WORLD MARITIME UNIVERSITY

EVALUATING SHIP-GENERATED WASTE RECEPTION FACILITIES IN SRI LANKAN COMMERCIAL PORTS: CHALLENGES, CAPACITY, AND FUTURE PERSPECTIVES

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A dissertation submitted to the World Maritime University in partial fulfillment

of the requirements for the award of the degree of Master of Science in Maritime Affairs

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

Signature):

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(Date): 23 September 2025

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Abstract

Title of Dissertation: **Evaluating Ship-Generated Waste Reception Facilities in Sri Lankan Commercial Ports: Challenges, Capacity, and Future Perspectives**

Degree: **Master of Science**

Ship-generated waste poses a significant threat to marine ecosystems, particularly in strategically located countries such as Sri Lanka. Approximately 60000 ships transit Sri Lankan waters annually; however, the underutilization of port waste reception facilities contributes to marine pollution challenges. This study provides the first comprehensive evaluation of ship-generated waste reception facilities and their operational capacities in four main commercial ports: Colombo, Galle, Hambantota, and Trincomalee. An eight-year dataset from the Marine Environment Protection Authority, 2017 - 2024, with 11503 data entries used for the data analysis part. The research employed a mixed-methods approach, combining quantitative analysis of waste reception volumes with qualitative analysis through a questionnaire method among all MEPA officials involved in this waste reception operation. The results showed a favourably centralised system related to Colombo port, which manages 80% of waste reception services. However, only 33% of arriving ships utilise waste reception facilities in Sri Lankan ports. Statistics demonstrated significant variations in the volumes of most of the 18 waste types under the MARPOL annexes I, IV, and V, across the four ports. Furthermore, inadequate infrastructure facilities for hazardous waste management, high treatment costs, and high transport costs to centralised facilities were identified as three critical challenges in the ship-generated waste management operation. Certain waste types, such as fluorescent bulbs, are identified as problematic due to the lack of proper disposal mechanisms, which creates a compliance gap. Based on the findings low utilisation rate and infrastructure gap, this study suggests that current waste management practices may contribute to pollution issues. The study recommends establishing port-area waste treatment facilities, expanding the GPS tracking system to all waste categories, strengthening the regulatory framework, and implementing capacity-building programs. These findings fill the existing knowledge gap in this field in Sri Lanka and provide essential baseline data for future infrastructure development projects related to strengthening MARPOL compliance, which aligns shipping practices with ocean health.

KEYWORDS: Hazardous waste, MARPOL compliance, marine pollution, port waste reception facilities, port waste management, ship-generated waste, Sri Lanka.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ANOVA	Analysis of Variance
CEA	Central Environment Authority
COVID-19	Coronavirus Disease 2019
EEZ	Exclusive Economic Zone
EPL	Environmental Protection License
GPS	Global Positioning System
HME	Harmful to the Marine Environment
IMO	International Maritime Organization
INGO	International Non-Governmental Organization
ISM	International Safety Management
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPA	Marine Environment Protection Authority
NGO	Non-Governmental Organization
SLPA	Sri Lanka Ports Authority
SLINEX	Sri Lanka India Naval Exercise
UNCTAD	United Nations Conference on Trade and Development
WMU	World Maritime University
WRS	Waste Reception Service

Chapter 1 Introduction

1.1 Background

Shipping is a cyclical, growing business that depends on global demand and supply (Carpenter & Macgill, 2005a). The industry is responsible for moving billions of dollars' worth of goods each day, which accounts for more than 90% by weight of global trade (Walker et al., 2018). It is generally accepted that shipping provides the most cost-effective transport method for goods worldwide when compared with road, rail, and air freight (Butt, 2007).

The Development of maritime transportation has led to more than 100,000 ships traversing the world's oceans annually, which additionally produces massive volumes of marine pollutants such as plastics, cargo residues, oily residues, and sewage, which ships discharge into the ocean (Ülker et al., 2023). Both land-based and marine-based sources contribute to marine pollution. However, marine sources, including ship-generated waste, are responsible for approximately 20% of marine pollution. This pollution significantly affects the marine environment and its ecosystems (Peters et al., 2019). Therefore, it is essential to develop adequate waste reception facilities in ports for the reception of ship-based waste to minimize the negative impacts from the shipping industry (Walker et al., 2018).

To address these environmental concerns, compliance with the International Convention for Prevention of Pollution from Ships (MARPOL) is essential through implementing waste reception guidelines for annexes I to VI in the port facilities (Ülker et al., 2023). Within MARPOL (Figure 1), Annex I focuses on the prevention of pollution by oil; Annex II focuses on the control of pollution by noxious liquid substances in bulk; Annex III focuses on the prevention of pollution by harmful substances carried by sea in package form, Annex IV focuses on the prevention of pollution by sewage from ships, Annex V focuses on prevention of pollution by garbage from ships, Annex VI focuses on the prevention of air pollution by ship (Jayakody et al., 2021).

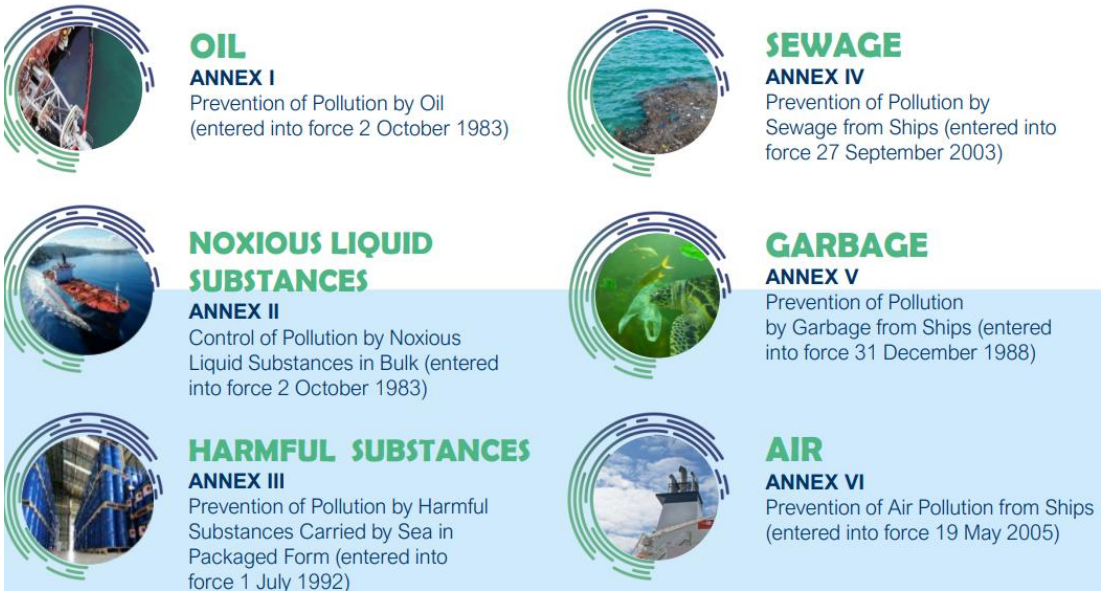
Sri Lanka occupies a good strategic location that connects numerous international shipping lanes between the east and the west. According to the strategic location, it has the potential to develop as a maritime hub (Jayakody et al., 2021b; Sri Lanka: A Maritime & Logistics Hub, n.d.). The country has four main commercial ports: Colombo, Galle, Hambantota, and Trincomalee. According to the Sri Lankan Ports Authority's annual report, 4819 ships arrived at these four ports in 2023, with 1598 ships utilizing the waste reception service. Because of this potential, there is a risk of increasing marine pollution with the development of the shipping industry.

Sri Lanka already ranks among the top global producers of maritime litter worldwide (Jambeck et al., 2015). In addition, the shipping industry also generates huge quantities of maritime litter because 60,000 estimated ships pass Sri Lankan waters annually, and these transboundary and EEZ activities contribute to marine pollution in Sri Lanka (Jayakody et al., 2021a). Because of this situation, it is essential for Sri Lankan port facilities to comply with MARPOL regulations in order to prevent marine pollution from ships. The Marine Pollution Prevention Act No. 35, 2008, empowers the Marine Environment Protection Authority (MEPA) as the leading regulatory agency and authorized government body to monitor MARPOL compliance (Jayakody et al., 2021a).

Today, Sri Lanka is already facing challenges managing ship-generated waste in various aspects, and these challenges will most certainly increase with the development and growth of global maritime transportation. In order to meet today's requirements for a circular economy and a sustainable framework, the country needs to provide improved port waste reception facilities that comply with current standards. However, a lack of research in Sri Lanka regarding these aspects has caused a significant knowledge gap. This research project addresses the knowledge gap by evaluating waste reception facilities at Sri Lanka's four commercial ports (Colombo, Galle, Hambantota, Trincomalee). The study will establish a baseline data set and propose practical solutions to improve ship-generated waste management and protect ocean health.

Figure 1

MARPOL Annexes I-VI



Note. From (International Convention for the Prevention of Pollution from Ships (MARPOL), n.d.)

Chapter 2 Research Methodology

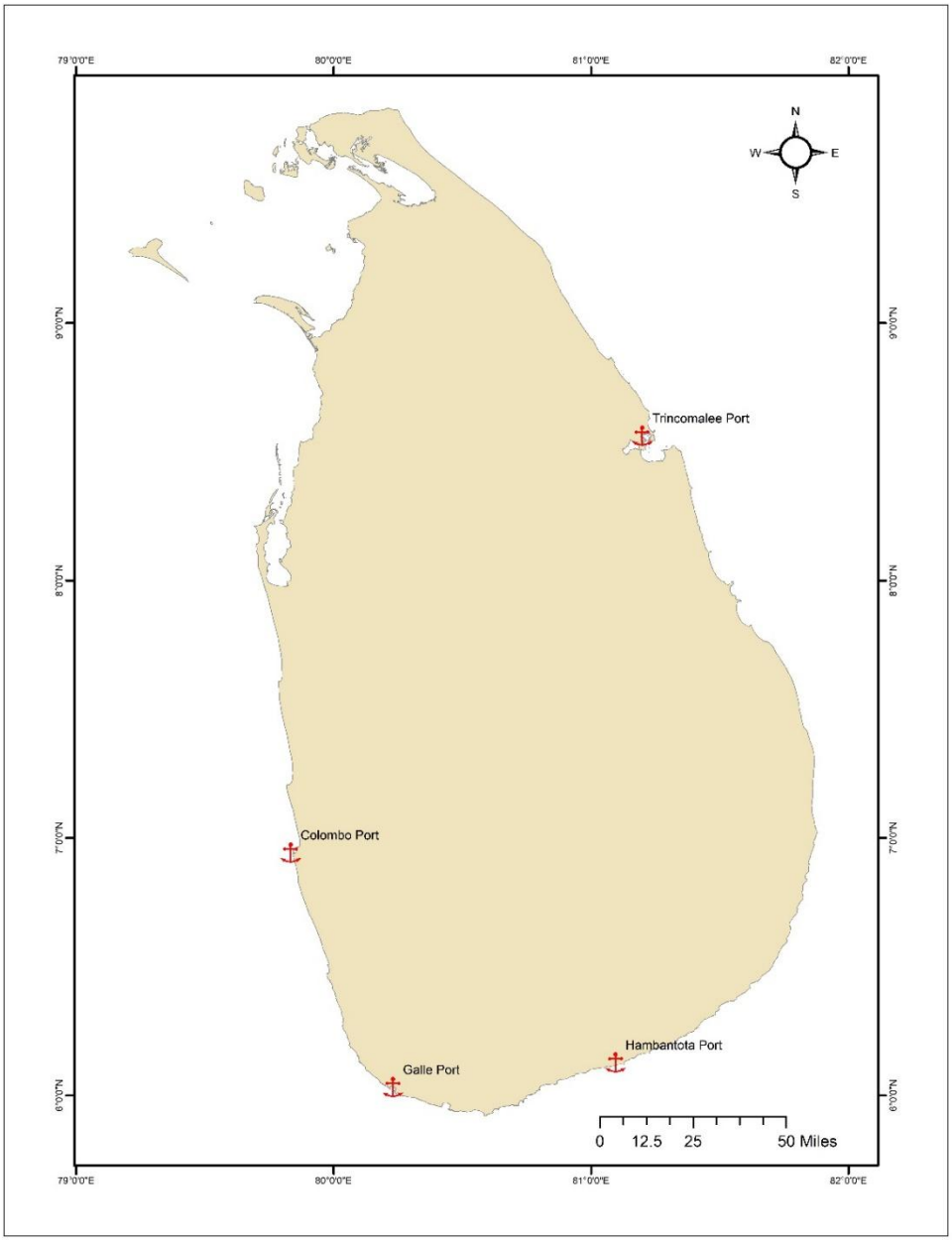
2.1 Research Area

Sri Lanka is located at the center of international shipping lanes connecting East and West (Jayakody et al., 2021a). Due to this high maritime traffic and reported pollution, Sri Lanka is listed among the top nations that discharge maritime litter to the ocean (Jambeck et al., 2015). The establishment of ship-generated waste reception baseline data became a very crucial for future perspectives and to reduce the negative impacts of the shipping industry. However, since no existing baseline data is available in Sri Lanka, this research focused on evaluating the waste reception facilities in Colombo, Galle, Hambanthota, and Trincomalee commercial ports in Sri Lanka to identify the current potential and fulfill the knowledge gap.

Colombo, located on the west coast at 6.9271°N, 79.8672°E, is the largest port in the country, which reported 4237 ship arrivals and is responsible for 87.8% of the country's total vessel traffic. The port employed 7433 workers and mainly concentrated on containerized cargo operations, processing 6.95 million TEU across four main terminals: JCT, ECT, SAGT, and CICT. In 2023, its cargo operations reached 34257 thousand tons, which represented 89.4% national total. (STRATEGIC DIRECTIONS 1 Annual Report 2023-Sri Lanka Ports Authority, n.d.). The port of Hambanthota, located on the southern coast at 6.1241°N, 81.1185°E, is the second largest port specialized for mixed cargo operations, which recorded 447 ship arrivals with 9.3% of shipping traffic, and cargo operations reached 2106 thousand tons, which represented 5.5% of the national total. The port of Trincomalee, specialised in bulk cargo operations, located on the east coast at 8.5874°N, 81.2152°E, recorded 102 ship arrivals with 2.1% of shipping traffic, and cargo operations reached 2014 thousand tons, which represented 5.3% of the national total. According to the SLPA annual report 2023, the port of Galle, specialised for limited commercial operations, located on the east coast at 6.0367°N, 80.2170°E, recorded 23 ship arrivals with 0.5% of shipping traffic, and its cargo operations reached 0.8 thousand tons, which represented 0.02% of the national total (Figure 2).

Figure 2

Major Commercial Ports in Sri Lanka



The Marine Environment Protection Authority (MEPA), that established under the Marine Pollution Prevention Act No. 35 of 2008, is the apex body for preventing marine pollution in Sri Lankan territorial waters, with a mandate to prevent, mitigate, and control marine pollution from sea-based and land-based sources. MEPA also

handled the ship-based waste reception service in Sri Lanka (Jayakody et al., 2021c) (Jayakody et al., 2021c). Under the Marine Pollution Prevention Act, the Government of Sri Lanka established the Waste Reception Service Regulation of 2016 to provide the mandatory provisions to prevent marine pollution in ports, terminals, dry docks, repair facilities, anchorages, or offshore marine facilities, for effective management of ship-based waste reception. Subsequently, MEPA initiated issuing permits and waste delivery receipts for shipboard waste removal, and all the relevant data recorded under the MEPA WRS database according to MARPOL annexes I, IV, and V (Table 1). The MEPA introduced this new procedure in 2016 and officially implemented it in all commercial ports from 2017. This research utilized all ship-generated waste reception data from the beginning (2017-2024) to establish a national baseline dataset.

Table 1

MARPOL Annexes and Related Waste Types

MARPOL Annex	Waste Type	Description
I	Oily Bilge Water	A mixture of fresh water, seawater, oil, sludge, chemicals, and other fluids that drain into the bilge
	Oily Residues	A mixture of waste from the purification of fuel or lubricating oil, or separated waste oil from OWS, oil filtering equipment, or oil collected in drip trays, and waste hydraulic and lubricating oils
	Oily Tank Wash	A mixture of oil, water, and dispersants generated from oil cargo tank cleaning
	Dirty Ballast Water	Contaminated water with oil when oil tanks are used to carry ballast water (a rare case)
	Scale and Sludge from Tank Cleaning	Residues and deposits generated during tank cleaning operations
	Other (Oil-related)	Range of oily materials not specifically listed in the above-mentioned oily waste types

IV	Sewage (Black water)	Drainage and other waters from any form of toilets and urinals, medical premises (sick bay), spaces containing living animals, or other wastewater mixed with drainage
V	Plastic	Comprises sheets, wrappings, bottles, drums, synthetic ropes, synthetic fishnets, plastic garbage bags, and empty chemical cans
	Food Waste	Any spoiled or unspoiled food substances, including fruits, vegetables, dairy products, milk products, and food scraps generated onboard.
	Domestic Waste	Paper, cardboard, fluorescent bulbs, synthetic materials, foils, metal cans, lids, glass, pantry packaging waste, and expired medicine
	Cooking Oil	Waste oil generated from onboard food preparation
	Incinerator Ashes	Ashes generated from on-board incinerators
	Operational Waste	Oily rags. Batteries, old ropes, jerry cans, wood, washing machines, scrap refrigerators, aerosols, ladders, fireworks and flares, chemicals, asbestos and paints, wooden pallets, stowage materials, rubber gloves, fluorescent tubes, torn working clothes
	Animal Carcass(es)	Remains of deceased livestock
	Fishing Gear	Only in fishing vessels: generated when fishing gear wears and tears beyond repair
	E-Waste	Electronic waste, computers, temperature controlling devices (AC- machines), telecommunication equipment, TVs, monitors, LED bulbs, consumer electronic devices
	Cargo Residues (Non-HME)	Cargo residues generated from loading, unloading, or washing operations that are not classified as Harmful to the Marine Environment-HME (grains, coal, and minerals)
	Cargo Residues (HME)	Cargo residues classified as Harmful to the Marine Environment

Note. Information synthesized from "Waste Reception Facilities - Options," by Port Esbjerg, 2022, May (https://portesbjerg.dk/downloads/garbage_reception_22.pdf); and "The Management of Ship-Generated Waste On-Board Ships," by CE Delft, n.d. (www.cedelft.eu).

This research used a mixed-method approach to evaluate ship-based waste reception facilities in Colombo, Galle, Hambanthota, and Trincomalee, the four major commercial ports in Sri Lanka. The study consisted of quantitative analysis of waste reception data from 2017 to 2024, with the qualitative data obtained from responsible MEPA officials who engaged in this operation, and field observations from the field visit to Sri Lanka. The study focused on these four ports because they represented Sri Lanka's major maritime infrastructure facilities, which handled large volumes of international maritime traffic. This research approach reflected the current national situation of ship-based waste reception and port-specific trends.

The research utilized both primary and secondary data sources; however, it mainly focused on secondary data sources, using two of them for its quantitative approach. The first, the Marine Environment Protection Authority (MEPA) Waste Reception Service (WRS) database, which provides records of all waste reception activities from 2017 to 2024 related to four commercial ports: Colombo, Galle, Hambanthota, and Trincomalee. This database consisted of detailed information, including vessel identification, waste categories according to MARPOL Annexes, and received waste volumes in cubic meters (m^3), reception dates, service provider details, and final disposal completion records. Secondly, the study utilized Sri Lankan Port Authority Annual Reports (2017-2024) to obtain official statistics on annual ship arrivals by port. That information facilitated the calculation of waste reception utilization rates.

While this research basically focused on secondary data sources, it also incorporated primary data sources. The research used structured questionnaires to collect data from all nine MEPA officials responsible for waste reception operations at the four ports.

These officers had deep knowledge of waste reception procedures, MARPOL compliance inspections, and waste reception certificates. This study developed a structured questionnaire using both open-ended and closed-ended questions to capture qualitative insights of four major areas: operational capacity of the existing facilities, operational challenges, handling procedures according to the MARPOL waste types, and future development perspectives (Appendix A).

The study conducted systematic field observations at all ports: Colombo, Galle, Hambanthota, and Trincomalee to validate questionnaire responses with the actual situation. The observations focused on waste reception operations, service provider activities, and infrastructure availability. Figure 3-6 illustrates the waste reception operations observed during the field visit

Figure 3

Waste reception in Colombo Port: *Garbage collection and waste oil collection at Sri Lanka's largest commercial port facility*

Figure 4

Waste Reception in Galle Port: Offshore Garbage Reception Operation & Waste Oil Reception

Figure 5

Waste Reception in Hambanthota Port: Garbage Reception Operation & Waste Oil Reception

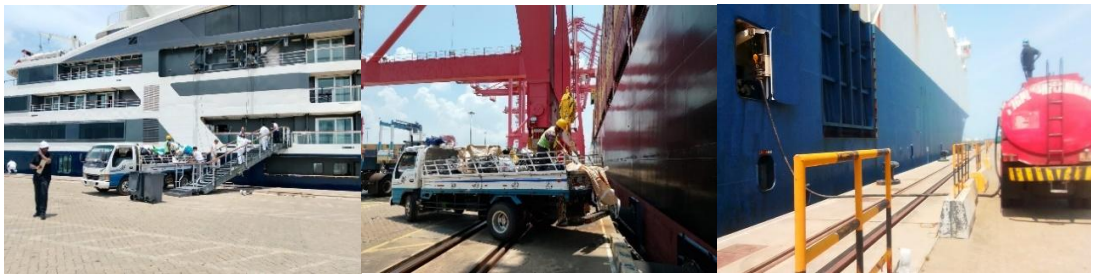


Figure 6

Waste Reception in Trincomalee Port: Offshore Garbage Reception Operation & Garbage Reception in Trincomalee Port

2.2 Data Analysis

The study conducted statistical analysis using R statistical software (version 4.4.2). It used a between-subjects design that compared four independent port groups with multiple waste types under the MARPOL Annexes I, IV, and V. The research focused on the two essential measurements for each waste type: waste type-based waste reception performance index (PS_i) and received waste volumes at port according to MARPOL waste types in cubic meters (m^3). PS_i calculated using Equation 1.

$$PS_i = \frac{W_i}{S_w} \quad [1]$$

Equation 1 used the variable "W_i" to represent the quantity of each waste type the waste reception facility received. Also used "S_W" to represent the number of ships that the facility provided with waste reception service. Essentially, the equation helped to evaluate ports based on the type of waste they received (Ülker et al., 2023). Instead of the waste type-based waste reception performance index (PS_i), the research used the term "waste reception per ship" to simplify the analysis. The received waste volumes according to MARPOL Annexes in cubic meters (m^3): Provided a direct measurement of the absolute volumes of waste types received at the ports.

The experimental design used a balanced structure with eight-year observations per port, from 2017 to 2024. This indicated the total sample size of 32 for each waste category, except the oily bilge water, cargo residues: Non-HME and HME, which had observations from 2021 to 2024, with a total sample size of 16 for each waste category.

For the hypothesis testing, the study tested the null hypothesis (H_0): all port mean volumes were equal ($\mu Colombo = \mu Galle = \mu Hambanthota = \mu Trincomalee$) against the alternative hypothesis (H_1): at least one port mean volume significantly differed from others. The research used one-way ANOVA to compare waste reception levels according to the waste types between four ports: Colombo, Galle, Hambanthota, and Trincomalee. This test applied well because the study measured continuous data (waste volumes) across four different ports, allowing them to compare waste reception per ship and total waste reception for each waste type at each port. Before running the

ANOVA, the study applied Bartlett's test to check that the data had similar variances among all ports. When this test showed unequal variance ($p<0.05$), the study proceeded with ANOVA, because this test can handle moderate variance differences when sample sizes were balanced. When ANOVA showed significant differences among the ports ($p<0.05$), the study used Tukey's HSD test to identify which specific ports differed from each other. Also, this test effectively controls errors when making multiple comparisons between port pairs. The study fixed its significance level at $\alpha=0.05$ for all tests and used 99% confidence intervals for Turkey HSD tests to provide more reliable results. This study handled missing data by removing incomplete observations from the analysis.

The research used thematic analysis to examine the questionnaire data and identified the common patterns in each section: operational capacities, operational challenges, waste handling procedures, evaluation, and future perspectives (Appendix A). Then analysed the responses by identifying the most frequent answers for each question and created a table that displayed each question with the most commonly selected answer or proposed solution based on the response frequency and questionnaire section. This table presents the most representative answers given by nine MEPA officials responsible for the waste reception operation in Colombo, Galle, Hambanthota, and Trincomalee commercial ports. However, two senior officials validated this table to ensure the accuracy of the operational situation. The research also combined these qualitative findings with quantitative data and field visit observations to develop a complete picture of current ship-generated waste reception effectiveness and identify the most important areas requiring improvement.

2.3 Ethics

As per the given guidelines, the research required submission of a research proposal, consent, research protocol, and questionnaire to the Research Ethics Committee (REC) of the World Maritime University (WMU) for obtaining prior approval to start research. The committee approved the research on the 28th of May 2025. As per the instructions given by REC, the research study obtained approval from the General

Manager of MEPA to access the MEPA WRS database through a signed consent form (Appendix C). The research process included explaining the conditions of the consent form to MEPA officials before distributing the questionnaire and the consent form.

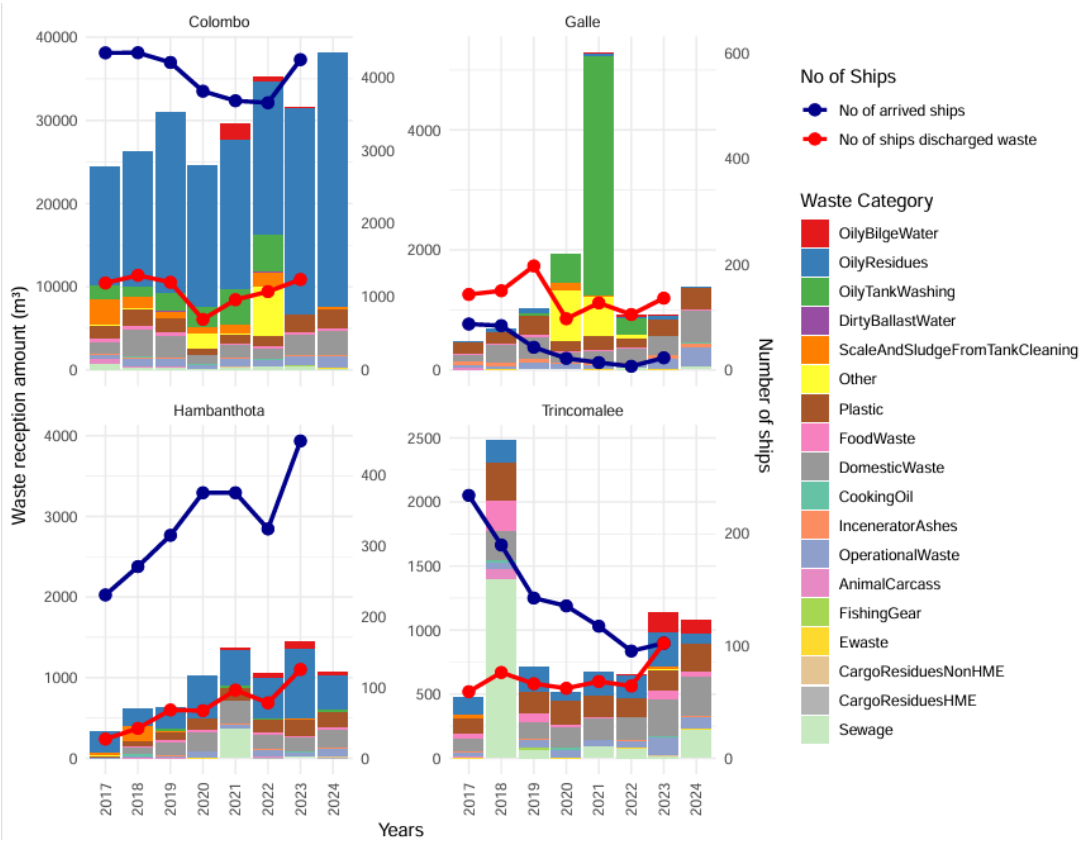
Chapter 3 Results and Analysis

3.1 Current Status of Waste Reception Facilities in Sri Lanka

This study imports data from the MEPA WRS database and SLPA Annual Reports to create a baseline dataset for analysis (Appendix E). It illustrates the current status of the waste reception facilities, with an eight-year trend (2017-2024) of the arrival of ships and the number of ships that utilize the waste reception facilities in four major commercial harbours in Sri Lanka (Figure 7). The results show fluctuations in the waste types in this period. However, a positive trend in the number of ships that utilize waste reception facilities in Sri Lankan ports over the period.

Figure 7

Maritime Traffic and Port Reception Service (2017-2024)



The research findings indicate that the highly centralized waste reception system is dominated by the Colombo Port (Table 2). It handles 80% of the ships that utilize waste reception service in Sri Lanka. This reflects that Colombo is the main maritime hub, 1598 ships utilize the waste reception service out of 4819 total number of arrival ships in 2023, and the average utilization rate of all ports is around 33% which indicates a potential to improve waste reception services in Sri Lanka (STRATEGIC DIRECTIONS 1 Annual Report 2023-Sri Lanka Ports Authority, n.d.).

Table 2

Port-wise Waste Reception Volumes by MARPOL Annexes (2017-2024)

	Waste Reception Percentage by MARPOL Annex			WRS Utilized Ship (%)
Port	Annex I (%)	Annex IV (%)	Annex V (%)	
Colombo	94	48	75	80
Galle	3	1	11	10
Hambantota	2	8	6	5
Trincomalee	1	42	8	5

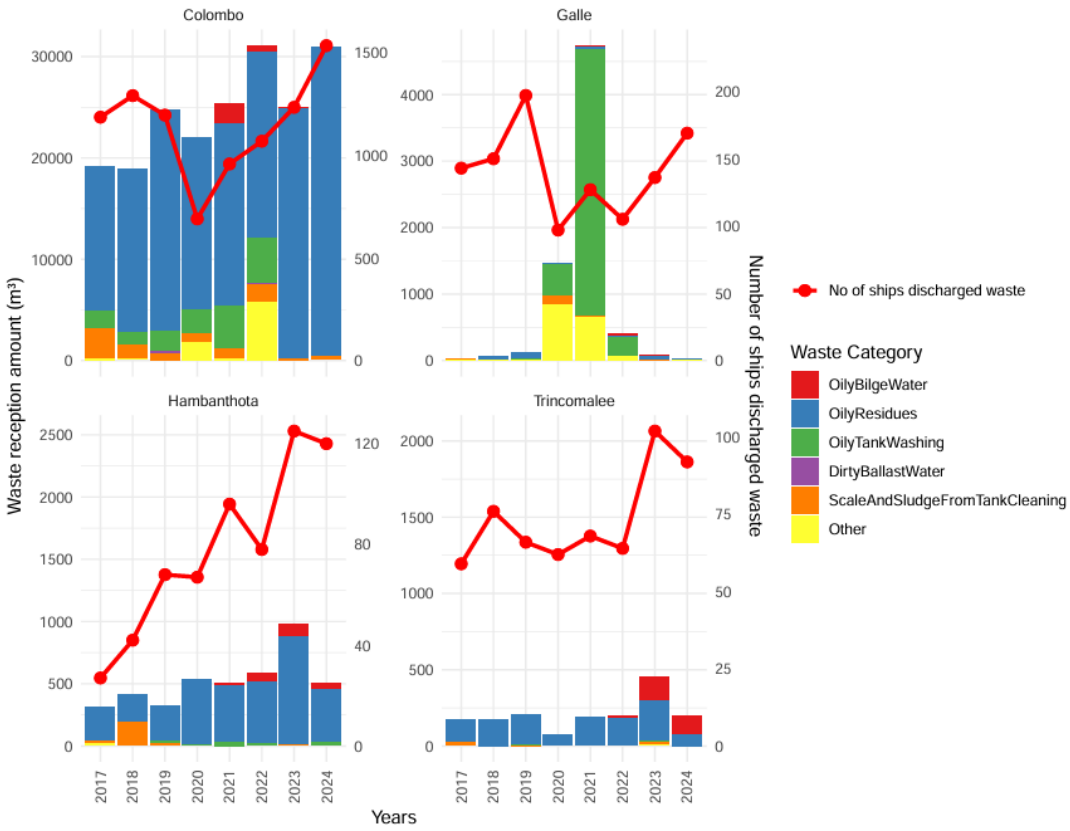
The data analysis, conducted according to the MARPOL Annexes I, IV, and V with 18 waste types (Table 1), and the results interpreted according to the same order as the MARPOL Annexes for further studies.

3.2 MARPOL Annex I Wastes (Oil-Related)

The waste reception distribution of MARPOL Annex I waste categories across the four commercial ports from 2017-2024 highlights that Colombo Port is dominant in MARPOL Annex I waste reception and is responsible for approximately 94% of total ship-generated oily waste reception in the country. Mainly, the analysis highlighted Colombo handling higher volumes compared to Galle, Hambantota, and Trincomalee (Figure 8).

Figure 8

MARPOL Annex I Waste Reception by Category and Port (m³/year)

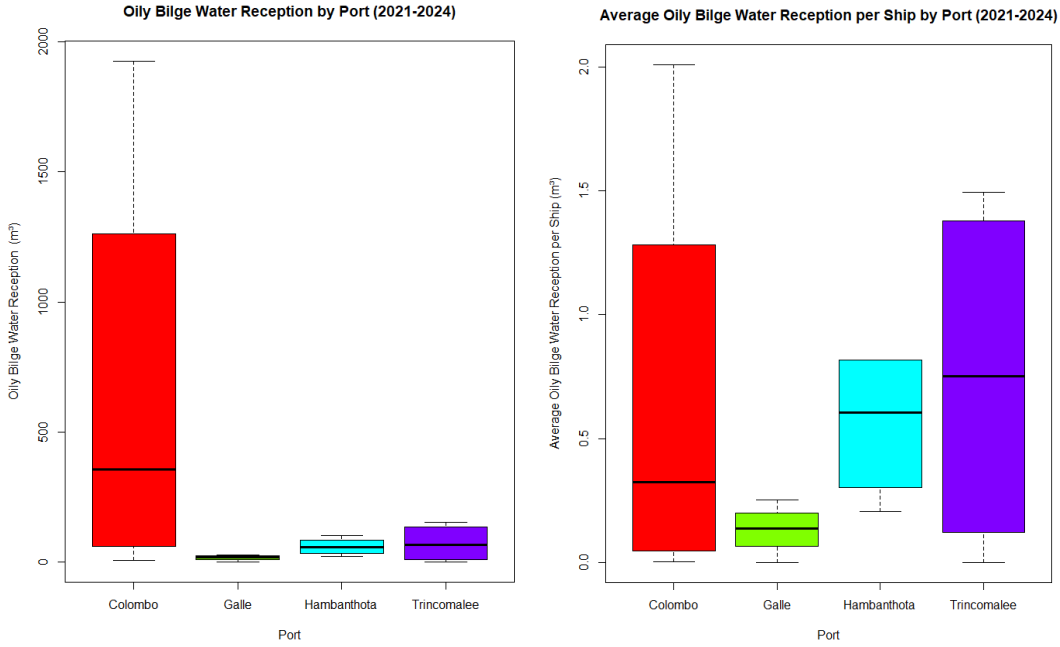


This research analyses waste types under each MARPOL Annex separately for a comprehensive analysis of this waste reception across the ports. The results highlight that the oily bilge water reception by ports indicates no statistically significant difference in oily bilge water reception volumes between ports (ANOVA results: F

(3,12) =1.917, p=0.181 with 16 missing observations). Similarly, the average oily bilge water reception per ship shows no significant difference among the ports (ANOVA results F (3,12) = 0.797, p=0.519) (Figure 9).

Figure 9

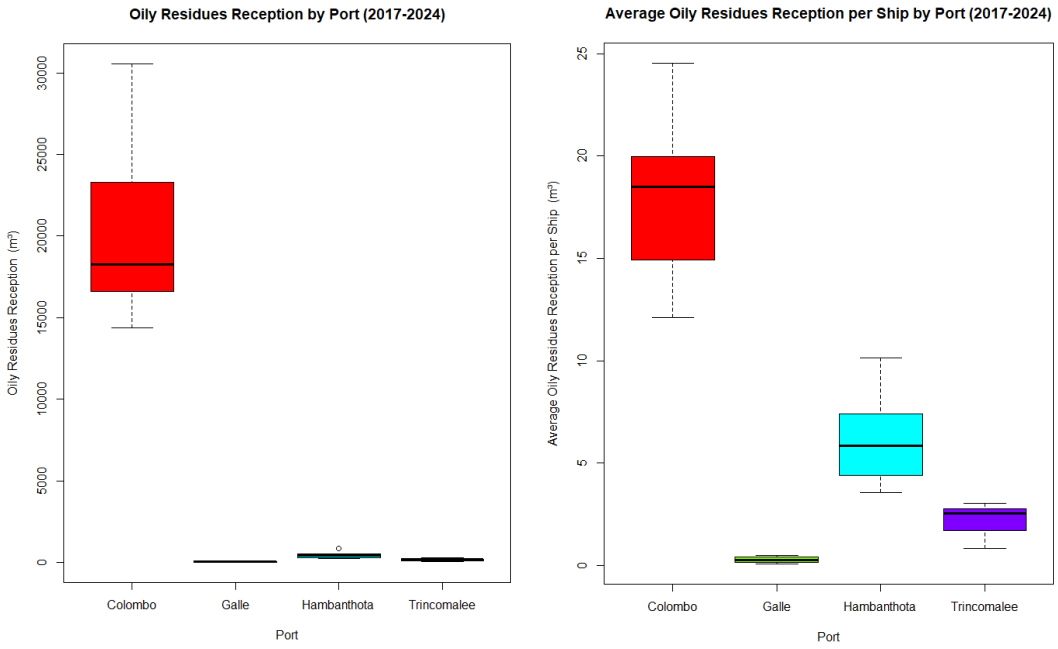
Boxplot of Oily Bilge Water Reception by Port



Colombo handles significantly more oily residue waste reception volume mean of 20,138.5 m³ across the ports, while other ports handle less: Hambanthota: 443.11 m³, Trincomalee: 162.45 m³, and Galle: 40.29 m³. The results indicate a highly significant difference in oily residue reception volumes among the ports (ANOVA results: F (3,28) =111.7, p=1.09e-15). Similarly, average oily residue reception per ship is also a highly significant difference between the ports. Colombo receives the highest volume per ship at 17.92 m³, followed by Trincomalee at 6.12 m³, Hambanthota at 2.24 m³, and Galle at 0.27 m³ with the ANOVA results: F (3,28) =90.82, p=1.54e-14) (Figure 10).

Figure 10

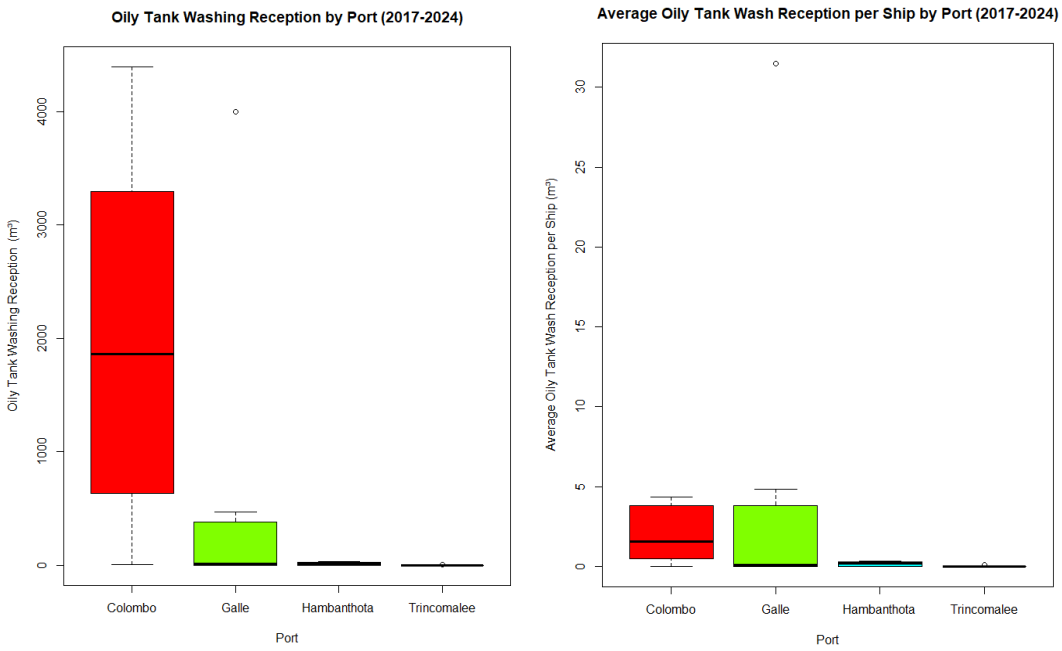
Boxplot of Oily Residues Reception by Port



Colombo and Galle handle the highest reception of oily tank wash across the ports, with means of 199.7 m^3 and 598.2 m^3, respectively. In comparison, the other ports handle the minimum volumes (Hambanthota: 13.42 m^3, Trincomalee: 1.13 m^3) (Figure 11). The ANOVA results show a significant difference in oily tank wash reception among the ports, F (3,28) =6.081, p=0.00254. However, the average reception of oily tank wash per ship shows no significant difference among ports, with Galle leading at 4.90 m^3, followed by Colombo at 2.01 m^3, Hambanthota at 0.15 m^3, and Trincomalee at 0.01 m^3 (ANOVA Results: F (3,28) =1.365, p=0.274).

Figure 11

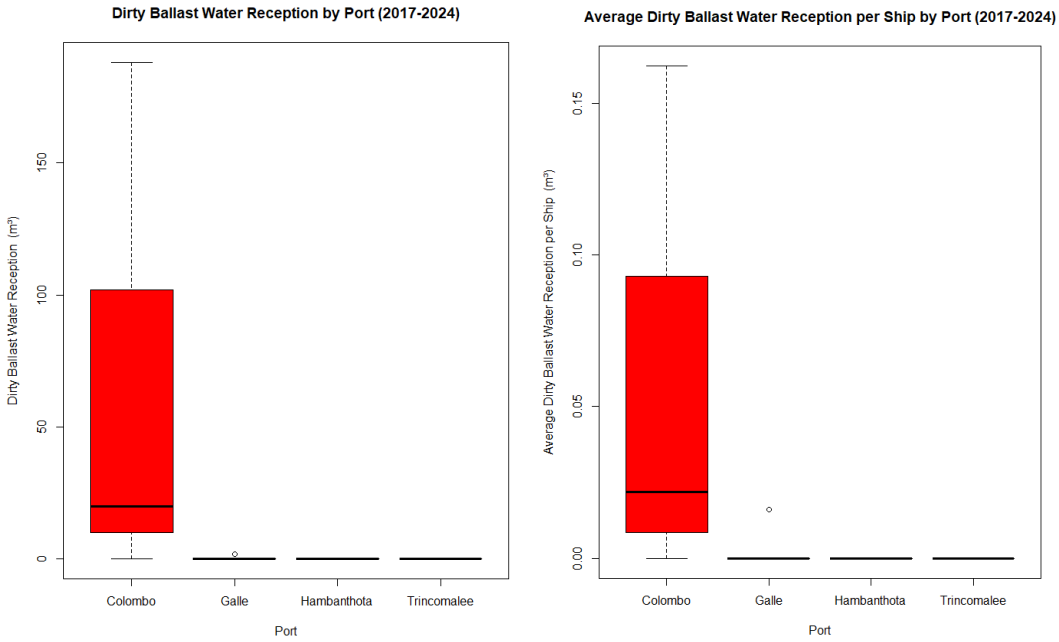
Boxplot of Oily Tank Wash Reception by Port



Colombo handles significantly high dirty ballast water reception volume, a mean of 56.4m³ across the ports, while other ports handle less: Galle 0.2 m³ and Hambanthota, Trincomalee receives zero (ANOVA results: F (3,28) =111.7, p=1.09e-15). The average dirty ballast water reception per ship. The ANOVA results show a significant difference between the ports: F (3,28) =4.396, p=0.0118. Similarly, Colombo receives the highest volume per ship at 0.051 m³, followed by Galle at 0.003 m³. Hambanthota and Trincomalee show zero reception (Figure 12).

Figure 12

Boxplot of Dirty Ballast Water Reception by Port

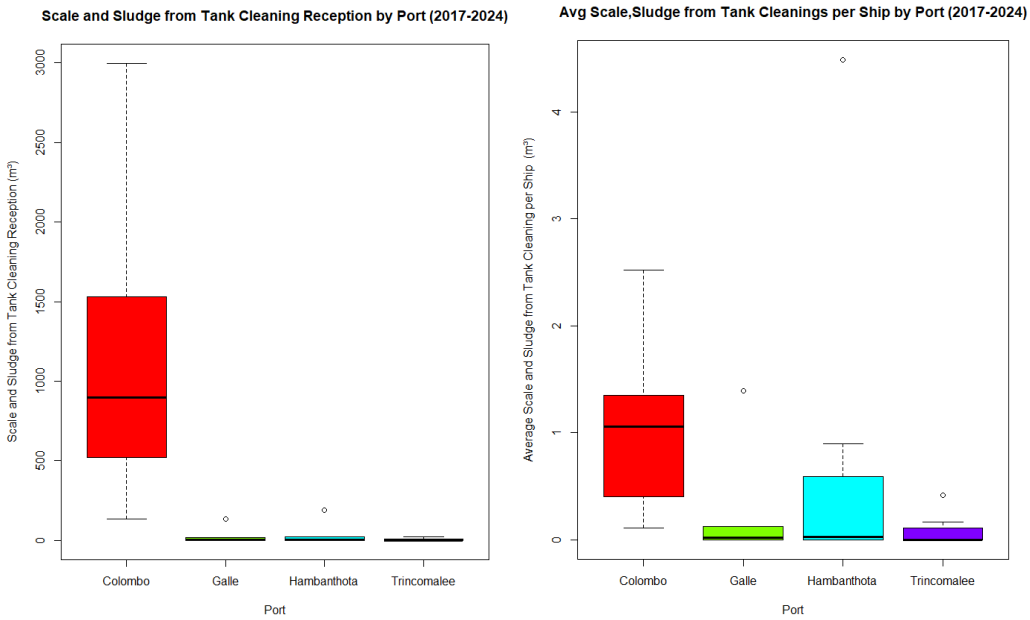


Colombo shows the highest scale and sludge reception with a mean of 1127.95 m^3 across the ports. Galle, Hambanthota, and Trincomalee show much lower volumes (Galle 21.75 m^3, Hambanthota 29.89 m^3, Trincomalee 5.58 m^3). The ANOVA results show a highly significant difference in Scale and Sludge reception among the ports,

F (3,28) =11.83, p=3.49e-5. Similarly, Colombo receives the highest scale and sludge reception volume per ship at 1.03 m^3, followed by Hambanthota at 0.72 m^3, Galle at 0.21 m^3, and Trincomalee at 0.08 m^3; however, the differences between ports are not statistically significant (ANOVA results: F (3,28) =1.929, p=0.148) (Figure 13).

Figure 13

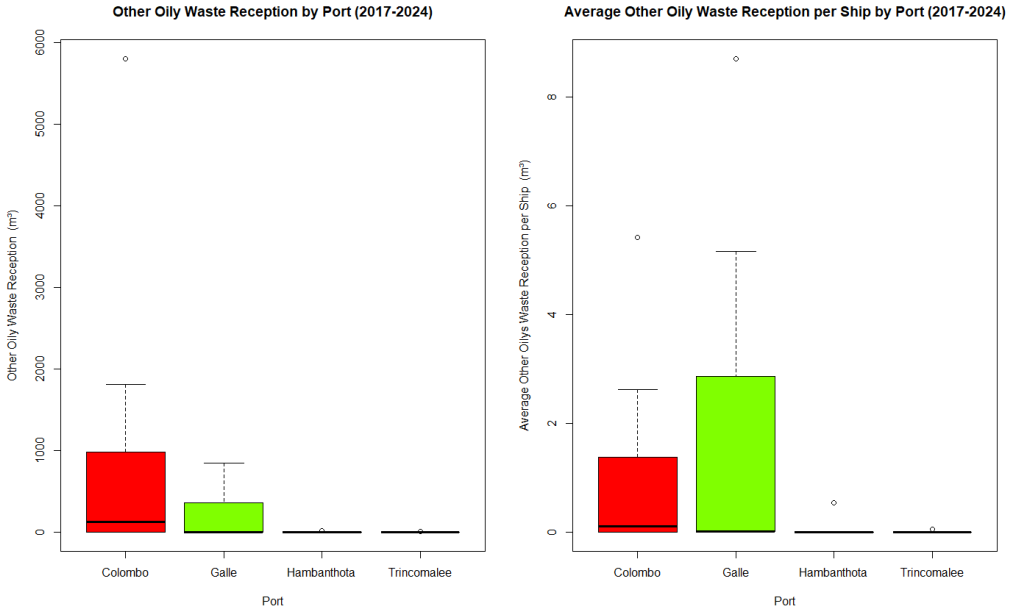
Boxplot of Scale and Sludge Reception by Port



Colombo shows the highest other oily waste reception across the ports, with a mean of 1000.5 m^3, while Galle handles 195.82 m^3, and other ports handling the minimum mean volumes near zero (Hambanthota 1.8 m^3, Trincomalee 0.63 m^3). The ANOVA results show no significant difference in volumes: F (3,28) =1.70, p=0.18. Similarly, Galle leads at 1.81m^3, followed by Colombo at 1.05 m^3, Hambanthota at 0.07 m^3, and Trincomalee at 0.01m^3 with no significant differences in average other oily waste reception per ship (ANOVA Results: F (3,28) =1.596, p=0.212) (Figure 14).

Figure 14

Boxplot of Other Oily Waste Reception by Port

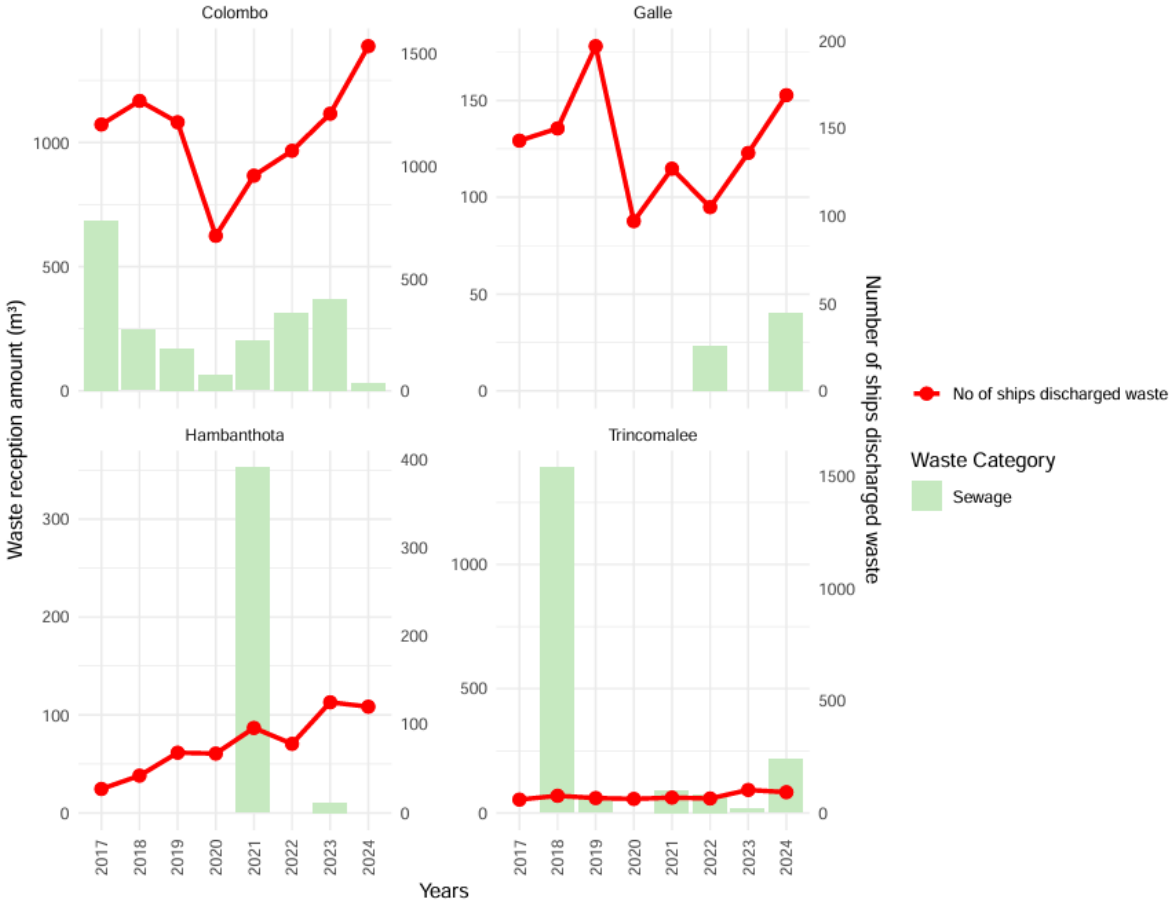


3.3 MARPOL Annex IV Waste (Sewage)

The results of waste reception distribution of MARPOL Annex IV sewage discharge volume across the four commercial ports from 2017-2024 show an interesting pattern related to the Trincomalee port, a high amount of discharge under lower ship traffic in 2018 (Figure 15).

Figure 15

MARPOL Annex IV Waste Reception by Port

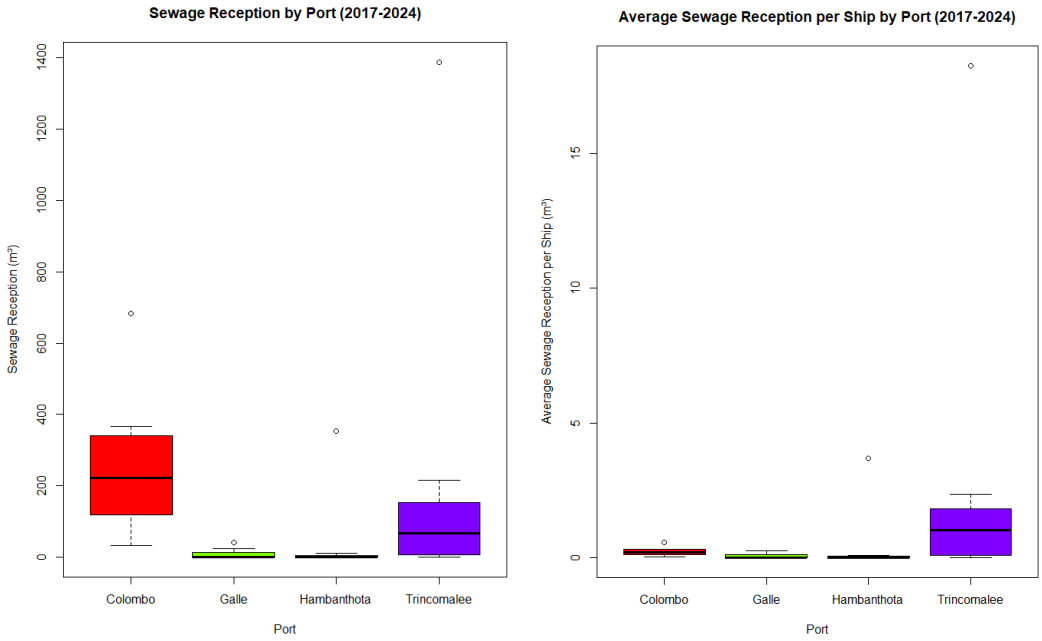


Colombo and Trincomalee show the highest sewage reception across the different ports, with the means of 259 m^3 and 229.9$m^{3,}$ respectively, while the other ports handle

the lower mean volumes (Galle 7.87 m^3, Hambanthota 45.27 m^3). The ANOVA result shows no significant difference in volumes: F (3,28) =1.83, p=0.163. Trincomalee shows the average sewage reception per ship, the highest sewage reception at 3.01 m^3, followed by Hambanthota at 0.47 m^3, Colombo at 0.23 m^3, and Galle at 0.06 m^3. Similarly, the ANOVA result shows no statistically significant difference in volumes across the ports: F (3,28) =1.535, p=0.227 (Figure 16).

Figure 16

Boxplot of Sewage Reception by Port

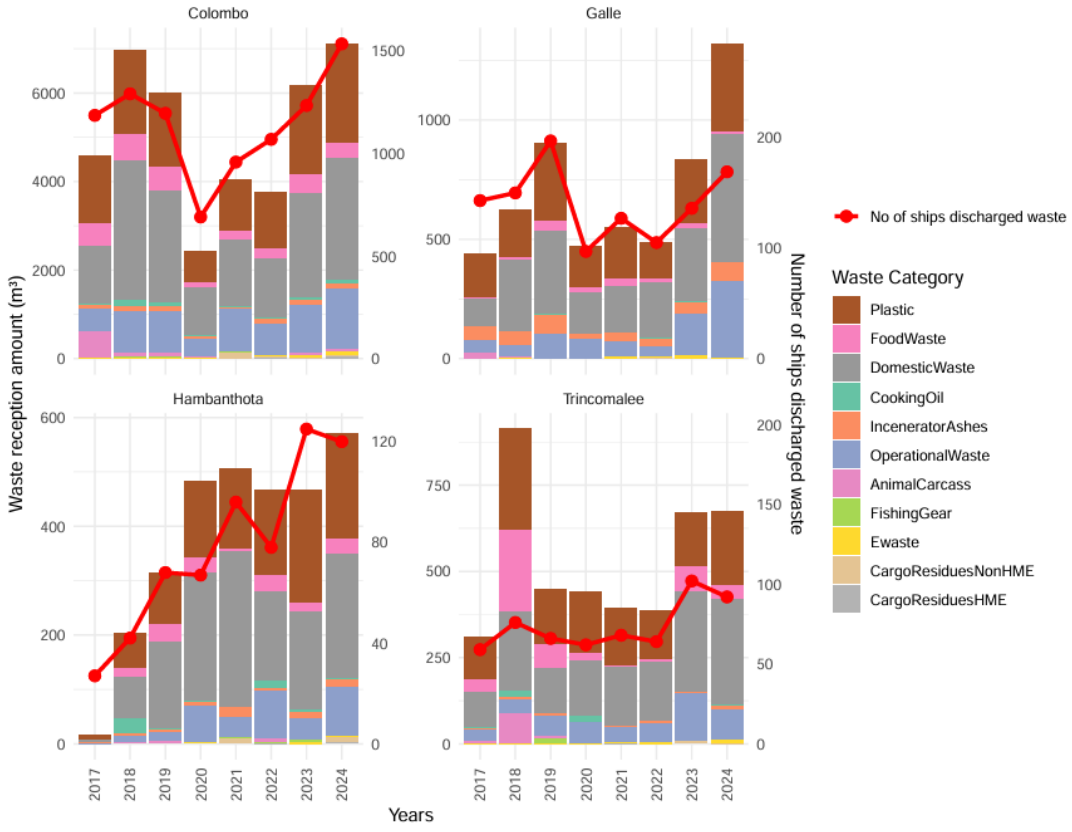


3.4 MARPOL Annex V Wastes (Garbage)

The waste reception distribution of MARPOL Annex V waste categories across the four commercial ports from 2017-2024 highlights that Colombo Port is the dominant MARPOL Annex V waste reception port and is responsible for approximately 75% of total ship-generated garbage reception. Mainly, this chart shows that plastic and domestic waste have dominated compared to the other categories (Figure 17).

Figure 17

MARPOL Annex V Waste Reception by Category and Port

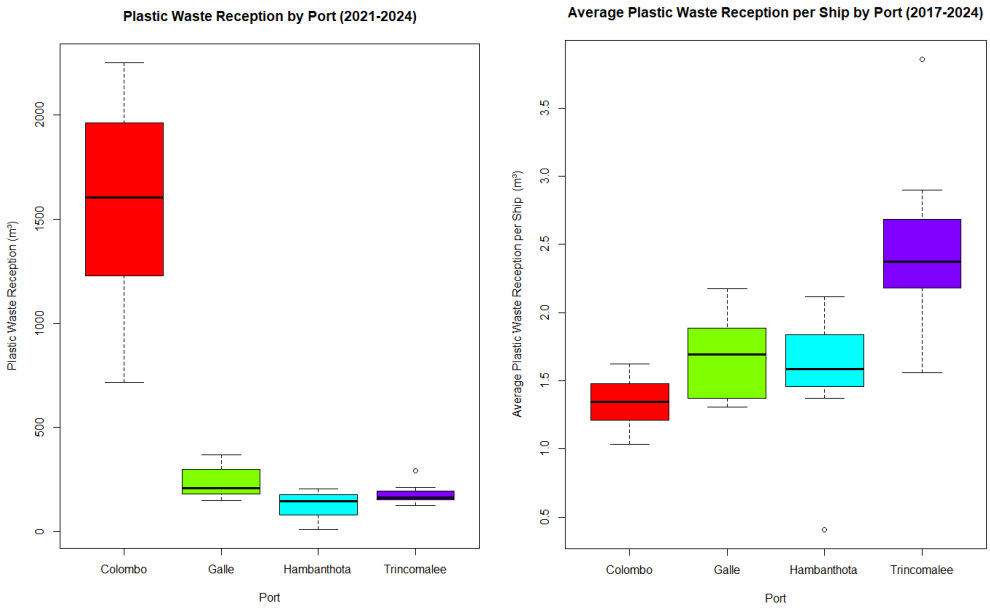


Colombo shows the highest plastic waste reception across the ports, with a mean of 1569.13 m³, while the other ports handle the relatively low volumes (Galle: 236.29 m³, Hambanthota: 127.21 m³, Trincomalee: 180.21 m³). The ANOVA results show a highly significant difference in plastic reception among the ports, F (3,28) =58.4, p=3.6e-12. The results of average reception of plastic per ship show there is a

significant difference among ports, with Trincomalee showing the highest at 2.49 m^3, followed by Galle at 1.67 m^3, Hambanthota at 1.53 m^3, and Colombo at 1.34 m^3 (ANOVA Results: F (3,28) =9.54, p=0.000166) (Figure 18).

Figure 18

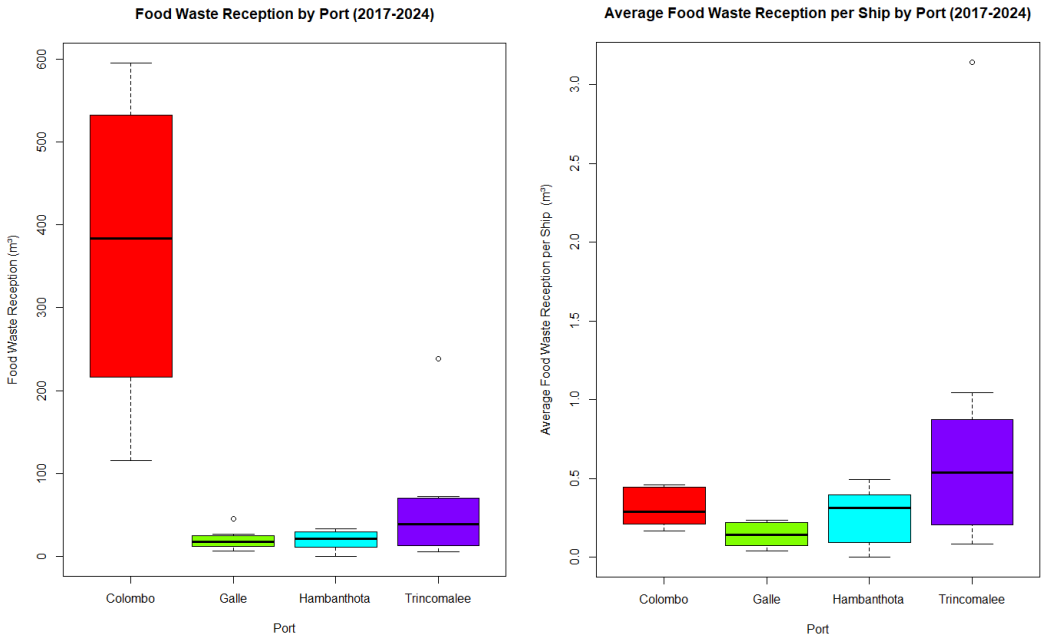
Boxplot of Plastic Waste Reception by Port



Colombo shows the highest food waste reception across the ports, with a mean of 371.90 m^3, followed by Trincomalee at 61.15 m^3, while the other ports handle similar minimum volumes (Galle: 19.75m^3, Hambanthota: 19.76 m^3). The ANOVA results show a highly significant difference in food waste reception among the ports, F (3,28) =24.48, p=5.57e-08. However, the results of average reception of food waste per ship highlight a marginally significant difference among ports, with Trincomalee leading at 0.81 m^3, followed by Colombo at 0.31 m^3, Hambanthota at 0.26 m^3, and Galle at 0.14 m^3 (ANOVA Results: F (3,28) =2.615, p=0.0708) (Figure 19).

Figure 19

Boxplot of Food Waste Reception by Port

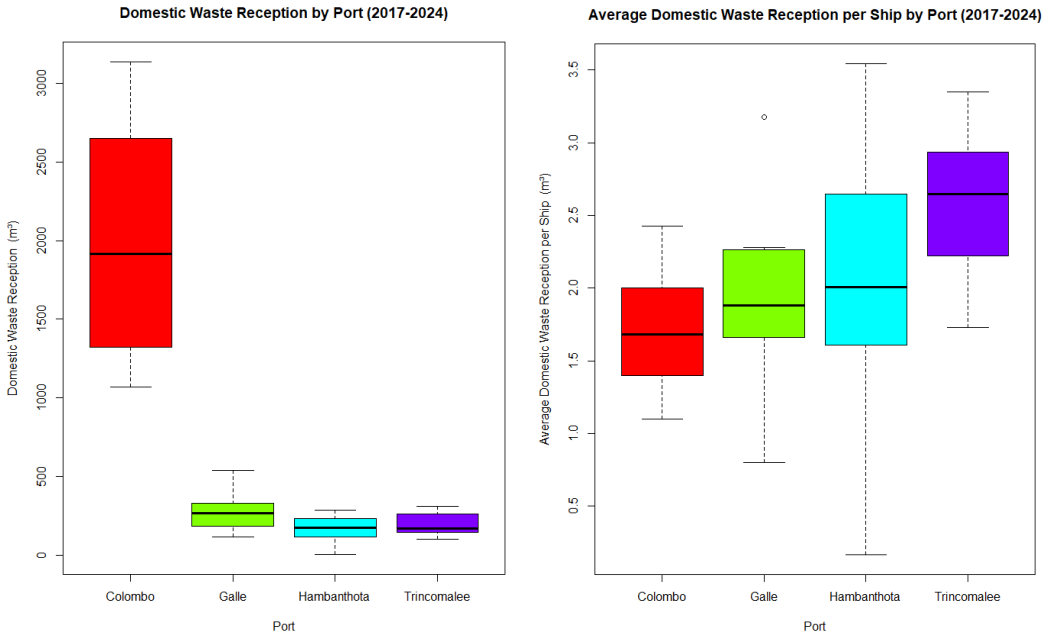


Colombo shows the highest domestic waste reception among the ports with a mean of 1996.8 m^3, while Galle handles 236.64 m^3, Hambanthota handles 166.62 m^3, and Trincomalee handles 195.25 m^3. The ANOVA results show a highly significant difference in domestic waste reception among the ports, F (3,28) =39.42, p=3.49e-10.

Trincomalee receives the highest domestic waste reception volume per ship at 2.59 m^3, followed by Hambanthota at 2.03 m^3, Galle at 1.95 m^3, and Colombo at 1.71 m^3; however, the differences between ports are not statistically significant (ANOVA results: F (3,28) =2.23, p=0.107) (Figure 20).

Figure 20

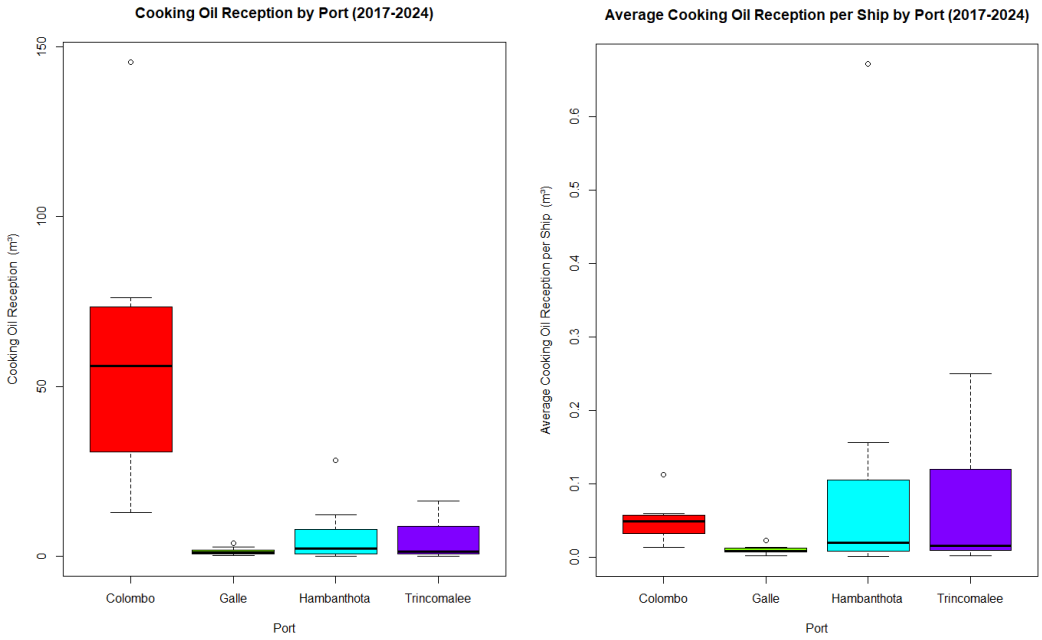
Boxplot of Domestic Waste Reception by Port



Colombo shows the highest cooking oil reception among the ports, with a mean of 59.80 m^3. Galle, Hambanthota, and Trincomalee show much lower volumes (Galle 1.41m^3, Hambanthota 6.22m^3, Trincomalee 4.6m^3). The ANOVA results show a highly significant difference in cooking oil reception among the ports, F (3,28) =13.44, p=1.28e-05. Hambanthota receives the highest volume of the average cooking oil reception per ship at 0.12 m^3, followed by Trincomalee at 0.07 m^3, Colombo at 0.05 m^3, and Galle at 0.01 m^3; however, the differences between ports are not statistically significant (ANOVA results: F (3,28) =1.929, p=0.148) (Figure 21).

Figure 21

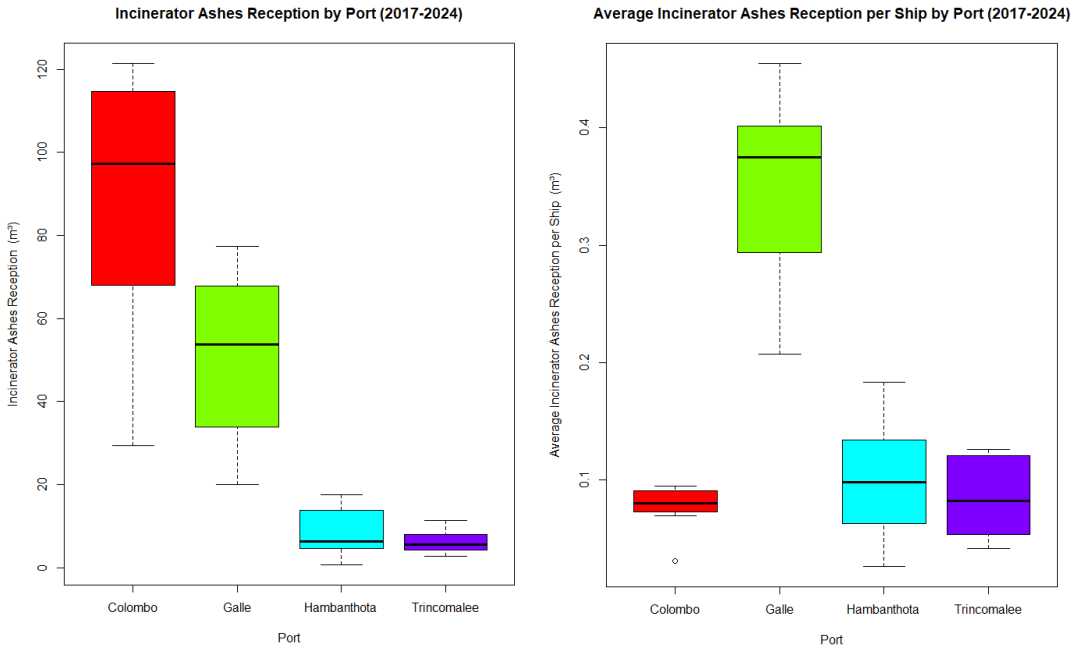
Boxplot of Cooking Oil Reception by Port



Colombo and Galle show the highest incinerator ashes reception across the four ports, with means of 88.85 m³ and 51.02 m³, while Hambanthota (8.44 m³) and Trincomalee (6.18 m³) show minimal volumes. The results indicate a highly significant difference in incinerator ashes reception volumes among the ports (ANOVA results: F (3,28) =32.39, p=3.03e-09). However, Galle receives the highest volume per ship at 0.35m³, followed by Hambanthota at 0.10 m³, Trincomalee at 0.08 m³, and Colombo at 0.08 m³. Similarly, the average incinerator ash reception per ship shows a highly significant difference between the ports (F (3,28) =52.68, p=1.23e-11). (Figure 22).

Figure 22

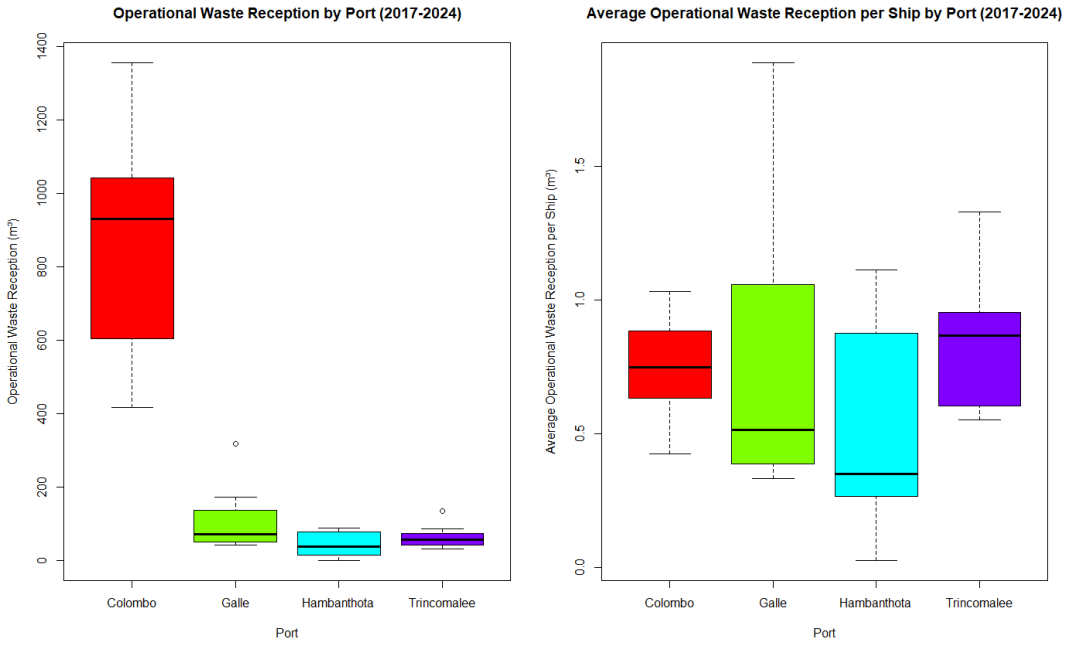
Boxplot of Incinerator Ashes Reception by Port



Colombo shows the highest operational waste reception among the ports with a mean of 866.4 m^3, while Galle handles 110.80 m^3, Hambanthota port handles 43.66 m^3, and Trincomalee handles 64.25. The ANOVA results show a highly significant difference in operational waste reception among the ports, F (3,28) =47.04, p=4.63e-11. However, Trincomalee receives the highest operational waste reception volume per ship at 0.84 m^3, followed by Galle at 0.77 m^3, Colombo at 0.75 m^3, and Hambanthota at 0.52 m^3, but the differences between ports are not statistically significant (ANOVA results: F (3,28) =1.135, p=0.352) (Figure 23).

Figure 23

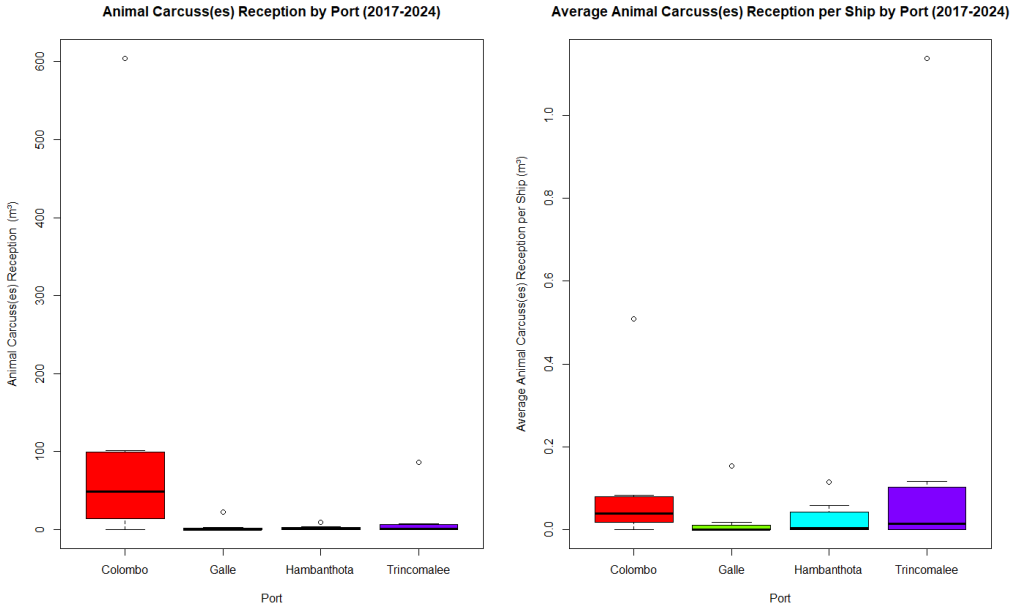
Boxplot of Operational Waste Reception by Port



Colombo shows the highest animal carcass reception across the ports, with a mean of 116.24 m^3, while the other ports handle the minimum volumes (Galle 3.17 m^3, Hambanthota 1.87 m^3, Trincomalee 12.68 m^3). The ANOVA results show a marginally significant difference in animal carcass reception among the ports, F (3,28) =2.37, p=0.09. However, Galle receives the highest animal carcasses reception volume per ship at 4.90 m^3, followed by Colombo at 2.01 $m^{3,}$ Hambanthota at 0.15 $m^{3,}$ and Trincomalee at 0.01 m^3, but the differences between ports are not statistically significant (ANOVA Results: F (3,28) =1.365, p=0.274) (Figure 24)

Figure 24

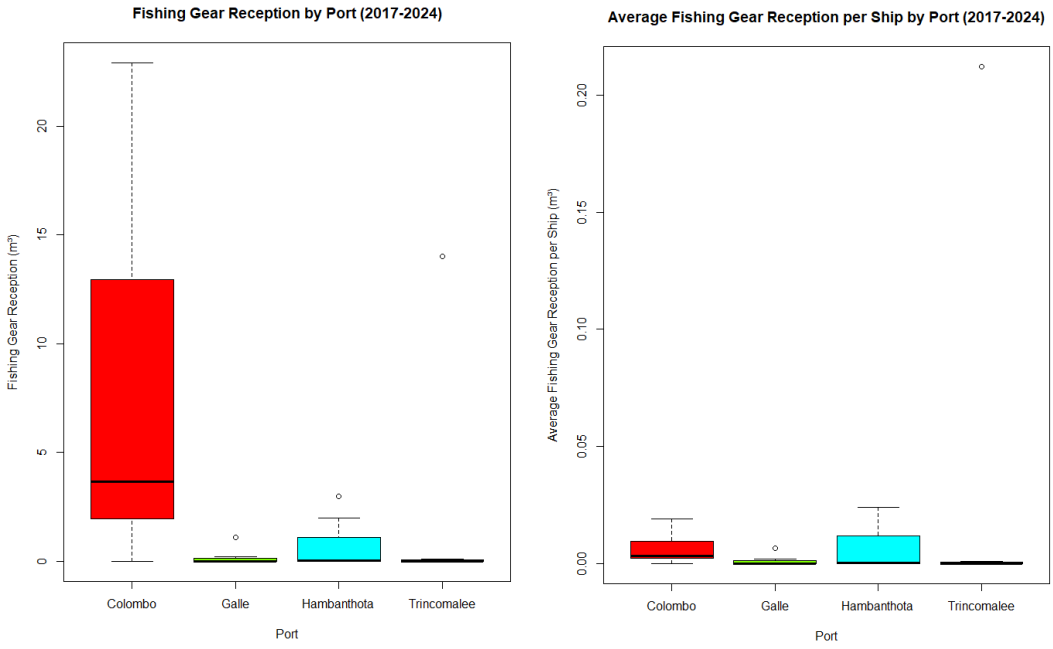
Boxplot of Animal Carcasses Reception by Port



Colombo shows the highest fishing gear reception among the ports with a mean of 7.5 m^3, while Trincomalee handles 1.76 m^3, Hambanthota port handles 0.65 m^3, and Galle handles 0.17 m^3. The ANOVA results show a highly significant difference in fishing gear reception among the ports, F (3,28) =3.8, 0.019. The right boxplot shows the average fishing gear reception per ship. Trincomalee receives the highest volume of fishing gear reception per ship at 0.027 m^3, followed by Colombo at 0.006 m^3, Hambanthota at 0.006 m^3, and Galle at 0.001 m^3; however, the differences between ports are not statistically significant (ANOVA results: F (3,28) =0.715, p=0.551) (Figure 25)

Figure 25

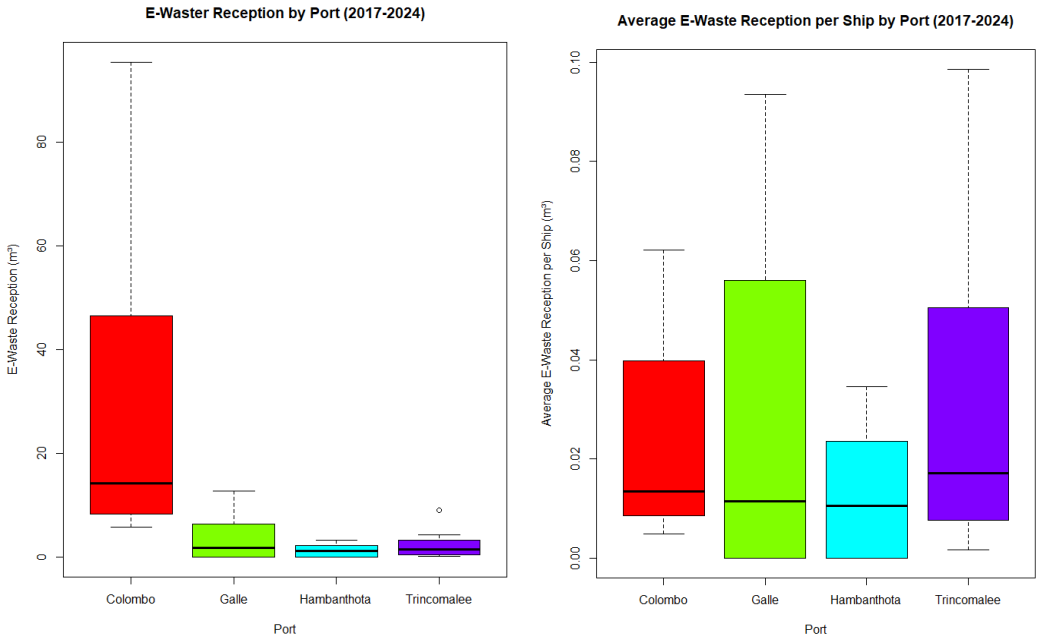
Boxplot of Fishing Gear Reception by Port



Colombo shows the highest E-waste reception with a mean of 29.86 m^3, while Galle handles 3.63 m^3, Trincomalee port handles 2.46 m^3, and Hambanthota handles 1.24 m^3. The ANOVA results show a significant difference in E-waste reception among the ports, F (3,28) =5.70, p=0.003. Trincomalee receives the highest E-waste reception volume per ship at 0.031 m^3, followed by Galle at 0.029 m^3, Colombo at 0.024m^3, and Hambanthota at 0.013 m^3; however, the differences between ports are not statistically significant (ANOVA results: F (3,28) =0.683, p=0.57) (Figure 26).

Figure 26

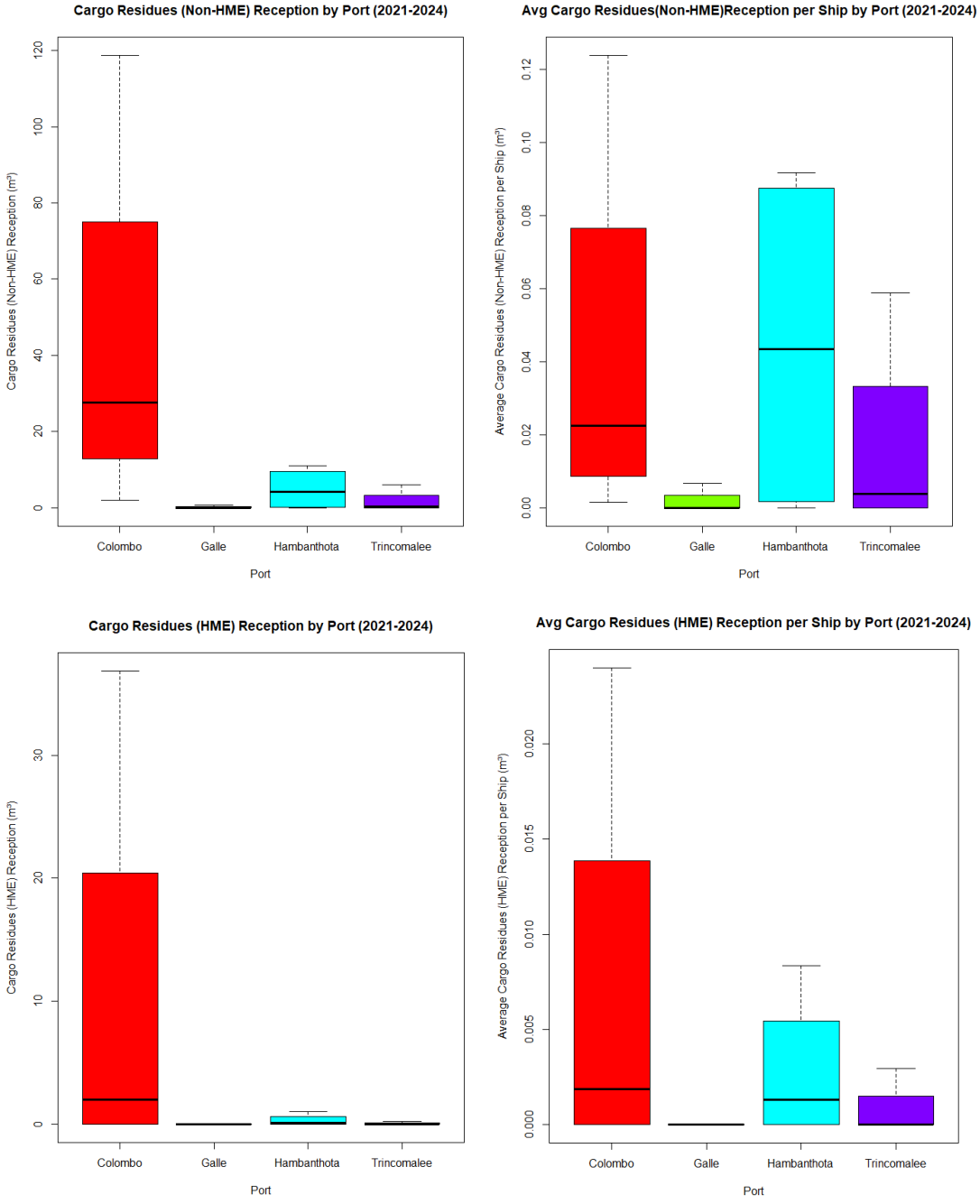
Boxplot of E-Waste by Port



Both Non-HME and HME cargo residues show limited data availability, with 16 missing observations. For Non-HME cargo residues, no significant differences among ports (ANOVA results: F (3,12) =2.625, p=0.0984), and it is the same for the HME cargo residues (ANOVA results: F (3,12) =1.276, p=0.327). Similarly, average Non-HME, HME cargo residues per ship showed no significant differences for both categories with the ANOVA results (F (3,12) =1.093, p=0.39), (F (3,12) =1.029, p=0.414) respectively (Figure 27).

Figure 27

Boxplot of Cargo Residues (Non-HME/HME) by Port



3.5 Waste Management Pathway

Ensuring recycling and proper disposal mechanisms are essential to manage the ship-generated waste types related to MARPOL Annexes, and it is crucial for environmental protection in Sri Lanka. The questionnaire responses from all MEPA officials representing all four ports reflect the current waste management practices related to MARPOL waste categories (Annex I - Oily waste, Annex IV - Sewage, Annex V - Garbage), from waste reception to final disposal (Table 3).

Table 3

Assessment of MARPOL Waste Management in Sri Lankan Ports

MARPOL Waste Management Pathways					
MARPOL Annex	**Waste Type**	**Waste Collection & Handling**	**Waste Reuse & Recycling**	**Final Disposal Method**	**Remarks**
Annex I **Oily Waste**	**Bilgewater/Dirty Ballast Water**	Treated onboard (Oily Water Separator) Collected by service providers	Recycle	Sent to the dewatering facility	Use approved facilities for dewatering, disposing of, or incinerating through appropriate facilities
	Sludge	Collected in onboard tanks Collected by service providers	Reused as fuel or recycle	Sent to the dewatering facility	Use approved facilities for dewatering, disposing of, or incinerating through appropriate facilities

	Oily Residues	Collected in onboard tanks Collected by service providers	Reused as fuel or recycle	Sent to the dewatering facility	Use approved facilities for dewatering, disposing of, or incinerating through appropriate facilities
	Oily Tank Wash	Collected in onboard tanks Treated onboard (Oily Water Separator) Collected by service providers	Reused as fuel or recycled	Sent to the dewatering facility	Use approved facilities for dewatering, disposing of, or incinerating through appropriate facilities
Annex IV **Sewage**	**Blackwater**	Treated onboard (Sewage Treatment Plant) Collected by service providers Discharged at sea per MARPOL limits	Not reused/recycled	Released into the municipal sewage facility	
Annex V **Garbage**	**Plastics**	Separated for recycling Collected by service providers	Sent to recycling facilities	Municipal council waste facility	Recyclable plastics are sent to an approved recycling facility

	Food Waste	Collected by service providers Discharged at sea (per regulations)	Composted	Municipal council waste facility Discharged within MARPOL limits Converted into animal feed	
	Domestic Waste (Paper, Glass, Metals)	Separated for recycling Collected by service providers	Recycled	Incinerated onboard Municipal council waste facility	
	Cargo Residues	Discharged at sea (per regulations) Collected by service providers	Not reused/recycled		
	Operational Waste	Collected at the port reception facility Collected by service providers	Recycled	Sent to a hazardous waste facility	
	Incinerator Ash	Collected by service providers	Not reused/recycled	Municipal council waste facility	
	Fishing Gear	Collected by service providers	Recycled	Sent to a plastic recycling facility	
	E-Waste	Collected by service providers	Recycled	Sent to a hazardous waste facility	

Hazardous Waste	**Batteries**	Collected by service providers	Reused in controlled conditions Recycled via hazardous waste processes	Incinerated at a specialized hazardous waste plant	Batteries are sent to a battery disposal facility
	Paints/ Chemicals	Collected by service providers	Recycled via hazardous waste processes	Incinerated at a specialized hazardous waste plant	
	Medical Waste (clinical waste/expired medicine)	Collected in a special onboard containment Collected by service providers	Recycled via hazardous waste processes	Incinerated at a specialized hazardous waste plant	
	Fluorescent Bulbs	Collected in a special onboard containment Not collected by service providers due to a lack of treatment facilities	Not reused/recycled		No sufficient facilities for disposal
	Oily rags	Collected by service providers	Not reused/recycled	Incinerated at a specialized hazardous waste plant	

Based on the questionnaire responses, the research identified existing waste management pathways of MARPOL waste types from collection to final disposal. The analysis highlights well-established procedures for most of the waste types, including proper recycling channels for oily waste, plastics, metals, and certain hazardous materials. The questionnaire responses also focused on identifying the current operational capacity, operational challenges, evaluation, and future perspectives. However, the research revealed critical gaps in disposal infrastructure, especially for

hazardous waste types such as fluorescent bulbs, which do not have sufficient treatment facilities. The questionnaire's evaluation section reflects that current port waste reception facilities as "moderately-effective-need improvements". The questionnaire responses suggest solutions to overcome these identified gaps to ensure the operational procedures of ship-generated waste reception align with environmental health (Table 4).

Table 4

Assessment of Ship-Generated Waste Reception Facilities in Sri Lankan Commercial Ports

Capacity		
Question	**Response**	
What are the types of ship-generated waste discharged to your port?	MARPOL Annex I	Oily Waste
	MARPOL Annex IV	Sewage
	MARPOL Annex V	Garbage
Challenges		
Question	**Response**	
What type/types of ship-generated waste are critical to manage in Sri Lanka? (Please select options)	MARPOL Annex V (Hazardous waste: Chemicals, Batteries, Fluorescent bulbs) MARPOL Annex III (Harmful package substances)	

What are the common challenges related to managing the above-mentioned ship-based waste categories? (Please select up to three options)	Lack of infrastructure facilities High cost of waste treatment High transportation costs to treatment facilities
Evaluation	
Question	**Response**
How do you rate the effectiveness of current waste reception facilities in Sri Lankan ports? (Please select an option)	Moderately effective - Need improvements
Future Perspective	
Question	**Response**
What are the suggested solutions to improve ship-based waste reception effectiveness in Sri Lanka?	Upgrade treatment facilities with new technologies Implementation of a GPS-based tracking system for MARPOL Annex V Develop treatment facilities in port areas Random inspections of ships and service providers' facilities are subject to ship waste management Develop recycling facilities in Municipal councils

	Take necessary actions to improve awareness and capacity building

Chapter 4 Discussion

This study is Sri Lanka's first comprehensive evaluation of ship-generated waste reception in four main commercial ports: Colombo, Galle, Hambanthota, and Trincomalee. The study establishes a baseline dataset for ship-generated waste reception in the country. The findings of this research show a highly centralized and underutilized waste reception system, as only 33% of the 4819 ships that arrived in 2023 used the waste reception service (Sri Lanka Ports Authority, 2023), while exceeding the rate observed in nearby international ports. (Fahmi et al., 2025) reported that a low 0.27% utilization rate at Indonesia's Tanjunu Priok port, where 96% of ships reported waste present. However, this difference between waste generation and waste reception is represented in terms of "waste gap" in the European Commission. The commission estimated at 7-34% for garbage, 10% for sewage, and 2.5% for oily waste, and this waste is potentially being discharged illegally to the marine environment (An EU action plan for the Circular Economy, Gambasha Barau, 2024). The United Nations Environment Program estimates that 5 million items of marine litter enter oceans daily from ships and predicts that more plastic than fish in the seas by 2050 INTERPOL. (2018). This illegal waste discharging is particularly affecting Sri Lankan waters because of the underutilization of port waste reception facilities, and is causing the country to rank among the top global maritime litter producers (EN, n.d.; Jambeck et al., 2015).

The study also highlights a centralized pattern at the Colombo port, which handles 80% of ships utilizing waste reception facilities and accounts for 94% of the country's total oil waste reception volume. This centralized nature also aligns with findings from Istanbul, where the Haydarpasa port performs its waste reception nearly 1.5-2 times higher than the Ambarli port (Ülker et al., 2023). The author elaborates on it according to the port size and vessel types. Similarly, Colombo is the dominant port that handles 87.8% of the national total container traffic and utilizes high waste reception volume. This research provides important baseline data related to the ship-based waste reception in Sri Lanka. Because the country is a developing maritime hub strategically

positioned along the major shipping routes, approximately 60,000 ships pass through its waters (Jayakody et al., 2021). Due to the high volume of maritime traffic, effective waste reception facilities are essential for marine environmental protection, aligning with shipping practices.

An eight-year analysis of the waste reception data illustrates the patterns of waste reception among MARPOL Annexes I-V. The study highlights the extreme oily waste management referred to MARPOL Annex I in Colombo, which processes 94% of national volumes (mean: 20.138.5 m^3 annually for oily residues), and it is highly significantly different from other ports. The reason is the high concentration of the dewatering facilities around Colombo and the comparatively high utilization of waste reception facilities due to high maritime traffic. In Bangladesh's Chittagong port, Similar challenges were identified, but, it is oppositely, due to a lack of infrastructure facilities, the Environment Management Unit could not operate effectively due to infrastructure limitations (Khondoker & Hasan, 2020). Also Marine Environment Protection Authority regulates this process in Sri Lanka, and there is already an established technical guideline that should be fulfilled while conducting oil-related waste reception, such as GPS-tracked tanker engagement in transportation, and all oily waste goes through a dewatering facility to ensure environmental safety of this operation. These practices are not followed in Bangladesh. In 2021, there was an outlier in the oily tank washing reception at Galle port, due to the out-of-port waste reception operation of the "Shanika Marine," the most prominent service provider in Sri Lanka. It was due to a seasonal job that used their barge in 2021, and after that, there were no high variations. This case was another example of the lack of infrastructure and logistics in other ports and their development potential in Sri Lanka.

Sewage reception referred to MARPOL Annex IV, Trincomalee port recorded extremely high reception volume in 2018, despite comparatively low ship traffic. According to the per-ship analysis, Trincomalee receives the highest average volume of sewage per ship, 3.01m^3, which was significantly higher than all other ports. It was due to the Naval exercise called "SLINEX 2018", which was conducted Sri Lankan

Navy and the Indian Navy with the participation of around 1000 naval personnel from both countries (*Sri Lanka Navy*, n.d.). This pattern aligns with Southampton's findings(Butt, 2007), where the cruise ships represent less than 1% of the global merchant fleet. It is responsible for 62.5% of all solid waste landed and highlighting how vessel type significantly influences waste management requirements.

Garbage reception, as referred to in MARPOL Annex V, shows an interesting port-specific pattern. While Colombo is dominated by receiving 75% national ship-based garbage reception, the garbage reception per ship analysis elaborates that the Trincomalee port receives higher volumes per ship for several categories (Plastic: 2.49 m^3/ship, domestic waste: 2.59 m^3/ship). This can be a result of the ship type, ship size, and operational differences between the ports, aligning with Southampton's findings (Butt, 2007). Another study should be conducted to find out these interconnections. It will be important to find out about future infrastructure planning. According to this study, Ship-based garbage mainly consists of plastic and domestic waste. But with the development of the maritime industry, critical gaps in waste management have been identified. The absence of sufficient waste disposal facilities for specific hazardous components, such as fluorescent bulbs, as noted in Table 4, indicates systemic failures. These deficiencies force service providers into a difficult position, which makes them refuse to collect these waste types from ships due to the unavailability of proper disposal methods. However, this potential creates improper disposal by ships or service providers, which causes environmental degradation. (Osmundsen, 2023) documented a similar infrastructure gap in Arctic regions, where the few ports function as plastic waste reception, even with MARPOL obligations.

The questionnaire responses identified infrastructure deficiencies, high treatment costs, and high transport costs as primary challenges to implementing ship-generated waste reception facilities. These challenges are not unique to Sri Lanka, but they reflect systemic issues in developing maritime nations globally. High operation costs are the major barrier; however, there is no published document related to waste reception costs in the Sri Lankan context. Nevertheless, some international publications have been

found. (Fahmi et al., 2025) documented those 250,000 Indonesian rupees per cubic meter fees at Tanjung Priok port. (Mobilik et al., 2016) documented those Malaysian ports charging USD 200-500 for garbage collection. These high costs violate MEPC.83(44) guidelines and discourage the use of these facilities. Most of the treatment facilities are centralized in Colombo, but there are problems with accepting chemical wastes and hazardous waste due to the deficiency of infrastructure facilities, high treatment costs, and high transportation costs, as mentioned in the questionnaire responses. The waste from distant ports located at Hambanthota, Trincomalee is transported to the treatment plants centralized in Colombo. Also, the questionnaire responses highlight that countries' waste reception facilities are moderately effective and need improvements. This reflects its need for infrastructure development. This infrastructure challenge extends beyond Sri Lanka. North Sea study of Carpenter & Macgill, n.d. found that, out of 65 ports, only 27 ports accepted chemical or noxious wastes, and 38 ports were not accepted due to the infrastructure gap. Under the statement “waste reception facilities are moderately effective and need improvements”, it is also mentioned that the requirement of improvements of the regularity framework. A similar case found internationally relates to implementation challenges in the Nigerian Apapa port, but it highlights that the issue is due to the lack of collaboration among the stakeholders (Gambasha Barau, 2024a). However, the Marine Environment Protection Authority (MEPA), Central Environment Authority (CEA), and Sri Lanka Ports Authority (SLPA) are the key stakeholders who govern this process. There is already an established 24-hour advance notification system, job-by-job permit issuing procedure, and GPS-tracked road tanker monitoring system regulated by MEPA, under the 2016 waste reception service regulation. As per the field observations, MEPA officials cannot board every arriving ship and conduct the inspections due to a shortage of trained officials and their tight schedules. So, there is a requirement to strengthen MEPA for the empowerment of the regulatory framework, and the government has to develop the waste treatment infrastructure adequate to the ship-based waste management requirement. According to (Butt, 2007), it emphasizes polluter pays and producer responsibility principles through Directive 2000/59/EC.

That framework should adapt to Sri Lanka with a spot fine system for MARPOL non-compliances to create a more enhanced regulatory framework.

Shifting from linear disposal to a circular economy will bring benefits to the Sri Lankan ports. Copenhagen and Malmö ports are good examples of that. They considered waste as a valuable resource. These ports practice a waste management plan which includes effective segregation methods, partnerships with recycling services to align with the EU Directives on waste collection to support recycling and reuse, and waste-to-energy projects (Copenhagen Malmö Port, n.d.). These models will provide practical solutions for the emerging environmental issues in Sri Lanka, and the circular economy principle will help to develop Sri Lanka as a sustainable maritime hub. The research identified that there is an urgent need for infrastructure development, especially for hazardous waste management. So strategic technology adoption is crucial, including a GPS Tracking system to monitor garbage reception related to MARPOL Annex V, from the receiving point to the final disposal point. Capacity building is another requirement to enhance the sustainable operation. Under that, related stakeholders such as service providers, MEPA, CEA, and SLPA officials, and treatment facility operators should receive comprehensive training on international waste management standards, proper handling procedures for hazardous wastes, MARPOL regulations, and emergency response procedures, and advanced waste treatment technologies that comply with the management of ship-generated waste. Similarly, strategic and technology adaptation procedures are recommended for Nigeria's Apapa port (Gambasha Barau, 2024b) to improve efficiency while reducing operational costs. The research suggests the development of treatment facilities in port areas to reduce transportation costs and carbon emissions while creating employment opportunities within the circular economic framework, which aligns shipping practices with environmental protection.4.1 Research Limitations

Because of the newly implemented procedure 2017-2020, some waste categories are not recorded, which caused the data limitation of waste categories in the MEPA WRS database. The notable concern is 16 missing observations in oily bilge water, cargo

residues (HME and Non-HME), which points to the inconsistencies of the reporting system. However, from 2021, it was recorded properly.

It is also important to note that the small size of the questionnaire responses, which involved all nine MEPA officials who engage in this WRS operation, may not have fully captured all operational gaps. So, there is a requirement to cover all stakeholders who engage in this waste reception operation in the future data collections.

Trincomalee and Galle ports mainly operate out of the port waste reception. The data on annual arriving ships was obtained from annual reports of the Sri Lankan Port Authority. That report only consists of the data of arriving vessels into the port. And the MEPA WRS database has recorded the data of ships that conduct the waste reception in the port, which consists of all waste reception that includes port and out-of-port waste reception operations, but there is no way to separate them. That is the reason for the number of waste-discharging ships is greater than the number of arriving ships (Figure 7).

Chapter 5 Conclusion

The baseline data (2017-2024) reveal the underutilization of waste reception facilities, which states that only 33% of arriving ships utilize waste reception facilities (1598 of 4819 in 2023). This “waste gap” potentially leads to illegal ocean discharges from ships. Colombo port handles 80% of all ship-based waste reception in the country and dominates due to the centralization of all treatment facilities and high maritime traffic. Also, the statistical analysis confirms a highly significant variation in waste reception capacities among the ports, highlighting Colombo. Because Colombo port receives 94% of MARPOL Annex I (Oily waste), 48% of Annex IV (Sewage), and 75% of Annex V (Garbage) of the total national ship-generated waste volume. Also, this research reveals waste type-specific findings. Colombo shows high dominance in oily residues reception that processing mean volume of 20,138.5 m^3 annually, with a high significance difference with other ports (p=1.09e-15). Trincomalee shows an unusual pattern in sewage reception per ship with 3.01m^3, due to the special naval exercise. Again, Colombo dominates in handling plastic and domestic waste with 1,569 m^3 and 1,997 m^3 in annual volumes, respectively. However, Trincomalee receives high volumes of plastic and domestic waste through the per ship analysis.

The research identifies the three critical challenges that affect the effectiveness of the waste reception operation. They have inadequate infrastructure for hazardous waste management, high treatment costs, and high transport costs to the centralized facilities. These challenges are mainly caused by handling MARPOL Annex V hazardous components, where the no sufficient facilities available for disposing of materials like fluorescent bulbs. However, these deficiencies create regulatory compliance gaps.

Not only these challenges, but there are positive elements that exist within the current framework. The presence of 28 registered service providers establishes a GPS tracking system for oily waste transport and comprehensive regulatory oversight by MEPA, demonstrating the institutional commitment to marine environment pollution prevention. This analysis shows the upward trend of waste reception utilization and

suggests capacity and infrastructure development requirements to align circular economic perspective, aligning with maritime health.

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Appendices A

QUESTIONNAIRE TO STUDY THE SHIP-GENERATED WASTE RECEPTION FACILITIES IN SRI LANKAN COMMERCIAL PORTS

Instructions
Please read the questions carefully and follow the instructions for each question

1. Port Name (Please check the relevant box)

   ☐ Colombo ☐ Galle ☐ Hambanthota ☐ Trincomalee

2. What are the types of ship-generated waste discharged to your port?
   (Please check the relevant boxes)

   ☐ MARPOL Annex I Oily Waste
   ☐ MARPOL Annex II Noxious liquids
   ☐ MARPOL Annex III Harmful package substances
   ☐ MARPOL Annex IV Sewage
   ☐ MARPOL Annex V Garbage
   ☐ MARPOL Annex VI Air pollutant-related waste

3. MARPOL Waste Types and End-of-Life Handling

MARPOL Annex	Waste Type	Waste Collection & Handling (Check if applicable)	Waste Reuse & Recycling (Check if applicable)	Final Disposal Method (Check if applicable)	Remarks
Annex I Oily Waste	Bilgewater/Dirty Ballast Water	☐ Collected in onboard tanks ☐ Discharged to a port reception facility ☐ Treated onboard (Oily Water Separator) ☐ Collected by service providers	☐ Reused as fuel ☐ Recycled ☐ Not reused/recycled	☐ Incinerated onboard ☐ Sent to hazardous waste facility ☐ Sent to the dewatering facility ☐ Discharged illegally (violation)	
	Sludge	☐ Collected in onboard tanks ☐ Discharged to a port reception facility ☐ Treated onboard (Oily Water Separator) ☐ Collected by service providers	☐ Reused as fuel ☐ Recycled ☐ Not reused/recycled	☐ Incinerated onboard ☐ Sent to hazardous waste facility ☐ Sent to the dewatering facility ☐ Discharged illegally (violation)	
	Oily Residues	☐ Collected in onboard tanks ☐ Discharged to a port reception facility ☐ Treated onboard (Oily Water Separator) ☐ Collected by service providers	☐ Reused as fuel ☐ Recycled ☐ Not reused/recycled	☐ Incinerated onboard ☐ Sent to hazardous waste facility ☐ Sent to the dewatering facility ☐ Discharged illegally (violation)	
	Oily Tank Wash	☐ Collected in onboard tanks ☐ Discharged to a port reception facility ☐ Treated onboard (Oily Water Separator) ☐ Collected by service providers	☐ Reused as fuel ☐ Recycled ☐ Not reused/recycled	☐ Incinerated onboard ☐ Sent to hazardous waste facility ☐ Sent to the dewatering facility ☐ Discharged illegally (violation)	

Annex IV Sewage	Blackwater	☐ Treated onboard (Sewage Treatment Plant) ☐ Discharged to a port reception facility ☐ Collected by service providers ☐ Discharged at sea per MARPOL limits	☐ Reused as treated water (if applicable) ☐ Not reused/recycled	☐ Released into the municipal sewage facility ☐ Used in agricultural irrigation ☐ Discharged illegally (violation)	
Annex V Garbage	Plastics	☐ Separated for recycling ☐ Mixed with general waste ☐ Collected by service providers ☐ Collected at the port reception facility	☐ Sent to recycling facilities ☐ Reused onboard ☐ Not reused/recycled	☐ Municipal council waste facility ☐ Incinerated without energy recovery ☐ Converted into energy ☐ Dumped at sea (violation)	
	Food Waste	☐ Collected at the port reception facility ☐ Collected by service providers ☐ Discharged at sea (per regulations)	☐ Composted ☐ Used for biogas ☐ Not reused/recycled	☐ Municipal council waste facility ☐ Discharged within MARPOL limits ☐ Converted into animal feed ☐ Illegally dumped near shore (violation)	
	Domestic Waste (Paper, Glass, Metals)	☐ Separated for recycling ☐ Mixed with general waste ☐ Collected by service providers ☐ Collected at the port reception facility	☐ Recycled ☐ Reused onboard ☐ Not reused/recycled	☐ Incinerated onboard ☐ Municipal council waste facility ☐ Dumped at sea (violation)	
	Cargo Residues	☐ Collected at the port reception facility ☐ Discharged at sea (per regulations) ☐ Collected by service providers	☐ Processed for reuse ☐ Not reused/recycled	☐ Recovered for industrial use ☐ Sent to hazardous waste facility ☐ Dumped at sea (violation)	

	Operational Waste	☐ Collected at the port reception facility ☐ Mixed with general waste ☐ Collected by service providers	☐ Recycled ☐ Reused onboard ☐ Not reused/recycled	☐ Sent to hazardous waste facility ☐ Incinerated onboard ☐ Illegally discarded at the port	
	Incinerator Ash	☐ Collected at the port reception facility ☐ Discharged at sea (per regulations) ☐ Collected by service providers	☐ Recycled for industrial use ☐ Not reused/recycled	☐ Stored onboard for proper disposal ☐ Municipal council waste facility ☐ Dumped illegally (violation)	
	Fishing Gear	☐ Collected at the port reception facility ☐ Left in the ocean (illegal disposal) ☐ Collected by service providers	☐ Recycled ☐ Reused by fisheries ☐ Not reused/recycled	☐ Sent to plastic recycling facility ☐ Converted into energy ☐ Dumped at sea (violation)	
	E-Waste	☐ Collected at the port reception facility ☐ Mixed with general waste ☐ Collected by service providers	☐ Recycled ☐ Reused onboard ☐ Not reused/recycled	☐ Sent to hazardous waste facility ☐ Incinerated onboard ☐ Illegally discarded at the port	
Hazardous Waste	☐ Batteries	☐ Collected in special onboard containment ☐ Discharged to the port hazardous waste facility ☐ Mixed with general waste ☐Collected by service providers	☐ Reused in controlled conditions ☐ Recycled via hazardous waste processes ☐ Not reused/recycled	☐ Incinerated at a specialized hazardous waste plant ☐ Landfilled in a controlled environment ☐ Illegally discarded (violation)	
	☐ Paints/ Chemicals	☐ Collected in special onboard containment ☐ Discharged to the port hazardous waste facility ☐ Mixed with general waste ☐Collected by service providers	☐ Reused in controlled conditions ☐ Recycled via hazardous waste processes ☐ Not reused/recycled	☐ Incinerated at a specialized hazardous waste plant ☐ Landfilled in a controlled environment ☐ Illegally discarded (violation)	

	☐ Medical Waste (clinical waste/expired medicine)	☐ Collected in a special onboard containment ☐ Discharged to the port hazardous waste facility ☐ Mixed with general waste ☐Collected by service providers	☐ Reused in controlled conditions ☐ Recycled via hazardous waste processes ☐ Not reused/recycled	☐ Incinerated at a specialized hazardous waste plant ☐ Landfilled in a controlled environment ☐ Illegally discarded (violation)	
	☐ Fluorescent Bulbs	☐ Collected in a special onboard containment ☐ Discharged to the port hazardous waste facility ☐ Mixed with general waste ☐Collected by service providers ☐ Not collected by service providers due to a lack of treatment facilities	☐ Reused in controlled conditions ☐ Recycled via hazardous waste processes ☐ Not reused/recycled	☐ Incinerated at a specialized hazardous waste plant ☐ Landfilled in a controlled environment ☐ Illegally discarded (violation)	
	☐ Oily rags	☐ Collected in a special onboard containment ☐ Discharged to the port hazardous waste facility ☐ Mixed with general waste ☐Collected by service providers ☐ Not collected by service providers due to a lack of treatment facilities	☐ Reused in controlled conditions ☐ Recycled via hazardous waste processes ☐ Not reused/recycled	☐ Incinerated at a specialized hazardous waste plant ☐ Landfilled in a controlled environment ☐ Illegally discarded (violation)	

4. What type/types of ship-generated waste are critical to manage in Sri Lanka? (Please select options)

- ☐ MARPOL Annex I — Oily Waste
- ☐ MARPOL Annex II — Noxious liquids
- ☐ MARPOL Annex III — Harmful package substances
- ☐ MARPOL Annex IV — Sewage
- ☐ MARPOL Annex V — Garbage
- ☐ MARPOL Annex V — Hazardous waste (Chemicals, Batteries, Fluorescent bulbs)
- ☐ MARPOL Annex VI — Air pollutant-related waste
- ☐ Other (Pls Specify) .....

5. What are the common challenges related to managing the above-mentioned ship-based waste categories? (Please select up to three options)

- ☐ Lack of infrastructure facilities
- ☐ Insufficient enforcement of MARPOL regulations
- ☐ High cost of waste treatment
- ☐ High transportation costs to treatment facilities
- ☐ Delays in waste collection and processing
- ☐ Other (Please Specify) .....

6. How do you rate the effectiveness of current waste reception facilities in Sri Lankan ports? (Please select option)

- ☐ Very effective - Sufficient facilities and proper operations
- ☐ Moderately effective - Need improvements
- ☐ Poor – Insufficient facilities
- ☐ Very poor – Handling waste is a major challenge

7. What are the suggested solutions to improve ship–based waste reception effectiveness in Sri Lanka?

- ☐ Upgrade treatment facilities with new technologies
- ☐ Enforcement of waste disposal and handling regulations
- ☐ Implementation of a GPS-based tracking system for MARPOL Annex V
- ☐ Develop treatment facilities in port areas
- ☐ Improve waste recycling mechanisms
- ☐ Other (Please Specify- Open answer)

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Appendices B

ANOVA Summary table for Waste Reception by MARPOL Annexes across the Ports

Waste Category	MARPOL Annex	F-value	p-value	Significance	Effect	Bartlett's Test (p-value)	Variance Homogeneity
MARPOL Annex I							
Oily Bilge Water	Annex 1	1.917	0.181	ns	No significant difference	2.14e-08	Violated
Oily Residues	Annex 1	111.7	1.09e-15	***	Highly significant	<2.2e-16	Violated
Oily Tank Wash	Annex 1	6.081	0.00254	**	Significant	<2.2e-16	Violated
Dirty Ballast Water	Annex 1	4.218	0.014	*	Significant	<2.2e-16	Violated
Scale and Sludge from Tank Cleaning	Annex 1	11.83	3.49e-05	***	Highly significant	<2.2e-16	Violated
Other (Oil-related)	Annex 1	1.705	0.189	ns	No significant difference	<2.2e-16	Violated
MARPOL Annex IV							
Sewage	Annex 4	1.838	0.163	ns	No significant difference	1.926e-09	Violated
MARPOL Annex V							
Plastic	Annex 5	58.4	3.6e-12	***	Highly significant	5.694e-10	Violated
Food Waste	Annex 5	24.48	5.57e-08	***	Highly significant	7.554e-11	Violated
Domestic Waste	Annex 5	39.42	3.49e-10	***	Highly significant	2.098e-10	Violated
Cooking Oil	Annex 5	13.44	1.28e-05	***	Highly significant	5.709e-12	Violated
Incinerator Ashes	Annex 5	32.39	3.03e-09	***	Highly significant	2.095e-07	Violated
Operational Waste	Annex 5	47.04	4.63e-11	***	Highly significant	7.089e-09	Violated
Animal Carcass(es)	Annex 5	2.377	0.0911	.	Marginally significant	<2.2e-16	Violated
Fishing Gear	Annex 5	3.879	0.0195	*	Significant	8.365e-10	Violated
E-Waste	Annex 5	5.704	0.00354	**	Significant	1.004e-13	Violated
Cargo Residues (Non-HME)	Annex 5	2.625	0.0984	.	Marginally significant	2.009e-08	Violated
Cargo Residues (HME)	Annex 5	1.276	0.327	ns	No significant difference	<2.2e-16	Violated

Significance levels: *** p < 0.001, ** p < 0.01, * p < 0.05, . p < 0.1, ns = not significant

ANOVA Summary table for Waste Reception by MARPOL Annexes per Ship across the Ports

Waste Category	F-value	p-value	Significance	Effect	Bartlett's Test (	Variance Homogeneity
MARPOL Annex I						
Oily Bilge Water	0.797	0.519	ns	No significant difference	0.01925	Violated
Oily Residues	90.82	1.54e-14	***	Highly significant	1.767e-09	Violated
Oily Tank Wash	1.365	0.274	ns	No significant difference	<2.2e-16	Violated
Dirty Ballast Water	4.396	0.0118	*	Significant	<2.2e-16	Violated
Scale and Sludge from Tank Cleaning	1.929	0.148	ns	No significant difference	5.286e-06	Violated
Other (Oil-related)	1.596	0.212	ns	No significant difference	<2.2e-16	Violated
MARPOL Annex IV						
Sewage	1.535	0.227	ns	No significant difference	<2.2e-16	Violated
MARPOL Annex V						
Plastic	9.54	0.000166	***	Highly significant	0.01525	Violated
Food Waste	2.615	0.0708	.	Marginally significant	1.589e-10	Violated
Domestic Waste	2.23	0.107	ns	No significant difference	0.1501	Maintained
Cooking Oil	0.988	0.413	ns	No significant difference	9.966e-12	Violated
Incinerator Ashes	52.68	1.23e-11	***	Highly significant	0.007918	Violated
Operational Waste	1.135	0.352	ns	No significant difference	0.04454	Violated
Animal Carcass(es)	0.847	0.48	ns	No significant difference	7.969e-08	Violated
Fishing Gear	0.715	0.551	ns	No significant difference	8.113e-15	Violated
E-Waste	0.683	0.57	ns	No significant difference	0.07378	Maintained
Cargo Residues (Non-HME)	1.093	0.39	ns	No significant difference	0.007525	Violated
Cargo Residues (HME)	1.029	0.414	ns	No significant difference	<2.2e-16	Violated

Significance levels: *** p < 0.001, ** p < 0.01, * p < 0.05, . p < 0.1, ns = not significant

Appendices C

Consent forms

WORLD MARITIME UNIVERSITY

General Manager,
Marine Environment Protection Authority,
Sri Lanka.

Dear Sir,

Requesting access to the Waste Reception Service (WRS) Database for Research Purposes

Thank you for agreeing to grant me access to the Waste Reception Service (WRS) database for this research survey, which is carried out in connection with a Dissertation that will be written by, in partial fulfillment of the requirements for the degree of Master of Science in Maritime Affairs at the World Maritime University in Malmo, Sweden.

The topic of the Dissertation is **Evaluating Ship-Generated Waste Reception Facilities in Sri Lankan Commercial Ports: Challenges, Capacity, and Future Perspectives**

The data provided by the Marine Environment Protection Authority, WRS Database will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. You may withdraw from the research data at any time, and your data will be immediately deleted.

The research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

Your permission to access the WRS database is highly appreciated.

The student's name	Madhura Thilina Kumara Delpachitra
Specialization	Ocean Sustainability Governance and Management
Email address	w1016164@wmu.se

* * *

I hereby consent to the use of data from the WRS database as outlined above, for the purpose of this academic research. I understand that all data will be held in strict confidence and permanently deleted upon completion of the researcher's enrolment

Name: A.J.M. Gunasekara

Signature:

Date: 02.07.2025

WORLD MARITIME UNIVERSITY

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation that will be written by the researcher, in partial fulfillment of the requirements for the degree of Master of Science in Maritime Affairs at the World Maritime University in Malmo, Sweden.

The topic of the Dissertation is **Evaluating Ship-Generated Waste Reception Facilities in Sri Lankan Commercial Ports: Challenges, Capacity, and Future Perspectives**

The information provided by you in this survey will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

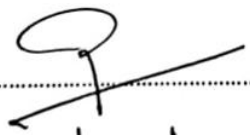
Your participation in the research survey is highly appreciated.

Student's name	Madhura Thilina Kumara Delpachitra
Specialization	Ocean Sustainability Governance and Management
Email address	w1016164@wmu.se

* * *

I consent to my personal data, as outlined above, being used for this study. I understand that all personal data relating to participants is held and processed in the strictest confidence, and will be deleted at the end of the researcher's enrolment.

Name: R.N. PRIYADARSHANA

Signature: 

Date: 02/07/2025.

WORLD MARITIME UNIVERSITY

Dear Participant,

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Your participation in the research survey is highly appreciated.

Student's name	Madhura Thilina Kumara Delpachitra
Specialization	Ocean Sustainability Governance and Management
Email address	w1016164@wmu.se

* * *

I consent to my personal data, as outlined above, being used for this study. I understand that all personal data relating to participants is held and processed in the strictest confidence, and will be deleted at the end of the researcher's enrolment.

Name: Indika Wijethna

Signature:

Date: 03/07/2025

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Name: H.N.S. Wijethunga

Signature: 

Date: 03.07.25

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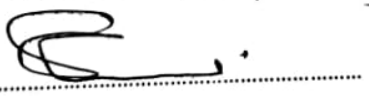
Name: T - Shripathy

Signature: 

Date: 05/07/2025

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Name: W.T.D.K.M.A Gunathilaka

Signature: .....

Date: 25/07-09

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Name: H.P.N.K. Senarathna

Signature: 

Date: 09-07-2025

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Name: Y. Prasath Kumara

Signature: 

Date: 2025-07-11

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Name: R.M.M.P. Rathnayaka

Signature: 

Date: 2025/7/15

Appendices D

WRS Registration 2024

S. No	Reg.No-2024	Service Provider	Waste Type			Ports			
			W. Oil	Garbage	Sewage	Colombo	Galle	Hamban	Trinco
1	2024/WRS/33	N.G.N. Ranjith Marine (Pvt) Ltd	Yes	Yes	Yes	√	√	√	√
2	2024/WRS/03	Marino Lanka (Pvt) Ltd	Yes	Yes	Yes	√	√	√	√
3	2024/WRS/02	Supreme Petro Lanaka (Pvt) Ltd	Yes	No	No	√	√	√	√
4	2024/WRS/07	Shanika Marine Company (Pvt) Ltd	Yes	Yes	No	√	√	√	√
5	2024/WRS/14	D.S. Marine Services (Pvt) Ltd	Yes	Yes	No	√	√	X	X
6	2024/WRS/05	Galaxy Marine Services (Pvt) Ltd.	Yes	Yes	Yes	√	√	√	√
7	2024/WRS/10	Prabala Traders Marine Services (Pvt) Ltd.	Yes	Yes	Yes	√	√	√	√
8	2024/WRS/11	Vismitha Marine Enterprises (Pvt) Ltd	Yes	Yes	Yes	√	√	√	√
9	2024/WRS/09	Malsha Globe Shipping Service (Pvt) Ltd	Yes	Yes	Yes	√	√	√	X
10	2024/WRS/06	New Colombo Harbor Suppliers Pvt Ltd	Yes	Yes	Yes	√	√	X	X
11	2024/WRS/28	Colombo Dockyard PLC	Yes	Yes	No	√	X	√	X
12	2024/WRS/08	KLS Marine Service (Pvt) Ltd	Yes	Yes	No	√	X	X	X
13	2024/WRS/04	GM Line Pvt Ltd	Yes	Yes	No	√	√	√	X
14	2024/WRS/17	N and Y Marine Services (Pvt) Ltd	Yes	Yes	No	√	√	√	√
15	2024/WRS/01	Insee Eco Cycle Lanka (Pvt) Ltd	Yes	Yes	No	√	X	X	X
16	2024/WRS/12	S.H..Willson Company (Pvt) Ltd	Yes	Yes	No	√	X	X	X
17	2024/WRS/15	Ceylon Logistics & Supply Services (Pvt) Ltd	Yes	Yes	Yes	√	√	√	√
18	2024/WRS/22	K.L.Gunasiri (Pvt) Ltd	No	Yes	No	X	√	X	X
19	2024/WRS/23	Lahiru Traders (Pvt) Ltd	No	Yes	No	X	√	X	X
20	2024/WRS/25	Nirman Lanka (Pvt) Ltd	No	Yes	Yes	X	X	√	X
21	2024/WRS/18	Sha RR (Pvt) Ltd	No	Yes	No	√	X	√	X
22	2024/WRS/19	Sisili Hanaro (Pvt) Ltd	No	Yes	No	√	√	√	√
23	2024/WRS/32	Sudha Shipping Services (Pvt) Ltd	No	Yes	No	√	X	X	X
24	2024/WRS/24	Asha Marine (Pvt) Ltd	No	Yes	No	X	X	X	√
25	2024/WRS/21	Jaya Marine	Yes	Yes	No	√	X	√	X
26	2024/WRS/34	Sudesh Enterprises & Export Pvt Ltd	Yes	Yes	No	√	√	√	√
27	2024/WRS/26	Sunmark Lanka Solutions Pvt Ltd	Yes	Yes	No	√	X	X	X
28	2024/WRS/36	White Crystal Lanka (Pvt) Ltd	Yes	Yes	No	√	X	X	X

Appendices E

Port	Year	Total_No_of_arrived_ships	No_of_ships_discharged_waste	OilyBilgeWater	OilyResidues	OilyTankWashing	DirtyBallastWater	ScaleAndSludgeFromTankCleaning	Other
Colombo	2017	4329	1187	NA	14352.83	1671.58	20.01	2997.16	142.85
Colombo	2018	4331	1292	NA	16228.47	1190.6	30.1	1390.78	111.2
Colombo	2019	4198	1197	NA	21790.64	2060.2	188.1	686.5	0
Colombo	2020	3806	691	NA	16949.12	2409.15	19.8	790.95	1810.08
Colombo	2021	3675	959	1926.03	18027.37	4184.2	19.7	1000.63	141.34
Colombo	2022	3648	1070	596.22	18454.67	4396.4	173.6	1672.2	5798.9
Colombo	2023	4237	1235	113.7	24754.94	6.8	0	132.3	0
Colombo	2024	3968	1536	4	30550.088	78.4	0	353.1	0
Galle	2017	87	143	NA	11	0	0	18.02	1.98
Galle	2018	84	150	NA	52.41	0	0	4.8	1
Galle	2019	43	197	NA	94.3	28.8	0	0.1	0.7
Galle	2020	22	97	NA	12.64	467.77	0	134.8	844.8
Galle	2021	14	127	16.3	51.43	3998.4	0	14.7	656.7
Galle	2022	7	105	26.4	19.11	290.4	1.69	0	59.4
Galle	2023	23	136	19.8	56.3	0	0	1.6	0
Galle	2024	4	169	0	25.15	0	0	0	2
Hambanthota	2017	230	27	NA	273.8	0	0	24.25	14.4
Hambanthota	2018	270	42	NA	222.44	0	0	188.48	0
Hambanthota	2019	314	68	NA	281.45	19.8	0	19.8	0
Hambanthota	2020	374	67	NA	528.01	7.5	0	0	0
Hambanthota	2021	374	96	19.8	447.63	33.83	0	0	0
Hambanthota	2022	323	78	63.52	497.79	19.8	0	0	0
Hambanthota	2023	447	125	102.21	866.993	0	0	6.6	0
Hambanthota	2024	116	120	47.4	426.815	26.4	0	0	0
Trincomalee	2017	233	59	NA	144.44	0	0	24.4	0
Trincomalee	2018	189	76	NA	175.25	0	0	0	0
Trincomalee	2019	142	66	NA	199.65	2	0	3.2	0
Trincomalee	2020	135	62	NA	69.85	0	0	0	0
Trincomalee	2021	117	68	0	185.35	0	0	0	0
Trincomalee	2022	95	64	15.5	179.8	0	0	0	0
Trincomalee	2023	102	102	152.47	267.78	7	0	17	5.1
Trincomalee	2024	6	92	115.86	77.49	0	0	0	0

Port	Year	Total_No_of_arrived_ships	No_of_ships_discharged_waste	Plastic	FoodWaste	DomesticWaste	CookingOil	IncineratorAshes	OperationalWaste	AnimalCarcass	FishingGear	Ewaste	CargoResiduesNonHME	CargoResiduesHME	Sewage
Colombo	2017	4329	1187	1529.67	515.82	1305.49	43.37	82	503.82	604.24	0	5.7	NA	NA	684
Colombo	2018	4331	1292	1919.54	595.25	3136.44	145.46	121.47	926.84	100.81	17.05	10.42	NA	NA	243.5
Colombo	2019	4198	1197	1676.65	548.41	2526.03	70.8	113.2	936.17	98.38	22.91	12.05	NA	NA	169.8
Colombo	2020	3806	691	715.57	115.7	1067.66	32.3	53.91	417.7	22.81	1	6.25	NA	NA	64.6
Colombo	2021	3675	959	1167.44	194.94	1499.63	12.92	29.45	990.74	0.22	2.91	16.21	118.73	0	199
Colombo	2022	3648	1070	1286.28	237.94	1334.98	28.9	93.61	704.64	5.52	3.28	33.62	31.21	3.97	313
Colombo	2023	4237	1235	2006.14	437.601	2333.28	68.5	100.873	1094.602	52.61	4.026	59.277	1.93	0	367
Colombo	2024	3968	1536	2251.785	329.603	2770.963	76.1671	116.3203	1356.8	45.4	8.85	95.406	24	36.86	31
Galle	2017	87	143	186.64	6.06	114.3	0.29	58.67	52.63	21.9	0	0	NA	NA	0
Galle	2018	84	150	196.3	11.54	299.56	1.09	57.27	49.92	2.5	0	2.31	NA	NA	0
Galle	2019	43	197	326.43	45.05	346.69	2.59	77.46	104.14	0.03	0	0	NA	NA	0
Galle	2020	22	97	174.12	22.77	171.1	0.7	20.06	82.53	0	0	0	NA	NA	0
Galle	2021	14	127	220.12	26.88	198.6	0.75	35.56	63.38	0	0	5.67	0	0	0
Galle	2022	7	105	150.57	15.35	236.01	1.13	32.22	42.49	0	0.2	7.08	0.7	0	23
Galle	2023	23	136	268.94	18.83	309.76	1.01	50.07	172.21	0.04	0.1	12.72	0	0	0
Galle	2024	4	169	367.24	11.53	537.14	3.77	76.89	319.11	0.9	1.1	1.27	0	0	40
Hambanthota	2017	230	27	11	0.05	4.5	0.02	0.7	0.7	0	0	0	NA	NA	0
Hambanthota	2018	270	42	64.7	17.04	74.53	28.22	5.75	11.72	1.1	0	0	NA	NA	0
Hambanthota	2019	314	68	93.13	33.5	158.45	3.68	3.51	17.18	4	0	0	NA	NA	0
Hambanthota	2020	374	67	141.85	25.8	237.41	0.73	6.7	67.9	0	0	2.32	NA	NA	0
Hambanthota	2021	374	96	148.54	4.98	284.9	1.23	17.55	37.13	0	2	2.01	8	0	352.2
Hambanthota	2022	323	78	157.27	30.31	164.67	12.14	5.74	86.83	8.9	0.21	0.35	0.27	0.2	0
Hambanthota	2023	447	125	206.69	17.305	179.81	3.125	11.985	39.31	0.99	3	3.27	0	0	10
Hambanthota	2024	116	120	194.5	29.132	228.699	0.6711	15.625	88.58	0	0.05	1.99	11	1	0
Trincomalee	2017	233	59	124.5	37.4	101.94	1.35	4.58	32.69	6.89	0	0.1	NA	NA	0
Trincomalee	2018	189	76	293.18	238.82	229.41	16.35	6.53	41.84	86.5	0	0.2	NA	NA	1388
Trincomalee	2019	142	66	163.25	69	129.17	0.57	8.32	57.97	5.82	14	0.97	NA	NA	60
Trincomalee	2020	135	62	179.67	20.21	162.09	15.51	2.81	59.5	0	0	0.78	NA	NA	0
Trincomalee	2021	117	68	165.8	5.76	169.19	0.61	4.15	44.32	0.5	0	2.32	0	0.2	89
Trincomalee	2022	95	64	143.97	5.38	171.4	0.08	7.6	54.8	0	0	4.28	0	0	73
Trincomalee	2023	102	102	158.98	71.81	290.682	1.91	4.18	135.61	0	0	2	6	0	14
Trincomalee	2024	6	92	212.29	40.864	308.15	1.129	11.27	87.33	1.75	0.1	9.07	0.7	0	215