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Study Of the Effect of Ship Ballast Water on Microorganisms and Organisms in The Port of Amurang

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Abstract

Ships are one of the most important modes of sea transportation for cargo and logistics. One vital system on board is the ballast water system, which functions to maintain the ship's stability and balance during navigation. However, ballasting and deballasting **a**ctivities can cause serious marine pollution due to the transfer of microorganisms and foreign aquatic species from one region to another. This process disrupts local ecosystems, poses health risks, and affects the coastal economy. Therefore, it is essential to manage ballast water in accordance with the D2 standard of the International Maritime Organization (IMO) Ballast Water Management Convention This research was conducted at Amurang Port using the TB. Raymond I vessel to determine the effectiveness of the heating treatment method for ballast water at temperatures above 75°C in reducing the number of microorganisms to meet the D2 standard. Sampling was carried out four times: seawater near the vessel, ballast water before treatment, ballast water after treatment, and seawater near the dock. Laboratory analyses were performed at the Manado Standardization and Industrial Services Center (BSPJI Manado).

The results showed that heating ballast water above 75°C effectively reduced the number of microorganisms from 7.1×10^3 CFU/mL before treatment to $<1.0 \times 10^1$ CFU/mL after treatment, with Coliform levels <1.8 MPN/100 mL, meeting both the IMO D2 standard and the Indonesian Government Regulation No. 22 of 2021 on seawater quality standards. Thus, the heating treatment method is proven to be effective in minimizing marine pollution caused by ballast water discharge and in supporting the preservation of marine ecosystems at Amurang Port.

Keywords: *Ballast Water, Ballast Water Treatment, Microorganisms, IMO, Amurang Port, Heating Method.*

INTRODUCTION

Ships play a crucial role as one of the main modes of sea transportation in the modern world, facilitating the movement of goods between regions and across nations. As global population and economic activity increase, the demand for maritime transport continues to grow, leading to a significant rise in the volume and types of cargo transported by sea. Consequently, maritime operations have become more advanced, efficient, and complex, yet they also pose environmental challenges that must be carefully managed.

One of the major environmental concerns in maritime operations is the management of ballast water. Ballast water is used on ships to maintain stability, balance, and propulsion efficiency, particularly when the vessel is not fully loaded. The ballasting and deballasting processes where seawater is taken in or discharged are essential for safe navigation. However, these processes can unintentionally transfer thousands of marine species, including microorganisms, plankton, larvae, and pathogens, from one ecosystem to another. This biological transfer has been identified as one of the main pathways for the spread of invasive aquatic species, which can disrupt local ecosystems, threaten biodiversity, harm marine life, and even affect human health.

The problem becomes evident when ballast water containing harmful or non-native organisms is discharged into new environments. These organisms may survive, reproduce, and establish new populations, causing ecological imbalance. The mixing of native and foreign species can result in genetic mutations, ecological competition, and in severe cases, the extinction of local species. Moreover, ballast water discharge has been linked to

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various health issues and economic losses, including contamination of seafood, decline in fisheries productivity, and ecosystem degradation.

To address this global issue, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) in February 2004, which entered into force in 2017. This convention mandates that all ships implement ballast water management systems to ensure that discharged ballast water meets the D2 standard, which limits the concentration of viable organisms to less than ten per milliliter. It also requires ships to maintain a ballast water record book and follow approved treatment procedures to prevent environmental contamination.

In Indonesia, ballast water management has also become a significant concern, given the country's vast maritime territory and heavy dependence on sea transportation. Improper discharge of ballast water in Indonesian waters has led to ecological disturbances, such as the introduction of foreign species and the occurrence of fish mortality events, as recorded in Lampung Bay in 2012. This highlights the urgent need for effective ballast water treatment technologies and strict regulatory enforcement.

Based on these considerations, this research focuses on the analysis of ballast water treatment through heating methods at temperatures above 75°C applied on the TB. Raymond I vessel at Amurang Port. The study aims to determine whether this treatment method effectively reduces the number of microorganisms and marine organisms in ballast water to comply with the IMO D2 standard. The results are expected to contribute to sustainable maritime operations and support Indonesia's efforts in protecting marine environments from invasive species.

RESEARCH METHODOLOGY

This research was conducted on the TB. Raymond I vessel at Amurang Port, South Minahasa, North Sulawesi, from January to December 2025. The study aimed to analyze the effectiveness of a heating treatment method applied to ballast water at temperatures above 75°C in reducing microorganisms and meeting the D2 Standard of the IMO Ballast Water Management Convention. The research involved field sampling and laboratory analysis using equipment such as sample bottles, a plankton net, a thermometer, and a gas stove to heat the ballast water to approximately 88°C. Four samples were collected: seawater near the vessel, ballast water before treatment, ballast water after treatment, and seawater near the port. Laboratory tests were conducted at the BSPJI Manado to measure the Total Plate Count (TPC) and Coliform levels in each sample. The results were analyzed descriptively and compared with the IMO D2 Standard and the Indonesian Government Regulation No. 22 of 2021 on seawater quality. This method was found to effectively reduce microorganism concentrations, ensuring that the treated ballast water was safe for discharge and environmentally compliant.

Result

This research was conducted to evaluate the effect of ballast water discharge on marine microorganisms and to assess the effectiveness of heating treatment in reducing microbial contamination to comply with the IMO D2 Standard. Laboratory analyses were performed at the Balai Standarisasi dan Pelayanan Jasa Industri (BSPJI) Manado, where Total Plate Count (TPC) and Coliform bacteria levels were measured from different water samples taken from the TB. Raymond I vessel at Amurang Port. The results obtained are presented in the following Tables 1.

The analysis of seawater samples near the vessel revealed a Total Plate Count (TPC) of 6.6×10^3 CFU/mL, which significantly exceeded the IMO D2 limit of 10 CFU/mL. This result indicates that the seawater surrounding the vessel was already contaminated with microorganisms, suggesting that microbial activity in the area was high even before ballast water discharge.

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Seawater sampled after passing through the ballast pipe is discharged back into the sea. The illustration is as Figure 1.

Table 1. Seawater Sample Near the Vessel

No.	Microorganism	Result (CFU/mL)	IMO D2 Standard
1	Total Plate Count (TPC)	6.6×10^3	10/mL

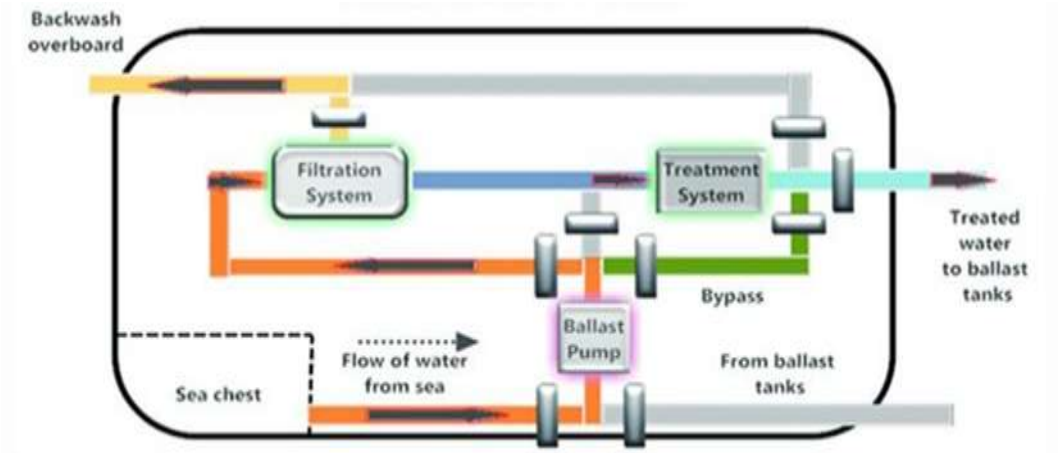

Figure 4.1 Ballasting Process, Flow chart of the ballast water system on the TB Raymond I ship showing the filtration and treatment process before water enters the ballast tank. Source: Researcher Data (2025)

Before undergoing treatment, the ballast water contained 7.1×10^3 CFU/mL of microorganisms, showing that the microbial population within the ballast tanks was even higher than in the surrounding seawater **Table 2**. This confirms that ballast water acts as a vector for transporting microorganisms and potentially invasive species between ports.

After heating treatment at a temperature above 75°C, the microbial concentration in the ballast water decreased drastically. The Total Plate Count was reduced to less than 1.0×10^1 CFU/mL, and Coliform bacteria were below 1.8 MPN/100mL. These values are well within the permissible limits of both the IMO D2 Standard and the Indonesian Government Regulation No. 22 of 2021 **Table 3**. The data clearly demonstrate that thermal treatment is highly effective in minimizing microbial contamination in ballast water Figure 2

Table 2. Ballast Water Before Treatment

No.	Microorganism	Result (CFU/mL)	IMO D2 Standard
1	Total Plate Count (TPC)	7.1×10^3	10/mL

Table 3. Ballast Water After Heating Treatment

No.	Parameter	Result	Standard	Conclusion
1	Total Plate Count (TPC)	$<1.0 \times 10^1$ CFU/mL	10/mL (IMO D2)	PASS
2	Total Coliform	<1.8 MPN/100mL	1000 MPN/100mL (PP No.22/2021)	PASS

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Figure 2. Treatment Method, the process of heating ballast water to a temperature above 75°C using simple equipment to reduce the number of microorganisms.
Source: Researcher Data (2025)

The seawater sample collected near the port after ballast discharge showed a Total Plate Count (TPC) of 6.4 × 10^2 CFU/mL. Although this value was higher than the IMO D2 threshold, it was still significantly lower compared to the initial seawater and untreated ballast water samples **Table 4**. This suggests that the treated ballast water had minimal impact on the microbial population in the surrounding environment. The overall results indicate that the heating treatment method is capable of significantly reducing microbial contamination, ensuring that discharged ballast water does not harm the marine ecosystem Figure 3.

Table 4. Seawater Near the Port After Discharge

No.	Microorganism	Result (CFU/mL)	IMO D2 Standard
1	Total Plate Count (TPC)	6.4 × 10^2	10/mL

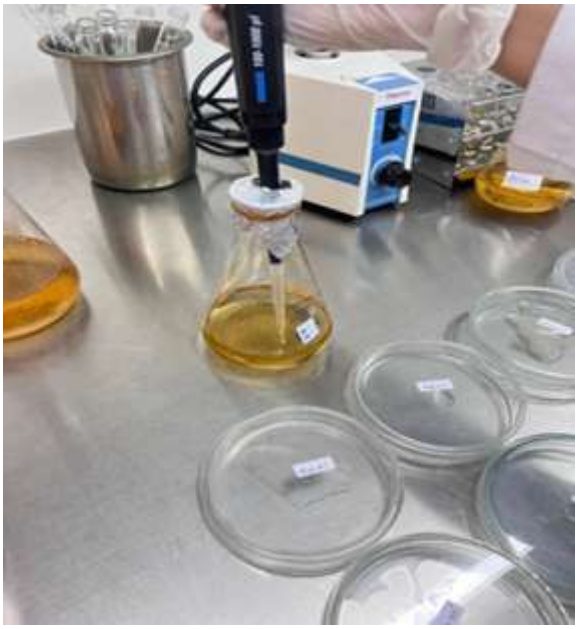

Figure 3. Sample Testing in the Laboratory
Microbiological analysis process at the BSPJI Manado Laboratory to measure Total Plate Count (TPC) and Coliform after treatment.

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In conclusion, the laboratory analyses confirmed that the heating treatment applied to the TB. Raymond I vessel's ballast water was effective in meeting both international and national standards for ballast water discharge. The drastic reduction in microbial counts demonstrates that this treatment method can serve as a reliable and environmentally sustainable solution for ballast water management. Therefore, implementing thermal treatment technology is recommended to minimize the spread of invasive species and to protect the marine environment in Indonesian ports.

CONCLUSION

The results of this study indicate that the heating treatment method applied to ballast water on the TB. Raymond I vessel at Amurang Port is highly effective in reducing microbial contamination to levels that comply with both the IMO Ballast Water Management (BWM) Convention D2 Standard and Indonesian Government Regulation No. 22 of 2021 concerning seawater quality.

Laboratory analyses showed that the Total Plate Count (TPC) in untreated ballast water reached 7.1×10^3 CFU/mL, which was significantly reduced to $<1.0 \times 10^1$ CFU/mL after heating treatment at temperatures above 75°C. Similarly, Coliform bacteria levels decreased from detectable levels to <1.8 MPN/100 mL, meeting the required safety standards. The seawater samples taken around the port after discharge also showed a marked decrease in microbial activity, confirming that the treated ballast water did not negatively affect the surrounding marine environment.

These findings demonstrate that thermal treatment is an effective, practical, and environmentally friendly approach for ballast water management. It not only ensures compliance with international maritime environmental regulations but also helps prevent the spread of invasive species, thereby contributing to the protection and sustainability of marine ecosystems in Indonesian waters..

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