management of onboard sewage.

Table 2. Research Respondents.

Initials	Interview Results	Description
FR	Inadequate equipment, causing performance not to be maximized	Performance
BA	Human resources are important in determining the success of activities	SDM
HT	Continuous maintenance needs to be ensured to support the operation of the ship.	Care
KL	Spare part in the engine room must always be on standby	Spare part
CU	Supervision and checking of the sewage tank needs to be done continuously.	Monitoring
DE	Monitoring and checking journals are not available, making control difficult	Journal
RT	The compressor is the main indicator and always reaps problems	Compressor
AR	The seeping sewage disturbs the peace and comfort of the crew, so it requires quick handling.	Handling

CF	Not fully understanding the function of sewage treatment on board ships in protecting the maritime environment	Protecting the Maritime Environment
HA	Sewage disposal needs to understand regulations/regulations	Regulation/Rules
TP	Never read maritime protection regulations	Socialization / Familiarization
NH	Equipment that does not meet standards is still in use	Equipment Availability

Data processed, 2023

Based on the results of observations and interviews with multiple respondents who provided responses or statements, the availability of liquid waste storage and processing facilities at PSV Surf Perdana is confirmed. However, in the implementation of waste disposal procedures according to Marpol 73/78, there remain discrepancies in the prescribed distance. Consequently, the ship's officer responsible for overseeing sewage management should establish a continuous monitoring schedule to ensure that the system's performance is executed in accordance with established protocols.

5 Conclusions And Suggestions

5.1 Conclusion

The sewage and wastewater treatment storage facilities aboard PSV Surf Perdana are operational and used for non-biodegradable waste storage. However, there are deficiencies in the waste disposal process, particularly regarding the appropriate disposal distance, as the waste is not being properly eliminated in accordance with established procedures and requirements. Additionally, discrepancies were found in the journal records, which are under the supervision of the chief officer and chief engineer. These discrepancies could affect marine inspections and the overall compliance with environmental regulations.

5.2 Suggestions

1. It is recommended that the ship's crew conduct regular safety meetings, preferably at the conclusion of each month, to ensure comprehensive understanding of sewage disposal procedures, including disposal distance protocols and sewage waste management, in order to maintain compliance with applicable regulations.
2. To enhance waste disposal discipline, it is advisable to implement a comprehensive waste management plan and establish standardized waste disposal procedures. These measures should include the strategic placement of appropriate labels throughout the waste disposal site.

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