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Assessing Ship Agency Procedural Management for Marine Waste Handling in Pelindo Marine Service Ports

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ABSTRACT

Purpose of the study: This study aims to assess the effectiveness of ship agency procedural management for marine waste handling implemented by PT Pelindo Marine Service (PMS) in compliance with international and national maritime environmental standards.

Materials and methods: A descriptive qualitative approach was employed utilizing a case study design. Data were collected via structured in-depth interviews with 48 purposively selected participants comprising ship agency officers, port waste management personnel, and ship representatives operating across Pelindo Marine Service branch ports. Triangulated data sources encompassed field observations, documentation analysis of Standard Operating Procedures (SOPs), and official port logbooks. Inductive thematic analysis following the (B & Michael, 1994) framework was applied. Risk assessment conformed to AS/NZS 4360:2004 methodology. Ethical clearance was obtained from the Karimun University Research Ethics Committee (Ref. No. KU-REC/2025/014).

Results: Findings reveal that PT PMS has established a five-stage waste disposal procedure aligned with MARPOL 73/78 and ISO 14001:2015; however, critical operational gaps persist. A risk matrix analysis identified 14 hazard categories across five procedural stages, with 6 categorised as high-risk. Facility capacity shortfalls were documented at 67% of branch ports, and crew waste segregation awareness was rated low by 58.3% of respondents. Manual documentation systems contributed to a 23% administrative error rate.

Conclusions: PT PMS demonstrates satisfactory regulatory compliance at the procedural framework level, yet significant implementation deficits undermine environmental outcomes. Digital transformation of waste documentation, expansion of port reception facilities, and systematic crew environmental education are urgently recommended to achieve full Green Port certification standards.

Keywords
ship agency management; marine waste handling; MARPOL 73/78; environmental compliance; port waste reception; occupational health and safety; Green Port.

INTRODUCTION

Global maritime trade generates an estimated 6.3 million tonnes of ship-generated waste annually, presenting substantial threats to marine ecosystem integrity and necessitating robust port-based waste management governance (Mohite & Mathew, 2025; Ülker et al., 2023). Ports, as critical nodes in the maritime supply chain, bear regulatory responsibility not only for cargo operations but also for the environmentally compliant reception, collection, and disposal of waste generated by vessels during transit and berthing (Notteboom et al., 2021; Saputra & Christin, 2024). In the Indonesian archipelagic context, where over 17,000 islands are interconnected through intensive coastal shipping, the management of ship-generated waste assumes particular urgency given the ecological fragility of tropical marine ecosystems.

PT Pelindo Marine Service (PMS), a wholly owned subsidiary of PT Pelabuhan Indonesia (Persero), occupies a strategic position in this governance landscape. Operating as a ship agency entity across multiple Indonesian port facilities, PT PMS serves as the operational intermediary between vessel owners, port authorities, and waste management contractors. This tripartite coordinating role encompasses administrative representation, logistics facilitation, and crucially, the management of marine waste in compliance with applicable international conventions and national regulations (Kuncowati et al., 2022; Mohite & Mathew, 2025).

Indonesia's maritime regulatory framework governing ship waste management derives from the International Maritime Organization's (IMO) MARPOL 73/78 Convention, encompassing Annexes I through V covering oil, noxious liquid substances, packaged harmful substances, sewage, and garbage respectively. These obligations are transposed into national law through Ministerial Regulation PM Number 58 of 2013 on Prevention of Pollution from Ships, complemented by ISO 14001:2015 Environmental Management System requirements adopted voluntarily by certified port operators (Latief et al., 2021; Notteboom et al., 2021). Effective ship agency procedural management is therefore not merely an operational consideration but a compliance imperative with legal, environmental, and reputational dimensions.

Critical Examination of Existing Literature

Scholarly inquiry into maritime waste management has generated a substantial body of evidence highlighting systemic

challenges across diverse port contexts. Ülker et al. (2023) developed an analytical methodology to evaluate Waste Reception Performance (WRP) across Istanbul ports, identifying infrastructure deficits and inter-agency coordination failures as primary performance determinants (Özbay et al., 2024). This methodological contribution informs the present study's analytical framework for assessing procedural effectiveness.

At the ship-level dimension, Kuncowati et al. (2022) proposed a safety and crew awareness-based model for onboard waste handling, demonstrating that attitudinal factors and knowledge gaps among maritime crews constitute significant antecedents of non-compliance with disposal procedures. Their longitudinal findings resonate with those of Latief et al. (2021), who examined MARPOL and SOLAS implementation in Indonesian vessels and identified critical weaknesses in crew training curricula and waste segregation practices. Complementarily, Yulianto et al. (2021) empirically assessed the Inaportnet Port Waste Management System at Tanjung Priok Port, documenting a 96% reporting compliance rate across a ten-month monitoring period, while concurrently noting persistent qualitative gaps between reported and actual waste disposal volumes(Mohite & Mathew, 2025).

From an occupational safety perspective, Murtadha & Ratni (2024) conducted a risk analysis of tugboat bunkering operations at PT Pelindo Marine Service, identifying exposure categories that overlap substantially with waste handling risk profiles. Similarly, (Prasetyawati et al., 2024) applied AS/NZS 4360 risk assessment methodology to traditional fishing vessels, establishing a methodological precedent applicable to port-based waste operations. Elizabeth et al. (2024) evaluated Occupational Safety and Health (OSH) Management System implementation in Indonesian shipyard contexts, identifying critical gaps in hazard communication and documentation that are structurally analogous to deficiencies observable in ship waste management environments.

The regulatory dimension of green port development in Indonesia has been examined by (Saputra & Christin, 2024), who assessed green port criteria at Merak Ferry Port, and by Fariya et al. (2019), who investigated sustainable ship recycling facility development. Collectively, these studies underscore the systemic nature of environmental management challenges in Indonesian maritime infrastructure and the need for comprehensive, standards-aligned procedural evaluation (Duffield et al., 2020).

Identification of Research Gaps

Despite the cumulative scholarly attention to maritime waste management, several critical knowledge lacunae persist. First, no published study has comprehensively evaluated the procedural management effectiveness of a ship agency entity—as distinct from port operators or vessel operators—in the Indonesian context. Ship agencies occupy a unique governance position as regulatory intermediaries, yet their specific procedural contributions and constraints in waste management remain largely unexamined. Second, existing quantitative studies predominantly employ single-site methodologies, limiting the generalisability of findings to multi-port operational environments. Third, the integration of occupational safety and health considerations into waste management procedural evaluation represents an underexplored dimension, despite the manifest physical risks associated with waste collection and handling activities. Fourth, the digital transformation potential for administrative documentation in ship waste management has received insufficient empirical attention in emerging maritime economy contexts.

Rationale and Objectives

This study addresses the identified gaps through a comprehensive, multi-method assessment of ship agency procedural management at PT Pelindo Marine Service. The research is motivated by the practical imperative to strengthen maritime environmental governance in Indonesia's growing port sector, and by the scholarly contribution of developing an evaluative framework applicable to ship agency entities across comparable regulatory environments. The specific objectives of this research are: (1) to document and map the existing five-stage ship waste handling procedure implemented by PT PMS; (2) to assess procedural compliance with MARPOL 73/78, PM 58/2013, ISO 14001:2015, and ISO 45001:2018 requirements; (3) to identify and categorise operational constraints and risk factors utilising AS/NZS 4360:2004 risk assessment methodology; (4) to evaluate crew and officer environmental awareness and training adequacy; and (5) to develop evidence-based recommendations for procedural optimisation aligned with Green Port management principles.

MATERIALS AND METHODS

Study Participants

Participants were purposively selected to ensure representation of all key stakeholder categories involved in ship waste management operations at PT PMS. The final study cohort comprised 48 participants distributed across three functional categories: (i) ship agency officers and branch managers (n = 18), responsible for administrative verification and coordination functions; (ii) port waste management and reception facility personnel (n = 20), engaged in operational waste collection, handling, and disposal activities; and (iii) ship representatives and vessel commanders (n = 10), responsible for onboard waste generation and declaration. Demographic profiling of the study cohort revealed a predominance of male participants (89.6%), consistent with the gender composition of the Indonesian maritime workforce. Participant age ranged from 24 to 57 years (mean = 38.4 ± 9.2 years). Professional experience in maritime or port operations ranged from 2 to 31 years (mean = 12.7 ± 6.8 years). Educational attainment spanned Diploma III (41.7%), Diploma IV/Bachelor's (45.8%), and Master's degree (12.5%) levels. Table 1 presents the complete demographic distribution of the study cohort.

Table 1. Demographic Characteristics of Study Cohort (N = 48)

Category	n	%	Age (Mean)	Experience (Years)
Agency Officers	18	37.5	41.2	14.3 ± 7.1
Waste Management Personnel	20	41.7	36.5	11.8 ± 6.2
Ship Representatives	10	20.8	38.0	12.1 ± 7.4
Total	48	100	38.4 ± 9.2	12.7 ± 6.8

Note: Values represent mean ± standard deviation where applicable.

Study Design

This research adopted an exploratory descriptive qualitative approach utilising a multi-site case study design (Yin, 2018). The case study method was selected given its capacity to generate contextually rich, process-oriented evidence regarding the "how" and "why" dimensions of procedural management effectiveness—dimensions that quantitative survey methodologies cannot adequately capture. A cross-sectional observational component supplemented the qualitative strand to enable systematic risk quantification.

Study Organisation and Methodological Framework

Data collection was conducted across three PT PMS branch port locations—selected to represent varying levels of operational scale and waste management infrastructure—over a four-month field research period (August–November 2024). The methodological framework integrated three complementary data collection instruments. First, structured in-depth interviews were conducted utilising a semi-structured interview protocol developed a priori from regulatory documents, the MARPOL convention text, and existing literature. Each interview lasted between 45 and 90 minutes, was audio-recorded with informed participant consent, and transcribed verbatim. Interview transcripts were validated through member checking procedures. Second, systematic non-participant field observations were conducted during operational waste handling activities across all five procedural stages. Observation sessions were documented through standardised field observation checklists aligned with ISO 14001:2015 operational control criteria and AS/NZS 4360:2004 hazard identification requirements. A total of 36 discrete observation sessions were completed. Third, documentation analysis encompassed the review of PT PMS Standard Operating Procedures (SOPs), waste disposal manifest records, Hazard Identification Risk Assessment and Risk Control (HIRARC) documents, port authority correspondence, and daily operational logbooks spanning the preceding 24 months.

The procedural algorithm for implementing the research protocol followed a four-phase sequence: (1) regulatory framework mapping and SOP documentation analysis; (2) stakeholder interview data collection and transcription; (3) field observation and risk assessment data collection; and (4) integrated inductive analysis and recommendation synthesis.

Statistical and Analytical Methods

Qualitative data analysis was conducted inductively following the (B & Michael, 1994) concurrent model of data reduction, data display, and conclusion drawing/verification. Initial open coding of interview transcripts and field observation notes was performed manually, followed by axial coding to identify relational categories, and selective coding to construct overarching theoretical propositions regarding procedural effectiveness. Data validity was ensured through methodological triangulation—cross-referencing interview, observation, and documentary data—and source triangulation by comparing participant accounts across the three stakeholder categories. Negative case analysis was employed to test the robustness of emerging interpretive categories.

Risk assessment data were analysed quantitatively using the AS/NZS 4360:2004 risk matrix methodology. Each identified hazard was assigned Likelihood (L) and Consequence (C) ratings on five-point ordinal scales, generating a composite Risk Rating (R = L × C) classified as Low (1–4), Moderate (5_9), High (10–179), or Extreme (15–25). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed for participant demographic data using SPSS Statistics Version 26.0.

Ethical Considerations

This study received full ethical approval from the Karimun University Research Ethics Committee (Reference Number: KU-REC/2025/014, approved 15 July 2025). All procedures were conducted in strict accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and applicable Indonesian national research ethics regulations (Peraturan Menteri Kesehatan No. 11 Tahun 2017). Written informed consent was obtained from all participants prior to their involvement in any data collection activity. Participants were explicitly informed of their right to withdraw without consequence at any stage of the research. All personal identifying information was anonymised using alphanumeric codes in the research record. No vulnerable populations were included in the study cohort. Audio recordings and transcripts are stored in password-protected archives accessible only to the principal investigators.

RESULTS

Procedural Framework Mapping

Documentary analysis confirmed that PT PMS implements a five-stage standard operational procedure for ship waste management, as detailed in Table 2. The procedure spans from initial waste disposal request submission through final reporting to port authority. This framework was found to be formally documented and internally distributed across all branch locations, constituting a regulatory-compliant procedural skeleton.

Table 2. PT Pelindo Marine Service Ship Waste Handling Procedural Stages

Stage	Procedure	Regulatory Reference	Key Stakeholders
1	Waste disposal application submission by vessel	MARPOL Annex V, Reg. 7; PM 58/2013 Art. 12	Ship Master, Ship Agent
2	Document verification by agency officer	MARPOL Annex I, Reg. 17; ISO 14001:2015 §8.1	Agency Officer, KSOP Authority
3	Coordination with waste reception facility operator	MARPOL Annex V, Reg. 7(2); IMO Res. MEPC.244(66)	Agency Officer, Facility Manager
4	Waste collection and disposal implementation	MARPOL 73/78 Annexes I–V; ISO 45001:2018 §8.1.2	Waste Contractor, Port Personnel
5	Reporting to port authority (KSOP/Inaportnet)	PM 58/2013 Art. 24; Inaportnet Circular 2020	Agency Officer, KSOP Authority

KSOP = Port Authority; PM = Ministerial Regulation; IMO = International Maritime Organization.

Regulatory Compliance Assessment

Cross-referencing the documented SOP against applicable regulatory requirements revealed an overall procedural compliance rate of 78.3% at the framework level. Stages 1, 2, and 5 demonstrated high textual alignment with MARPOL provisions and PM 58/2013 requirements. However, Stage 4 (waste collection and disposal) exhibited the lowest compliance rating (61.2%), primarily attributable to documented shortfalls in physical infrastructure and waste segregation implementation. Only 33.3% of branch ports reviewed possessed reception facility capacity sufficient to accommodate peak daily waste volumes as required under MARPOL Annex V, Regulation 7. Compliance with ISO 14001:2015 was assessed across the five operational control clauses most directly relevant to waste management (Clauses 8.1 through 8.2). PT PMS achieved full compliance on Clause 8.1 (Operational Planning and Control) at its primary port facility but demonstrated partial compliance (55–70%) at branch facilities. ISO 45001:2018 compliance assessment identified critical gaps in hazard communication (Clause 8.2.4) and emergency preparedness procedures (Clause 8.2) across all surveyed locations, consistent with the findings of (Nainggolan & Hendra, 2023).

Risk Assessment Findings

The AS/NZS 4360:2004 risk matrix analysis identified a total of 14 discrete hazard categories across the five procedural stages. Table 3 presents the risk classification results.

Table 3. AS/NZS 4360:2004 Risk Assessment Results by Procedural Stage

Stage	Hazard Category	Likelihood (L)	Consequence (C)	Risk (L×C)	Risk Level
1	Incomplete waste declaration documents	4	3	12	High
2	Verification delays – administrative backlog	3	2	6	Moderate
3	Inadequate reception facility capacity	4	4	16	High
3	Inter-agency coordination failure	3	4	12	High
4	Worker exposure to hazardous chemical waste	4	5	20	Extreme
4	Inadequate Personal Protective Equipment (PPE)	3	4	12	High
4	Waste leakage to port water during transfer	3	5	15	Extreme
5	Inaccurate or delayed waste reporting	4	3	12	High

Risk Level: Low (1–4); Moderate (5_9); High (10–14); Extreme (15–25). Source: AS/NZS 4360:2004.

Two hazard categories were classified as Extreme risk: worker exposure to hazardous chemical waste (R = 20) and waste leakage to port waters during transfer operations (R = 15). Six categories received High risk ratings (R = 10–14), encompassing documentation deficiencies, facility capacity shortfalls, inter-agency coordination failures, inadequate PPE provision, and reporting inaccuracies. These findings are consistent with the hazard profiles documented by (Murtadha & Ratni, 2024) in adjacent bunkering operations at PT PMS facilities.

Operational Constraint Analysis

Interview-derived data identified four primary operational constraint clusters. First, infrastructure deficits: 67% of branch port respondents reported that waste reception facility capacity was insufficient to accommodate daily waste volumes from calling vessels during peak traffic periods, necessitating ad hoc containment arrangements that increase leakage risk. Second, crew awareness and segregation non-compliance: 58.3% of agency officer respondents rated vessel crew awareness of MARPOL waste segregation requirements as “low” or “very low,” with oil sludge and domestic waste streams most frequently found co-mingled at reception, creating hazardous material handling complications (Kuncowati et al., 2022). Third, manual documentation vulnerabilities: analysis of 24 months’ waste disposal manifest records identified a 23% rate of incomplete or erroneous entries attributable to manual data capture processes, consistent with the digitalisation gaps identified by (Yulianto et al., 2021). Fourth, multi-agency coordination latency: average elapsed time from waste disposal application submission (Stage 1) to collection commencement (Stage 4) was documented at 4.8 hours, with coordination delays between PT PMS, KSOP, and contracted waste management operators identified as the principal causal factor.

DISCUSSION

Interpretation of Research Outcomes

The principal finding of this study—that PT Pelindo Marine Service demonstrates satisfactory procedural compliance at the documentation level yet exhibits significant implementation gaps in operational execution—reflects a widely documented phenomenon in maritime environmental governance: the “paper compliance” paradox, wherein regulatory adherence at the procedural framework level does not translate to commensurate environmental outcomes in practice (Kuncowati et al., 2022; Ülker et al., 2023). This paradox is structurally generated by the asymmetry between the formalistic requirements of MARPOL and national regulatory instruments—which primarily assess documentary evidence—and the operational realities of port waste management, which are shaped by infrastructure constraints, workforce training adequacy, and real-time coordination capacity (Argüello, 2020; Mohite & Mathew, 2025).

The identification of two Extreme-risk hazard categories—hazardous chemical waste exposure and port water contamination during transfer—corroborates the risk severity assessments documented by (Murtadha & Ratni, 2024) in bunkering operations and by (Prasetyawati et al., 2024) in traditional fishing vessel contexts. The elevation of these hazards to Extreme classification reflects a convergence of high likelihood of occurrence (attributable to infrastructure shortfalls and inadequate PPE provision) with potentially catastrophic consequences for worker health and marine ecosystem integrity (Atacan et al., 2023). Critically, these findings indicate that the existing HIRARC documentation maintained by PT PMS—while formally compliant with Government Regulation No. 50 of 2012—has not translated into effective operational risk reduction.

Comparison with Antecedent Studies

The 78.3% framework compliance rate documented in this study compares favourably with findings from comparable

emerging maritime economy contexts. Yulianto et al. (2021) documented a 96% waste reporting compliance rate at Tanjung Priok Port, the most developed Indonesian port facility, suggesting that infrastructural maturity strongly mediates compliance outcomes(Maskun et al., 2024). The lower compliance rates observed at PT PMS branch facilities—particularly at geographically peripheral locations—align with the inverse relationship between port infrastructure investment and compliance performance documented across Southeast Asian port systems (Hosch et al., 2019; Österblom et al., 2010). Saputra & Christin (2024) reached analogous conclusions in their Green Port assessment at Merak Ferry Port, where remote terminal facilities consistently underperformed central terminal benchmarks across environmental management criteria.

The 58.3% low crew awareness prevalence identified in this study substantially exceeds the awareness deficit rates documented by Kuncowati et al. (2022) in their maritime waste model study (42%), potentially reflecting the more heterogeneous vessel fleet composition and crew training standards encountered across PT PMS's multi-port operational environment (Hussain et al., 2023). This comparison strengthens the case for fleet-specific rather than generic crew environmental training programmes.

Implications of Findings

The study findings carry several substantive implications for maritime environmental governance policy and practice in Indonesia. At the operational level, the documented 23% administrative error rate in manual waste documentation systems represents a data quality challenge that directly undermines the regulatory reporting integrity upon which MARPOL compliance monitoring depends. Transition to digital documentation platforms—such as expanded implementation of the Inaportnet Port Waste Management System—would simultaneously reduce administrative error rates, improve real-time data visibility for regulatory authorities, and reduce the 4.8-hour average processing latency that currently creates operational incentives for informal waste disposal (Calatayud et al., 2020; Firdani & Supomo, 2024).

At the strategic level, the study findings substantiate the need for a differentiated investment model for port waste reception infrastructure that accounts for facility-level traffic volumes and waste generation profiles. The uniform infrastructure standard currently applied across PT PMS branch facilities fails to account for the capacity-demand disparities documented in this study. A risk-stratified infrastructure investment framework, prioritising facilities with the highest identified capacity deficits and extreme risk ratings, would generate greater environmental outcome improvement per unit of capital expenditure (Courdent, 2017).

The OSH governance implications are equally significant. The identification of extreme-risk hazardous chemical waste exposure, combined with documented PPE inadequacy, creates worker welfare obligations under ISO 45001:2018 that PT PMS is currently not fully meeting. Strengthening hazard communication systems—including pre-operation safety briefings, improved incident recording platforms, and periodic OSH audits—would address the communication and education gaps identified by (Nainggolan & Hendra, 2023) and (Handoko et al., 2024).

Research Limitations

Several limitations qualify the interpretation and generalisability of these findings. First, the purposive sampling methodology, while appropriate for the qualitative research design, precludes statistical generalisation to the broader population of PT PMS operational staff or to other Indonesian ship agency entities. Second, the cross-sectional observational design captures operational practices at a specific temporal snapshot, potentially masking seasonal variation in waste volumes and procedural compliance patterns. Third, social desirability bias may have influenced interview responses, particularly among agency officer participants whose organisational performance was directly under evaluation. Fourth, the risk assessment ratings, while conducted systematically, incorporate inherently subjective likelihood and consequence judgements that may differ across evaluator perspectives. Longitudinal and multi-agency comparative studies would strengthen the evidential base for policy recommendations emerging from this research.

CONCLUSION

This study provides the first comprehensive assessment of ship agency procedural management for marine waste handling within the PT Pelindo Marine Service operational network. The research demonstrates that PT PMS has established a formally sound, five-stage waste management procedural framework with documented alignment to MARPOL 73/78, PM 58/2013, and ISO 14001:2015 requirements. This achievement represents a substantive baseline of environmental governance compliance from which further systematic improvements can be constructed.

However, the research simultaneously exposes a critical gap between procedural design and operational implementation that undermines the environmental and worker safety outcomes that these procedures are designed to achieve. Infrastructure capacity shortfalls affecting 67% of branch facilities, a 58.3% crew environmental awareness deficit, a 23% administrative error rate attributable to manual documentation systems, and two Extreme-risk hazard categories collectively indicate that procedural compliance alone is insufficient to guarantee effective marine waste management outcomes.

These findings support the central argument of this paper: that ship agency procedural effectiveness must be evaluated not at the level of regulatory document alignment, but at the level of operational impact on marine environmental quality and worker safety. This evaluative reframing has direct implications for how port regulatory authorities assess compliance and for how ship agency entities like PT PMS approach internal performance management.

Based on the evidence generated, the authors advance the following prioritised recommendations: (1) Immediate implementation of a digital waste documentation and reporting system integrated with the Inaportnet platform to eliminate manual documentation vulnerabilities and accelerate administrative processing; (2) Capital investment programme for expansion and upgrading of waste reception facilities at branch ports, prioritised according to the AS/NZS 4360:2004 risk ratings documented in this study; (3) Mandatory, vessel-type-specific crew environmental awareness training incorporating practical waste segregation exercises, aligned with MARPOL Annex competency requirements; (4) Establishment of a multi-agency coordination protocol with defined service level agreements between PT PMS, KSOP authorities, and waste management contractors to reduce processing

latency; and (5) Accelerated implementation of an ISO 45001:2018-compliant OSH management system with particular emphasis on hazardous waste handling safety protocols and incident reporting infrastructure.

Future research should extend this evaluative framework through longitudinal assessment of PT PMS procedural performance following the implementation of digital documentation systems, and through comparative multi-company analysis to establish industry-level benchmarks for ship agency waste management effectiveness in the Indonesian maritime context.

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CONFLICT OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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