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The Role of Pakistani Seafarers in Sustainable Marine Waste Management, Exploring Challenges

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Introduction

The marine industry is a vital component of the global economy, serving as the backbone of international trade by facilitating the movement of goods across seas. Central to this industry are seafarers, who play an indispensable role in ensuring the smooth operation of shipping activities. However, the rapid expansion of human activity and industrial operations has led to significant environmental challenges, particularly in the marine environment. Among these, the improper disposal of waste in marine ecosystems has emerged as a critical issue, posing severe threats to biodiversity and ecological balance. For countries with extensive coastlines, such as Pakistan, the dangers are particularly pronounced. Pakistan faces increasing risks to its coasts and marine environments due to escalating pollution levels, necessitating immediate and effective interventions. The country's maritime sector, including its seafarers, bears a significant responsibility to combat these challenges by adopting and implementing environmentally sustainable waste management systems (Kamis et al., 2020).

Sustainable marine waste management involves a multifaceted approach to minimizing waste generation, ensuring the proper disposal of waste, and educating maritime personnel on eco-friendly practices. A critical instrument in this regard is MARPOL, which stands for Marine Pollution, a comprehensive legal framework developed by the International Maritime Organization (IMO). MARPOL provides guidelines and standards for controlling pollution from ships, thereby equipping seafarers with the necessary protocols to mitigate marine waste effectively. By actively engaging Pakistani seafarers in adhering to MARPOL standards and other sustainable practices, the country not only safeguards its marine ecosystems but also elevates the global perception of its maritime industry. Sustainable practices in waste management can enhance Pakistan's standing in the international shipping community, reflecting its commitment to environmental stewardship and global marine conservation efforts (Abirami, 2024).

Additionally, the study intends to assess how such practices influence seafarers' job satisfaction, recognizing that job contentment often correlates with a sense of purpose and alignment with ethical work standards. Moreover, the research underscores the significance of Pakistani seafarers in contributing to the sustainable management of existing waste while emphasizing their potential to act as catalysts for broader

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ecological reforms within the maritime sector (Abirami, 2024).

The integration of sustainable practices within the maritime sector not only benefits the environment but also has far-reaching socio-economic impacts. For Pakistani seafarers, embracing sustainable waste management practices can lead to the development of a more resilient and competitive maritime industry. This, in turn, can create new opportunities for economic growth, enhance job security, and foster a culture of environmental responsibility. Moreover, as global awareness of environmental issues continues to rise, the demand for sustainable maritime practices is likely to increase. By positioning themselves as leaders in this area, Pakistani seafarers can play a crucial role in shaping the future of the country's maritime sector (Ullah et al., 2021).

The marine industry faces a growing imperative to address the challenges of waste management and environmental sustainability. For Pakistan, a country with a vulnerable coastline and an emerging maritime sector, the role of seafarers in sustainable waste management cannot be overstated. This study aims to shed light on their contributions, challenges, and potential in promoting eco-friendly practices within the maritime domain. By empowering seafarers with the knowledge, skills, and resources needed for effective waste management, Pakistan can take significant strides toward safeguarding its marine ecosystems while strengthening its position as a responsible and sustainable maritime nation. Through a combination of strategic interventions, capacity-building efforts, and policy reforms, the country's seafarers can emerge as key drivers of environmental sustainability in the global marine industry.

Problem Statement

Pakistan's coastal waters face a growing threat due to poor waste management practices, particularly in the marine industry. The unchecked disposal of waste from ships, lack of awareness, and inadequate enforcement of international environmental standards exacerbate marine pollution (Abirami, 2024). Pakistani seafarers play crucial role in ensuring sustainable marine waste management, but their engagement in sustainable practices has been underexplored.

The relationship between sustainable waste management and seafarers' job satisfaction has not been thoroughly studied. This study aims to provide a comprehensive understanding of how Pakistani seafarers can be better equipped to take a more active role in marine sustainability.

Objectives

RO1: To determine Pakistani seafarers' current knowledge and role of marine waste management.

RO 2: To identify the relationship between sustainable waste management and seafarers' job satisfaction.

RO3: To identify challenges faced by Pakistani seafarers in sustainable marine waste management.

Rationale of the Study

The study addresses marine pollution, which has both local and global implications, and aims to provide valuable insights into how to enhance their contribution to sustainable marine waste management. It also fills a gap in the literature concerning the role of seafarers in environmental sustainability, specifically in Pakistan. While much research has been conducted on global marine waste management and the role of seafarers, there is limited information on how Pakistani seafarers are contributing to these efforts. This study provided a country-specific

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perspective, highlighting the unique challenges faced by Pakistani maritime workers and the opportunities for improvement.

Industrial Applications

The research on "The Role of Pakistani Seafarers in Sustainable Marine Waste Management in Pakistan: Exploring Challenges" has significant industrial applications, particularly in the maritime, shipping, and waste management sectors. The insights gained from this study can be instrumental in enhancing operational efficiency and improving environmental compliance.

One of the primary industrial applications of this research is its relevance to improving environmental compliance among shipping companies. Compliance with international maritime regulations such as the MARPOL Convention is critical for companies operating in international waters. By addressing knowledge gaps and challenges Pakistani seafarers face in managing waste, shipping companies can improve their compliance strategies and foster a culture of sustainability.

Sustainable waste management practices can potentially improve operational efficiency within the maritime industry. Efficient waste management systems on ships can reduce waste generation, minimize disposal costs, and improve resource utilization. The research highlights how seafarers can contribute to optimizing waste management operations leading to more cost-effective practices(Ringbom,2020).

Research Methodology

This research directly supports the goals of green shipping by identifying how seafarers can contribute to more sustainable waste management practices on ships. The study can inform the development of policies and programs aimed at reducing the use of single-use plastics on ships, improving the handling of hazardous waste, and promoting the use of biodegradable materials.(Gulseven, 2020).

This study adopts a quantitative approach to examine the role of Pakistani seafarers in sustainable marine waste management. Through structured questionnaires distributed to 100 respondents, the research assesses seafarers' knowledge, perceptions, and challenges in implementing sustainable waste practices. The survey, designed with closed-ended Likert scale questions, ensures standardized responses for statistical analysis. Additionally, a SWOT analysis evaluates internal and external factors affecting waste management adoption, providing strategic insights into opportunities and barriers within the maritime sector. Convenience sampling was used to recruit participants from major ports like KPT and Gwadar, with maritime unions and training institutions facilitating outreach.

Data analysis was conducted using SPSS, employing descriptive statistics such as frequencies, percentages, mean, and standard deviation to summarize responses. Correlation analysis, using Pearson's coefficient, explored relationships between variables like seafarers' knowledge, attitudes, and job satisfaction. The findings highlight how awareness of marine waste regulations influences perceptions and operational challenges, offering insights into enhancing sustainability practices in maritime operations.

Demographic Analysis

The age distribution of the respondents, as demonstrated in the graph, reveals that the majority (52.8%) fall within the age group of 36 to 45 years, showing a considerable representation of mid-career professionals.

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This is followed by the 26 to 35 age group, which accounts for 38%, showing a significant proportion of younger seafarers actively contributing to the crew. The 18 to 25 age group comprises 6.5%, reflecting a smaller segment of entry-level professionals, while only 2.8% of respondents are aged 46 and above, highlighting limited participation from senior or late-career individuals. These findings underscore a workforce primarily composed of mid-level and early-career seafarers, as shown in Figure 1.

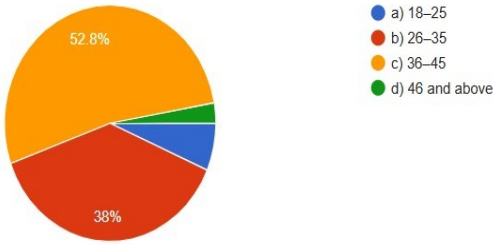

Figure 1 Age distribution of the respondents working in the marine environment

Figure 2 showed the distribution of respondents in terms of their professional experience, it has been found that most of the respondents 73.1% had professional training of 10 years or less which clearly states that most of the respondent have started their professional careers. However, 11-20 years of working experience was reported by only 20.4% of the respondents which indicates that mid-career seafarers are also present but in a small number. These results describe a high density of relatively inexperienced professionals in the maritime sector, together with a rather significant number of experienced ones. This also indicates a trend in younger generation to adapt the marine related profession.

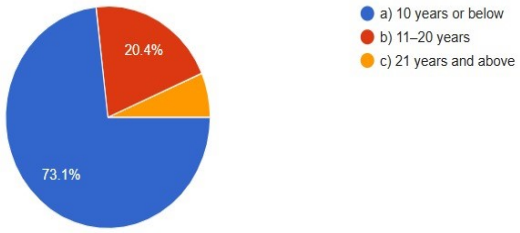

Figure 2 Pie chart of experience distribution

In Figure 3 the graph demonstrating the allocation by experience of the respondents represents that 71.4% of the respondents are engine officers emphasizing their important job in the maritime workforce. Deck officers account for 11.4%, and they are the minority of the other related professionals whose specialty is in the navigation of ships and other related operations. Furthermore, the crew members are 17.1% which means that the companies have relatively involved people performing support and maintenance duties. These distributions discuss the distinct tasks of engine officers in marine works, at the same time promoting the sections that involve deck officers and crew members.

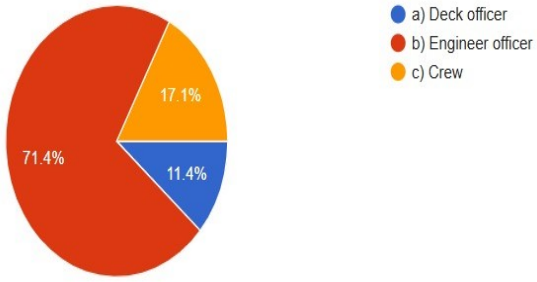

Figure 3 Pie chart of job role distribution

Knowledge of Sustainable Marine Waste Management SMW

Figure 4 shows the familiarity with MARPOL regulations related to marine waste management across different job roles. Engineer Officers have the highest level of familiarity, with 76.47% strongly agreeing. Desk Officers have moderate

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familiarity, with 39.06% strongly agreeing and 13.89% agreeing. However, 16.67% strongly disagree and another 16.67% disagree, indicating a considerable percentage with lower awareness. Crew members have moderate familiarity, with 25% strongly agreeing and 22.92% agreeing. A significant portion with limited knowledge is indicated by 39.58% strongly disagreeing or disagreeing. These percentages revealed the variation in understanding of MARPOL regulations.

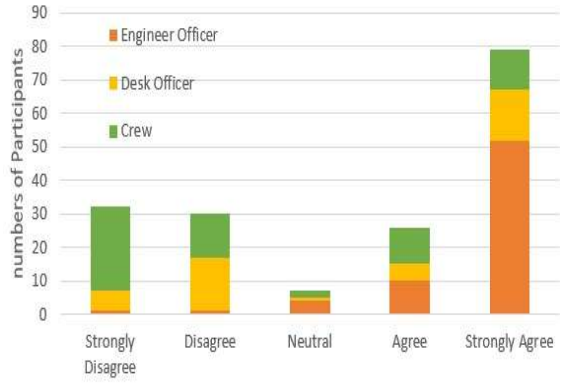

Figure 4 Knowledge of Participants about MARPOL related to SMW

Onboard Waste Segregation Practices

Figure 5 illustrates follow-up waste segregation practices on board, A small proportion of respondents (5%) strongly disagree, indicating minimal non-compliance with waste segregation practices. A slightly larger group (10%) disagree, suggesting some reluctance or inconsistency in adhering to these practices. The majority of respondents are neutral (30%) or agree (30%), reflecting a significant number of individuals who either follow waste segregation practices inconsistently or are uncertain about their regularity. Additionally, 20% of respondents strongly agree, showing a solid commitment to waste segregation. The chart revealed a positive attitude toward waste segregation practices on board.

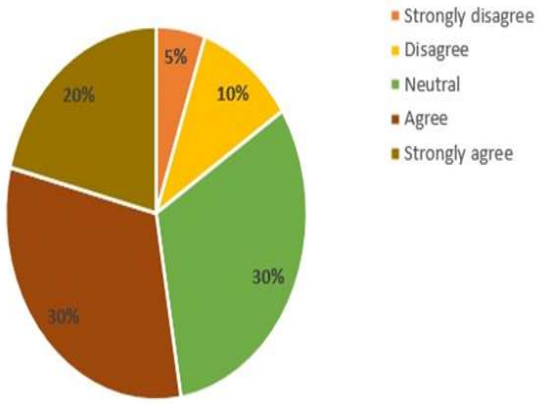

Figure 5 Follow-up waste segregation practices on board

Job Role-Based Requirement for Sustainable Marine Waste Management Training

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Figure 6 illustrates the distribution of responses regarding the need for sustainable marine waste management training across different job roles. Among Engineer Officers, 51.47% agree or strongly agree that training is necessary. Desk Officers show a higher level of support, with 62.5% agreeing or strongly agreeing, reflecting a significant endorsement for training. Crew members exhibit the strongest demand for training, with 83.34% agreeing or strongly agreeing, indicating a clear need for sustainable marine waste management education within this group.

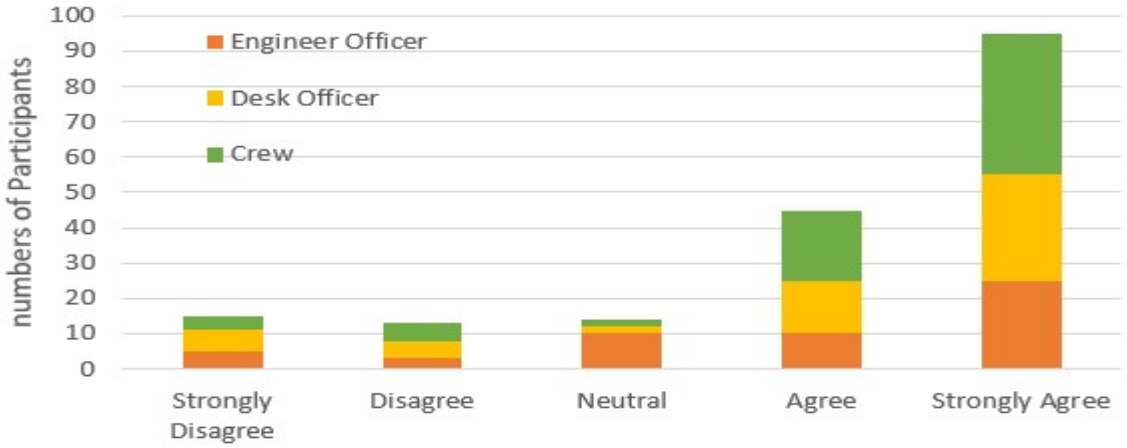

Figure 6 SMW training requirement based on job role

Descriptive statistics of variables

Table 1 presents the mean and standard deviation of key variables related to sustainable marine waste management (SMW) practices. Seafarers show high familiarity with MARPOL regulations (M = 4.1, SD = 0.8) and strong participation in waste segregation (M = 4.2, SD = 0.7). However, job satisfaction is moderate (M = 3.7, SD = 0.9), and access to proper waste management tools at ports is low (M = 2.8, SD = 1.2), indicating significant challenges. The highest consensus is on the need for SMW training (M = 4.5, SD = 0.6), while managerial support remains mixed (M = 3.2, SD = 1.0). These findings highlight strengths in regulatory awareness and waste segregation but emphasize the need for better infrastructure and management involvement.

Table 1 Descriptive Statistics of Variables

Variable	Mean (M)	Standard Deviation (SD)
Knowledge with MARPOL Regulations	4.1	0.8
Job Satisfaction Score	3.7	0.9
Participation in Waste Segregation	4.2	0.7
Access to Proper Waste Management Techniques	2.8	1.2
Training Needs in SMW	4.5	0.6
Managerial Support for SMW	3.2	1.0

Statistical analysis

The study reveals significant correlations among knowledge of marine waste

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management, job satisfaction, sustainable waste management, and challenges in implementation, offering insights aligned with the research objectives. For RO1, knowledge of marine waste management strongly correlates with sustainable waste management (0.81) and challenges in implementation (0.72), indicating that well-informed seafarers are more engaged in sustainable practices but face complexities in execution. Regarding RO2, a moderate positive correlation (0.701) between job satisfaction and sustainable waste management suggests that sustainable practices enhance job fulfillment, reflecting alignment with environmental values. For RO3, challenges in implementation show moderate correlations with both sustainable waste management (0.721) and job satisfaction (0.73), highlighting how these obstacles may impact seafarers' satisfaction and their ability to adopt sustainable practices effectively, shown in Table 2.

Table 2 Correlation

Correlations

		Knowledge of Marine waste Management	Job satisfaction	Sustainable waste Management	Challenges in implementation
Knowledge of Marine waste Management	Pearson Correlation	1	.75	.81	.72
	Sig. (2-tailed)		.658	.761	.655
	N	100	100	100	100
Job satisfaction	Pearson Correlation	.75	1	.701	.73
	Sig. (2-tailed)	.658		.683	.551
	N	100	100	100	100
Sustainable waste Management	Pearson Correlation	.81	.701	1	.721
	Sig. (2-tailed)	.761	.683		.647
	N	100	100	100	100
Challenges in implementation	Pearson Correlation	.72	.73	.721	1
	Sig. (2-tailed)	.655	.551	.647	
	N	100	100	100	100

Challenges related to Marine waste management

The Table 3, shows some answers concerning different issues related to the marine waste problems. Concerning the aspect of time and resources not well allocated to waste management during operations, 86% responded either in

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agreement or strong agreement since this is recognized as a major challenge. 4% strongly disagree or disagree and 10% are neutral. Consistent with this, the percentage of the respondents in relation to the statement 'Limited access to proper waste disposal facilities at ports' indicates that respondents agreed or strongly agreed that there is limited access at the ports to proper ways of disposing wastes, 90 percent to be precise. Insufficient backing of management in enforcing sustainable waste management practices is also a problem, with 90% of the respondents agreeing or strongly agreeing to the statement above underlining the role of managerial support for sustainable practice. With regard to SWM awareness and training, 86% of responses indicated agreement or strong agreement in this area, and this shows that a lack of knowledge and training are major issues. There are 78% agree or strongly agree with the statement that there is lack of clear guidelines and regulations on SWM, need to have better guidance in SMW practices. This study shows that time, resources, facilities, management support, training, and regulations are the significant factors determining the view of marine waste management.

Table 3 Response about challenges in SWM adoption

Challenges	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Insufficient time and resources are allocated to waste management tasks during operations	2%	2%	10%	65%	21%
Limited access to proper waste disposal facilities at ports hinders effective waste management	3%	5%	2%	25%	65%
Inadequate support from management for implementing sustainable waste management practices	2%	5%	3%	20%	70%
Lack of awareness and training on SWM	5%	8%	1%	21%	65%
Lack of clear guidelines and regulations on SWM	1%	9%	12%	38%	40%

SWOT Analysis: Evaluating Pakistani Seafarers' Role in Sustainable Marine Waste Management

Pakistani seafarers play a crucial role in sustainable marine waste management, influenced by internal strengths and weaknesses as well as external opportunities and threats. Their adaptability, resilience, and basic knowledge of MARPOL regulations, particularly among Engineer Officers, provide a strong foundation for compliance. Additionally, their willingness to engage in sustainability training and exposure to global shipping environments enhance their understanding of best practices. However, inconsistencies in MARPOL familiarity, particularly among junior crew members, alongside limited onboard resources and managerial support, hinder effective waste management implementation. The absence of clear guidelines further contributes to varying compliance levels.

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Opportunities arise from increasing global focus on environmental sustainability, IMO regulations, and access to training programs that integrate emerging technologies for waste management. Collaborations between maritime organizations and environmental groups also provide valuable resources. However, challenges such as inadequate port waste disposal facilities, financial constraints, and resistance to change within the industry threaten sustainable practices. Economic and geopolitical instabilities further divert attention from sustainability efforts. Addressing these issues requires improved training, enhanced infrastructure, and stronger enforcement mechanisms to ensure consistent and effective marine waste management.

Results

The study explores key aspects of sustainable marine waste (SMW) education and practices onboard, highlighting training needs, knowledge gaps, and operational challenges. While seafarers demonstrate varying levels of MARPOL regulation awareness, Engineer Officers show the highest comprehension due to their direct involvement in waste management. In contrast, Desk Officers and junior crew members display inconsistent knowledge, emphasizing the need for targeted training.

Waste segregation practices receive mixed adherence, with many seafarers showing commitment, yet operational barriers such as unclear guidelines and insufficient managerial support hinder consistent implementation. The demand for SMW training is high across all ranks, underlining the necessity for role-specific programs to enhance competency.

The study finds a strong correlation between knowledge, job satisfaction, and sustainable waste management, reinforcing the importance of training. However, challenges persist, including resource constraints, inadequate waste disposal facilities at ports, and limited managerial commitment. Addressing these issues requires institutional support, infrastructure investment, and stricter enforcement of waste management policies to ensure compliance and environmental sustainability in the maritime sector.

Conclusion

The marine industry's environmental conservation remains crucial, and effective marine waste management is one of the most important parts of it. As previously mentioned, this research exposes knowledge, training, and resources gaps that impede compliance with MARPOL laws. While Engineer Officers have a satisfactory level of awareness, Desk Officer and Crew Member familiarity is significantly less, which necessitates their training.

Unsatisfactory port facilities, insufficient management support, and unsystematic policies are challenges that impede sustainable waste practices. These barriers need to be resolved by unifying training, organizational commitment, and well-defined instructions to improve compliance and effective waste management.

Recommendations

i. Role Specific Training: Create focused MARPOL inductions for all staff members.

ii. Operational Prioritization: Dedicate adequate time and effort towards waste segregation and disposal.

iii. Infrastructure Investment: Port waste disposal sites should be upgraded to comply with international standards.

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iv. Managerial Support: Leadership commitment towards sustainability needs to be encouraged.

v. Clear Policies: Simple and straightforward guidelines needs to be formulated for waste management so that employees can comply.

vi. Monitoring & Evaluation: Continuous assessment and feedback systems to improve practices need to be put in place.

vii. Strong environmental responsibility and long-term sustainability from a maritime perspective can be achieved by addressing such issues.

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