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EVALUATION OF NITROGEN DIOXIDE (NO2) CONCENTRATION AND CALCULATION IN INDONESIAN AIR POLLUTION INDEXING SYSTEM

Ria Andriani[1], Arief Sabdo Yuwono[2], Sigid Hariyadi[3]

Abstract- Indonesian air pollution indexing system namely ISPU is stipulated as Head Decree of Environmental Impact Control Agency Number 107 Year 1997 about Calculation and Reporting on Information of Air Pollution Standard Index (ISPU). All parameters in the index has its own concentration range for every Air Pollution Standard Index number ranging from 0 to 500, except for nitrogen dioxide parameter that takes range from 200 to 500 of the Air Pollution Standard Index number with 1130 µg/m3 as minimum concentration. In this research, measurement and evaluation of ambient air quality for nitrogen dioxide concentration is using secondary and primary data from some area in indonesia. Nitrogen dioxide parameter was evaluated for the adaptation of National Ambient Air Quality Standards to air pollution indexing system in Indonesia. This research describe about maximum nitrogen dioxide concentration data that collected from oil and gas processing facilities in Indonesia at a couple of years. The research indicated that nitrogen dioxide parameter does not give significant contribution for Air Pollution Standard Index status in Indonesia. The determination of an Air Pollution Standard Index status was based on the most dominant parameter, while nitrogen dioxide was never as determiner for it. Maximum number of Air Pollution Standard Index for nitrogen dioxide was 33, while the minimum standard is 200. Range for maximum concentration from monitoring data in Indonesia was merely 2 to 187 µg/m3 and it was similar to some research carried out in in other counties with 0.4 – 150 µg/m3. The toxicity evaluation of nitrogen dioxide parameter from selected literatures indicated that, there is effect to individual with asthma at concentration between 99.64 – 564 µg/m3. Indonesian authority need to reconsider standard for nitrogen dioxide parameter to determine Air Pollution Standard Index. The adaptation of National Ambient Air Quality Standards to Air Pollution Standard Index in Indonesia should consider the need of a study that appropriate to Indonesian conditions. This research could be an input for Indonesian government regulation in air pollution indexing system, especially for nitrogen dioxide parameter. The summarised data of nitrogen dioxide concentration and Air Pollution Standard Index status could be the first input to it.
Keywords – Air Pollution Standard Index, Evaluation, Monitoring Data, Nitrogen Dioxide

1. INTRODUCTION

Air pollution nowadays takes many attention from the world and become critical issue that is related to global environment. Li et al. (2015) stated that air pollution remains a critical global problem. Gorai et al. (2015) reported that it gives big effect to human health population. Air pollution become one of the important pollution aspect that affect to human and any other organisms. Air pollution index is one of the tools that can be a reference to measure, calculate and determine air pollution in particular condition.

Many countries or institutions are already developing air pollution index such as; United States of America/USA (National Ambient Air Quality Standard/NAAQS), China (Individual Air Quality Index/IAQI), Canada (Air Quality Health Index/AQHI), etc. (EPA 1976; Li et al. 2017; Kanchan and Goyal 2015). Indonesia as developing country with many industries and populations, also has an air pollution index in the form of government regulation. Air pollution index in Indonesia referred to Decree of Head Environmental Impact Control Agency (EICA) Number 107 Year 1997 about Calculation and Reporting also Information of Air Pollution Standard Index (ISPU). Indonesian Air pollution indexing system is an adaptation of USA standards that is NAAQS.

The air quality parameters on the ISPU includes NO2, SO2, O3, CO, and PM10. Almost all parameter in the index has its own concentration range for every ISPU value from 50 to 500, except for NO2 parameter that only has range concentration starting from 200 to 500 ISPU score. Range concentration for NO2 parameter also jump from 0 µg/m3 to 1130 µg/m3 for ISPU score 200, while the maximum peak for ISPU score 500 is at 3750 µg/m3. This condition was the same as it reference that is NAAQS.

The adaptation of other country standards or regulations must be assessed through studies that appropriate to specific country conditions. This research is an evaluation for the adaptation of NAAQS to air pollution indexing system in Indonesia,

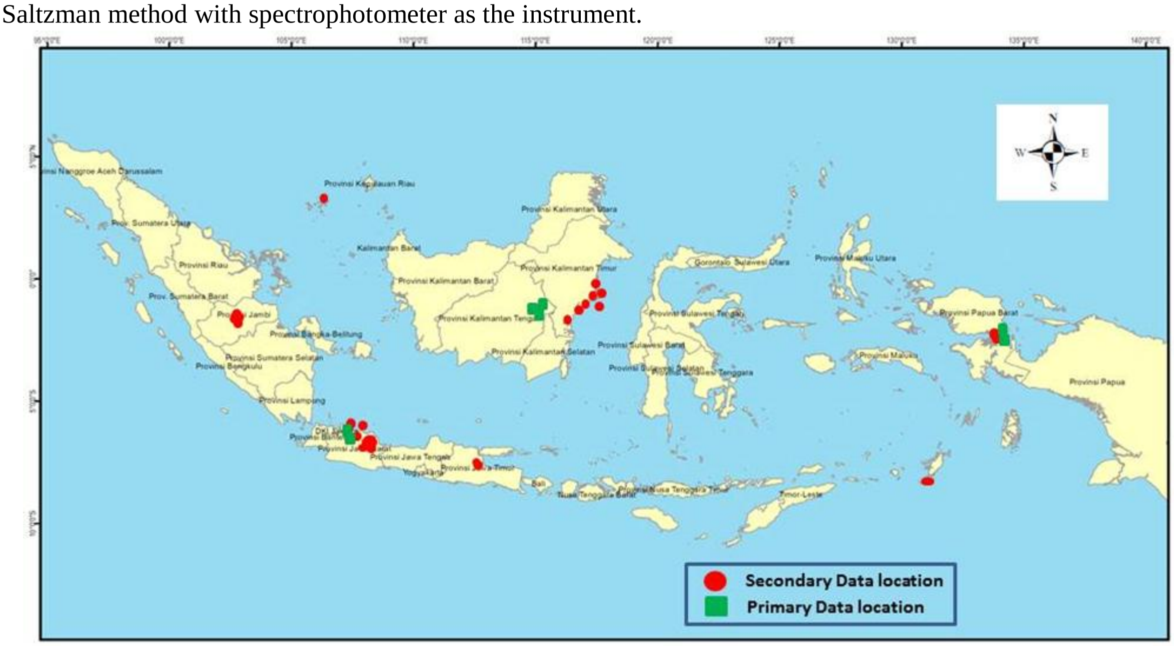
[1] Natural Resources and Environmental Management Studies Program, Bogor Agricultural University, Bogor, Indonesia
[2] Department of Civil and Environmental Engineering, Bogor Agricultural University, Bogor, Indonesia
[3] Department of Aquatic Resources Management, Bogor Agricultural University, Bogor, Indonesia

especially for the concentration of NO2 parameter. In this research the maximum NO2 concentration in Indonesia was described from air monitoring data of selected places in Indonesia at a couple of years. Roy et al. (2010) stated that monitoring and evaluation of ambient air quality is one of important step to control air pollution. Obligation of ambient air quality monitoring in Indonesia which refers to Government Regulation Number 41 year 1999 on Air Pollution Control, is an industry benchmark for monitoring ambient air quality. Unfortunately, air quality monitoring data in each industry is relatively widespread in each industry or institution.
Selection of nitrogen dioxide parameter for this research because not many or it is very less journal publication about NO2 parameter and it connection with the air pollution index especially in Indonesia. Ragettli et al. (2014) reported that NO2 is a marker for traffic related outdoor air pollution parameter. Nitrogen dioxide is also one of the primary ambient air pollutant. Steinle et al. (2013) stated that air quality is affected of pollutant such as nitrogen oxide (NOx), particulate matter (PM), carbon monoxide (CO) and ground level ozone (O3). As the main air pollutant, the rules that governing nitrogen dioxide parameter must be clear and appropriate to the conditions of a country.
Objectives of the research are as follows; (1) Evaluation of the adaptation of NAAQS for air pollution indexing system in Indonesia; (2) Evaluation of nitrogen dioxide number index at ISPU for concentration less than 1130 µg/m3; and (3) Toxicity evaluation of nitrogen dioxide parameter for concentration less than 1130 µg/m3.

2. METHODS

2.1 Data Collection

Indonesia as a tropical country only has two seasons, namely dry and rainy season. Secondary data used for this research is not limited to dry season or rainy season, but all season data. Secondary data collection for this research was from Jambi Province, West Java Province, East Kalimantan Province, East Java Province, Riau Islands Province, Maluku Province, and West Papua Province. This research using 2 (two) to 10 (ten) years monitoring data from several area in Indonesia. Jambi Province from 2008 - 2016, West Java Province from 2008 - 2017, East Kalimantan Province from 2005 - 2014, East Java Province from 2010 - 2014, Riau Islands Province years 2006 and 2008, Maluku Province from 2011 - 2012, and West Papua Province from 2017 - 2018. Primary data collection was conducted in DKI Jakarta Province, West Java Province, Central Kalimantan Province, and West Papua Province. Survey for primary data sampling for this research was around October 2017 until March 2018. Monitoring data collection is generally located at oil and gas processing facilities in Indonesia. The location of research data is presented in Figure 1.
The Location of Research Area- Selection of each primary data sampling location is done intentionally (purposive). The primary data sampling locations represent some of the major islands in Indonesia, as well as secondary data locations. Nitrogen dioxide primary data sampling from each location are using impinger and absorbent solution. The analysis are using Griess Saltzman method with spectrophotometer as the instrument.



2.2. Analysis Data

The evaluation for nitrogen dioxide concentration on this research was by collecting secondary data that can represent Indonesian area. Monitoring data of parameter NO2, CO, SO2, O3, and PM10 were tabulated using Microsoft Excel. The data then grouped based on each province's origin location. Next, the data from each province were screened to identify the maximum number from every area, with equation:

x = Max (x1, x2, x3,…xi) (1)

Where x is maximum monitoring data of pollutant x and i means sequence data. The maximum number of every location in each province then go into equation number (2) to calculate the ISPU score for all parameters. Next, the determination of ISPU score using the most dominant parameter by calculating ISPU score from all parameters. The equation is:

$$I = \frac{I_a - I_b}{X_a - X_b}(X_x - X_b) + I_b \quad (2)$$

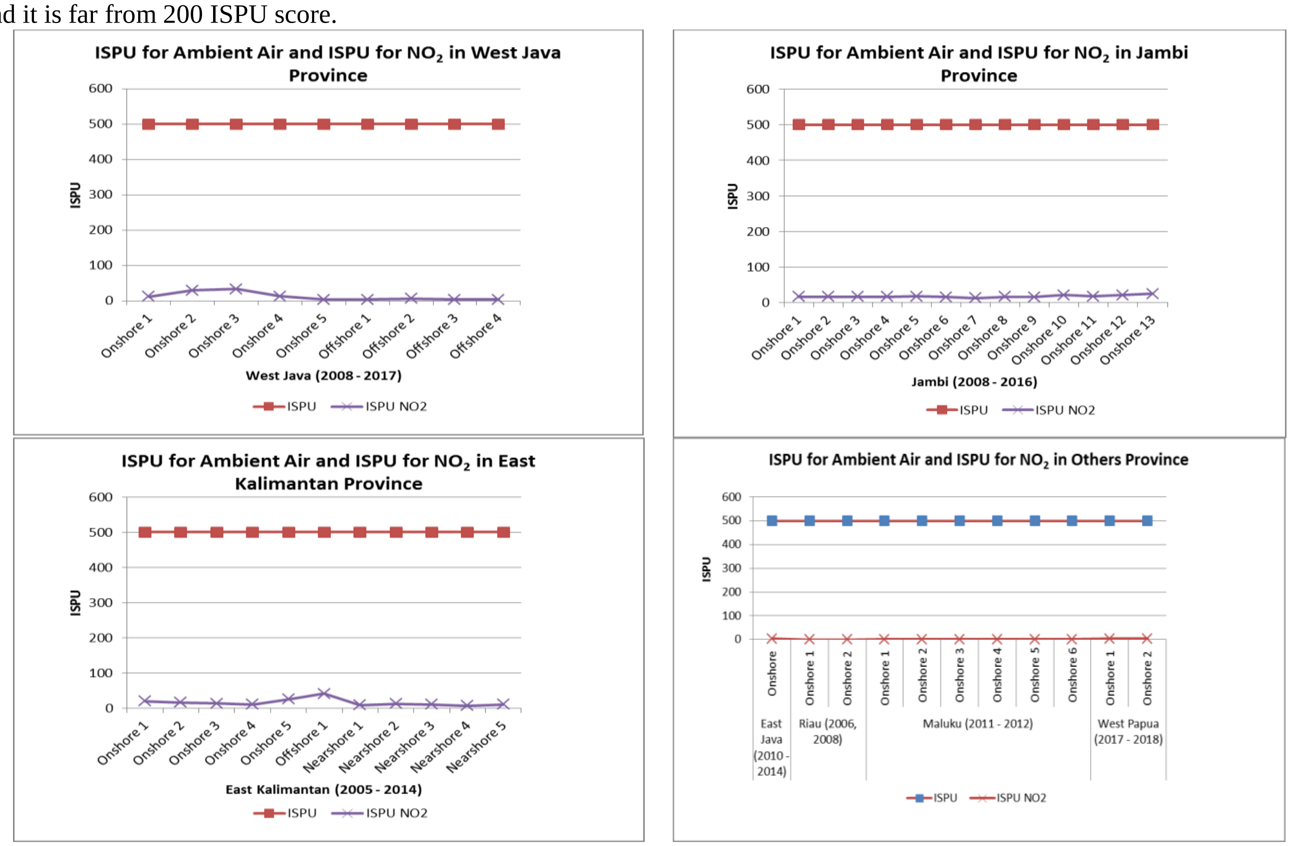
Where I is index for pollutant x, Ia is ISPU score corresponding with Xa, Ib is ISPU score corresponding with Xb, Xa is mean breakpoint that is greater than or equal to Xx, Xb is mean breakpoint that is less than or equal to Xx, and Xx is rounded concentration of pollutant x or for this research is the maximum number of pollutant x.

The data is then presented on the graph. Representing data by graphics are meant to easily see the most dominant parameter that represented ISPU and to determine nitrogen dioxide parameter position in the ISPU. Graphic data overlay will contain ISPU score for parameter dominant, ISPU score for NO2 parameter and the maximum concentration of NO2. ISPU calculation for nitrogen dioxide parameter are using the maximum data. The calculation are needed to see nitrogen dioxide parameter contribution for an ISPU. The primary data that is obtained from site also be used for secondary data verification.

For ISPU status data calculation there are parameter that converted, such as parameter sulphur dioxide and carbon monoxide. Parameter sulphur dioxide originally monitored for 1 hour, though even there is data that monitored for 24 hours. Data monitoring for ISPU of sulphur dioxide parameter is 24 hours and to obtain that requirement, 1 hour data then converted into 24 hours. Meanwhile, carbon monoxide parameter also converted to 8 hours as part of requirement from 1 hour and 24 hours data monitoring. Based on Indonesian Government Regulation Number 41 Years 1999, monitoring SO2, CO, and NO2 parameters should be done for 1 hour, 24 hours or 1 year duration, while for O3 is monitored for 1 hour or 1 year.

3. EXPERIMENT AND RESULT

Nitrogen dioxide parameter in Indonesia, from all the research data does not give big contribution for an ISPU status. Carbon monoxide takes the lead mostly from all others parameters as the dominant. The minimum ISPU score is 200 for nitrogen dioxide parameter, even hard to reach it. As shown in the graphic in Figure 2, the maximum ISPU for nitrogen dioxide is 33 and it is far from 200 ISPU score.



Comparation ISPU Calculation for Ambient Air and ISPU for Nitrogen Dioxide Parameter in West Java, Jambi, East Kalimantan, and Other Provinces In Indonesia

Concentration of nitrogen dioxide monitoring data in Indonesia, that was used in this research was in range of 2–187 µg/m3. The maximum concentration from all data monitoring for several years shown in Figure 3. On the graph, nitrogen dioxide concentration is delivered in the form of logarithm, because the gap between the minimum standard and the maximum concentration obtained was too far. The maximum nitrogen dioxide concentration from secondary data is 187 µg/m3, while the minimum concentration standard of ISPU is 1130 µg/m3.

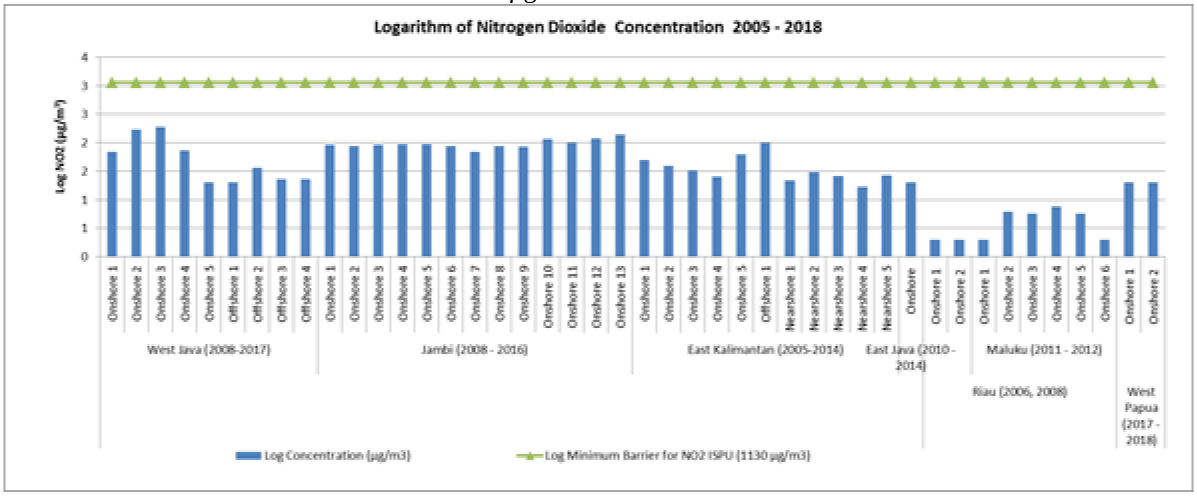


Figure 3. Monitoring Maximum Nitrogen Dioxide Concentration in Indonesia From 2005 – 2018

To verify the monitoring data in Figure 3, it was also decided to take sampling in several area as primary data survey. The result nitrogen dioxide concentration from primary data survey were all <20 µg/m3 (Table 1). There were no different result between primary and secondary data for nitrogen dioxide parameter. Nitrogen dioxide parameter in ambient air was sampled for 1 (one) hour in every location. Nitrogen dioxide parameter was detected at very low concentration, mostly under 20 µg/m3 in Jakarta, West Java, Central Kalimantan and West Papua. Monitoring times ranging from October to March are usually dominated by the rainy season that could be a cause of low concentrations of nitrogen dioxide.

Table -1 Nitrogen Dioxide Concentration from Primary Data Survey

No	Location		1 hour Concentration of NO2 (µg/m3)
1	Jakarta (Feb 2018)	Onshore 1	<20
2		Onshore 2	<20
3		Onshore 3	<20
4	West Java (Jan - March 2018)	Offshore 1	<20
5		Offshore 2	<20
6		Offshore 3	<20
7		Offshore 4	<20
8		Onshore 1	<20
9		Onshore 2	<20
10		Onshore 3	<20
11		Onshore 4	<20
12		Onshore 5	<20
13		Onshore 6	<20
14	Central Kalimantan (Oct 2018)	Onshore 1	<20
15		Onshore 2	<20
16		Onshore 3	<20
17		Onshore 4	<20
18		Onshore 5	<20
19		Onshore 6	<20
20	West Papua (Feb 2018)	Onshore 1	<20
21		Onshore 2	<20

4. DISCUSSION

Based on the monitoring data from this research, nitrogen dioxide concentration in Indonesia were in the range of 2 to 187 µg/m3. Secondary data monitoring result were also verified by the primary data, the nitrogen dioxide concentrations were in the same range. Concentration of nitrogen dioxide parameter in some other countries as presented in Table 2 were ranged between 0.4– 150 µg/m3. The concentration range are almost similar to the monitoring data that is presented in this research.

Table -2 Nitrogen Dioxide Monitoring Data from Selected Countries

No	Country	NO2 Concentration	Conversion (µg/m3)**	Measurement	Sampling Location	Reference
1	Belgium	13.1 – 26.9 µg/m3	13.1 – 26.9 µg/m3	-	Wallonia, Belgium	Collart et al. 2018
2	Canada	LOD* - 9.1 ppb	LOD – 17.1 µg/m3	Continuous passive sampler	Near to oil and gas industry in British Columbia	Islam et al. 2016
		0.2 – 18.1 ppb	0.38 – 34 µg/m3	Continuous passive sampler	Alberta	Bari et al. 2015
3	Japan	0.021 – 0.080 ppm	39.5 – 150.4 µg/m3	Daily average hourly value	Shinjuku City, Tokyo	You et al. 2017
4	France	19.3 µg/m3	19.3 µg/m3	Annual mean	French national electricity and gas company	Bentayeb et al. 2015
5	Germany	11.5 – 62.8 µg/m3	11.5 – 62.8 µg/m3	Annual average	No information	Fuertes et al. 2016
6	Italy	32.28 – 66.35 µg/m3	32.28 – 66.35 µg/m3	Hourly average	Urban city in Catania	Rosario and Francesco 2016
7	Massachusetts	7.9 – 15.8 ppb	14.9 – 29.7 µg/m3	Annual average	Urban area	Rosofsky et al. 2018
8	Vietnam	45.3 – 54.4 µg/m3	45.3 – 54.4 µg/m3	24 hours	Urban area	Nhung et al. (2018)
9	Brazil	1.1 – 21 µg/m3	1.1 – 21 µg/m3	Continuous passive sampler	Urban and forest area in Rondonia, Salvador, Curitiba	Campos et al. 2010

NOTE: *LOD = Limit of detected; **Conversion from ppb to µg/m3 are using WHO conversion factor, 1 ppb NO2 = 1.88 µg/m3 at 25 oC and 1013 mb (DEFRA 2018)

Li et al. 2017 reported that air pollution index in China called as Individual Air Quality Index/IAQI, parameter NO2 has its own index starting from 0, 50, 100, 150, 200, and 500. Meanwhile in Indonesia, minimum threshold for nitrogen dioxide parameter on ISPU score of 200 or equal with NO2 concentration of 1130 µg/m3 maybe need to reconsider. Contribution of nitrogen dioxide for an air pollution index calculation was rare, and it is necessary to see the update toxicology evaluation of nitrogen dioxide concentration on human health. When a dominant parameter become a decision of ISPU status, one needs to see whether it can represent any other parameters and give safety feeling to human being who can access it. It means that the critical parameter that shown as ISPU status is the parameter that one should pay more attention.

Belanger et al. (2013) stated that kids with asthma that exposed to NO2 indoors at low level standard (53 ppb), is at risk for increased asthma morbidity. Ezratty et al. (2014) corroborates Belanger et al. (2013) statement by reporting that repeated peak of NO2 at certain concentration without allergen exposure can increase airway inflammation in asthmatics. Brown (2015) reported that NO2 gives relevant effect clinically and significant statistically to airway responsiveness of individual with asthma that exposed while rest. Exposure NO2 to individual with asthma happen about 70% increase in non-specific airway responsiveness at range concentration 200 – 300 ppb for 30 minutes and at concentration 100 ppb for 60 minutes (Brown 2015). Based on that findings, nitrogen dioxide parameter affect to individual with asthma at level 53 ppb or 99.64 µg/m3 at indoor and at level 100 ppb or 188 µg/m3 for 60 minutes outdoor while rest or 200 – 300 ppb or 376 – 564 µg/m3 for 30 minutes outdoor while rest. Conversion from ppb to µg/m3 is based on WHO conversion factor, where 1 ppb NO2 = 1.88 µg/m3 at 25 oC and 1013 mb (DEFRA 2018).

5. CONCLUSION

Conclusion from the evaluation that presented in this research is; (1) this research coud be an input to Indonesian government regulation in air pollution sector or air pollution indexing system, especially for nitrogen dioxide parameter. Adaptation of NAAQS for air pollution indexing system in Indonesia should be followed with appropriate study that represented Indonesian condition. The summaries data of nitrogen dioxide concentration and ISPU status in Indonesia, could be the first input to it. (2) The maximum nitrogen dioxide concentration data was much less the minimum limit (1130 µg/m3), suggesting that the limit is too high for Indonesian reference. (3) The toxicity evaluation of nitrogen dioxide parameter from some literatures is also indicates that there is effect to individual with asthma at concentration between 99.64 – 564 µg/m3.

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