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RESEARCH ARTICLE

POLLUTION OF THE SEAS BY SHIP WASTE: A CASE STUDY OF THE PORT OF AL-KHOMS CITY

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ABSTRACT

The town of Al-Khoms in Libya, with Libya focusing its financial system on exporting oil and receiving exports of consumer goods, the town is at once connected to the ocean and the coastal area, and the included management of this region contributes to the sustainable improvement approach. All over the arena, the trouble of air pollution from sea visitors is an area that has no longer been nicely researched, particularly when this form of traffic is continuously growing. On Mina Al Khoms, the studies ambitions to show the following emissions: (CO2), (NOX), (CO), risky natural compounds, sulfur dioxide (SO2), particulate remember (PM). In line ships at some stage in maneuvers for the years 2021, 2022 and 2023. Statistical evaluation turned into also made and appropriate conclusions had been made for CO2 when you consider that all different emissions are linearly dependent. the analyzes inside the hoteling and maneuvering section of line ships, it could be concluded that in 2022 there was a slight increase for emissions, however in standard there has been not an enormous increase inside the number of line ships and multiplied site visitors. The effects obtained from the Al-Khoms Port case study provide pointers that cause further discount in harmful fuel emissions, monitoring and integrating them into the control of urban ports.

KEYWORDS

ship, waste, Al-Khoms, pollution, emissions, urban ports

1. INTRODUCTION

Maritime transport a taken into consideration a most electricity-green mode of delivery considering that it could bring the largest amount of shipment with the least power ate up. However, it has a negative effect at the surroundings and human fitness (Walker et al., 2019). Pollution from ships are not restricted to maritime injuries however also happens for the duration of normal navigation and deliver operations. The primary resources of pollution from ships are sea discharges, gas emissions, and noise (Anderson et a., 2016).

The seen impact of sea pollutants from ships extends beyond the immediate place of the vessel, affecting international locations and regions throughout the globe. Atmospheric Tran's boundary switch and worldwide atmospheric dispersion of airborne pollutants and greenhouse gases make a contribution to the deterioration of air satisfactory (Lonati et al., 2010). This paper makes a speciality of the analysis of primary pollutants, particularly nitrogen oxides (NOX), (CO), (VOC), (SO2), particulate count (PM) and (CO2), which collectively contribute to the deterioration of air exceptional (Sorte et al., 2020). In addition, numerous assets of pollutants emanate from ships, which includes oil spills, ballast waters, grey waters, black waters, anti-fouling patent, noise, soled waste, as illustrated in Figure 1 (Eyring et al., 2010).

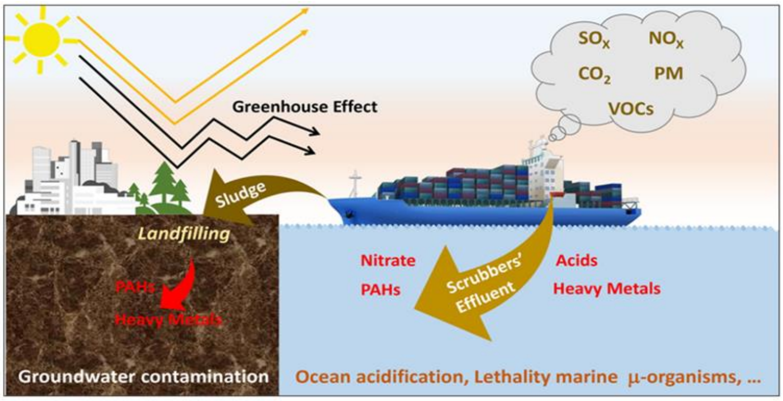

Figure 1: Impact of shipping in Environmental.

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The World Health Organization (WHO), air pollution turned into accountable for four.2 million deaths in 2016 (WHO, 2020). When evaluating the emission values from 5 typically used (EMEP, TNOMACC_III, E-PRTR, EDGAR, and STEAM), it is determined that transport contributes sixteen% of average NOX emissions, 11% of SOX emissions, and five% of PM10 emissions (Russo et al., 2018). European coastal areas, transport emissions contribute among 1% and seven% of ambient air PM10 ranges, 1% and 14% of PM2.5 stages, and as a minimum 12% in PM1 stages. Additionally, delivery emissions account for 7% to 24% of ambient air NO2 concentrations, with the highest values recorded within the Netherlands and Denmark (Viana et al., 2014). Locally launched NOX from ships is a chief contributor to ozone production in the Mediterranean region. If NOX emissions from ships had been excluded, floor ozone concentrations could lower with the aid of 15% (Viana et al., 2014).

The effect of deliver emissions on air nice and human health is mainly large in coastal communities. Exposure to (NO2 and CO) emissions in ports has been connected to bronchitis signs, even as exposure to SO2 emissions is related to breathing issues and premature births (Merk, 2014). It is crucial to note that as policies and regulation on land sources result in decreased emissions, the relative impact of maritime shipping on a worldwide scale will boom, especially thinking about its persisted growth. Therefore, implementing limits on dangerous gases from maritime transport is essential to reduce this effect. The International Convention on the Prevention of Pollution from Ships (MARPOL) plays a prime function in regulating transport pollutants, several directives have been followed to complement and provide in addition clarity in particular regions. Table 1 provides an overview of the organizations, conventions, and laws related to ship emissions.

Table 1: Recent Agreements and Regulations Related to Ship Emissions.

Organization	Agreement/Regulation	Description	Year
International Maritime Organization (IMO)	IMO Initial Strategy on Greenhouse Gas Emissions Reduction from Ships (IMO)	Aims to reduce greenhouse gas emissions from ships by 50% by 2050 and achieve zero net emissions by 2050	2023
			(various amendments since)
		Emission Control Areas (ECAs) designated by MARPOL Annex VI have stricter emission limits for SOx and NOx.	
	NOx Technical Code (Marpol Convention)	Establishes technical standards for reducing NOx emissions from marine diesel engines.	2006
	Energy Efficiency Design Index (EEDI) (IMO)	Requires new ships to be designed for improved energy efficiency.	2013
	Ship Energy Efficiency Management Plan (SEEMP)	Requires ships to develop and implement a plan for improving operational energy efficiency.	2013
International Labour Organization (ILO)	ILO Air Pollution (Seafarers) Convention, 2003 (No. 188)	Sets standards for protecting seafarers from exposure to air pollution on board ships.	2003
European Union	Sulphur Emission Directive (Sulphur Emission Directive)	Limits sulfur oxide emissions from ships in European waters	2015
			(various amendments since)
		Emission Control Areas (ECAs) designated by MARPOL Annex VI have stricter emission limits for SOx and NOx.	
	NOx Technical Code	Establishes technical standards for reducing NOx emissions from marine diesel engines.	2006
	Energy Efficiency Design Index (EEDI)	Requires new ships to be designed for improved energy efficiency.	2013
	Ship Energy Efficiency Management Plan (SEEMP)	Requires ships to develop and implement a plan for improving operational energy efficiency.	2013
United States	Clean Air Act (Clean Air Act)	Regulates air emissions from ships in US waters	1970 (with subsequent amendments)

The first column of the table lists the groups, conventions, and law, whilst the second one column affords their abbreviations, third column in brief describes their roles, and the fourth column shows the years of established order or access into force for instance, the International Maritime Organization (IMO) is a business enterprise chargeable for deliver protection, protection, and pollution prevention. In phrases of greenhouse fuel emissions in shipping, carbon dioxide is launched throughout the combustion fossil fuels. According to the fourth (IMO) take a look at on greenhouse gas emissions (2020), the maritime sector contributes, 2.89% to total greenhouse fuel emissions (4th IMO Greenhouse Gas Study, 2020). This study also shows that shipping is responsible , approximately 1,056 million tons of (CO2) emissions annually, Projections indicate that shipping emissions could increase by 92% to 120% of the 2008 levels by 2050 (4th IMO Greenhouse Gas Study, 2020).

Shipping also contributes to the emission of sulphur oxides (SOX) through the combustion of fossil fuels. Various authors report that shipping accounts for 5% to 8% of anthropogenic SOX emissions (Eyring et al., 2005; Corbet et al., 2017). The sulphur content material in fossil fuels can vary relying at the gasoline type. Sulphur oxides have bad influences on human fitness and the surroundings (Toscan and Murena, 2019; Aderson et al., 2015). The IMO has been gradually reducing the sulphur content in marine fuels. The limits for sulphur content are as follows: four.50 percentage by weight earlier than January 1, 2012; three.50 percentage with the aid of weight from January 1, 2012 onwards; and 0.50% by way of weight from January 1, 2020 onwards. EU Directive 2005/33/EC, ships should use gas with sulphur content under zero.1percentage through weight at the same time as at berths in ports (Merico et al., 2017). The equal stringent restriction of zero.10 percentage through weight is already applied in emission control regions (ECAs), designated by using the International Maritime Organization (Convention, 1973). Another method of limiting air pollutants is through putting in exhaust gas cleaning structures, known as "scrubbers." Ships prepared with scrubbers can keep applying heavy fuel oil with a sulphur content material of 3.5%. (IMO, 2016). Nitrogen oxide (NOX) emissions from ships arise whilst fuel burns at high temperatures within the ship's inner combustion engine. The transport sector as an entire contributes to fifteen% of anthropogenic NOX emissions (Marpol Convention). NOX emissions have environmental impacts which includes inflicting acid rain and contributing to the formation of ground-level ozone while blended with risky organic compounds (VOCs), which also have an effect on human health (Sulphur Emission Directive; Clean Air Act). The MARPOL Annex VI regulates NOX emissions. Different manipulate degrees (Tiers) are implemented based at the ship's construction date. Tier I applies to ships constructed after January 1, 2000; Tier II applies to ships constructed after 2011, and Tier III applies to ships constructed after 2016. The NOX emission limits range for slow-pace engines (<130 rpm), excessive-velocity engines (>2000 rpm), and intermediate-speed engines (a hundred thirty < n < 2200 rpm) (Nitrogen Oxidex (No_x)-Regulation 13, 2020).

Particulate matter (PM) refers to aerosols consisting of solid debris and liquid droplets observed in the air, and they may be categorized primarily based on size. PM10 refers to inhalable particles with a diameter large than 2.5 micrometers and smaller than 10 micrometers, while PM2.Five refers to high-quality particles that are 2.5 micrometers and smaller. PM pollution affects human fitness by using inflicting lung inflammation and proscribing the passage of oxygen to the blood (Sulphur Emission Directive; Clean Air Act). According to the European Environment Agency (EEA), lengthy-term exposure to PM2.Five concentrations in 2016 turned into accountable for over 412,000 untimely deaths in Europe (Saraco et al., 2013). Non-methane risky organic compounds (NMVOCs) are a collection of organic compounds emitted into the ecosystem from numerous assets, consisting of combustion. NMVOCs have negative influences on the surroundings and human fitness (Sulphur Emission Directive; Aderson et al., 2015).

Air pollutants from ships may be assessed globally, which considers emissions for the duration of ship navigation, or domestically, focusing on emissions in ports or close by port areas (Sulphur Emission Directive). Approximately 70% of ship emissions are anticipated to occur within 400 km of land and might considerably affect the air pleasant in coastal areas (Eyring et al., 2010). Several research were performed on port emissions related to delivery, however evaluating their consequences is tough because of the use of different methodologies (Merk, 2014). Two essential processes are usually used for estimating emissions: the bottom-up method and the absolutely top-down technique (Kilic and Tzannatos, 2014). Based on a review of scientific literature comparing bottom-up and top-down methodologies and taking into account that our research problem is completely dependent on ship activity data, the bottom-up approach was used.

The bottom-up approach uses more information from the Automatic Identification System (AIS), including ship characteristics, shipping stages, loading factors and the time spent in each stage (Nunes et al., 2017). In evaluation, the pinnacle-down technique is based on solid gasoline records and the gasoline emission thing. The uncertainties related to the top-down technique revolve around whether or not bunker gasoline sale records are representative (Eyring et al., 2010). the 4th IMO GHG look at, sources of uncertainties in the top-down method can include fuels suggested underneath distinct classes or being accounted for in each country wide and international navigation classes (IMO). The bottom-up method technique has been used to estimate gas emissions at several ports, including the Port of Zadar in Croatia, the Port of Busan in Korea, the Port of Izmir in Turkey, the Port of Barcelona in Spain, the Port of Yangshan in China, and Portuguese ports including Lishues, And Stopal, Cinch, and Viana do Castelo (Alver et al., 2018; Deniz and Kilic, 2009; Knezevic et al., 2018).

The targets of this paper are to examine correlations between emissions at some stage in the discovered length, in particular in the maneuvering and hoteling stages, pick out seasonal fluctuations, and provide hints on how to reduce gas emissions to improve the first-class of existence within the city port place.

2. Materials and Methods

The predominant variables used are time spent in the motel/maneuvering and emissions. Regarding the previous research problem of emission, the following hypotheses can be said:

- There changed into no full-size increase within the emission of harmful gases during the located length;
- There is not any change inside the fashion of CO2 emission over a length of 3 months to twelve months.

A port is located at latitude (`41°32 north) and longitude (`15.5°14 east). The port was established on an area of 249 hectares. Operating company: Libyan Ports Company ((Socialist Ports Company). Port activity: commercial for general cargo / bulk cargo / containers / passengers / livestock / public services / oil dock. Capacity: (3.5 million tons annually) largest tonnage / draft, for a ship can receive: (35,000 tons / 11 metres).

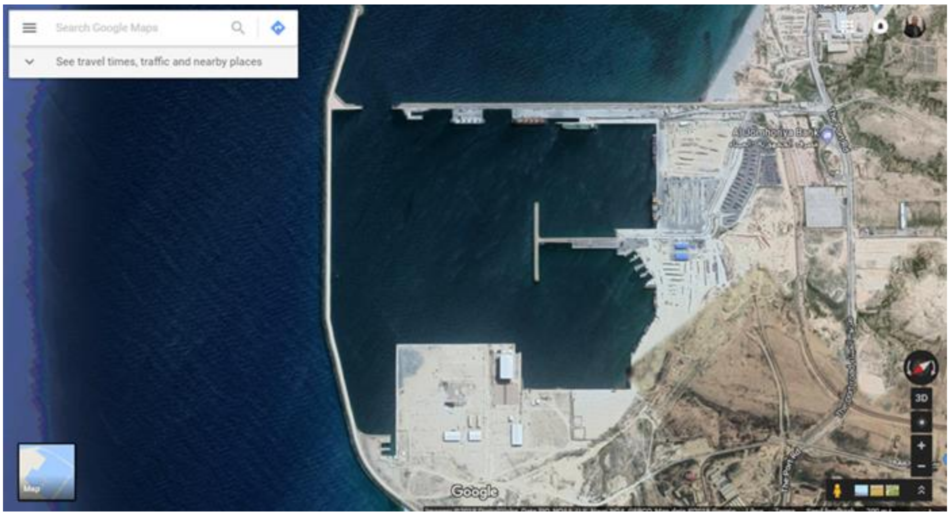

Figure 2: Ship arrivals inside the City port of Al-Khoms.

3. Emission Estimation for City Port of Al-Khoms

An incremental emissions estimation methodology to the EMEP/EEA Handbook of Environmental Impurities Inventories for Air Gases methodology was used to estimate port emissions. As mentioned in the introduction, the bottom-up approach uses more detailed information in estimating emissions. Although several methods exist for calculating emissions, the third layer method was used because it provides insight into the emissions of different ship activities, such as maneuvering, parking and cruising (Knezevic et al., 2018). By comparing several references for estimating emissions (ENTEC 2002, ENTEC 2007, and EMEP/EEA 2019 Shipping Tier 3 - Ship Movement Accounting), older emission factors were used due to the fact that modern literature only provides emission factors for NOx, VOCs, and suspended particulate matter. . By comparing modern literature and ancient literature, the emission factors for VOCs were identical, and there were slight differences in the emission factors for suspended particulate matter and NOx.

Emission factors from the ENTEC study were adopted to estimate pollutants. Prime engine load ratio (LFME), reserve engine load ratio (LFAE), and time of prime engine operation (TOME) during the maneuvering and parking phase are the most important factors affecting emissions. Their values are shown in Table 2 (ENTEC, 2010). Emission factors depend on several factors, such as the type of primary engine, the type of backup engine and the type of fuel.

Furthermore, the vessels were divided by engine speed (slow speed diesel (SSD), medium speed diesel (MSD), high speed diesel (HSD), gas turbine, and steam turbine) and fuel types (RO "heavy oil" (heavy fuel oil), MDO "marine diesel oil" and MGO "marine fuel oil"). There are different main emission factors. An emissions estimation methodology similar to the EMEP/EEA methodology was used to estimate port emissions. As noted in the introduction, the bottom-up approach uses more detailed information in estimating emissions. Although there are many methods used to calculate emissions, the third layer method was used because it provides insight into the emissions of different ship activities, such as moving, standing and cruising (Knezevic et al., 2018). By comparing several references for estimating emissions (ENTEC 2002, ENTEC 2007, and EMEP/EEA 2019 Shipping Tier 3 – Ship Movement Accounting), older emission factors were used since there is no recent literature providing emission factors for NOx, VOCs and suspended particulate matter. After comparing modern literature and ancient literature, it was found that the

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emission factors for VOCs were identical, and there were slight differences in the emission factors for suspended particulate matter and NOx.

Emission factors from the ENTEC study were adopted to estimate pollutants. Primary prime mover load ratio (LFME), standby prime mover load ratio (LFAE), and time of prime mover operation (TOME) during the move and park phase are the most important factors affecting emissions. Their values are shown in Table 2 (ENTEC, 2010). Emission factors depend on several factors, such as the type of primary engine, the type of backup engine, and the type of fuel. Furthermore, ships were divided by engine speed (slow speed diesel (SSD), medium speed diesel (MSD), high speed diesel (HSD), gas turbine, and steam turbine) and fuel types (RO "residual oil" (heavy fuel oil), MDO "marine diesel oil", and MGO "marine fuel oil"). There are emission factors.

Table 2: The foremost and the auxiliary engine load factors. In addition, the main engine time of operation.

Phase	LFME (%)	TOME (%)	LFAE (%)
Hoteling (except tankers)	20	100	50
Hoteling (tankers)	20	5	40
Maneuvering	20	100	50

Table 3: Main and auxiliary engine emission elements for maneuvering and at berth.

Engine Type	Fuel Type	NOx Pre (g/kWh)	NOx Post (g/kWh)	SO2 (g/kWh)	CO2 (g/kWh)	VOC (g/kWh)	PM (g/kWh)
Main Engine	MDO	10.6	8.8	6.8	710	1.5	1.2
Auxiliary Engine	MDO	13.9	11.5	6.5	690	0.4	0.4

4. Results and Discussion

A ship emissions estimation methodology using activity-based estimation for the port city of Al Khoms was used to calculate ship emissions. Ship emissions were estimated at the maneuvering and berthing phase. The berthing phase is responsible for the largest share of emissions in the port: 8.1% for nitrogen oxides (NOx), 78.0% for fine particulate matter (PM2.5), and 88.5% for sulfur dioxide (SOx) (Deniz and Kilic, 2009). These ratios can vary depending on the time spent in the docking phase and the duration of the maneuvering phase (Sulphur Emission Directive). Total emissions in tons for the pop-up standards are shown in Figure III. They are displayed for each month and year, as shown in the third figure. The highest amount of emissions in 2022 was calculated during the maneuvering phase and mooring operations for all pollutants studied.

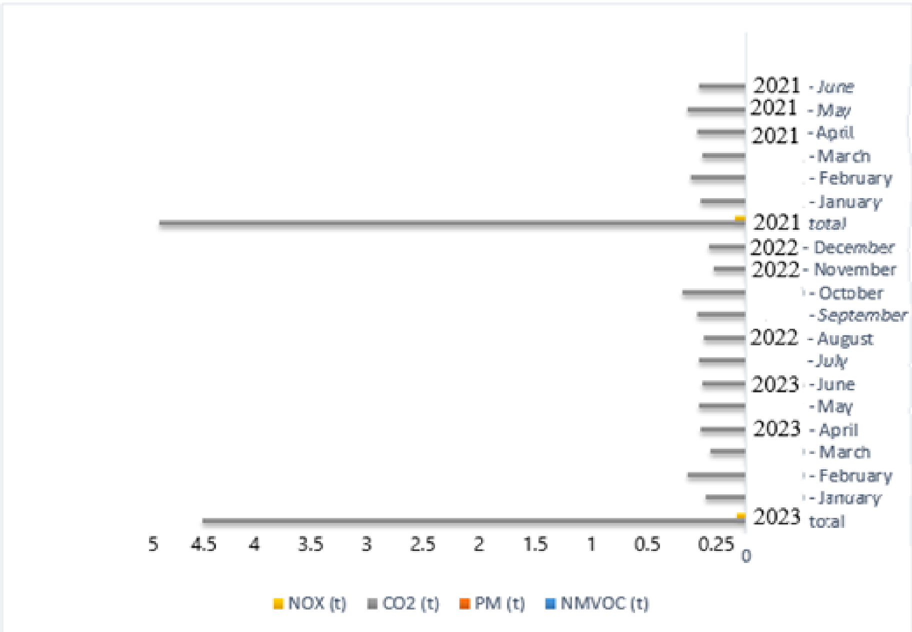

Figure 3: Total emissions in heaps emitted parameters.

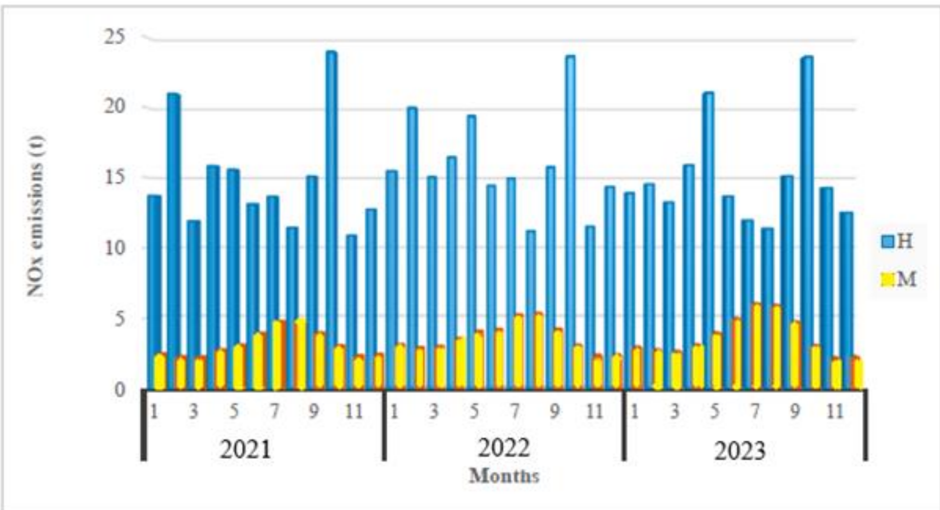

Figure 4: NOX emissions through 3 years

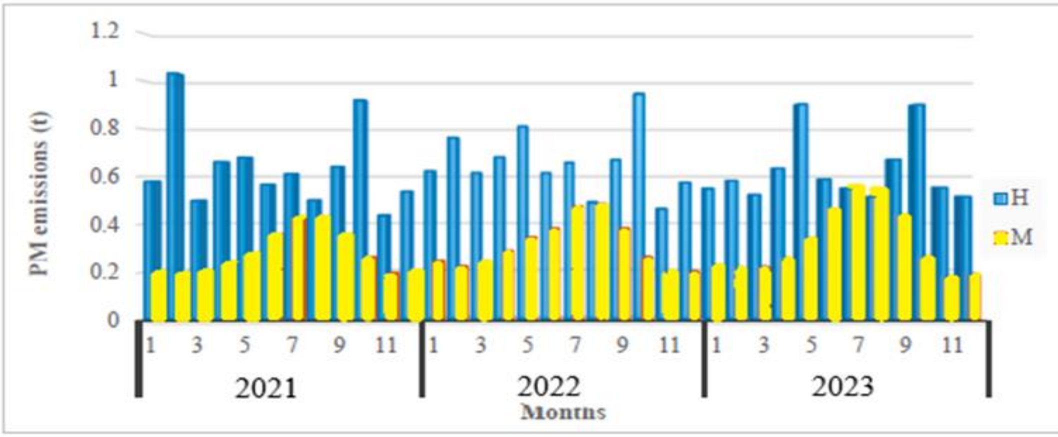

Figure 5: PM emissions through 3 years.

As depicted in Figures 3, 4, and 5, the lodging phase at the hotel contributes the majority of SO2 emissions, exhibiting several peaks throughout the year. In contrast, emissions during the maneuvering phase demonstrate seasonal variations over the course of the year and are generally significantly lower than emissions during the hotel lodging phase. The annual total of sulfur dioxide emissions is noteworthy. Al-Khoms Port is characterized by relatively lower NOx emissions but higher PM emissions compared to certain other ports worldwide that have been mentioned in relation to pollution levels.

5. Conclusions

This study examines the emissions of pollutants and gases from conventional ships during the maneuvering and hoteling phases in port cities. The research focuses on Al-Khoms port as a case study .During the hoteling phase, when the ship is berthed, the auxiliary engines contribute more to emissions compared to the "at sea" phase. In the maneuvering phase, the propulsion engines operate at low loads while the auxiliary engines operate at their highest load to provide additional comfort for onboard equipment like thrusters. Dock operations typically involve higher engine loads, especially during the unloading of goods and vehicles. Ships are expected to keep their auxiliary engines running throughout their time in port. Emission patterns during the maneuvering phase exhibit seasonality, which corresponds to an increase in ferry traffic starting from the end of May, with the highest number of arrivals in July, August, and September. On the other hand, emission patterns during the hoteling phase do not show seasonality but depend on the number of ships and the duration of their stay in port. When comparing all emissions, (CO2), (NOX), volatile organic compounds (VOCs), (SO2), and particulate matter (PM) are found to be linearly related. It is evident from the data that carbon dioxide emissions have the most significant impact on pollution. Analysis of CO2 emission trends in 2021, 2022, and 2023 indicates that average emissions remained stable despite variations in the number of ships and length of stay in port.

References

4th IMO Greenhouse Gas Study 2020, Mepc 75/7/15. 2020, Volume 74. Available online: https://safety4sea.com/wp-content/uploads/2020/08/MEPC-75-7-15-Fourth-IMO-GHG-Study-2020-Final-report-Secretariat.pdf (accessed on 30 September 2020).

Alver, F., Saraç, B., ¸Sahin Ülkü, A., 2018. Estimating of shipping emissions in the Samsun Port from 2010 to 2015.Atmos. Pollut. Res., 9, Pp. 822–828.

Anderson, B., Den Boer, E., Ng, S., Dunlap, L., Hon, G., Nelissen, D., Agrawal, A., Faber, J., Ray, J., 2015. Study of Emission Control and Energy E_ciency Measures for Ships in the Port Area; International Maritime Organization (IMO): London, UK.

Andersson, K., Baldi, F., Brynolf, S., Lindgren, J.F., Granhag, L., Svensson, E., 2016. Shipping and the Environment.In Shipping and the Environment: Improving Environmental Performance in Marine Transportation; Springer Science and Business Media LLC: Berlin/Heidelberg, Germany.

Clean Air Act: https://www.epa.gov/clean-air-act-overview

Convention, M., 1973. International Convention for the Prevention of Pollution from Ships; MARPOL Conv. Outl.; International Maritime Organization (IMO): London, UK.

Corbett, J.J., Winebrake, J.J., Green, E.H., Kasibhatla, P., Eyring, V., Lauer, A., 2007. Mortality from Ship Emissions:A Global Assessment. Environ. Sci. Technol., 41, Pp. 8512–8518.

Deniz, C., Kilic, A., 2009. Estimation and assessment of shipping emissions in the region of Ambarlı Port, Turkey.Environ. Prog. Sustain. Energy., 29, Pp. 107–115.

ENTEC. 2020. UK Ship Emissions Inventory Final Report. 2010. Available online: https://ukair.defra.gov.uk/assets/documents/reports/cat15/1012131459_21897_Final_Report_291110.pdf (accessed on 25 September 2020).

EPlovilo. 2020. Available online: https://eplovilo.pomorstvo.hr/#/public/dashboard (accessed on 2 September 2020).

Eyring, V., Isaksen, I.S.A., Berntsen, T., Collins, W.J., Corbett, J.J., Endresen, Ø., Grainger, R.G., Moldanova, J., Schlager, H., Stevenson, D.S., 2010. Transport impacts on atmosphere and climate: Shipping. Atmos. Environ., 44, Pp. 4735–4771.

Eyring, V., Köhler, H.W., Van Aardenne, J., Lauer, A., 2005. Emissions from international shipping: 1. the last 50 years. J. Geophys. Res. Space Phys., 110, Pp. 171–182.

IMO Initial Strategy on Greenhouse Gas Emissions Reduction from Ships: https://www.imo.org/en/MediaCentre/PressBriefings/pages/Revised-GHG-reduction-strategy-for-global-shipping-adopted-.aspx

IMO. The 2020 Global Sulphur Limit: FAQ. 2016, pp. 1–5. Available online: http://www.imo.org/en/MediaCentre/HotTopics/GHG/Documents/FAQ_2020_English.pdf (accessed on 26 September 2020).

Kilic, A., Tzannatos, E., 2014. ShiP emissions and their externalities at the container terminal of Piraeus—Greece.Int. J. Environ. Res., 8, Pp. 1329–1340.

Kneževic´, V., Radonja, R., Dundovic´, C., 2018. Emission Inventory of Marine Tra_c for the Port of Zadar. Pomorstvo, 32, Pp. 239–244.

Lonati, G., Cernuschi, S., Sidi, S., 2010. Air quality impact assessment of at-berth ship emissions: Case-study for the project of a new freight port. Sci. Total. Environ., 409, Pp. 192–200.

MARPOLConvention: https://www.imo.org/en/About/Pages/Default.aspx

Merico, E., Gambaro, A., Argiriou, A., Alebic-Juretic, A., Barbaro, E., Cesari, D., Chasapidis, L., Dimopoulos, S., Dinoi, A., Donateo, A., 2017. Atmospheric impact of ship tra_c in four Adriatic-Ionian port-cities: Comparison and harmonization of dierent approaches. Transp. Res. Part D Transp. Environ., 50, Pp. 431–445.

Merk, O., 2014. Shipping Emissions in Ports; International Transport Forum Discussion Papers 2014/20; OECD Publishing: Paris, France, 2014. International Maritime Organization (IMO): https://imo.org/

Nitrogen Oxides (NOx)—Regulation 13. Available online: http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)----Regulation-13.aspx (accessed on 22 September 2020).

Nunes, R., Alvim-Ferraz, M., Martins, F., Sousa, S., 2017. Assessment of shipping emissions on four ports of Portugal. Environ. Pollut., 231, Pp. 1370–1379.

Russo, M., Leitão, J., Gama, C., Ferreira, J., Monteiro, A., Shipping emissions over Europe: A state-of-the-art and comparative analysis. Atmos. Environ., 177, Pp. 187–194.

Saraço˘ glu, H., Deniz, C., Kılıç, A., 2013. An Investigation on the E_ects of Ship Sourced Emissions in Izmir Port, Turkey. Sci. World J., Pp. 218324.

Sorte, S., Rodrigues, V., Borrego, C., Monteiro, A., 2020. Impact of harbour activities on local air quality: A review.Environ. Pollut., 257, Pp. 113542.

Sulphur Emission Directive: https://marine-offshore.bureauveritas.com /newsroom/european-directive-sulphur-content-marine-fuels

Toscano, D., Murena, F., 2019. Atmospheric ship emissions in ports: A review. Correlation with data of ship trac.Atmos. Environ. X, 4, Pp. 100050.

Viana, M., Hammingh, P., Colette, A., Querol, X., Degraeuwe, B., De Vlieger, I., Van Aardenne, J., 2014. Impact of maritime transport emissions on coastal air quality in Europe. Atmos. Environ., 90, Pp. 96–105.

Walker, T.R., Adebambo, O., Feijoo, M.C.D.A., Elhaimer, E., Hossain, T., Edwards, S.J., Morrison, C.E., Romo, J., Sharma, N., Taylor, S., 2019. Environmental Effects of Marine Transportation. World SeasEnviron. Eval., 3, Pp. 505–530.

WHO. 2020. Available online: https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwidebreathe-polluted-air-but-more-countries-are-taking-action (accessed on 2 September 2020).