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Effect of The Use of Diesel-Biodiesel on Air Emissions and Exhaust Gas Opacity of Mining Equipment in West Banko IUP - PT Bukit Asam Tbk

Bambang Dwi Setiyawan [1*], Poedji Loekitowati Hariani[2], Leily Nurul Komariah[3]

[1]*Environmental Management Department, Graduate School of Universitas Sriwijaya, Palembang, Indonesia*
[2]*Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Sriwijaya, Ogan Ilir, Indonesia*
[3]*Department of Chemical Engineering, Faculty of Engineering, Universitas Sriwijaya, Ogan Ilir, Indonesia*
**Corresponding author: bams_dwiyan@gmail.com*

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Abstract: PT Bukit Asam Tbk has adopted the use of plant-based diesel oil in compliance with the rules established by the Minister of Energy and Mineral Resources No. 12 of 2015 from previously using fossil diesel. One of the decarbonization program's initiatives to reduce emissions is to replace the use of fossil fuels with biodiesel for all production equipment. To obtain results on the decrease or increase in the environmental quality of the use of fossil fuels and biodiesel, this research requires comparative data obtained from the results of ambient air quality, emissions, and opacity test. Based on research data in the years 2018 – 2022, the emission quality test was obtained with an average CO parameter of 550.83 mg/nm^3, which exceeded the quality standard of 540 mg/nm^3, SO_2 parameter of 79.03 mg/nm^3 from the quality standard of 900 mg/nm^3. The NO_2 parameter is 161.29b mg/nm^3 from the quality standard of 1200 mg/nm^3, with the quality standard parameters referring to thw Minister of Environment and Forestry Regulation No. 15 of 2019. Based on quantitative analysis approaches method and trend analysis obtained the emission results experienced an increase with trend line analysis but were still below the quality standards. The results at IUP Banko Barat for mobile equipment sources were obtained at 5.23% HSU, while for static equipment sources, they were obtained at 9.88% HSU from the quality standard of 40% based on South Sumatera Governor Regulation No. 06 of 2016. It can be concluded that the variance of fuel use for the 2018-2022 period has no significant effect on the air quality test emissions and opacity results because it is still below the quality standard.
Keywords: emission, opacity, ambient, biodiesel, quality requirements

1. Introduction

Utilizing green alternative energy sources is one way the company shows its dedication to carrying out mining operations by good mining practices and environmental sustainability [1]. The government has announced the use of plant-based diesel as a Life Cycle Assessment (LCA) [2] to support the use of renewable alternative energy [3] and support the downstream of the palm oil industry [4], as well as initiatives to reduce air emissions, including CO, SO_2, NO_2, particulate and opacity [5] and the impact of greenhouse gases (GHG) [6]. Plans for coal production to increase every year and the realization of achieving the targets given require an increase in the amount of production equipment and its supports, which will impact increasing the consumption of fuel oil (BBM) used. Fuel consumption at PT Bukit Asam Tbk (PTBA) for production equipment has experienced adaptation in its use for mining operational equipment and support units, especially for diesel types, starting from pure fossil diesel until now, which has used diesel types mixed with vegetable types [7]. Vegetable-type fuel is mandatory for government programs to reduce pollutant levels and air emissions [8].

The use of fuel made from plants is one way that PTBA complies with supporting government initiatives [9]. Based on established regulations (Permen ESDM No. 12 of 2015), which are required for all industries, especially mining coal, the use of a blend of fossil and plant fuels to support the realization of "eco-green" has been implemented for all mining operational equipment and supporting tools since 2019 [10]. Currently, 30% of diesel oil contains biodiesel blended in, according to the Director General of Oil and Gas Decree No. 145.K/10/DJM.T/2020, with standards and quality requirements.

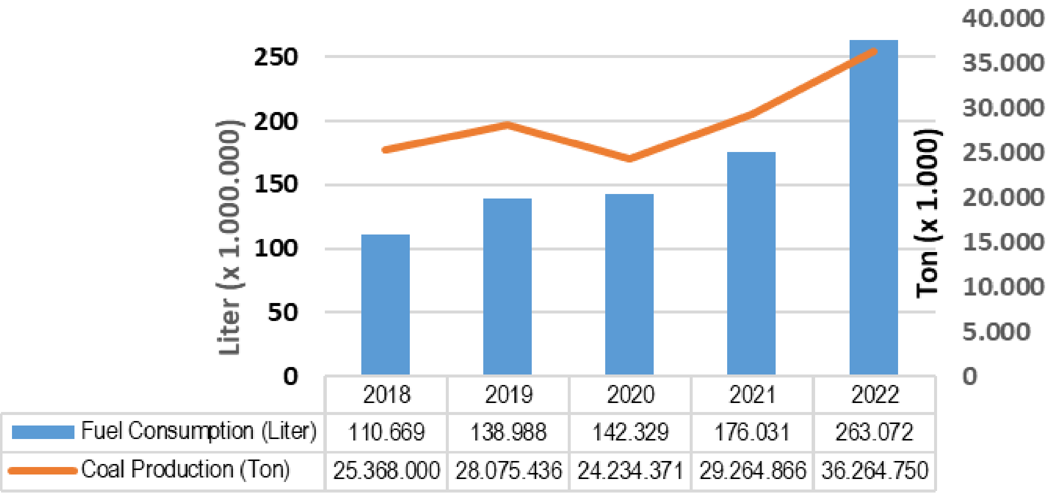


Figure 1. Fuel Consumption & Coal Production

In its implementation, PTBA makes monitoring efforts [11] to determine the magnitude of the environmental impact resulting [12] from the use of fuel on the main mining operational equipment, which is a mobile source such as excavators, bulldozers, haulage, motor graders, and compactors, while the supporting equipment, which is an indirect source, is stationary, namely the electric drive generator and light tower. PTBA's production achievements from 2018 to 2022 have increased, followed by an increase in diesel fuel consumption, as shown in Graph 1 (Figure 1). Fuel use from this activity will have an impact on the environment, particularly air quality [13], which leads to exhaust gas emissions (opacity) from various mining operational equipment, which will also have an impact on the health of mine workers and the surrounding environment [14] as well as on the efficiency of machine tools.

2. Material and Methods

The research was conducted in the Tanjung Enim mining area, Muara Enim Regency, precisely at the Banko Barat mining site, covering 3 research locations: Banko Barat (BB), Banko Tengah Atas (BTA) and Banko Tengah Bawah (BTB) with the coordinates of Mining Business License (IUP) 3°43'3.28" South Latitude and 103°48'8.45" East. (Figure 2). The research method conducted is a type of quantitative research [15] with a descriptive approach [16] based on linear regression analysis and coefficient of determination to provide an overview of the amount of air quality on fuel use in the last 5 years (2018-2022).

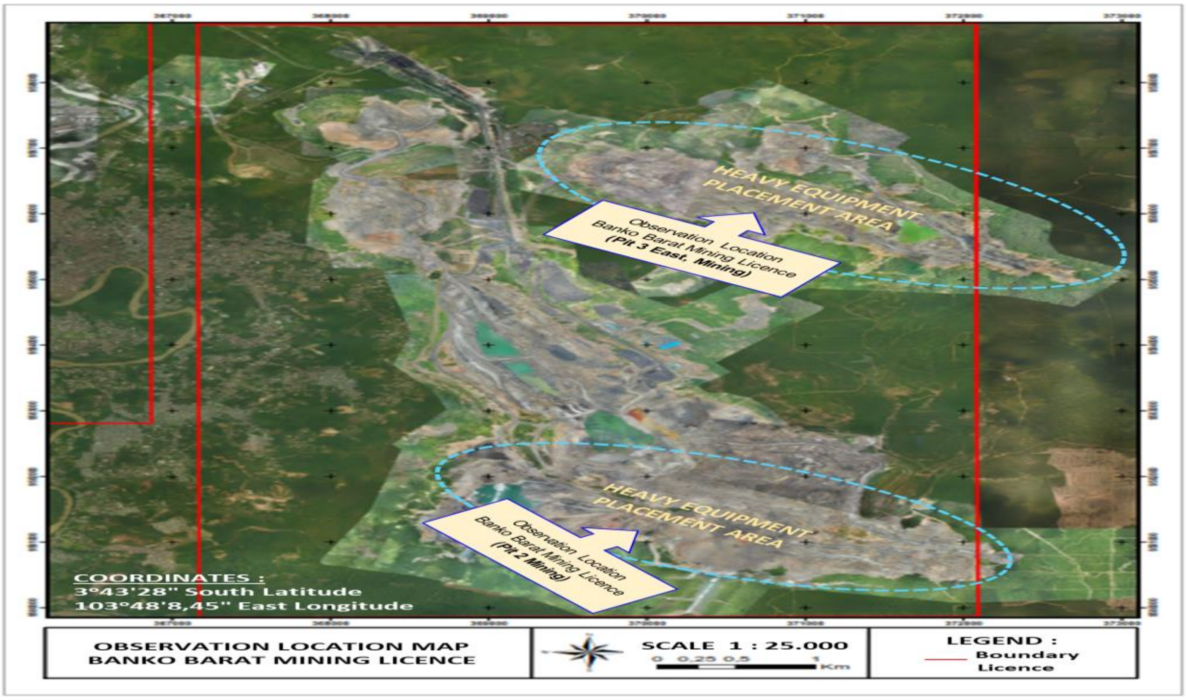


Figure 2. Air Quality Sampling Research

The following are the methods used for collecting data:

1. Conduct an inspection and inventory of the mining equipment data that will be tested for quality by the circumstances, provided that the unit has good performance and is prepared to operate with Mechanical Availability (MA > 85%), as the functionality of each piece of equipment will affect the workload of the machine. [17], [18] to influence the outcomes of tests on the efficacy of exhaust gas emissions and opacity [19].

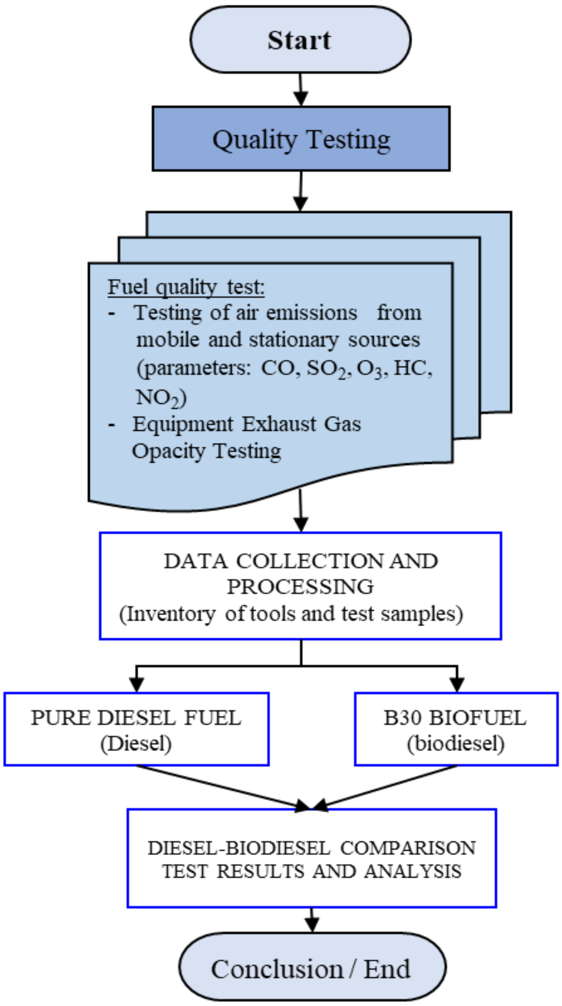


Figure 3. Flow Diagram Research

2. Testing test samples for ambient air quality, emissions, and exhaust opacity of by parameters using a standard sampling method based on the Indonesian National Standard (SNI) shown in Table 1. The test is conducted by Party III, which has been recommended by the government through a certified business entity that is national and eligible for testing. For ambient air testing and on mining operational equipment (moving or static sources), sampling is done on-site. The Diesel Smoke Tester Opacity Meter Hesbon HD 410 and Opacity Smoketer (OPA-102) are the instruments used in measuring air quality tests for ambient, emission, and exhaust gas (opacity)[20].
3. The tested air quality was analyzed by comparing the parameters of the test results according to the standards set by the government as applicable regulations [21], then compiled using Minitab v.18 and Windows Excel software tools to summarize and manage statistical data.

The test standards and parameters for quality test results in accordance with the quality standards established for ambient, emissions, and exhaust gases (opacity) in mining sector locations are tested in accordance with the standard procedures and rules outlined in Table 1. Table 2 is the quality standards based on the government according to regulations for ambient air, and Table 3 is the quality standards based on the government according to regulations for air emissions, also Table 4 is the quality standards based on the government according to regulations for opacity of equipments.

3. Results and Discussion

The results shown in the following Figure were obtained from the processing of the ambient air quality test data at the West Banko IUP location at the three mining locations, namely Banko Barat (BB), Banko Tengah Atas (BTA), and Banko Tengah Bawah (BTB), with limited discussion according to the results of testing implementation with parameters Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Sodium Dioxide (NO_2), Ozone (O_3), and Hydro Carbon (HC).

With the largest test result of 2,290 mg/Nm^3 from the standard quality standard of 30,000 mg/Nm^3 at the Banko Tengah Atas (BTA) location in 2021, the average CO-Ambient value is still significantly below the quality standard set for the three locations where data was taken before the operation, according to the results based on the data shown in Figure 4. The trend line of regression analysis for CO-ambient air quality obtained a value of $y = 285.55x + 361.77$, indicating that the average quality increase for the 2018–2022 period is each addition of 1 independent variable point (x) but still below the standard quality required by regulations. The value of the coefficient of determination (R^2) was obtained at 74.71%, indicating that the independent variable (x)'s contribution has an effect and that the trend line of regression analysis for CO–ambient air quality.

Table 1. Methode of Sampling Air Quality Test

Air Quality Parameter	Method of Sampling
Air Ambient / Emission:	
a. Carbon Monoxide (CO)	SNI 19-7117.21:2005
b. Sulphur Dioxide (SO_2)	SNI 19-7117.21:2005
c. Nitrogen Dioxide (NO_2)	SNI 19-7117.21:2005
d. Ozone (O_3)	SNI 19-7117.21:2005
e. Hydrocarbon (HC)	SNI 19-7117.21:2005
Opacity	**Method of Sampling**
a. Mobile Source Emissions	SNI 19-7117.21:2005
b. Static Source Emissions	SNI 19-7117.21:2005

Table 2. Regulation & Quality Standards of Air Ambient

Air Ambient Parameter	Unit	Quality Standard (1)	Quality Standard (2)
a. Carbon Monoxide (CO)	mg/Nm^3	10000	30000
b. Sulphur Dioxide (SO_2)	mg/Nm^3	150	900
c. Nitrogen Dioxide (NO_2)	mg/Nm^3	200	400
d. Ozone (O_3)	mg/Nm^3	150	235
e. Hydrocarbon (HC)	mg/Nm^3	160	160

Note:
(1) *Indonesian Government Regulation No. 22 in 2021*
(2) *South Sumatera Governor Regulation No.17 in 2005*

Table 3. Regulation & Quality Standard of Air Emissions

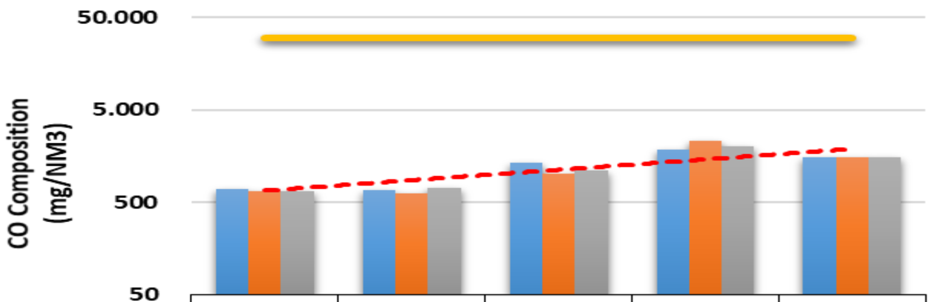
Air Emissions Parameter	Unit	Quality Standard (1)	Quality Standard (2)
a. Carbon Monoxide (CO)	mg/Nm^3	540	-
b. Sulphur Dioxide (SO_2)	mg/Nm^3	600	600
c. Nitrogen Oxides (NO_x)	mg/Nm^3	1200	800
d. Dust, Particulate	mg/Nm^3	120	250
e. Opacity	%	-	20

Note:
(1) *Ministry of Environmental & Forestry Regulation No. P.15/MENLHK/SETJEN/KUM.1/4/2019, Attachment IX B*
(2) *South Sumatera Governor Regulation No.06 in 2012*

Table 4. Regulation & Quality Standard of Opacity

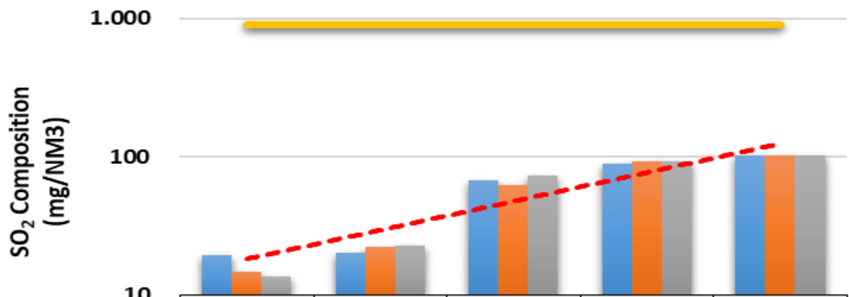
Equipment Opacity Parameter	Unit	Quality Standard **(1)**	Quality Standard **(2)**
a. Mobile Source Emissions *(for GVW ≤ 3,5 tonnes)*	%	20	40
b. Static Source Emissions	%	20	40

Note:
(1) Ministry of Environment Regulation. No.05 in 2006,
(2) South Sumatera Governor Regulation No.6 in 2012,
(2) South Sumatera Governor Regulation No.4 in 2014



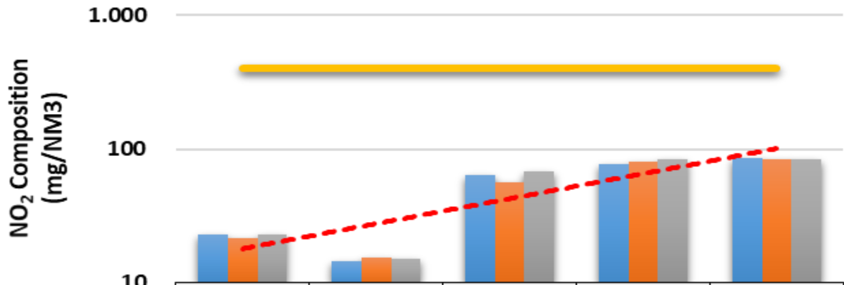
	2018	2019	2020	2021	2022
CO BB Composition	690	679	1.336	1.861	1.527
CO BTA Composition	661	631	1.011	2.290	1.527
CO BTB Composition	661	722	1.107	2.004	1.527
Quality Standards - CO	30.000	30.000	30.000	30.000	30.000

Figure 4. Test Result Ambient Air of CO



	2018	2019	2020	2021	2022
SO2 BB Composition	20	20	67	90	102
SO2 BTA Composition	15	22	62	92	102
SO2 BTB Composition	14	23	73	92	102
Quality Standards - SO2	900	900	900	900	900

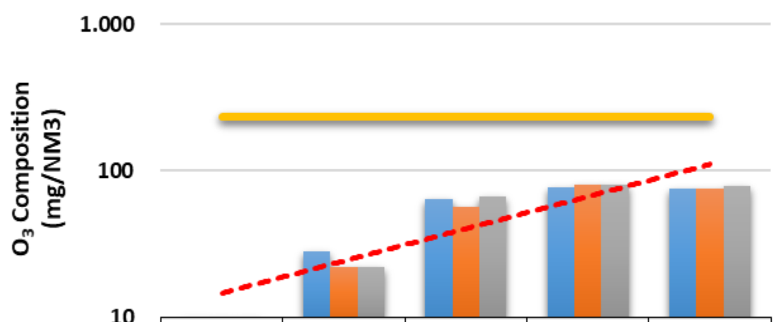
Figure 5. Test Result Ambient Air of SO_2



	2018	2019	2020	2021	2022
NO2 BB Composition	23	15	64	78	85
NO2 BTA Composition	21	15	57	81	85
NO2 BTB Composition	23	15	67	83	85
Quality Standards - NO2	400	400	400	400	400

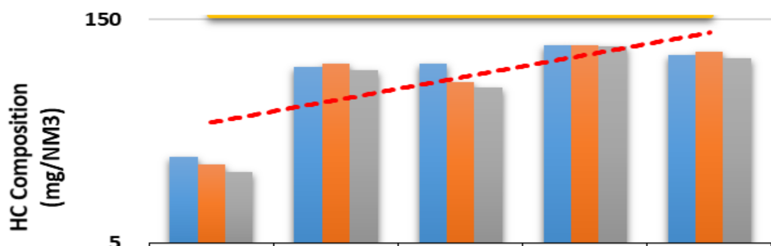
Figure 6. Test Result Ambient Air of NO_2

Test data for SO_2-Ambient values (Figure 5), on average, are still far below the established quality standards, namely from the test results obtained for the three locations in 2022, it reaches the largest value, which is 102 mg/Nm^3 of the 900 mg quality standard /Nm^3, obtained on site. From the data processing, the test results for the average NO_2-Ambient value (Figure 6) are still far below the established quality standard, namely from the test results obtained the largest is 85 mg/Nm^3 from the quality standard of 400 mg/Nm^3. This will occur in 2022 for all three locations.



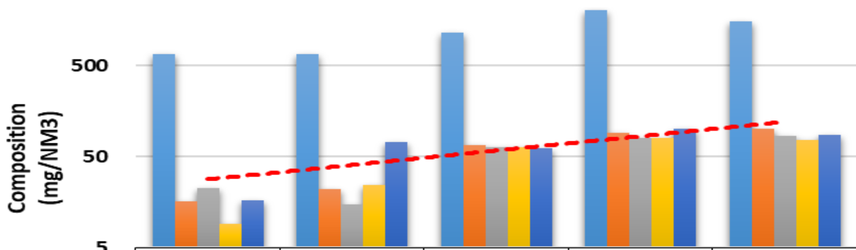
	2018	2019	2020	2021	2022
O3 BB Composition	10	28	65	78	76
O3 BTA Composition	8	22	57	81	75
O3 BTB Composition	9	22	66	81	79
Quality Standards - O3	235	235	235	235	235

Figure 7. Test Result Ambient Air of O_3



	2018	2019	2020	2021	2022
HC BB Composition	19	73	77	101	88
HC BTA Composition	17	77	58	102	92
HC BTB Composition	15	69	53	100	84
Quality Standards - HC	160	160	160	160	160

Figure 8. Test Result Ambient Air of HC



	2018	2019	2020	2021	2022
CO Composition	670	678	1.151	2.051	1.527
SO2 Composition	16	22	67	92	102
NO2 Composition	22	15	63	80	85
O3 Composition	9	24	63	80	77
HC Composition	17	73	63	101	88

Figure 9. Total Test Result Ambient Air

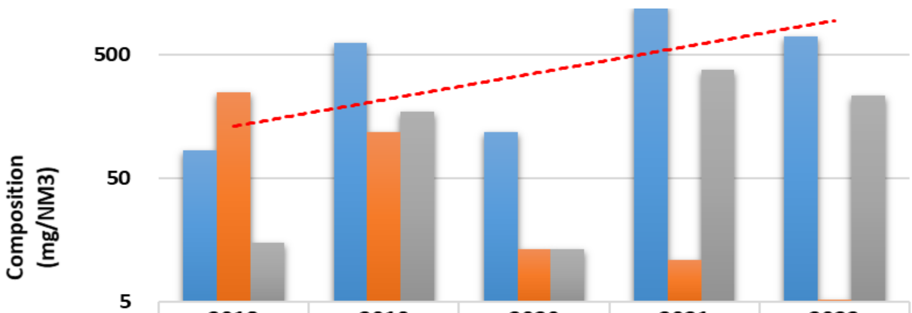
Processing of test results data (Figure 7) for the average O_3-Ambient value is still far below the established quality standard, namely with the largest value data obtained from the test results of 81 mg/Nm^3 from the quality standard of 235 mg/Nm^3 located at the location BTA and BTB. The test results (Figure 8) for the average HC-Ambient value are still far below the established quality. The test results obtained are the largest in the BTA location, which is 102 mg/Nm^3 for the 2021 period from the regulatory quality standard of 160 mg/Nm^3.

In total, the ambient air quality shown in Figure 9 for the IUP Banko Barat at 3 locations obtained results that were below the quality standards set according to regulations, for the next year, the ambient quality will decrease, but it will still be below quality standards. Figure 4-9, based on linear equation data, explains that the increase in ambient air quality parameter values will increase with the addition of production equipment to increase production targets. In terms of data, the correlation coefficient R^2 represents a value of 69% - 93% (Table 5). This shows that ambient air quality will be influenced by equipment activity in increasing production.

Table 5. Quality & Regression Analysis Results

Parameter	Ambient Standard	Test Result	Regression Analysis
CO	30000	1215	$y = 285.55x+361.77$ $R^2 = 0.7471$
SO_2	900	60	$y = 23.491x-10.574$ $R^2 = 0.9289$
NO_2	400	53	$y = 18.789x-3.5442$ $R^2 = 0.8506$
O_3	235	50	$y = 18.068x-2.9408$ $R^2 = 0.694$
HC	160	68	$y=16.565x+21.724$ $R^2 = 0.6951$

Data Table 5 demonstrates that for the last five years (2018–2022), the results of the linear regression analysis for ambient air with the variable (y = air quality) have been positive for the composition of ambient air (CO and HC) and negative for the composition (SO_2, NO_2, and O_3). The results will be positive when the value is increased by one point. These results demonstrate that, even though there has been an increase in the value of the increase in quality test results, the validation of ambient air quality results is still good and below the quality standard, meaning that positive results will be obtained for the following period when the minimum average value is the same as the real conditions for the previous five years.



	2018	2019	2020	2021	2022
CO Composition	84	621	118	1.233	698
SO2 Composition	248	118	13	11	5
NO2 Composition	15	171	13	374	234

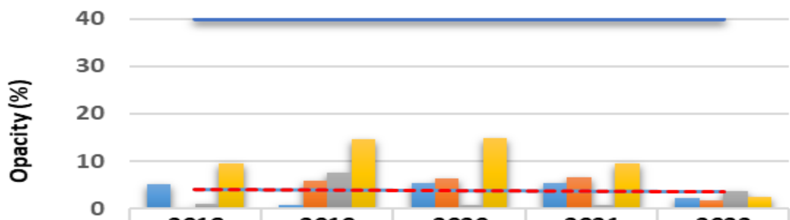
Figure 10. EmissionTest Result Static Source Equipment

Based on data processing of emission air quality test results for the period 2018-2022, the results are shown in Figure 10, that emission from static sources (Generators and Light Towers) as a whole, shows that the composition of CO, SO_2, and NO_2 is still below the quality standard (Table 6), namely: SO_2 composition with an average realization of 79 mg/Nm^3 from a regulatory standard of 900 mg/Nm^3 and NO_2 composition with an average realization of 161 mg/Nm^3 from a regulatory standard of 400 mg/Nm^3, while for composition CO with an average realization of 551 mg/Nm^3 experienced an increase in test results from the regulatory standard of 540 mg/Nm^3 or by 102%, there has been an increase in the population of mining production equipment. The results of Trend Analysis obtained a value of $y = 183.95x - 1.0246$, which in reality has a negative value, but future predictions will experience an increase in quality test results, but still below the quality standard. For the opacity test results for mobile source emissions at the West Banko location, the results are shown in Figure 11.

Table 6. Quality & Regression Result Opacity Unit

Parameter	Emission Standard (*)	Test Result	Regression Analysis
CO	540	551	y =285.55x+361.77
SO_2	600	79	y =23.491x-10.574
NO_2	1200	161	y =18.789x-3.5442

Note:
(*) *Ministry of Environmental & Forestry Regulation No. P.15/MENLHK/SETJEN/KUM.1/4/2019, Attachment IX B*

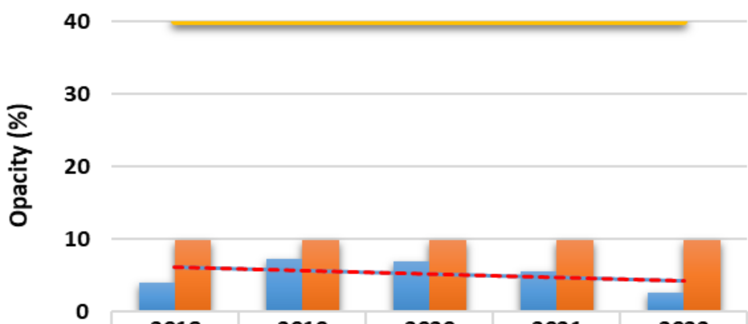


	2018	2019	2020	2021	2022
Excav. Opacity	5.15	0.68	5.50	5.36	2.29
Dozer Opacity	0.25	5.94	6.36	6.70	1.77
Haulage Opacity	0.93	7.69	0.88	0.68	3.69
Supporting Opacity	9.54	14.61	14.77	9.43	2.41
Opacity Standard	40	40	40	40	40

Figure 11. Opacity Test Result for Equipment

Equipment (vehicles and heavy equipment) subjected to exhaust gas testing (opacity) is classified into 4 groups according to their work function consisting of:

1) Loading Equipment Group (Excavator), which is equivalent to the type of unit PC 3000, PC 2000, PC 1250, PC 400, PC 300 and PC 200, with an average of 3.80% Hartridge Smoke Unit (HSU).
2) Digging and Dozing Equipment Group (Bulldozers), which is equivalent to the type units D375, D8R, D155, D85 and D65, with an average of 4.20% HSU.
3) Hauling Equipment Group, consisting of Belaz (120 tons), HD 785, Cat777, and DT 30 tons, with an average of 2.77% HSU.
4) Supporting Equipment Group, divided into 2 work functions, namely main supporting equipment, consisting of Motor Grader and Compactor, while supporting equipment is in the form of operational vehicles (light vehicles), including operational vehicles (LV), Employee Buses, Fuel Trucks, Water Truck and Oil Truck, with an average of 10.15% HSU.
5) The results of the exhaust gas tests conducted on heavy vehicles and equipment reveal that the actual opacity of the entire apparatus is still below the 40% HSU requirement and has declined as indicated by the trend line of the test results, which was calculated using the equation y = 0.1032x + 4.1059 to determine the equipment's opacity standards in accordance with regulations.



	2018	2019	2020	2021	2022
Mobile Source Equipment	3.97	7.23	6.88	5.54	2.54
Static Source Equipment	9.9	9.90	9.90	9.80	9.90
Opacity Standard	40	40	40	40	40

Figure 12. Opacity Test Mobile & Static Equipment

Figure 12 displays the results of measuring the opacity of moving and static sources. The average values for moving sources are 5.23% HSU and 9.88% HSU, respectively. The total displayed in the test findings is y = 0.454x + 6.5923 in a positive trend line. It has reduced from the opacity test results, demonstrating that the opacity test results are still below the regulatory quality limits of 40%.

4. Conclusion

The results of research on environmental quality from the use of diesel and biodiesel variants show results that are not very significant. The test results based on research and analytical processing, the test obtained that the ambient and emission air quality in the West Banko area complies with regulatory requirements and has a positive trend line and opacity of the use of diesel and biodiesel does not significantly change the outcome impact as it is still below the quality standards as per regulations; however, the air quality will experience a trend line increase for the upcoming period with an increasing population mining equipment and production target.

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