The Waste Management Value Chain Related to Marine and Port Operations – Case study of Port of Oulu

AFRY Finland Oy
Elektroniikkatie 13
Oulu
Finland

Phone +358 10 3311
Registered office in Vantaa
Corp. id: 0625905-6
VAT: FI06259056

afry.com

Author
Pirilä, Minna
Näsilä, Varpu
Phone
+358 44 319 0981
E-mail
minna.pirila@afry.com

Date
05/07/2021

Project
101016579-001

Client
Baltic Sea Action Group

The Waste Management Value Chain Related to Marine and Port Operations – Case Study of Port of Oulu

AFRY Finland Oy

Contents

1 Introduction

There are about 2,000 cargo ships sailing in the Baltic Sea every day, with an estimation of 25,000 workers on board. Different kinds of waste are generated on board, from solid waste (garbage), wastewaters and sludges to cargo-specific washing waters. Marine regulations set limits for discharges of waste types that are either harmful (HME) or non-harmful to marine environment (NHME). According to the regulations, cargo ships can discharge legally, under certain conditions, treated sewage, grey waters and ground food waste into the Baltic Sea. This applies also at the Baltic Sea, even though it is considerably fragile due to its shallow waters and low salt content, and one of the most polluted seas in the world. The discharge, containing bacteria, nutrients and microplastics, generates eutrophication, oxygen depletion and increases the amount of marine litter.

Responsible shipping operators, including ferries operating between Finland, Sweden and Estonia and cargo ships operating in scheduled traffic already leave their waste at ports, and there is so called "No Special Fee" -payment system at the Baltic ports. The system includes that a waste fee is charged regardless of whether the ship leaves its waste at the port or not. (BSAG, 2021). Problem is that many cargo ships sailing at the Baltic Sea are not aware of the special conditions of this sea or the No Special Fee -system.

Baltic Sea Action Group (BSAG) which is an independent, non-profit organization, has launched a project to examine the waste flows and related information flows at the ports, and the Port of Oulu has been acting as a pilot port in the project. The Port of Oulu was selected to be the pilot case, as it is a busy general port with strong focus on developing its actions and processes.

Numerous stakeholders participated in the pilot project, covering different parts of the value chain: ships, shipowners, shipbrokers, port operators, waste management companies and transport companies. The pilot project aims at recognizing each operator's role in the value chain and identifying possible bottlenecks in the chain: what are the difficulties that lead to discharging waste into the sea and prevent from bringing and discharging it ashore? To tackle the challenges, the project aims at recognizing what could be done to ease the process of waste discharge at the port, and waste recovery.

The pilot project is linked to the BSAG's project on responsible shipping, funded by the European Maritime and Fisheries Fund's Finnish Operational Program 2014–2020, aiming at reducing the environmental burden of shipping. The pilot project concentrates in the following questions:

- How could the discharges into the Baltic Sea be reduced?
- How could the ships be encouraged to leave their waste to ports?
- How could the ship generated waste be managed more efficiently at ports?
- How could the waste recovery and utilization be increased?
- How could the communications and information exchange between the stakeholders be improved?

The project was performed by interviewing first representatives from different parties of the waste management value chain. After the interviews, a workshop was arranged to further discuss and process the challenges identified in the interviews, and to generate ideas for improvement.

2 Legislation and policy overview

2.1 International Convention for the Prevention of Pollution from Ships (MARPOL)

The International Convention for the Prevention of Pollution from Ships (MARPOL) is an international convention adopted at IMO. It is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The regulations of the convention are defined in six technical annexes. (IMO 2019a).

- Annex I Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)
- Annex II Regulations for the Prevention of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)
- Annex IV Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)
- Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)
- Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005)

2.2 PRF Directive and the Environmental Protection Law of Shipping

The renewed PRF Directive 2019/883/EU (directive on port reception facilities for the delivery of waste from ships) has to be adopted in the national legislation before 28.6.2021. In Finland, the directive will be put in force by the new "Merenkulun ympäristönsuojelulaki (the Environmental Protection Law of Shipping), Alusjätelaki" (HE71/2021) (number of the old law: 1672/2009). The new law suggests changes for the following issues (European Commission, 2019; Sarlin, 2021):

a) The national enforcement of the PRF Directive
b) The regulation of shipments of harmful and dangerous cargoes and waste between ships and the supply of fuel
c) Extending the ban on oil spills to cover also biofuels and extending the oil spill charges to inland waters
d) Clarification of certain provisions related to the implementation of the Sulfur Directive
e) Limiting the application of ballast water regulation to certain icebreakers
f) Harmonization of cost recovery system across the ports in member countries
g) 100% indirect fee for solid wastes.

Indirect fee, also called "No Special Fee", is defined in the PRF Directive 2019/883/EU as a "fee paid for the provision of port reception facility services, irrespective of the actual delivery of waste from ships", and allows ships to discharge waste under MARPOL Annexes I, IV and V to port reception facilities (PRF), with no extra costs. This indirect fee is charged even if no waste is left to ports and is based on ship's characteristics and waste type. The fee was already to some extent in force during the earlier PRF Directive 2000/59/EC. No Special Fee -system is recommended to all Baltic Sea ports by HELCOM. (Directive 2019/883/EU; HELCOM Recommendation 28E/10).

2.2.1 New Requirements to Ports' Reception Facilities

According to the directive, all ports must have adequate reception facilities to meet the needs of the ships normally using the port without causing undue delay. Here, the adequacy relates both to the operational conditions of the facility in view of the user needs, as well as to the environmental management of the facilities in accordance with Union's waste law. (European Commission, 2019)

In addition, new requirements for commercial ports include the reception of the so called municipal solid waste components such as cardboard, paper, biowaste, metal etc., as well as used batteries and e-waste. A port's reception facility can be any facility which is fixed, floating or mobile and capable of providing the service of receiving the waste from ships. (European Commission, 2019; Sarlin, 2021)

2.2.2 New Requirements related to Ports' Waste Reception and Handling Plans

All the ports have differences based on geographic location, size, administrative set-up and ownership, and by the type of ships that normally visit. Thus, the waste management systems are different, and reflect the differences at municipal level and downstream waste management infrastructure. However, the main waste management principles are specified in the directive, and requirements set for the waste management plans of the ports. The waste management plans should at least describe the needs for the reception facilities, the existing reception facilities, and the following information:

a) location of port reception facilities applicable to each berth, and, where relevant, their opening hours;
b) list of waste from ships normally managed by the port;
c) list of contact points, the port reception facility operators and the services offered;
d) description of the procedures for delivery of the waste;
e) description of the cost recovery system, including waste management schemes and funds.

In addition, the plan would be approved for five-year periods, as now the approved period is only three years. The re-approval has to be made every five years or after significant changes in the port operations. Also, the directive allows for several ports in the same geographical region to develop jointly the waste reception and handling plans. Commercial ports should include the information regarding their key waste management issues into the Union Maritime Information and Exchange system SafeSeaNET. (European Commission, 2019).

2.2.3 New Requirements for Vessels

An advance waste notification has to be done prior the arrival to a port. The notification should be done:

a) at least 24 hours prior to arrival, if the port of call is known;
b) as soon as the port of call is known, if this information is available less than 24 hours prior to arrival; or
c) at the latest upon departure from the previous port, if the duration of the voyage is less than 24 hours

The directive also defines a mandatory waste delivery obligation for all vessels. However, there are exceptions for this rule, including the following:

- there is sufficient dedicated storage capacity for all waste that has been accumulated and will be accumulated during the intended voyage of the ship until the next port of call
- the ship only calls at anchorage for less than 24 hours or under adverse weather conditions

The Port reception facility operator should provide without undue delay, a waste delivery receipt to the master of the ship. (European Commission, 2019)

3 The Waste Management Value Chain Related to Shipping and Port Operations

The waste management value chain related to shipping and port operations can be divided into three distinct phases, shown in Figure 1.

1. operations performed before, during and after cargo handling
2. operations performed on board
3. operations performed at ports and later in the waste management facilities

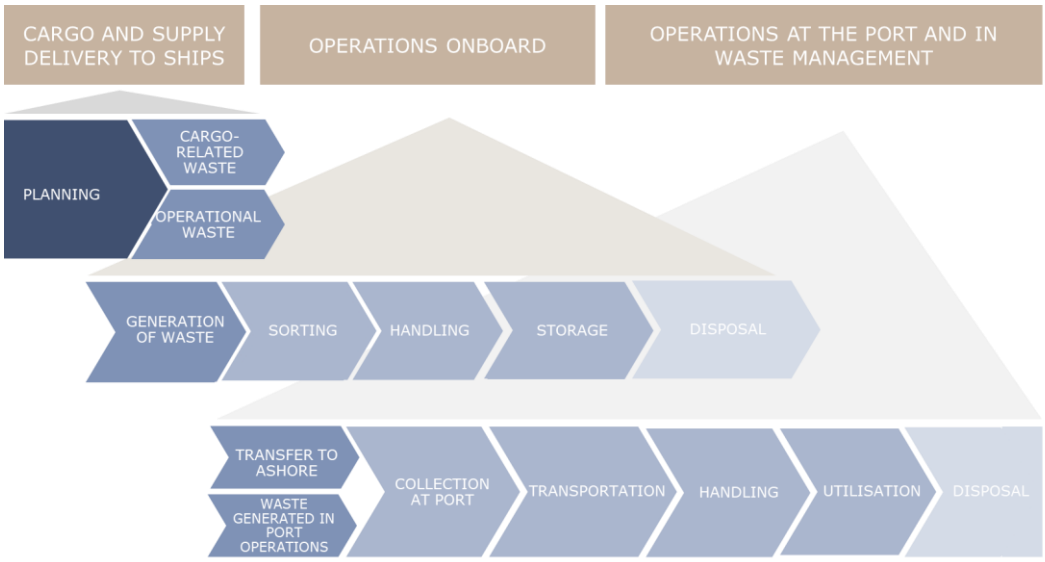

Figure 1 The waste management value chain related to shipping and port operations.

Operations performed before and during the loading of ships include careful planning and a forecast of the types and amounts of the waste that is generated in the ships. Waste can be cargo-related or it is generated during the ships´operational stage. The ships´personnel and management need to be informed about the waste management services at ports.

Operations performed on board, after waste is generated, include sorting, handling and stocking the waste. The ports need to know about the amounts and types of waste that will be transported to them, in advance, and therefore a waste notification must be supplied.

Operations performed at ports and regarding waste management include transferring of waste from ships to the port, collection of waste at the port, transportation of waste, utilization and final disposal. The amount of waste and its handling must be reported and an appropriate report consistent with the environmental permit of the final disposal must be provided.

3.1 The waste management value chain related to Port of Oulu

Port of Oulu (Figure 2) is an active port in the Bothnian Bay, the largest general port in the area. The Port has three harbours including Oritkari, Nuottasaari and Vihreäsaari. The Port of Oulu is visited by approximately 550 ships every year with forest industry products, liquid fuels and forest industry raw materials being the most important categories. Port of Oulu aims at becoming the pioneer of responsible port operations and encourages all kinds of improvements and development activities. (Port of Oulu, 2021)

Figure 2 Port of Oulu (https://ouluport.com/en/whats-new/for-the-media/).

3.1.1 Different actors along the value chain

Port of Oulu is a good example of a value chain with numerous stakeholders. Figure 3 presents the waste management value chain with stakeholders related to Port of Oulu. Not that not all the stakeholders are included but only those that were contacted during this pilot project.

There are several port operators at the port of Oulu, including Herman Andersson Oy, Oy M. Rauanheimo Ab, BB Logistics, Baltic Tank, and Neot Group. Herman Andersson Oy is the main provider of terminal and stevedoring operations at Port of Oulu. They offer a wide range of services from warehousing to stuffing and stripping of all kinds of cargo units and to loading and unloading of trucks and railway cars. They also provide ship agency services. (Port Oulu, 2021)

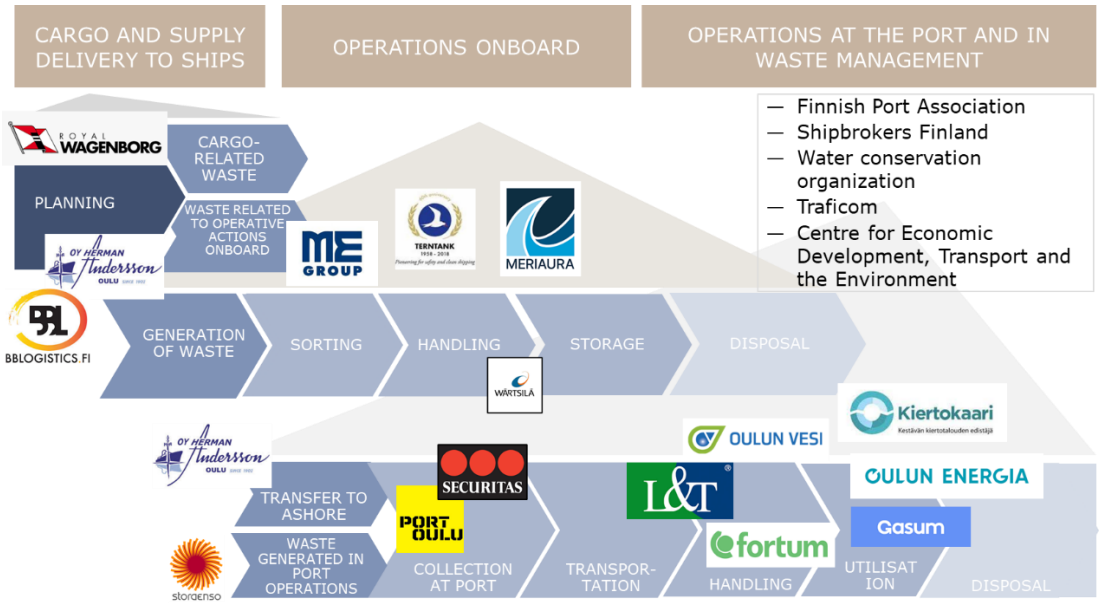

Figure 3 The waste management value chain related to Port of Oulu.

3.1.2 Interviews

The work included contacting and interviewing a broad range of actors to find out the different waste streams, their management and utilization possibilities as well as the information flow along the value chain.

The aim of the interviews was to get a truthful overall picture of all the issues and challenges related to the waste management at shipping and port operations as well as the goals and the willingness of the stakeholders to improve the current situation.

During the project, altogether 40 representatives of stakeholders including Port of Oulu, ship owners, ship brokers, port operators, waste management companies etc. were interviewed. The interviewed stakeholders are listed in Table 1.

Table 1 The interviewed stakeholders.

Role	Company
Port	Port of Oulu
Port operators	Herman Andersson Oy
	BB Logistics
Shipowners	Royal Wagenborg
	Terntank
	Meriaura Group
Ships	Mirva VG (Meriaura Group)
	Ternsund (Terntank)
	Thamesborg (Wagenborg)
Ship services and gate operations	Securitas Oy
Ship chandler	Ab ME Group Oy Ltd
Waste Management	Lassila & Tikanoja Oy
	Fortum Waste Solutions Oy
	Kiertokaari Oy
	Gasum Oy
	Oulun Energia Oy
Nearby industry	Stora Enso Oyj
Union for the ports	Finnish Port Association
Water conservation association	Vesiensuojeluyhdistys

3.1.3 Workshop

After interviewing a wide range of actors along the waste management value chain, a workshop was organized to tackle the bottlenecks found out during the interviews. All the interviewed actors and a couple of other representatives from the value chain were invited into the workshop, and altogether 25 participants attended.

During the workshop, new ideas and best practices for better waste management and better communication were discussed and improvement opportunities were generated. The workshop was divided into three working groups with the topics of:

1) wastewaters and food waste
2) solid waste and hold washing waters
3) communication and flow of information

Each working group was filling a MIRO -platform (whiteboard) with different aims and questions related to the waste management value chain.

4 Results and Discussion

4.1 Wastewater Management

4.1.1 Current situation and challenges of wastewater management

The current situation of the wastewater management was discussed mainly during the interviews. The management on board and the discharge of wastewaters as well as the challenges related to these issues are presented below.

"Wastewater" is used in this report as a general term of different kinds of waters that are generated on ships, and that contain as impurities dissolved or insoluble substances. Typical wastewater types generated on ships are:

- sewage, i.e. black water, is wastewater that is generated from toilets
- grey water is wastewater without fecal contamination, generated from other sources than toilet, such as from sinks, showers, washing machines and dishwashers
- hold washing waters, generated when a ship's hold is washed after the cargo has been unloaded and that can contain cargo residues as impurities

Management on board

Most of the ships have sewage treatment plants (STP) on board. However, their functionality is not monitored. Thus, some of them are working, and some are either not working or not used. The processes have also different techniques for removing pollutants, some of them might only disinfect the water, some remove the suspended solids and the newest ones also remove nutrients. The identified challenges are presented in Table 2.

Table 2 Identified Challenges in the current situation of wastewater management on board.

Identified challenges
Most of the ships have a combined tank for both grey and black waters making all the wastewaters black waters.
Checking the functionality of the STP-process on board is difficult.
Biological processes are sensitive and vulnerable to malfunctions. For example, the Membrane Bioreactor (MBR) process would require the sludge removal regularly. However, this is often not done, and the sludge can block up the whole process, and cause all the wastewater to be discharged at sea as an overflow.
Storage of untreated sewage is challenging due to the formation of hydrogen sulfide and to the storage capacity.
If only the sewage sludges are stored on board, it also forms hydrogen sulfide and the sludge might harden at the bottom of the tank, which makes it difficult to remove.
The content of the hold washing waters is often unknown, and the washing waters can be a combination of washing several different cargo types. This makes them more expensive to treat.
The level of knowledge among ship personnel about sewage treatment methodologies and the mechanism of eutrophication varies significantly. A common misbelief is that all STP-processes would remove nutrients from the

sewage, even if some of the processes only disinfect the sewage leaving all nutrients in the discharge. Another inconsecutive practice is that sewage might be purified from nutrients, but the sludge where nutrients are condensed during STP-process, is finally discharged into sea separately.

Discharging the wastewaters

Most of the cargo ships discharge their treated sewage and sewage sludges into the Baltic Sea increasing the nutrient load and eutrophication. The identified challenges are presented in Table 3.

Table 3 Identified Challenges in the current situation of wastewater discharges.

Identified challenges
The treated sewage can be legally discharged at sea wherever at the sea (even at the archipelago), and the untreated sewage can be discharged legally at sea at 12 miles distance from ashore.
Transferring of the wastewaters from ships to port is not easy currently, as the port does not have fixed reception facility, and every time a separate tanker truck must be ordered.
At some ports, wastewater discharge and unloading/loading of cargo cannot be done simultaneously.
There is not enough knowledge among the ship personnel about the environmental issues, especially about the eutrophication of the Baltic Sea due to excess nutrient load.

4.1.2 Improvement opportunities for wastewater management

The improvement opportunities for the wastewater management and their discharge and utilization was discussed and brainstormed in the workshop. The results from the workshop (MIRO-boards) are shown in Figure 4 and 5. Figure 4 presents the improvement opportunities along the value chain, and in Figure 5, the improvement opportunities are ordered and valued according to their implementation costs and easiness (y-axis) and increasing positive environmental impacts (x-axis). The main results/findings are described below the figures.

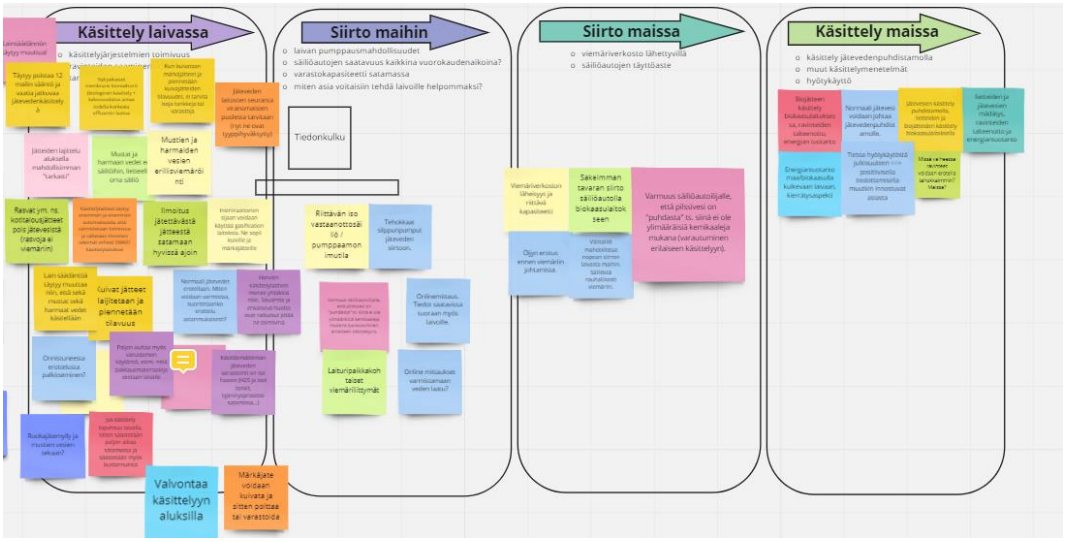

Figure 4 MIRO-board for the improvement opportunities for wastewater and food waste management along the value chain.

Figure 5 MIRO-board for evaluating the improvement opportunities of wastewater management.

Management on board

Based on the interviews and workshop results, the following improvement opportunities/activities were suggested:

- The type certification for STP on board is not enough, but monitoring, maintenance and verifications of the functionality are needed.
- The technical remote support from the supplier could help with the monitoring and maintenance of the STP processes.
- Automatization of the STP processes could help to prevent the human errors and create smarter treatment processes

- Aeration and mixing of the storage tanks could prevent the formation of hydrogen sulfide and hardening of the sludge. Also, online measurement of the hydrogen sulfide would prevent accidents.
- In larger vessels, the sewage sludges are dried and incinerated. The incineration ashes are then left at port.
- Water usage optimization for washing the hold would decrease the water volumes needing treatment (the bigger the volumes, the higher costs).
- Online measurements of wastewater quality could help to design correct treatment option e.g. for hold washing waters.

Discharging the wastewaters

The following improvement opportunities were suggested:

- Concentrating to the advance notifications, adding at least the existing information, where the wastewater is from, what kind of cargo has been washed (in case of hold washing waters), etc. The earlier the information reaches the waste management company, the better the waste can be handled, and the costs might as well decrease.
- Increasing awareness among ship personnel of the wastewater reception possibilities at ports.
- Separate reception facilities on each berth, i.e. adequate tanks or sewage disposal systems straight to drainage would make easier to leave wastewaters at ports.
- The newest berths at Port of Oulu do already have the ability to connect to the sewer network.
- The port could give extra bonus (Baltic Sea Bonus) for ships that leave their wastewaters at port.
- Increasing the environmental awareness and training of the ship personnel for them to better understand the consequences of wastewater discharges at sea.

Handling and utilization of the wastewaters according to circular economy principles

The following improvement opportunities were suggested:

- The grey and black waters could be led directly to the municipal wastewater treatment plants.
- The sewage sludges are good raw material for biogas production, where both energy and nutrients can be recovered and utilized
    - The biogas can be utilized e.g. as fuel for ships or other transportation
- Hold washing waters that contain fertilizers are important to get into treatment on land, as their nutrient load can be significant.
    - Selection of correct treatment method is crucial from circular economy as well as cost perspective, as fertilizers are very difficult in thermal and wastewater treatment, but easy to treat together with biodegradable waste in biogas plants (as long as they don’t contain harmful substances for the biological process as contaminants).

4.2 Solid waste management

4.2.1 Current situation and challenges of solid waste management

The current situation of the solid waste management was discussed mainly during the interviews. The management on board and transferring the waste to port reception facilities as well as the challenges related to these issues are presented below.

In this report, general term "solid waste" is used to mean all waste types that are not wastewaters. The term is almost a synonym to the term "Garbage", which is used in Marpol Annex V and defined to include "*all kinds of food, domestic and operational waste, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically*" (IMO 2019b.) However, the term solid waste is not exactly defined in regulations and the selection of the term for this report has been done to emphasise the nature of the waste types from waste management and treatment perspective rather than regulative perspective.

Sorting of waste on board

It was noted that the solid waste fractions are collected separately and sorted quite well on board currently.

Regulations and classification of solid non-hazardous waste is regulated in MARPOL Annex V, Prevention of Pollution by Garbage from Ships. The recommended garbage types that should be separated, according to MARPOL Annex V are (THE MARINE ENVIRONMENT PROTECTION COMMITTEE 2017):

1. non-recyclable plastics and plastics mixed with non-plastic garbage
2. rags
3. recyclable material:
    a. cooking oil
    b. glass
    c. aluminium cans
    d. paper, cardboard, corrugated board
    e. wood
    f. metal
    g. plastics; (including styrofoam or other similar plastic material)
4. E-waste generated on board (e.g. electronic cards, gadgets, instruments, equipment, computers, printer cartridges, etc.)
5. garbage that might present a hazard to the ship or crew (e.g. oily rags, light bulbs, acids, chemicals, batteries, etc.).

In practice, the garbage types that are separated at the ship are dependent on several factors such as space, possibilities to arrange storage on board of different garbage fractions and the amount of separate types that are generated on board. According to interviews during the work, typical fractions to be collected are:

- food waste
- metal
- plastic at some shipping companies
- glass
- general / domestic waste.
- paper, cardboard, corrugated board, sometimes in different fractions
- oily rags
- e-waste

For example, the food waste is often collected separately, frozen, and then discharged to the port reception facilities. A ship arriving from a non-EU port must keep international catering waste separately from other food waste. Since international catering waste is not included in Annex V it is not covered by the No Special Fee -system, and related costs must be paid separately.

The identified challenges related to sorting waste on board are presented in Table 4.

Table 4. Identified challenges related to sorting of waste on board.

Identified challenges
The MARPOL regulation uses different titles for waste fractions than what are used in the waste management ashore. Also, the guidelines for sorting and management of the waste might differ between MARPOL regulation and ashore.
The information according to MARPOL should be shared to the waste management companies handling the waste from ports in order the waste fractions to be better recycled and utilized.
All the ports are different, and their waste management differ from each other, thus the ship personnel might get confused of the different practices
During longer voyages, biowaste will start to decompose. On-board treatment such as composting is difficult as the vessel is vibrating and densifying material. Many ships are therefore freezing the food waste before discharging it at ports.
Importance of the attitude of ship's officers towards sorting and proper waste management was emphasized.
After the waste fractions are sorted on board, someone from the ship's personnel will take the garbage out from the ship, normally in garbage bags. If the bags are not clearly marked with tags or by specific colour, it is impossible for the responsible person to recognise different waste types and to take them into right bins at the harbour.
Sometimes utilities that are brought to ships are overpacked or packed in unnecessarily big cardboard boxes, which generates waste in vain.

Waste fractions received at the port

The port waste management plan i.e. the port waste reception and handling plan has a central role in defining the management operations and final handling of the waste.

In Finland in general, and also in the Port of Oulu, Waste management plan regulated by the PRF directive and MYSL defines the waste fractions that are collected in the harbour. Fractions are named according to waste directive, waste law and waste list (jätedirektiivi, jätelaki, jäteluettelo). In Oulu, the following fractions are collected at the wharf:

- hazardous waste (different fractions collected separately)
- biowaste
- metal
- cardboard
- paper
- glass
- wood
- burnable waste
- fluorescence tubes

Garbage Record book is required from all ships of 400 gross tonnage and above as well as some other vessel types. (IMO 2019b)

The identified challenges related to the waste reception facilities at port are presented in Table 5.

Table 5 Identified challenges related to waste fractions received at the port. Note that not all challenges are mentioned specifically in relation to Port of Oulu but are general observations of ship personnel that are visiting regularly several ports.

Identified challenges
If waste has been sorted properly on board, but on the harbour wharf there is only a mixed waste container, it might frustrate the ship personnel and decrease their motivation in sorting.
If the waste reception area is in disorder and messy, it makes leaving the waste difficult or even impossible, and decreases the motivation.
The route /passageway from the berth to the waste reception facilities might be long, without signs and dark. Taking the waste from the ship by walking, especially by one person only, can be heavy job and include even safety risks. Also, if the distance to waste reception facility is long, leaving the waste to port is time-consuming and reserves one member of the crew for a long time.
Differences between sorting instructions on board and ashore can cause confusion.

4.2.2 Improvement opportunities for solid waste management

The improvement opportunities for the solid waste management and their transfer and utilization was discussed and brainstormed in the workshop. The results from the workshop (MIRO-boards) are shown in Figure 6 and 7. Figure 6 presents the improvement opportunities along the value chain, and in Figure 7, the improvement opportunities are ordered and evaluated according to their implementation (y-axis) and impacts (x-axis). The main results/findings are described below the figures.

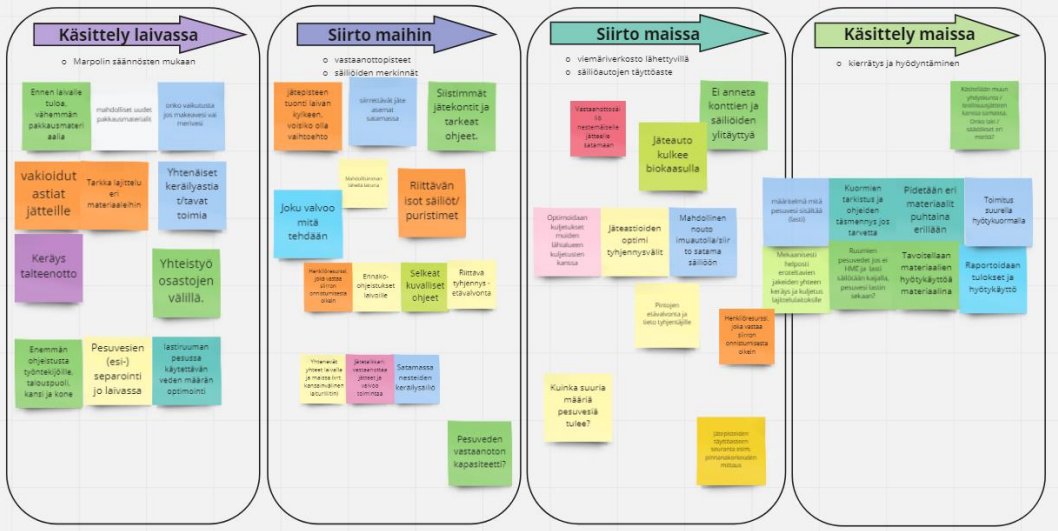

Figure 6 MIRO-board for the improvement opportunities for solid waste management along the value chain.

Figure 7 MIRO-board for evaluating the improvement opportunities

Sorting of waste on board

Based on the interviews and workshop results, the following improvement opportunities/activities were suggested:

- Sorting needs to be made easy and it has to be clearly instructed. It was proposed that different colour codes for different waste fractions would be used to signal different waste fractions both on board and ashore. Uniform Nordic pictograms (recycling symbols) are already widely in use in Denmark, Sweden and Norway, and under way in Finland. Taking the pictograms into use both on the ships and in the harbours would help to deliver waste bags into right containers.
- The collaboration between ships and shipowners as well as between different departments at ships should be improved.
- The waste generated on board comes from the packaging, consumables, food etc. that are brought to the ship. All the suppliers should be notified about the waste minimization target, so they could e.g. optimize the packaging materials. It is possible to consider taking waste minimization aspect into account when tendering the consumables contracts.
- General knowledge of waste management among the ship personnel should be increased.

Waste fractions received at the port

Based on the interviews and workshop results, the following improvement opportunities/activities were suggested:

- It was recognized that very important is to pay attention in keeping up the motivation of ships' personnel to sort and handle waste properly. Leaving waste at the ports should be made as easy as possible, keeping in mind that the smallest practical arrangements can have effect on the motivation of the personnel.
- Location to waste containers shall be clearly instructed, e.g. with maps at the berths, where the location of the waste reception area is shown.
- The route to the waste reception facilities should be clear, and clearly signed

- The waste reception area should be tidy and easily accessible, and bins easy to use. In Oulu waste bins are located inside containers which are ventilated and lighted, and this was welcomed as good solution.
- Making sure that there is enough storage capacity in the containers and bins, requires follow-up and updates if necessary.
- The signals on the containers should be provided by several languages and clearly with universal symbols. Preferably same terminology as in Marpol annexes should be used at least parallel to terminology ashore.
- Waste reception areas shall be as near the berth as possible. Recommendation would be to have movable mobile containers that could be moved beside the ship during harbour stay (in use in some harbours already). Would it even be possible to agree on the responsibilities so that the port operating companies would take care of moving the waste containers near the ship when it arrives the harbour?
- Monitoring the waste volumes and optimization of emptying of the containers could help in ensuring that there is enough space in the containers.
- It was proposed that there would be a waste coordinator or a waste management officer at the port, who would give guidance on waste management issues and watch that instructions are followed, and facilities are working. Orders of special waste management services would go through one person, who would have experience, information and right contacts available.
- Harbours waste management plan has central role in arranging the waste management in practice on the harbour, as it defines what fractions and where are collected. Continuous improving principle is to be followed to meet the practical requirements of the ships and to keep the waste management plan up to date.
- Consideration, if there are possibilities to give credit on good work for a ship's personnel.

4.3 Communication and Flow of Information

4.3.1 The current situation and challenges of communication and information flow

The interviews and workshop were used to acquire information on what the challenges and bottlenecks regarding the waste management information flow on ships and portside operations are. The main issue for the key players was identified as the lack of common information systems. Different services and practices offered in different ports mean that the crew on board needs to find relevant information from fragmented sources. The problems deriving from this take many forms, which are briefly described below.

Each operator (ship, port, waste handler) collects data on waste and waste management according to their own guidelines (e.g. Marpol at sea, port waste management plan and national legislation on land), resulting in mismatched waste labeling.

To sort the waste exactly according to every port's requirements, the crew would need advance information on which waste fractions are accepted in different ports and what are instructions on their sorting. Sorting instructions might differ by every port even in one country, as they reflect the requirements of local waste management systems and -processes.

A related issue transpired from the workshop conversations: The shipping companies often have explicit guidelines for waste management, and procedures and sustainability in waste handling has been considered. Implementation of the guidelines might however vary on ships, for reasons that remained unclear. Possible identified reasons could be lack of education on the environmental issues, or lost motivation for example because of non-systematic sorting instructions and labelling.

Marpol regulations state time limits inside which the ships arriving to ports need to give pre-information on the waste they are about to leave in the port. Standard waste streams that are handled with clear routines are normally part of everyday work for the ports and would not require pre-information from the arriving ships in order to receive the waste. For non-standard, occasionally arising waste streams like holds' washing waters, on the other hand, the port operators receive information on the contents of waste usually too late. If the information of waste amount and its properties would reach the port early enough, the waste management operators would have enough time to arrange an optimal treatment method for the waste and ensure cost-effective service.

No special fee -arrangement can be an effective system in ensuring that there is financial incentive for the ships to leave their waste on the ports and not discharging them in the sea, as the ships have to pay the fee in any case, did they leave waste at the port or not. However, the system has some drawbacks from the perspective of efficient waste management. As the ports need to decide in advance the waste fees without knowing the amount of ships visiting the port in the coming year or the amount of waste they leave, they need to make compromises on the level of offered services to avoid excessive cost burden, which could affect their competitiveness. Also, the system can unintentionally make the port act as a gatekeeper of the information, as the ships and waste management companies do not naturally discuss about the waste, as the ships are in contact with the port, which in turn is in contact and contractual relation with the waste management company. Information that could be relevant from the technical perspective, isn't necessarily transferred effectively as it can change, dilute or be delayed during the information transport chain. Understanding about the circumstances on the ship doesn't reach the waste management company and on the other hand the ships and shipping companies do not receive exact information about the treatment methods and plants ashore.

The identified challenges related to communication and flow of information are presented in Table 6.

Table 6 Identified challenges related to communication and flow of information.

Identified challenges
Often, the waste volumes reported in the advance waste notification are estimated by visual approximation, and the port as well as the waste management companies would need more accurate information for the reporting and planning purposes. For managing standard waste streams, the inaccuracy normally isn't a problem, but in case the port needs to order a separate truck to receive the waste, it is more important to get exact information on the waste amount.
Data that is required to be gathered about the waste is regulated according to Marpol regulations and is relevant from the marine environment protection perspective. However, it is not often sufficient or relevant from the perspective of planning cost-effective treatment for the varying waste streams.
The information regarding waste management possibilities and services at ports are separated and the information is often difficult to find.
The knowledge and awareness of the requirements and guidelines is often inadequate among the ship personnel.
There is often a misunderstanding among the ship personnel, that the treated wastewaters would be harmless for the marine environment, which is not the case, as they contain a lot of nutrients and other pollutants.
The shipowners often have well established environmental guidelines and sustainability/responsibility strategies. However, the information does not always reach the ship personnel or is not fully implemented in waste management practices. For ship owners it is easier to instruct on control their own ships than time chartered vessels.

4.3.2 Improvement opportunities for communication and information flow

Improvement opportunities for communication and information flow was discussed and brainstormed in the workshop. The results from the workshop (MIRO-boards) are shown in Figure 8 and 9. Figure 8 presents the improvement opportunities along the value chain, and in Figure 9, the improvement opportunities are ordered and evaluated according to their implementation (y-axis) and impacts (x-axis). The main results/findings are described below the figures.

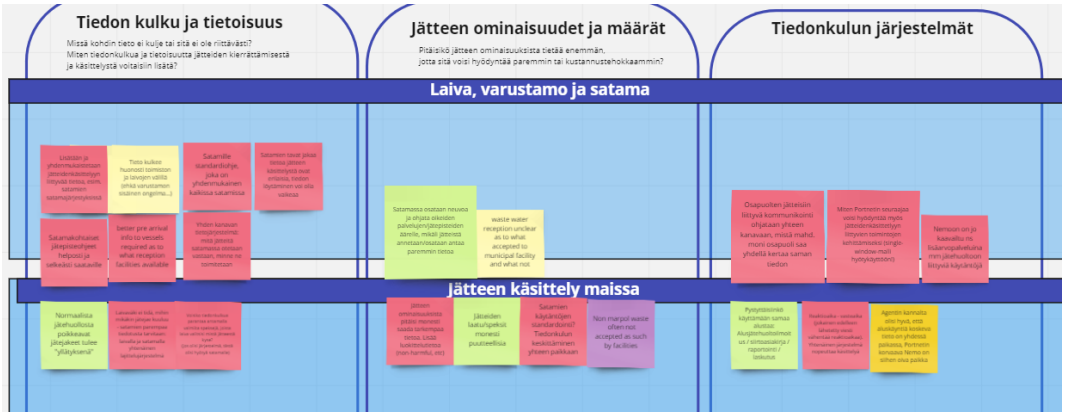

Figure 8 MIRO-board for improvement opportunities related to communication and information flow.

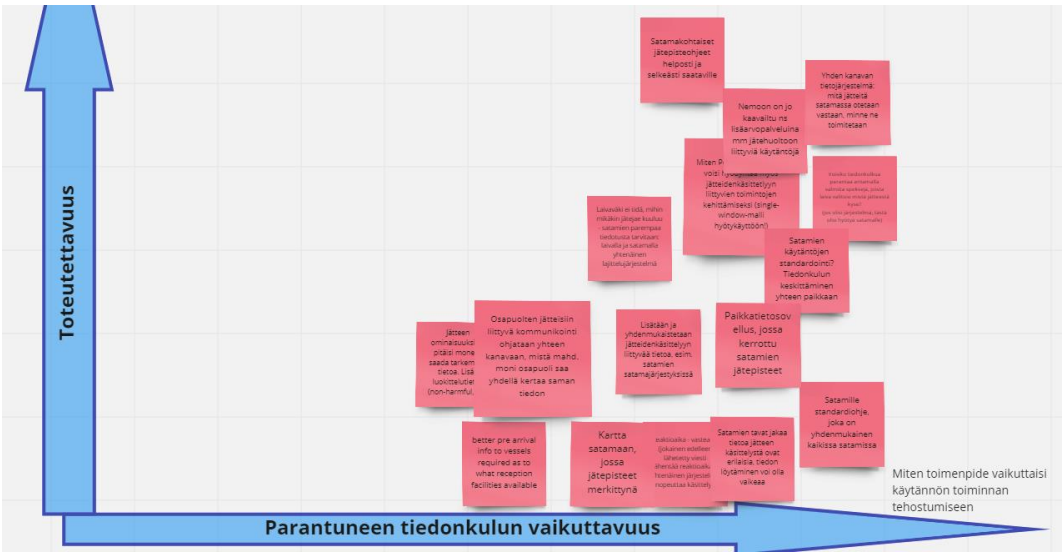

Figure 9 MIRO-board for evaluating the improvement opportunities of communication.

To alleviate the problems deriving from information availability, the Baltic Sea Action Group (BSAG), together with the Finnish maritime cluster, has created an information package on waste collection in different ports. The information package is online, and it contains facts about pricing and waste fractions collected in each port (Available: https://www.bsag.fi/wp-content/uploads/2021/03/BalticSeaWasteFee-info_Port-of-Rauma_202103.pdf). The package aims at improving the information flow, and waste management onboard the ships and ashore. The correct separation of waste could further be made effortless by implementing the Nordic pictogram- and color coding of waste both in ports and on board the vessels. The environmental education of the crew is also crucial, as attitudes were identified as an important factor in waste recycling.

The waste management facilities benefit from advance knowledge on waste properties. The composition of solid waste is commonly well described or known, but liquid wastes, e.g. hold wash waters' chemical data is often insufficient in relation to the needs of the waste treatment operator, as the requirements for information are regulated from marine environment protection perspective. When the waste is labeled as unknown, the inherent liabilities increase costs. As different individuals are responsible for operation and handling of the costs, the parties do not have an interest in making a difference to avoid suboptimal solutions. This issue could be mitigated by creating ready specs from the waste handling unit to the ships. The crew could then choose from different wash water types. The different types could be integrated in agreements on waste handling costs.

A new information system, Nemo, is currently being constructed. This would be an optimal time to include needed waste management aspects in the upcoming system. Different operators should discuss about separate and common goals, which could be added in Nemo as an additional service.

Improvement opportunities:

- The advance notification of the waste (fractions, quality and volumes) should be done as soon as the information is available.
- Increasing awareness and knowledge on environmental issues among ship personnel, e.g. already during the nautical school.
- Increasing awareness and knowledge about the requirements and guidelines, especially about the No Special Fee -system.
- Determining the responsibilities for updating the information, as the databases are only as good as the quality of information filled in, which in turn requires work from the parties.
- Harmonizing the practices at different ports.
- Establishing and maintaining good communication and information flow between different stakeholders. The ports to take a strong role in delivering information between different parties. Alternatively finding practices through which the waste management companies can discuss the waste composition directly with the ship from the technical perspective, to ensure most cost-effective treatment method and ensuring that the contractual conditions make this possible.
- The shipowners could use the sustainability and responsibility as a branding tool for marketing for responsible transportation
- The new NEMO-system could have extra services about waste management issues to boost efficient information exchange between different parties in the waste chain.

5 Conclusions and recommendations

As a result of the project, an overall picture of all the issues and challenges related to the waste management at shipping and port operations as well as the goals and the willingness of the stakeholders to improve the current situation, was assessed. New ideas and best practices for improved waste management and utilization and better communication were generated, and improvement opportunities suggested based on circular economy principles.

Active communication and collaboration are vital for understanding the environmental boundaries and possibilities within the value chain. This pilot project has already brought the stakeholders together, and concrete collaborative results have already been gained, e.g. in the field of utilizing the hold washing waters to recover valuable compounds such as nutrients. Workshop that was arranged during this pilot project showed that there is space for more information and experiences exchange between the sea and land - issues that are clear at a waste management company are not familiar at the ships, and on the contrary there can be circumstances on the ships that affect the waste management chain significantly but are not familiar to waste management companies that work mainly on land.

No special fee is an effective system from the perspective of protecting marine environment but can involve inefficiencies in the information flow from the sea to the land and can decrease flexibility in terms of waste management solutions. The pilot project showed that there is space and willingness to increase the discussion and therefore understanding of the circumstances at the sea and ashore for different parties. Ships, ship owners and marine authorities can learn more about the waste management ecosystem on land. The port is part of the ecosystem, and surrounded by different types of waste treatment plants, which serve large number of different customers. Operators on land on the other hand meet customers who can change their location, i.e the ships visit several ports with varying waste management systems and instructions, not to mention the other ships of the shipping company, or even the time-chartered vessels. Information exchange system Nemo is currently under development and its potential should be utilised also to boost efficient information exchange between different parties in the waste chain.

As a conclusion, it would be recommended to increase awareness and knowledge of environmental protection among seafarers and to provide more environmental education for ship personnel, already during the nautical school. This would hopefully increase the willingness for voluntary actions regarding the waste and wastewater management and their disposal at port instead of at sea. Also, keeping up the motivation of the crews by making sure that small practical issues work in every part of the waste chain, and continuously finding ways to improve existing practices.

References

BSAG, 2021. Available: https://www.bsag.fi/en/balticseawastefeeinfo-to-ships/

European Commission, 2019. Directive (EU) 2019/883 of the European Parliament and of the Council of 17 April 2019 on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC

HELCOM Recommendation 28E/10. APPLICATION OF THE NO-SPECIAL-FEE SYSTEM TO SHIP-GENERATED WASTES AND MARINE LITTER CAUGHT IN FISHING NETS IN THE BALTIC SEA AREA. Available: http://archive.iwlearn.net/helcom.fi/Recommendations/en_GB/rec28E_10/index.html Accessed 5.7.2021.

IMO. 2019a. International Convention for the Prevention of Pollution from Ships (MARPOL). Available: https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx. Accessed: 30.5.2021.

IMO. 2019b. Prevention of Pollution by Garbage from Ships. Available: https://www.imo.org/en/OurWork/Environment/Pages/Garbage-Default.aspx . Accessed : 30.5.2021

THE MARINE ENVIRONMENT PROTECTION COMMITTEE. 2017. ANNEX 21 RESOLUTION MEPC.295(71) (adopted on 7 July 2017) 2017 GUIDELINES FOR THE IMPLEMENTATION OF MARPOL ANNEX V

Port of Oulu Ltd. 2017. Jätehuoltosuunnitelma.

Port of Oulu, 2021. Websites. Available: https://ouluport.com/en/home/. Viewed 22.6.2021.

Port Oulu, 2021. Port Handbook. Available: https://ouluport.com/oulun-sataman-handbook-2021-22/ Viewed 22.6.2021.

Sarlin, L. 2021. Merenkulun ympäristönsuojelulain uudet velvoitteet satamille ja laivoille. Seminar presentation in Baltic Sea Action Group Webinar about Resbonsible Shipping on 8th of June, 2021.