

Contaminant Reduction from Ship Wastewater Using Treatment Technology

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Abstract: Ship wastewater is one of the potential sources of marine pollution because it may contain organic matter, nutrients, suspended solids, oil, chemicals, and microorganisms. If wastewater is discharged into the marine environment without adequate treatment, it can negatively affect water quality and marine ecosystems. Therefore, appropriate wastewater treatment technology is needed to reduce contaminants before wastewater is released from ships. This article discusses the application of treatment technology for reducing contaminants in ship wastewater. A literature review method was used by examining scientific publications related to ship wastewater characteristics, wastewater treatment processes, and contaminant reduction technologies. The treatment processes may include physical, biological, and chemical methods, depending on the type and concentration of contaminants present in the wastewater. The reviewed studies indicate that proper treatment can reduce pollutants and improve the quality of treated wastewater before discharge. The effectiveness of the treatment system depends on factors such as wastewater characteristics, treatment technology, operating conditions, maintenance, and system capacity. The application of appropriate wastewater treatment technology can therefore support pollution prevention, improve environmental protection, and contribute to more sustainable maritime operations.

Keywords: Ship Wastewater; Contaminant Reduction; Wastewater Treatment; Marine Pollution; Treatment Technology

1. Introduction

Ships play an important role in transportation, trade, tourism, and other maritime activities, but their operation also produces different types of wastewater that can become a source of marine pollution. Ship wastewater may originate from toilets, bathrooms, kitchens, laundry activities, accommodation areas, and other onboard operations. Depending on its source, the wastewater can contain organic matter, nutrients, suspended solids, oil and grease, detergents, chemicals, and microorganisms. When wastewater is discharged into the marine environment without adequate treatment, these contaminants can reduce water quality and potentially affect marine organisms and coastal ecosystems. Therefore, wastewater management is an important aspect of sustainable ship operations and marine environmental protection [1].

The characteristics of ship wastewater can vary depending on the type of vessel, number of people onboard, operational activities, and duration of the voyage. Domestic wastewater from toilets may contain high levels of organic matter and microorganisms, while wastewater from kitchens and laundry activities can contain fats, oils, detergents, and suspended solids. Some ship operations may also produce wastewater containing chemical substances or other pollutants. The different characteristics of these waste streams create challenges in selecting an appropriate treatment system. A treatment process that is effective for one type of contaminant may not provide the same performance for another contaminant, making proper wastewater characterization an important step in pollution control [2].

Wastewater treatment technology provides an approach for reducing contaminants before treated wastewater is discharged into the marine environment. Treatment systems can generally involve physical, biological, and chemical processes, which may be applied individually or in combination depending on the wastewater characteristics. Physical treatment can remove larger suspended materials, while biological processes can reduce biodegradable organic matter through microbial activity. Chemical processes can also be

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used to support the removal or reduction of specific contaminants. The combination of these processes can improve treatment performance and produce wastewater with characteristics that are more suitable for discharge or further use [3].

The application of wastewater treatment systems on ships also requires consideration of operational limitations. Space, energy consumption, equipment capacity, maintenance requirements, and variations in wastewater flow can influence the design and performance of treatment systems. Unlike land-based facilities, shipboard treatment systems must operate within limited spaces and changing operating conditions while maintaining reliable performance during voyages. Regular monitoring and maintenance are therefore necessary to ensure that treatment equipment continues to function properly. Proper management is also important because treatment system failure or poor operation may result in insufficient contaminant reduction and increase the risk of marine pollution [4].

Contaminant reduction from ship wastewater is therefore an important part of efforts to minimize the environmental impact of maritime activities. The selection and application of suitable treatment technology can help reduce pollutant loads, maintain marine water quality, and support compliance with environmental requirements. In addition, improvements in treatment processes can provide opportunities to develop more efficient and sustainable shipboard wastewater management systems. This article discusses the characteristics of contaminants in ship wastewater and the application of physical, biological, and chemical treatment technologies for reducing these contaminants. The discussion also considers factors affecting treatment effectiveness and the challenges of implementing wastewater treatment systems in shipboard environments [5].

2. Materials and Methods

This study uses a literature review method to examine contaminant reduction from ship wastewater using wastewater treatment technology. The materials used in this study consist of scientific journal articles, research papers, academic books, and other relevant publications related to ship wastewater, marine pollution, wastewater treatment, and contaminant reduction. The selected literature focuses on wastewater generated from ships and the treatment technologies used to reduce pollutants before wastewater is discharged into the marine environment [6].

The literature was collected through academic databases and scientific publications using keywords such as “ship wastewater treatment,” “marine wastewater,” “shipboard wastewater treatment,” “contaminant reduction,” “marine pollution,” and “wastewater treatment technology.” The selected references were evaluated based on their relevance to the characteristics of ship wastewater, types of contaminants, treatment processes, and treatment performance. Studies discussing different sources of ship wastewater, including sewage, greywater, kitchen wastewater, and oily wastewater, were also considered to provide a broader understanding of contaminants generated during ship operations [7].

The analysis focused on identifying the main contaminants present in ship wastewater and the treatment processes used to reduce them. Physical, biological, and chemical treatment technologies were reviewed based on their functions and applications. Physical processes were considered for the removal of suspended solids, oil, grease, and other larger particles, while biological treatment was evaluated based on its ability to reduce biodegradable organic matter and nutrients. Chemical treatment was examined in relation to the removal or reduction of specific contaminants that may not be sufficiently treated through physical or biological processes [8].

The effectiveness of each treatment approach was analyzed by considering its ability to reduce contaminant concentrations and improve the quality of treated wastewater. Factors such as treatment capacity, operating conditions, wastewater characteristics, retention time, energy requirements, and maintenance were also considered because they can influence treatment performance. Particular attention was given to the suitability of treatment technologies for shipboard applications, where available space, equipment size, energy consumption, and changing wastewater flow can affect system design and operation [9].

Finally, the information obtained from the reviewed literature was compared and organized to identify the advantages, limitations, and potential applications of different wastewater treatment technologies on ships. The analysis considered the relationship between wastewater characteristics and treatment selection, as well as the importance of proper operation and maintenance in maintaining contaminant removal performance. The findings from this review were then used as the basis for discussing how suitable treatment technologies can contribute to reducing marine pollution and supporting more sustainable ship operations [10].

3. Results

The reviewed studies indicate that ship wastewater contains various contaminants, including organic matter,

suspended solids, nutrients, oil and grease, detergents, and microorganisms. The amount and type of contaminants can differ depending on the type of ship, number of people onboard, daily activities, and operating conditions. This variation shows that wastewater treatment systems need to consider the characteristics of the wastewater before the treatment process is selected [11].

Physical treatment, such as screening, sedimentation, filtration, and oil separation, was found to be useful for removing larger solids, suspended particles, and oil or grease. Biological treatment provides an important role in reducing biodegradable organic matter, particularly BOD and COD, through microbial activity. Chemical treatment, including coagulation, oxidation, and disinfection, can further reduce specific pollutants and microorganisms that may remain after physical or biological treatment [12].

The results also show that combining several treatment processes can provide better contaminant reduction than using only one process. Integrated systems can treat different types of pollutants through different treatment stages, while also improving the quality of the final wastewater. However, treatment performance may change due to factors such as wastewater loading, treatment capacity, temperature, salinity, retention time, and operating conditions [13].

Overall, appropriate wastewater treatment technology can significantly improve the quality of ship wastewater before discharge. The effectiveness of the system depends not only on its contaminant removal capability but also on energy consumption, maintenance, available space, and operational reliability. Therefore, compact and efficient treatment systems are important for supporting wastewater management and reducing pollution from ships to the marine environment [14].

4. Discussion

The results show that ship wastewater requires more than one treatment process because it contains different types of contaminants. Physical treatment is useful for removing solids and oil, while biological treatment mainly reduces organic matter such as BOD and COD. Chemical treatment can be added when specific pollutants or microorganisms need further reduction. This combination is important because each treatment process has different functions and limitations. Therefore, an integrated treatment system can provide more effective contaminant reduction and produce better-quality wastewater before discharge [15].

The application of wastewater treatment technology on ships also needs to consider practical conditions such as limited space, energy requirements, wastewater flow, maintenance, and changing operating conditions during voyages. A treatment system that works well in a laboratory may require adjustments to operate effectively onboard. For this reason, compact, reliable, and easy-to-maintain technology is important for ship applications. Proper operation and regular maintenance are also needed to maintain treatment performance and prevent the discharge of untreated or inadequately treated wastewater into the marine environment [16].

5. Conclusion

The treatment of ship wastewater is an important part of preventing marine pollution caused by maritime activities. Wastewater generated onboard can contain different pollutants that may affect marine water quality when they are not properly managed. The reviewed studies demonstrate that wastewater treatment can reduce the pollutant load and improve the quality of wastewater before discharge. Therefore, contaminant reduction should be considered as an important part of shipboard environmental management rather than only as a technical requirement for wastewater disposal.

The effectiveness of a ship wastewater treatment system is closely related to how well the technology is matched with the conditions of the vessel and the characteristics of the wastewater. Factors such as wastewater volume, changes in pollutant concentration, available space, energy consumption, maintenance, and operational conditions need to be considered during system design and operation. A treatment system with high removal performance may not be practical if it requires excessive space, energy, or complicated maintenance. This shows that successful wastewater management depends on both treatment performance and the practicality of the system in actual ship operations.

In the future, the development of ship wastewater treatment should focus on systems that are efficient, compact, reliable, and environmentally sustainable. Better monitoring and automation can also help operators identify changes in wastewater conditions and maintain stable treatment performance during voyages. Further research is needed to evaluate treatment technologies under different ship operating conditions and to develop systems that can provide consistent contaminant reduction with reasonable energy and maintenance requirements. Through continuous improvement of treatment technology and proper wastewater management, the maritime sector can reduce its environmental impact and support more

sustainable use of marine environments.

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