

Environmental Impact in Port Operation for Sustainability

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ABSTRACT

Over the last couple of decades, many researchers have studied to determine the impact from air pollution toward health on human risk in port operation for sustainability. Basically, the main aims of this project are to identify the emission for air pollution from ship in port area, determine the emission for air pollution from ship in port area and classify the risk on human health in near port area with comparing to air quality index (AQI) global category. Indonesia's Batam Island is located near Singapore, which also under global shipping lanes. With large domestic and international shipping operation, total ship berthing in this port area of Batam increased from year-to-year. This data proved that level of air pollution in area port cannot be tolerated. The data had been obtained by co-operation from Politeknik Negeri Batam for the rating of emission in the year 2013. The total number of ships and also the total emission contributed by the ships in port and also during maneuvering require to be considered. The types of emission taken into account are emission of NO_x, SO_x, PM₁₀, CO₂, and CO. The obtained results indicate that the total emissions by ships increased with period growth of the total number of ships in the coming years. It is important to identify existing and potential impacts for health risk of the level emission in port. Therefore, the results obtained from this study are expected to guide and helps to minimize and control the level of air pollution in the port, the environmental impact of port operations and provide recommendations as future reference.

KEY WORDS: *Air Pollution, Rating Of Emission from Ship Berthing per Year, Health Risk and Type And Level Air Quality In*

Environmental Impact

NOMENCLATURE

PM	Particulate Matters
SO _x	Sulfur Oxides
NO _x	Nitrogen Oxides
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
SFC	Specific Fuel Consumption
AQI	Air Quality Index
ppm	Parts per Million

1.0 INTRODUCTION

In the port operation for environment case, biological and chemical processes cause the problem in the community of ecosystem on the nutrients and pollutants in port operation area that mostly come from the physical transports and processes (J. Zhu, 2006). Emissions of air pollutants from ships while they are in port represent a small fraction of total emissions from shipping exhaust emissions that concentrated near populated areas.

The main pollutants emitted by ships are SO_x, NO_x, CO₂, PM and CO. To evaluate air pollution impacts of ports requires consideration of sources, including information vessels (B. Diane, 2004). Modification in power engine vessel, totalize the fuel consumption used for each type of ship and estimation ship berthing in area port is required for prevent the quality of air pollution that produced during operation. Many researchers have studied that the health risk for human body, mostly in respiratory system, commonly happen in area with bad air quality.

2.0 LITERATURE REVIEW

Environmental management of port operations is taking on a consistently higher profile as the port sector responds to the

challenges of new and evolving legislation aimed specifically at environment protection.

To permanently upgrade the port's physical infrastructure, as all policies, reforms and regulations that influence the infrastructure and operations of port facilities including shipping services become the issues of transportation and the environment is related in nature because environmental system impacted by transportation activities support..

2.1 Source of air pollutants in port

The major source of air pollution in port is the emission from ship operation. As with any polluting industry, there is a menu of measures available to mitigate or eliminate health impacts because ports are very complex pollution sources, the best approach is to define the alternatives that can make significant improvements in air quality, and set goals for best environmental practices that achievable. Marine vessels pour out 14% of the NO_x, and 5% of the SO_x from all fossil fuel sources (Corbett et al., 2001), while the road transport has representing more than 50% of CO and NMVOC emissions, and less than 20% for NO_x (C.Gariazzo, 2007).

2.2 Health effects of air quality in port

The impact of air pollution at port is dominated by SO₂, NO_x, PM, CO and VOC. This emission can effect to health problem include asthma, other respiratory diseases, cardiovascular disease, lung cancer and premature mortality (Bailey and Solomon, 2004). For small particles from Diesel exhaust are particulate matter, Nitrogen oxides, and Sulfur oxides.

Dozens of studies have shown that long-term exposure to diesel exhaust significantly increases risk of lung cancer (Bhatia et al., 1998). Particulate matter form a coarse dust that cause lung cancer (Pope et al., 2002).

Numerous studies have found that NO_x can cause toxic effects on the airways (Davies et al., 1997), leading to inflammation and to asthmatic reactions.

Table 2.1: Type of classification of ship berthing in port (Corinair, 2011)

no	Kind of Boats	Hp	SPECIFIC FUEL CONSUMPTION		
			KW	g/KWh	km/l
1	Large Tug Boat	2.820	2.059	203	0.61
2	Vessel Container	31.409	22.929	203	-
3	Vessel Dry Bulk	11.002	8.032	203	-
4	Tanker	6.695	6.695	203	-

2.3 Theoretical Method

To measure the air pollution in port under the times required theoretical method that consist of performance and operability concept. The result of the data can be used to detect the rating of emissions in port which produced by ship. Data result will be compared with category of AQI to detect level of pollution and risk for human health.

2.3.1 Performance Concept

To finding the volume gas emitted in under times, the specification of ships requires to be calculated. The main data needed include power engine ship and specific fuel consumption.

2.3.1.1 The number of Frequency

The number of frequency of a ship and vessel in a year is total required time in a port, Tp, under total operation days, Tt, can be expressed as:

$$F_s = T_p/T_t \quad (2.1)$$

Many factor influence the rate of emission, especially from fuel consumption. Gas emission from ship exhaust mostly is CO₂, PM₁₀, NO_x and SO_x. Fuel ship consumption need to be find, since emission gas from chemical in fuel that give energy power to engine ship.

$$Ch = (P_i \times MCR \times SFC) \quad (2.2)$$

Where Ch is fuel consumption in hour (Kg/h), P_i is shaft power of vessel, MCR is a percentage engine for maximum continuous rating and SFC represent specific fuel consumption (g/KWh).

$$C = 2 \times (N \times Ch \times L)/V \quad (2.3)$$

C is fuel consumption in year (ton/year), N is number of ship in year, L refers to the distance route (Km) and V in speed of ship (Km/h).

Table 2.2: Emission factor for ship operation (Corinair, 2012)

Detail	Emission Factor						
	Fuel	NO _x	HC	CO	PM ₁₀	SOX	CO2
Main Engine (cruise)	BFO	57.7	0.9	7.4	3.8	2 x S % fuel	74.1
	MDO/MGO	57.1	1	7.4	1.5	2 x S % fuel	74.1
Main Engine (Manouver - ing & Hoteling)	BFO	42.3	2.5	7.4	10.3	2 x S % fuel	74.1
	MDO/MGO	43	2.6	7.4	4	2 x S % fuel	74.1
Auxiliary Engine	BFO	49.4	1.7	7.4	3.5	2 x S % fuel	74.1
	MDO/MGO	48.6	1.8	7.4	1.4	2 x S % fuel	74.1

2.3.1.2 The Volume of gas Emitted

The literature study is a method to collect and analyze all data related to the environmental impact at expansion fishing port. Through this analysis, roughly view and understanding about the environmental impacts that occur in the fishing port can be obtained and prediction of the overcome result can be acquired. ϵ_g is an emission factor (CO₂, NO_x and SO_x) in g/kWh.

$$E_g = \epsilon_g \times (C \times P_i \times T) \times F_s \quad (2.4)$$

Where ϵ_g is an emission factor (PM₁₀, CO, NO_x and SO_x) in g/kWh, T is total time vessel operates per year.

2.3.2 Operability Concept

Air Quality index (AQI) is an indicator of the air quality by calculated based on average time parameter of solid particles less than 10 microns (PM₁₀), Sulfur Dioxide (SO₂), Nitrogen Dioxide (NO₂). AQI also can determine effects of emission from air pollutant into human health.

Table 2.3: Air Quality index (AQI) and advisory (AQI, 2013)

AQI Category	status	Clean Air Campaign Health Advisory
0-50	Good	The air quality is good and you can engage in outdoor physical activity without health concerns.
51-100	Moderate	People with heart and lung diseases such as asthma, and children, are especially susceptible.
101-150	Unhealthy for Sensitive Groups	In this range the outdoor air is more likely to be unhealthy for more people such as children, people who are sensitive to ozone, and people with heart or lung disease
151-200	Unhealthy	Most people should restrict their outdoor exertion to morning or late evening hours when the ozone is low, to avoid high ozone exposures.
200-300	Very Unhealthy	Increasingly more people will be affected by ozone.
over 300	Hazardous	Everyone should avoid all outdoor exertion.

3.0 METHODOLOGY

This study was conducted to analysis the impact of air quality on port environmental problem and to formulate the improvement method. The flow chart that have been design, show the sequent of work plan that will be used to achieve the objective of this study. For this project there are involves three methods to ensure that the objective is achieved.

3.1 Development of literature review

Air Quality index (AQI) is an indicator of the air quality by calculated based on average time parameter of solid particles less than 10 microns (PM₁₀), Sulfur Dioxide (SO₂), Nitrogen Dioxide (NO₂). AQI also can determine effects of emission from air pollutant into human health.

3.2 Development of the sources and level of air quality

Literature review will be used as a guideline in determine level of the sources and impact to the environment result. On this study, rating is constructed to provide the researcher a rough idea on how the outcome or result would turn out in the end of the study. In other word, framework will evaluate based on the rating for the level of cases.

3.3 Classification for health risk in based on rating emission

The stage follow under the Air Quality Index (AQI) global category for several years from pollution of air such as CO₂, NO_x, PM₁₀, CO and SO_x emission based on the data only. From this case the thesis can be determined for sustainable.

4.0 RESULT AND DISCUSSION

Batam Island is strategically to sea transportation for local and International destination. This chapter will do estimation regarding environmental impact in ports and shipyards from ship berthing in Batam area; in Terminal Umum Sekupang, Terminal Umum Curah Cair Kabil, Terminal khusus PT. McDermott Indonesia, Terminal khusus PT. Bangun Adya Bahan and PT. Worldwide Equipment S.E.A in year 2013.

4.1 Identify the of ship berthing in port

The information from Kantor Pelabuhan Batam, which the data ports obtained for domestic transportation port terminal, international transportation port terminal and shipyard company port terminal.

Total for each type of ship is different from the port that ship berthed; Terminal Umum Sekupang have the highest for general cargo and container ship with 2,380 and 12 ships, Terminal Umum Curah Cair Kabil for tongkang and Tanker with 56 and 429 ships and also 120 tug boats in Terminal Khusus Bangun Adya Bahan.

According figure 4.1, Umum Curah Cair Kabil port has the highest cargo transferred because location for sea transportation for domestic and international from Singapore and Malaysia.

Table 4.1: Data of ports and total ship berthing in year 2013

Port	Tug Boat		Tongkang		General Cargo		Container		Vessel		Tanker	
	no. of ship	Gt(total)	no. of ship	Gt(total)	no. of ship	Gt(total)	no. of ship	Gt(total)	no. of ship	Gt(total)	no. of ship	Gt(total)
Terminal Umum sekupang	5	1,961	11	21,000	2,380	4,069,665	12	9,161	4	6,235	3	2,541
Terminal Umum Curah Cair Kabil	56	29,729	836	1,519,346	47	132,915	1	890	8	8,678	419	2,963,216
terminal khusus McDermott Indonesia	6	1,616	42	66,540	47	316,742	2	2,368	20	35,801	0	0
terminal khusus Bangun Adya Bahan	120	20,468	15	23,908	9	58,639	5	2,049	43	40,068	1	2,618
PT. Worldwide Equipment S.E.A	34	11,136	30	43,500	2	3,474	0	0	2	8,345	3	1,660

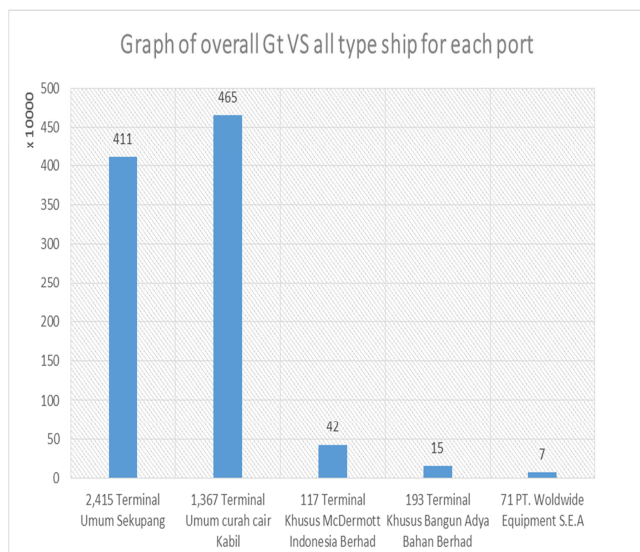


Figure 4.1: Graph of overall gross tonnage from all type of ship in each port

4.2 Total emission factor in ports

Emission factor from the data of authorities is based on the real values from several ports in Batam Island. NO_x, SO_x, HC, PM₁₀, CO and CO₂ in the list have already equated based on required unit and average time ship in port, such as PM₁₀ in µg/m³ and CO in ppm for average in 1 day.

Table 4.2: Air pollution results in ports

Port	Emission Factor					
	NO _x	SO _x	HC	PM ₁₀	CO	CO ₂
Terminal Umum sekupang	77.8	51.61	3.78	4.86	12.73	126,674.57
Terminal Umum Curah Cair Kabil	44.15	29.41	2.18	2.84	7.25	71,666.74
PT. Terminal Khusus McDermott Indonesia	14.8	9.85	0.73	0.94	2.43	22,294.40
PT. Terminal Khusus Bangun Adya Bahan	8.74	5.83	0.43	0.57	1.44	12,236.63
PT. Worldwide Equipment S.E.A	4.43	2.98	0.22	0.3	0.73	6,407.22

4.3 Estimated the rating of emission for future

The estimation of emission rating in air quality was taken according the real data that already obtain and explain before. Assumption that the increment for total ship berth in port is 10 percent for next year used to determine the high of the emission factor under limit that have been taken.

Results from Terminal Umum Curah Cair kabil will become the initial sample data. The reason that Terminal Umum Curah Cair Kabil is one of major port that operating in Batam Island for domestic and international, which assumption that number of ship come for future higher and accepted.

Table 4.3: The result forecast of emission rating per year

Year	No. Ship	Gross Tonnage	Increment (%)	Rating of Emission			
				NO _x	SO _x	PM ₁₀	CO
2013	1,367	4,654,774	-	44.15	29.41	2.18	7.25
2014	1,504	5,120,251	10	48.57	32.35	2.40	7.98
2015	1,654	5,632,277	10	53.42	35.59	2.64	8.77
2016	1,819	6,195,504	10	58.76	39.14	2.90	9.65
2017	2,001	6,815,055	10	64.64	43.06	3.19	10.61

In table 4.3, the increment in 10 percent of number ship in port per year gives the cargo load also increase.

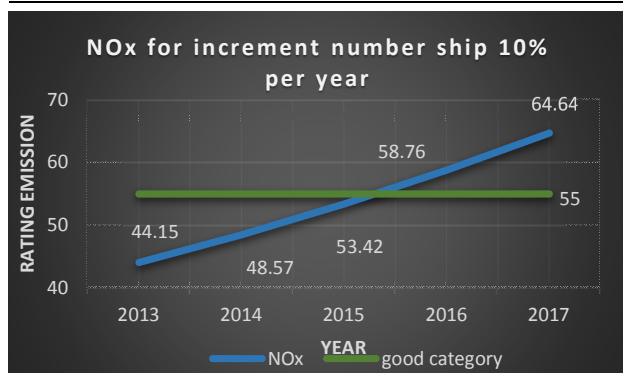


Figure 4.2: Emission rating for NO_x

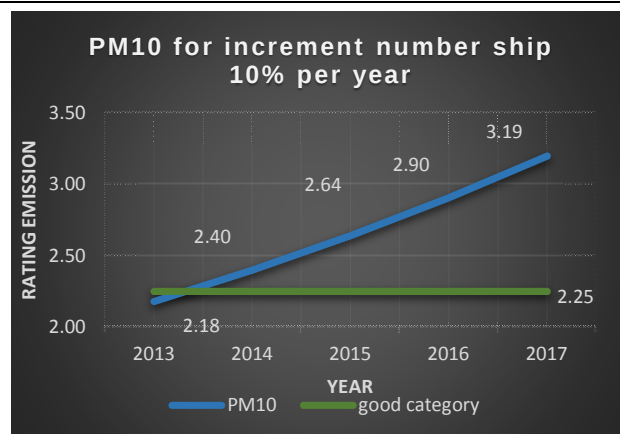


Figure 4.4: Emission rating for PM₁₀

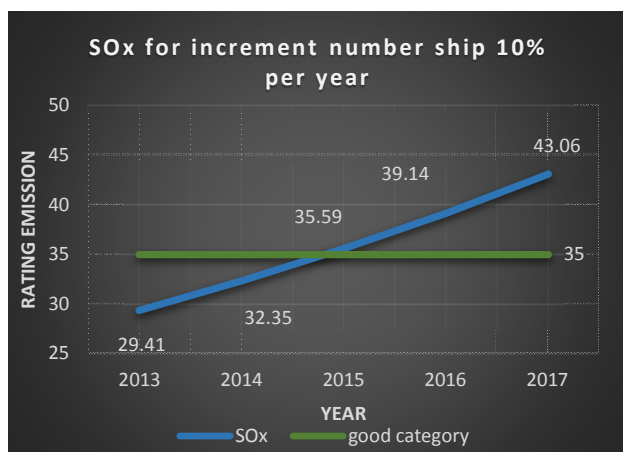


Figure 4.3: Emission rating for SO_x

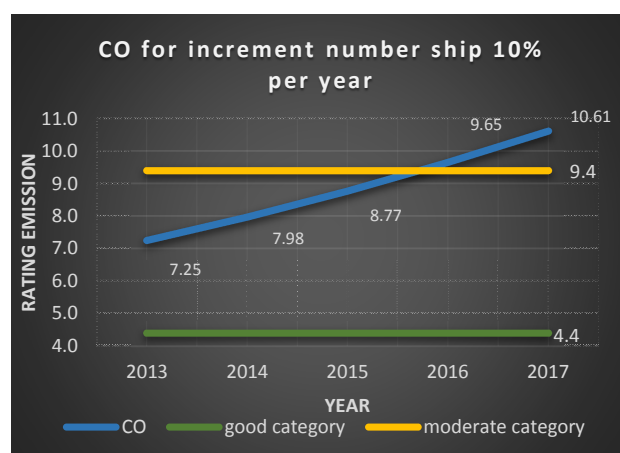


Figure 4.4: Emission rating for PM₁₀

NO_x, SO_x, and PM₁₀ based on the figure graphs shown the condition under good category in initial year 2013, NO_x and SO_x larger than AQI for good category during in year 2015 and for PM₁₀ have been increase into moderate category in year 2014. The good category for NO_x, SO_x, and PM₁₀ emission are under rate of 55 ppb, 35 ppm and 2.25 µg/m³.

From year 2013 until 2015, CO value still under moderate category with rate of emission in 9.4 ppm and from year 2014, the level of pollution predicted under unhealthy for sensitive group category since higher than 94 ppm.

4.4 Health risk from emission pollutions

From results for year 2013 to 2017, mostly the emission rating has predicting still under good and moderate category except CO emission under moderate and lightly pollute category.

Table 4.4: Effect of air pollution based on the AQI category
(source: Healthy Air Campaign)

Air Pollution	category	health effects based on category
<u>NO_x</u>	good	People with asthma or other respiratory diseases, the elderly, and children are the groups most at risk.
	moderated	Unusually sensitive individuals may experience respiratory symptoms.
<u>SO_x</u>	good	No health implications.
	moderated	People with asthma are the group most at risk.
PM10	good	People with respiratory disease are the group most at risk.
	moderated	Unusually sensitive people should consider reducing prolonged or heavy exertion and Unusually sensitive people should consider reducing prolonged or heavy exertion.
CO	moderated	People with heart disease are the group most at risk.
	Slightly unhealthy	Increasing likelihood of reduced exercise tolerance due to increased cardiovascular symptoms, such as chest pain, in people with cardiovascular disease.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this research is successfully achieved where the type and level of environmental impact for port operations has been managed. Throughout this research, the level of environmental impact caused by the port operations is still under control for several years.

Based on the results of the study, the information from this thesis included:

- The source data for this thesis is taken from ports in Batam Island, Indonesia, with cooperation from the authority from Universitas Politeknik Batam and permission from government of Indonesia.
- The rating of emission by shipping operation in area near port location predicted by increment total ship rise 10 percent per year with real source from year 2013.
- Level from several air pollution with comparison of AQI which estimated that the condition under good and

Problems; water pollution, erosion and other for minimize the case for future.

moderated category.

- Risk, such as disease in human body system, already listed for cause can be occur for year 2013 to 2017.

5.2 Recommendation

There are several recommendations have been made for further study in the future hence completing the environmental impact of port operations for sustainability. The author is suggested to improve the methodology to prepare appropriate framework model in assessing the environmental impact of the port for references. The data required for case study must have at least in five years for give the result more accurately. Moreover, the similar study can do with different impact in environment .

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