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Evaluation of the Air Pollutant Standard Index (ISPU) parameter concentration limits in industrial estates on Java Island

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Abstract. *Due to the harmful effects of air pollution on health, outdoor air pollution standards are getting stricter. Because of environmental changes, the Minister of Environment and Forestry Regulation No. 14/2020 must reevaluate the concentration limits for ISPU parameters. This study aimed to examine the concentration ranges and ISPU values for SO_2, NO_2, CO, O_3, and PM_{10} in industrial estates on Java Island, and set concentration limits for five relevant ISPU parameters based on the results of monitoring, sampling, and toxicity studies. A drop in the average concentration of the five ISPU parameters in 2022 compared to monitoring from 2015 to 2019 shows that the air quality in industrial estates on Java Island is improving. The ISPU values between 10 and 56 are in the good-to-moderate range, which means that the air quality is still good enough for the health of humans, animals, and plants. The relevant concentration limit recommendations for ISPU in good-to-moderate categories for SO_2, NO_2, CO, O_3, and PM_{10} were 42–77 $\mu g/Nm^3$, 29–120 $\mu g/Nm^3$, 3519–5037 $\mu g/Nm^3$, 33–97 $\mu g/Nm^3$, and 29–82 $\mu g/Nm^3$, respectively. The results of this study can be used to improve Indonesia's ambient air quality index system (ISPU).*

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INTRODUCTION

Air pollution is a global environmental problem that is attracting significant attention worldwide. Li et al. (2015) stated that air pollution is a critical global health problem. World Health Organization (WHO) data show that ambient air pollution contributes to 7.6% of all deaths and is responsible for 4.2 million deaths worldwide (WHO 2016). Rapid urbanization has increased the number of motorized vehicles, and industrial growth has seriously affected human life and the environment (Shrivastava et al. 2013). In 2021, Indonesia's population reached 272 million, representing a growth rate of 1.22 % (BPS 2022). Gorai et al. (2015) state that air pollution affects the health of a large proportion of the urban population. Emissions from industrial chimneys and motorized vehicles generally influence the decline in air quality in urban areas. Based on data from the Central Bureau of Statistics, there was an increase in medium and large industries by 1,225

manufacturing companies in Indonesia from 2018 to 2019 (BPS 2021). The growth rate of motorized vehicles also contributes significantly to air pollution (Darmawan 2018).

The number of motorized vehicles in Indonesia from 2019 to 2021 has increased by 7%, which is equivalent to more than 10 million motorized vehicles (BPS 2022). The concentrations of traffic-related air pollutants, such as NO_2, PM_{10}, and CO, are higher in urban areas (Physick et al. 2011). The concentrations of NO_2, SO_2, PM_{10}, and CO on roadsides in urban areas in Indonesia in 2019 were 4–86 μg/Nm^3, 8–108 μg/Nm^3, 18–128 μg/Nm^3, and 113–6,313 μg/Nm^3, respectively (KLHK 2020). Several studies have shown adverse effects of SO_2, NO_2, CO, O_3, and PM_{10} on health. PM_{10} can enter the respiratory tract and cause respiratory and cardiovascular diseases (Momtazan et al. 2018; Bodor et al. 2021). There is an effect on individuals with asthma with exposure to NO_2 concentrations of 99.64–564 μg/Nm^3 (Andriani et al. 2018). Short-term exposure to ambient CO of 8 mg/m^3 significantly increases cardiovascular risk, especially heart disease in Beijing, China (Li et al. 2018). SO_2 is a critical air pollutant owing to the high use of fossil fuels in industry, and the average concentration of SO_2 from monitoring for nine years in Japan is 157 μg/Nm^3 (You et al. 2017). The relative risk of mortality from respiratory disease caused by an increase in O_3 concentrations of 20 μg/Nm^3 over the past 18 years in the United States is 0.23–6.6% (WHO 2006; Wang et al. 2019).

Monitoring and evaluating ambient air quality is an essential step in controlling air pollution. Therefore, an index for determining the air quality is necessary (Roy et al. 2010). The ISPU, also known as the Air Pollutant Standard Index, was previously governed by Decree Number 107/1997 of the Head of the Environmental Impact Management Agency regarding the technical guidelines for calculating and reporting ISPU information. The ISPU accounts for five (5) parameters: particulate matter (PM_{10}), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3). The latest regulations regarding ISPU are stipulated in the Minister of Environment and Forestry Regulation Number 14/2020 (PerMen LHK No. 14/2020), with the addition of two (2) other parameters: particulates ($PM_{2.5}$) and hydrocarbons (HC), as well as changes in the concentration limit of five other parameters. The final ISPU value was determined based on the dominant parameter, which had the highest ISPU equivalent value among the seven (7) existing parameters (PerMen LHK 2020).

The five categories of ISPU values indicate the quality of ambient air: good (0–50), moderate (51–100), unhealthy (101–200), very unhealthy (201–300), and hazardous (> 300). The adverse effects of ambient air pollution on human health have led to increasingly stringent outdoor air pollution standards. In Indonesia, the Air Pollutant Standard Index (ISPU) adopts the National Ambient Air Quality Standards (NAAQS) developed by the United States Environmental Protection Agency (USEPA) as a benchmark for ambient air quality. Environmental changes necessitate further research regarding the concentration limits for the ISPU parameters in the Ministry of Environment and Forestry Regulation Number 14/2020. Moreover, to date, a limited number of comprehensive reviews or evaluations have been conducted in Indonesia on the designated ISPU parameters. This study provides an overview of the ambient air quality related to five ISPU parameters on Java. This study aimed to evaluate the concentration ranges and ISPU values of SO_2, NO_2, CO, O_3, and PM_{10} in ambient air in industrial estates on Java Island and determine the concentration limits for five relevant ISPU parameters based on a compilation of monitoring results, direct measurements in the field, and toxicity studies of ISPU parameters.

METHODS

Research Location and Time

Field research with sampling of five ISPU parameters (SO_2, NO_2, CO, O_3, and PM_{10}) was carried out on September 2022 at six (6) sampling points. The sampling location is around industrial areas in Bekasi Regency, West Java Province, and includes three sampling points in the Delta Silicon Industrial Estate and three points in the MM2100 Industrial Estate. The characteristics of the sampling location were divided into three categories: industrial forecourts, settlements, and highways in the two aforementioned areas. The sampling

location was chosen purposively considering that Bekasi Regency is one of the most industrial areas on Java Island. The selection of sampling locations was also based on data from monitoring the concentration of five ISPU parameters from 2015 to 2019 in the Banten, West Java, and East Java provinces at 57,377 sampling points. Figure 1 presents the locations of the research sampling points in Bekasi Regency, West Java Province.

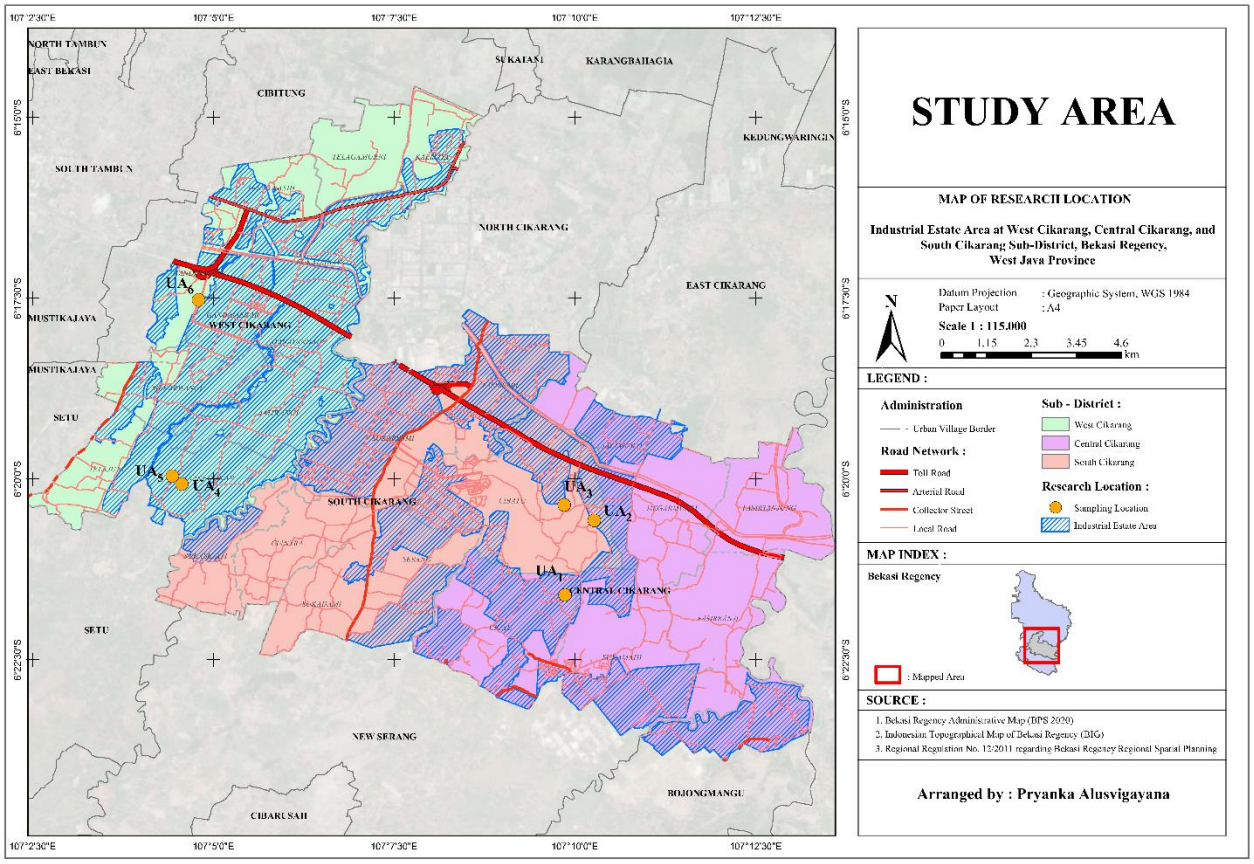

Figure 1 Location of research sampling points in Bekasi Regency, West Java Province

Data Collection

Secondary data collection in this study was carried out by recapitulating the results of monitoring the concentrations of SO_2, NO_2, CO, O_3, and PM_{10} in Banten, West Java, and East Java Provinces from 2015 to 2019 sourced from PT Unilab Perdana as a research partner. Toxicity data for the five ISPU parameters that affect human health were obtained from a previous study. Primary data were collected in September 2022 by sampling SO_2, NO_2, CO, O_3, and PM_{10} in ambient air at six sampling points in Bekasi Regency, West Java. Five ISPU parameters were sampled for one (1) hour of measurement at each sampling point using equipment such as an impinger, flowmeter, spectrophotometer, high-volume air sampler (HVAS), and CO analyzer. Temperature, wind speed, relative humidity (RH), and air pressure were also measured during the sampling of the five ISPU parameters using a thermometer, anemometer, hygrometer, and barometer.

Data Analysis

The data analysis in this study consisted of three stages, beginning with the recapitulation of SO_2, NO_2, CO, O_3, and PM_{10} parameters based on monitoring results from 2015 to 2019 and sampling results in 2022. The province of origin groups the data for each research location, and Microsoft Excel 365 was used to calculate the maximum, minimum, and average concentrations for each parameter. Table 1 lists the applicable Indonesian National Standards (SNI) for sampling and analysis methods for the concentrations of SO_2, NO_2, CO, O_3, and PM_{10}. The concentration results of the five ISPU parameters were calculated under standard

conditions for ambient air (25 °C, 760 mmHg), as stipulated by regulations in Indonesia, and expressed in units of μg/Nm^3. The next stage involved calculating the ISPU value based on the highest ISPU equivalent value among the calculated parameters. The ISPU value is determined using the following formula, which refers to PerMen LHK (2020). Table 2 displays the values of I_a, I_b, X_a, X_b, and air quality categories for each ISPU parameter.

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

Remark:

I = ISPU value for pollutant x

I_a = ISPU value associated with X_a

I_b = ISPU value associated with X_b

X_a = ambient concentration greater than or equal to X_x

X_b = ambient concentration less than or equal to X_x

X_x = ambient concentration of pollutant x

Table 1 Indoneian National Standards (SNI) for concentration analysis of 5 ISPU parameters

Parameter	Unit	SNI	Method	Tool
Sulfur Dioxide (SO_2)	μg/Nm^3	7119-7:2017	Pararosaniline	Spectrophotometer
Nitrogen Dioxide (NO_2)	μg/Nm^3	7119-2:2017	Griess Saltzman	Spectrophotometer
Ozone (O_3)	μg/Nm^3	7119-8:2017	Neutral Buffer potassium Iodide	Spectrophotometer
Carbon Monoxide (CO)	ppm	7119.10-2011	Non-Dispersive Infrared	CO analyzer
Particulate (PM_{10})	μg/Nm^3	7119.15:2016	Gravimetry	High Volume Air Sampler (HVAS)

Table 2 The Air Pollutant Standard Index (ISPU) in Indonesia, based on the PerMen LHK No. 14/2020

Parameter	Measurement time	Concentration limits on ISPU value (μg/Nm^3)				
		0–50	51–100	101–200	201–300	> 300
		Good	Moderate	Unhealthy	Very unhealthy	Hazardous
Particulate (PM_{10})	24 hours	50	150	350	420	500
Particulate ($PM_{2.5}$)		15.5	55.4	150.4	250.4	500
Sulfur dioxide (SO_2)		50	180	400	800	1,200
Carbon monoxide (CO)		4,000	8,000	15,000	30,000	45,000
Ozone (O_3)		120	235	400	800	1,000
Nitrogen dioxide (NO_2)		80	200	1,130	2,260	3,000
Hydrocarbons (HC)		45	100	215	432	648

In the last stage, a toxicity study was conducted to examine the development of health science regarding the concentrations of SO_2, NO_2, CO, O_3, and PM_{10} that affect humans. A literature review was conducted to determine the effects of SO_2, NO_2, CO, O_3, and PM_{10} exposure on health. Literature summarizes the concentration of each parameter that affects human health. Finally, the Ministry of Environment and Forestry's

Regulation Number 14/2020 was used to decide categories and health advice based on toxicity studies that have been done.

RESULTS AND DISCUSSION

Evaluation of SO_2, NO_2, CO, O_3, and PM_{10} Concentrations in Ambient Air in Industrial Areas of Java Island

Monitoring of ambient air for SO_2, NO_2, CO, O_3, and PM_{10} parameters from 2015 to 2019 was carried out in three provinces on Java Island, namely, Banten, West Java, and East Java Provinces, at 57,377 sampling points. Generally, monitoring locations are located around industrial areas. The average concentration of each parameter from all the monitoring data for the five years is shown in Figure 2.

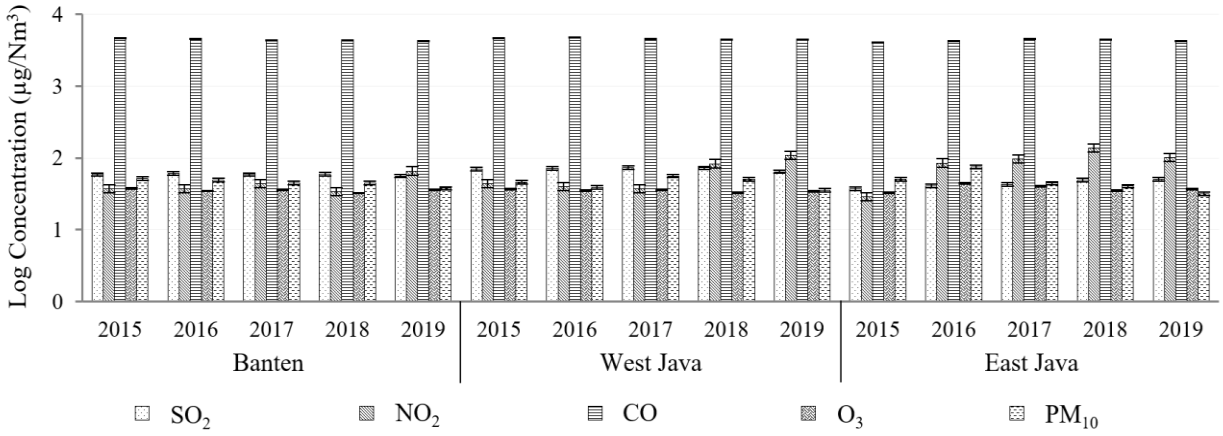

Figure 2 Average annual concentration of five ISPU parameters in Banten, West Java, and East Java over the 2015–2019 monitoring period

The annual average concentrations of SO_2, NO_2, CO, O_3, and PM_{10} in the three provinces from 2015 to 2019 were 37–74 µg/Nm^3, 29–136 µg/Nm^3, 4,072–4,706 µg/Nm^3, 32–44 µg/Nm^3, and 31–75 µg/Nm^3, respectively. Based on Table 2, the maximum concentration limits still in the good category (ISPU value of 0–50) on the Air Pollutant Standard Index (ISPU) in Indonesia for SO_2, NO_2, CO, O_3, and PM_{10} are 52 µg/Nm^3, 80 µg/Nm^3, 4,000 µg/Nm^3, 120 µg/Nm^3, and 50 µg/Nm^3, respectively (PerMen LHK 2020). The maximum average concentration values for SO_2, NO_2, CO, and PM_{10} were above the maximum concentration limit in the good category at the ISPU. Only the O_3 parameter, whose concentration is below the maximum concentration limit, is in the good category stipulated in applicable regulations.

The results of monitoring ambient air in several countries (Table 3) yield concentration ranges for SO_2, NO_2, CO, O_3, and PM_{10} parameters of 1–157 µg/Nm^3, 4–150 µg/Nm^3, 538–5,152 µg/Nm^3, 44–555 µg/Nm^3, and 24–404 µg/Nm^3, respectively. Compared with the monitoring results in three provinces in Indonesia, the maximum concentration values for the five ISPU parameters tend to be higher in other countries. Data verification from the monitoring results for five ISPU parameters was carried out by taking SO_2, NO_2, CO, O_3, and PM_{10} samples in September 2022. The selected sampling locations were in the vicinity of industrial areas in the Bekasi Regency, West Java. Five ISPU parameters were sampled at six sampling points. The 2022 sampling results are shown in Figure 3.

The concentrations of SO_2, NO_2, CO, O_3, and PM_{10} based on the results of sampling in West Java Province ranged from 29 to 41 µg/Nm^3, 24–37 µg/Nm^3, 764–2,406 µg/Nm^3, 30–42 µg/Nm^3, and 2–34 µg/Nm^3, respectively. The average concentrations of the sampling results for each parameter were 34 µg/Nm^3, 30 µg/Nm^3, 1,604 µg/Nm^3, 37 µg/Nm^3, and 10 µg/Nm^3, respectively. Compared with the maximum concentration limit in the good category at ISPU in Table 2, the maximum concentration value for each ISPU parameter

based on the sampling results was below the applicable standards. This shows that all the concentration values from the 2022 sampling results for the five ISPU parameters were still good.

Table 3 Monitoring results for SO_2, NO_2, CO, O_3, and PM_{10} concentrations in several countries

Country	Air pollutant concentration (µg/Nm^3)					Measurement	Sampling location	Reference
	SO_2	NO_2	CO	O_3	PM_{10}			
Japan	23–157	59–150	538–687	44–53	24–34	Hourly daily average	Shinjuku, Tokyo, Japan	You et al. (2017)
Vietnam	32–150	49–122	2,656–5,152	121–555	93–404	Daily average	2 monitoring stations in Hanoi, Vietnam	Nhung et al. (2018)
China	14–35	50–106	1,070–2,690	97–290	95–339	Daily average	Urban area in Chengdu, China	Qiu et al. (2018)
Italy	17–26	107–132	3,618–4,900	101–105	76–100	Hourly daily average	4 monitoring stations in Catania, Italy	Rosario and Francesco (2016)
Iran	21–116	29–80		44–107		Annual average	6 sampling locations in Tabriz, Iran	Ghozikali et al. (2016)
		76		297	86	Annual average	Kermanshah, Iran	Khaniabadi et al. (2017)
Canada	1–10	4–34		55–110		Monthly average	Alberta, Canada	Bari et al. (2015)
South Korea		48–143			52–82	Annual average	277 monitoring sites in South Korea	Kim and Song (2017)

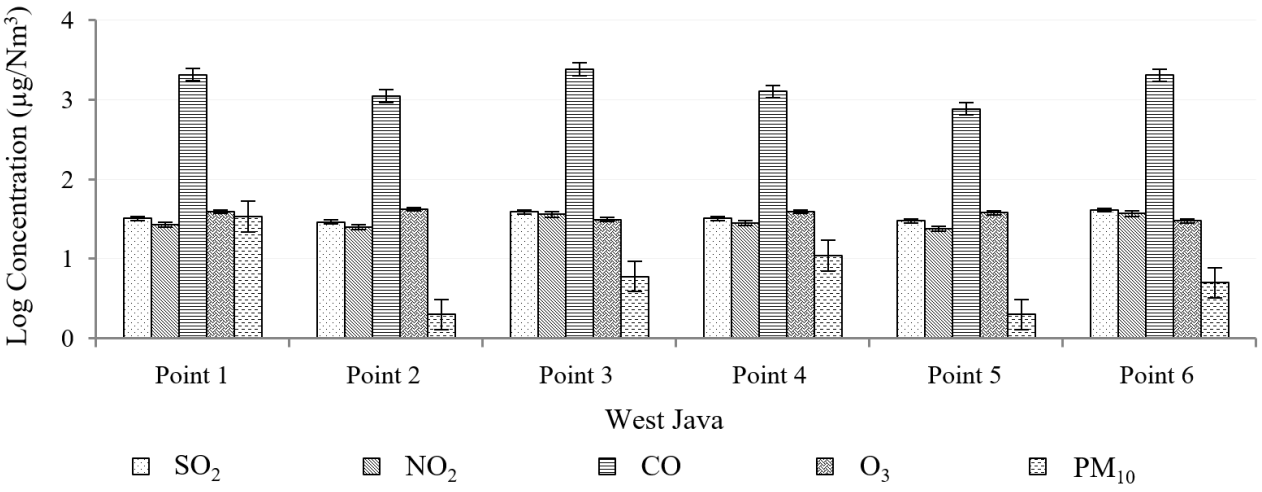

Figure 3 Concentration of five ISPU parameters from the 2022 sampling results in West Java

There was a decrease in the concentration values of the five ISPU parameters from the 2022 sampling results in West Java compared to the concentration values from monitoring results from 2015 to 2019 in Banten, West Java, and East Java. The COVID-19 pandemic can potentially decrease pollutant levels by restricting people's mobility, reducing the use of motorized transportation, and curtailing various industrial activities (Rushayati et al. 2020). Moreover, according to Rendana and Komariah's (2021) study, the decrease in the Air Pollution Index (API) values for SO_2, NO_2, CO, and PM_{10} in Jakarta was caused by large-scale social restrictions. The decrease in the concentration of the five ISPU parameters from the 2022 sampling results indicates increased ambient air quality in industrial areas on Java Island, especially in Bekasi Regency, West Java.

Air Pollutant Standard Index (ISPU) Value in Industrial Areas on Java Island

The Air Pollutant Standard Index (ISPU) is a number that does not have units that describe the condition of ambient air quality in specific locations based on its impact on human health, aesthetic values, and other living things (PerMen LHK 2020). The ISPU values for SO_2, NO_2, CO, O_3, and PM_{10} were determined by calculating the annual average concentrations in ambient air monitoring in Banten, West Java, and East Java Provinces from 2015 to 2019, as presented in Figure 4. The annual mean concentrations of SO_2, NO_2, CO, O_3, and PM_{10} were 64 μg/Nm^3, 61 μg/Nm^3, 4,458 μg/Nm^3, 35 μg/Nm^3, and 44 μg/Nm^3, respectively. The corresponding ISPU values for these parameters were 55, 38, 56, 15, and 44, respectively. The ISPU values for the SO_2 and CO parameters were 55 and 56, respectively, included in the moderate category, indicating that the air quality level is acceptable for human, animal, and plant health. At the same time, the ISPU values for NO_2, O_3, and PM_{10} were less than 50, which is included in the good category so that the air quality level does not harm humans, animals, and plants. The number on the top of the graph bar in Figure 4 shows the highest ISPU value that can be reached from the dominant ISPU parameter for each year in the three provinces. From 2015 to 2019, the dominant parameter in the Banten Province was CO, with an ISPU value range of 53–57. The highest ISPU value in the West Java Province was 62 in 2019, with NO_2 as the dominant parameter. NO_2 was also the dominant parameter in East Java Province, with the highest ISPU value of 73 in 2018 and included in the moderate category.

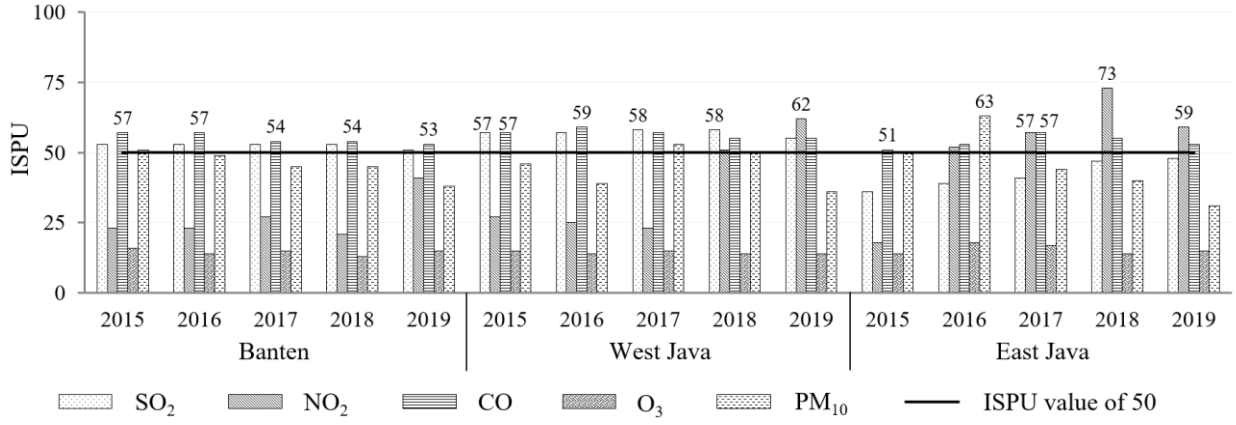

Figure 4 ISPU value from 2015-2019 monitoring results in Banten, West Java, and East Java

Before the Minister of Environment and Forestry Regulation No. 14/2020 stipulation, ISPU in Indonesia was regulated in KepMen LH No. 45/1997 and Kep.Ka Bapedal No. 107/1997. In previous regulations, NO_2 has never been the dominant parameter in determining ISPU values, because NO_2 concentration limits for ISPU values of 50 and 100 do not exist (Andriani et al. 2018). Furthermore, the NO_2 concentration limit for the ISPU value of 200 was too high at 1,130 μg/Nm^3, which is significantly different from the field measurements of NO_2 concentration.

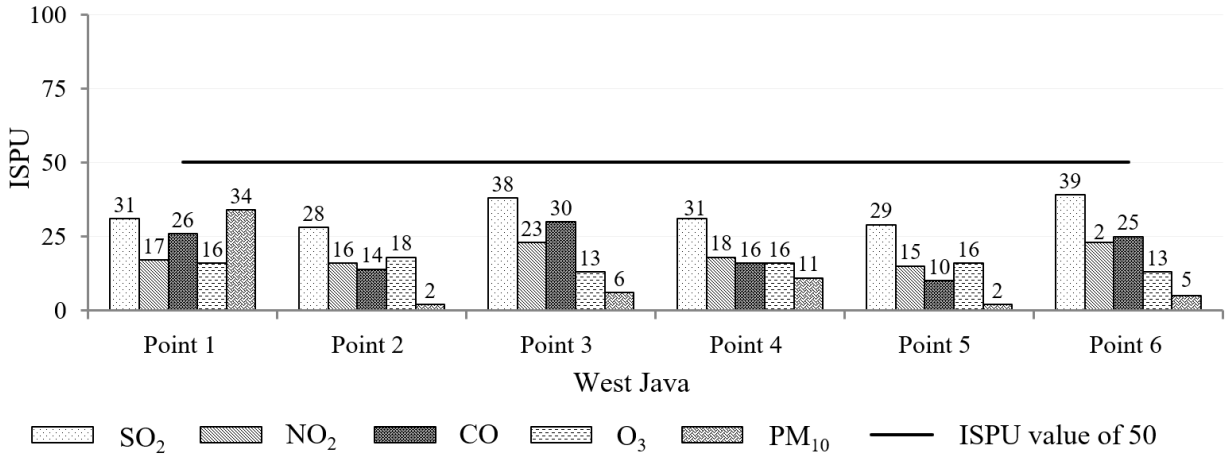

Figure 5 ISPU value from the 2022 sampling results in West Java

The average concentrations of SO_2, NO_2, CO, O_3, and PM_{10} at the six sampling points in West Java were 34 μg/Nm^3, 30 μg/Nm^3, 1,604 μg/Nm^3, 37 μg/Nm^3, and 10 μg/Nm^3, respectively. The ISPU values based on the average concentrations of the sampling results for SO_2, NO_2, CO, O_3, and PM_{10} were 33, 19, 20, 15, and 10, respectively. The graph in Figure 5 shows that all ISPU values from the sampling results were less than 50 and were included in the good category. This indicates that the ambient air quality level at the six sampling points around the industrial area of West Java does not harm human, animal, or plant health. The critical pollutant or dominant parameter at sampling point 1 was PM_{10} with an ISPU value of 34. Meanwhile, for sampling points 2 to 6, SO_2 acted as the dominant parameter, with ISPU values at sampling points 28, 38, 31, 29, and 39.

Toxicity Study and Relevant Concentration Limit for ISPU Parameter

Air pollution is a major risk factor for global public health in the 21st century. Several studies have linked severe diseases to air pollution in various age groups (Bodor et al. 2022). According to the WHO Health Organization (2015), air pollution is responsible for the deaths of seven million people worldwide every year. There was a strong correlation between air pollution and increased morbidity and mortality. Toxicity studies are needed to understand the development of health science, especially regarding the concentrations of SO_2, NO_2, CO, O_3, and PM_{10} that affect human health. Some of the disease risks that can arise from exposure to the five ISPU parameters are related to lung and heart function in humans. The impacts of exposure to SO_2, NO_2, CO, O_3, and PM_{10} on human health are presented in Table 4 for further use as materials to determine the concentration limits for the relevant ISPU parameters.

The relevant concentration limit is the quality standard value for a particular air pollutant concentration that is deemed permissible in ambient air. The concentration limit for air pollutants varies across countries depending on the standards used. In Indonesia, the concentration limit for air pollutants stipulated in Ministry of Environment and Forestry Regulation No. 14/2020 is sourced from the National Ambient Air Quality Standards (NAAQS) of the United States. The determination of this concentration limit is not based on direct research conducted in Indonesia, potentially resulting in an inadequate representation of ambient air conditions in the country. As an initial evaluation of the Air Pollutant Standard Index (ISPU) in PerMen LHK No. 14/2020, the relevant concentration limits were determined based on the average of the minimum and maximum concentration values for each ISPU parameter from the monitoring results, sampling results, and toxicity studies. Table 5 lists the recommended concentration limits for the five relevant ISPU parameters. Air quality levels that do not negatively affect human, animal, and plant health are found with ISPU values of 0–50 in the good category (PerMen LHK 2020). The relevant concentrations for the ISPU values of 0–50 were

42 μg/Nm^3 for SO_2, 29 μg/Nm^3 for NO_2, 3,519 μg/Nm^3 for CO, 33 μg/Nm^3 for O_3, and 29 μg/Nm^3 for PM_{10}. An ISPU value of 51–100 in the moderate category is expressed as an acceptable level of air quality for human, animal, and plant health. Everyone can still perform activities outside, and only sensitive groups must reduce their physical activity (PerMen LHK 2020). The relevant concentration limits for the ISPU values of 51–100 were 77 μg/Nm^3 for SO_2, 120 μg/Nm^3 for NO_2, 5,037 μg/Nm^3 for CO, 97 μg/Nm^3 for O_3, and 82 μg/Nm^3 for PM_{10}.

Table 4 Health effects of exposure to the five ISPU parameters

Pollutant parameters	Concentration (μg/Nm^3)	Duration (hour)	Exposure impact	Reference
SO_2	61	1	Increasing prevalence of asthma in New York, USA	Gorai et al. (2014)
	97–116	24	Chronic obstructive pulmonary disease (COPD) in Tabriz, Iran	Khan and Siddiqui (2014); Ghozikali et al. (2016)
NO_2	21–34	6–24	No significant effects on pulmonary function and asthma symptoms in children	Gaffin *et. al* (2017); Paulin et al. (2017)
	99.64–188	1	Outdoor exposure affects asthmatics	Andriani et al. (2018); Brown (2015)
CO	5,722	24	Increasing cardiorespiratory complaints in Denver, Colorado	Chen et al. (2007)
	8,000	24	Cardiovascular risk and coronary heart disease in Beijing, China	Li et al. (2018)
O_3	36	1	Affect asthmatics	Ghozikali et al. (2014)
	85.7–206	8	Increased mortality from cardiovascular and respiratory disease	Tao et al. (2012); Orellano et al. (2020)
PM_{10}	53.8	24	Increased risk of lung cancer in Italy	Consonni et al. (2018)
	65.5–135.5	24	Affects asthmatics at an industrial site in Port Harcourt, Nigeria	Akinfolarin et al. (2017)

One of the reasons underlying this research is that studies on determining the concentration limits or standards for air pollutants to evaluate regulations are rarely conducted in Indonesia. Related publications to this research can be found in Andriani et al. (2018), who discussed the evaluation of nitrogen dioxide (NO_2) concentration as one of the ISPU parameters and its calculations in Indonesia's air pollution index system. The results of her study stated that the NO_2 concentration recommended for ISPU values of 0–50 is 96 μg/Nm^3, and for ISPU values of 51–100 is 196 μg/Nm^3 (Andriani 2018). The relevant NO_2 concentrations in Table 5 were slightly lower than those in Andriani's (2018) study, possibly because of the different data sources used.

The concentration values for each ISPU parameter listed in Table 5 are recommended as relevant concentration limits because they are based on the average values compiled from three relevant data sources on ambient air conditions on Java Island over the last few years. The relevant concentration limit recommendations in Table 5 are lower than those in PerMen LHK No. 14/2020 (Table 2). This could be because the average concentrations for each ISPU parameter in the monitoring results, sampling results, and toxicity studies are also relatively lower than the concentration limits set out in the regulations. The relevant concentration limits suggested in this study can be used as input and reference material by the Ministry of Environment and Forestry (KLHK) to improve environmental regulations in Indonesia, especially in determining the status of ambient air quality based on the ISPU parameters in PerMen LHK No. 14/2020.

Table 5 Relevant concentration limit recommendations for ISPU parameter

ISPU value	Concentration (μg/Nm^3)	ISPU parameter					Relevant concentration limits (μg/Nm^3)				
		SO_2	NO_2	CO	O_3	PM_{10}	SO_2	NO_2	CO	O_3	PM_{10}
0–50 (Good)	Minimum:						42	29	3,519	33	29
	- Monitoring (2015-2019)	37	29	4,072	32	31					
	- Sampling (2022)	29	24	764	30	2					
	- Toxicity Study (Table 4)	61	34	5,722	36	53.8					
51–100 (Moderate)	Maximum:						77	120	5,037	97	82
	- Monitoring (2015-2019)	74	136	4,706	44	75					
	- Sampling (2022)	41	37	2,406	42	34					
	- Toxicity Study (Table 4)	116	188	8,000	206	135.5					

CONCLUSION

Ambient air quality improvement in industrial areas on Java Island (Banten, West Java, and East Java provinces) is indicated by a decrease in the average concentration of the five ISPU parameters in 2022 compared to monitoring from 2015 to 2019. The ISPU values range from 10 to 56 and are included in the good-to-moderate category, indicating that the ambient air quality in industrial areas on Java Island is still acceptable for human, animal, and plant health. The relevant concentration limit recommendations for the ISPU values in the good (0–50) and moderate (51–100) categories were 42 μg/Nm^3 and 77 μg/Nm^3 for SO_2; 29 μg/Nm^3 and 120 μg/Nm^3 for NO_2; 3,519 μg/Nm^3 and 5,037 μg/Nm^3 for CO; 33 μg/Nm^3 and 97 μg/Nm^3 for O_3; and 29 μg/Nm^3 and 82 μg/Nm^3 for PM_{10}. The results of this study can be used as a guide to determine an ambient air quality index system to change the concentration limits for ISPU in Indonesia contained in PerMen LHK No. 14/2020.

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