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# STUDY

# MINIMISING NUTRIENT DISCHARGES FROM FERTILISER TRANSPORT BY SEA IN THE BALTIC SEA REGION

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# CONTENTS

# 1. EXECUTIVE SUMMARY

There is a justified concern that fertilisers and related raw materials are discharged into the environment during the logistics process at ports and during transport by ships. Fertilisers are released to the environment during the cargo handling process. The same applies to cleaning cargo holds because there are no proper reception facilities for wash waters or tank lorries are not considered such a facility. However, there is not enough information to make conclusions about volumes discharged into the environment. This would require a more detailed study.

Some ports in the Baltic Sea Region have good technology and operational practices. There are also ports with less focus on environmental aspects, and especially receiving wash waters from ships' holds requires attention.

There are technologies and operational practices which can considerably reduce fertiliser product discharge into the environment. The first, easy and inexpensive step is to train the workforce.

**Best Available Technology**

It is not easy to say exactly and universally what the best handling method for fertiliser cargo is. Obviously, the system should be as much mechanised and closed as possible. The most closed cargo handling system is bulk containers, especially, if the containers are loaded at the factory and unloaded at the end user. The second best system for loading is to use feeder holes on hatches with a closed conveyor system at the terminal, but not all ships are equipped with such feeder holes.

Bulk handling is typically the most economical method of transport, if that is possible (depending on the market, user, reception port, etc.). A bulk handling conveyor system is quite well protected against dusting, when it is designed properly. Most of the dusting occurs at crossing points, e.g. supplying the conveyor, crossing between two conveyors and loading to ship. Conventional handling by crane may cause a lot of loss if not done properly. Investing in proper crane grabs is also quite a small investment.

Screw and pneumatic unloaders supplying cargo directly to closed conveyor systems are the best methods for unloading. However, grab unloading by crane is possible as well, but requires properly closed grabs and anti-dust-designed hoppers supplying cargo directly to closed conveyor systems. The training of crane operators is vital.

A simple and cost-effective method for an existing terminal is to develop attitude and train people. Modern equipment, in addition to attitude and training, will be good for the environment and for business because of increased productivity and improved cargo condition.

**Port reception facilities**

There are just few ports which receive cargo hold wash waters and process them in their own treatment facilities. In many cases, there are limitations on the quality of cargo hold wash waters (seawater or content is not suitable for the cleaning process). This report analysed 15 fertiliser ports as requested by the Client. It is important to understand that cargo hold wash waters are not necessarily fertiliser-based at a fertiliser loading port, but can contain anything that the ship has transported previously. Port reception facilities are needed at every port, not just at ports handling fertilisers.

It is neither mandatory nor even necessarily technically possible to pump hold wash waters directly into a pipeline and to a treatment facility at the port. It is assumed that there is no ship-to-shore water interface to pump water ashore (a pipeline or lorry) on all ships. Freezing temperatures may be a challenge and warm water and steam may be needed.

According to an assessment made by Ramboll, it is expected that a tank lorry will be the interface between the vessel and the port in many cases. Tank lorries are most probably an economical transport solution for small quantities and/or relatively short distances. Tank lorries, paid by the shipowner, were mentioned at many ports as the means of transport for hold wash water.

Ramboll does not have data on hold washing water discharge from larger vessels as there are no known cases of such discharge operations. In the 2014 Ramboll Kokkola report it was estimated that a large bulk carrier could discharge 100 to 600 $m^3$ of hold wash water, depending on ship size, previous cargo and the washing method used. It is technically possible to use tank lorries for high quantities (assuming pumping through a ship interface or separate pumps) and it can be feasible if the dumping ground is in close proximity. However, their operation is most probably very slow and requires more time and therefore could lead to high costs.

The amount of hold wash waters can be minimised by dry cleaning the hold before water cleaning. Water cleaning should be carried out at a high pressure rather than using high volumes of water. Industrial vacuum cleaners were considered in the 2014 Ramboll Kokkola report, but practical applications are not known; their efficiency and practicability are doubtful.

**Conclusions**
Fertiliser cargo handling and wash waters from the cleaning of ships' holds require attention and further studies and influencing the operators and Baltic Sea governments.

There are several different methods for handling fertiliser at ports. Some ports have more efficient mitigation measures than others. There are some very good technological examples of minimised discharge into the environment. Using containers, closed bulk systems and big bags were assessed to be best practices. Cost and benefit comparison is a complicated issue and all cases should be analysed independently. The selection of cargo handling equipment is mostly based on economic feasibility. It might be the case that not all ports or shippers consider the environmental side of their investment.

It is difficult to make an overall estimation of volumes lost to the natural environment. A more detailed study for estimating these volumes is recommended.

**Recommendations**
It is recommended that port terminals use modern technology and train their personnel. Terminals operate on a commercial basis and it is unclear if any clear limits for discharge into the environment have been set or if they are followed. Mandatory regulations should be used if cooperation and education do not give satisfactory results – both in the EU and in an international context.

It is unclear what a port reception facility actually means: does it mean a fixed treatment facility or just a possibility to pump wash waters to a tank lorry? "No special fee" -regulation (ships are charged a fee regardless of discharging or not discharging waste) could be considered to be a regulatory option.

It is recommended to prepare detailed studies on the volumes lost to the environment from cargo handling and from washing cargo holds.

# 2. INTRODUCTION

### 2.1 Purpose of this study

There is a justified concern that fertilisers and related raw materials are discharged into the environment during the logistics process at ports and during transport by ships. These products, especially nitrogen and phosphorus, cause eutrophication. It has been recognised that such discharge is mainly due to dust and the spillage of materials while loading and unloading a ship, as well as when cleaning ships' holds.

This study intends to give an overview of the situation, including capacities, handling volumes, methods and operational practices.

### 2.2 Methodology

This study has been prepared in accordance with the Terms of Reference delivered by the Client. Data has been collected from public sources and interviews have been conducted wherever possible. The authors' expertise has been effectively utilised in introducing the Best Available Technologies.

The Client has selected the following ports in the Baltic Sea for analyses:

1. Klaipeda
2. St. Petersburg
3. Tallinn – Muuga
4. Ventspils
5. Rostock
6. Riga
7. HaminaKotka
8. Uusikaupunki
9. Vyborg
10. Ust-Luga
11. Lübeck
12. Kokkola
13. Sillamäe
14. Kaliningrad
15. Liepaja

### 2.3 Team

The team consists of Ramboll's experts from Finland, Germany and Russia:

**Matti Utriainen** has a background as a Master Mariner, a Port Traffic Manager and Deputy Managing Director at a logistics and stevedoring company. These duties have provided him with a wide practical expertise in cargo handling technology and operations. Matti has been working for more than 15 years as a consultant specialised in port and transport logistics. He has had several projects concerning bulk handling worldwide, which include fertiliser terminals at the Port of HaminaKotka and Bangladesh. He has also produced a study concerning methods for washing ships' holds and related water treatment.

**Anton Ivshin** has worked with Ramboll Russia since 2014 and specialises in environmental and social impact assessment, environmental due diligence and EHS compliance auditing. Anton graduated from Lomonosov Moscow State University with a degree in Environmental and Natural Resource Management with the focus on environmental geochemistry and health, and has experience in fieldwork, environmental data collection and analysis. Anton's research interests include the behaviour of oil in soils.

**Nils Heine** holds an MSc degree in Operation and Management of Maritime Systems and a diploma in Business Administration and is a qualified shipping businessman, who works as a Senior Consultant at Ramboll Deutschland GmbH. His expertise is in the logistical and financial interdependence of the port and logistics industry in Europe, its digitalisation and the use of intelligent transport systems. Mr Heine was Managing Director, Shareholder and Consultant at CPL Competence at Ports and Logistics GmbH until March 2020. Mr Heine has been working in the port, maritime and logistics industry for more than 15 years.

# 3. OVERVIEW OF FERTILISER DISCHARGE FROM SHIPPING ACTIVITIES

## 3.1 General

Shipping-related nutrient discharges originate from exhaust gases, the accommodation functions of ships (sewage), accidents and cargo operations. This report focuses on cargo operations. Cargo operations are further divided into the following categories:

- spillage and dust discharge into the air at ports (unloading vehicle, transport and loading a ship);
- spillage to the ground and water;
- handling of wash water from ships' holds.

Cargo handling methods covered in this study include dry bulk, liquid bulk, break bulk (bags) or containers (bulk or bags in containers). This study puts the focus on dry bulk as it is considered to have the greatest impact.

There is no doubt that some fertiliser cargo is lost and discharged into the environment during cargo operations. However, there is a lack of information, which has, according to interviews in Finland, led to some confusion about the volume of the loss. Lost cargo is an environmental issue, but also a business case. As an example, the spot price of urea is at around EUR 200/tonne[1]. Reducing the loss of cargo is considered important according to the interviews conducted for this study.

## 3.2 Shortage of bulk cargo during transport

### 3.2.1 Principles

Assessing the volumes discharged into the environment is not an objective of this study and a more detailed separate study of the topic is recommended. It was mentioned in the interviews that a 0.5% or higher loss of cargo, presented in some discussions and, e.g. freight agreements, is likely to be a result of commercially affected measurement inaccuracy rather than discharge into to the environment. A more detailed study on the subject is needed to verify lost volumes. The loss is highly dependent on the ship's size, hold structure (smooth box or support frame structures in the hold) and handling methods, as well as cleaning practices at a port. Some best practices are explained later in this study.

### 3.2.2 Shortage *en route*

Shortage of cargo between loading and unloading is a typical issue in the shipping industry. This does not necessarily mean that the cargo is being discharged into the sea, but mainly that there are challenges in measuring it. Therefore, it is typical that a +/-0.5% allowance is included in charter parties and even a 1.5% difference is not rare.

Cargo is measured at the port by vehicle or conveyor scales at both ends, i.e. at the loading port and the discharge port. The accuracy of such scales is theoretically approximately +/-0.5%. Some suppliers have suggested that it might even be +/-1.0% in practice. A draft survey is another typical method for measuring cargo. A draft survey is made by calculating the hydrostatic state of a ship before and after loading or unloading. This process is made by reading draught marks on the ship's hull, measuring tanks (fuel, fresh water, lubricating oil, etc.) using tape and calculating various other ship conditions and corrections. There are numerous circumstances for errors and

[1] https://www.indexmundi.com/commodities/?commodity=urea&months=120

inaccuracies starting from the state of the sea, making reading of draught marks difficult (Figure 1). Such errors can produce inaccuracy levels of several percentage points.

Another notable issue is that, theoretically, a seller has the motivation to show larger volumes and a buyer has the motivation to show lesser volumes for business reasons.

**Figure 1: Effect of sea state makes reading draught marks difficult (https://i2.wp.com/sevensurveyor.com/wp-content/uploads/2011/01/Draftmark.jpg)**

### 3.2.3 Shortage at the loading or discharge port

There are different kinds of cargo handling methods in use. Cargo loss during cargo handling occurs mainly through spillage from the system or through dusting. In some cases, handling will be done by front loaders, lorries and grab cranes, which will allow more spillage than a completely closed conveyor system. Dusting during loading to the hold could occur even with a closed conveyor system. Some handling methods are more closed than others. These are explained in detail in Part 5.

### 3.2.4 Shortage due to washing cargo holds

Ships wash their holds in approximately 80% to 90% of the cases after each cargo. Typically, washing is carried out using sea water *en route* or at the previous discharge port. Time should be allowed for drying the holds. The volume of fertiliser in the wash water depends on the cleaning method and the structure of the hold. A more detailed explanation is presented in Part 6.

## 3.3 Previous studies

There have been a few attempts to research nutrient discharge into the sea. The issue is estimated very roughly in the article published in the Marine Pollution Bulletin on 21 June 2016. This article suggests that 0.05% of cargo is lost during the whole shipping process (loading, unloading and washing the holds). This article covered all international shipping by large vessels rather than the Baltic Sea alone.

The Baltic Marine Environment Protection Commission (HELCOM) created a questionnaire in 2018, intended to study volumes and mitigation measures at Baltic Sea terminals. The results were somewhat disappointing as they received only 11 responses.

Availability of information was found to be a challenge in this study as well.

# 4. VOLUMES AND EQUIPMENT AT PORTS

## 4.1 General

The Terms of Reference for this study aimed at finding out detailed transport volumes compiled separately for each product. Unfortunately, such detailed information was not available due to business confidentiality issues. Most of the fertiliser transport volumes in the Baltic Sea Region are export transports.

The following chapters present fertiliser volumes as one group. Additionally, cargo handling methods are described in as much detail as possible, mostly based on public information and Ramboll's expertise.

## 4.2 Ports in Finland

### 4.2.1 Volumes

The Port of HaminaKotka, in particular, the Mussalo port area in Kotka, handles most of the fertiliser volumes in Finland. Its traffic involves transit cargo from Russia for exports to various countries. Ports in Kokkola and Uusikaupunki handle volumes related to the fertiliser factory at the port. The port in Uusikaupunki is a private port in the factory area (Figure 2 and Table 1).

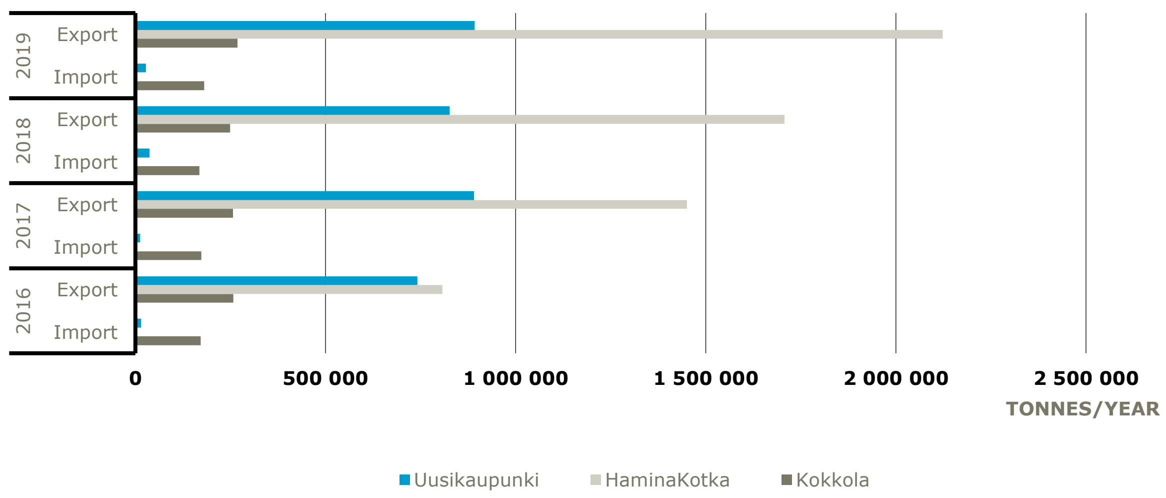


**Figure 2: Volume in Finland (OSF)**

**Table 1: Volume in Finland (OSF)**

| Port | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export | Import | Export |
| Kokkola | 171,679 | 257,161 | 172,905 | 256,969 | 168,223 | 248,871 | 180,891 | 268,517 |
| HaminaKotka | 3,178 | 806,837 | 1,287 | 1,450,461 | 0 | 1,707,343 | 2,546 | 2,122,685 |
| Uusikaupunki | 14,892 | 741,327 | 12,492 | 890,377 | 37,089 | 826,346 | 28,056 | 891,963 |

### 4.2.2 HaminaKotka Ltd.

The bulk fertiliser port activities at the Port of HaminaKotka are located at the Mussalo port area in Kotka. The bulk berth used for fertiliser transport is approximately 600 m long. The bulk handling storage area consists of eight storage buildings (5,000 to 8,000 m$^2$ each). There are currently two operators: Fertilog Ltd. and M. Rauanheimo Ltd. Fertilog is a Russian-owned company specialising in transit transport from Russia. Its net sales in 2019 were EUR 12.4 million and its operating profit was EUR 4.4 million. The company employed 11 people. Rauanheimo is Finland's leading port operator, operating at 10 Finnish ports. The company is part of KWH Logistics. Rauanheimo's net sales in 2019 were EUR 102.1 million and its operating profit was EUR 2.6 million. It employed 205 people.

All the cargo is transit cargo transported in bulk by rail from Russia. Ship sizes vary: there are 3,000 to 5,000 DWT coasters and larger 30,000 to 60,000 DWT ships. According to the environmental permit (Port of HaminaKotka Ltd.) documents issued by the Regional State Administrative Agencies, Fertilog Ltd. is handling mainly urea, but also some other fertiliser products (different phosphates, ammonium sulphate, calcium ammonium nitrate and fertilisers containing combinations of nitrogen, phosphorus and sulphur). M. Rauanheimo Ltd. did not provide information on the type of fertilisers they transport, and information is not available publicly because the company started its fertiliser transport business in 2018/2019.

Currently, no environmental permit is required for fertiliser transport specifically, but the port expects that it might be needed in the future. However, the environmental permit for the port (Port of HaminaKotka ltd.) includes requirements for fertiliser transport as well. It is not known how much operators consider environmental issues. According to the port, there is a separate storm water collection system in the fertiliser terminal area with sediment basins and sampling facilities. However, filtering is challenging as fertilisers are mainly water-soluble. Storm water inlets can be closed in order to avoid excessive discharge into the collection system in case of leakage.

The handling system of Fertilog Ltd. consists of the following items (Figure 3, Figure 4 and Figure 5):

- covered rail unloading pit with conveyor and stacker transport to the storage facility;
- front loader supplying a conveyor inside the building;
- covered conveyor system to transport fertiliser to the mobile link conveyor;
- closed mobile shiploader with an open chute to direct the flow.

Some spillage occurs, especially in the connection point of the horizontal link conveyor, as the conveyor is not completely closed. According to news released by Fertilog Ltd. (26 June 2020), the new bulk terminal building will increase fertiliser transport by 500,000 tonnes annually. The current capacity is not known, but it is expected to be 2 to 3 million tonnes annually.

**Figure 3: View of the Fertilog Ltd. terminal in Mussalo, Kotka (https://fertilog-group.fi/fi/fertilog-oy)**

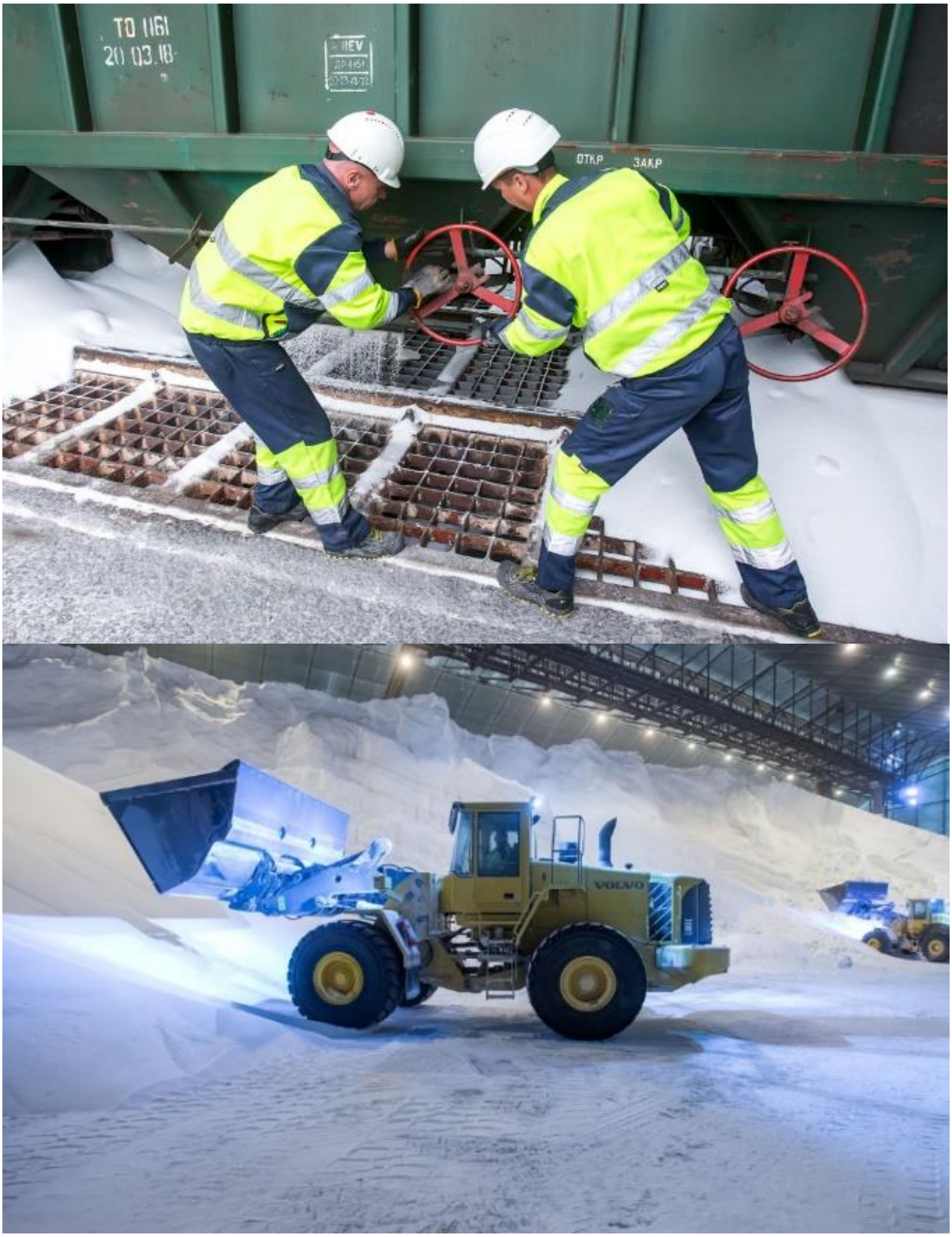


**Figure 4: Unloading rail wagons and handling in the storage building (https://fertilog-group.fi/fi/fertilog-oy)**

**Figure 5: Mobile shiploader (https://fertilog-group.fi/fi/fertilog-oy)**

M. Rauanheimo Ltd. uses shiploaders on rail, mobile shiploaders and cranes for fertiliser cargo. Some spillage occurs at the port as seen from the figures below (Figure 6). However, the company is expanding their business and improving their equipment. Former import activities as seen in the figure below are turning into exporting transit fertilisers from Russia. According to news released by Rauanheimo (autumn 2020), the current capacity, little more than 1 million tonnes/year, will be increased by 1 to 1.5 million tonnes/year as a result of the investments.

**Figure 6: M. Rauanheimo Ltd., Terminal in Mussalo, Kotka (https://www.rauanheimo.com/2020/02/07/mussalon-investointi-ohjelma-etenee-aikataulussa/)**

### 4.2.3 Uusikaupunki

Yara is a global supplier of mineral fertilisers, industrial chemicals and environmental products with a turnover of USD 12.9 billion. Yara has a fertiliser factory and a port in Uusikaupunki, southwestern Finland. The factory produces fertilisers (NPK) and nitric acid and unloads raw materials for the process. Fertilisers are transported in bulk (including bulk containers) or in bags. The length of the berth is approximately 340 metres.

The ship loading process is done by partly closed conveyors. The height of the shiploader chute is controlled in order to avoid dusting. Raw materials are unloaded by cranes and grabs into hoppers and forwarded by a closed conveyor system. The discharge of the cargo into the environment is minimal during the process according to Yara Ltd. Storm water is drained into a collection system and is used in the further process of the factory.

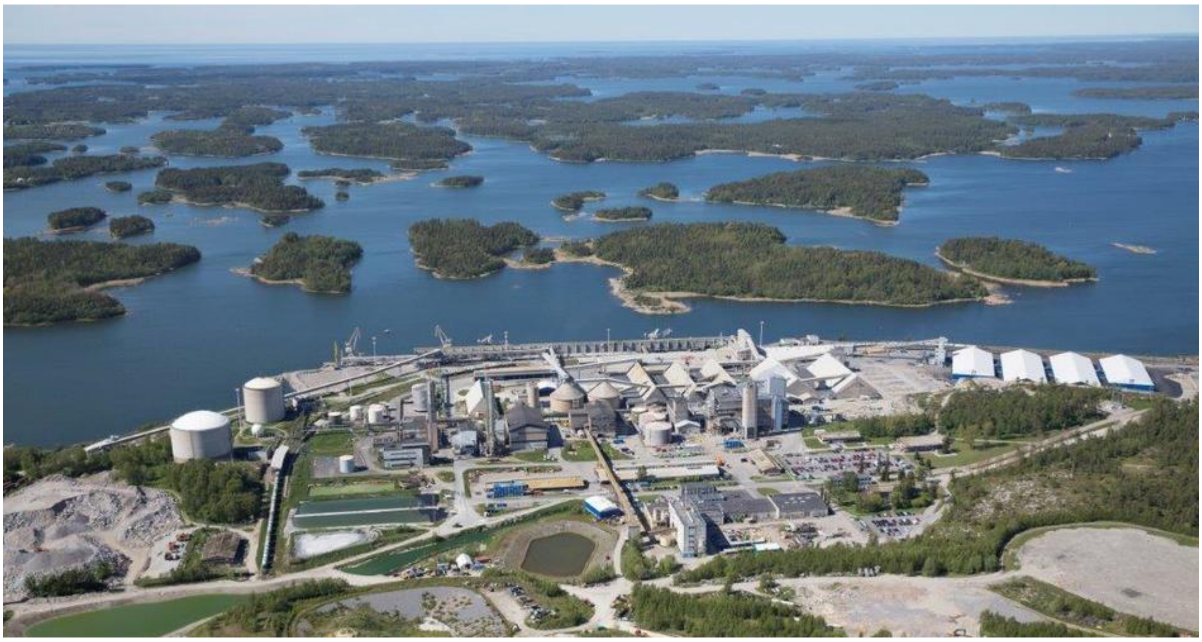

**Figure 7: (https://www.yara.fi/tietoa-yarasta/yara-suomi/toimipaikat/uusikaupunki/ymparisto/)**

### 4.2.4 Kokkola

Yara produces approximately 200,000 tonnes of animal feed phosphates and 220,000 tonnes of potassium sulphate/year in Kokkola. Additionally, liquid ammonia and phosphoric acid are stored and delivered from its site. Potassium sulphate is used for producing fertilisers or is used as a fertiliser itself. The Silverstone berth is approximately 120 metres long and the General Port berth is approximately 300 metres long.

Fertilisers are typically loaded by cranes. The cargo is transported from storage to the quay side by front loaders, which take it to a special collection area (large steel buckets). The quay area is cleaned immediately after cargo operation. Yara has advised crane and front loader operators to use conservative bucket loads and moderate speeds during operations. Figure 8 below shows some white cargo remaining on the berth, but the cargo itself is not known.

Figure 8: Silverstone berth used for fertiliser transport (https://portofkokkola.fi/satamat/hopeakiven-satama/)

Figure 9: An example of cranes used for loading fertiliser cargo (https://portofkokkola.fi/satamat/kantasatama/)

## 4.3 Ports in Estonia

### 4.3.1 Tallinn – Muuga

The DBT Terminal is situated in the Muuga Harbour. The main activity of the terminal is the provision of transit services (transshipment, warehousing, blending and bagging) to the owners of bulk and general cargo. The majority of the cargo is made up of granulated mineral fertilisers.

The terminal also handles granulated ammonium nitrate, which is a combustion-promoting material and a strong oxidizer of Class 5.1, which can burn and, under certain conditions, can also explode (https://www.dbt.eu/dbt-safety/).

The cargo handling system is closed, including one portal crane, one ship loader, two hopper car discharging stations and one blending and bagging plant. The fertiliser conveyor system and the shiploader are specifically designed for fertilisers and are considered to be the best available technology according to the Port of Tallinn. The conveyors are closed and equipped with dust filters. The shiploader has a cascade-type loading spout to minimise dust emissions. The typical loading rate is 750 tonnes/h. The cargo handling system seems to be completely closed as shown in the figure below.

The total volume of fertiliser transported is approximately 2 million tonnes/year. This includes nitrogen-based (N), phosphorus-based (P), potassium-based (K) and mixed-based (NPK) types of fertilisers.

According to the port, storm water does not have any contact with fertilisers and is treated with filters.


**Figure 10: (https://www.dbt.eu/blog/2017/05/08/panamax-85-000-mt/)**

### 4.3.2 Sillamäe

The BCT Terminal of AS DBT in the Sillamäe Harbour deals with the transshipment and storage of liquefied ammonia and liquid chemical goods (mainly the complex liquid fertiliser UAN, i.e. urea-ammonia nitrate solution). These are transported in closed pipelines. The BCT Terminal was opened in 2009 (https://www.dbt.eu/).

EuroChem Terminal Sillamäe AS was established in February 2004 to process liquid chemical raw materials at a chemical terminal in Estonia (https://www.eurochem.ee/).

Information concerning volumes was not available and the operators did not provide information.

**Figure 11: View of the Port of Sillamäe from the sea (https://www.silport.ee/eng/multimedia.html#1004eng)**

**Figure 12: AS DBT terminal at Sillamäe (https://www.dbt.eu/photo-sillamae/)**

Figure 13: View of the Port of Sillamäe; a mobile bulk shiploader on the right (https://www.silport.ee/eng/multimedia.html#1004eng)

## 4.4 Port in Lithuania

### 4.4.1 Klaipeda

Fertiliser volumes in Lithuanian ports related to this study are presented in the following table.

Table 2: Volumes in Klaipeda, tonnes (2016-2018), by OSP

| Port | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export |
| Klaipeda | 1,387,700 | 9,952,000 | 1,583,000 | 10,723,000 | 1,826,500 | 11,033,400 |

(Volumes of organic and chemical fertilisers at the Klaipeda port, retrieved from OSP https://osp.stat.gov.lt/statistiniu-rodikliu-analize#/)

Figure 14: Fertiliser handling quays at the Klaipeda Seaport (KLASCO l., BEGA r., (Photos: https://www.portofklaipeda.lt, http://www.bega.lt)

The Port of Klaipeda is the biggest port in Lithuania and one of the northernmost ice-free ports on the Baltic Sea. Fertiliser handling volumes are the highest in the Baltic Sea region. The port welcomed over 7,000 ships in 2018, generating 56.2 million tonnes of throughput (ops.stat.gov.lt). Nearly 25% of the total volume handled can be considered to belong to fertiliser handling – dry and liquid. Klaipeda is a multipurpose, universal and deep-water port offering a seabed depth of 14.5 m and a quay length of 24.7 km.

Klaipeda recorded a total throughput of 56,205,700 tonnes (ops.stat.gov.lt, 2018), of which 13,946,800 tonnes was referred to as fertiliser. Reducing the total amount of fertilisers handled (2018) by the amount of liquid fertilisers handled (2018, 1,086,900 tonnes) leaves 12,859,900 tonnes of dry bulk fertilisers handled. The dry bulk fertilisers consisted of organic and chemical fertilisers. At the Klaipeda Port, there are three bulk fertiliser terminals and two liquid fertiliser terminals. The cargo is mainly handled by two companies, KLASCO and BEGA.

KLASCO (AB Klaipeda Stevedoring Company) runs 60,000 to 65,000-tonne vessels and has storage capacities of 220,000 tonnes (2 warehouses, 4 sections each) for bulk fertiliser and for 15,000 tonnes of packed fertiliser. The company handles liquid and dry fertiliser cargo in one fifth of the whole port area at a maximum draught of 13.8 m at their berths. Vessel loading capacities amount to 15,000 tonnes/day and 250 wagons can be discharged at the same time. The bulk terminal for mineral fertiliser capacity is quoted at 3,500,000 tonnes/year. The company is expanding the mineral fertiliser terminal with a new warehouse (capacity: 100,000 tonnes), a new wagon unloading station and a conveyor gallery with a ship loader. According to the information available, all conveyors in use are covered.

Klasco exports Belaruskali fertiliser products to a large extent. In 2018, 10.098 million tonnes of fertiliser came from Belaruskali, producing predominantly potassium chloride. Other products come, e.g. from Achema, as nitrogen fertiliser (ammonium nitrate N34.4), calcium ammonium nitrate (N27), nitrogen fertiliser with calcium, nitrogen fertiliser with sulphur and urea (N46.5). In addition, liquid fertiliser (diluted at destination) consisting of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) is handled, too. The cargo is handled mainly unpacked.

BEGA operations take place between Berths Nos 66 and 72 at the Klaipeda Port. Dry bulk fertiliser is handled at their Berths Nos 69 to 72, excluding Berth No 71, which is used for liquid fertilisers only. The company solely handles dry bulk fertilisers unpacked. According to Bega, their terminal facilities contain mechanised warehouses, with an accumulated dry fertiliser capacity of 185,000 tonnes. Further terminal features include three railcar discharging stations, transport galleries and three loaders (stationary and mobile). Their conveyor belt systems are covered. Discharging rate from railcars is reported at 1,500 tonnes/hour and ship loading rates are listed at 2,500 tonnes/hour. Vessel loading capacity reaches up to 20,000 tonnes a day (12,000 tonnes/day for railcar unloading). The BEGA terminal’s capacity is reported to be 3.7 million tonnes.

BEGA holds close ties with the fertiliser production company EuroChem. The Russian company provides predominantly mineral fertiliser. Their fertiliser production is based on phosphate as a primary component, imported as raw material via the Klaipeda port and BEGA. In addition, the group imports ammonia by sea. The phosphate and ammonia are forwarded to the AB Lifosa production facilities (by the EuroChem Group) to produce various phosphate-based fertilisers. Their products of diammonium phosphate (DAP), mono-ammonium phosphate (MAP) and urea phosphate (UP) are exported via the Klaipeda Seaport, in reverse. All seaport exports are traded in dry bulk form. (Other AB Lifosa products are distributed on land.)

**Figure 15: View of the Bega terminal in Klaipeda (Source: http://www.bega.lt/en/terminal/bulk-cargo/dry-bulk-fertilisers-terminal/)**

## 4.5 Ports in Latvia

Fertiliser volumes in Latvian ports related to this study are presented in the following table.

**Table 3: Volumes at Latvian ports in tonnes**

| Ports | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export | Import | Export |
| Riga | | 1,299,500 | | 1,388,300 | | 1,554,600 | | 2,067,600 |
| Liepaja | | 460,000 | | 1,197,300 | | 1,467,900 | | 1,053,800 |
| Ventspils | | 347,000 | | 195,100 | | 386,500 | | 476,400 |

### 4.5.1 Riga

The Freeport of Riga lies on both banks of the River Daugava about 15 kilometres inland from the Gulf of Riga. The Latvian capital city is at about 80 nautical miles west-southwest of the Port of Parnu in Estonia and at about 235 kilometres northeast of Lithuania's Klaipėda State Seaport. The port is strategically connected to the Trans-European Transport road and rail Network (TEN-T) providing an efficient use of different modes of freight transport.

The Freeport of Riga is a multifunctional port, handling all types of cargo from various regions. In 2016, total cargo handled was 37.1 million tonnes. Of these, 7.6%, or 2.8 million tonnes, represents fertilisers handled. In 2017, the share of the total volume of cargo handled at the Freeport of Riga decreased by 9.2% compared to the previous year, including a decrease in the volume of fertiliser transshipment by 14.9% to 2.4 million tonnes.

There are two main terminals in Riga which handle fertilisers. Firstly, there is the Riga Fertiliser Terminal LLC (RFT). It is a joint venture founded by Riga Commercial Port LLC (RTO) and Uralchem Freight Limited, a subsidiary of OJSC Uralchem. The RFT is a modern terminal, with a completely closed cargo handling solution launched at the end of 2013. Dusting could happen during ship loading, but it is minimised with a telescopic cascade chute. This terminal is a good example of the best available design of a modern fertiliser export terminal (https://www.rft.lv/en/). The RFT is an advanced terminal for the transshipment and temporary storage of bulk fertilisers such as ammonium nitrate and ammonia. Other loading methods include using big bags directly in shipment or loading directly from specialised container systems, such as those developed by Ultramar.

In addition to the RFT, the Alpha Osta Terminal mainly operates with mineral fertilisers (dry bulk nitric phosphate). Currently, the terminal includes five berths with a total length of 565 metres. A depth of 13.5 metres allows the mooring of large-capacity vessels.

**Figure 16: Riga Fertiliser Terminal, Riga (http://www.lnk-industries.lv/en/project/2)**

### 4.5.2 Liepaja

The area of the Port of Liepaja is concurrently the territory of the Liepaja Special Economic Zone (SEZ). In 2019, bulk cargo in Liepaja SEZ accounted for 76% of the total cargo turnover. Bulk cargo in 2019 amounted to 5.57 million tonnes. The main commodity groups in this segment are mineral fertilisers, cereal and its products, other chemical bulk cargo, wood chips and construction materials, e.g. cement. Liepaja is the only Latvian port maintaining negative dynamics of fertiliser transshipment volumes (Table 3).

Fertiliser stevedoring companies include:

- GIROLAT terminal,
- LSEZ Ltd. 'DUNA' – big bag handling.

Girolat forwards ammonium sulphate, urea and NPK (nitrogen, phosphorus and potassium). They offer logistic distribution in flexi-bags (single-/multi-layer) or in ISO containers. They further offer drum packaging and loading. The conveying installation is covered.

DUNA has two berths at Liepaja, a quay length of 290 metres and six closed warehouses for dry cargo. The warehouses have capacities of 4,320 m² (1), 2,461 m² (1) and 490 m² (4). There are portal cranes with different payloads between 12 and 16 tonnes.

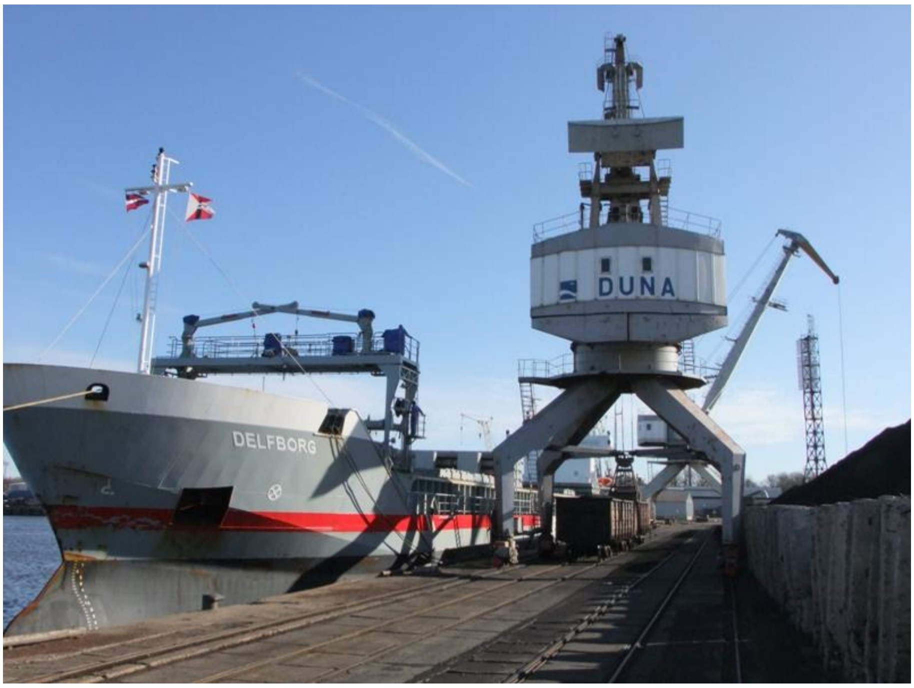


**Figure 17: The Duna terminal in Liepaja (Source: https://liepaja-sez.lv/en/lsez/lsez-kapitalsabiedribas/10-duna)**

NPK Expert produces fertilisers which are primarily shipped via Liepaja. Their fertilisers include different N+P+K variations, urea N, ammophos, potassium chloride (KCl), ammonium nitrate, ammonium sulphate, DAP and potassium sulphate, fertiliser briquettes (packaged) and smart fertiliser grades (packaged). Their majority are handled packaged.

**Figure 18: View of big bag handling in Liepaja (Source: https://irliepaja.lv/bizness/veiksminieks-npk-expert-aiziet-pa-skuju-taku/)**

Figure 19: View of the Liepaja Special Economic Zone, Liepaja (http://www.nfr.ru/)

Figure 20: The Ekers Stividors LP Terminal, Liepaja (https://liepaja-sez.lv/en)

### 4.5.3 Ventspils

Ventspils is located in northwestern Latvia, situated by the Venta River and the Baltic Sea. The Freeport of Ventspils is an all year ice-free deep-water port with various transport connections and logistics opportunities. It is one of the leading deep-water ports in the European Union on the East coast of the Baltic Sea. A depth of 17.5 metres allows the mooring of large-capacity ships. A total of 1,500 metres of berth length can accommodate five vessels simultaneously.

JSC 'Kālija Parks' is one of the largest dry bulk cargo terminals in Europe which handle mineral fertilisers. Two deep-water berths with a depth of 14.5 metres allow handling of two PANAMAX-type vessels with a deadweight of 75,000 tonnes simultaneously. Berth No 4 has a length of 295 metres and a depth of 14.5 metres. There are two shiploaders with a capacity of 1.500 tonnes/hour each. Furthermore, Berth No 4a has a length of 356 metres with a depth of 15.5 metres. There is one shiploader with a capacity of 3,000 tonnes/hour. The total loading rate of vessels is up to 6,000 tonnes/hour and 40,000 tonnes/day. The terminal is specialised in the transshipment of mineral fertilisers, such as potassium (K), with handling capacities of 7.5 million tonnes/year.

The total capacity of storage premises is 140,000 tonnes. There is an arc-type warehouse with two sections, which allow up to 100,000 tonnes of fertiliser to be stored. The product is unloaded by two cranes with a capacity of 1,000 tonnes/hour each. Additionally, there are four dome-type warehouses with a capacity of 10,000 tonnes each. The product is unloaded with mechanical vehicles via reception bunkers in the floor. These warehouses allow the simultaneous storage of six types of fertiliser.

**Figure 21: View of the Freeport of Ventspils, Ventspils (Miks Mihails Ignats / Shutterstock)**

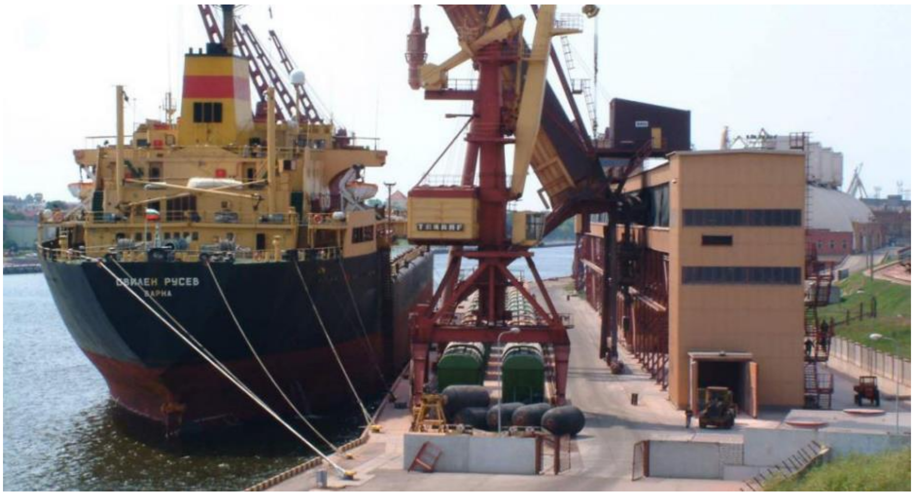

**Figure 22: Kālija Parks Terminal, Ventspils (http://www.portofventspils.lv/en/port-services/terminals/kalija-parks/)**

URALCHEM's Ventamonjaks is the largest liquid ammonia transshipment terminal on the Baltic Sea with a capacity of 1.5 million tonnes/year. Three deep-water berths accept ships carrying up to 60,000 tonnes. The terminal's nonstop operation enables 250 tank cars to be handled daily.

## 4.6 Ports in Germany

Fertiliser volumes in German ports related to this study are presented in the following table.

**Table 4: Volumes in Rostock and Lübeck, tonnes (2016-2019)**

| Ports | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export | Import | Export |
| Rostock | 745,385 | 903,545 | 682,385 | 845,337 | 604,878 | 812,880 | 661,664 | 916,120 |
| Lübeck | 359,488 | 5,454 | 330,411 | 42,146 | 231,754 | 15,574 | 225,195 | 5,591 |

(https://www-genesis.destatis.de/)

### 4.6.1 Rostock

**Figure 23: Rostock Port, Berths Nos 12 and 21 (left), and the Rostock Cargo and Fishery Port (right) (Images: https://www.rostock-port.de/, https://www.rfh.de/)**

Rostock has gained international importance as a universal centre of transshipment in Northern Germany. The port has a quay length of 11 km and includes 47 berths, about 1 km² of general storage area and 175,000 m² of sheltered storage. With a seabed depth of 14.5 m, the port handled 25.7 million tonnes of throughput in 2019. The port plans to deepen its fairway to 16.5 m in the foreseeable future.

Total fertiliser throughput in 2019 increased up to 1,577,784 tonnes from 1,417,758 tonnes (2018). Fertiliser at the Rostock Port is handled at four different locations and by three different companies: Rostock Port, the Rostock Cargo and Fishery Port and Yara itself. As recent figures indicate, 680,000 tonnes of dry fertiliser throughput was handled by the Rostock Port (stevedoring company) at Pier III (Berths Nos 12 and 21) and 300,000 tonnes dry fertiliser by the Rostock Cargo and Fishery Port. In addition, liquid fertilisers account for about 597,800 tonnes.

(The county's agricultural sector is also supplied by the Lübeck port. Therefore, the volumes handled at Rostock differ from the region's agricultural demand for fertilisers.)
In Rostock, Yara itself handles exclusively liquid fertilisers like ammonia and AHL (ammonium nitrate urea solution), but also produces granular fertilisers at their Rostock production facility. Their dry fertilisers are not shipped from their own quays, but through the Rostock Port and the Rostock Cargo and Fishery Port. Therefore, those volumes (about 400,000 tonnes) are taken into account in the figures of dry volumes of the other two. *Note: The Rostock Cargo and Fishery Port additionally handles Yara fertiliser products from another Yara production facility, separated from Yara Rostock. This means that Yara's throughput might be higher than Yara's production figures indicated for their Rostock production facility. (Since Yara itself only exports liquid fertilisers, which are forwarded to the quay by pipes, there is no indication for potential leakage.)*

The Rostock Port handles mostly nitrate fertilisers, like calcium ammonium nitrate. The company runs a ship loader purpose-built for fertilisers (with a capacity of 1,000 tonnes/hour) and a wagon unloading station. There are two storage sheds, including covered storage with a capacity of 60,000 tonnes. The sheds are connected to the quay by a 700 m conveyor belt system. The forwarding system here is a covered and fixed installation. The fertiliser types handled at the Rostock Port are calcium ammonium nitrate (CAS), axan, sulphates (of 24% nitrate), potash, diammonium phosphate (DAP) and sewage sludge ash (SSA). Besides DAP, phosphate makes up 4% to 9% in SSA. Dolomite, a lime fertiliser, is imported to serve the Yara production plant, too.

The Rostock Cargo and Fishery Port (RFH) handles axan fertiliser, urea nitrate and other fertilisers. The cargo port runs handling operations with conveyor belts and riddles. The belts and the riddles are predominantly covered, but connection points between two forwarding belts mostly lack complete coverage (Figure 6). The company has recently introduced a new 3,000 m² fertiliser storage hall. Fertiliser handling at the RFH is performed by external companies, operating lorries and cargo trains, partly also handling and maintaining handling equipment (e.g. mixing machinery). The RFH port handles no phosphorus compounds, but nitrate fertiliser and urea nitrogen.

In some cases, cargo is unloaded from trains directly to the ship as shown in the figures below. Here, fertiliser cargo is loaded onto the ship, while the fertiliser travels on a partly covered conveyer belt upwards, until it falls down into the ship's hold through a nozzle at the belt's end.

**Figure 24: Conveyor belt system between a wagon and a fertiliser loading ship [Ramboll, GER]**


**Figure 25: A wagon's chute [Ramboll, GER]**

**Figure 26: Strainer between parts of a two-belt system [Ramboll, GER]**

**Figure 27: End of the second belt forwarding fertiliser onto the ship [Ramboll, GER]**

### 4.6.2 Lübeck

**Figure 28: Lehmannkai 3 (left), Vorwerkhafen (Lagerhaus Lübeck, m.), ATR Landhandel quay (right). (Images: https://www.hans-lehmann.de; http://www.lagerhaus-luebeck.de; https://www.lhg.com)**

The Lübeck Port is located in the southwestern part of the Baltic Sea, representing also a transshipment hub in the region. The ports operate a dense network, including fertiliser handling. The location consists of many ports and operating companies. Fertilisers are handled by four companies: Hans Lehmann KG, Umschlag & Handels GmbH Lübeck (Lagerhaus Lübeck), ATR Landhandel GmbH & Co. KG and Burmann Hafenlogistik GmbH. All four companies together handled a total fertiliser throughput of 230,786 tonnes in 2019 (Genesis database, German National Statistics).

The Lehmann company handles fertilisers at their Lehmannkai 3 facility. This 550 m long quay offers a seabed depth of 7.5 m and a storage area of 90,000 m². The berths are equipped with a 16-tonne and a 8-tonne grabbing crane. There is additional equipment for bulk cargo handling, like covered sheds and floor conveyors. The loading and unloading process is uncovered. High dust release may occur.

The Lagerhaus Lübeck company also has a fertiliser throughput and is established at the LMG port. The company runs two quays with a length of 110 m and 120 m. Water depth is reported to be 8 m, and thus ships carrying up to 10,000 tonnes of cargo can be loaded and dispatched. Handling is supported by a hydraulic shovel, which can be equipped with a cup picker arm, a grapple and a magnet system. The company uses a fixed covered conveyor installation to forward fertilisers and covered sheds to store bulk fertilisers. Additionally, the company handles liquid fertilisers (30,000 tonnes of storage capacity, 150,000 tonnes of reloading capacity).

**Figure 29: Cargo handling in Lübeck (http://www.lagerhaus-luebeck.de)**

**Figure 30: Cargo handling in Lübeck (http://www.lagerhaus-luebeck.de)**

The ATR Landhandel is established at the Lübecker Vorwerker Hafen. They possess their own blending and mixing equipment and their own straining equipment for dry bulk fertilisers. The company produces as well as stevedores its own cargo at the Lübeck Port. Fertilisers are loaded and unloaded by a fixed installation right next to the quay. The whole process is covered by a shed, from which the only seaside connection is a downpipe. Inside the facility, the fertilisers are forwarded by cup elevators. The fertilisers are stored in silo cells. The company runs about 60 different storage facilities at undetermined locations.

Burmann Hafenlogistik, as the fourth largest fertiliser operator at the Lübeck Port, handles dry fertilisers at the Lübeck Schlutupkai 1. The quay measures 185 m in total length and guaranteed berth depth is 5 m, with an optional depth of 7.5 m. Handling is facilitated by two mobile shovel tugmasters, translifters, forklifts and reach stackers. Next to the quay stands a covered shed. The conveyors used for forwarding fertiliser are completely covered. Nozzles with downpipes hinder fertiliser dust to escape into the environment. Burmann handles mostly urea.

Figure 31: Cargo handling in Lübeck (http://www.burmann-hafenlogistik.de/)

The exact shares within the total volume for each company cannot be determined, but the highest proportion is handled by Lagerhaus Lübeck. Mostly nitrate fertilisers are handled, thus nitrate approximately accounts for about 60% to 70% of the total fertiliser throughput volume at the Lübeck Port. Burmann Hafenlogistik and Hans Lehmann KG also handle packaged fertilisers (big bags), but only to a small extent. No information regarding potassium and phosphorus composition could be accessed.

## 4.7 Ports in Russia

Fertiliser volumes in Russian ports related to this study are presented in the following table.

Table 5: Volumes in Russian ports

| Ports | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export | Import | Export |
| St. Petersburg | | | 232 | 9,656,030 | 214 | 8,812,190 | 597 | 8,910,450 |
| Vyborg | | | 0 | 474,280 | 0 | 545,450 | 0 | 409,510 |
| Ust-Luga | | | 1,598 | 3,277,930 | 563 | 3,684,910 | 921 | 4,122,660 |
| Kaliningrad | | | N/A | N/A | N/A | N/A | N/A | N/A |

Kaliningrad provided no valid information.

### 4.7.1 St. Petersburg

JSC 'Baltic Bulk Terminal' (BBT) is a universal transshipment complex for mineral fertilisers of various grades transported by railcars to seagoing vessels with possible short-term storage in a warehouse. BBT is the only Russian potash transshipment terminal owned by Uralkali. The maximum annual transshipment capacity of BBT is 7.4 million tonnes. Uralkali's planned production capacity growth will be supported by backup transshipment facilities available at BBT. The terminal has a closed handling system with cascade-type ship loaders. (https://www.uralkali.com/).

**Figure 32: Warehouse for the storage of mineral fertilisers at BBT, JSC (https://morproekt.ru/engprojects/935-baltic-bulk-terminal-port-of-st-petersburg-baltic-sea-basin)**

AO Sea Port of Saint Petersburg (part of UCL Port, a stevedoring division of the International Transportation Group UCL Holding) is the largest stevedoring services provider handling all types of dry cargo at Big Port St. Petersburg. The company continues to increase the handling of big bags with mineral fertilisers, such as ammonium nitrate, urea, potassium sulphate, potassium chloride, ammophos, MCP, ANP fertiliser — their volume has surged to over 0.5 million tonnes in 2019 (Figure 30)[2].

**Figure 33: Handling of big bags at the AO Sea Port of Saint Petersburg (http://www.seaport.spb.ru/press/photo/2/)**

[2] https://cargo-report.info/stat/ports-baltic/

The volume of bulk transshipment of mineral fertilisers is almost half less – 0.24 million tonnes. To handle containers with fertilisers, the Sea Port operates two LIEBHERR mobile cranes with spreaders, five reach stackers, terminal tractors and other relevant equipment (Figure 31 and Figure 32).

**Figure 34: Handling of containers at the AO Sea Port of Saint Petersburg (http://www.seaport.spb.ru/press/photo/5/?photos.offset=6)**


**Figure 35: Handling of containers at the AO Sea Port of Saint Petersburg (https://mka.spb.ru/press-center/news/gruzooborot-morskogo-porta-sankt-peterburg-vyros-na-3)**

Ultramar is one of the biggest fertiliser forwarding companies, operating from the terminals of Saint Petersburg and Ust-Luga (cf. Section 4.7.3). The company forwards the fertilisers in containers, generating nearly no cargo loss through handling.

**Figure 36: Container/big bags filling and forwarding installation of Ultramar in Saint Petersburg (https://www.ultramar.ru/en)**

Ultramar and PhosAgro are Russia's largest carriers of containerised fertilisers. While Ultramar just provides the forwarding service, Phosagro exports their own fertiliser via St. Petersburg and the Baltic Ports. PhosAgro is the largest phosphate-based fertiliser producer in Europe (combining all DAP/MAP/NP/NPK/NPS volumes). They further trade in feed phosphates, ammonia and sodium tripolyphosphate. The cargo is traded packed or containerised, reducing any chances of spillage.

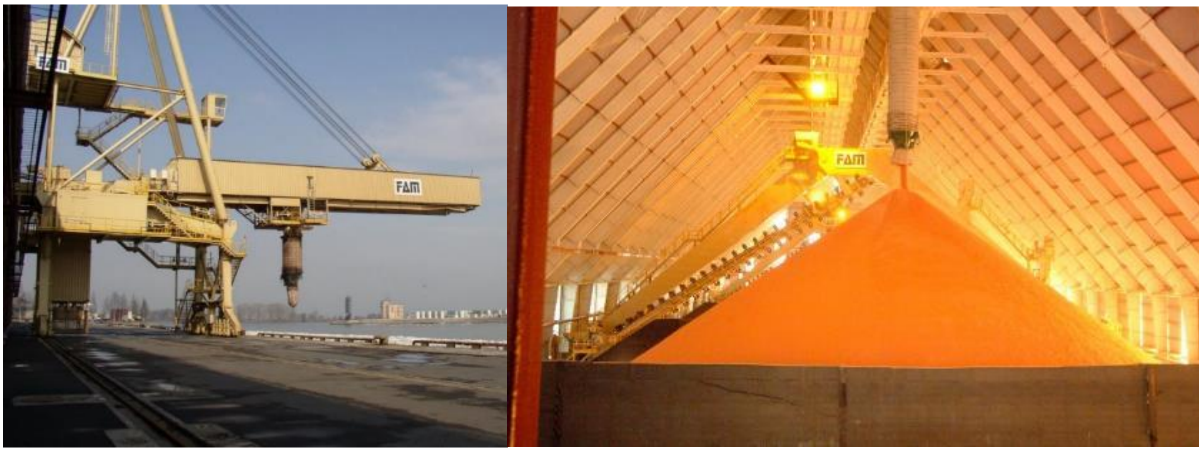


**Figure 37: Baltic Bulk Terminal (http://www.lnkcom.ru/gallerys/gallery_2/p1/, http://www.bbtspb.ru/)**

### 4.7.2 Vyborg

The Port of Vyborg is situated in the Gulf of Vyborg, approximately 40 km from the Finnish border. It has extensive connection via rail, road, sea and river to the transport network. The port is accessible all year round with icebreaker assistance. The seaport of Vyborg is operated by Port

Logistic Ltd. The company provides for the transshipment of various types of general cargo, dry and liquid bulk (mineral fertilisers, pellets, coal, ore, timber, scrap metal and aluminium hydroxide) and chemical liquid bulk.

Port Logistic Ltd. exports NPK, urea and ANP fertilisers in bulk and big bags (Figure 31). The big bag transport method is closed, and there is neither discharge nor hold cleaning waters. Approximately 40,000 tonnes of fertilisers are exported in big bags annually. Bulk cargo is, with a share of 93% of the total cargo turnover, the primarily type of cargo handled in Vyborg. Mineral bulk fertilisers represent 25% of the total turnover, meaning approximately 400,000 to 500,000 tonnes of fertiliser/year.

The port has a variety of equipment used for handling the cargo. There are nine portal cranes with lifting capacities of up to 20 tonnes. Additionally, there is a mobile crane with a lifting capacity of up to 104 tonnes. Furthermore, several lifting trucks, tractors and roll-trailers are available for the handling process.

The Port of Vyborg has stated a commitment to environmental issues according to their website. It mentions that '*To prevent the contamination of the water area, the port uses effluent treatment facilities for storm water with a capacity of 300 m³/ day. These facilities ensure that the maximum concentration levels of harmful substances are not exceeded.'*
(http://www.portlog.ru/en/environment/).

**Figure 38: Port Logistic, Vyborg (http://www.portlog.ru/en/cargo-transshipment/)**

Figure 39: Loading of big bags at Port Logistic, Vyborg (http://www.portlog.ru/en/cargo-transshipment/)

### 4.7.3 Ust-Luga

The Port of Ust-Luga is situated on the southern coast of the Gulf of Finland, approximately 100 km west of St. Petersburg. Ust-Luga is a major bulk port on the Baltic Sea, mainly ice-free all year round. It exports oil, coal and fertilisers. There are three main terminals that are focused on handling bulk cargo: the Ultramar Terminal, the European Sulphur Terminal and the planned EuroChem Fertiliser Terminal.

As mentioned above, Ultramar is one of the biggest fertiliser-forwarding companies, operating terminals in St. Petersburg and in Ust-Luga. Ultramar handles mainly mineral fertilisers in addition to other bulk cargo via the 'Smart Bulk Terminal' (SBT) located at Multipurpose Terminal YUG-2. The terminal was founded in cooperation with the largest Russian fertiliser producer PhosAgro, with the key objective of transshipping bulk fertilisers in the port of Ust-Luga.
Primarily muriate, nitro-phosphates, phosphates and other types of fertiliser are handled at the terminal. On 1 January 2015, a high-capacity wagon-unloading station was put into operation, and the cargo turnover of the first stage of the terminal amounts to 1.5 million tonnes/year. Furthermore, the planned cargo turnover of the second stage is up to 3 million tonnes/year. The terminal's main business is the specialised handling of mineral bulk fertilisers in unique bulk containers. After unloading the fertiliser from hopper wagons, it is loaded into the previously mentioned special bulk containers directly. These containers are utilised as a means for loading the vessels and elements of a mobile warehouse at the same time. Additionally, the specialised units allow the accumulation of various cargo lots without the restrictions of different warehouse sections. Due to the unique storage option, there is an unlimited storage capacity for different fertiliser brands compared to conventional warehouse complexes. Moreover, the unified design ensures a high ship loading rate.

Using bulk containers, as Ultramar does, will allow shipping on container vessels and thus cargo hold cleaning is not necessary. Dust issues are practically avoided at the port.

The European Sulphur Terminal is also located at the Port of Ust-Luga. The terminal features high-technology equipment for handling fertilisers, granulated and crushed sulphur. The terminal has two berths with a total frontage of 500 metres and a depth of 16 metres. They have a transshipment capacity of 4.5 million tonnes/year, but are only using 15% of the declared capacity.

There is a wagon unloading station equipped with a wagon tippler. Furthermore, a system of conveyors and transfer towers assures the transport of the products from the unloading station to the warehouse and the ship loader. Thus, there is an automated ship loader with a capacity of 2,000 tonnes/hour.

EuroChem is a major nitrogen and phosphate fertiliser company. The company plans to build a bulk terminal for the shipment of mineral fertilisers at the Port of Ust-Luga. The terminal is mainly intended for the transshipment of exported fertilisers from railway transport to sea vessels and vice versa for their import in special purpose containers. Furthermore, the terminal’s capacity is forecast to be 6,025 million tonnes/year. The transshipment cargo type is forecast to be nitro-phosphorus and potash fertilisers as well as phosphates.
The development of the terminal is planned in three stages. Within these stages, two berths are planned to be built. The share of fertilisers handled in containers will decrease from Stage 1 to 3, while the transshipment of bulk fertilisers will increase over the stages.


**Figure 40: Smart Bulk Terminal, Ust-Luga (https://www.ultramar.ru/smart-bulk-terminal)**

### 4.7.4 Kaliningrad

The Port of Kaliningrad did not provide cargo handling volumes. The most recent data of 2018 indicates that only 9,200 tonnes of mineral fertilisers were handled at the Port of Kaliningrad, which is less than 0.1% of the total fertiliser export from the Russian Baltic ports.
Based at the Kaliningrad Sea Fishing Port, the two-terminal Andrex complex with a capacity of 0.9 million tonnes/year is owned by Acron, one of the leading Russian NPK producers. According to Acron’s reporting documentation, no fertiliser was transshipped in 2019.

Figure 41: View of the Kaliningrad Sea Fishing Port, Kaliningrad (http://www.nfr.ru/)

## 4.8 Conclusions

Part 4 covers 15 ports selected for this assessment. It was found that these ports had many different handling methods in use. Choosing a handling method is a complex issue. Selection relates to market practices for the product, sales lot size, end user practices and supply chain (e.g. the capabilities of a receiving port).

Many of the ports did not provide detailed information on their operations and statistics. Therefore, there is limited information available for detailed conclusions for each port. It is obvious that the ports handling liquid fertiliser or fertilisers in containers are unlikely to make any discharge into the environment during their operations. Bulk handling is typically the most economic method of transport if that is possible (market, user, reception port, etc.). A properly constructed bulk handling conveyor system is quite well protected against dusting. Most of the dusting occurs at crossing points e.g. supplying the conveyor, crossing between two conveyors and loading to ship.

Grab handling is used at some ports and is often considered to emit more dust. However, dusting can be reduced by using a properly closed grab and by training operators (e.g. feasible fill rate of the grab, proper closing and opening height). A hopper should also have dust management features (passive or active). It seems that closed systems are currently more often used for loading than for unloading in the Baltic Sea region. Therefore, there is a risk that unloading is more prone to dust.

# 5. BEST AVAILABLE TECHNOLOGY

## 5.1 Challenges in handling fertilisers

Handling fertilisers, at least dry bulk fertilisers, causes some leakage under current practice, depending on the handling method. Therefore, fertiliser discharge into the environment should be avoided as much as possible by using the latest technology and work practices.

The Best Available Technology (BAT) is introduced in the following chapters. These chapters focus on minimising spillage and dust. There are several methods to reduce spillage by using appropriate handling methods. Typically, dust issues at bulk ports are mitigated by water mist or spray. Some chemicals can be used for creating a protective coating on a bulk stack. However, fertilisers and related raw materials should be protected from moisture and this method cannot be used.

There are several complicated issues when comparing handling methods, their combinations, related costs and benefits. Firstly, the method should meet market demand and commercial requirements. As an example, containers or bags cannot be used if a customer is not able to use containers or bags. Secondly, there are several port-related issues to consider. Some examples are listed below:

- investment costs (crane-based systems might be cheaper than conveyor systems, presuming that a conveyor is not used with a crane);
- operating costs (electrically operated conveyor systems are typically cheaper to operate);
- operational set-up (the storage facility is not next to the quay);
- utilisation rate of the equipment (a more versatile crane (grab operation) can be used for other cargo handling at the port, while a conveyor-based ship loading system can be used just for the dedicated bulk operations;
- flexibility (in addition to the utilisation rate, mobile equipment can be sold or replaced easily);
- reliability and redundancy (there are cases that ship loaders require more service than a simpler crane configuration; a crane can be replaced in case of malfunction, but a ship loader system has to be repaired on location);
- values (it is unknown how much terminal operators consider the environmental aspects of investments).

These issues should be considered in conjunction with the following method descriptions.

## 5.2 Rail unloaders

Rail unloaders should be closed systems. In some cases, fertilisers are unloaded by using simple pit and front loaders for transport to a storage building. This method is not preferred as dust cannot be controlled. It is not known if any pits are operational in the Baltic Sea region. Closed unloader systems are preferred for dust and moisture control. The unloading system should have dust filtering and/or other mechanical systems to avoid dust (see Figure 46).

## 5.3 Conveyors

A belt conveyor is a conventional bulk transport method. A belt conveyor can be installed covered or uncovered. The cover is intended to avoid dusting, but also to protect the cargo from moisture and contamination, which has commercial benefits. The main issues arise typically at hoppers supplying the belt, at connection points between two belts and at the point of loading into a vessel.

There are several different kinds of conveyors in the market in addition to the conventional belt conveyor. Some of the potential conveyors for fertiliser transport are explained in the following chapters.

A **double belt** provides protection for the cargo and reduces the possibility of dusting and cargo spillage (Figure 42). The main reason for using it is the possibility of higher conveyor angles and different shapes.
https://www.ckit.co.za/secure/conveyor/sandwich/sandwich_basics_funcdescript.htm

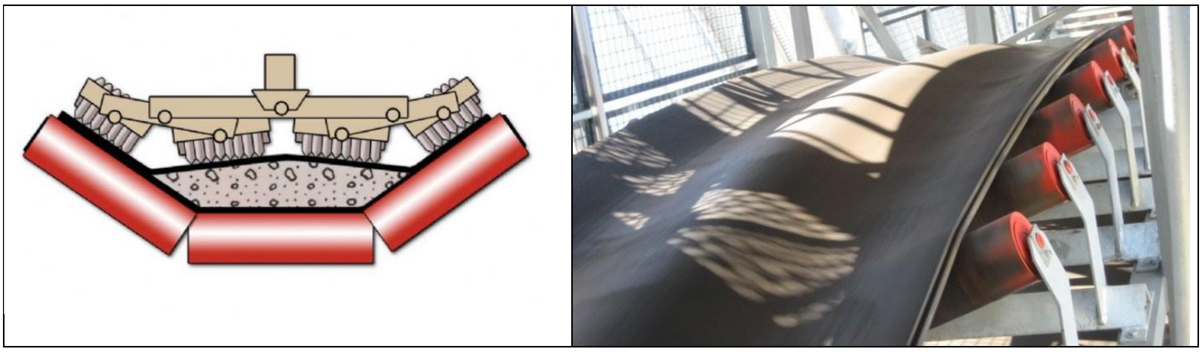

**Figure 42: Examples of double belt conveyors**

A **pipe conveyor** forms a closed structure, which allows very flexible alignment for the conveyor. It also provides good protection for the cargo (Figure 43 and Figure 44).

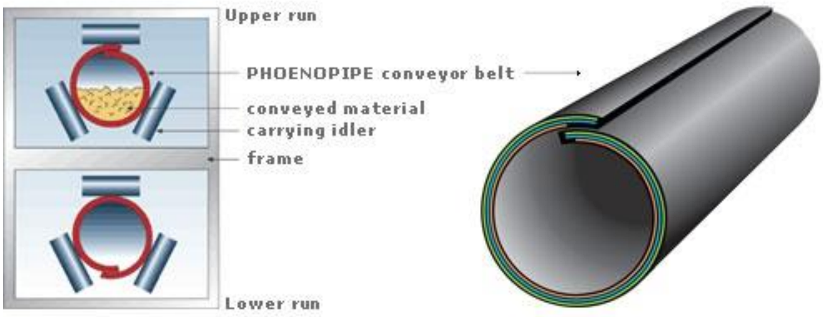


**Figure 43: Example of a pipe conveyor (https://www.phoenix-conveyorbelts.com/)**

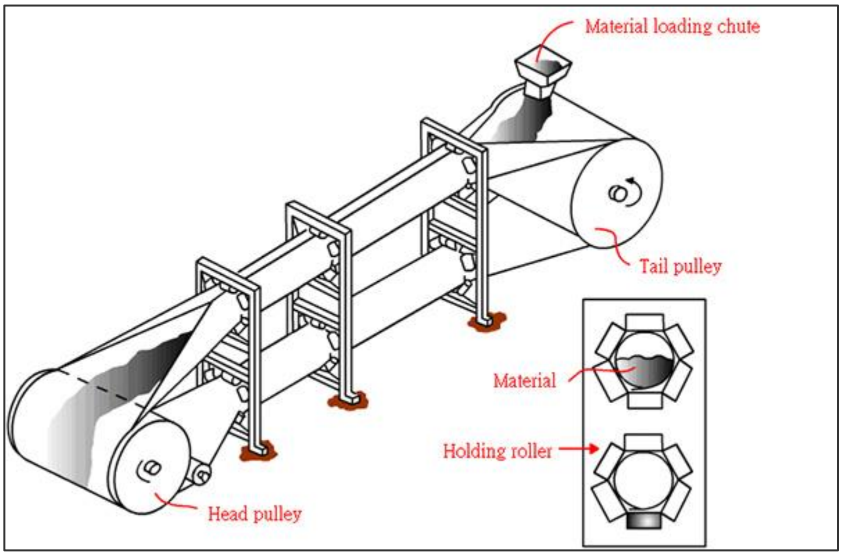


**Figure 44: Working principle of a pipe conveyor (https://www.pgl.com.tw/en/2-2251-52023/product/Pipe-Conveyor-Belt-Manufacturers-id300244.html)**

### 5.4 Storage facilities

Storage facilities should be closed and protected from rain because the goods are water-soluble. Different kinds of buildings are used. According to interviews, domes (Figure 16) can be considered the best available technology, because they are specially designed for dry bulk materials, are closed and form a single stack inside the dome. The downside is higher costs. The same efficiency can be reached with other storage types as well. PVC-covered conventional buildings are also in use and generally acceptable, but there could be some issues in transporting cargo outside the building.

### 5.5 Ship cargo handling systems

The conventional method is to use grab cranes. A better option is to use closed grabs instead of open-top ones. In the event of mechanised loading by a ship loader, the best solution is to use a closed system, i.e. a cascade-type telescoping loader (Figure 51 and Figure 52) for export cargo instead of rotating chutes (Figure 50). Typically, ship loaders are used for loading and cranes for unloading, but cranes can be used for loading as well. Ramboll does not have statistical data, but screw or pneumatic unloaders are rare in the Baltic Sea region.

#### 5.5.1 Clamshell grabs

Grabs are used to load or unload cargo to or from a ship, but mostly for unloading, and therefore they make it prone to dusting. A grab can be attached to a conventional wire rope crane or a hydraulic material handler (excavator type). There are different types of clamshell grabs available. A conventional grab is operated by ropes (or hydraulics or electricity) and has an open top, which allows spillage and dusting. Closed clamshell grabs are available and ensure less dusting due to wind (Figure 45). There are also solutions to close the clamshell more efficiently by edge design. Hydraulic closing and opening of the clamshell would give more precise control when compared with wire rope operation.

Tarpaulins can be used between the berth and the ship to avoid spillage to the sea. However, this might not be even needed if proper grabs and operational practices are followed.

**Figure 45: Example of a conventional open-top grab (left) and a closed grab (right)**

Operational practices have a major role in minimising dusting when using grabs. Training is needed for optimising grab load, proper closing and movement between the ship and the quay as well as opening height to the hopper or ship's hold. Opening the grab too high results in dusting. There is also special integrated software for automation and lift optimisation.

### 5.5.2 Unloading hoppers

The simplest way is to use air curtains locally for minimising wind impact on, e.g. a hopper. Massive wind fences are used at some bulk ports to minimise the impact of high winds. There are special hoppers designed specifically to avoid dusting (Figure 46). The crane operator should be trained because operating practices have a major impact as well (especially the opening height and the correct level of filling the hopper when opening the grab). Filling the hopper excessively will reduce the functionality of dust filtering and other mechanical solutions as well as productivity in some cases because the supply to the conveyor is interrupted.

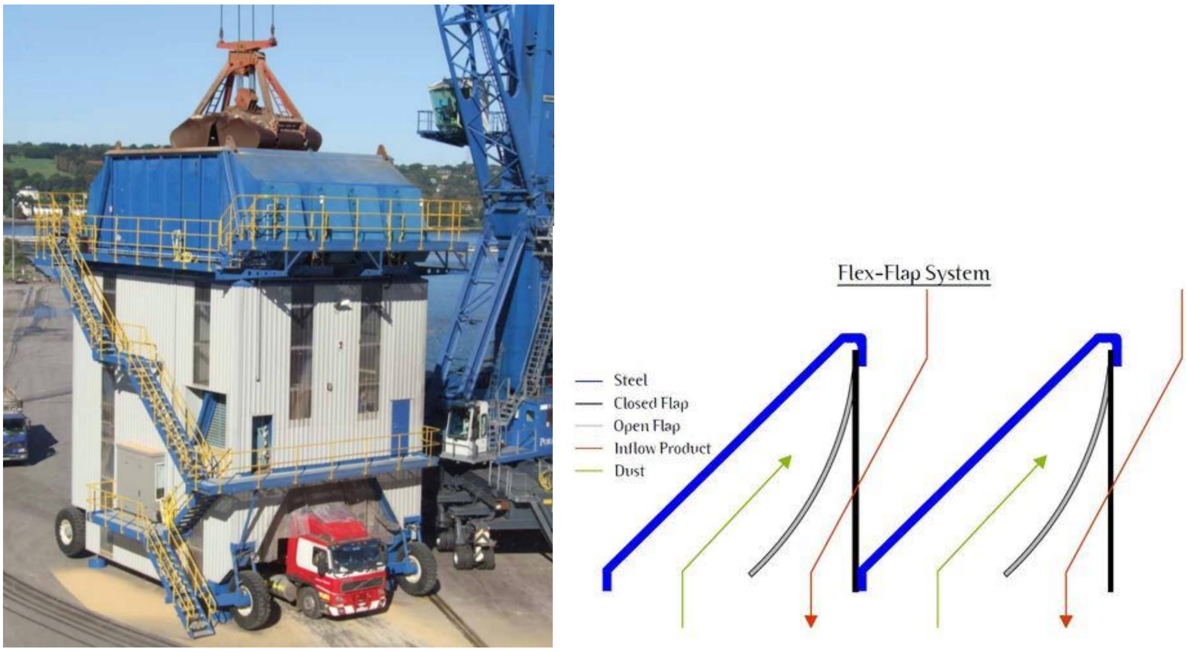


**Figure 46: Example of a hopper with a special dust management system (http://www.docksolid.com/)**

### 5.5.3 Unloaders

Ship unloaders are used for unloading in addition to cranes. Screw unloaders (Figure 47) and pneumatic unloaders (Figure 48) are typical technologies. Both systems can be designed to be completely closed for protecting the natural environment and the product. The choice between the two depends on product specification, productivity requirements, etc. Screw unloaders can provide higher productivity (3,000 tonnes/h) compared to pneumatic (<1,000 tonnes/h).

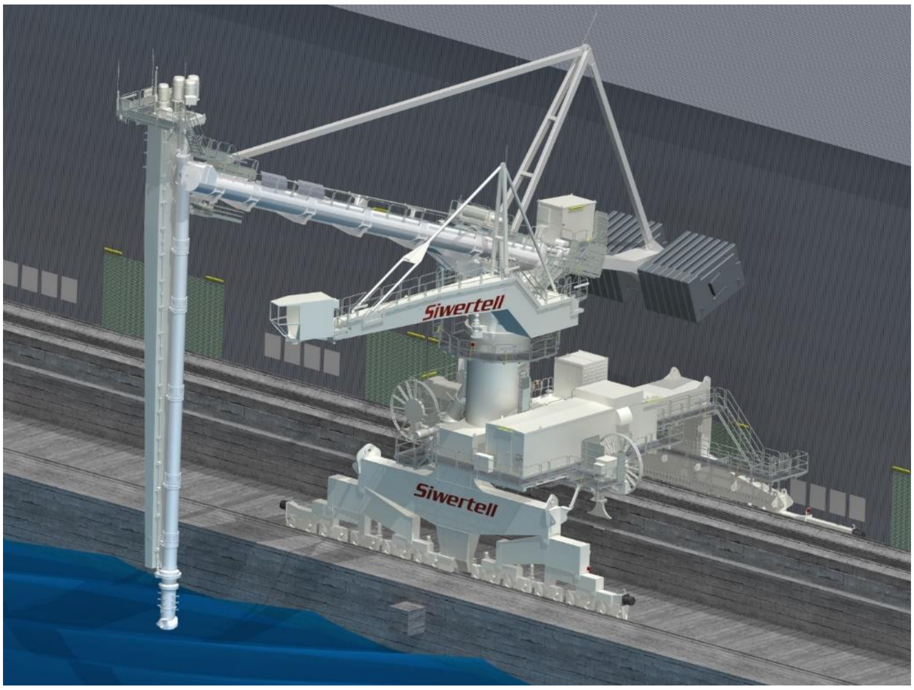


**Figure 47: Example of a screw unloader (https://bruks-siwertell.com/products/ship-unloaders)**


Figure 48: Example of a pneumatic unloader (http://www.vigan.com)

### 5.5.4 Closed ship loaders

It is likely that a new terminal will be equipped with a modern ship loading system (Figure 49). This system is highly automated and closed to avoid spillage to the natural environment and to protect the cargo from moisture and contamination. Such a system can be mounted on rail or a lighter mobile system. Typically, mobile equipment is not as efficient as a rail-based system for preventing spillage and dusting.


Figure 49: A modern ship loader in Klaipeda (https://www.bruks-siwertell.com/cases/ship-loader-lithuania)

### 5.5.5 Chutes

Rotating trimming chutes are often used with ship loaders because of their ability to fill hold spaces efficiently, adapting to the shape of the hold (Figure 50). These trimming chutes are either fixed in height or adjustable (telescopic; Figure 51 and Figure 52). Dust formation is a downside of this system (especially if it is not telescopic), but it is mostly better than conventional grab handling.


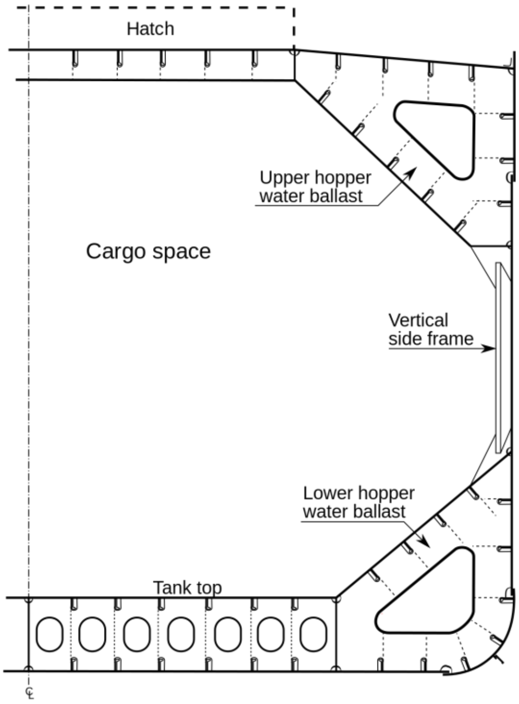


**Figure 50: Rotating trimmer spout (left; http://clevelandcascades.co.uk) and structure of a large bulk carrier (right; © Rémi Kaupp, CC-BY-SA-2.5, Wikimedia Commons)**

Cascade chutes are more advanced as the cargo flows down with lower velocity through a series of buckets (Figure 51). Buckets are covered by a sleeve and the system is telescopic.

**Figure 51: Principle of cascade chutes (http://clevelandcascades.co.uk)**

**Figure 52: Example of a ship loader with a cascade chute. Note the smooth box-shaped hold. (http://clevelandcascades.co.uk)**

### 5.5.6 Feeder hole loading

Some ships have feeder hole openings on their cargo holds' hatch covers (Figure 53). These are often called 'cement holes' because they are often used for cement handling. Feeder hole openings allow dust-free loading and cargo handling by keeping hatches closed during the process. The method has been tested at the Yara factory in Uusikaupunki. The main reason is to enable loading when it is raining and therefore to increase productivity. Naturally, this method should reduce dusting, but the tested equipment was not suited for the purpose.

Ramboll does not have information on how much this method is used in fertiliser transport and how many ships actually have these feeder holes installed. It might be possible to install them later. Ramboll's understanding is that this method is not widely used for fertiliser transport.

**Figure 53: Example of using feeder holes on the hatch cover (https://www.colleywest.bc.ca/feeder-hole-loading-2/)**

### 5.5.7 Bulk containers

Sometimes bulk cargo is transported in containers (Figure 54). Typically, containers are used for small volumes or when it is considered viable to deliver containers frequently in order to avoid storage at the delivery location; JOT (just-on-time) – a basic logistics principle. However, bulk containers can be used as a system at large scale as seen in the Port of Ust-Luga (Figure 40).


**Figure 54: Example of a bulk container with inner liner (https://fluidizingliner.com/)**

### 5.5.8 Bulk container spreaders

This bulk container system is used for a closed system from the plant or mine to the ship (Figure 55 and Figure 56). The container is typically covered, and dusting occurs only when the cargo is poured into the ship's hold. Productivity of 1,000 tonnes/h can be achieved according to the supplier (productivity in bulk loading is typically 500 to 2,000 tonnes/h).


Figure 55: Ram Spreaders (https://www.ramspreaders.com)

Figure 56: Bulk container spreader in action (https://www.ramspreaders.com/4121-mhc-image-gallery/)

### 5.5.9 Bags

In some situations, big bags or bags on pallet could be used (e.g. Figure 39). Usability depends on the product, market, destination, etc. Bags are naturally a closed system and normally dusting is minimal. Bags could be 25 to 50 kg bags on pallet or 'big bags' (1,000 to 2,000 kg). In some cases, bag handling is slower than bulk handling (especially loading) and might not utilise the ship's capacity as well as bulk shipment. However, an efficient crane and crane attachment for lifting could be comparative to bulk handling in the case of smaller vessels. Bags are typically single-use and therefore plastic waste is produced.

### 5.6 Storm water management

Storm water management can be done by filtering, collecting at the wastewater treatment facility and by closing storm drain inlets (collecting material dry before drainage). Filtering water-soluble products in ports is challenging, if not impossible. Ports are often located outside the city storm water network and common (municipal) water treatment plants do not have capacity or a suitable process to deal with storm water from ports.

In Rostock, storm water that is not considered to be polluted or otherwise contaminated is allowed to run off from handling areas to unpaved areas. Unpaved areas are green grounds, i.e. non-compacted soil without paving. Potentially contaminated storm water (e.g. water from parking areas) is retained by liquid separators and pre-treated. For usual handling practice, neither reception nor generation of potentially contaminated water is expected. Even if there is probably always a bit of nutrient spillage in usual handling practice, this proportion is considered to be insufficient to contaminate waters. (Contaminated waters are considered to be those explained in Section 6.)

In Lübeck, storm water is retained and treated in special purification basins before being channelled into the River Trave.

### 5.7 Cleaning

Cleaning the quay side and terminal area by using a mechanical sweeper machine (dry without water) is important for avoiding discharges to the environment. Storm drain inlets should be closed during cleaning. In most cases, conveyor belts had been covered to hinder fertiliser particles from entering the environment and protecting the cargo from moisture. There are vehicle wheel cleaning systems at some ports (e.g. Kokkola) for minimising dust spreading by vehicles, but it is not known if water-soluble wastewater is collected or filtered. Ramboll does not have data from other ports.

### 5.8 Theoretical cost benefit analyses

Every terminal is unique, and it is impossible to prepare a detailed cost estimate for a given terminal or all terminals without a deep understanding of the operation, capacity, area, storage and measurements of each terminal. Some examples of costs are presented in the tables below (Table 6 and Table 7). Similarly, it is difficult to compare benefits. Benefits could be savings on workforce costs, value of cargo (less loss) and energy or increased productivity (thus reducing time at the port) due to more efficient operations, etc. Time has value in shipping as well and service providers try to optimise between short time (high productivity) and costs. As an example, the daily rate is currently around USD 10,000 for a handymax bulk ship (30,000 to 50,000 tonnes of cargo capacity) and USD 3,000 to 4,000 for a ship with 3,500 tonnes of cargo capacity.

**Table 6: Examples of costs**

| Equipment | Unit | Min. | Max. |
|---|---|---|---|
| Crane | EUR each | 1,000,000 | 3,000,000 |
| Grab | EUR each | 50,000 | 150,000 |
| Hopper | EUR each | 50,000 | 200,000 |
| Unloader (screw or pneumatic) | EUR each | 500,000 | 2,000,000 |
| Conveyor | EUR/m | 5,000 | 10,000 |
| Cascade loading chute | EUR each | 50,000 | 300,000 |

**Table 7: Examples of benefits**

| Benefit | Unit | Min. | Max. |
|---|---|---|---|
| Workforce | EUR/person/year | 30,000 | 70,000 |
| Value of cargo | EUR/tonne | 100 | 300 |
| Value of the damage to the marine environment | ? | ? | ? |

Changing from crane/grab unloading or loading to a mechanised solution (unloader or loader) does not necessarily reduce the workforce because an operator is needed for both. Cargo has a value and reducing loss will be a quantifiable profit (e.g. urea costs EUR 200/tonne). The volume and value of cargo lost to the environment is unknown.

### 5.9 Conclusions

The selection of cargo handling equipment is mostly based on economic feasibility. This feasibility assessment should be done for each port separately. It might be the case that not all ports or shippers consider the environmental side of their investment. Selections of cargo methods relate, e.g. to the following issues:

- market practices;
- typical sales lot (quite often 3,000 to 5,000 tonnes in the Baltic Sea, i.e. a shipload);
- supply chain limitations (e.g. receiver and receiving port capabilities);
- end user requirements (e.g. a farmer using 25 kg bags or 1,000 kg big bags).

This part of the report introduced methods familiar to the experts. It is obvious that the ports handling liquid fertiliser or fertilisers in containers are unlikely to make any discharge into the environment during their operations, especially if the containers are loaded at the factory and unloaded at the end user. The second best system for loading is to use feeder holes on hatches with a closed conveyor system at the terminal, but not all ships are equipped with such feeder holes and the method is not used widely for fertiliser transport.

Bulk handling is typically the most economic method of transport if that is possible (market, user, reception port, etc.). A bulk handling conveyor system is quite well protected against dusting when it is designed properly. Most of the dusting occurs at crossing points, e.g. supplying the conveyor, crossing between two conveyors and loading to ship. Cleaning the quay and the terminal area with a mechanical sweeper machine (dry without water) is important.

Grab handling is used at some ports and is often considered to emit more dust. However, dusting can be reduced by using a properly closed grab and by training operators (e.g. feasible fill rate of the grab, proper closing and opening height). A hopper related to grab handling should also have dust management features (passive or active).

Ramboll recommends that the technology for a new terminal should be chosen by considering the best available technology and operational practices for the product concerned and with proper attention to environmental aspects. Training, information and cooperation are the most effective, easy and cheap methods for improvement.

# 6. PORT RECEPTION FACILITIES FOR RECEIVING CARGO HOLD WASH WATERS

## 6.1 Washing practices on board of vessels

According to the interviews, 80% to 90% of ships wash their hold after each cargo. Ship type and size have a major impact on cleaning practices and the cargo hold wash waters produced. A large bulk carrier (approximately 50,000 tonnes, for example) has a visible frame structure inside the hold, while a modern coaster (3,000 to 5,000 DWT), typically used in fertiliser transport within the Baltic Sea, is box-shaped and has a smooth plated surface (Figure 57).

**Figure 57: Example of the difference in hold structure: a large (Hervé Cozanet / CC BY-SA (http://creativecommons.org/licenses/by-sa/3.0/)) vs. a small vessel (David Stanley from Nanaimo, Canada / CC BY.**

A large bulk carrier can produce 50 to 200 tonnes or even more cargo hold wash water after cleaning the holds. A typical amount for a coaster is 5 to 15 tonnes. According to the interviews, less than 100 kg of cargo could be left in the hold in a box-shaped coaster (3,000-5,000 DWT), if it is carefully dry-cleaned before washing by water. It was also mentioned that non-harmful chemicals are used sometimes before loading grains or feedstuffs.

Market practices recognise some standards for assessing cleanliness. In the dry bulk trades, there are essentially five grades of hold cleanliness:

1. hospital clean or 'stringent' cleanliness,
2. grain clean or high cleanliness,
3. normal clean,
4. shovel clean,
5. load on top.

Ships tend to wash their holds at the discharging port or *en route* from the previous discharge port to the next loading port in order to save time. Cargo hold should be dried before loading the next cargo. Cargo hold wash waters are either pumped overboard or collected in tanks. Cargo hold wash waters can be discharged at the next loading port.

In some rare cases, cleaning takes place at the port of loading, when the ship discharges its cargo and loads the next cargo at the same port. In most cases cargo hold wash waters are discharged into tank cars and transported for cleaning or dumping to the appropriate dumping area, which could be an industrial or municipal dumping yard. Typically, water treatment facilities avoid receiving seawater-based hold cleaning water. Sometimes cargo hold wash waters are transported to a toxic waste disposal plant, depending on their content. A simple dumping area is likely the most economical option, while transporting to a toxic waste disposal plant could be quite expensive, depending also on transport distance.

Commercial washing services are also used at some ports (e.g. Kokkola), where special industrial high-pressure cleaning lorries are used for cleaning with minimal amounts of water (10 to 30 $m^2$). This water is pumped to the same lorry and is transported for treatment or to an appropriate dumping yard.

Fire hoses are a conventional method for cleaning the holds. This method consumes a lot of water. There is no legislation that prevents the fire hose method. Some shipowners have invested in ship-based pressure cleaning equipment to increase productivity and reduce cargo hold wash water volumes.

There is also commercially available hold washing equipment especially for larger vessels. Robots have been developed for hold cleaning, but these are considered experimental at the moment. https://cliin.dk/ (Figure 58).

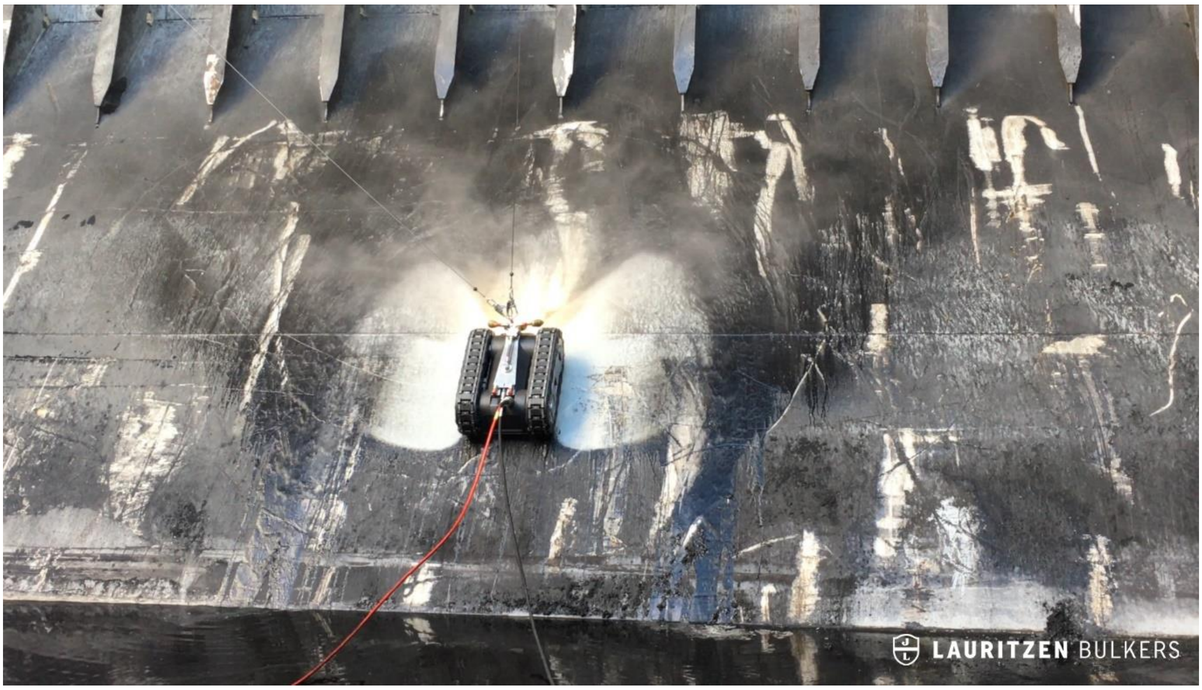


**Figure 58: Example of a robot cleaning a hold (https://www.j-lauritzen.com/lauritzen-bulkers-and-cliin-collaborate-robots-clean-cargo-holds)**

Dry ice ($CO_2$, carbon dioxide) has been considered a waterless method, but its functionality is doubtful and there is no information regarding successful applications.

## 6.2 International regulations

MARPOL comprises probably the most well-known and binding international regulations for marine issues. The revised MARPOL Annex V (1.1.2013) prohibits the discharge of garbage into the sea. The Baltic Sea is a special area. Non-harmful cargo can be discharged to the sea (>12 NM from land), if there are no reception facilities at either the loading or discharge port. It should be noted that fertilisers are not considered a harmful substance. MARPOL Annex V does not include the dust generated by potentially harmful cargo, e.g. remaining cargo particles after sweeping. It is somewhat unclear what should be considered a reception facility: should it be a fixed cleaning facility or simply can a tank lorry be considered such a facility?

### 6.3 Available reception facilities on the Baltic Sea

Typically, ports do not have dedicated reception facilities for water originating from hold cleaning processes. Delivering cargo hold wash waters ashore is the responsibility of the shipowner. Fertiliser factories could receive fertiliser-based cargo hold wash waters and use it in their process. However, it is quite rare that a ship discharges fertiliser-based cargo hold wash waters at a loading port intended for loading fertilisers. This water from washing the holds could include residual particles from various types of cargo (e.g. grain, iron ore, coal). There is no data available on how often ship agents order tank trucks for this purpose.

**1. Klaipeda**

Currently, there are three reception facilities at the port to receive wastewater. According to the port, on the completion of discharge, all holds will be cleaned according to the vessel master's requirements. Subsequently, cargo residues, like wash waters, will be delivered directly to the operator of oil terminals. Hazardous waste is not received at all (except for oily waters). One reception facility had to be demolished during the construction of the new Ro-Ro-Terminal (Berth No 80/81). The port is aware that its waste management plan is outdated due to the increase in vessel traffic and the current waste quantities collected. A possible new location for receiving and treating bilge water has been examined along the sea ferry terminal, probably as part of a bunker. It may be built in the future.

**2. St. Petersburg**

There are no receiving facilities in St. Petersburg according to Ramboll's information. It is not known how much ships are using tank lorry transport.

**3. Tallinn – Muuga**

Tallinn – Muuga does not receive wash water. Wash water should be transported by tank lorries at ship-owners' cost.

**4. Ventspils**

There are no receiving facilities in Ventspils according to Ramboll's information. It is not known how much ships are using tank lorry transport.

**5. Rostock**

At the port of Rostock, cargo wash water is collected by lorries and is discharged to the wastewater treatment plant, depending on its composition (case-by-case review).

**6. Riga**

There are no receiving facilities in Riga according to Ramboll's information. It is not known how much ships are using tank lorry transport.

**7. HaminaKotka**

The Port of HaminaKotka does not receive hold wash water. Hold wash water should be transported by tank lorry at the ship-owners' cost. According to the port authority, Port of HaminaKotka Ltd., washing cargo holds is not allowed at the port. It is assumed that ships will arrive with cargo holds already cleaned and ready to load cargo. There are no receiving facilities or practices for cargo hold wash water, because national legislation does not require it. Ships can order a tank lorry to remove cargo hold wash water at their own cost, but this rarely happens. It should be noted that ships are 'tramp ships' that make chartering contracts on a spot basis. The previous cargo could be something other than fertilisers.[3]

**8. Uusikaupunki**

Yara receives fertiliser-based cargo hold washing waters, which can be used in the process. Other wash waters should be transported by tank lorries at the ship-owners' cost. Yara does not have data on tank lorry transports.

**9. Vyborg**

There are no receiving facilities according to Ramboll's information. It is not known how much ships are using tank lorry transport.

**10. Ust-Luga**

There are no receiving facilities in Ust-Luga according to Ramboll's information. It is not known how much ships are using tank lorry transport.

**11. Lübeck**

The Port of Lübeck does not receive cargo hold wash water.

**12. Kokkola**

The Port of Kokkola does not receive wash water. Wash water should be transported by tank lorries at the shipowners' cost.

The Port of Kokkola does not have plans for improving reception issues as it is responsibility of the shipowner. Ramboll prepared a background report in 2014 on hold wash water issues as part of a larger development project. Approximately 20 to 40 hold washing operations are performed at the port annually for vessels less than 6,000 DWT. Washing operations were performed mostly (no valid data) with industrial high pressure cleaning lorries, which also transported used wash water to different legal dumping areas (industrial site next to the port or the municipally owned Ekorosk Ltd.). Water quantities were between 6 to 15 $m^3$ according to the interviews. It was estimated that fire hose cleaning could produce as much as 35 $m^3$ of wash water from a small vessel. Fresh vs. sea water issues were not considered a challenge in this case. Different options were considered, such as building a fixed pipeline from the quay to the storage tanks (see Section 6.4).

**13. Sillamäe**

There was no information available regarding Sillamäe.

**14. Kaliningrad**

Based on the information received from the port authorities, the shipmaster determines that there are no adequate reception facilities at the receiving terminals.

**15. Liepaja**

There are no receiving facilities in Liepaja according to Ramboll's information. It is not known how much ships are using tank lorry transport.

[3] Phone interview 16 April 2020; Port of HaminaKotka, Markku Koskinen, Director of Traffic Operations, Captain

## 6.4 Recognised challenges and mitigation measures

It is neither mandatory nor even necessarily technically possible to pump hold wash waters directly into a pipeline and to a treatment facility at ports. It is assumed that there is no ship-to-shore water interface to pump water ashore (pipeline or lorry) on all ships.
Freezing temperatures may be a challenge and warm water and steam could be needed. Ship hatches must be closed or partly closed during washing in freezing temperatures. It is not known if antifreeze (alcohol) has been used.

According to the assessment made by Ramboll, it is expected that a tank lorry will be the interface between the vessel and the port in many cases. Tank lorries are most probably an economical transport solution for small quantities and/or relatively short distances. It might not be a key issue whether the treatment facility is at the port or elsewhere. Tank lorries, paid by the shipowner, were mentioned at many ports as the means of transport for hold wash water.

Ramboll does not have data on hold wash water discharge from larger vessels as there are no known cases of such discharge operations. In the 2014 Ramboll Kokkola report it was estimated that a large bulk carrier could discharge 100 to 600 $m^3$ of hold wash water, depending on ship size, previous cargo and the washing method used. It is technically possible to use tank lorries for high quantities (assuming pumping through a ship interface or separate pumps) and it could be feasible if the dumping ground is in close proximity. However, their operation is most probably very slow and requires more time and therefore could lead to high costs. The 2014 Ramboll Kokkola report suggested that an intermediate tank could be an option for balancing capacity, but practical applications are not known. The capacity of the tank was assumed to be two times of a possible larger vessel, i.e. 500 to 600 $m^3$, but this estimate was not based on any calculations.

Hold wash waters can be minimised by dry cleaning the hold before water cleaning. Firstly, the hold must be emptied carefully by the cargo handling equipment (e.g. a crane) using a brush and a shovel as well as a small front loader, if needed. Secondly, the hold should be cleaned using a brush, a shovel and a bucket. Water cleaning should be carried out at a high pressure rather than using high volumes of water. Industrial vacuum cleaners were considered in the 2014 Ramboll Kokkola report, but practical applications are not known; their efficiency and practicability are doubtful.

# 7. CONCLUSIONS

There is no doubt that fertiliser cargo is released into the environment during the cargo handling process. The same applies to cleaning the cargo holds because there are no proper reception facilities. The cargo lost during transport is at some level a measurement inaccuracy issue. However, the volumes discharged into the environment (during cargo handling and cargo hold washing) are not clear and this issue would require additional studies. It should be noted that the difference between terminals may be considerable. The difference is not only due to technology, but it is also an attitude and training issue.

**Volumes and equipment**

The intention was to find out detailed volumes of different fertiliser cargo. However, this was not possible due to business confidentiality issues. Volumes are listed in the summary table below.

**Table 2: Summary**

| Ports | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | Import | Export | Import | Export | Import | Export | Import | Export |
| Kokkola | 171,679 | 257,161 | 172,905 | 256,969 | 168,223 | 248,871 | 180,891 | 268,517 |
| HaminaKotka | 3,178 | 806,837 | 1,287 | 1,450,461 | 0 | 1,707,343 | 2,546 | 2,122,685 |
| Uusikaupunki | 14,892 | 741,327 | 12,492 | 890,377 | 37,089 | 826,346 | 28,056 | 891,963 |
| Muuga | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Sillamäe | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Klaipeda | 1,387,700 | 9,952,000 | 1,583,000 | 10,723,00 | 1,826,500 | 11,033,40 | N/A | N/A |
| Riga | 0 | 1,299,500 | 0 | 1,388,300 | 0 | 1,554,600 | 0 | 2,067,600 |
| Liepaja | 0 | 460,000 | 0 | 1,197,300 | 0 | 1,467,900 | 0 | 1,053,800 |
| Ventspils | 0 | 347,000 | 0 | 195,100 | 0 | 386,500 | 0 | 476,400 |
| Rostock | 745,385 | 903,545 | 682,385 | 845,337 | 604,878 | 812,880 | 661,664 | 916,120 |
| Lübeck | 359,488 | 5,454 | 330,411 | 42,146 | 231,754 | 15,574 | 225,195 | 5,591 |
| St. Petersburg | N/A | N/A | 232 | 9,656,030 | 214 | 8,812,190 | 597 | 8,910,450 |
| Vyborg | N/A | N/A | 1,598 | 3,277,930 | 563 | 3,684,910 | 921 | 4,122,660 |
| Ust-Luga | 0 | 525,000 | 0 | 474,280 | 0 | 545,450 | 0 | 409,510 |
| Kaliningrad | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

Muuga stated that they transported approximately 2 million tonnes/year.
Sillamäe and Kaliningrad did not provide information.

There are several different methods for handling fertilisers at ports. Some of the ports have more efficient mitigation measures than others. There are some very good technological examples of minimised discharge into the environment. Using containers, closed bulk systems and big bags were assessed to be best practices. Cost and benefit comparison is a complicated issue and all cases should be analysed independently. The selection of cargo handling equipment is mostly based on economic feasibility. It might be the case that not all ports or shippers consider the environmental side of their investment.

The bulk cargo handling equipment used varies a lot. Some terminals have a modern, closed process where discharge into the environment is minimal. At some other ports, cargo is handled by conventional grab cranes.

It is difficult to make an overall estimate of volumes lost to the natural environment. A more detailed study for estimating these volumes is recommended.

**Best Available Technology**
It is not easy to say exactly and universally what the best handling method is for fertiliser cargo. Obviously, the system should be as mechanised and closed as possible. The most closed cargo handling system is bulk containers, especially, if the containers are loaded at the factory and unloaded at the end user. The second best system for loading is to use feeder holes on hatches with a closed conveyor system at the terminal, but not all ships are equipped with such feeder holes.

Bulk handling is typically the most economical method of transport if that is possible (market, user, reception port, etc.). A bulk handling conveyor system is quite well protected against dusting, when it is designed properly. Most of the dusting occurs at crossing points, e.g. supplying the conveyor, crossing between two conveyors and loading to ship.

Screw and pneumatic unloaders supplying cargo directly to closed conveyor systems are the best methods for unloading. However, grab unloading by crane is possible as well but requires properly closed grabs and anti-dust designed hoppers supplying cargo directly to closed conveyor systems. The training of crane operators is vital.

A simple and cost-effective method for an existing terminal is to develop attitude and train people. Modern equipment, in addition to attitude and training, will be good for both the environment and business because of its increased productivity and improved cargo condition.

**Port reception facilities**
There are just a few ports which receive cargo hold wash waters from the cargo hold cleaning operation for their own facilities. In many cases, there are limitations on the quality of cargo hold wash waters (seawater or water contained in the hold is not suitable for the cleaning process). This report analysed 15 fertiliser ports as requested by the Client. It is important to understand that cargo hold wash waters are not necessarily fertiliser-based at a fertiliser loading port, but can contain anything that the ship has transported previously. Port reception facilities are needed at every port, not just at ports handling fertilisers.

It is neither mandatory nor even necessarily technically possible to pump hold wash waters directly into a pipeline and to a treatment facility at ports. It is assumed that there is no ship–to-shore water interface to pump water ashore (pipeline or lorry) on all ships. Freezing temperatures may be a challenge and warm water and steam could be needed.

According to the assessment made by Ramboll, it is expected that a tank lorry will be the interface between the vessel and the port in many cases. Tank lorries are most probably an economical transport solution for small quantities and/or relatively short distances. Tank lorries, paid by the shipowner, were mentioned at many ports as the means of transport for hold wash water.

Ramboll does not have data on hold wash water discharge from larger vessels as there are no known cases of such discharge operations. In the 2014 Ramboll Kokkola report it was estimated that a large bulk carrier could discharge 100 to 600 $m^3$ of hold wash water, depending on ship size, previous cargo and the washing method used. It is technically possible to use tank lorries for high quantities (assuming pumping trough a ship interface or separate pumps) and could be feasible if the dumping ground is in close proximity. However, their operation is most probably very slow and requires more time and therefore could lead to high costs.

Hold wash waters can be minimised by dry cleaning the hold before water cleaning. Water cleaning should be carried out at a high pressure rather than using high volumes of water. Industrial vacuum cleaners were considered in the 2014 Ramboll Kokkola report, but practical applications are not known; their efficiency and practicability are doubtful.

**Recommendations**

It is recommended that port terminals use modern technology and train their workers. Terminals operate on a commercial basis and it is unclear if clear limits for discharge into the environment have been set or if they are monitored. Mandatory regulations should be used, if cooperation and education do not give satisfactory results – both in the EU and in an international context.

It is unclear what a port reception facility actually means: does it mean a fixed treatment facility or just a possibility to pump wash waters to a tank truck? "No special fee" -regulation (ships are charged a fee regardless of discharging or not discharging waste) could be considered to be a regulatory option.

It is recommended to prepare detailed studies considering volumes lost to into the environment from cargo handling and from washing cargo holds.

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