Minimisation of nutrient losses in ports in the Baltic Sea

Proposal for BATs/BEPs for dry bulk fertilizer storage and handling

CE Delft

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Content

Summary

Annually, over 45 million tons of fertilisers are handled in the ports of the Baltic Sea region. The marine transportation of fertilisers has been identified as a possible significant source of nutrient discharges into the Baltic Sea, as some of the fertilisers can be released into the water during loading, unloading and transportation.

Excessive nutrient discharges can lead to eutrophication, a phenomenon that stimulates algal growth and triggers hypoxic seawater conditions. This results in a decline of species diversity, deterioration of water quality, and adverse impacts on marine ecosystems and economic and recreational values.

This study developed a reference document on Best Available Technologies or Techniques (BATs) and Best Environmental Practices (BEPs) to minimise nutrient losses during storing, handling and transporting dry bulk fertiliser in the Baltic Sea region. The document can be used to promote sustainable practices both at practical levels (ports, terminals, manufacturers and shipping companies) and at policy and regulatory levels (HELCOM and national authorities).

By conducting a thorough literature review and interviewing numerous stakeholders, we have identified and assessed approximately 70 Best Available Technologies or Techniques (BATs) and Best Environmental Practices (BEPs). We have identified which stakeholders are involved in the BATs and BEPs and we have qualitatively estimated the impact of the BATs and BEPs. These BATs and BEPs are categorized into seven relevant topics: handling and storage of dry bulk fertilisers, cleaning equipment and routines, management of stormwater and snow, monitoring for improvement of processes, improving communication between the stakeholders, developing skills through training and education & policy makers and authorities. Many of the identified measures fall under both BATs and BEPs. Therefore, the reference document does not distinguish between BATs and BEPs.

Best Available Technologies/Techniques and Best Environmental Practices

Table 1 shows a summary of the BATs/BEPs with the largest impact[1] on minimising nutrient losses. These BATs/BEPs can be applied voluntarily by companies or required by environmental authorities. For stakeholders with sufficient funds, it is recommended to implement all these BATs/BEPs. If this is not the case, a financial consideration must be made of which measures are the most relevant to the stakeholder in question.

Table 1 - Condensed overview of the BATs/BEPs with the largest impact on minimising nutrient losses

BAT/BEP	Financial investment	Type of stakeholder(s) involved
Preventing nutrient losses during dry bulk fertiliser handling and transportation through best practices such as closing the empty bucket between the ship and the berth, maintaining the clamshells of the bucket/grab, applying a dusting off move during fertiliser handling, filling the bulk fertiliser to the allowable limit on the bucket (marked by a line), using a	€-€€	Port, terminal, manufacturer

[1] Annex A explains how the impact per BAT/BEP is determined.

BAT/BEP	Financial investment	Type of stakeholder(s) involved
prevention cover between ship and berth, and considering weather conditions.		
Using **closed equipment** during dry bulk fertiliser handling and transportation to minimise nutrient losses.	€€€	Port, terminal, manufacturer
Regularly cleaning the storage and handling areas to prevent nutrient losses from spreading and being released into the seawater.	€-€€	Port, terminal, manufacturer
Training and education of personnel to explain the impact of nutrient losses in the Baltic Sea and procedures established to prevent nutrient losses. Training of crane operators is the most important.	€	Port, terminal, manufacturer and shipping company
Agreements between stakeholders in the fertiliser supply chain by contract to apply certain BATs/BEPs.	€€	Port, terminal, manufacturer and shipping company
Monitoring of stormwater content (taking and analysing samples).	€€	Port, terminal, manufacturer
Investing in **stormwater collecting and treatment systems.**	€€€	Port, terminal, manufacturer

The most critical moment for leakages is during the transfer of dry bulk fertilisers from ship to quay or vice versa. Prevention of nutrient losses during this process is therefore the priority. The losses can often be prevented by implementing simple best practices that require a relatively low investment. For example, a very effective nutrient loss prevention method is not overfilling the bucket while (un)loading the ship. The use of closed equipment during storage and handling, and the use of storm water collecting and treatment systems are BATs/BEPs with a large impact on the minimisation of nutrient losses, but also involve large investment costs compared to the other measures. Another example of high-impact practices is regular and thorough cleaning of the berth and storage areas. Training and education enable personnel to understand the impact of nutrient losses in the Baltic Sea and how cargo handling processes contribute to these losses. This helps to raise awareness and motivates personnel to incorporate BATs and BEPs into their daily operational procedures (e.g. prevention or cleaning techniques). While this may initially extend operations and add some costs due to the extra time required for e.g. cleaning, it ultimately leads to more efficient and responsible port management. In the event that personnel responsible for handling goods are also responsible for cleaning, fewer ships may be loaded or unloaded. Analysing stormwater samples is a valuable way of gaining insight on how much fertiliser has been lost and where the process can be improved. Finally, contractual agreements between stakeholders in the fertiliser supply chain increase the likelihood that the BATs/BEPs will actually be applied.

Thus, there are several BATs/BEPs that can help minimise nutrient losses during the storage, handling and transportation of dry bulk fertiliser. Collaboration among different stakeholders is essential in addressing this problem. In the Baltic Sea region, collaboration is very possible since stakeholders are involved in multiple parts of the process. As an example, manufacturers are also sometimes shareholders of the terminals where they (un)load the cargo.

Policy makers and authorities

Nutrient losses in the Baltic Sea are causing an environmental problem which has stimulated social pressure. National authorities and intergovernmental organisations such as HELCOM have a crucial role in mitigating these losses. They can for example advance the utilisation of BATs/BEPs in the environmental permits they issue for ports and terminals, and encourage and require investing in port reception facilities for hold wash water.

List of abbreviations

Table 2 – List of abbreviations

Abbreviation	Description
AWT	All Weather Terminal
BATs	Best Available Technologies or Techniques
BATs/BEPs	Best Available Technologies or Techniques (BATs) and Best Environmental Practices (BEPs)
BEPs	Best Environmental Practices
HELCOM	The Baltic Marine Environmental Protection Commission, also known as the Helsinki Commission

1 Introduction

1.1 Background

Annually, over 45 million tons of fertilisers are handled in the ports of the Baltic Sea region. The marine transportation of fertilisers has been identified as a possible significant source of nutrient discharges into the Baltic Sea, as some of the fertilisers can be released into the water during loading, unloading and transportation.

Excessive nutrient discharges can lead to eutrophication, a phenomenon that stimulates algal growth and triggers hypoxic seawater conditions. This results in a decline of species diversity, deterioration of water quality, and adverse impacts on marine ecosystems and economic and recreational values.

The Baltic Marine Environment Protection Commission, also known as the Helsinki Commission (HELCOM), is an intergovernmental organisation that governs the convention on the protection of the marine environment of the Baltic Sea region. The Baltic Sea Action Plan, HELCOM's strategic program of measures and actions, includes a comprehensive list ofactions to be implemented by 2030 to achieve a good environmental status of the Baltic Sea. This plan states that nutrient losses during storage and handling of dry bulk fertilisers in the Baltic Sea ports represent a substantial source of nutrient pollution which is insufficiently addressed. Action S21 aims to develop and introduce best technologies, techniques and practices (BATs/BEPs) to minimise nutrient losses during the storage, handling and transportation of dry bulk fertilisers in the Baltic Sea region by 2024.

HELCOM Observers John Nurminen Foundation, Race for the Baltic and Coalition Clean Baltic have worked together since 2019 to reduce the nutrient discharges from the marine transportation of fertilisers in the Baltic Sea region. These organisations have drafted a BATs/BEPs document in cooperation with ports, port operators and other stakeholders. In this context, John Nurminen Foundation has asked CE Delft to finalise the reference document on best available technologies, techniques and environmental practices (BATs/BEPs) to minimise the nutrient losses during the storage, handling and transportation of dry bulk fertilisers in the Baltic Sea.

1.2 Objective and scope

The aim of this study is to develop a reference document on best available technologies, techniques and environmental practices (BATs/BEPs) to minimise nutrient losses during storing, handling and transporting dry bulk fertilisers in the Baltic Sea region.

Several types of stakeholders are involved in the storage and handling of dry bulk fertilisers. This reference document is intended for all stakeholders. It can be used to promote sustainable practices both at policy and regulatory levels (HELCOM and national authorities) and at practical level (ports, terminals, operators, manufacturers and ships).

This study does not include:
- a quantitative analysis of the aspects which are included in the reference document;
- an inventory and analysis of current and future legislations affecting the subject of this study.

1.3 Outline of the report

The interrelationships between the various stakeholders involved in dry bulk fertiliser storage and handling are briefly described in Chapter 2. Then we have listed all BATs/BEPs and recommendations to minimise nutrient losses during the storage, handling and transportation of dry bulk fertilisers. Chapter 3 focuses on BATs/BEPs related to handling and storage while Chapter 4 focuses on cleaning equipment and routines. Chapter 5 deals with management of stormwater and snow. Chapter 6 describes the BAT and BEP related to the monitoring activities to improve the cargo handling and storage process. Chapter 7 discusses actions that can be undertaken to improve communication and Chapter 8 details BATs/BEPs related to training and education. Chapter 9 is aimed specifically at various policy makers. Finally, the conclusions are presented in Chapter 10.

2 Stakeholders and their mutual relationships

There are different types of stakeholders involved in the handling and storage of dry bulk fertilisers. This chapter briefly describes the stakeholders involved and their relationships.

2.1 Several types of stakeholders

From the production of the fertilisers to the delivery to the customer, multiple stakeholders are involved. Simplified summary:

- First of all, raw material is delivered to the manufacturer.
- Then the raw materials are used to produce the fertilisers.
- The fertilisers may be temporarily stored at the manufacturer.
- To deliver the fertilisers to the cargo owner(s), the fertilisers need to be transported. Transport of fertilisers can be done over land (e.g., by trains and trucks), but it is often done over sea by ships.
- The ships use ports for the transshipment of the fertilisers.
- depending on the size of the port, the port can consist of multiple terminals, with each terminal often handling its own type of cargo;
- Stevedoring companies are responsible for the loading and unloading of the cargo of ships at the terminal.
- Fertilisers may be temporarily stored at terminals and ports before being moved on to the customer.
- The final distance to be travelled to the customer is often overland (e.g. by trains and trucks).

2.2 Interrelationships of the stakeholders

Section 2.1 simply explains which stakeholders are theoretically involved in the handling and storage of dry bulk fertilisers. In practice, this is sometimes more complicated:

- A port is often operated by port operators. However, the port operator does not always own the piece of land on which the port is located.
- Sometimes a port is so small that it consists only of a single terminal. In that case it is sometimes difficult to distinguish who is meant by the port (operator) and who is meant by the terminal (operator). In contrast, when a port is large, many stakeholders may be active within the port.
- In case the manufacturer is located near the waterfront, the manufacturer may load fertilisers on moored ships for transportation (via transhipment ports) to the customer. In such a situation the manufacturer[2] can be also be seen as the port (operator) and/or the terminal (operator).
- In specific cases, manufacturers may own handling equipment and warehouses at the transhipment port. And sometimes they are even co-owners or shareholders of the port.

[2] Manufacturers have a strong role in some BAT/BEP tables in this report. This is based on the fact that in addition to running a fertiliser plant, they often own ports and/or are responsible for port operations.

The stakeholders mentioned in Section 2.1 can thus fulfil dual roles. Therefore, it is not possible to make a clear distinction between the responsibilities of the different stakeholders. It really depends on the situation.

In the following chapters we provide an overview of BATs/BEPs and recommendations for different categories. For each BAT/BEP we give an indication of the stakeholders involved. Since stakeholder responsibilities depend on the situation, it is important to consider to what extent the BATs/BEPs in the following chapters fit your own situation. For each BAT/BEP, we have also indicated the potential impact. Annex A explains how the impact per BAT/BEP is determined. Annex B provides a list of organisations and individuals we interviewed for this study.

3 Handling and storage of dry bulk fertilisers

During dry bulk fertiliser handling and storage, the priority is to minimise the nutrient losses that end up on the ground, in the air and in the water. This chapter provides an overview of BATs/BEPs and recommendations related to the handling and storage of dry bulk fertilisers. Section 3.1 focuses on general handling and storage, Section 3.2 focuses on ship-to-shore loading and unloading[3], Section 3.3 on onshore vehicles, and Section 3.4 on storage. Section 3.5 provides recommendations on handling and storage of dry bulk fertilisers.

3.1 General handling and storage

Table 3 provides an overview of BATs/BEPs related to the handling and storage of dry bulk fertilisers. Port (operators), terminal (operators), shipping companies and manufacturers are all involved.

Table 3 - Overview of BATs/BEPs related to general handling and storage

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
1	The buckets should have a line marked 20 cm below the edge to show the allowable limits of fertiliser carried to prevent spillage during handling. This helps the crane drivers not to overfill the buckets.		X				+++	€
2	Implementation of wind speed limits that prevent operation above certain wind speeds (often 10-15 m/s).	X	X		X		+++	€€
3	Minimising the transport distance between the ship and the storage destination to ensure a continuous handling process while minimising nutrient losses. This is however strongly dependent on the port infrastructure and the layout of the terminal.	X	X		X		+++	€€
4	Diminishing dusting during loading of cargo by placing the base of the chute next to the cargo or using height adjustable fill pipes/fill tubes/cascade tubes.		X		X		+++	€€
5	The use of a closed conveyor belt systems to prevent dusting.	X	X		X		+++	€€€

[3] A distinction has been made between 'General handling and storage' (in Section 3.1), which includes all general BATs and BEPs related to handling and storage of fertilisers at the port/terminal and 'Ship-to-shore loading and unloading' (in Section 3.2) , which includes BATs and BEPs specially aimed at reducing spillage at the berth or between the ship and the berth during ship-to-shore (un)loading of fertilisers.

		Stakeholders					Impact	
6	The use of a conveyor belt system designed with optimal parameters that help in minimising nutrient losses. Examples of such parameters are the slope angles and as few as possible switching/connection points since that is where significant losses can occur.	X	X		X		+++	€€€
7	Make sure that the conveyor belts are dry and warm before the cargo is handled. This prevents the fertiliser from sticking and leaving residues on the belt. One way to ensure this is by running the belts well before loading.	X	X		X		++	€
8	Perform regular maintenance checks before and after operations to prevent spillages during the handling of cargo. Make sure all equipment is working smoothly and check whether the dust filters installed in the conveyor belts are still effective.		X				++	€
9	Handling of bulk cargo in closed containers[4]. This is mainly suitable for small volumes of fertilisers in cases where the cargo does not need to be stored for prolonged periods.	X	X		X		++	€€
10	Cargo can be transported in bags in order to minimise dust formation[5] during cargo handling.		X		X		++	€€
11	Modern vibrating screens equipped with a dust collector can be used during screening to minimise dust spillage.	X	X		X		++	€€
12	Use dust suppressing techniques where possible in the handling equipment. Examples are baghouses, filters, screw conveyors and vacuum collecting systems.	X	X		X		++	€€
13	The use of conveyor belt system with internal speed-dampening mechanisms to minimise dusting. For example baffles can be used in fill pipes, cascades in tubes or hoppers or a loading head can be used to regulate output speed of cargo.	X	X		X		++	€€€
14	Scraper blades can be used during fertiliser storage and removal from storage, which transport the fertilisers by pushing them upwards, can be used to prevent dust formation by minimising the free fall of the cargo.	X	X				+	€€

[4] Containers are mainly used for long-distance fertiliser transport and are not commonly used for fertiliser transport in the Baltic Sea. However, they have the added advantage that closed containers can be loaded regardless of the weather conditions.

[5] It must be mentioned that the handing of dry bulk fertilisers in bags does not only have the advantage to minimise dust, but that is also has some disadvantages. The handling process is less efficient and slower, the ship probably does not use her full capacity and the bags are often single-use.

3.2 Ship-to-shore loading and unloading of dry bulk fertilisers

Table 4 provides an overview of BATs/BEPs related to ship-to-shore loading and unloading of dry bulk fertilisers. The terminal (operator) and the shipping company are mainly involved in these BATs/BEPs. However, it is important to know the interrelationships between the stakeholders. For example, the BATs/BEPs for a terminal may also apply to a manufacturer or a small port (operator).

Table 4 - Overview of BATs/BEPs related to ship-to-shore loading and unloading of dry bulk fertilisers

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
15	Perform regular maintenance checks on the clamshell buckets before and after operations to prevent spillages during loading and unloading of cargo. During maintenance, check whether the grab still closes tightly.		X		X		+++	€
16	Before the bucket starts to move to/from the berth for (un)loading, crane operators should apply a so-called 'dusting off move'. This decreases the chances of fertilisers dropping during the transportation, as the 'dusting off move' clears fertilisers from the bucket that could potentially fall during transport.		X		X		+++	€
17	The bucket should be closed the moment after fertiliser is released and the bucket is brought back to pick up the next batch of fertiliser. The BAT can be applied during loading and unloading of fertilisers. This is especially important for cranes handling lower quality grains which are more sticky, leaving residues of fertilizer in the bucket. In case the bucket is not closed the residues could be released onto the berth.		X		X		+++	€
18	Covering the whole area between ship and berth to prevent the grabber from moving over the open water (causing direct spillages in the harbour). An example of a cover is a durable tarpaulin, which is a versatile cover suitable in less windy ports. A more robust prevention cover that can withstand heavier weather conditions is a prevention cover made of wood and steel.		X	X	X		+++	€€
19	Use closed systems as much as possible. This reduces dust formation and cleaning (which in turn reduces costs), but also increases the productivity since operations are made weather-independent. Examples of closed systems are conveyors, chutes, telescopic arm unloaders, telescopic trim chutes and screw unloaders.	X	X		X		+++	€€€
20	The use of hatch covers on the ship's cargo hold openings. The closed-off holes minimise dust spillages and enables unloading independent of the weather conditions. However, this is only suitable for ships with feeder hole openings on their cargo holds.			X			+++	€€€

		Stakeholders					Impact	
21	Unloading cargo under a roof or a covered berth. This is currently seldom implemented. However, it could decrease downtime in operations in case of rainfall. In this way, terminal operators could allocate more time to cargo handling, making sure the process is done with more attention to minimising nutrient losses.	X	X		X		++	€€
22	Using bulk containers and bulk container spreaders. Bulk container spreaders enable the unloading of fertiliser (stored in containers) into the cargo hold by tilting the container and can be used to minimise dust formation.	X	X				++	€€
23	Reducing dust generation by using wind protection covers. Examples of such covers could be wind barriers or special dust control systems attached to hoppers.	X	X		X		++	€€

3.3 Onshore vehicles (trains, trucks, cars)

Table 5 provides an overview of the BATs/BEPs related to onshore vehicles involved in the handling of dry bulk fertilisers. The terminal (operator), the manufacturer and the owner of the hinterland transport are mainly involved in these BATs/BEPs. However, the BATs/BEPs for a terminal (operator) may also apply to the port (operator). The onshore vehicles can be owned by the terminal, but also by a third party.

Table 5 - Overview of BATs/BEPs related to onshore vehicles involved in the handling of dry bulk fertilisers

		Stakeholders						Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Owner hinterland transport	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
24	Loading and unloading of trains in covered areas. This practice prevents dust spreading.		X					+++	€€
25	Applying hard surfaces to the roads. Examples include concrete or asphalt which can be easily cleaned if fertilisers are spilled.	X	X			X		++	€€€
26	Using different vehicles inside the storage buildings and outside to prevent fertiliser residues from being transported out of storage areas with vehicles.		X					++	€€€

3.4 Storage of cargo

Table 6 provides an overview of BATs/BEPs related to the storage of dry bulk fertilisers. These BATs/BEPs are intended for stakeholders which (temporarily) store cargo. These are mainly ports, terminals and manufactures.

Table 6 – Overview of BATs/BEPs related to the storage of dry bulk fertilisers

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
27	Fertilisers are best stored in a closed and dry environment to shelter from wind and minimise dust formation. Examples of storage facilities are silos, bunkers, hoppers and containers. The same applies for storing of cleaned cargo residues.	X	X		X		+++	€€€
28	When hoppers are being used to store cargo, electrically closable hoppers are recommended. This is very useful because in the case of quick degradation of weather conditions the system can be shut off rapidly, reducing losses of fertiliser and preventing fertiliser from being damaged.	X	X		X		+	€€€

3.5 Recommendations for handling and storage of dry bulk fertilisers

Prevention should be the main aspect within minimisation of fertiliser spills.
Various technologies and best practices can be applied to prevent fertiliser spills during handling and storage of dry bulk fertilisers. Which technologies and practices are the best to implement depends on what kind of stakeholder you are, which BATs/BEPs you already have implemented and what kind of financing resources are available.

With respect to ports and terminals, a distinction can generally be made between ports/ terminals that are specialised in the handling and storage of fertilisers, and ports/terminals that handle all kinds of cargo, under which fertilisers are handled occasionally. For fertiliser specialised terminals it is recommended to invest in closed handling systems, which would limit fertiliser spillage to the minimum. However, dust formation is still possible in closed systems, which means that it is important to minimise the slope and heights for minimal dust formation.

Some ports have wind speed limits (10-15 m/s) after which handling operation will be stopped, as mentioned by multiple interviewees and stakeholders. Other measures that can limit dust formation include putting hatches on ships' cargo holds, unloading cargo under a berth with a roof (in an all weather terminal, AWT), and using wind protection covers.

The interviews conducted indicate that the largest spills occur when open systems are in place. It is therefore important to minimise all distances of fertiliser transport within the chain, such as the distance between the ship and the berth (as dropped fertiliser instantly falls in the water) and the height from which fertiliser is being dropped (which minimises dust formation). An interviewee pointed out that the maximum chute height should be approximately 50 centimetres.

Regular maintenance checks of equipment are important. This includes checking the buckets for leaks and checking the effectiveness of dust filters.

Finally, the quality of the fertilisers is also important during loading and unloading operations. Low quality fertilisers are more likely to stick to the bucket, which can lead to more drops of residue during handling. Closing the bucket after unloading the cargo or applying a so-called ‘dusting off move’ can result in less spillage, but requires an extra step from the crane operators.

4 Cleaning equipment and routines

Cleaning is important to remove any fertiliser spills after dry bulk fertiliser handling and storage to prevent them from spreading and entering the seawater. Section 4.1 focuses on cleaning of berths and surrounding areas, while Section 4.2 focuses on cleaning of the ships.

4.1 Cleaning of berths and surrounding areas

Table 7 provides an overview of the BATs/BEPs related to the cleaning of berths and surrounding areas. These BATs/BEPs are mainly intended for stakeholders who conduct activities on the berth. These are terminal operators, port operators and fertilizer manufacturers located on the waterfront.

Table 7 - Overview of BATs/BEPs related to the cleaning of berths and surrounding areas

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
29	Cleaning berth immediately after each loading and unloading operation, ideally on a more frequent basis throughout the day (e.g. in the breaks between the (un)loading operations). The berth should also always be cleaned before it starts raining or snowing, requiring careful monitoring of the weather forecasts.	X	X		X		+++	€
30	A clean-up checklist can minimise fertiliser spills in the (un)loading and storage area. The checklist should specify the steps that prevent spillages and ensure proper cleaning. This may apply to operations performed at the ports and terminals, on board the ship and at the production location. The checklist should also include guidelines to follow once spillages occur (specific to all weather conditions). It also serves to keep cleaning standards high in ports where employees rotate frequently.	X	X	X	X		+++	€
31	Cleaning berth and surrounding areas using (mechanical) sweeping brushes or cleaning equipment with a vacuum function to guarantee better cleaning.	X	X		X		+++	€€
32	Port and terminal areas can be cleaned with water only under the condition that this waste water is collected and treated in a wastewater treatment plant.	X	X	X	X		++	€
33	The collected fertiliser spills must be managed according to environmental standards and protocols defined by environmental authorities. The spillage material should be properly returned to the manufacturer, reused or properly disposed of.	X	X		X	X	++	€€

		Stakeholders					Impact	
34	Cleaning of vehicle tyres, since fertilisers can be spread by vehicles stationed in the port and terminal areas. The spreading of fertiliser can be prevented by vehicle tire cleaning systems. The wastewater from vehicle washing should be collected and treated in a wastewater treatment plant.	X	X		X		+	€

Recommendations for cleaning of berth and surrounding areas

After prevention, cleaning should be the next step. Several interviews with ports, terminals and shipping companies emphasised that spill prevention should be one of the priorities, because cleaning up fertiliser spills can be time consuming and expensive. Furthermore, weather conditions can influence the cleaning process:

- snow, rain and wind impede the process; and
- snow and fertiliser look very similar, which makes it difficult to distinguish these two.

It is recommended to clean the berth during or immediately after each (un)loading operation, for example once every two hours. When rain or snowfall is expected, additional cleaning is necessary to avoid fertilisers being washed into the sea. Cleaning equipment using vacuum systems are more effective than for example brush systems. When fertilisers are still present on the berth, vehicles should not be allowed, as they can cause dusting and spread fertilisers to other areas.

Some ports have a very high rotation of employees. Visual inspections in combination with a clean-up checklist or cleaning protocol can then be useful to guarantee a high level of clean-up during spillage. Once the fertiliser spills are removed, it is important that the fertilisers are disposed of in a correct way. In some ports, spilled fertilisers are returned to the manufacturer or provided to farmers.

If the terminal does not properly clean the berth area, the port authority can order external cleaning services and send the invoice to the terminal. This action can motivate the terminal to ensure adequate cleaning practices in the future. It is then important that this is legally established in contracts between the port and the terminal so that the port may take these steps.

4.2 Cleaning of ships

Table 8 provides an overview of the BATs/BEPs related to the cleaning of ships.
These BATs/BEPs are intended for shipping companies and stakeholders involved in loading and unloading the ships.

Table 8 - Overview of BATs/BEPs related to the cleaning of ships

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
35	Clean cargo residues from ship holds (dry cleaning) before they are washed with water. This significantly reduces the amount of nutrients ending up in the cargo hold wash water. Some vessels are only responsible for transporting fertilisers and then sometimes dry cleaning suffices which omits the issue of wastewater discharging at the port of arrival.			X			+++	€
36	Do not allow the vessel to proceed to the next port until all fertiliser spills have been removed from the deck and the gangways by brushes (dry cleaning).	X	X	X			+++	€€
37	Ensure that ships can deliver their wash water to the port/terminal and that this can be done in an efficient manner (for example collection trucks are readily available at a given time and terminal). This prevents discharge of nutrient carrying wastewater at sea[6].	X	X	X		X	+++	€€€
38	Ships can be cleaned with water only under the condition that this waste water is collected and treated in a wastewater treatment plant. It is currently quite common for ships to go to sea to clean the hold.	X	X	X	X		++	€
39	The cleaning process of the ship's cargo holds with water should be done under high pressure rather than using high volumes of water. This practise reduces the costs of delivering wastewaters and puts less strain on the port reception facilities for hold wash waters. Due to dry cleaning beforehand and high-pressure washing often only being possible in the lower areas of the cargo hold, the reduction of wash water is relatively limited.	X	X	X			+	€

Recommendations for cleaning of ships

From interviews, it became clear that spillage of fertilisers on the deck of the ship and fertilisers in wash water ending up in the sea is a big issue. Fertilisers are being washed off the deck into the sea after the ship has departed, if the deck is not properly cleaned after unloading operation and this is legal in many countries. It is the responsibility of the shipping company to clean the ship's deck after (un)loading.

[6] Discharge of wash water can be very time consuming and also relatively expensive (due to water volumes but also time 'wasted' for the shipping company). This leads to ships discharging wash water at sea, more than 12 nm away from the shore.

Interviews with shipping companies indicate that the extent of fertiliser spills on the decks of ships can be relatively large when (un)loading is not done carefully. More careful (un)loading takes more time and extra steps, and could be considered less efficient by the fertiliser terminals. During (un)loading operation, the ship's crew should therefore talk with the terminal operator if fertilisers are spilled and remind him to lower the height of the bucket, since the terminal is the party responsible for (un)loading. In addition, ports and terminals could notify ships before departure that the deck must be cleaned after (un)loading. However, it is the responsibility of the terminal to prevent fertilisers falling on the deck. It is recommended that contracts between the cargo owner, the shipping company and the terminal operator specify who has what responsibility when it comes to cleaning and handling of collected spillage.

After cleaning the ship's cargo hold, ships are left with wash water containing fertilisers. Facilities to discharge wash water are often inadequate. In many ports, the reception facility essentially consists of a waste truck that receives wash water during its own and port operational hours only. Occasionally, the vessel must shift to another berth to dispose of wash water. This increases expenses and is impractical. Ships should be able to discharge their wash waters ashore twenty-four hours per day. In case wash water collection facilities do exist in the port/terminal, it is often relatively expensive to deliver the wash water. Because of these reasons and because of the fact that fertilisers are not indicated as 'harmful substances to the marine environment', ships regularly choose to discharge wash water into the sea. Ports should be required or incentivised to secure they have adequate reception facilities for cargo hold wash water. Ship owners should subsequently be required or incentivised by national authorities or port authorities to deliver their wash water ashore.

If dry cleaning methods are used to remove most of the fertilisers from the cargo hold before wet cleaning, less water is needed to clean the cargo hold because much of the fertiliser has already been removed, making the delivery of wash water ashore less expensive. If there is sufficient incentive to deliver the wash water ashore, this will result in less fertiliser being discharged into the sea. Fertilisers removed by dry cleaning can, for example, be collected in big bags on board of the ship so that they can be returned afterwards to the manufacturer.

5 Management of stormwater and snow

Moisture is a major threat for the handling, storage and transport of fertilisers. Fertilisers have a high solubility in water, which means that they readily absorb water vapour or moisture during handling, storage and transport and can form a saturated solution leading to caking and lumping. When this occurs, it leads to qualitative losses.

This chapter focuses on the management of stormwater and snow. After heavy rainfall and/or snowfall, the (snow)water carries nutrient losses and other pollutants that remain on the ground. To prevent this polluted water from entering the sea, Table 9 lists BATs/BEPs related to the management of stormwater and snow. Who is responsible for the management of stormwater and snow can be debatable. Depending on the situation, this may be a shared responsibility between the landowner or the shareholders of the port, the port/terminal operator and possibly the manufacturer that operates in the port.

Table 9 - Overview of BATs/BEPs related to management of stormwater and snow

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
40	Covering of outlets, wells and drainage systems with blind covers before operations helps to contain the fertiliser on the quay and eases the cleaning process before the fertiliser enters drainage systems and flows directly into sea.	X	X		X		+++	€
41	Capture stormwater and treat it before it is discharged into the sea. In some ports, where fertiliser plants are on the port grounds, the stormwater can be drained and treated at the wastewater plant.	X			X		+++	€€€
42	In winter, collect snow from berths in a dedicated area with appropriate stormwater management to prevent fertiliser spills from entering the sea when the snow melts.	X	X		X		++	€

Recommendations for management of stormwater and snow

After preventing and cleaning up of fertiliser spills, the management of stormwater and snow is certainly also an important aspect which contributes to the minimisation of nutrient losses. In an ideal situation stormwater or snow is not only collected but also treated before it is discharged into the sea. By treating the stormwater, phosphorus and nitrogen can be removed before they enter the sea. However, this does require enough available space and the necessary investments. A good and relatively inexpensive way to determine the extent

of the problem of fertilisers in stormwater is to take flowing water samples[7] and send them to a laboratory for analysis. The results can be utilised to predict the annual discharge. Monitoring of stormwater also reveals how operators have succeeded in spillage prevention and cleaning. More detailed explanation can be found in Section 6.1.
A simple method to prevent fertilisers from entering stormwater is to cover all wells and drainage systems during (un)loading operations. This also allows for better cleaning.

Countries around the Baltic Sea can experience heavy snowfall in winter. When the berth is covered with snow, it is difficult to distinguish between snow and fertilisers. When the snow melts, it can transport fertilisers trapped into the snow into the sea. Many ports therefore shut down fertiliser handling operations during rain and snowfall, but the exact restrictions vary from port to port.

It is recommended to collect snow regularly and to store the snow at a designated area, where it remains until it is melted. When the snow melts, the runoff containing fertilisers should ideally be treated before it returns to the sea. The most effective method is to pass the melted snow through a wastewater treatment system. The largest obstacle is that ports are often overcrowded, limiting space for snow storage and water treatment units.
In addition, significant investment and operational costs are associated with the water treatment units.

[7] For example, from the outlet of a discharge pipe. However, this is not always technically feasible, for example, if the outlet of the pipe is located below the sea surface.

6 Monitoring of process improvement

This chapter is about monitoring. Although monitoring does not directly lead to minimising nutrient losses during storing, handling and transporting dry bulk fertilisers, it is a valuable way of gaining insight on how much fertiliser has been lost and where the process can be improved. Section 6.1 focuses on the monitoring of residues and discharges. Section 6.2 focuses on the monitoring of the process.

6.1 Monitoring of residues and discharges

Table 10 provides an overview of BATs/BEPs related to the monitoring of residues and discharges. Most relevant stakeholders are the ports and the terminals.

Table 10 - Overview of BATs/BEPs related to monitoring of residues and discharges

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
43	Monitoring of residues in cargo hold wash water of ships mainly transporting fertilisers to measure their contents and use correct disposal methods. Some ports do not accept wash waters from vessels if the exact contents is not known. Therefore this is an important practise.			X			++	€
44	Monitoring of phosphorus and nitrogen content of stormwater by sampling techniques to measure the amount of pollution discharged into the sea. This data could be further used to estimate the effects of nutrient discharges on the environment in terms of eutrophication.	X	X		X		++	€€
45	Monitoring of air quality at the ports' weather station to keep track of the dust particulates in the air. This could aid in monitoring of dust formation due to fertiliser handling. Protocols regarding operations can be put in place when the dust levels exceed limits.	X	X				+	€€

Recommendations for monitoring of residues and discharges

Ports, operators, and shipping companies should be aware of the nutrient load they cause. Due to the dilution effect, their loading cannot be properly detected in seawater, but should be evaluated based on stormwater and hold wash water sampling. To estimate the nutrient load ending up in the sea through stormwaters, information is needed on the amount of precipitation, the catchment area of the port's drainage pipeline collecting stormwaters, and the nutrient concentrations in stormwater wells.

Nutrient concentrations in stormwater wells are highest for rain immediately after fertiliser handling, but some of the fertiliser loss remains e.g. in the pores of the dock's asphalt and can be flushed during rain even when fertilizer handling is not in progress. Thus, stormwater samples are needed both during rain and right after fertiliser handling and at other times.

Since continuous measurement of all nutrient concentrations is not possible, an estimate of total loading can be prepared by combining data on stormwater quality with handled fertiliser volumes. In this method, load estimates are calculated for fertiliser handling events and, on the other hand, for times when fertilisers are not handled:

- Nutrient loading associated with fertiliser handling can be assessed by determining a loading factor, which describes the nutrient loading per handled ton of fertiliser based on stormwater sampling immediately after fertiliser handling. The loading factor for each sampling occasion is calculated based on the measured nutrient concentration in stormwater, flow (which can be monitored or estimated based on rainfall and catchment area), and the amount of handled fertiliser. Annual loading is obtained by multiplying the average loading factor of the sampling occasions by the total amount of fertilisers handled during the year.
- Additional nutrient loading may occur between fertiliser handling events, when fertiliser remaining in the asphalt of the dock area is slowly washed out. The role of this delayed pollution can be assessed through additional stormwater sampling when fertiliser handling does not take place, and estimation of pollution loading based on nutrient concentration and stormwater flow.

To gain knowledge on the actual fertiliser load in stormwater during and outside of (un)loading activities of fertilisers, it is important to conduct representative sampling. The easiest sampling method is grab sampling with a stick and bucket. A more sophisticated method is automatic sampling. where the samples can be taken depending on the stormwater flow or at given time intervals. Of these, the automatic flow-based sampling will give the most accurate estimate of average nutrient concentrations, whereby flow-interval sampling would be the most accurate compared to time-interval sampling (R.D. Harmel et al., 2023).

Due to high variation in nutrient concentrations, conclusions cannot be drawn based on a single sample. Instead, several samples should be taken during a storm event and combined to form a composite sample. This applies to both manual and automatic sampling. In other words, during a storm event, it is recommended to take samples at short intervals (e.g. six samples per hour, ideally reflecting the intensity of the rain) and merge them into a composite sample, rather than to take one sample per hour and analyse these samples individually. This gives a more accurate average value. Before starting the stormwater sampling, it is important to follow the weather forecast to plan the manual sampling or to program the automatic sampler.

A monitoring program can include more frequent sampling and more extensive analyses at first (e.g. first year), especially if previous water quality data is not available. Based on the results, sampling frequency and number of analyses can be reduced. In the second phase, samples can be taken less often and can be merged into composite samples.

In general, the monitoring of residues and discharges should be recorded, taking special care to negative deviations (higher discharges) in observation results. Along with a documentation on the monitoring of discharges, a protocol should be assembled to describe how higher discharges should be fixed.

Each country has different or a lack of regulations regarding monitoring pollution from stormwater. The sampling method, frequency, allowed concentrations and calculation methodologies all differ. As an example, the port of Åhus (Sweden) is awaiting established requirements in pollution amounts from the authorities. In the meantime they are monitoring and taking actions to reduce nutrient discharge. Sampling of a storm event is fixed to four samples per hour into one sampling bottle and the number of bottles depends on the length of the storm event. All bottles are merged to an composite sample and the result from the analysis during the year gives an average value, used to calculate the annual load in kilograms. In the last five years, the discharges of nutrients have been halved. The port of Åhus is also currently working on setting up a collection system for the treatment of stormwater. On the other hand, the port of Klaipeda (Lithuania) monitors their own nitrogen and phosphorous concentrations (in µg/l) four times per year during storm events.

Monitoring should be planned case specifically according to the quality of storm water, and pollutants and hazardous substances potentially ending up in the sea. Estimates of total nutrient loading, during/around (un)loading of fertilisers, but also the representative loading during timeframes when no fertilisers are being (un)loaded, should be calculated. Also plan for needed actions or restrictions should be imposed if the stormwater monitoring indicates that the total nutrient load is considerable.

6.2 Monitoring the process

Table 11 provides an overview of the BATs/BEPs related to the monitoring of the cargo handling process. These BATs/BEPs are intendent for the stakeholders who are directly involved in the cargo handling process, such as the port operator, the terminal operator, the fertiliser manufacturer and the shipping company.

Table 11 - Overview of BATs/BEPs related to monitoring of the cargo handling process

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
46	Continuous monitoring of the work, for example, by cameras and visual inspections. The terminal operator can for example monitor the crane driver performance. Port authorities and terminal operators can monitor the cleaning procedures. In this way, improper performance can be corrected and/or penalised and prevented in the future.	X	X	X	X		++	€
47	Monitoring of equipment, for example, the dust filters in the machinery, the effectiveness of the closed systems/conveyor belts, the containers, etc. The terminal operators should conduct this monitoring process regularly, at least before and after handling the cargo loads.	X	X				++	€
48	Monitoring and forecasting weather conditions can help estimate and determine potential interruptions during work and when cleaning is needed. The port authorities	X	X	X	X		++	€

		Stakeholders					Impact	
	can monitor the weather and terminal operators are also responsible for organising their work and cleaning schedules around the weather forecast. The monitoring and forecasting of weather conditions is also very important for monitoring the concentrations of nutrient discharges in stormwater and can help to control the automatic sampler.							

Recommendations for monitoring of the cargo handling process

It is important for employees to be supported in reporting nutrient losses and possible danger of nutrient spillage within the fertiliser handling process. This can be achieved by offering employees a reward when reporting nutrient losses and possible danger of nutrient spillage, but can also be achieved using cameras to conduct visual inspections.
When spillage or nutrient losses has occurred, employees responsible for the cargo handling process may receive feedback, or in severe cases, can be penalised. The interviews with port operators showed that monitoring the equipment is very important as well, especially the grab bucket. Leaks in the bucket could cause a constant spillage flow of fertilisers during the entire process. Because of this, the grabber is one of the most important aspects during maintenance checks.

7 Improving communication between different stakeholders

Communication is a broad topic that can include all stakeholders within the fertiliser supply chain. Improving communication among stakeholders, giving each other feedback and sharing knowledge can indirectly ensure minimisation of nutrient losses caused by dry bulk fertiliser storage and handling. Table 12 provides therefore an overview of the BATs/BEPs related to the improvement of communication between the stakeholders.

Table 12 - Overview of BATs/BEPs related to the improvement of stakeholder communication

		Stakeholders						Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Cargo owner	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
49	Rewarding workers to achieve minimal nutrient losses, similar to what is done to reward safety regulations and practises in ports. Rewards can include certain prizes/lunch incentives or bonuses.		X	X	X	X		+++	€
50	BATs/BEPs should be a standard component/ requirement for shipment contracts to avoid major nutrient losses during transportation. In this way, handling and storage requirements can be guaranteed. Manufacturers that have the fertilisers transported by a third party can play a significant role in this.	X	X	X	X	X		+++	€€
51	Agreements between port/terminal and shipping company often working with each other on the specifications for feeder holes for closed loading.	X	X		X			+++	€€
52	Sharing experiences and good practices with relevant stakeholders. A platform can be set up to share good practices to boost cooperation.	X	X	X	X	X	X	++	€
53	Good communication between port and terminal. The port has a responsibility to contact the terminal if it is found that fertiliser losses are significant and a protocol is needed.	X	X					++	€
54	Employees need regular feedback on their job performance and it is necessary to see together what can be improved in order to minimise nutrient losses (very important for crane operators for example).	X	X		X	X		++	€
55	Monitoring details should be shared with operators and authorities. This helps to raise awareness about the problem and encourage	X	X		X	X		+	€

		Stakeholders						Impact	
	more action to decrease nutrient losses. Monthly goals of nutrient discharge levels can be created to stimulate employees.								
56	Having individual conversations between the port and the companies operating in the port area about environmental issues can lead to preventive measures and good improvements.	X	X		X			+	€

Recommendations for improvement of communication

Some interviews revealed that ignorance and lack of motivation to reduce fertiliser spillage are major problems within the fertiliser handling process. According to some companies within the fertiliser supply chain, a large proportion of employees are unaware of the consequences of spilling fertilisers into the sea. Awareness can be raised through improvement of communication. Various best practices are possible. Offering rewards for minimal fertiliser losses or when employees report environmental concerns, can create an incentive to prevent fertiliser losses to the sea. On the other hand, regular feedback and/or penalties when high fertiliser losses occur are a way to address the problem and increase awareness among employees.

Manufacturers can play an important indirect role in minimising nutrient losses caused by dry bulk fertiliser handling. They are often the stakeholders who arrange the transport of the fertilisers to the customers. BATs/BEPs should be a standard component/requirement for shipment contracts to avoid major nutrient losses during transportation.

Finally, agreements between ports and terminals can also be improved. Often, although it depends on the country, ports receive an environmental permit while the terminals are the ones who actually perform certain operations resulting in potential nutrient losses. It is recommended that ports can legally hold terminals accountable for this as well, and it does not just stop at conversations and requests to improve.

8 Developing skills through training and education

Human actions are required during handling and storage of dry bulk fertilisers. This does not only apply to the actual cargo handling, but also before and afterwards, during for example, cleaning operations, management of stormwater and snow, and during monitoring operations. Training and education of personnel is necessary to develop the right skills. Table 13 provides an overview of the BATs/BEPs related to training and education, both for land personnel and crew on board.

Table 13 -Overview of BATs/BEPs related to training and education

		Stakeholders					Impact	
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation	Financial investment
57	Cargo handling should be kept to a minimum or even stopped in bad/windy weather conditions. The crew should be educated on the adequate protocol regarding operations to minimise nutrient losses in bad weather conditions. Operations should be limited if winds exceed 10-15 m/s (depending on the port).	X	X	X	X		+++	€
58	Educate the crane operators to close the bucket the moment after the bucket releases the fertiliser and it is brought back to pick up the next batch of fertilisers. This is especially important for cranes handling lower quality grains which are more sticky, leaving residues of fertiliser in the bucket that could be released onto the berth if the bucket is not closed in that moment.	X	X		X		+++	€
59	Experienced personnel, both on shore and on board, is very important. Especially when using older/less innovative equipment that has a higher risk of spillage, training is crucial for careful handling. Combination of well-trained personnel and adequate equipment is ideal.	X	X	X	X		+++	€€
60	When new and more efficient equipment is installed and used, personnel should be trained in its proper application and maintenance.	X	X		X		++	€

		Stakeholders					Impact	
61	Create awareness amongst the employees and different stakeholders about the consequences of fertiliser losses. This can be done by workshops where the effects of nutrient losses are explained along with the BATs/BEPs put in place. During this workshop an open, safe space should be created to encourage stakeholders to look ahead and brainstorm together about possible solutions to the problem. Awareness of citizens is also necessary to put pressure and gain more support to the environmental challenge.	X	X	X	X	X	++	€

Recommendations for training and education

As mentioned in the previous chapter, a large proportion of employees are unaware of the consequences of spilling fertilisers into the sea. Training and education are good ways to create awareness and to teach staff how to reduce nutrient losses. Careful handling and storage require more time for the stakeholders involved, but will result in significant reductions in time required to clean up spilled fertiliser.

The terminals handling fertilisers are most familiar with the specific area, the available equipment and the employees. They should be able to develop a training for their employees.

Well-educated employees will be more motivated to take measures to prevent fertiliser spills. Training/education for crane operators is especially important, because they are the first to come in contact with the cargo and because (un)loading operation is a problematic part for the cargo handling process when it comes to nutrient losses. Crane operators must learn that time efficiency is not the most important thing and what are the consequences of saving time by overfilling the bucket. The ultimate goal will be to have a well-educated crane operator operating using high quality equipment they are familiar with.

9 Policy makers and authorities

When it comes to the handling and storage of dry bulk fertilisers, the focus is often on the contributions that direct stakeholders such as ports, terminals, shipping companies and fertiliser manufacturers can make to minimise the nutrient losses. However, other stakeholders such as policymakers and authorities are indirectly involved in the process. This chapter pays special attention to these indirectly involved stakeholders. Table 14 provides therefore an overview of BATs/BEPs especially for policy makers and authorities.

Table 14 - Overview of BATs/BEPs especially for policy makers and authorities

		Stakeholders					Impact[8]
#	Description BATs/BEPs	Port	Terminal & stevedoring	Shipping company	Fertiliser manufacturer	Authorities & policy makers	Loss minimisation
62	Realizing environmental permits for all ports and terminals in the Baltic Sea region. Environmental permits should be more standardized in all countries surrounding the Baltic Sea, so that all actors are equally competitive and there is no disadvantage for ports which have more stricter permits due to encouragement of implementing BATs/BEPs to minimise fertiliser losses.	X	X-			X	+++
63	Providing training materials to ports, terminals, shipping companies, fertiliser manufacturers and owners. These training materials can be used during regular audits.	X	X			X	+++
64	Implement legislation to minimise nutrient losses in the Baltic Sea. HELCOM is in a good position to issue a recommendation for handling fertilisers in the Baltic Sea region. However, it is thereby important to consider the financial viability of each port when it comes to the implementation of certain BATs/BEPs.					X	+++
65	Ensure that ports have adequate reception facilities for the disposal of hold wash waters. This should be enforced and controlled by environmental authorities of each country.	X	X	X		X	+++
66	It can be relatively expensive to discharge wash waters at appropriate facilities (depending on the size of ship, port, etc.), so ships often discharge into the sea. Policy makers (such as HELCOM and national ministries) should be able to make discharging wash water in ports more financially attractive. This could be done for example by introducing higher port fees and requiring that every vessel must to pay for water discharge	X		X		X	+++

[8] Because it is not readily possible to make a qualitatively estimate of the financial investment required for policy measures, the 'financial investment impact' column is not included in this table.

		Stakeholders					Impact[8]
	services, not only the vessels that actually use the water reception services. This can be a good incentive to make the use of wash water facilities more uniform and common. Another solution could be that ports look into companies that offer removal of wash water to prevent them from charging unrealistic prices.						
67	Conduct regular audits. Policy makers and authorities can support ports and terminals by controlling that processes are being carried out correctly.					X	++

Recommendations specifically for policy makers and authorities

Requirements for fertiliser handling and nutrient losses varies from country to country. In Lithuania for example, companies need to use closed systems at terminals that specialise in cargo with high dispersion. If this is not possible due to capacity restraints, terminals in Lithuania must take measures to minimise dispersion, taking into account the volume of operations, the wind and distance to neighbours. Other countries around the Baltic Sea have different or no legislation when it comes to handling of fertilisers. It is therefore important to raise awareness that fertiliser spillage causes serious harm to the marine environment, even though fertilisers are not classified by HELCOM as hazardous substances. To create a level playing field, it is recommended that regulations will be developed which apply to all countries in the Baltic Sea region and involve minimising nutrient losses during cargo handling. The realisation of environmental permits not only for ports, but also for terminals contributes to this.

Another relevant topic are port reception facilities for cargo hold wash water and cargo residues. Policy makers and authorities can play an important role in realising adequate port reception facilities and by providing financial incentives for ships to actually use these facilities.

10 Conclusions

This report is a reference document on best available technologies, techniques and environmental practices (BATs/BEPs) to minimise nutrient losses during storing, handling and transporting dry bulk fertilisers in the Baltic Sea region. The document can be used to promote sustainable practices both at practical level (ports, terminals, manufacturers and shipping companies) and at policy and regulatory levels (HELCOM and authorities).

Through a combination of literature review and interviews, we have identified and assessed approximately 70 Best Available Technologies or Techniques and Best Environmental Practices (BATs/BEPs). We have identified which stakeholders are involved in the BATs/BEPs and we have qualitatively estimated the impact of the BATs and BEPs. These BATs and BEPs are categorized into seven relevant topics: handling and storage of dry bulk fertilisers, cleaning equipment and routines, management of stormwater and snow, monitoring for improvement of processes, improving communication between stakeholders, developing skills through training and education & policy makers and authorities.

Table 15 shows a summary of BATs/BEPs with the largest impact on minimising nutrient losses. These BATs/BEPs can be applied voluntarily by companies. For stakeholders with sufficient funding, it is recommended to implement all these BATs/BEPs. If this is not the case, a financial consideration must be made of which measures are most relevant to the stakeholder in question.

Table 15 - Condensed overview of BATs/BEPs with the larges impact on minimising nutrient losses

BAT/BEP	Financial investment	Type of stakeholder(s) involved
Preventing nutrient losses during dry bulk fertiliser handling and transportation through best practices such as closing the empty bucket between the ship and the berth, maintaining the clamshells of the bucket/grab, applying a dusting off move during fertiliser handling, filling the bulk fertiliser to the allowable limit on the bucket (marked by a line), using a prevention cover between ship ad berth and considering weather conditions.	€-€€	Port, terminal, manufacturer
Using **closed equipment** during dry bulk fertiliser handling and transportation to minimise nutrient losses.	€€€	Port, terminal, manufacturer
Regularly cleaning the storage and handling areas to prevent nutrient losses from spreading and being released into the seawater.	€-€€	Port, terminal, manufacturer
Training and education of personnel to explain the impact of nutrient losses in the Baltic Sea and procedures put in place to prevent nutrient losses. Training of crane operators is most important.	€	Port, terminal, manufacturer and shipping company
Agreements between stakeholders in the fertiliser supply chain by contract to apply certain BATs/BEPs.	€€	Port, terminal, manufacturer and shipping company
Monitoring of stormwater content (taking and analysing samples).	€€	Port, terminal, manufacturer
Investing in **stormwater collecting and treatment systems.**	€€€	Port, terminal, manufacturer

The most critical moment for leakages is during the transfer of dry bulk fertilisers from ship to quay or vice versa. Prevention of nutrient losses during this process is therefore the priority. The losses can often be prevented by implementing simple best practices that require a relatively low investment. A simple example is not overfilling the bucket while (un)loading the ship. The use of closed equipment during storage and handling and the use of storm water collecting and treatment systems are BATs/BEPs with a large impact on the minimisation of nutrient losses, but also involve large investment costs compared to the other measures. Regular and proper cleaning is the next step. Through training and education, personnel can learn prevention and cleaning skills and become aware of the problem. However, prevention and cleaning can imply longer operational time (and costs) or that the port capacity is not sufficient anymore since cleaning requires additional time and hence with the same amount of personnel less ships can be loaded/unloaded. Analysing storm water samples is a valuable way of gaining insight on how much fertiliser has been lost and where the process can be improved. Finally, contractual agreements between stakeholders in the fertiliser supply chain increase the likelihood that the BATs/BEPs will actually be applied.

Thus, there are several BATs/BEPs that can help minimise nutrient losses during storing, handling and transportation of dry bulk fertilisers. Collaboration among different stakeholders is essential in addressing this problem. In the Baltic Sea region, this is very possible since stakeholders are involved in multiple parts of the process. As an example, manufacturers are also sometimes shareholders of the terminals where they (un)load the cargo.

Nutrient losses in the Baltic Sea are causing an environmental problem which has stimulated social pressure. National authorities and intergovernmental organisations such as HELCOM have a crucial role in mitigating these losses. They can for example advance the utilisation of BATs/BEPs in the environmental permits they issue for ports and terminals, and encourage and require investing in port reception facilities for hold wash water.

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A Definition of impact of BATs/BEPs

This report is a reference document on best available technologies, techniques and environmental practices (BATs/BEPs) to minimise nutrient losses from dry bulk fertiliser storage and handling in the Baltic Sea region. The BATs/BEPs are divided into a number of relevant categories, such as handling and storage, cleaning, monitoring, training, etc. Based on literature review, interviews and expert judgement, we qualitatively distinguished between high-impact and subsidiary measures. We make this distinction by using two types of indicators:

- impact on loss minimisation;
- required investment costs.

For each indicator we use a scale of colours to indicate the degree of impact. The meaning of the colour coding is shown in Table 16 and Table 17.

Table 16 - Colour coding for the impact on loss minimisation of a certain BAT/BEP

Colour	Meaning
+++	High impact on loss minimisation
++	Medium impact on loss minimisation/dependent on the situation/not always easy to determine
+	Limited impact on loss minimisation

Table 17 - Colour coding for the required investment costs of a certain BAT/BEP

Colour	Meaning
€	Limited investment costs required
€€	Medium investment costs required/dependent on the situation/not always easy to determine
€€€	High investment costs

For each BAT/BEP a green colour is selected for the impact on loss minimisation (see Table 16) and a blue colour is selected for the corresponding investment costs for this BAT/BEP (see Table 17). This may result in different colour combinations, which is shown in Table 18. These colour combinations allow a qualitative distinction to be made between high-impact (dark green) and subsidiary measures (light green), while also considering the associated investment costs:

- The combination of dark green and dark blue are the measures where environmental benefits can easily be gained, also called ‘low hanging fruit’.
- The combination of dark green and light blue shows high impact measures for stakeholders with investment opportunities. Often the larger ports have more investment opportunities.
- The light green measures are the subsidiary measures, where there is also a distinction in associated investment costs.

Table 18 - Colour coding of BATs/BEPs combining two indicators

	Impact		
BATs/BEPs	**Loss minimisation**	**Financial investment**	**Explanation of meaning**
BAT/BEP # 1	+++	€	High impact measure, low hanging fruit
BAT/BEP # 2	+++	€€	High impact measure
BAT/BEP # 3	+++	€€€	High impact measure for stakeholders with investment opportunities
BAT/BEP # 4	++	€	Medium impact measure with little investment costs
BAT/BEP # 5	++	€€	Medium impact measure
BAT/BEP # 6	++	€€€	Medium impact measure with high investment costs
BAT/BEP # 7	+	€	Subsidiary measure with little investment costs
BAT/BEP # 8	+	€€	Subsidiary measure
BAT/BEP # 9	+	€€€	Subsidiary measure with high investment costs

The colour coding can help stakeholders to choose which BATs/BEPs to focus on and invest in.

B Interviewed organisations and individuals

Table 19 provides a list of organisations and persons interviewed.

Table 19 - List of organisations and persons interviewed

#	Type of organisation	Organisation	Interviewed person(s)
1	Shipping company	ESL Shipping	Suvi-Tuuli Lappalainen*
2	Shipping company	AtoB@C shipping AB	Marie-Luise Heddens
3	Port	Åhus Port, Sweden	Roberto Zigante
4	Port	Port of Klaipeda, Lithuania	Aistė Kubiliūtė
5	Port operator/stevedoring	Rauanheimo (Part of KWH Logistics)	Pasi Salmela
6	Fertiliser manufacturer	Fosfan SA	Natalia Skugariew
7	Fertiliser manufacturer	Yara Uusikaupunki	Sami Kortelainen & Heikki Turkki

* Suvi-Tuuli Lappalainen currently works for ESL Shipping, but mainly shared her experience from a port perspective because of her previous career.