

Analysis Of The Implementation Of Water Ballast Management On The Mv. Sinar Kuta

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ABSTRACT

This study aims to analyze the effectiveness of ballast water management technology, the level of compliance with the Ballast Water Management System (BWMS), and the operational challenges faced by the crew of the MV. Sinar Kuta using a qualitative field approach. Through direct observation, interviews with 24 crew members, and analysis of technical documents and international regulations, it was found that the crew's limited understanding of the Water Ballast Management Plan and Ballast Water Treatment system negatively impacts the optimization of system operations. This has the potential to reduce the level of compliance with regulations and increase the risk of marine pollution and the spread of invasive species. The analysis shows that although the technology used has met most BWMC standards, cost constraints and operational adaptation remain major obstacles. These findings emphasize the importance of improving crew training and the efficiency of the ballast water management system to support compliance with international standards and the sustainable conservation of maritime ecosystems.

Keywords: *Ballast Water, Ballast Water Treatment System (BWTS), Ballast Water Management Convention (BWMC).*

ABSTRAK

Penelitian ini bertujuan untuk menganalisis efektivitas teknologi pengelolaan air ballast, tingkat kepatuhan terhadap Ballast Water Management System (BWMS), serta tantangan operasional yang dihadapi oleh kru kapal MV. Sinar Kuta dengan menggunakan pendekatan kualitatif lapangan. Melalui observasi langsung, wawancara terhadap 24 kru kapal, dan analisis dokumen teknis serta regulasi internasional, ditemukan bahwa keterbatasan pemahaman kru terhadap Water Ballast Management Plan dan sistem Ballast Water Treatment berdampak negatif terhadap optimalisasi pengoperasian sistem. Hal ini berpotensi menurunkan tingkat kepatuhan terhadap regulasi dan meningkatkan risiko pencemaran laut serta penyebaran spesies invasif. Analisis menunjukkan bahwa meskipun teknologi yang digunakan telah memenuhi sebagian besar standar BWMC, kendala biaya dan adaptasi operasional masih menjadi hambatan utama. Temuan ini menekankan pentingnya peningkatan pelatihan kru dan efisiensi sistem pengelolaan air ballast guna mendukung kepatuhan terhadap standar internasional serta pelestarian ekosistem maritim secara berkelanjutan.

Kata kunci: Air Ballast, Ballast Water Treatment System (BWTS), Ballast Water Management Convention (BWMC).

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1. INTRODUCTION

In modern shipping, ballasting and deballasting are common technical procedures performed by merchant vessels, both before and after loading. Ballasting is the process of filling ballast tanks with seawater when the ship is empty, aiming to maintain stability, balance, and performance during navigation. Conversely, deballasting involves removing ballast water after the ship has been loaded to adjust the ship's weight and draft for safe and efficient operation.

While both processes are technically essential, they have significant ecological consequences. Ballast water discharged into unloading port waters often contains invasive associated species. These alien species are carried from the loading port and have the potential to disrupt the balance of the local ecosystem at the destination port. The impacts can include damage to marine habitats, reduced biodiversity, and disruption to economic activities that depend on a healthy aquatic environment, such as fisheries and marine tourism (Simatupang et al., 2024).

The phenomenon of species migration through ballast water is known as bioinvasion and has become a serious concern in the international maritime world. Seawater used in the ballasting process and then discharged during deballasting can carry various microorganisms, including pathogens, bacteria, and viruses, as well as sediment from loading ports. When this water is released without adequate treatment, it introduces foreign organisms into a new environment that may not have the resilience or natural mechanisms to deal with them. This can cause long-term and difficult-to-control ecological disruptions (Wang et al., 2020).

Each country has a different regulatory approach to managing these risks, depending on geographic conditions, technological capacity, and the intensity of shipping activity. Developed countries have generally implemented high-tech ballast water treatment systems, while developing countries still face challenges in terms of infrastructure, human resources, and regulatory understanding. In this context,

Indonesia, as an archipelagic nation with more than 17,000 islands and dense shipping lanes, plays a strategic role in controlling the environmental impact of ballast water.

In response to the ecological threats posed by ballast water, the International Maritime Organization (IMO) issued the Ballast Water Management Convention (BWMC) which came into effect globally in 2017. This convention sets standards for ballast water management through two main approaches, namely D-1 (exchange standard) and D-2 (performance standard). D-1 regulates the exchange of ballast water on the high seas, while D-2 requires ballast water treatment using technological systems capable of eliminating living organisms to a certain level.

The technology used to meet the D-2 standard is known as a Ballast Water Treatment System (BWTS). This system generally combines filtration and sterilization methods, such as ultraviolet (UV) light, electrochlorination, or ozonation. While BWTS is technically capable of reducing the risk of bioinvasion, its implementation in the field is not always smooth. One major challenge is the crew's lack of understanding of the Water Ballast Management Plan (WBMP), an operational document that governs ballast water management procedures in accordance with international regulations. The lack of training and socialization regarding the BWTS system also leads to operational errors that potentially violate IMO regulations (Bai & Li, 2021; Ishola & Kontovas, 2022).

In Indonesia, these challenges are further complicated by limited port facilities, diverse vessel types, and uneven implementation of BWTS across the national fleet. Furthermore, there remains a gap between international regulations and national policies governing ballast water management. This creates uncertainty in implementation, particularly for vessels operating on both domestic and international routes.

This research is motivated by the need to understand in-depth the implementation of ballast water treatment systems on Indonesian-flagged vessels, and to assess their effectiveness in meeting the D-2 standards set by the IMO. Using a case study-based approach and operational analysis, this research aims to identify technical constraints, procedural weaknesses, and opportunities for improvement in sustainable ballast water management.

The theoretical basis for this research is derived from various previous studies relevant to ballast water management and the implementation of BWTS. These

studies not only provide a conceptual framework but also present empirical data to support operational analysis. The literature review focused on research directly related to the methodology, scope, and technical challenges of implementing BWTS on ships. Therefore, the approach used in this study has strong validity and is able to comprehensively explain the problem.

Overall, ballast water management is a strategic issue in modern shipping, requiring synergy between technology, regulations, and human resources. As a maritime nation, Indonesia must be able to adapt to international standards, taking into account local conditions and national capacity. This research is expected to make a significant contribution to the development of more environmentally friendly policies and operational practices, as well as to raise ship crew awareness of the importance of sustainable ballast water management.

2. METHOD

This study uses a descriptive qualitative method to analyze the implementation of Ballast Water Treatment System (BWTS) on ships and the level of compliance with the D-1/D-2 standards set by the International Maritime Organization (IMO). This approach was chosen because it is able to provide an in-depth understanding of various factors that influence the implementation of BWTS, including technical, operational, regulatory, and environmental aspects, based on the direct experience of maritime industry players. As an analytical tool, this study applies Fishbone Analysis (Ishikawa Diagram) to identify and group the root causes of obstacles in the implementation of BWTS and non-compliance with the D-1/D-2 standards. The analysis focused on MV Sinar Kuta with the main cause categories including Man (crew competence and training), Machine (condition and effectiveness of BWTS equipment), Method (operational procedures and understanding of regulations), and Environment (environmental conditions and port provisions).

The unit of analysis in this study includes human resources involved in the operation of the BWTS, the Alfa Laval Pure Ballast 3.1 BWTS technical systems and procedures, operational methods reviewed through interviews with the First Officer as the Person in Charge of ballasting activities and one of the crew members, as well as environmental factors observed during the voyage of the MV Sinar Kuta on the route to Singapore. Data collection was conducted through field research and literature review. Field research included direct observation of the BWTS operation

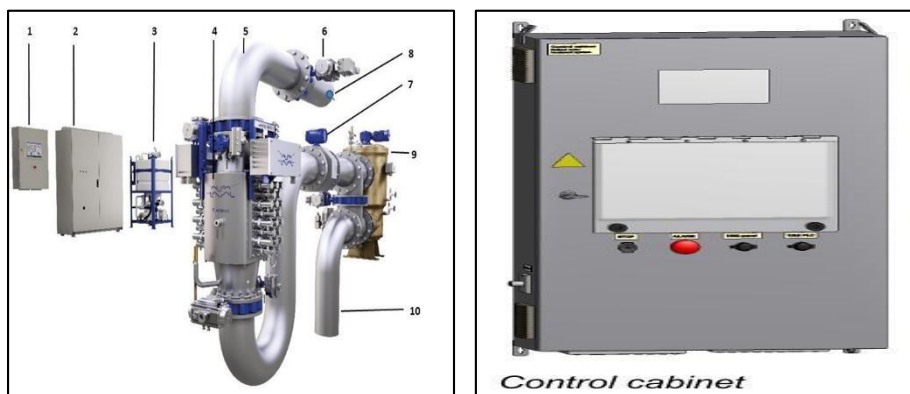
and interviews with the ship's crew to obtain data on the understanding, experience, and obstacles in implementing the Ballast Water Management Plan in accordance with the Ballast Water Management Convention (BWMC). The literature review was conducted by examining literature, regulations, and academic sources related to ballast water management to strengthen the basis of the analysis. Data analysis was conducted descriptively qualitatively with the researcher as the main instrument. Through Fishbone Analysis, the cause-and-effect relationships of the problems found can be systematically mapped, resulting in evidence-based strategic recommendations to improve the effectiveness of BWTS implementation and compliance with IMO D-1/D-2 standards.

3. RESEARCH RESULTS AND DISCUSSION

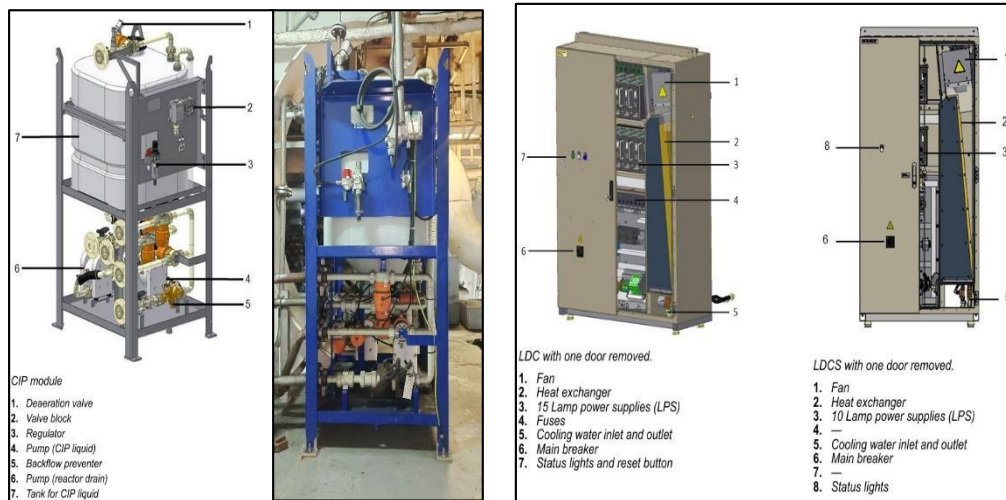
In this thesis, the author presents a comprehensive overview of the implementation of Ballast Water Management on MV. Sinar Kuta as the object of research with the title "Analysis of Ballast Management Implementation on MV. Sinar Kuta". This research was conducted during sea practice for 11 months and 5 days, focusing on the effectiveness of the implementation of the Ballast Water Treatment System (BWTS) and the level of ship compliance with international provisions, especially the D2 Ballast Water Management Convention. Through this research, it is hoped that readers will gain a comprehensive understanding of the implementation of ballast water management on board ships to prevent the spread of invasive marine organisms. MV. Sinar Kuta is a bulk carrier ship with a deadweight capacity of 87,334 MT owned by PT. Samudera Indonesia Ship Management and registered at the Port of Jakarta. This ship was built by HudongZhonghua Shipbuilding (Group) Co., Ltd. and launched on August 23, 2010.

Manufacturer	ALFAVLAVAL AB TUMBA, SWEDEN
Type/Model	PURE BALLAST 3.2 3000
Treatment Rated Capacity (m ³ /h)	3000
Technology Employed	FILTRATION AND ULTRAVIOLET RADIATION
Installation Location	ENGINE ROOM, 3RD DECK PORT SIDE
Type Approval Certificate (TAC) No.	TAP 0000018Z REVISION NO.4
TAC Issuing Authority	DNV GL ON BEHALF OF NORWEGIAN MARITIME AUTHORITY, MINISTRY OF INFRASTRUCTURE AND TRANSPORT ITALIAN COAST GUARD.

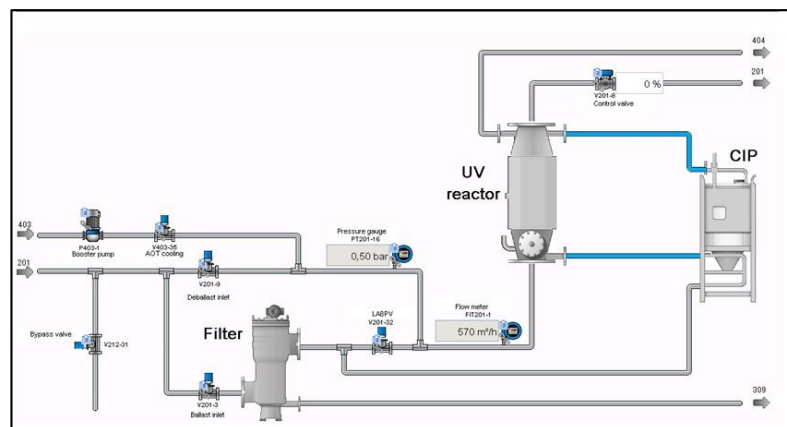
To meet the IMO D2 standard, the vessel is equipped with the Alfa Laval PureBallast 3.2 Ballast Water Treatment System, which uses a combination of filtration technology and chemical-free ultraviolet (UV) light. The system is designed to operate efficiently in a variety of water conditions, including high turbidity and variations in salinity and temperature during the voyage.



Alfa Laval PureBallast 3.2 has a processing capacity of up to 3000 m³/hour and is installed in the engine room deck 3 on the port side. This system has obtained a Type Approval Certificate (TAC) from DNV GL on behalf of the Norwegian and Italian maritime authorities. The advantages of this system lie in its automated flow control and real-time data monitoring capabilities integrated with the ship management system, thus enabling safe, efficient ballast operation in accordance with international regulations. The main components of the BWTS on the MV. Sinar Kuta include a control cabinet, lamp drive cabinet (LDC), Cleaning-In-Place (CIP) module, UV reactor, ballast water inlet and outlet, control valve, flow meter with conductivity sensor, sampling point, and filter unit. The UV reactor is the core component that functions to sterilize ballast water using a medium-pressure UV lamp protected by a quartz glass casing and equipped with a layered cooling system to prevent overheating. All components are automatically controlled through the control panel to minimize manual intervention and improve system reliability.

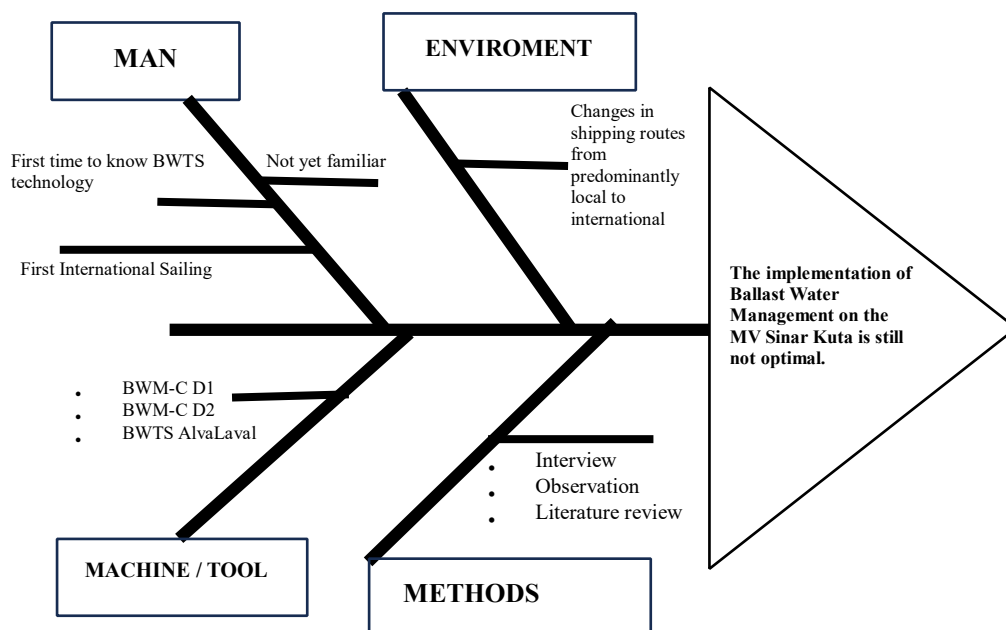


The ballasting process begins with the entry of seawater through the ballast water inlet, which is equipped with a pre-filter to remove large particles. The water then undergoes a further filtration stage before being sterilized in a UV reactor. After meeting the IMO D2 biological standard, the ballast water is channeled into the ship's ballast tanks. During this process, a flow control system and automatic sensors monitor the water pressure, flow rate, and conductivity to ensure operational efficiency and stability. Conversely, in the deballasting process, the ballast water is pumped out of the tanks, re-filtered, sterilized with UV, and then discharged into the sea through the ballast water outlet in an environmentally safe condition. To maintain system performance, a Clean-In-Place (CIP) process is carried out periodically after ballasting and deballasting.



The CIP process cleans sediment, biofouling, and contaminants that can reduce the effectiveness of filtration and UV sterilization. With proper maintenance and continuous monitoring of operational parameters, the BWTS system on the MV. Sinar Kuta is able to operate optimally and meet the regulatory requirements of D1

and D2 of the Ballast Water Management Convention. In addition to technical aspects, this study also highlights the importance of training and outreach to the crew. Through simulations, safety meetings, and documentation of BWTS operational procedures, the crew's understanding of ballast water management increased significantly. This shows that the success of BWTS implementation is not only determined by technology, but also by the competence of human resources in operating and maintaining the system according to established standards.



The analysis of the problems of implementing the Ballast Water Management System (BWMS) on the MV Sinar Kuta was conducted using the fishbone analysis method to identify the main causal factors that affect the operational effectiveness of the system. This method was chosen because it is able to systematically describe the cause-and-effect relationship between the main problems and their supporting factors, both from human, machine, method, and environmental aspects. The analysis focused on the implementation of the Alfa Laval Pure Ballast 3.2 Ballast Water Treatment System (BWTS) and the challenges faced by the crew in meeting IMO D1/D2 standards.

From the human aspect, it was found that limited crew understanding was the dominant factor hindering the effectiveness of the BWMS. Observations and interviews with the First Officer indicated that most crew were unfamiliar with BWTS technology due to their domestic shipping background and limited experience using UV-based sterilization and filtration systems. The lack of simulation-based training and hands-on practice led to errors in system setup, potentially reducing BWTS

from domestic operations to international standards. The crew's lack of understanding of BWTS technology, system setup errors, and limited monitoring are major obstacles to maintaining operational efficiency and regulatory compliance. Therefore, socialization and simulation-based training are considered crucial to improving crew competency in operating the BWTS effectively. Overall, the fishbone analysis results indicate that the problems with the BWMS implementation on the MV Sinar Kuta are influenced by a combination of human, machine, method, and environmental factors. Human and method factors are the main causes with the highest risk level. The crew's lack of understanding of Ballast Water Management and the use of BWTS that is not fully in accordance with Standard Operating Procedures (SOPs) are priority issues that need to be addressed. Therefore, improving crew training, refining SOPs, strengthening the monitoring system, and optimizing recording through the Ballast Water Record Book are strategic steps to increase the effectiveness of BWMS implementation and ensure ongoing compliance with IMO regulations.

4. CLOCLUSION

The implementation of Ballast Water Management on the MV Sinar Kuta is still not optimal due to the crew's limited understanding of the operation of the Ballast Water Treatment System (BWTS), the complexity of the technical system that requires good operational coordination, and the potential environmental impacts due to suboptimal ballast water management. Crews who are new to international shipping still face difficulties in implementing ballast water sterilization procedures according to IMO D1/D2 standards, so competency improvement through structured, continuous, and practice-based training is essential. In addition, improvements to operational procedures, consistency in filling out the Ballast Water Record Book, and increased coordination between deck and engine crews are necessary to minimize technical and administrative errors. From an environmental perspective, the implementation of consistent mitigation strategies and stricter operational supervision are important to prevent the spread of alien species and maintain the balance of the marine ecosystem. By optimizing aspects of human resources, work methods, and monitoring systems, the implementation of Ballast Water Management on the MV Sinar Kuta is expected to run more effectively, efficiently, and in accordance with applicable international regulations.

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