TRANSNAV
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 17
Number 3
September 2023
DOI: 10.12716/1001.17.03.05

Environmental Risk Assessment in the Background of Armed Conflict in the Black Sea Area. A Case Study for a Container Terminal in the Port of Constanța

N.O. Stefanov & L. Rauca
University Politehnica of Bucharest, Bucharest, Romania

ABSTRACT: The year 2022 was marked by economic risks with potentially very sensitive impacts for countries in the Black Sea region. Given the limited capacity of Ukrainian ports, as well as the sanctions imposed on Russia, due to ongoing conflict, it was necessary to identify new destinations capable of taking over the flow of goods that normally went to the countries involved in this conflict. In addition to the risks specific to maritime transport, the risk of armed conflict comes with new challenges that can also materialize in the form of environmental impact. To analyze this potential impact, the study is being focused mainly on the analysis of the pollution risk generated by the emissions caused by the vessels calling the container terminal CSCT, located in Constanța harbor, and the emissions generated by the vehicles moving in the terminal. As estimated from the start all levels of pollution have increased, with the level of CO2 increasing from 11072.7 tons in 2021 to 11915.7 tons in 2022. The NOx emissions have a similar trend, as well as the other emission level measured and calculated.

1 INTRODUCTION

Most of the world's maritime ports are important concentrations of economic activity, potential development, and, at the same time, major sources of pollution, imposing major risks. Furthermore, giant ships, with giant engines running on conventional fuels, with significant journeys made by diesel vehicles (in a single day), diesel locomotives with kilometer-long trains, as well as other polluting equipment and similar port activities lead to a significant number of environmental effects that can seriously disturb local communities and the environment surrounding the harbors. These types of impacts range from increased risk of diseases, such as respiratory disease or different types of cancer, to increased regional smog, poor water quality, and harm to local communities or public lands.

Most of Europe's major ports have been constantly expanding to accommodate larger ships, as well as higher volumes of cargo. The annual growth of international trade has led to a corresponding rapid increase in the number of goods transported by sea, this being the most cost-efficient mean of transportation [1]. Despite the enormous growth in the shipping sector, in general, most pollution prevention efforts at the regional and national levels, until now, have focused mainly on other sources of pollution, while the environmental impact on ports has substantially increased.

In this context, maritime ports are now among the least regulated sources of pollution in the world. This leads to the fact that most ports are heavy polluters, releasing uncontrollable and uncontrolled amounts of emissions with a major impact on air and water

quality in nearby communities, endangering health, and affecting marine habitats [2].

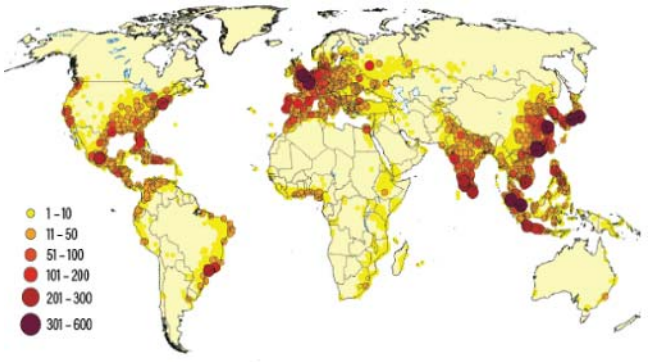

Figure 1. Cardiopulmonary mortality related to shipping PM emissions in global port areas [1]

Nevertheless, vessels operating in ports, vehicles, trains, cranes, and other cargo handling equipment, release large amounts of air pollution affecting the health of harbor workers and people living in nearby living areas, contributing in a significant manner to air pollution at a regional level in general.

Many epidemiologic studies have proven that diesel exhaust emissions increase the risk of cancer, while a 2020 California state study found that diesel emissions are responsible for at least 70% of cancer-related illnesses, all of these being caused by air pollution [1]. In a similar way, more recent studies have linked diesel exhaust emissions to diseases such as asthma. Most of the air pollutants from diesel engines which are generated in maritime harbors, that can affect human health include particulate matter (known as PM), volatile organic compounds (known as VOCs), nitrogen oxides (known as NOx), and sulfur oxides (known as SOx). On the research done on cruise ships calling Dubrovnik, emissions from vessels are a major source of pollution, affecting human health and natural environment [13]. The same study is highlighting that the trend is the increasing of cruise vessels in the area, thus the need of measures to limit the emissions quantities.

The biggest number of port-related sources of air pollution can mainly be attributed to the fact that pollution from vehicles, power plants, and refineries is somewhat controlled by applying local, regional, and national regulations, while the biggest amount of strictly port-related pollution has continued to increase with very little regulatory control being applied.

Port operations can cause significant damage to water quality and subsequently to marine life and related ecosystems, as well as human health. These effects may include bacterial and viral contamination of commercial fish and shellfish, depletion of oxygen, as well as bioaccumulation of certain toxins in fish. Major water quality concerns in ports include sewage and toxic discharges from ships, stormwater runoff, and dredging activities.

2 REVIEW OF INTERNATIONAL AND REGIONAL REGULATIONS

2.1 *International regulation*

In the 8th - 9th decades of the 20th century, the environmental protection policy represented a new direction of action for Europe, the green parties and non-governmental organizations being the first to press for the acceptance of higher standards of the regulation than they would have been adopted at the national level [4]. This situation changed in the 1990s, when the stronger European economic climate and the recognition of all the costs of environmental protection (which had not been anticipated in the past), led to a much more cautious approach to this matter.

During this period there were a series of discussions, not only at the European level but also at the world level, especially in the context of the UN (United Nations) Framework Convention on Climate Change (UNFCCC). This Convention was signed in 1992, at the summit organized by the United Nations in Rio de Janeiro, by 154 states. It contains the commitment of industrialized countries to reduce the emissions of gases that produce the greenhouse effect. In addition to this, it was decided to regularly hold conferences with the signatory states on the topic of climate protection. The framework convention for climate entered into force in 1994 and has since been ratified by almost all the countries of the world.

Consequently, after the year 2000, the European environmental policy developed from a small group of mainly technical measures to one of the most well-known aspects of the European Union's activity, covering, today, almost the entire spectrum of environmental problems. The promotion of sustainable development and a high level of environmental protection were included as important objectives in the European treaties.

The first measures that were taken were intended to improve the quality of life, reduce pollution, as well as introducing the principle of pollution prevention [5]. These three objectives were added, and later, prudence in the use of natural resources.

As far as the Treaty of Lisbon is concerned, it reiterates that the environment is one of the areas in which the attributions belong both to the European Union and to the Member States and that, when it intervenes in this area, the Union must contribute to the achievement of clear objectives: preserving, protecting and improving the quality of the environment; protection of people's health; encouraging a sensible and rational use of natural resources; the international promotion of measures designed to counter environmental problems on a regional or global scale and especially the fight against climate change.

The IMO regulation under MARPOL, in regard to emissions, have been gradually strengthen and the maximum sulfur limit in fuel oil is set to 0.1% in ECA areas and 0.5% in other areas, from 1st January 2020. From 1st January 2021, North Sea and Baltic Sea areas are added into ECA Tier 3, requiring a reduction of NOx with 80%relative to Tier 1 [14].

2.2 *Regional regulation*

In the field of marine environment protection, the Danube-Black Sea region is facing an important problem. The Black Sea area is of great importance for Romania, both for tourism, and for the fishing industry, energy, and navigation. The intensive use of the waters of the Black Sea in recent years, however, created great problems stemming from the degradation of water quality and quantity and drastically reduced biodiversity. The pollution that comes to the Danube stops in the Black Sea and affects a large area, and for this reason, the European Union strives to determine the countries in the region to act in improving the quality of the environment in the area.

Europe represents the largest oil importing market, importing approximately one-third of the total oil worldwide. 90% of all oil and oil products are transported to and from Europe by sea, which inevitably generates pollution. Either because of accidents or simply through maritime operations, the marine environment is degraded, spilling oil into the water constitutes a threat to the environment, and national authorities are responsible for water clean-up operations [7]. Under these conditions, subregional cooperation intensified, also determined by the emergence of new problems that necessitated the adoption of a special protection regime against the degradation of the marine environment. IMO drew up, at the beginning of the 1990s, the project of a Regional Contingency Plan to combat oil pollution of the Black Sea, a plan finalized at the level of experts in two meetings and ratified by the countries bordering the Black Sea.

Figure 2. New exclusive economic zone delimitation in the Black Sea after the invasion of Ukraine [9]

The Regional Contingency Plan was signed by Romania, Bulgaria, and Turkey in 2003. As part of this Regional Plan, the National Pollution Response Plan, mentioned throughout this paper, was approved in Romania. On April 21, 1992, in Bucharest, the representatives of the riparian states of the Pontic basin, Bulgaria, Georgia, Romania, the Russian Federation, Turkey, and Ukraine, signed the Convention on the Protection of the Black Sea against Pollution, accompanied by: the Protocol on the Protection of the Marine Environment of the Black Sea against land-based pollution and the Protocol on cooperation in combating pollution with oil and other harmful substances of the Black Sea marine environment against discharge pollution.

At the same time, in the period of pre-adherence to the European Union, but also after that, measures were taken in Romania to improve the state of the waters of the Danube and the Black Sea. Despite all this, the state of marine ecosystems remains a sensitive subject, primarily due to the pressures exerted by the socioeconomic system [6]. Based on this, an evaluation of the ecological state of the marine environment along the Romanian coast takes place annually, through the analysis of the physical, chemical, and biological components. Thanks to these measures, an improvement in the ecological state of the Black Sea ecosystem has been observed, such as blooms have been reduced (to the point of disappearing in some places), the mass mortality of organisms has decreased, and some have reappeared organisms that were considered extinct.

The research activity on the basis of which the marine environment is assessed is carried out by the National Institute of Marine Research and Development Grigore Antipa from Constanta, which operates with financial support from the Ministry of Environment and Water Management. Romania got involved, being especially active in the Consultative Groups for biodiversity conservation and pollution control and monitoring, contributed to the preparation of the joint report on the ecological state of the Black Sea ecosystem, as well as to the definition of the lists of species that can be found in Annexes II and IV of the Protocol on the Conservation of Biodiversity and the Natural Framework of the Black Sea.

3 RESEARCH METHODOLOGY

The research is focused on analysing the pollution risk from the emissions caused by the vessels calling terminal CSCT, located in Constanta, Romania, and the emissions generated by vehicles moving in the terminal. Based on public information and [3], in 2021 - 88 container vessels and in 2022 – 85 container vessels arrived at the terminal. CSCT terminal consists of five berths, from 121 to 125.

In the context of the Russia-Ukraine conflict that started on February 24, 2022, the situation had negative repercussions not only for Ukraine but for the entire Black Sea region.

Overall, the year 2021 represents a real turning point in overcoming economic problems caused by the COVID-19 pandemic related to limited business activities, but there is no doubt that the year 2022 brought new challenges. Due to the conflict, the Ukrainian economy is at a standstill, seaports are closed, and commercial ships are not allowed to enter, therefore import/export with trading partners is restricted [9]. As Ukraine accounted for about a third of Black Sea container turnover, the conflict had a significant negative impact on the region, leading to

an estimated 35% reduction in container volumes in 2022.

Containerized cargo volumes in the terminals operated along the Black Sea region increased by 2.6% in 2021 (a total of 2,425,671 TEU) compared to the previous year, which can be considered a sign of a post-pandemic economic recovery. The volume of cargo containers increased in all countries except Georgia. The largest increase was achieved by Russia with 11.97%, while in Georgia there was a decrease of 12.70%. However, Ukraine maintained its leading position in the Black Sea region, with a total volume of containerized cargo of 829,725 TEU, followed by Russia with 660,581 TEU, and Romania – with 481,210 TEU [9]. The volume of imports in the mentioned countries increased by 2.38% compared to 2020. The largest increase in the volume of imports was recorded by Russia and Romania – 10.39% and 6.37%, respectively. In Ukraine and Bulgaria, there was an increase of 5.56% and 0.64%, while in Georgia the volume of imports decreased by 17.79%. Exports from the region increased by 2.88%, mainly due to increases in the volume of exports from Russia and Georgia of 14.01% and 14.20%. In Bulgaria, there was an increase in the export volume of full containers – 4.68%, while the export volume in Ukraine and Romania decreased by 3.87% and 1.28%, in that order.

Thus, the percentage of loaded container volumes handled by each country in 2021 was distributed as follows: Ukraine – 34.21%, Russia (Black Sea) – 27.23%, Romania – 19.84%, Georgia – 10.20%, Bulgaria – 8.52%.

The current situation has significantly disrupted the regional supply chain in the Black Sea basin and led to operational difficulties, such as the repositioning of Ukrainian import flows to different countries in the region and the delivery of part of the goods via other modes of transport. This obviously leads to an increase in additional demurrage and detention, and storage costs for containers loaded with destination Ukraine. Operational difficulties, especially in planning for empty containers, ultimately create problems in supply chains, becoming inevitably a global issue.

It is important to note that Russia is also an important part of the Black Sea region through the port of Novorossiysk. According to international sanctions against Russia, a dramatic reduction in container traffic is expected in the port of Novorossiysk (only food, humanitarian and medical goods are allowed).

Due to the imposed sanctions, the main shipping container lines do not receive goods of Russian origin, therefore it is expected that the Black Sea container traffic will decrease by about 25% and the monthly volumes in the region will decrease by about 60% (depending on how long the conflict lasts and the sanctions). Only a small part of these volumes (8%) represents intra-regional containerized maritime traffic. The remaining 52% are container volumes connected by ocean routes to Asia, Europe, America, and Africa [8].

International sanctions against Russia, in addition to suspending the transport of goods of Russian origin, have a significant negative impact on containerized cargo volumes from neighbouring countries and on maritime transport services. The area covering the Caucasus and Central Asia countries represents a clear example of this fact, having in mind the main idea that the Black Sea basin is a gateway to Asian countries. As a result of the existing restrictions, the freight transport of Russian-owned companies is also rejected.

In the long term, the impact of Russian aggression in Ukraine on container traffic in the Black Sea region has several directions. At this time, it is impossible to predict exactly how much these countries will be affected. It will be possible to accurately record post-factum losses when we have available statistics on container turnover from the past period.

3.1 *Calculation methodology*

The calculation of the ships and vehicles' emissions was realized using a software/calculation tool developed by The Technological University of Denmark (DTU) and the University of Southern Denmark. The software is calculating the main pollutants (CO2, NOx, SOx, CO, HC, and PM) and fuel oil consumption. By entering the main particulars of the vessel and nautical information, the calculation tool returns approximate emission figures [12]. The pollutants were determined in two situations: during the port stay and while manoeuvring from/to the pilot station. In the Constanța South Container Terminal, also known as the CSCT terminal, the distance from the pilot boarding ground and the berth is approximately 3 NM. For the calculation of manoeuvring emissions, each port call was considered twice. For the vehicles' emissions, the emissions were calculated considering the EURO norm, the average weight of a container, and the driving distance. For this study, all vehicles were considered EURO norm 5, the average weight of a container was deemed to be 15 t and the driving distance in the terminal was considered 10 km.

Figure 3. Constanța South Container Terminal (aerial vew) [4]

The ship's emissions are determined using the below general formula [2]:

Emission = FOC x CF x EF

where:
FOC is Fuel Oil Consumption
CF is Control Factor - depends on the emission reduction technology
EF is the Emission Factor

3.2 *Case study*

The study calculates the total emission during the port stay and during manoeuvring in the CSCT terminal in Constanța, Romania, in 2021 and 2022. In 2021, 443 ships' calls, and in 2022, 406 ships' calls were registered at the terminal [11]. Even though the total number of the vessel is slightly lower, the duration of port stay in 2022 was over 1 500 hrs longer. This indicates that the emission quantities increased in 2022 compared with 2021 (as it is presented in Tables 4 and 6).

Observations:
- 2022 statistics (in terms of the number of vessels and vehicles) were not officially released, the case study is based on non-official data;
- All vehicles were considered EURO norm 5 and the average weight of a vehicle was 15 t;
- The emissions are based on a ship model and do not consider any retrofits which might decrease the pollution.

The summary regarding the number of vessels is presented in Table 1.

It is noticed that the number of small feeders has considerably increased in 2022 compared with 2021. The average year of construction of the same vessels has decreased by 11 years.

Table 2. Number of vehicles in the terminal in 2021 and 2022

Year	No of vehicles
2021	158530
2022	206161
Total	364691

The number of vehicles in 2022 increased by 25% compared with 2021, which means that the number of TEUs increased and explains the increase in vessels' port stay.

3.3 *Results of emission calculation*

The following tables show the summary of emissions by type of pollutant. The calculations were done both during manoeuvring and berthing, using the calculation tool presented in 3.1 Calculation Methodology. As per [8], the type of fuel used in Constanta roads is MGO with 0.1% sulphur content.

It is observed that, even if the number of calls decreased in 2022, the total duration of port stay increased by 15%, meaning that the quantity of cargo increased in 2022, compared to 2021.

Table 1. Summary of the vessels calling CSCT terminal in 2021 and 2022 (adapted from [3])

Vessel size (TEU)	No of vessels by size		No of calls by size		Total port stay by size (hrs)		Average year of built by size	
	2021	2022	2021	2022	2021	2022	2021	2022
< 1000	6	15	8	61	203.1	874.1	2007	1996
1001-2000	35	31	197	168	2869.7	3333.8	2003	2003
2001-3000	26	24	164	143	3603.5	4100.6	2000	2001
>3000	21	15	74	34	2485.8	2390.1	2011	2012
Total	88	85	443	406	9162.1	10698.6		

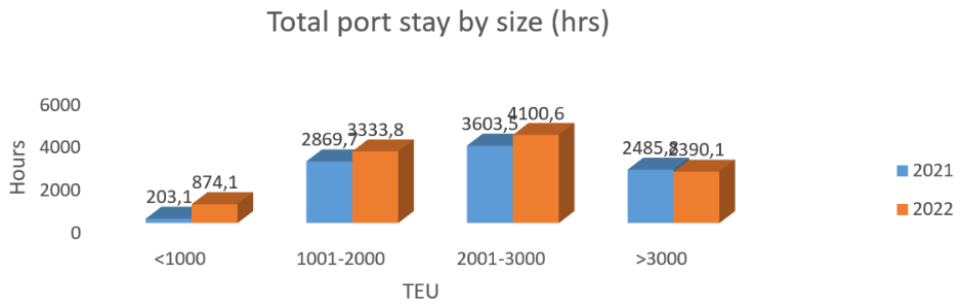

Figure 4. Total port stay by size (hrs)

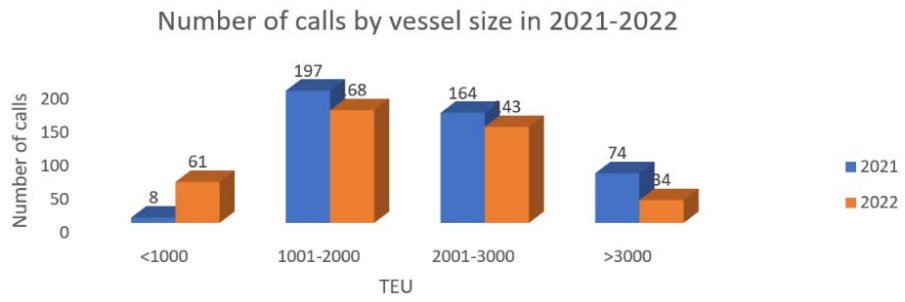

Figure 5. Number of calls by vessel size in 2021-2022

Table 3. Summary of emissions per size of the vessel during the port stay in 2021 (adapted from [3])

Size (TEU)	No of vessels	Total port stay (hrs)	CO_2 (t)	NOx (kg)	SOx (kg)	CO (kg)	HC (kg)	PM (kg)
< 1000	6	203.1	42	648.5	27.5	33.8	33.8	18.2
1001-2000	35	2869.7	1165.9	18007.3	761.6	937.9	937.9	504.7
2001-3000	26	3603.5	2532.8	39121.7	1661.1	2037.6	2037.6	1096.9
> 3001	21	2485.8	5713.5	88271.3	3743.8	4597.9	4597.9	2474.4
Total	88	9162.1	9454.2	146048.8	6194	7607.2	7607.2	4094.2

Table 4. Summary of emissions per size of the vessel during manoeuvring in 2021 (adapted from [3])

Size (TEU)	No of vessels	No of calls	CO_2 (kg)	NOx (kg)	SOx (kg)	CO (kg)	HC (kg)	PM (kg)
< 1000	6	8	2712	55.8	0	1.9	2.28	1.14
1001-2000	35	197	125652	2653.8	118.2	89.3	107.9	58.9
2001-3000	26	164	143658	3022.8	98.4	100.3	124.6	65.9
> 3001	21	74	102150	2020.2	69	73.9	86.6	46.8
Total	88	443	374172	7752.6	285.6	265.4	321.38	172.74

Table 5. Summary of emissions per size of vessel during port stay in 2022

Size (TEU)	No of vessels	Total port stay (hrs)	CO_2 (kg)	NOx (kg)	SOx (kg)	CO (kg)	HC (kg)	PM (kg)
< 1000	15	874.1	146.3	2268.7	97.3	119.5	119.5	65.1
1001-2000	31	3333.8	1294.7	19984.1	848.7	1040.4	1040.4	559.9
2001-3000	24	4100.6	2689.5	43452	1838.7	2263.3	2263.3	1218.6
> 3001	15	2390.1	5733.9	88640.4	3758.8	4617.1	4617.1	2484.8
Total	85	10698.6	9864.4	154345.2	6543.5	8040.3	8040.3	4328.4

Table 6. Summary of emissions per size of the vessel during manoeuvring in 2022

Size (TEU)	No of vessels	No of calls	CO_2 (kg)	NOx (kg)	SOx (kg)	CO (kg)	HC (kg)	PM (kg)
< 1000	15	61	21036	454.8	7.3	15.2	18.7	9.9
1001-2000	31	168	100536	2098.2	100.8	71.3	84.3	47.1
2001-3000	24	143	127590	2728.8	85.8	90	111.8	58.7
> 3001	15	34	53802	1054.8	39	39.5	45.8	24.2
Total	85	406	302964	6336.6	232.9	216	260.6	139.9

Table 7. Total emissions at berth and during manoeuvring in 2021 and 2022 (t)

	CO_2		NOx		SOx		CO		HC		PM	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
At berth	9454.2	9864.4	146.1	154.3	6.2	6.5	7.6	8.0	7.6	8.0	4.1	4.3
Maneuv.	374.2	303.0	7.8	6.3	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.1
Total	9828.4	10167.4	153.9	160.7	6.5	6.8	7.9	8.3	7.9	8.3	4.3	4.5

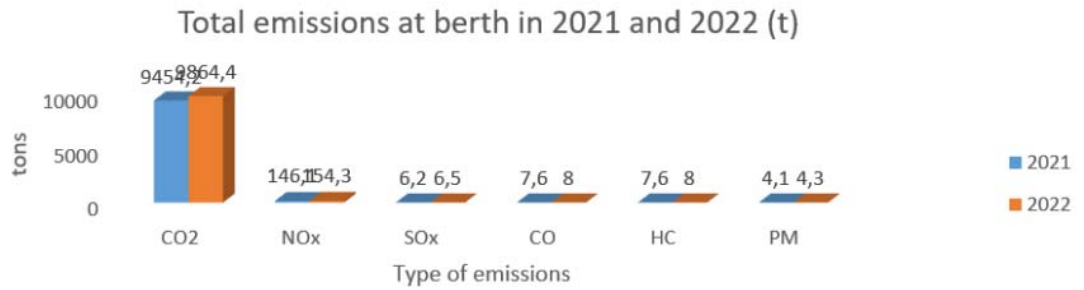

Figure 6. Total emissions at berth in 2021 and 2022 (t)

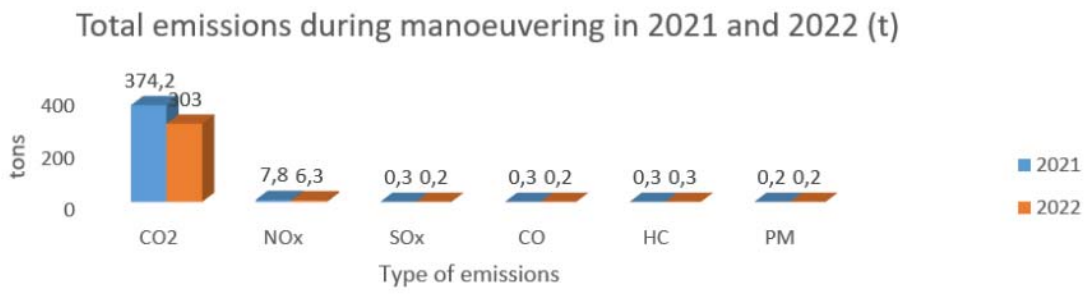

Figure 7. Total emissions during manoeuvring in 2021 and 2022 (t)

Table 7 summaries the emissions at berth and during manoeuvring in 2021 and 2022. At berth, all the emissions, have increased due to longer duration of port stay. Because the number of vessels has decreased in 2022, the emission during manoeuvrings has slightly decreased in 2022, compared with 2021.

Table 8. Total emissions by vehicles (2021 & 2022) (t)

Year	No of vehicles	CO_2	NOx	SOx	CO	HC	PM
2021	158530	1344.33	4.20	0.01	0.21	0.03	0.04
2022	206161	1748.25	5.46	0.01	0.27	0.04	0.05
Total	364691	3092.58	9.66	0.02	0.47	0.07	0.09

The number of vehicles increased by 30% in 2022, therefore all emissions quantities have increased, with CO_2 having the most significant impact.

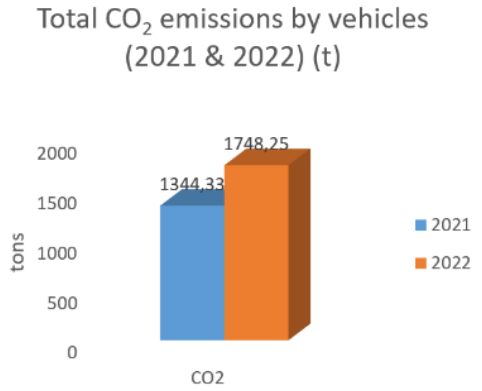

Figure 8. Total CO_2 emissions by vehicles 2021 and 2022 (t)

4 CONCLUSIONS

The case study of this research was focused mainly on the analysis of the pollution risk generated by the emissions caused by the vessels calling the container terminal CSCT, located in Constanta harbor, Romania, and emissions generated by the vehicles traveling in the terminal.

The focus of the study tries to determine if there is a correlation between high-risk events (such as the war in Ukraine) and the risk of higher pollution in port areas such as Constanța, once the main container traffic has been directed to other ports in the Black Sea area, Constanța being one largest port in this area.

The information gathered to achieve the main objective of this study has been available from the official reports of CSCT keeping in mind the main container vessels, with 443 container vessels' calls in CSCT in 2021, and 406 container vessels' calls at this terminal in 2022. Even if the number of vessels has decreased official numbers show that the TEU number handled in the overall Constanța harbor has increased. It is important to mention that occupies only a small part of this port, the CSCT terminal consists of only five berths, from No. 121 to No. 125.

As presented, certain categories of ships had a more intense presence in the harbor in 2022, which is why the number of calls has increased along with the total duration of port stay. As estimated from the start all levels of pollution have increased, with the level of CO2 increasing from 11072.7 tons in 2021 to 11915.7 tons in 2022. The NOx emissions have a similar trend, as well as the other emission level measured and calculated.

REFERENCES

[1] Kristensen, H. O., "Energy demand and exhaust gas emissions of marine engines", Clean Shipping Currents, Vol. 1(6), pp. 18-26, Jun. 2012;

[2] Lee, H., Park, D., Choo, S., and Pham, H. T., "Estimation of the non-greenhouse gas emissions inventory from ships in the port of Incheon", Sustainability, Issue 12(19), 8231, pp. 172-181, May 2020;

[3] Rauca, L., Batrânca, G., "Assessment of Business Process vs Environmental impact of Ship Emissions: The Case of a Container Terminal in Constanța Port, Romania", 40th IBIMA International Conference, Seville, Spain, (ISBN: 979-8-9867719-0-8) and (ISSN: 2767-9640), pp. 101-116, Jun. 2022;

[4] Dumitrache, C., Dumitrache, R., Tamaș, R., Cibula M.N., "The Particularities of the Closing Processes of Project in the Context of Sustainability Requirments", Postmodern Openings, pp. 81-88, Jan. 2021;

[5] Stanca, C., Cupșa, O.S., Stângă V.G., "The Evaluation of the environmental impact and external factors of urban transport in Constanța", IOP Conference Series: Materials Science and Engineering, 95(1), pp. 63-72, May 2015;

[6] Rondinelli, D., Berry, M., "Multimodal Transportation, Logistics, and the Environment: Managing Interactions in a Global Economy", IOP Conference, Issue 228(1), pp. 11-28, Jan. 2020;

[7] Ellis, J., "Assessing Safety Risks for the Sea Transport Link of a Multimodal Dangerous Goods Transport Chain", Chalmers University of Technology, pp. 16-28, Feb. 2017;

[8] *** DIRECTIVE (EU) 2016/802 Of The European Parliament And Of The Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels, (2016), 'Official Journal of the European Union', ISSN 1977-0677;

[9] *** https://www.intermodal-logistics.ro/impactul-razboiului-rusia-ucraina-asupra-transportului-maritim-containerizat-in-regiunea-marii-negre;

[10] *** https://wellpack.org/ro/cum-transforma-razboiul-din-ucraina-logistica-europeana-si-cum-afecteaza-preturile/.

[11] Constanta Port, Annual Report (2021), Port of Constanta, [Online], [Retrived March, 2023], https://www.portofconstantza.com/pn/portal/static.do?x=get&package_id=np_statistici_port&resource=AR2021.pdf

[12] Danish Shipping (2016), 'Calculation tool for assessment of ships' energy consumption and fuel gas emissions, including CO_2_ (EEDI)', [Retrived March, 2023], https://www.danishshipping.dk/en/policy/klimapolitik/beregningsvaerktoejer/

[13] Zekić, A., Ivče, R., & Radonja, R. (2022). Emission inventory of ships calling at the port of Dubrovnik. TransNav: International Journal on Marine Navigation and Safety of Sea Transportation, 16.

[14] Kanaboshi, H., Sano, F., Oda, J., Akimoto, K., & Onishi, N. (2021). Cost-efficient measures in the oil refinery and petrochemical sectors for the reduction of CO2 emissions under the Paris Agreement and air pollution under the MARPOL Convention. Energy and Climate Change, 2, 100027.