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Research Paper

Assessing the Environmental Costs of Port Emissions: The Case of Trabzon Port

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Abstract: In this study, the exhaust gas emissions generated from ships in the Trabzon port were assessed as 906 t y^{-1} for NO_X, 409 t y^{-1} for SO_X, 52.160 t y^{-1} for CO_2, 54 t y^{-1} for PM, 38 t y^{-1} for VOC based on ship activity-based method. General cargo and tanker vessels are accountable for the 87% exhaust gas emissions in the port, and container, bulk carrier, other vessels such as tugs, service boats follow it. Ship-borne air emissions are emitted at cruising mode (81%), followed by port mode (18%). Port emissions in the Trabzon port may have negative effects on the health of a minimum of 33.922 people living 1 km from the port area including other emissions (domestic heating, road traffic, and industry). The environmental cost of the port emissions for each pollutant has been estimated as $32 million and $47.039 per ship call. All kinds of emission sources in the harbour area should be detected and measures to decrease the emissions should be executed in this context. This is the first study to estimate the Trabzon port emissions in the Black Sea region.

Keywords: *Trabzon, environmental pollution, port, emissions, environmental costs*

Introduction

Marine ports are important economic activity centres where countries carry out their import and export activities. Although seaports are often associated with industrial commercial activities, they are usually situated in or near settlements, schools, etc. The reason for this is to benefit from the labour force of the region and to make an economic contribution to the region. Due to the proximity of the ports to residential areas, people living in that area face health risks due to the air pollution created by the ports. The most important source of port emissions is shipping. Hundreds of trucks, tractors, locomotives, load handling machines, etc. working in the port area are among the other sources of air pollution in the port area (NRDC, 2004). The diseases caused by air pollution are mainly respiratory and cardiovascular, asthma, bronchitis, premature death, and lung cancer. Many epidemiological studies have discovered that diesel exhaust gas emissions increase cancer risks, and they are responsible for 70% of the cancer risk from air pollution (CARB, 1998; Mauderly, 1992; Ulfvarson et al., 1991). Emissions from ships' diesel engines that may adversely affect human health include sulphur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM). Port related emissions have been investigated by many studies such as Alver *et al*. (2018), Goldsworthy and Goldsworthy (2015), Deniz and Kilic (2009), López-Aparicio *et al*. (2015); Popa and Florin (2014); Yang *et al*. (2007), Lonati *et al*. (2010), Saracoglu et al. (2013), Song (2014), Bayirhan *et al*. (2019), Mersin *et al*. (2019), and Tokuslu (2020) and concluded that emissions from shipping cause illness and they affect the quality of life of people living close to the port area.

Trabzon, in terms of air pollution, is one of the most polluted cities in Turkey (Türk & Kavraz, 2011). Previous studies such as Türk *et al*., (2008; 2011), Tezel *et al*. (2019), Yomralioglu *et al*. (2009), Topbaş *et al*. (2004), Uzunali (2004) and Çuhadaroğlu and Demirci (1997; 2000) have almost exclusively focused on the relationships between air pollution and meteorological factors, and emission-related health problems in the Trabzon region. Türk *et al*. (2008; 2011) investigated the effects of air pollution on human health in the city of Trabzon between 2005 and 2007, and they found that due to the use of low-quality coal for heating in residential areas, air pollution occurred at a high level in the winter period in Trabzon and had a serious effect on human health with the increase in the number of air pollution-related diseases. A traffic emission inventory was developed by Tezel et al. (2019) and the relationship between NOx and noise pollution from road traffic was measured in Trabzon. The results of the study indicated that percentages of the population exposed to traffic-related NOx and noise levels above the regulatory limits were 10% and 21%, respectively. Yomralioglu *et al*. (2009) examined 1.150

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cancer cases in Trabzon province. Cancer density map was produced by using GIS, and correlations between cancer types and geographical factors were analysed. They found that breast cancer cases commonly occurred in residential areas that are generally situated on the coast and along valleys and within the low elevation class. Çuhadaroğlu and Demirci (1997) investigated the relationship between outdoor air quality and meteorological factors, such as wind speed, relative humidity ratio and temperature using the code SPSS. According to the results, for some months there was a moderate and weak level of relation between the SO_2 level and the meteorological factors in Trabzon city. Another study was performed by Çuhadaroğlu and Demirci (2000) and they explored the relationship between air pollution and wind speeds of different directions using the code SPSS. They found that there was a weak level of relation between air pollution concentrations and wind speeds in urban Trabzon.

No prior studies have examined port emissions in the port Trabzon. Port emissions are also one of the main pollutant sources of the city of Trabzon and should be considered in this context. To fill this gap, the main aim of this investigation is to calculate the ship-borne air emissions and assess the environmental costs of port emissions. This study will help to create a port emission inventory of the Trabzon port. This study focuses on only port emissions generated from ships and doesn`t engage with other city emissions (residential heating, road traffic, and industry).

Material and Method

Study Area

Trabzon port is located at the centre of the city of Trabzon and situated on the historical silk road on the route of Iran, Iraq, Russia, and Turkey (Figure 1). The port is one of Turkey's most important and busy port and surrounded by the cities of Rize, Giresun, Gumushane, and Bayburt on the eastern side of the Black Sea region. The Trabzon Port has been built to be able to berth all kinds of ships and serves 2.000 ships per year. Its capacity is 250.000 passengers, 2.000.000 tons of bulk dry cargo, 1.830.000 tons of general cargo, and 10,000 vehicles with 175.000 TEU containers. Trabzon Port has an open area that allows 2.500.000 tons of cargo to be stored annually and closed warehouses where 500.000 tons of cargo are stored annually. There is a 306.000 m^2 bonded area in the port. The port is operated by Trabzon Port Operations as of 2003 (Atliaş, 2019). The harbour has 9 docks that deliver loading and unloading activities between the vessels and the shore with a total length of 1.525 meters.

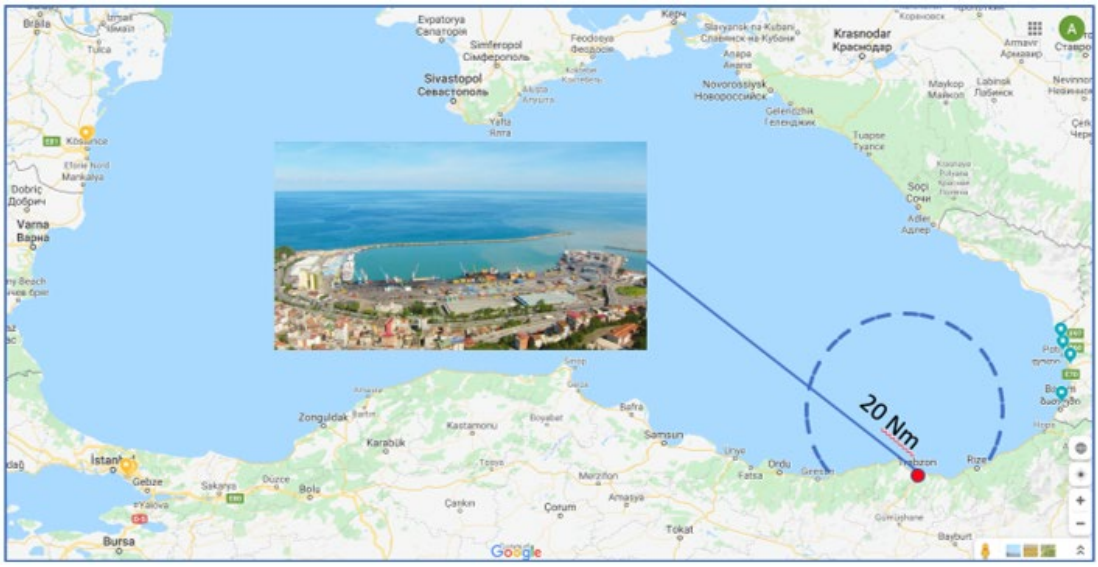


Figure 1. The Trabzon Port (Atliaş, 2019)

Calculation Method

In this research, the up-down approach was used to calculate the port emissions in the Trabzon port based on data. For calculation, Entec UK Limited methodology was preferred which is commonly used in literature for ship-borne emission assessments. The ship estimation equation (1) is stated as;

$$E_{cruising} = D * [[ME * ME\ LF\ ]+ [AE * AE\ LF\ ]\ ]* EF_{cruising}\ / V) \quad \text{(Equation 1)}$$
$$E_{manoeuvring} = T * [[\ ME * ME\ LF\ ]+ [AE * AE\ LF\ ]\ ]*\ EF_{manoeuvring}$$
$$E_{port} = T * AE * AE\ LF * EF_{port}$$

D is the ship navigating distance, ME is the power of the main engine, ME LF is the main engine load factor, AE is the power of the auxiliary engine, AE LF is the auxiliary engine load factor, EF is the emission factors according to operational modes (cruising, manoeuvring, port), V is the vessel speed and T is the times of manoeuvring and port activities.

The data in this research contains the type of vessel, tonnage, speed, operation times and these data were achieved from the port authority. Total navigating distance from the Trabzon port is 20 nm. Times during manoeuvring and port modes were calculated in hours (Entec, 2005). The average time for manoeuvring for all types of visiting vessels is 1 hour and port times of every vessel's calls were 38 hours for a tanker, 14 hours for the container, 52 hours for general cargo, bulk carrier and 27 hours for other vessels (research, ro-ro cargo, passenger, *etc*.) respectively. Table 1 presents the emission factors for each operational mode (Entec, 2002; 2005; 2007).

Table 1. Emission Factors According to the Type of Ships

Ship Types	**NOx**			**SOx**			**CO_2**			**VOC**			**PM**		
	C	M	P	C	M	P	C	M	P	C	M	P	C	M	P
Liquefied Gas	8	8.9	8.8	12.4	12.5	6.9	816	818	795	0.31	0.67	0.6	1.03	1.55	1.2
Chemical	14.6	11.9	11.6	11	12.2	5.7	650	715	698	0.55	1.04	1	1.34	1.6	1.2
Tanker	13.3	11.2	11	11.7	12.7	7.8	690	745	730	0.5	1.1	1.1	1.43	1.82	1.5
Bulk Carrier	15.9	12.6	11.5	10.6	11.9	1.6	627	698	690	0.59	1.3	0.5	1.61	1.84	0.5
General Cargo	14.5	11.9	11.4	10.9	12.1	1.2	649	715	691	0.54	1.03	0.5	1.28	1.59	0.4
Container	15.5	12.3	11.4	10.8	12	1.4	635	705	690	0.57	1.19	0.5	1.56	1.73	0.5
Ro-Ro Cargo	13.7	11.5	11.3	11.1	12.2	1.3	655	719	692	0.52	1.06	0.5	1.17	1.68	0.5
Passenger	11.9	10.6	11.2	11.8	12.6	1.5	697	747	696	0.46	0.97	0.5	0.81	1.71	0.5

C: Cruising, M: Manoeuvring, P: Port

Vessel speeds by vessel types are shown in Table 2 (Entec, 2005). The main engine load factors were %80 for the cruise, %20 for manoeuvring, %20 for port and auxiliary engine load factors were %30 for the cruise, %40 for manoeuvring, %50 for the port (EMEP/EEA, 2016a; EMEP/EEA, 2016b).

Table 2. Vessel Speeds

Type of Vessels	**Speed (knots)**
Liquefied Gas	16.90
Chemical	13.70
Tanker	14.00
Bulk Carrier	14.30
General Cargo	12.30
Container	19.30
Ro-Ro Cargo	15.40
Passenger	20.80
Fishing Vessels	13.90
Tug	12.90

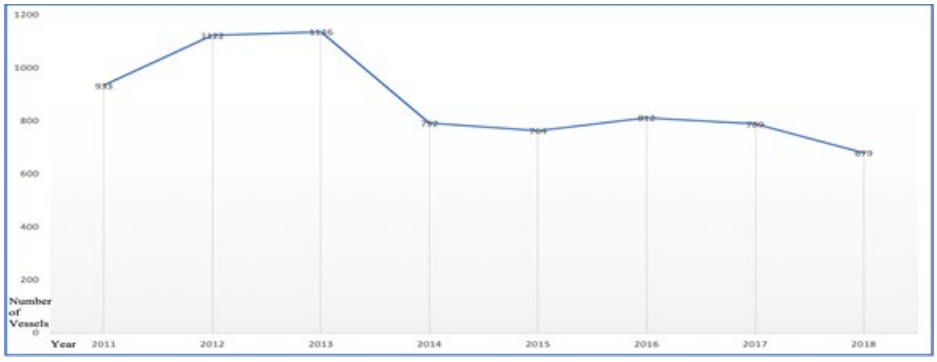


Figure 2. Ship Activities in the Trabzon Port (TDGCS, 2019)

The vessel activities in the port between 2011 and 2018 are illustrated in Figure 2 (TDGCS, 2019). In 2013, 1136 vessels visited the port and on average 878 vessels were hosted in the port during years. Generally, four types of vessels visit the port such as general cargo (70%), tanker (21%), bulk carrier (6%), container (1%), and other ships (2%) yearly (Figure 3).

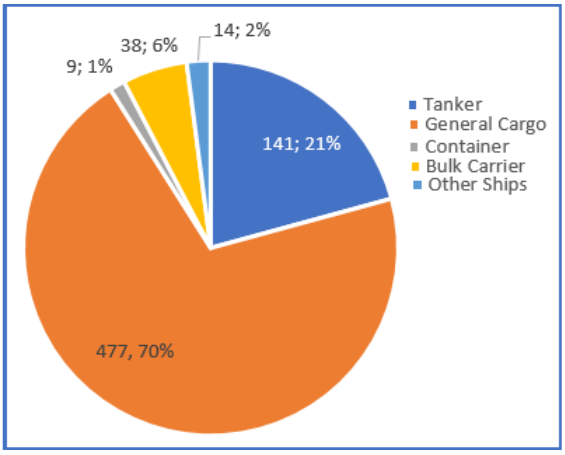
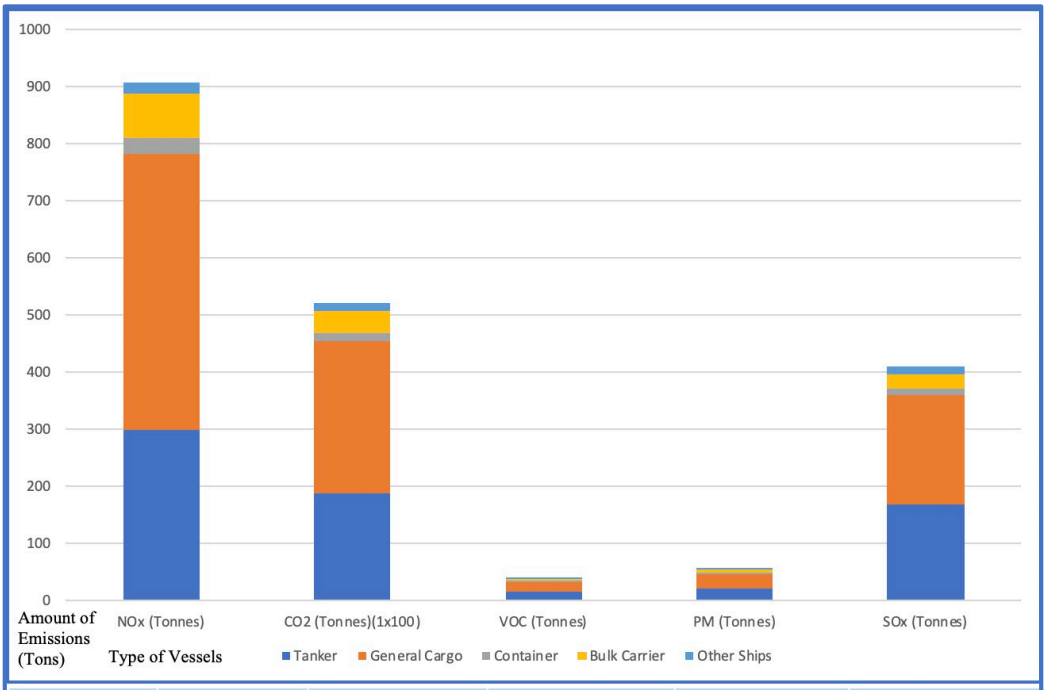


Figure 3. Types of Vessels Visiting the Trabzon Port



Type of Vessels	NOx (Tonnes)	CO2 (Tonnes)(1x100)	VOC (Tonnes)	PM (Tonnes)	SOx (Tonnes)
Tanker	298	187,55	14	22	167
General Cargo	485	265,86	19	24	192
Container	28	13,73	1	2	11
Bulk Carrier	77	39,13	3	5	27
Other Ships	18	15,33	1	1	12
TOTAL	906	521,6	38	54	409

Figure 4. Yearly Emissions According to Vessel Types

Results and Discussion

Port Emissions

In this study, port emissions in the Trabzon port during operational modes (cruising, manoeuvring, and port) were assessed as 906 t y^{-1} for NO_X, 52.160 t y^{-1} for CO_2, 409 t y^{-1} for SO_X, 38 t y^{-1} for VOC, 54 t y^{-1} for PM for 2018. Yearly shipping emissions according to vessel types are presented in Figure 4.

Tanker and general cargo vessels produce the maximum level of emissions in the port and they make 87% of all the total port emissions. Bulk carriers, containers, and other vessels emit the rest of 13% emissions. These results match those observed in earlier studies such as Saracoglu *et al*. (2013); Alver *at al*. (2018); Popa and Florin (2014); Deniz and Kilic (2009) that general cargo and tanker vessels are the main emitters in the studied ports.

The cruising mode emissions are much more than the port and manoeuvring modes emissions. Figure 5 presents the emission rates during the operational modes. Cruising mode emissions are responsible for 81% of all port emissions, port mode emissions are 18%, and manoeuvring mode emissions are 1% of it.

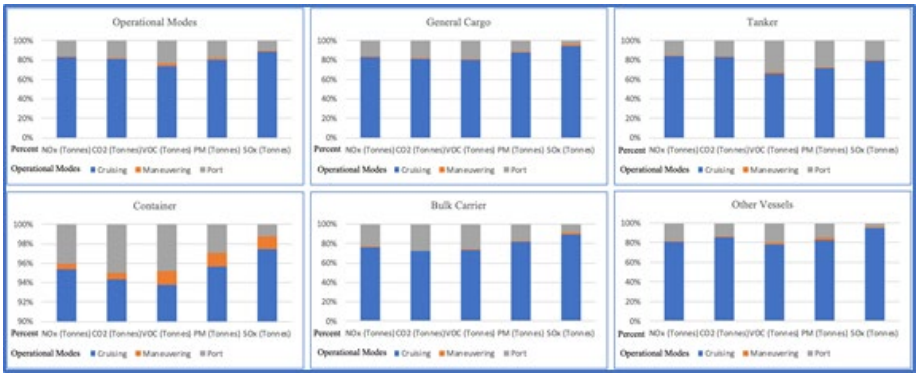


Figure 5. The Emission Rates During the Operational Modes

The Trabzon port emissions comparison with other ports emissions are presented in Table 3 and it can be assessed that the Trabzon port can be recognized as a minimum size harbour in the world-wide context.

Table 3. Comparison of Port Emissions

Ports	Year of Study	Hosted Number of Ships	NOx (ton y^{-1})	CO_2 (ton y^{-1})	PM (ton y^{-1})	SO_X (ton y^{-1})	Source
Ambarli Port, Turkey	2005	5.432	845	78.590	36	242	Deniz and Kilic, 2009
The Samsun Port	2015	2.504	728	-	64	574	Alver at al., 2018
Yangshan Port, China	2009	6.518	10.758	578.444	859	1.136	Song, 2014
The Port of Oslo, Norway	2013	3.004	759	56.289	18	260	Lopez-Aparicio et al., 2015
Port of Oakland, USA	2012	1.916	2.591	133.005	67	289	EIC, 2012
Izmir Port, Turkey	2007	2.806	1.923	82.753	165	1.405	Saraçoğlu et al., 2013
Las Palmas Port, Spain	2011	3.183	4.237	208.697	338	1.420	Tichavska and Tovar, 2015
The Trabzon Port	2018	679	906	52.160	54	409	This Study

Effects of Port Emissions on People

The population of Trabzon city is 807.903 according to the 2018 census conducted by Turkey Statistics Institute and the city has 18 districts. The port takes place in the Ortahisar district and this district is the biggest in the city with a population of 317.520 people. This district has 85 neighbourhoods. The neighbourhoods are divided into 5 zones according to distance from the port, starting from 0 km from the harbour area; **zone 1** (0-1 km from the harbour), **zone 2** (1-2 km from the harbour), **zone 3** (2-3 km from the harbour), **zone 4** (3-4 km from the harbour), **zone 5** (4-5 km from the harbour). There are 49 neighbourhoods within 5km from the Trabzon port which are under the threat of port emissions. The population to be affected by port emissions are shown in Table 4. At least 33.922 people living 1 km (zone 1) from the Trabzon port will be at risk due to harmful port emissions such as SO_X, NO_X, PM including other city emissions (residential heating, road traffic, and industry). As moved away from the port area, the number of people who will be exposed to emissions also increases. As seen

in Table 4, a maximum of 235.512 people will be in danger for any emissions, including port emissions. These results agree with the findings of other studies, in which Corbett et al. (2007); Eyring et al. (2009); NRDC (2004); Deniz and Kilic (2009) stated that the diesel engines of vessels, including other port vehicles, produce a large amount of air pollution that jeopardizes the health of people working in the port area and living near the port. All kinds of emission sources in the harbour area should be detected and measures to decrease the emissions should be executed in this context.

Table 4. Population to be Affected by Port Emissions

Zone 1 neighbourhoods	**Zone 2 neighbourhoods**	**Zone 3 neighbourhoods**	**Zone 4 neighbourhoods**	**Zone 5 neighbourhoods**
İskenderpaşa	Bahçecik	Çukurçayır	Aydınlıkevler	2 Nolu Beşirli
Boztepe	1 Nolu Erdoğdu	Üniversite	Soğuksu	1 Nolu Beşirli
Yenicuma	Kalkınma	3 Nolu Erdoğdu	Yeşiltepe	Karşıyaka
Gazipaşa	Kaymaklı	2 Nolu Erdoğdu	Fatih	Kutlugün
Cumhuriyet	2 Nolu Bostancı	İnönü	Toklu	Gölçayır
Değirmendere	Hızırbey	Yalı	Konaklar	Bengisu
Esentepe	Gülbaharhatun	Yenimahalle	Kanuni	Çilekli
Kemerkaya	Sanayi	1 Nolu Bostancı	Bulak	Aktoprak
Çömlekçi	Çarşı	Kurtuluş	Beştaş	
	Pazarkapı		Fatih Sultan	
	Ortahisar		Çamoba	
	Zafer			
Total Zone 1 Population	**Total Zone 1-2 Population**	**Total Zone 1-3 Population**	**Total Zone 1-4 Population**	**Total Zone 1-5 Population**
33.922	76.998	160.054	220.717	235.512

Environmental Costs

The environmental cost of the Trabzon port emission releases for each pollutant has been predicted for 2018 and was $32 million and $47.039 per ship call (Table 5). These results can be matched with further environmental costs. Berechman and Tseng (2010) analysed the environmental costs of Kaohsiung port as $123 million per year. Maragkogianni and Papaefthimiou (2015) assessed the releases of cruise vessels hosted by Greece ports such as Piraeus, Santorini, Mykonos, Corfu and Katakolo as €24.25 million. Song (2014) calculated the Shanghai Yangshan port`s social cost and eco-efficiency and the total social cost and eco-efficiency performance was found as $287 million, $36,528 respectively.

Table 5. Environmental Costs of the Trabzon Port

Pollutants	**NO_X**	**CO_2**	**VOC**	**PM**	**SO_X**	**Total Environmental Costs**
Environmental cost (Lee et al., 2010)	4.992 $/ton	26 $/ton	1.390 $/ton	375.888 $/ton	13.960 $/ton	-
The amount of port emissions	906 tons	52.160 tons	38 tons	54 tons	409 tons	-
Total environmental costs	4.522.752$	1.356.160$	52.820$	20.297.952$	5.709.640$	31.939.324$

Conclusion

The air emissions generated from ships in the Trabzon port were assessed as 906 t y^{-1} for NO_X, 409 t y^{-1} for SO_X, 52.160 t y^{-1} for CO_2, 54 t y^{-1} for PM, 38 t y^{-1} for VOC. General cargo and tanker vessels are accountable for the 87% exhaust gas emissions in the port, and container, bulk carrier, other vessels such as tugs, passenger vessels, service boats follow it. Ship-borne air emissions are emitted at cruising mode (81%), followed by port mode (18%). Port mode emissions are more than the manoeuvring mode (1%) since harbour handling activities are longer than the manoeuvring events. The following conclusions can be drawn from the present study that port emissions in the Trabzon port may have negative effects on the health of a minimum of 33.922 people living 1 km from the port area including other emissions (domestic heating, road traffic, and industry). All kinds of emission sources in the harbour area should be detected and measures to decrease the emissions should be executed in this context. This is the first study to estimate the Trabzon port emissions in the Black Sea region. The

present study made some remarkable contributions to literature about port emissions and supported other port emissions in the region.

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References

Alport Trabzon Liman İşletmeciliği AŞ (ATLIAŞ), (2019) Trabzon Port – *www.trabzonport.com.tr/* (retrieved on December 2019).

Alver F, Sarac BA, Sahin UA, (2018) Estimating of shipping emissions in the Samsun Port from 2010-2015. *Atmospheric Pollution Research,* **9** (2018) 822-828, *https://doi.org/10.1016/j.apr.2018.02.003*

Bayırhan İ, Mersin K, Tokuşlu A, Gazioğlu C, (2019) Modelling of Ship Originated Exhaust Gas Emissions in the Strait of Istanbul (Bosphorus). *International Journal of Environment and Geoinformatics*, **6** (3), 238-243. *https://doi.org/10.30897/ijegeo.457184*.

Berechman J, Tseng PH, (2010) Estimating the environmental costs of port related emissions: The case of Kaohsiung, *Transportation Research Part D* **17** (2012) 35–38. *doi: 10.1016/j.trd.2011.09.009.*

California Air Resources Board (CARB), (1998) *Draft Diesel Exposure Assessment*, A-7.

Corbett JJ, Winebrake JJ, Green EH, Kasibhatla P, Eyring V, Lauer A, (2007) Mortality from ship emissions: a global assessment, *Environmental Science & Technology* **41** (24), 8512–8518. *doi: 10.1021/es071686z*.

Çuhadaroğlu B, Demirci E, (1997) Influence of some meteorological factors on air pollution in Trabzon City, *Energy and Buildings*, **25**, 179-184, 1997

Çuhadaroğlu B, Demirci E, (2000) Statistical analysis of wind circulation and air pollution in urban Trabzon. *Energy and Buildings* **31** (2000) 49–53.

Deniz C, Kilic A, (2009) Estimation and assessment of shipping emissions in the region of Ambarlı Port, Turkey, *Environ. Prog. Sustain. Energy* 107-115. *http://dx.doi.org/10.1002/ep.10373*.

EMEP/EEA, (2016a) *International Maritime Navigation, International Inland Navigation, National Navigation (Shipping), National Fishing, Military (Shipping), and Recreational Boats*.

EMEP/EEA, (2016b) EMEP/EEA *Air Pollutant Emission Inventory Guidebook 2016.*

Entec, (2002) *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community*, European Commission, Final Report, Northwich, UK.

Entec, (2005) *European Commission, Directorate General Environment Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments*, Task 1 - Preliminary Assignment of Ship Emissions to European Countries, Final Report, August 2005

Entec, (2007) *Ship Emissions Inventory Mediterranean Sea*, Final Report for Concawe.

Environ International Corporation (EIC), (2012) *Port of Oakland, Seaport Air Emissions Inventory*, Novato, California November 5, 2013.

Eyring V, Isaksen I, Berntsen T, Collins W, Corbett J, Endresen O, Grainger R, Moldanova J, Schlager H, Stevenson D, (2009) Transport impacts on atmosphere and climate: Shipping, *Atmospheric Environment* **44** (2010) 4735–4771. *http://dx.doi.org/10.1016/j.atmosenv.2009.04.059*.

Goldsworthy L, Goldsworthy B, (2015) Modelling of ship engine exhaust emissions in ports and extensive coastal waters based on terrestrial AIS data; An Australian case study, *Environmental Modelling & Software* **63** (2015) 45-60. *http://dx.doi.org/10.1016/j.envsoft.2014.09.009*.

Lee PTW, Hu KC, Chen T, (2010) External costs of domestic container transportation: short-sea shipping versus trucking in Taiwan, *Transport Reviews* **30**, 315-335.

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, *Science of the Total Environment* **409** (2010) 192–200. *doi: 10.1016/j.scitotenv.2010.08.029*.

Lopez-Aparicio S, Tønnesen D, Thanh TN, Neilson H, (2015) Shipping emissions in a Nordic port: Assessment of mitigation strategies, *Transportation Research Part D* **53** (2017) 205–216. *http://dx.doi.org/10.1016/j.trd.2017.04.021*.

Maragkogianni A, Papaefthimiou S, (2015) Evaluating the social cost of cruise ships air emissions in major ports of Greece, *Transportation Research Part D*. **36** (2015), 10-17. *http://dx.doi.org/10.1016/j.trd.2015.02.014*

Mauderly JL, (1992) *Diesel exhaust, Environmental Toxicants: Human Exposures and Their Health Effects,* ed. M Lippman (New York: Van Nostrand Reinhold).

Mersin K, Bayırhan İ, Gazioğlu C, (2019) Review of CO_2 Emission and Reducing Methods in Maritime Transportation, *Thermal Sciences*, 1-8.

Natural Resources Defense Council (NRDC), (2004) *Harboring Pollution: Strategies to Clean up U.S. Ports.* NewYork, USA: The Natural Resources Defense Council.

Popa C, Filorin N, (2014) *Shipping Air Pollution Assessment. Study Case on Constanta Port*, 14th International Multidisciplinary Scientific GeoConference SGEM 2014. *doi:10.5593/sgem2014/b42/s19.067*

Saraçoglu H, Deniz C, Kilic A, (2013) An investigation on the effects of ship sourced emissions in Izmir port, Turkey, *Sci. World J.* 2013 *http://dx.doi.org/10.1155/2013/218324*.

Song S, (2014) Ship emissions inventory, social cost and eco-efficiency in Shanghai Yangshan port, *Atmos. Environ.* **82**, 288-297. *http://dx.doi.org/10.1016/j.atmosenv.2013.10.006*.

Tezel MN, Sari D, Ozkurt N, Keskin SS, (2019) Combined NOx and noise pollution from road traffic in Trabzon, Turkey. *Science of the Total Environment* **696** (2019) 134044. *https://doi.org/10.1016/j.scitotenv.2019.134044*.

Tichavska M, Tovar B, (2015) Port-city exhaust emission model: An application to cruise and ferry operations in Las Palmas Port, *Transportation Research Part A* **78** (2015) 347–360. *http://dx.doi.org/10.1016/j.tra.2015.05.021*.

Topbaş M, Can G, Kapucu M, (2004) Effects of local decisions on air pollution in Trabzon, Turkey during 1994-2000, *Turkish Journal of Public Health* **2** (2), 80-84, 2004

Tokuslu A, (2020) Analyzing the Energy Efficiency Design Index (EEDI) Performance of a Container Ship. *International Journal of Environment and Geoinformatics (IJEGEO)*, **7(2)**: 114-119. *DOI: 10.30897/ijegeo*

Turkish Directorate General of Coastal Safety (TDGCS), (2019) *Port Statistics*, web page: *https://atlantis.udhb.gov.tr/istatistik/istatistik_gemi.aspx*, (retrieved on December 2019).

Türk YA, Kavraz M, Türk MH, (2008) *Trabzon Kentinde Hava Kirliligi ve İnsan Sagligina Etkileri*, (In Turkish), Hava Kirliliği ve Kontrolü Ulusal Sempozyumu-2008, 22-25 Ekim 2008, Hatay.

Türk YA, Kavraz M, (2011) *Air Pollutants and Its Effects on Human Healthy: The Case of the City Trabzon*. In AM. Moldoveanu (Ed.), Advanced Topics in Environmental Health and Air Pollution Case Studies (pp.251-268).

Ulfvarson U, Alexandersson R, Dahlgvist M, Elkolm U, Bergstrom B, (1991) Pulmonary function in workers exposed to diesel exhausts: The effect of control measures," *American Journal of Industrial Medicine*, Vol. **19**, 3 (1991): 283–289.

Uzunali D, (2004) *Air pollution maps based on the data collected between 1998 and 2002 for the center of Trabzon City*, (In Turkish), M.Sc. Thesis, Department of Mechanical Engineering, Karadeniz Technical University.

Yang DQ, Kwan SH, Lu T, Fu QY, Cheng JM, Streets DG, Wu YM, Li JJ, (2007) An emission inventory of marine vessels in Shanghai in 2003, *Environ. Sci. Technol.* **41**, 5183-5190. *http://dx.doi.org/10.1021/es061979c*.

Yomralioglu T, Colak EH, Aydinoglu AC, (2009) Geo-Relationship between Cancer Cases and the Environment by GIS: A Case Study of Trabzon in Turkey. *Int. J. Environ. Res. Public Health 2009*, **6**, 3190-3204; doi: *10.3390/ijerph6123190*.