The impact of port traffic activities on noise level at Jakarta international container terminal I (JICT I) port of Tanjung Priok, North Jakarta

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Abstract. One of the largest and busiest ports in Indonesia that handles more than 30% of Indonesia's non-oil and gas commodities is located in Tanjung Priok. The purpose of this research is to analyze the noise level and compare it with the noise level standard by Ministry of Environmental regulations No. 48/11/1996 and analyze the noise levels from traffic activities in JICT I. The primary noise level data of \( \text{Leq} \) (Equivalent Noise Level) on sampling points number 9 at JICT I area was taken using the Sound Level Meter. Secondary data includes the schedule and type of incoming ships, as well as the JICT I Tanjung Priok Port layout. Sampling data was taken during 24 hours activities, which on daytime for 16 hours (06.00-22.00 WIB) and night time for 8 hours (22.00-06.00 WIB). The results showed a high level of noise almost occurred at all points, especially at night and the peak appeared on Saturdays which was with a noise range of 83-85 dB (A). The main noise source is caused by truck and container loading and unloading activities. Therefore, the conclusion is the noise level caused by JICT I Tanjung Priok activities has exceeded the noise level standard by Ministry of Environmental regulation No. 48/11/1996 and by Jakarta Governor’s Regulation No. 551/2001 which was 70 dB(A). The vehicle speed restriction and replacement of crane engine from diesel to electric has been implemented. However, it still have not been able to reduce the impact of the noise. An alternative that can be applied is to use a sound barrier or the construction of Onshore Power Supply (OPS).

Keywords: Noise Level, Port Noises, Environmental Noises

1. Introduction
Port facilities have diverse and complex activities so that activities carried out within the boundary have significant environmental impacts as a relevant source of pollution that must be considered for sustainable port development [1]. Noise is a common pollutant that can be generated from inside and outside the room. Noise affects life throughout the world. Outside sources can be linked to construction sites, road traffic, or noise generated from airplanes, trains, industries and factories etc. Noise in the room may have sources such as telephone, electricity and other equipment etc. Noise is a sound pollution which is the third most dangerous type of pollution, after air and water pollution in big cities. Noise pollution is the impact of urbanization and industrialization, vehicle traffic or increased vehicles in circulation and population, commercial activities, disturbing noise especially from the use of church’s public address system, social gatherings, marriages, and captive generation equipment [2]. Noise can affect health, interfere with activities, and interfere with normal cognitive processes. Over
the last few decades, mobility of people and goods has increased, which has increased the amount of traffic and environmental noise. So noise emissions from various transportation modes including seaports have become a major concern to environmental and governmental agencies [3]. Noise pollution derived from port activities can have serious affects to health, as well as annoyance for the citizens living nearby the port area and to the environment. In this sense, several studies have addressed the present regulatory framework regarding ship noise both in air and in water [4].

Noise sources in various sectors with different characteristics can be found in ports. Sources include ferries, ships and trade operations, industrial and shipyards as well as auxiliary services. Local populations, port workers and tourists as well as terrestrial and marine ecosystems are affected by these activities. In particular, the noise generated by ships has an impact inside and outside the ship itself on both crew workers, passengers as well as the surroundings areas. The assessment of the impact is currently difficult due to the lack of specific standard instruments and indicators able to characterize and control the ship noise [5].

Indonesia is a maritime country, one island separated from another by extensive ocean. Therefore, shipping has become an important sector in supporting social life, economy, government, defense and security, culture, and other activities. The port has several complex activities, this makes it an important source of pollution, especially when the port is located very close to a residential area, because in its daily life, the port also has links with local residents living around the port area. Ports management is needed to prevent causes of pollution where one of them is noise. The aim of the ports management is to create good conditions to support the function of the port and the surrounding environment. In Indonesia, noise level study in the port area can be said to be rarely found. The Government of Indonesia, through the Minister of the Environment, has established environmental noise standard regulations through Ministry of Environmental regulation Number 48 / MENLH / 11/1996 [6] which regulates the noise standard limits in residential areas or other public facilities. The port has several noise sources with several different characteristics, which are ship engines, trading operations, container operations and other activities. According to Suroto W, 2010 [7] there are basically three types of noise sources, which is point noise sources, field noise sources and line noise sources. Noise pollution can cause negative effect as to natural ecosystem or residential population and also to human health [1] because according to Buchari, 2008 [8], noise causes various disruptions to the workforce, such as psychological disorders, physiological disorders, communication disorders, and deafness.

The purpose of this research is to determine the intensity of noise caused by port activities both from motorized machinery and goods loading activities. The goal of this study are 1) measure the noise level at Jakarta International Container Terminal (JICT I) Tanjung Priok port using the Sound Level Meter tool and compare the results to noise level standards by Indonesian Minister of The Environment Regulation No. 48/11/1996 and Jakarta Governor’s Regulation No. 551/2001; 2) counts the noise level that sourced by JICT I activities; and 3) analyse the noise control efforts.

2. Research Method
In order to collect the field data, the location that would represent the port were selected. Data collection was conducted by two methods, which are the primary and secondary data. Primary data is the noise intensity data obtained by carrying out direct measurements in the field using a Sound Level Meter that was carried out for 24 hours. Whereas, the secondary data which includes the ship schedule and JICT I port layout in detail the location of the measurement points. There are nine measurement points that were selected, include JICT I West Berth, JICT I North Berth, JICT I Container Yard Area, and entrance gate. Noise measurement sampling points are shown in Table 1 and Figure 1.

The locations are spread around the port in order to give a reasonable sampling of the noise level [3]. The noise and activity data were collected from April 2019 to June 2019. This study was conducted with study area boundaries only concerning the JICT I. The noise level measurement was carried out for 1 day (24 hours) in a period of two weeks using a sound level meter measuring device by recording the maximum value of noise caused at the time of activity at the port and calculating the
index noise based on the Indonesia Minister of Environment Regulation No. 48 of 1996 concerning noise level standards.

Table 1. Noise Measurement Sampling Points

| Points Number | Location                     |
|---------------|------------------------------|
| 1-3           | JICT I West Berth            |
| 4-6           | JICT I North Berth           |
| 7-8           | JICT I Container Yard Area   |
| 9             | Entrance Gate                |

Figure 1. Noise Measurement Sampling Points

2.1 Environmental Noise Measurement

Based on the Indonesia Minister of Environment Regulation No. 48 of 1996 concerning Noise Level Standards that the measurement of environmental noise is carried out by recording data every 5 seconds for 10 minutes. Measurement time was carried out during 24-hour activity during the day, which was the highest level of activity for 16 hours at an interval of 6:00 to 22:00 WIB and nighttime activities at an interval of 22.00-06.00. Each measurement must be able to represent a certain time interval by setting at least 4 measurement times during the day and at night at least 3 measurement times.

Noise levels should be described as their average character or the statistical behavior of their variations because it can vary significantly over a short period. Usually, environmental sounds are described in terms of an average level that has the same acoustical energy as the average of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq} [9].

The noise level at minute 1 was calculated using the following equation [6]:

\[
L_{eq \, minute \, 1} = 10 \log \frac{1}{60} (10^{0.1 \times L_{1}} + \cdots + 10^{0.1 \times L_{12}}) \times 5 \, dB_{(A)}
\]  

(1)

L_{eq} is the fluctuating noise level (dB(A)), L_{1} is the noise level on the first 5 seconds (dB(A)), and L_{12} is the noise level at 60 (dB(A)).

The noise level at minute 10 was calculated using the following equation [6]:

\[
L_{eq \, minute \, 10} = 10 \log \frac{1}{60} (10^{0.1 \times L_{2}} + \cdots + 10^{0.1 \times L_{12}}) \times 5 \, dB_{(A)}
\]
Leq minute 10 = 10 Log $\left( \frac{1}{10} \left( 10^{0.1 \times L_1} + \ldots + 10^{0.1 \times L_{10}} \right) \times 1 \right) \text{ dB(A)}$ \hspace{1cm} (2)

$L_{eq}$ is the fluctuating noise level (dB(A)), $L_1$ noise level at the first minute (dB(A)), $L_{10}$ is the noise level at the 10th minute (dB(A)).

The noise level at the day was calculated using the following equation [6]:

$L_s = 10 \log \left( \frac{1}{16} \sum_{i=1}^{4} 10^{0.1 \times L_i} + T_4 \times 10^{0.1 \times L_4} \right) \text{ dB(A)}$ \hspace{1cm} (3)

$L_s$ is the $L_{eq}$ during the day (dB(A)), $L_1$-4 is the $L_{eq}$ 10 minute at the first until fourth segment dB(A), $T$ is the total measurement time (hour).

The noise level at the night was calculated using the following equation [6]:

$L_M = 10 \log \left( \frac{1}{8} \sum_{i=5}^{7} 10^{0.1 \times L_i} + T_7 \times 10^{0.1 \times L_7} \right) \text{ dB(A)}$ \hspace{1cm} (4)

$L_M$ is the $L_{eq}$ during the night (dB (A)) and $L_5$-7 is the $L_{eq}$ 10 minute at the fifth until seventh segment (dB(A)).

The noise level for one day (day and night) was calculated using the following equation [6]:

$L_{SM} = 10 \log \left( \frac{1}{24} \left( 16 \times 10^{0.1 \times L_5} + 8 \times 10^{0.1 \times (L_m + 5)} \right) \right) \text{ dB(A)}$ \hspace{1cm} (5)

$L_{SM}$ is the $L_{eq}$ during the day (dB(A)) and $L_m$ is the $L_{eq}$ during the night (dB(A)).

2.2 Noise Emission Caused by Traffic Activities

One of the main sources of the noise emission in ports was caused by traffic activities. Table 2 shows the vehicle noise emission as the function of speed that will be used for the noise calculation.

Table 2. Vehicle noise emissions dB (A) as a function of speed

| No | Vehicle Type | Speed (km/h) | 50  | 60  | 70  | 80  | 90  |
|----|--------------|--------------|-----|-----|-----|-----|-----|
| 1  | Motorcycle   | 60 dB (A)    | 62  | 64  | 67  | 68  |
| 2  | Sedan        | 63 dB (A)    | 65  | 70  | 72  | 74  |
| 3  | Microbus     | 73 dB (A)    | 77  | 78  | 82  | 83  |
| 4  | Bus          | 80 dB (A)    | 81  | 82  | 83  | 84  |
| 5  | Truck        | 83 dB (A)    | 83  | 84  | 85  | 86  |

The following equation is used to calculate the noise that caused by moving objects [6]:

$Leq (i) = Loe + 10 \log \left( \frac{N_i}{v \times T \times D} \right) + 10 \log \left( \frac{15}{D} \right) - 13$ \hspace{1cm} (6)

$Loe$ is the noise emission as a function of speed, $v$ is the vehicles speed (m/sec), $N$ is the numbers of vehicles, $D$ is the distance from vehicle to measurement point.

The following equation is used to calculate the total $Leq$ value [6]:

$Leq (total) = 10 \log \left( 10^{L_{1/10}} + 10^{L_{2/10}} + \ldots + 10^{L_{9/10}} \right)$ \hspace{1cm} (7)
Ln is the noise level (L1−Ln), Leq is the equivalent continuous noise level (dB(A))

3. Results and Discussion

3.1 Environmental Noise and Noise Emission Caused by Traffic Activities

After measuring over two weeks there was a similar result between the first week and the second week. The results of noise measurements at nine measurement points over two weeks the obtained noise level figures every week can be seen in Figure 2 and Figure 3.

Figure 2. Noise Level at Nine Measurement Points on Week 1

Figure 3. Noise Level at Nine Measurement Points on Week 2

Figure 2 shows the condition of the noise level at nine measurement points at week 1 of measurement (April 22 2019-28 April 2019). In general, the highest noise was observed on Thursday, Friday, until peaking on Saturday marked by the highest point tends to be on that day and then the noise level decreased on Sunday to Wednesday because of reduced activity at the port. While at point 9, where that point is the JICT entrance was observed that truck activities at that point tends to be constant. Compared to the first week, in the second week the tendency was almost the same as the first week. It can be seen in Figure 3 seems a little varied. However, it is still visible that the measurement
point with a relatively constant noise level is the same as the previous week's point 9, and the peak noise level was on Fridays and Saturdays.

Reviewing the two comparisons, high noise was observed at 6 points located on the west and north jetty due to truck and crane activities, while the lowest noise was observed on Sunday to Tuesday, which is at almost all points. Based on the results of these measurements, the reduction in noise occurring last Sunday would continue to rise until it peaks on Friday and Saturday. Then the noise would go down again on Sunday. This was due to heavy vehicle activity which tends to increase towards the end of the week.

Measurements made at nine measurement points also indicate a tendency for more crowded port activities to occur at night. It can be compared through Figure 4.

![Figure 4. Ls, Lm, and Lsm at Nine Measurement Points](image)

The equivalent continuous noise levels ($L_{eq}$), average sound levels for day-time, night-time and day-night times were all found to be higher than the permissible limit of 70 db(A) as prescribed by Indonesian Minister of Environment Regulation No. 48/11/1996 [6] and Jakarta Governor’s Regulation No. 551/2001 [13] (Figure 4). Furthermore, the total number of vehicular flow per day and the percentages of heavy vehicles also determine the noise levels in urban areas. As, the number of heavy duty trucks, buses and motor bikes increase, so also the noise levels. Noise is a function of the percentage of heavy duty vehicles i.e. the higher the heavy duty vehicle percentage, the higher the noise level [2].

Measurement made at nine measurement points indicate a tendency for more crowded port activities occur at night. Therefore, the workers who are exposed to the highest noise are shift 3, which are between 23.00 – 07.00. Referring to Jabodetabek Transportation Management Agency regulation, heavy vehicles may only operate above 22.00 hours. From Figure 4, it can be seen the results of these measurements that the activities of heavy vehicles such as container trucks were in accordance with regulations. It shows that the impact of the events on the equivalent level of the background noise is significant and has to be taken into account.

### 3.2 Correlation between Environmental Noise and Noise Emission Caused by Traffic Activities

The relationship between noise level and the number of motor vehicles passing at a point can be approached by linear regression [10]. In the regression model, the independent variable explains the dependent variable. In a simple regression analysis, the relationship between variables is linear, where changes in the X variable will be followed by changes in the Y variables permanently. Relationship of noise levels on the vehicle equivalent can be seen in Figure 5.
Figure 5. Relationship of Noise Levels on the Vehicle Equivalent Amount on Monday, April 22 2018, Week 1

From equation above, the value of $R^2$ is 0.9332 for Monday on the first week was obtained. With correlation coefficient ($R^2$) of 0.9332, it means that the number of vehicles had an effect of 93% on noise level. From the data and statistics, it is showed that the number of vehicles is closely related to the level of noise, but the number of vehicles does not only influence noise, but there are other factors that influence the background noise at each sampling location. This due to in that area, the noise that observed can also be caused by human activities in the area not only because of traffic factors.

Correlation analysis results showed that the equivalent sound level for the current parameters of transport flow (high intensity of traffic with significantly prevailing passenger vehicles in its structure) is influenced by total number of vehicles, while separate groups of vehicles (motorcycles, sedans, microbuses, buses, and trucks) have insignificant impact [11].

Equipment such as cranes, forklifts, but also trucks and vehicles for the maintenance of ports resulted an important step towards reducing noise levels. In terms of traffic noise, interventions aimed to pave the road surface with sound absorbing asphalt and set direction and speed limit signs along the roads to reduce traffic and limit traffic noise [5].

Vehicle speed greatly affects the high and low noise level. The faster the speed of vehicles, the higher the rate noise produced. In the port area especially JICT I, speed vehicles are limited tp 10 – 20 km/hour. The results of measurements of speed and amount vehicles at 3 western pier points and 3 northern pier points in week 1 can be seen in Table 3 and Table 4.

| Time Segment | Transportation Type | Number of Vehicles with Speed of 10 – 20 km/hour |
|--------------|---------------------|-----------------------------------------------|
|              |                     | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| L1           | Truck               | 2      | 1       | 3         | 3        | 5      | 4        | 3      |
| L2           |                      | 4      | 5       | 4         | 7        | 7      | 8        | 6      |
| L3           |                      | 7      | 6       | 7         | 8        | 10     | 9        | 7      |
| L4           |                      | 9      | 10      | 11        | 12       | 15     | 14       | 12     |
| L5           |                      | 12     | 11      | 12        | 14       | 13     | 11       | 9      |
| L6           |                      | 10     | 8       | 10        | 11       | 12     | 12       | 8      |
| L7           |                      | 6      | 5       | 6         | 8        | 8      | 7        | 4      |
| Total        |                     | 50     | 46      | 53        | 63       | 70     | 65       | 49     |
Table 4. Number of Vehicles at North Pier

| Time Segment | Transportation Type | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|--------------|---------------------|--------|---------|-----------|----------|--------|----------|--------|
| L1           | Truck               | 4      | 1       | 2         | 2        | 6      | 3        | 1      |
| L2           | Truck               | 6      | 3       | 3         | 5        | 9      | 8        | 4      |
| L3           | Truck               | 9      | 4       | 5         | 7        | 10     | 10       | 5      |
| L4           | Truck               | 10     | 8       | 9         | 11       | 16     | 13       | 8      |
| L5           | Truck               | 14     | 10      | 10        | 12       | 11     | 11       | 10     |
| L6           | Truck               | 12     | 6       | 8         | 10       | 9      | 11       | 7      |
| L7           | Truck               | 7      | 3       | 5         | 8        | 7      | 8        | 5      |
| Total        |                     | 55     | 35      | 42        | 55       | 68     | 64       | 40     |

As it is shown in Table 3 and Table 4, the highest number of vehicles was at night, which was in the 5 and 6 time segments. The most populous day was Friday and Saturday, because JICT I operations are full on that day. Using the data in Table 3 and Table 4, its is seen that the highest contribution of noise is from the truck activities.

3.3 Noise Maps for The Port

In making noise maps, the Surfer application is used. Surfer can be determined as a software used for making contour maps and three-dimensional modeling based on the grid. This software plots irregular XYZ tabular data into sheets of regular rectangular points (grids). Grid is a series of vertical and horizontal as a basis for forming three dimensional contours and surfaces. After calculating the average L<sub>SM</sub>, the noise points are then visualized in the range as in Figure 6. Noise level is based on

Figure 6. Overall Noise Map for Day and Night Period
the lowest and highest noise level which is then leveled with a range of 5 dB(A) in accordance with Minister of Environment Regulation No. 48 of 1996.

As illustrated in Figure 6, the noise at nine points was almost evenly distributed in range of 80 – 83 dB(A) and it was seen that all points of the noise level exceeded the standard set >70 dB(A) for the port area. The maximum noise distribution was at point 9 where at that point, there was constant truck activity in and out of the port area. The noise impact of the port container activities on high priority or sensitive areas can be evaluated by using the noise maps [5]. Traffic in JICT I is dominated by truck vehicles, because trucks are used to transport containers from ships or commonly called corgodoring activities. Traffic at JICT has a fluctuating level of crowd, most populated hours were at night around 21.00 until 03.00.

3.4 Methods of Protection from Noise
There are various methods for protection from external noise sources in the cities: engineering and administrative methods in the source of noise itself; city planning, construction and acoustic methods on the way of noise spread; design and construction (increase of soundproof qualities of enclosing structures) and planning methods at the noise protection object. Plants absorb sound well too. Even conifers allow reducing the level of automobile noise by 6-9 dB(A). Special methods of planting – in several rows – allow achieving positive results in combating noise. The best results are shown by combination of trees and bushes. However, according to the researches, plants are inefficient in combating low frequency noise. Therefore other measures should be taken for protection from truck noise, taking into account prevailing low frequencies in the sound of their engines [11].

JICT I already had some environmental protections such as changed several RTGC (Rubber Tyred Gantry Crane) from diesel power to electricity to virtually eliminate pollutant emissions and reduce the resulting expenditure to reducing air emissions and repairs; waste recycle has been applied to control the wastewater disposal, dangerous residues and other kind of waste; and the limitation of vehicle speed to control the noise level from truck machine.

According to Maria, 2013 [12], there are some steps can be done to reduce the noise level impact, some of them are soft driving to reduces noisy cargo handling operations by driving the vehicle slowly, lower driving speeds resulting in lower engine noise, soft working by working and handling the container cargo slowly, onshore power supply as an auxiliary engine replacement to generate electricity to the ship, and noise walls and barriers to prevent the noise propagation out of the port area.

The following recommendation should be taken into consideration for future port development or expansion which may result in excessive noise. These recommendations are classified as source mitigating measures, propagation measures, and receiver measure [9]:

- **Source mitigating measures** can reduce or eliminate noise directly at the source. Ships, trucks, and cargo handling equipment are the main sources of noises at container terminals. Examples of source mitigating measures for these noise sources are: installing insulation materials to sound intensive components; using absorbing building materials; using silent equipment (low noise versions cost little extra); slowing speed of putting down a container; instead of using diesel or diesel-electric moving equipment, use electrical; create a barriers by using tree.

- **Propagation measures** reduce or block the transmission of noise in its pathway from the source to receiver. Usually, by using physical barriers that attenuate or deflect the noise propagation this can be achieved. Also, by optimizing the terminal layout, reducing the driving distances for the cargo handling equipment, using container stacks as barriers, changing the work schedule, etc, the transmission of noise can be reduced.

- **Receiver measures** are considered to be passive measures and may be used in residential areas to shield the inhabitants from noise disturbances. The last option if the noise pollution cannot be reduced after using source and propagation measures are these passive measures. The
installation of passive noise control measures is based on calculated or measured outside noise levels.

4. Conclusion
The noise levels (24 hours) at nine measurement points showed high noise levels almost occur at all points, especially at night and peak on Friday and Saturday with a noise range of 83-85 dB (A). The higher vehicle volume, the higher noise will be caused and also the greater number of wheels from motor vehicles produces greater noise due to wheel friction against the road surface. Noise level equation caused by the traffic at the berth point 6 showed results of ≥70 dB(A). If the noise level compared to Jakarta Governor’s Regulation No. 551/2001 [7] and Indonesia Minister of Environment Regulation No. 48/11/1996 which is 70 dB(A) for sea port, then all of the measurement points is exceed the noise level standard. Controlling management to limit vehicle speed have been made by JICT, an additional alternative is to use OPS and to work smoothly and slowly in handling cargo so that impulse noise can be reduced.

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