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Analysis of the traffic of chemical tankers in the Szczecin and Świnoujście seaports

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Abstract

The ecological protection of the Baltic Sea against extremely noxious pollution by chemical substances is one of the major issues faced by the states that are located on its shore. In this article, the transport of chemicals in bulk has been analysed. An attempt has been made at grouping dangerous chemical substances based on their negative impact on the environment. Databases that were available have been studied with respect to various chemicals transported in the seaports of Szczecin and Świnoujście. Based on the data available, an attempt at analysing the traffic of tankers carrying noxious chemical substances has been taken up.

Introduction

The turnover of goods in the Baltic Sea amounts to 15% of the entire traffic of goods around the globe, which makes it one of the world's busiest navigation waterways. The Baltic is a basin where the exchange of water requires many years, so any ecological catastrophe caused by failure of a chemical tanker could lead to dire consequences, affecting the area for many years and potentially leading to the degradation of the entire ecosystem.

In 2010, transportation of liquid bulk cargo in the Baltic Sea comprised about 290 million tonnes of petroleum and petroleum-based products, at least 11 million tonnes of liquid chemicals, and 4 million tonnes of other liquid bulk substances (Posti & Hakkinen, 2012); whereas in 2002 the transportation of bulk chemicals summed up to 4.9 million tons (Hanninen & Rytkonen, 2006). As the data show, despite the world economic crisis, in the recent years there has been a considerable increase in chemical cargo transported across the Baltic Sea. The dynamic development of the economies of the countries that border the Baltic Sea, although financially positive, causes concerns among sea services due to the increasing risk of ecological accidents.

The International Maritime Organisation (IMO) granted the Baltic region the status of "special area", in other words, an area of special ecological sensitivity. This move should be followed by further actions that would minimise the probability of chemical pollution in the Baltic Sea, which could result from emergency leaks from chemical tankers or collisions between ships that carry chemicals.

In spite of the great ecological loss that would ensue from the leakage of petroleum-based products, the emergency proceedings are not very clearly defined. The diversity of chemical substances that are transported, and the necessity to be familiar with the reactions that may occur if they come into in contact with water, mean that practically each substance should be provided with a specific algorithm of actions to be taken.

This diversity leads us to conclude that no rescue service can prepare for all the possible emergencies. The analysis of the size, frequency and specific characteristics of the traffic in a given region could be the basis for a better diagnosing of the problem.

Selected aspects of transporting bulk chemicals

Sea transport is the best method of carrying large amounts of chemical substances over long distances. Not all chemical substances carried by ships are considered to be dangerous. According to the OPRC-HNS protocol, hazardous and noxious substances (HNS) are those (other than oils) that – once introduced in the sea environment – can pose a threat to human health, be detrimental to living resources and sea life, as well as damage or disturb other parties using the sea according to the law (OPRC-HNS Protocol, 2000). Hazardous and noxious substances can be: inflammable, toxic, explosive, caustic, or reactive. Due to their specific features, it is necessary to distinguish an additional group of substances, those that after leakage lead to the production of harmful gaseous fume (naturally, they can have all the above-mentioned features).

Dangerous chemical substances are transported by sea as solid or liquid cargo, in bulk or containers. Hazardous cargo in containers is subject to regulations stated in the IMDG code, which is part of the annex to the 3rd MARPOL 73/87 Convention. The IMDG code divides hazardous substances transported by sea into nine classes. Chemicals transported in bulk are subject to the following legal regulations established by the IMO:

- IGC code – International Code for the construction and equipment of ships carrying liquefied gases in bulk;
- IBC code – International Code for the construction and equipment of ships carrying liquefied chemicals in bulk;
- IMSBC code – International Code for maritime solid bulk cargoes.

Hazardous and noxious chemical substances can be transported by means of:

- Bulk carriers –used to transport solid dry bulk cargo;
- Chemical tankers –used to transport mass liquid bulk cargo, and divided according to the type of segregation of the products transported, benzene among others;
- Oil tankers –used to transport chemicals in specially dedicated containers except petroleum products, for example styrene;
- Gas carriers –used to transport high pressure or low-temperature liquefied gas, and divided into LNG (Liquefied Natural Gas) methane and LPG (Liquefied Petroleum Gas) propane and butane;
- Container carriers –used to transport cargo in standardized containers, which allow for quicker handling; containers can be used for transporting dry and liquid cargo in special containers, so-called isotanks;
- General cargo carriers – used to transport loosely packaged cargo, such as bags or pallets;
- RORO vessels – used to transport liquid or solid bulk or packaged cargo loaded on trailers or wagons.

Almost every type of ship can transport more than one noxious and hazardous substance, which causes more complications due to the possibility of creating mixtures in case of a failure. Even a relatively small quantity of chemicals can pose a threat, for example in contact with water aluminium phosphide creates phosphine (PH3), a toxic gas.

Specialized chemical tankers with their own systems of pipelines and pumping stations can transport as much as sixty different chemical substances. The majority of chemicals carried on the Baltic Sea are transported in special tankers with separate containers. These are universal ships dedicated to transporting various liquid cargo; they have between ten and sixty separate cargo containers. Diverse chemical substances require different conditions during transport. Some freight requires heating, other cooling. Caustic chemicals will require containers of the highest-quality stainless steel.

The Marine Environment Protection Committee of the International Maritime Organisation published a guide entitled "Manual on Chemical Pollution", whose aim is to help the governments implement protocols on the actions to take in the event of pollution caused by hazardous and noxious substances.

The specific features of the Baltic Sea have forced the surrounding states to establish the Baltic Marine Environment Protection Commission (HELCOM), an intergovernmental regional organisation that bases its regulations on the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL). HELCOM is an executive body that completes the tasks stated in the Convention for the protection of sea environment in the Baltic Sea region of March 22, 1974. In Poland, it came into effect on May 3, 1980. HELCOM published the guide entitled "Manual on Co-operation in Response to Marine Pollution" dedicated to operational cooperation, supervision and prevention from flooding. The guide comprises two volumes; the first one is dedicated to cooperation in preventing the pollution of seas, and the other one is devoted to cooperation in case of chemical leaks.

Table 1. IMO's list of the 20 most dangerous chemicals (author's own work based on MEPC/OPRC-HNS/TG 10/5/4)

No.	Chemical	Major threat posed by transporting the substance							
		Causes the production of fume	Caustic or irritant	Toxic	Inflammable	Explosive	Reactive		
							Exothermic reaction in contact with water	Oxidizing	Polymerizing
1.	Sulphuric acid	x	x				x		
2.	Hydrochloric acid	x	x				x		
3.	Sodium hydroxide / Caustic soda	x	x				x		
4.	Phosphoric acid	x	x				x		
5.	Nitric acid	x	x				x		
6.	LNG/LPG				x	x			
7.	Ammonia			x					
8.	Benzene				x	x			
9.	Xylene				x	x			
10.	Phenol			x	x				
11.	Styrene			x	x				
12.	Methanol				x	x			
13.	Ethylene			x					
14.	Chlorine			x					
15.	Acetone				x	x			
16.	Ammonium nitrate					x		x	
17.	Urea		x						
18.	Toluene				x	x			
19.	Acrylonitrile			x	x				x
20.	Vinyl			x	x				x

In 2010, the International Maritime Organisation published a list of the twenty most dangerous chemicals, excluding petroleum and vegetable oils (Table 1). It was drafted by the IMO on the basis of data collected on the quantity of substances produced, most frequently transported chemicals, and those that are leaked most often.

By analysing the table above, it is possible to group the substances (with respect to each chemical substance's characteristic features) into three categories:

- Caustic substances that cause the production of fume and react exothermically in contact with water;
- Inflammable, explosive, and toxic (they have at least one, and most often two, of the features mentioned), but not reactive substances;
- Inflammable, explosive, toxic (they have at least one, and most often two, of the features mentioned), and reactive with water substances.

This division, or a similar one, can be the basis for further work on preventing ecological consequences of any failure while transporting chemical substances by sea.

Databases concerning the transportation of bulk chemicals, their limitations and resources

It is estimated that about 2,000 different chemicals are regularly transported around the world. It is very difficult to gather reliable information about the actual data concerning the transportation of hazardous and noxious cargo. No global database exists; statistics are collected locally or by institutions that are established individually in a given country.

In Poland, it is possible to obtain data on the seaports of Szczecin and Świnoujście using several databases:

- Marine Statistical Centre (MSC), which is a unit of the Central Statistical Office. The main tasks of the Statistical Centre include organising research, and drafting and publishing the results of statistical studies and analyses on maritime economy (CSO, 2015);
- Szczecin and Świnoujście Seaports Authority (SSSA);
- Vessel Traffic Services (VTS). Ships having lengths of 20 m or more are obliged to notify the

Table 2. Comparison of the characteristic features of databases dealing with the character of transported commodities available in Poland

Data-base	Source of information	Character of data	Option of accessing the data	Type of data	Level of how detailed the data are with respect to transporting chemicals	On the basis of the data, is it possible, directly or after analysis, to define the specific features of the cargo of chemical substances?
MSC	Information about the turnover of cargo and ship traffic coming from the representatives of ships that call at seaports and are submitted to the Statistical Centre through harbour master's offices and harbour authorities as stipulated by the European Parliament and Council Directive 2009/42/WE	Widely available	Data are published every year in the "Statistical Yearbook for Maritime Economy" and in "Maritime Economy"	Non-changeable statistical data	Data state the general size of the transportation divided into major groups of chemical substances, also including the division into handling ports	no
SSSA		Widely available	Data are published on the website of the Board of the Seaports of Szczecin and Świnoujście	Non-changeable statistical data	Information is provided according to cargo groups. Chemical substances are not isolated and can be found in the following cargo groups: "Other mass cargo", "General cargo" and "Petroleum and petroleum products"	no
VTS	Actions taken by the VTS services are mainly based on the information sent orally from ships through VHF radiotelephones, shore radar devices, automatic identification system (AIS) and radio direction finders (RDF). The data gathered are presented in a program for graphic presentation at the operation station	Data with limited access	The system can be accessed by captains, ship owners and users of SafeSeaNet (among others, Coast Guard, Customs Officers, SAR and port managing entities)	Dynamic data quoted in real time that are used for current navigation control	General data including dangerous cargo	no
PHICS	Ships adopting to the system send information about the crew, passengers, waste and hazardous cargo	Data with limited access	The system can be accessed by captains, ship owners and users of SafeSeaNet (among others, Coast Guard, Customs Officers, SAR and port managing entities)	Dynamic data quoted in real time that are used for current navigation control	General data including dangerous cargo	yes
AIS	AIS shore stations receive signals from ships equipped with transponders (of A and B classes), which makes it possible to identify them, and read statistical and dynamic parameters	Widely available	Data are available for the owners of an AIS receiver	Dynamic data quoted in real time that are used for current navigation control	The system will not let us read detailed information about the cargo. AIS makes it possible to send detailed information about hazardous cargo via ciphered messages. The data can only be read by the parties interested once the information has been properly decoded	no

services about the presence, class and amount of hazardous cargo carried on board. In the area of Szczecin and Świnoujście, the VTS are managed by the Director of the Maritime Office in Szczecin;
- Polish Harbours Information and Control System (PHICS) is an electronic system for collecting and storing information about ships carrying hazardous passengers or cargo;
- Automatic Identification System (AIS). It is aimed at sending data between ships and in the communication between ships and the shore. The objective of the system was to improve the safety of navigation. AIS shore stations receive signals from ships equipped with transponders (A and B class), which makes it possible to identify them and read statistical and dynamic parameters. Information about the position and movement of the ships is projected in real time onto electronic maps.

The information in the table illustrates that the statistical data collected (CSO/GUS, Seaport Board) are good material for research and economic forecasts related to sea transport, but do not provide data that would allow to analyse the specific needs in case of ecological catastrophes as a result of a failure or accidents at sea.

Dynamic (AIS, VTS) data are sufficient for the current management of ship traffic in a given basin, but in emergency situations due to a failure in the transportation of chemical substances they only allow for routine actions that do not take into account the specific characteristics of the cargo being carried.

By analysing the information contained in Table 2, it can be concluded that no database provides data sufficient to form a protocol for the complex work required to protect the area from potential ecological catastrophe in case of failure of a vessel carrying chemical substances. More information should be gathered regarding the substances that are transported and the threats that may result from their leakage. The data should provide answers to the following questions: which safeguard measures should all rescue units be equipped with, which measures should be used by units operating in an area characterized by heavy traffic of vessels transporting a given substance, and which measures should only be applied by specialised entities within the scope of international cooperation between Russia and the eight Baltic states belonging to the EU.

Analysis of the traffic and transportation of chemicals in the Szczecin and Świnoujście seaports

The volume of sea transport in Poland is currently increasing, although liquid bulk cargo has decreased slightly in comparison with the year 2010 (Figure 1). In 2013, the turnover of chemicals in Polish seaports equalled 3393 thousand tons. Nearly half of the turnover of chemical substances involved European Union states, whereas the registered contribution of Africa and America was smaller.

Based on a detailed analysis of hazardous cargo that PHICS was notified of, it is possible to quantitatively analyse the vessels that called at the Szczecin and Świnoujście seaports in 2013. The Szczecin seaport was called at by 3670 ships; the Świnoujście seaport was called at by 5344 ships (including passenger ships).

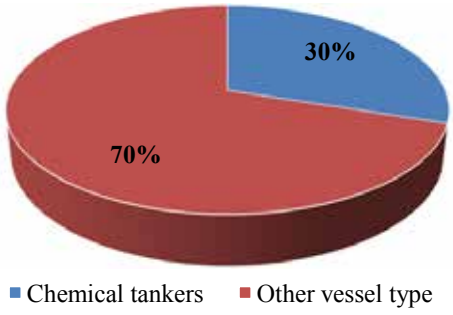

Figure 2. Distribution of vessels carrying chemicals in Szczecin port in 2013 (PHICS, 2015)

On the basis of the data analysed, it was possible to distinguish a group of 113 chemical tankers and 263 ships of other type that at least partially transported chemical cargo (Figure 2). Cargo handled in the Szczecin port mainly includes fertilizers, sodium sulphate, urea, ammonium nitrate, methanol, and sulphite lye. The names of the cargo submitted to the PHICS system have not been standardized, thus

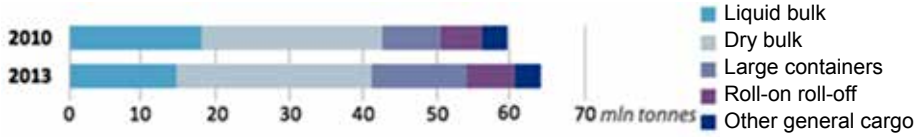

Figure 1. Total cargo traffic in 2010 and 2013 (CSO (GUS), 2014)

Table 3. Turnover in the seaports of Szczecin and Świnoujście in 2012 and 2013 (Szczecin and Świnoujście seaports, www.port.szczecin.pl)

No.	Cargo group	Total turnover with the weight of transport means that were used to move general cargo in ferry traffic					
		2012		2013		%	
		December	12 months	December	12 months	5:3	6:4
1	Coal	394.5	4,257.4	316.3	4,529.4	80.2	106.4
2	Ore	39.9	720.8	144.2	2,654.7	361.4	368.3
3	Other mass types	242.1	4,040.4	331.2	2,887.6	136.8	71.5
4	Corn	146.5	1,394.4	220.1	1,648.5	150.2	118.2
5	Wood	3.3	25.2	0.6	16.8	18.2	66.7
6	General cargo	655.7	9,425.5	682.7	9,392.2	104.1	99.6
	including:						
	ferry general cargo	437.5	6,451	465.9	6,623.7	106.5	102.7
7	Petroleum and petroleum products	116.9	1,403	160.8	1,620.8	137.6	115.5
Total turnover in the seaports of Szczecin and Świnoujście		**1,598.9**	**21,266.7**	**1,856**	**22,750**	**116.1**	**107**
8	Handling of TEU containers (20')	3,967	52,179	5,412	62,307	136.4	119.4

there is a considerable freedom as far as the name of cargo are concerned (from names in the native language to English names; from specialist to colloquial names), which is why the data prepared may include mistakes.

The Board of the Szczecin and Świnoujście Seaports prepares data on the turnover of cargo in the ports. The information is provided according to cargo groups (Table 3). Chemical substances are not isolated and may be included in the following categories: "Other mass cargo", "General cargo" and "Petroleum and petroleum products".

According to the CSO (GUS) data, the Szczecin and Świnoujście seaports contributed to 39.75% of the overall turnover of chemicals in Poland. Figure 3 presents the percentage contribution of each type of chemicals. The CSO (GUS) data only refer to the main groups of chemical cargo without any detailed distinctions (Figure 3 is expressed in % and Table 4 in thousands of tonnes).

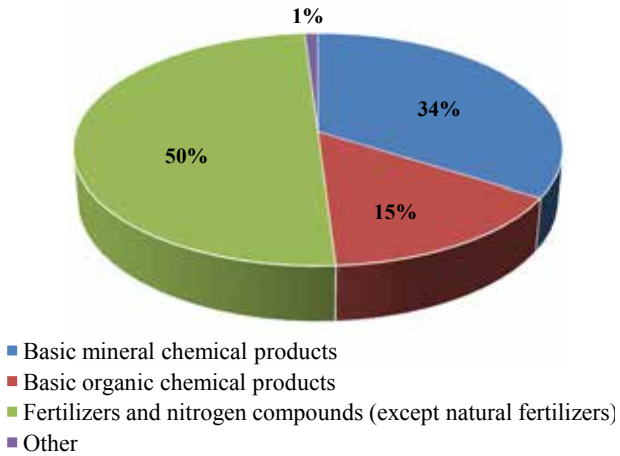

Figure 3. Total turnover of chemical cargo in Polish seaports in 2013 (CSO (GUS), 2014)

Table 4. Turnover of chemical cargo in Polish seaports in 2013 (CSO (GUS), 2014)

The turnover of chemical cargo in Polish seaports in 2013	[thousands of tonnes]
Fertilizers and nitrogen compounds (except natural fertilizers)	1,153.6
Basic mineral chemical products	522.2
Basic organic chemical products	1,681.0
Other:	
– *basic plastics and synthetic rubber in primary forms*	1.3
– *pharmaceuticals and parachemicals including pesticides and other agro-chemical products*	0.1
– *rubber or plastic products*	0.9
– *other goods from the 08 section otherwise unclassified*	33.9

Having collected all the statistical data from the CSO (GUS), Szczecin and Świnoujscie Seaports Authority seaports and our own analyses of PHICS forms, it is possible to determine the size of the transportation of chemical cargo in the Szczecin and Świnoujście seaports. The turnover of chemical cargo in the analysed year 2013 summed up to 1348.7 thousand tonnes. This cargo was carried by 113 chemical tankers and 263 ships of other type that at least partially transported chemical substances.

Based on the data available, it has not been possible to define the percentage distribution of each group of chemical substances handled in the Szczecin and Świnoujście seaports. The data submitted by ships do not take into account the specific information that

would be necessary to assess the ecological threat related to the transportation of chemicals.

Conclusions

The issues related to the ecological protection of the Baltic Sea were among the leading topics assigned by the European Union at the beginning of the 21st century to the governments of Baltic states and international institutions specialized in sea matters. Protecting the Baltic against particularly dangerous chemical substances has become a priority. This should be achieved, on the one hand, by removing many substances that are located on the sea bottom and form part of the cargo of shipwrecks that have not been removed; on the other hand, by preparing appropriate services to act quickly, efficiently, and in a coordinated way in case of a failure of any vessel transporting chemical substances. Due to the diversity of reactions that substances can produce when in contact with water and among each other, the complexity of this problem requires many specialized actions that demand versatile preparation. It is impossible to prepare rescue services for all possible emergencies that can occur in the event of such a failure. In order to prepare the main course of action for the protection of Baltic waters against the consequences of chemical leakage, it is necessary to analyse the cargo that is being carried within this basin. No database that collects information about the cargo transported by sea possesses such data. The study conducted for the Szczecin and Świnoujście seaports showed that the information is gathered with different aims. It would at least make sense to periodically collect more detailed data about the type of cargo transported in order to be able to establish the main methods of protection against any chemical failure. It should be realized that for security reasons such information would have to remain secret and available only to a narrow circle of people dealing with this issue. Thus, it would be possible to prepare port services for protection against the negative consequences of the most frequently encountered chemical substances that are carried by ships into Polish ports. Furthermore, close international cooperation is crucial to define specialised tasks related to chemical substances less frequently encountered in cargo. Some actions have already been taken. The International Maritime Organisation published a list of the twenty most dangerous chemicals. In 2010, European Union commissions drafted a strategy for the Baltic Sea, which encompassed Russia and the eight Baltic states belonging to the EU. The political will allows us to assume that research and analyses into the above-mentioned issues will be taken up without delay.

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