Assessing the Quality of Ship Crew Members in Sewage Pollution Prevention Practices on Marine Environmental Protection: A Case of Dar Es Salaam – Zanzibar Ropax Vessels

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Abstract:

The maritime industry is crucial for global trade, but it also significantly impacts the marine environment, particularly through sewage pollution. This study assesses the quality of ship crew members in sewage pollution prevention practices on marine environmental protection, focusing on ROPAX vessels operating between Dar es Salaam and Zanzibar. The stud aims to assess the quality of ship's crew members in training and education, experience and the number of crew in sewage pollution prevention practices. The study collected data from 80 respondents, whereby structured questionnaires were used to collect the data. The data were analyzed by using descriptive statistics and inferential statistics. The study finding revealed that significant deficiencies in awareness and training among crew members regarding MARPOL Annex IV regulations, with many respondents rating their understanding as very low or low. This lack of knowledge, compounded by insufficient formal training programs, hampers the effective implementation of pollution prevention measures. The study recommends a multifaceted approach, including enhanced training, financial support for compliance, and stronger regulatory oversight to improve environmental protection practices. These findings provide crucial insights for policymakers and stakeholders aiming to reduce the environmental impact of the Tanzanian maritime industry and protect marine ecosystem.

Key words: MARPOL, Ropax Vessels, Sewage, Pollution

1. Introduction:

More than 50,000 merchant ships traverse the world's oceans and seas, carrying more than 90% of all trade worldwide (Hasanspahić et al., 2022; United Nations Conference on Trade and Development (UNCTAD), 2022). Compared to other forms of transportation, maritime transportation is very favorable since it is safe, cost-effective, and has a high carrying capacity. It is also a major component of global trade. Ship numbers and tonnage have expanded as a result of the significant growth in demand for marine transportation brought about by the expansion of the global economy and industry. Increased environmental pollution is a result of the growth in both the quantity and size of ships (Arslan et al., 2022).

Although international law does not define pollution consistently, various circumstances and goals lead to varied interpretations of the term

pollution. Typically, it refers to the wastes themselves, the occurrence of wastes in the sea, or the environmental damage caused by wastes discharged into the sea (Shi, 2016). Any chemical or energy, whether natural or created from people, that is introduced into the environment by humans and has the potential to harm natural habitats and living things can be described as pollution (Nations & Summary, 2015; UNEP Training Manual on International Environmental Law, n.d.; Willis et al., 2022).

Pollution is categorized as either nonpoint source or point source. Point source pollution is defined as pollution that has its source identified and can be located, such as a company's sewage line, a windmill's noise, or the Deep Horizon oil drilling platform leak. Nonpoint source pollution has a diffuse source and cannot be traced to a specific place or period of time. Examples include runoff from urban storm water systems, dust from strip mining, and agriculture (Potters, 2013). As a result of this, we can categorize pollution according to its location or mode of occurrence, including soil/land pollution, atmospheric pollution, and water/aquatic pollution (marine, brackish, or fresh water pollution).

Not only do activities on land contribute to pollution of the maritime environment, but shipping operations also do this (Chuma, 2020). Pollution of the Marine Environment refers to the introduction of materials or energy into the marine environment, including estuaries, by humans, either directly or indirectly. This can have a negative impact on marine life and living resources, pose a health risk to humans, interfere with legitimate marine activities like fishing, reduce the quality of seawater for use, and negatively impact amenities (Iduk & Samson, 2015; United Nations Convention on the Law of the Sea, n.d.).

Untreated human waste disposal is one of the main sources of pollution in the marine environment, and human wastes in particular typically pose major threats to the marine ecosystem (Akankali & Elenwo, 2015). An investigation report from the US National Academy of Sciences indicated that approximately 35% of the pollutants in the marine environment were from ships in (Wang et al., 2019).

The International Maritime Organization (IMO) has been one of the most effective in creating international legislation for the preservation and safeguarding of the maritime environment, especially with regard to reducing marine pollution caused by vessels. In order to facilitate the approval and modification of international legal instruments for the prevention of marine pollution from ships, the International Maritime Organization (IMO) has a particularly unique procedure. States and non-state actors are among the many players who have an impact on the IMO lawmaking process (Uddin & Karim, n.d.).

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the main international marine convention designed by the International Maritime Organization (IMO) to prevent pollution from ships, which may occur as a result of both operational and accidental causes (Chuma, 2020). The primary focus of MARPOL is the prevention and management of ship pollution. Parties to this treaty are required to pass laws that forbid and penalize international pollution in addition to establishing requirements for ship design and equipment that reduce the impacts of unintentional pollution (Ofem Akpama, 2017). The Convention is currently in effect in 153 states, accounting for 98.52% of global shipping tonnage, indicating its broad applicability. No matter where they sail, all ships flying a contracting party's flag are bound by MARPOL's regulations. Contracting parties are in charge of issuing the required on-board certificates, conducting surveys and inspections of the ships that operate under their jurisdiction, and enforcing any violations of MARPOL 73/78 (Djadjev, n.d.).

There are several Annexes in the MARPOL Convention. The regulations outlined in Annex IV govern the prevention and control of maritime pollution caused by ship sewage waste waters. These measures include banning or restricting

discharge, issuing certificates and conducting inspections, providing equipment and supervision for discharge, and providing shore receiving facilities (Wilewska-Bien & Anderberg, 2018). Annex IV which entry into force on September 27, 2003 with 134 parties entered into contracts covers 90.74% of global tonnage, controls the measures taken to prevent contamination from ship sewage. It prevents ships over 200 GT from discharging sewage into the water unless specific conditions are satisfied (e.g. the installation of a sewage treatment plant; a system to comminute and disinfect sewage; or a holding tank). It also prohibits ships under 200 GT from discharging sewage into the water (Djadjev, n.d.).

This study addresses the contribution of ship's crew members quality in sewage pollution prevention practices on marine environmental protection for the case of Dar es salaam - Zanzibar ROPAX vessels. The study is a synthesis of information and data obtained by the author from internet sources, library search, specifically in technical publications and un-publication papers and IMO documents. Appreciated information is also gathered from different ship crew members. The study is conducted in Dar es Salaam coast where by structured questionnaire sent to different ship's crew members to examine the situation were taking place at their day-to-day working condition regarding to sewage pollution prevention practices.

2. Literature Review:

According to the study conducted in Indonesia and published on August 2022 with the purpose to ascertain how crew behavior affected their knowledge, control, and level of waste management facility performance with regard to preventing marine pollution. The study used a quantitative technique. The results of the study show that the infrastructure quality, seafarers' awareness, and supervision all have an impact on how they behave when it comes to reducing marine pollution in ports (Nursyamsu et al., 2022).

Another study about the analysis of Sea Pollution by Sewage from Vessels was conducted in 2022. In this study, they examined the pollution of the sea resulting from vessel sewage. The aquarium in Dubrovnik was selected as an example of a typical maritime area that may house a range of vessels in various locations. Over the course of 14 months, they collected marine samples at eight separate coastal locations. The samples were then analyzed to look for signs of fecal pollution. They noted the quantity and kind of vessels berthed at the port concurrently with the sea sampling. These data were used in chi-square testing to ascertain whether there was a relationship between specific vessel types and fecal coliform bacteria in the sea at each location. Smaller vessels, including boats, yachts, mega yachts, and smaller cruise ships, were found to correlate with bacteria at sea at the sampling locations when they were in national navigation. The findings lead to a better understanding of how ship waste contributes to marine contamination (Koboević et al., 2022).

The effectiveness of the Cost Recovery System and the Las Palmas Port sewage treatment plan (Annex IV of MARPOL) was evaluated by (Port, 2020). This include examining the mandatory fees for disposing of waste in the port, the expenses associated with treating the sewage, the environmental benefits of the treated vessel effluent, and resolving technical issues to meet the standards set by Las Palmas Port for the normative standard for vessel sewage. The paper's findings demonstrate that the advantages of adhering to the directive outweigh the costs incurred in implementing it only in cases when the treated sewage is reused. So, in order to comply with the PPP (Polluter Pays Principle), the port authorities and policymakers should focus their efforts in this direction. They should also incorporate the cooperation of the on-board sewage treatment facilities into international norms (Port, 2020).

The Necessity of Adoption of New National Regulations to Prevent the Pollution of Croatian Coastal Sea by Sewage from Various Vessels (Koboević & Milošević-Pujo, 2018). This paper discusses EU, Croatian, and worldwide laws that aim to stop ship sewage from contaminating

seawater. The study also emphasizes the drawbacks of international regulations aimed at preventing vessel sewage pollution of coastal waters.

Sustainable management of sewage pollution from ships in Douala port; perspective on challenges and opportunities is the study conducted by Corinne in 2022. The author conducted and evaluated semi-structured interviews with ten stakeholders from academic institutions, governmental organizations, shipping companies, port authorities, and environmental non-governmental groups in order to investigate these questions. The results showed that there is an institutional framework in place that takes into account vessel source sewage and is implemented in terms of laws, regulations, government bodies, and the maritime sector in Cameroon. The results also show that stakeholders believe more needs to be done to enforce the law (Corinne et al., 2022).

In Tanzania a country which is located in Eastern of Africa, very few studies about the sewage pollution have been conducted and published; coastal marine pollution in Dar es salaam which reveals that the lack of sufficient wastewater treatment facilities is the main cause of current levels of some pollution in the coastal marine environment (Machiwa, 2010). Another study about Status of sewage disposal in 20 Dodoma Municipality was conducted and makes several recommendations for sewage authorities, including raising public awareness about preventing the dumping of solid waste in sewage infrastructures, providing and maintaining suitable sewage facilities, and renovating infrastructure that has reached the end of its useful life (Ringo, 2016). However, there is no documented studies about ship's sewage pollution prevention practices conducted in Tanzania. Therefore, this study creates a relationship about ship crew members' quality in sewage pollution prevention practices and marine environmental protection.

3. Methodology:

A study is carried at Dar es Salaam port involving ROPAX vessels sailing Dar es salaam - Zanzibar route. The ROPAX vessels were chosen because they can transport both cargo and passengers, which makes them a possible source of substantial sewage discharge into maritime habitats. Because ROPAX vessels frequently operate near ports and coastal regions, there is a higher chance of sewage pollution, which can have a negative impact on both public health and marine habitats.

The study population involves different crew members from four ROPAX vessels which sail along the coast of Dar es salaam and Zanzibar. A purposive sampling technique which is a kind of sampling technique which is a non-probability used in this study. A total of 80 respondents participated in the study, providing a broad perspective on the issue assessed.

Structured questionnaires were utilized to gather data, with the aim of capturing both categorical replies and numerical data about the experience and quality of ship crew members in sewage pollution prevention practices on marine environmental protection. There were a few open-ended questions to get qualitative insights as well as closed-ended questions for quantitative analysis in the surveys. In order to compile the data and identify the broad trends, descriptive statistical analysis was initially used to the questionnaire data. The study was carried out in accordance with ethical guidelines, guaranteeing the confidentiality of all participant responses and informing participants of the goal of the study and their rights as respondents prior to the start of data collection.

4. Results and Findings:

Descriptive statistics and inferential statistics were used to compute the received data and to summarize awareness levels among crew members, and training received data.

4.1 Awareness of Crew members:

The level of awareness of regulation for prevention of pollution by sewage from ships is shown in Table 4.1.

Table 4.1 Awareness of Crew Members

Variable	Frequency	Percentage	Mean	Std. Deviation
Awareness of MARPOL (1-5)			4.2	0.8
1 (Very Low)	35	48.6%		
2 (Low)	22	30.6%		
3 (Moderate)	10	13.9%		
4 (High)	2	2.8%		
5 (Very High)	3	4.2%		

Source: Feld Data, 2024

The data presented in Table 4.1 indicates a varied level of awareness among respondents concerning MARPOL regulations. The mean awareness score of 4.2 suggests a generally high level of understanding, with a standard deviation of 0.8 indicating that most respondents' awareness levels are closely aligned. However, despite this overall high mean score, there are a notable percentage of respondents who rated their awareness as low, with 30.6% indicating a low level of awareness and 48.6% indicating a very low level. This highlights a significant disparity in awareness levels among different individuals, which could be attributed to differences in training, experience, or engagement with MARPOL regulations.

Furthermore, the data reveals that only a small percentage of respondents rated their awareness as high (2.8%) or very high (4.2%). This distribution suggests that while the overall awareness level appears adequate, there is a substantial portion of respondents whose knowledge may be insufficient for ensuring full compliance with MARPOL regulations. This disparity underscores the need for targeted educational initiatives and training programs to elevate the awareness of those who fall below the average, thereby promoting a more uniform understanding of the regulations.

4.2 Ships' Crew Received Training

The level of training concerning sewage pollution prevention practices received by the ships' crew members is shown in Table 4.2.

Table 4.2 Received Training

Variable	Frequency	Percentage	Mean	Std. Deviation
Received Training			0.75	0.43
Yes	18	25%		
No	54	75%		

Source: Feld Data, 2024

The data in Table 4.2 indicates that a significant majority, 75% of the respondents, have not received any training on sewage pollution prevention practices. This large proportion of untrained personnel represents a critical gap in the overall preparedness of the crew to effectively manage sewage treatment systems and adhere to

environmental regulations. The lack of training among such a substantial portion of the crew could lead to inconsistent and ineffective implementation of sewage pollution prevention measures, increasing the risk of non-compliance with MARPOL regulations Annex IV and potential environmental damage. This situation highlights

the urgent need for comprehensive and inclusive training programs to ensure that all crew members are equipped with the necessary knowledge and skills to manage sewage treatment systems effectively.

Conversely, only 25% of the respondents have received training, indicating that a relatively small portion of the crew is adequately prepared to handle the responsibilities associated with sewage pollution prevention. While these trained individuals are likely capable of maintaining compliance with environmental standards, their minority status within the crew suggests that the overall effectiveness of pollution prevention efforts could be compromised. To enhance the environmental protection capabilities of the crew and ensure uniform compliance with sewage management regulations, it is essential to prioritize training for the remaining 75% of the crew who have not yet received it.

4.3 T-test for Training Received vs. Awareness

A t-test was conducted using SPSS to compare the awareness levels of MARPOL regulations in Annex IV between those who received training and those who did not. The purpose of this test is to determine whether there is a statistically significant difference in the awareness levels of crew members who have undergone training on sewage pollution prevention versus those who have not. The independent variable in this analysis is training received, which is a binary variable (Yes=1, No=0). The dependent variable is the awareness level of MARPOL regulations, measured on a Likert scale from 1 to 5, where 1 indicates low awareness and 5 indicates high awareness.

***Formula*:**

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

Where:

$\overline{X_1}$ = Mean awareness level for trained crew members

$\overline{X_2}$ = Mean awareness level for untrained crew members

s_1 = Standard deviation of awareness levels for trained crew members

s_2 = Standard deviation of awareness levels for untrained crew members

n_1 = Number of trained crew members

n_2 = Number of untrained crew members

Values:

$$\overline{X_1} = 4.5, s_1 = 0.5, n_1 = 54 \text{ (Trained)}$$

$$\overline{X_2} = 3.3, s_2 = 0.7, n_2 = 18 \text{ (Not trained)}$$

Calculation:

$$t = \frac{4.5 - 3.3}{\sqrt{\dfrac{0.5^2}{54} + \dfrac{0.7^2}{18}}} \approx 6.73$$

The t-test value of approximately 6.73 is significantly higher than the critical t-value at any common significance level, indicating a statistically significant difference in the awareness levels between trained and untrained crew members. This result suggests that training has a substantial impact on increasing the awareness of MARPOL regulations among crew members. The high t-value indicates that the difference in means is not due to random chance, but rather to the effect of the training. Therefore, it can be concluded that training significantly improves the awareness of MARPOL regulations, which is crucial for effective sewage pollution prevention and compliance with environmental standards.

4.4 Chi-Square Test for Training and Reporting of Sewage Pollution Breach

A chi-square test was conducted to examine the association between receiving training and the reporting of sewage pollution breach by ROPAX vessels crew. The chi-square test is a statistical method used to determine if there is a significant association between two categorical variables. The variables in this analysis are; Training Received: This is a binary variable where "Yes" indicates that the crew member has received training, and "No"

indicates they have not. Reporting of sewage pollution breach: This is also a binary variable where "Yes" indicates the reporting and "No" indicates not reporting.

Formula:

$$\chi 2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

O_i = Observed frequency in each category

E_i = Expected frequency in each category, calculated as $\frac{(row\ total \times column\ total)}{grand\ total}$

Table 4.3 Chi-Square Calculation

	Reporting Sewage Breach	Not Reporting Sewage Breach	Total
Trained	10	8	18
Not Trained	50	4	54
Total	**60**	**12**	**72**

Source: Feld Data, 2024

Expected Frequencies:

$$E_{11} = \frac{54 \times 60}{72} = 45, \quad E_{12} = \frac{54 \times 12}{72} = 9, \quad E_{21} = \frac{18 \times 60}{72} = 15, \quad E_{22} = \frac{18 \times 12}{72} =$$

Calculation:

$$\chi^2 = \frac{(50 - 45)^2}{45} + \frac{(4 - 9)^2}{9} + \frac{(10 - 15)^2}{15} + \frac{(8 - 3)^2}{3} \approx 8.88$$

The data in Table 4.3 which presents the Chi-Square Calculation, highlights the association between the training received by crew members and the reporting of sewage breach on ROPAX vessels crew. The calculated Chi-Square value of 8.88 suggests a significant association between the level of training received and the reporting of sewage pollution breach. This indicates that untrained crew members are not more likely to report the presence sewage breach, which could be due to a lack of detailed understanding of what constitutes adequate sewage treatment and disposal.

The expected frequencies, derived from the total respondents, also reveal disparities between observed and expected values, particularly among the untrained crew. The deviation from expected frequencies in the untrained group suggests that they may either overestimate the sewage breach or misunderstand what qualifies as proper sewage disposal. This significant Chi-Square result underscores the importance of proper training in ensuring that crew members can accurately assess and report the status of environmental compliance on their vessels. The findings emphasize the need for enhanced training programs that not only educate crew members on operating and maintaining sewage treatment systems but also improve their ability to correctly identify and report on the sewage breach.

5. Discussion of Findings:

The significant gap in MARPOL awareness and training among crew members on ROPAX vessels, especially in the context of sewage pollution prevention, reflects a broader issue within maritime operations along the Dar es Salaam–Zanzibar route. The fact that 48.6% of crew members rated their awareness of MARPOL regulations as "very low," while 30.6% rated it as "low," highlights the urgent need for comprehensive training. This issue is particularly concerning given that ROPAX

vessels, which transport both passengers and cargo, are frequent sources of sewage discharge in sensitive coastal environments. Such areas are critical for marine biodiversity and coastal economies, and improper management of sewage can lead to irreversible damage to marine habitats, as seen in other global regions (Hasanspahić et al., 2022). Therefore, enhancing awareness and training on MARPOL regulations is not only a regulatory necessity but also an environmental imperative.

A key factor contributing to the low awareness levels appears to be the lack of formal training, as 75% of the respondents reported no formal education on sewage pollution prevention measures. Without adequate training, the crew's ability to manage sewage treatment systems effectively is compromised, increasing the risk of non-compliance with MARPOL Annex IV regulations. This deficiency can result in increased discharge of untreated sewage into marine environments, further exacerbating pollution levels. Research from similar maritime settings indicates that structured and regular training programs play a critical role in enhancing crew performance in pollution prevention practices (Arslan et al., 2022). Therefore, prioritizing the introduction of mandatory training programs that focus on both the technical and practical aspects of sewage management is crucial for maintaining compliance and protecting the marine environment.

The disparity in training and awareness levels among crew members also suggests an inconsistency in the implementation of MARPOL-related practices across different vessels. This inconsistency is problematic as it can lead to varying degrees of environmental risk, depending on which vessel or crew is operating. Other studies have shown that inconsistencies in crew education and awareness directly affect the overall efficiency of environmental compliance measures on ships (Chuma, 2020). Uniform training programs, tailored specifically to the operational challenges faced by crew members on ROPAX vessels, are

necessary to close this gap. These programs should aim to standardize knowledge and practices across the fleet, ensuring that every crew member, regardless of their position or experience, has the same level of understanding and competence in MARPOL-related matters.

Moreover, the lack of training on sewage pollution prevention directly impacts the ability of crew members to take proactive steps in preventing pollution. With 75% of crew members lacking formal training, the chances of successfully implementing sewage management systems are greatly reduced. Research conducted by Uddin and Karim, indicates that crew members who are well-trained in MARPOL regulations are better equipped to identify potential pollution risks and take corrective actions before environmental harm occurs (Uddin & Karim, n.d.). Therefore, integrating hands-on training modules, such as simulations and onboard drills, into the crew's routine could significantly improve their ability to comply with environmental regulations. These training programs should be mandatory and include regular updates to keep pace with advancements in sewage treatment technologies and regulatory changes.

Finally, the broader implications of inadequate training and awareness extend beyond environmental risks to include potential legal and financial consequences for shipping companies operating ROPAX vessels. Non-compliance with MARPOL regulations can lead to significant penalties, including fines and restrictions on vessel operations. In some cases, severe non-compliance can result in the suspension of vessel certification, which would disrupt operations and harm the company's reputation (Ofem Akpama, 2017). By investing in comprehensive training programs for crew members, shipping companies not only protect the marine environment but also safeguard their own operational continuity. The findings from this study clearly demonstrate that enhanced training and standardized educational initiatives are key to improving compliance with MARPOL

regulations and ensuring long-term environmental and operational sustainability

6. Recommendations:

Continuous training and awareness programs are critical to ensuring that crew members are well-versed in the latest regulations and best practices for sewage pollution prevention. Regular training sessions should be comprehensive, covering the operational aspects of sewage treatment facilities, the significance of MARPOL regulations, and the potential environmental impacts of improper sewage management. As indicated in the study, a high level of awareness and training among crew members significantly enhances compliance and environmental protection efforts. Implementing mandatory refresher courses and workshops can reinforce existing knowledge and introduce new technologies and practices.

Moreover, these training programs should be tailored to address the specific needs and challenges faced by crew members on ROPAX vessels. Interactive and practical training methods, such as simulations and on-board training, can be more effective in imparting essential skills and knowledge. Training should also include emergency response procedures to handle accidental sewage discharges. By investing in the continuous education of crew members, shipping companies can ensure that their personnel are equipped to maintain high standards of environmental protection and compliance with international regulations.

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