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Reformulation of the Indonesian Air Quality Index Based on Field Measurement of Ambient Nitrogen Dioxide (NO_2)

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Abstract

One of the parameters of the Indonesian Air Pollution Standard Index (ISPU) is Nitrogen Dioxide (NO_2) with a minimum concentration of 1130 µg/Nm³ in ISPU 200. The objective of this research was to evaluate the minimum concentration of NO_2 in ISPU and determination the correct minimum concentration of NO_2 . This research was conducted from February until April 2020 by direct field measurement and analysis of secondary data compiled by a private company in Jakarta, Indonesia. The procedure to measure the NO_2 concentration was based on the national guideline, namely SNI 19-7119.2-2005. The range concentration of NO_2 in Jakarta, Bandung, Gresik, and Surabaya in 2016-2019 was 23-59 µg/Nm³. The maximum ISPU number in the three locations was only 10. This number was relatively low comparing to ISPU NO_2 minimum standard of 200. Based on data and toxicity study, the relevant concentration of NO_2 for ISPU 50 is 11-39 µg/Nm³, and for ISPU 100 is 40-85 µg/Nm³.

Keywords - concentration, Indonesian air pollution standard index, measurement, Nitrogen Dioxide, toxicity.

I. INTRODUCTION

Air pollution is the release of substances into the atmosphere, such as chemicals or particles in the air that are harmful to the health of living things and have become a significant problem in metropolitan cities because of pollution originating from the industrial sector, traffic density and global warming [1]. The adverse effects of air pollution on public health are evidence that forms the basis for setting stricter air quality standards to show ambient air quality in many countries [2].

Monitoring air quality is essential in determining the level of air health that will have an impact on living things in a country. The State of Indonesia has rules relating to the importance of air quality, which is contained in the Decree of the Head of the Environmental Impact Management Agency Number 107 the Year 1997 concerning Calculation and Reporting and Information on Air Pollution Standards Index. The parameters calculated in the ISPU rules are PM_{10}, SO_2, CO, O_3, and NO_2 (Bapedal 1997). Air quality is characterised by the categories divided according to the concentration of each parameter. The air quality category consists of good, moderate, unhealthy, very unhealthy, and dangerous categories. The air parameters on ISPU have the minimum concentration for the five parameters and are converted to ISPU numbers which are categorised into ISPU 50, 100, 200, 300, 400, and 500.

The NO_2 parameter has a difference compared to the four other parameters because it does not have a minimum ambient number at ISPU 50 and 100. The lowest NO_2 concentration is found in the ISPU 200 category with a minimum concentration limit of 1130 µg/Nm^3. The main concern of researchers is the lack of research on NO_2 parameters, and there has been no follow-up related to the evaluation of the minimum number of NO_2 . This study aims to determine the minimum number of NO_2 on ISPU parameters 50 and 100 that are suitable for toxicity, to measure NO_2 directly in Jakarta, Bandung and Gresik, and evaluate the minimum concentration of measurement results with the minimum NO_2 concentration on ISPU.

II. MATERIALS AND METHOD

II.I. Data Collection

There are two types of data used in this research, i.e. secondary data that were collected based on direct measurement during 2016-2019 in Jakarta, Bandung, Gresik dan Surabaya, and primary data that was also obtained by direct sampling in Gresik and Surabaya March 2020.

Direct measurement, as primary data was carried out in March 2020. The data collection is located around the industrial area, and traffic area in Java Island, Indonesia. The location for this research data is presented in Fig. 1. The instrument used in the direct measurement of Nitrogen Dioxide (NO_2) is impinger and absorbent solution. The analysis was carried according to Griess-Saltzman method by using a spectrophotometer.

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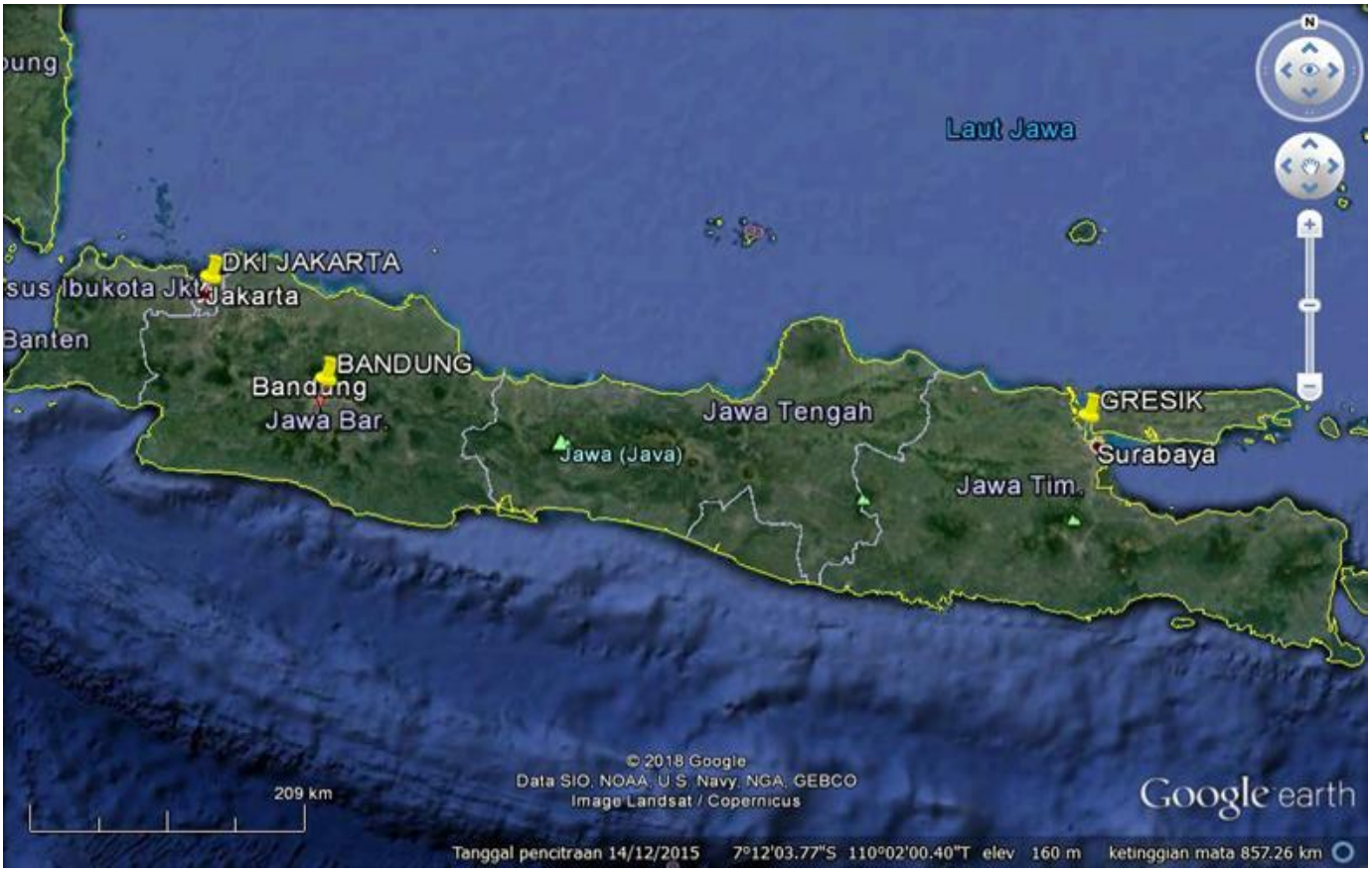

Figure 1. Map of research locations

II.II. Data Analysis

Nitrogen Dioxide (NO_2) concentration result of secondary data collection was collected and tabulated using *Microsoft Excel*. The data grouped by province's origin location. Next, data from each province is identified based on the maximum, minimum, and average number. The maximum and the minimum numbers from every province were used to calculate the ISPU number for NO_2 parameter, as presented in Eq. 1.

$$I = \frac{I_a - I_b}{X_a - X_b} (Xx - Xb) + Ib \quad (1)$$

Where:

I = the index for pollutant x

Ia = ISPU number corresponding with Xa

Ib = ISPU number corresponding with Xb,

Xa = mean breakpoint that is greater than or equal to Xx,

Xb = mean breakpoint that is less than or equal to Xx

Xx = the concentration of pollutant x or for in this case is the maximum and minimum numbers of NO_2.

The data is presented in graphical form to find out the NO_2 parameter in ISPU easily. Graphic data overlay contains ISPU number for maximum and minimum data. The primary data is obtained from the site also used for secondary data verification. Based on Indonesian Government Regulation Number 41/1999, monitoring data Nitrogen Dioxide (NO_2) parameter could be carried out for 1 hour, 24 hours or one-year duration.

III. RESULTS AND DISCUSSION

The concentration of Nitrogen Dioxide (NO_2) in secondary data is the result of monitoring in 2016-2019. Monitoring was carried out in three provinces, with a total sampling location point of 4781 and had a concentration ranging from 6-57 µg / Nm^3. The maximum, minimum, and average NO_2 concentrations are presented in Fig. 2.

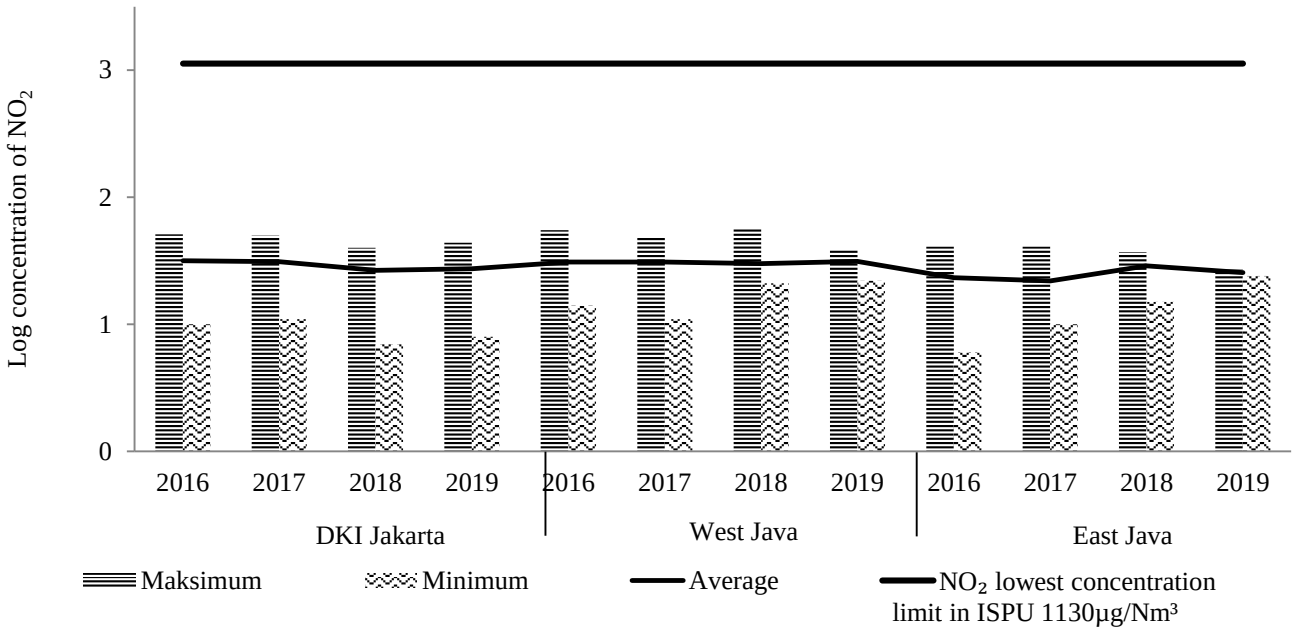

Figure 2. Monitoring result of NO_2 concentration in Java Island.

The graph is displayed in logarithmic scale since the differences between maximum concentration and the minimum limit in ISPU was too far. The maximum concentration of Nitrogen Dioxide (NO_2) from the secondary data is 57 µg/Nm³, while the minimum is merely six µg/Nm³, and the average is 28 µg/Nm³. On the other hand, the minimum concentration standard as stated in ISPU guideline is 1130 µg/Nm³. The primary data obtained from the direct sampling in Gresik and Surabaya is presented in Table 1.

Based on Table 1, Nitrogen Dioxide (NO_2) concentration collected from primary data survey lies in the range of 23.5-58.9 µg/Nm³. Nitrogen Dioxide in ambient air was sampled for one hour in every location. There was no significant different result between secondary and primary data for NO_2 concentration. Data collection on NO_2 concentrations in selected countries was also carried out using literature studies as presented in Table 2.

Table 1. The concentration of NO_2 in ambient air

No.	Location	Location code	NO_2 concentration (µg/Nm³)
1	Pos Pelabuhan	UA-1	24.8
2	Kantor Kelurahan Sidomoro	UA-2	58.3
3	Stadion Joko Samudro	UA-3	58.9
4	Jalan Perak Timur	UA-4	35.5
5	Jalan Jakarta	UA-5	44.4
6	Jalan Kenjeran	UA-6	23.5

Table 2. NO_2 concentration in selected countries

No.	Country	NO_2 concentration		Sampling location	Reference
		Original concentration	Expressed in μg/Nm³		
1	Malaysia	1-53 ppb	3-139	Langkawi Island	[3]
2	China	13-254 μg/Nm³	13-254	Sanghai	[4; 5; 6]
3	Iran	21.4-74.5 μg/Nm³	21-75	Teheran	[7]
4	Finland	0.2-25.2 ppb	1-66	Espoo	[8]
5	Romania	0.2-93 μg/Nm³	0.2-93	Galati and Braila	[9]
6	Denmark	25.1 μg/Nm³	25	Danish	[10]
7	Spain	25.9-84.6 μg/Nm³	26-85	Barcelona	[11]
8	Germany	27.6-53.3 μg/Nm³	28-53	Bochum, Essen	[12]
9	USA	11.7 ppb	31	Massachusetts	[13]
10	USA	33 ppb	86	New York	[14]
11	USA	12.6-20 ppb	33-52	California	[15]
12	Australia	8-71 μg/Nm³	8-71	Sydney	[16]

Based on Table 2, the concentration of NO_2 in several countries ranges between 0.2-254 μg/Nm³. All the concentration is lower than the minimum concentration on ISPU. ISPU refers to NAAQS that was made in 1976. However, based on the new literature and the result of Nitrogen Dioxide (NO_2) concentration measurement obtained are smaller than the minimum standard of ISPU. The minimum limit of ISPU number for NO_2 parameter is 200, while the ISPU number from the secondary and primary data presented in Fig. 3.

ISPU number from secondary data ranges between 1-10, which is the maximum concentration is 57 μg/Nm³. The ISPU number from the primary data is in between 4-10, which the maximum concentration is 58.93 μg/Nm³. As described in Fig. 3 and the ISPU number for primary data, the NO_2 ISPU on every location on Decree of Head Environmental Impact Control Agency Number 107/1997 is in a good category.

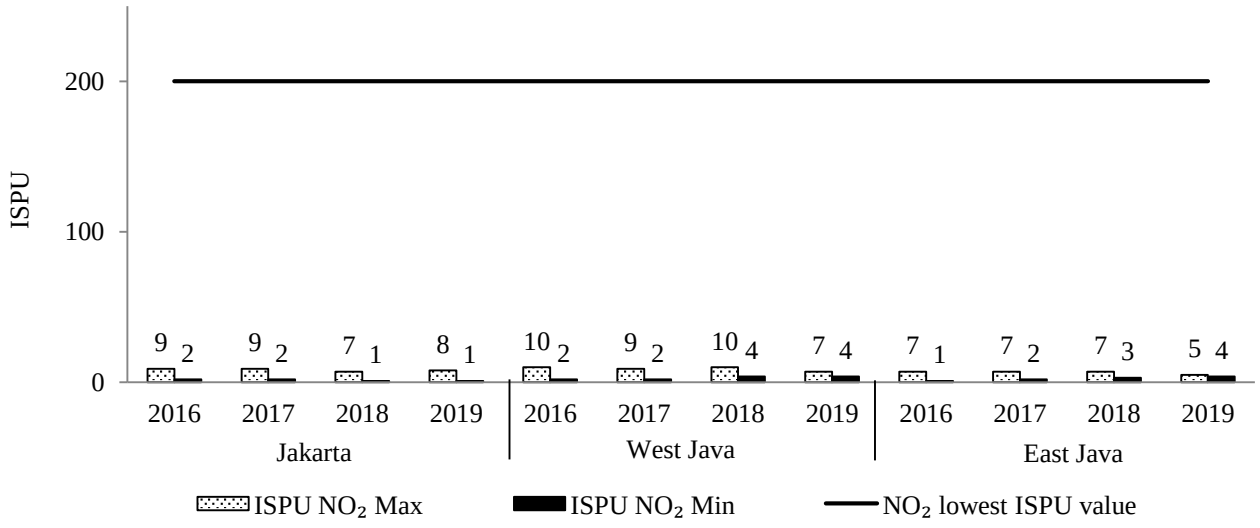

Figure 3. ISPU number obtained from NO_2 concentration in Java Island

According to Li et al. [5], NO_2 concentration of 31 μg/Nm³ did not cause headaches or asthma. In Barcelona, children aged 7-10 years who are exposed to ambient air with NO_2 concentrations of 25.9-84.6 μg/Nm³ will affect metabolism, respiratory problems, and can trigger inflammation in the brain [11]. According to Schikowski and Altug [17], respiratory problems and adverse effects on cognitive decline can occur if humans are exposed to NO_2 concentrations of 52 μg/Nm³. NO_2 concentration of 31-49.81 μg/Nm³ can induce disruption of lipid metabolism in animals [18]. According to Sheng and Zhu [18], plants exposed to NO_2 more than 18.8 μg/Nm³ will cause damage to plants, and plants cannot survive.

IV. CONCLUSION

The concentration of Nitrogen Dioxide (NO_2) from the monitoring data in Jakarta, Bandung, Gresik and Surabaya on 2016-2019 is in the range between 6-57 μg/Nm³, and the concentration based on the primary data in Gresik and Surabaya is in the range between 25-58,93 μg/Nm³. The maximum number for each data is 10, which are far lower than the minimum ISPU number for NO_2 parameter. Based on the toxicity study of NO_2 , the relevant concentration of NO_2 for ISPU 50 is 11-39 μg/Nm³, whereas for ISPU 100 is 40-85 μg/Nm³.

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