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Analysis Characteristics Regional Biophysics Air, Water and Condition of North Konawe

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Abstract: Mining activities in North Konawe pose significant environmental challenges due to the exploration and exploitation of natural resources. This study aims to identify and analyze the sustainable efforts undertaken by PT. Sumber Bumiputera in monitoring and managing environmental impacts within its Mining Business License (IUP) area. A qualitative descriptive approach was applied, with data collected through field observations, interviews with stakeholders, and analysis of environmental documents from the company. The findings reveal that PT. Sumber Bumiputera has implemented several environmental management strategies, including land rehabilitation, waste management, and systematic monitoring of water and air quality. These efforts align with existing environmental regulations and aim to mitigate the negative impacts of mining activities. However, there are areas where improvements are necessary, such as enhancing community engagement, strengthening monitoring mechanisms, and increasing compliance with sustainability standards. Strengthening these aspects can contribute to more effective environmental management and long-term ecological balance. This research highlights the importance of continuous environmental monitoring and adaptive management strategies to minimize the adverse effects of mining operations while ensuring sustainable resource utilization.

Keywords: Environment; Mining; Monitoring, North Konawe; Sustainability.

Introduction

Human behavior that does not pay attention to environmental sustainability will be the main cause of environmental degradation which will also lead to a decrease in environmental quality, even a decrease in the quality of human life (Hadi et al., 2023; Siddiqua et al., 2022; Ukaogo et al., 2020). The problem of degradation and decline in environmental quality is more caused by high levels of environmental pollution (Akhtar et al., 2021; Singh & Singh, 2017; Wassie, 2020). Based on Government Regulation Number 22 of 2021 Concerning the Implementation of Environmental Protection and Management, the environment is defined as a spatial unity that includes all objects, forces and conditions of living creatures, including humans and their behavior. influence the environment, continuity of life, and welfare of humans and other creatures.

Realizing this, the government issued a regulation requiring every business or activity that has a direct impact on the quality of the environment to be equipped with an Environmental Impact Analysis (AMDAL) document. One part of the AMDAL document is the Environmental Management Plan document, which must be implemented by business or activity actors as regulated in Government Regulation Number 22 of 2021.

Supervising the implementation of environmental management to anticipate impacts on an activity is outlined in the Environmental Monitoring Plan document (Perkasa, 2019; Syafni et al., 2022). Thus, environmental monitoring is a process of observing, recording, measuring, and documenting, both verbally

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and visually, according to specific standard procedures on one or several environmental components using one or several parameters as benchmarks which are carried out in a planned, scheduled, and controlled manner within a specific time cycle (Sanoff, 2016).

Apart from managing environmental impacts, the impacts that arise on the lives of communities around the operational area are also a concern that needs to be continuously monitored and managed (Nawawi et al., 2015; Sengupta, 2021; Vanclay et al., 2015).

Previous research by Wibowo et al. (2020) examined water quality in coastal areas affected by mining activities, showing an increase in heavy metal concentrations in the waters. Additionally, a study by Ameliyah et al. (2025) analyzed patterns of air temperature and rainfall changes in tropical regions as an impact of deforestation and land-use changes. The findings of these studies indicate that changes in a region's biophysical conditions are highly influenced by anthropogenic activities and natural factors in a given area.

Mining activities make a significant contribution to the economy but also significantly impact the environment (Carvalho, 2017; Sonter et al., 2017; Yang et al., 2023). Utilization of natural resources, especially minerals, will cause changes in an ecosystem, thereby changing community patterns (Bringezu et al., 2016; George et al., 2018; Judijanto et al., 2023; Wan et al., 2015). North Konawe Regency, as an area rich in mineral resources, is a location for intensive mining activities. PT. Sumber Bumiputera, one of the companies operating in this region, is responsible for ensuring that its activities comply with the principles of sustainable development. This research evaluates environmental monitoring efforts implemented in the PT IUP area of Sumber Bumiputera (Bahri & Trisnawati, 2021).

The novelty of this research lies in the in-depth analysis of the biophysical characteristics of air, water, and environmental conditions in North Konawe with a focus on the mining activities of PT Sumber Bumi Putera. This research not only identifies general environmental parameters, but also explores the specific impacts of mining activities on air and water quality around the operation area. With a more holistic approach and based on the latest data, this research contributes to providing a comprehensive picture of environmental dynamics in areas with extractive industry activities, which previously remained limited in academic studies.

The purpose of this study is to analyse the biophysical condition of the environment, particularly the air, water, and ecosystem changes in the North Konawe region due to the activities of PT Sumber Bumi Putera. This research also aims to evaluate the extent to which mining activities affect environmental quality and identify potential mitigation of negative impacts. With the results of this study, it is expected to provide recommendations for local governments and related companies in managing the environment sustainably and designing more effective policies for environmental protection in mining areas.

Method

This research uses a qualitative descriptive approach with a case study method, which aims to analyze the environmental impacts in the mining area of PT. Sumber Bumiputera. Data was collected through field observations, interviews, and document analysis. Primary data was collected through direct observation at mining locations, interviews with companies and surrounding communities, and environmental quality measurements. Meanwhile, secondary data was obtained from AMDAL documents, environmental monitoring reports, government regulations related to the environment, and relevant literature (Delgado & Romero, 2016; Firmansyah & Masrun, 2021; Lei et al., 2016).

Field observation techniques are carried out by observing environmental conditions around the IUP PT. Sumber Bumiputera will identify the impact of mining activities on the community's air, water, land, flora, fauna, and social life. In addition, interviews were conducted with company management to understand the environmental management strategies implemented and with local communities to gain perspectives on the impact of mining activities on their lives. Interviews also involve relevant agencies to obtain an objective view of the implementation of environmental policies. The documentation collected includes company environmental monitoring reports, analysis of regulations such as Government Regulation Number 22 of 2021 concerning Environmental Management, and other documents such as the Environmental Management Plan and Environmental Monitoring Plan.

Data analysis uses various methods depending on the environmental parameters studied. For air quality analysis, this study measures the concentrations of Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2), Carbon Monoxide (CO), PM10, and PM2.5. Sampling was carried out at three main points, namely at the workshop location (U1), fit location (U2), and office and mess location (U3). Monitoring results are compared with quality standards based on Government Regulation 22 of 2021. Meanwhile, water quality analysis is carried out by monitoring three types of water sources: river water, clean water used by the community, and waste water from sediment ponds. Water quality analysis is carried out using the Pollution Index (IPj) calculation method based on Minister of the Environment Decree Number 115 of 2003, with parameters such as TSS, pH, Iron (Fe), Cobalt (Co), Lead (Pb), Zinc (Zn), Copper (Cu), Cadmium (Cd), and Chromium (Cr+6).

Soil quality analysis is carried out through field observations and laboratory analysis to assess parameters such as soil pH, total nitrogen, available phosphorus, available potassium, organic matter, porosity, and soil permeability. The results of this analysis are used to determine post-mining reclamation strategies. Monitoring of flora and fauna is also carried out to identify the presence of native vegetation before and after mining activities and determine the conservation status of species based on the IUCN Red List and CITES.

The social, economic, cultural, and public health impacts from mining activities are evaluated through interviews and impact analysis using parameters such as employment and business opportunities, increased community income, public health, and community perceptions of mining activities. Management of hazardous and toxic waste (B3) is also monitored at temporary storage facilities (TPS LB3), where waste processing is carried out in accordance with government regulations.

To ensure the validity and accuracy of the data, this research carried out evaluations in three main aspects, namely trend evaluation by comparing monitoring data from previous periods, critical level evaluation to determine whether there are environmental parameters that approach or exceed critical thresholds, and compliance evaluation by comparing monitoring results against quality standards that have been established in government regulations (Setiawan et al., 2022).

Instruments and measurement standards used in this research include standard tools and methods such as SNI 7119-7:2017, SNI 7119-2:2017, SNI 19-7119-8:2005, and Gas Analyzer for air quality measurements, as well as Gravimetric, Spectrophotometric, and Atomic Absorption Spectroscopy (AAS) methods for water and soil quality analysis.

Overall, the qualitative descriptive approach with case studies in this research allows for comprehensive mapping of environmental conditions and evaluation of the effectiveness of environmental management strategies implemented by PT. Sumber Bumiputera. With a combination of field observations, interviews, and laboratory analysis, this research provides an in-depth picture of the environmental impacts of mining activities as well as the mitigation measures that the company has taken.

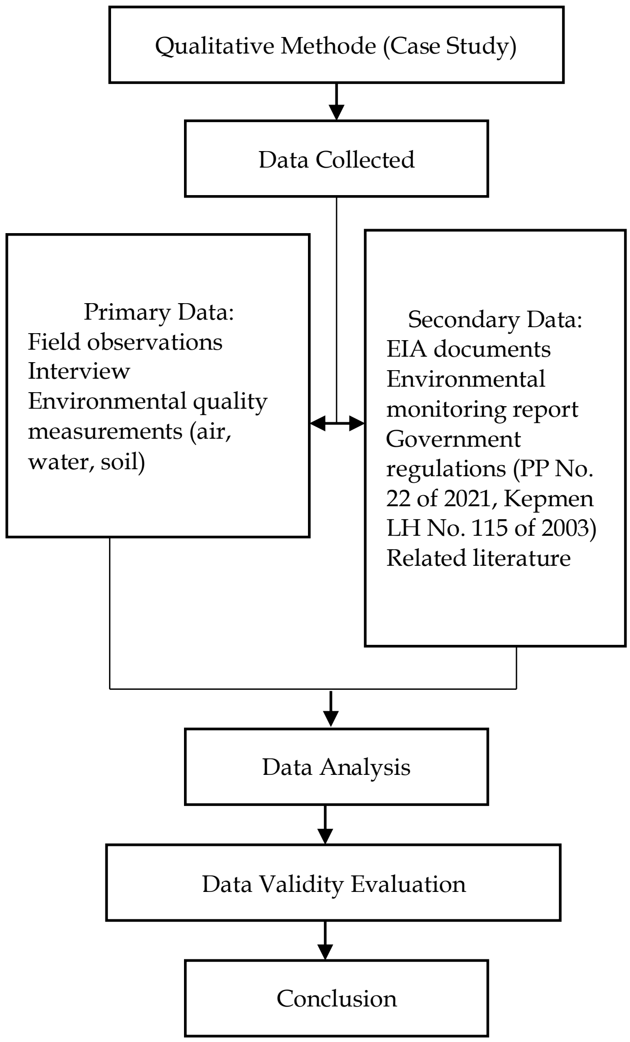

Figure 1. Research Flowchart

Result and Discussion

Air Quality

The environmental component affected is air ambient due to mining activities which will affect the air quality around the mining area and the environment around the activity location (Asif et al., 2018; Kurniati et al., 2023; Sánchez de la Campa et al., 2015; Saputra & Muhardi, 2022).

Table 1. Air Quality Monitoring Results at PT. Mining Sites. Source Earth Prince

Parameter Test	Unit	Time	Test Results			Raw	Test Method
		Recruitment	U-01	U-02	U-03	Stop	
Sulfur Dioxide (SOx)	µg/m³	1 hour	48.90	35.50	18.60	150	SNI 7119-7:2017
Nitrogen Dioxide (NOx)	µg/m³	1 hour	65.80	48.20	22.10	200	SNI 7119-2:2017
Carbon Monoxide (CO)	µg/m³	1 hour	3.800	2.200	1.500	10.000	NDIR
Oxidants as Ozone (O_3)	µg/m³	1 hour	26.00	24.00	20.00	150	SNI 19- 7119-8:2005
Hydrocarbons	µg/m³	1 hour	32.00	28.00	16.80	160	Gas Analyzer
TSP dust	µg/m³	1 hour	119.40	125.80	98.70	230	SNI 7119-3:2017
PM 2.5	µg/m³	1 hour	30.5	38.9	22.4	55	Gravimetry
PM 10	µg/m³	1 hour	48.2	54.1	36.2	75	Gravimetry

You Are Dead:
*) Government Regulation no. 22/2021 concerning Air Pollution Control. Note:

U-01 = (S = 03^0 31′ 48.1″ E = 122^0 10′ 38,9″)

U-02 = (S = 03$^{0\ 31}$′ 19.7″ E = 122^0 11′ 25,3″)

U -03 = (S = 03$^{0\ 31}$' 24.8" E = 122^0 11' 25,3")

Based on the results of air quality parameter analysis in the second semester of 2024 monitoring, it shows that the air quality values are still below the environmental quality standard threshold so that environmental management activities, especially air quality, have met environmental requirements. The results of this monitoring also show that the noise values at both locations are below the required quality threshold. This condition is still far below BM because there has been no mining activity for a year.

Water Quality Monitoring
River water

From the results of monitoring and calculating the pollution rating parameter index (Ci/Lij) it can be seen that almost all the measured parameters are still is below the quality standards as required in Republic of Indonesia Government Regulations Number 22 of 2021 concerning Water Quality Management and Water Pollution Control for Looking at the overall water quality, an analysis of river water quality is carried out using the pollution index calculation method (IPj).

Table 2. Results of river water quality measurements in the PT IUP area. Sumber Bumiputera

Test Parameters	Unit	Test Results	Quality Standards		Test Method
			Class 1	Class 2	
Physics					
*Temperatur	^{0}C	26.80		Dev. 3	SNI 06-6989.1.23-2005
*Total Disolved Solid (TDS)	mg/l	169	1000	1000	SNI 6989.27-2019
*Total Suspendid Solid (TSS)	mg/l	14.60	40	50	SNI 6989.3-2019
Chemistry					
*pH (Degree of Acidity)	-	8.08	6-9	6-9	SNI 6989.11-2019
Disolved Oxygen (DO)	mg/l	6.30	6	4	SNI 06-6989.14-2004
Chemical Oxygen Demand (COD)	mg/l	12.80	10	25	SNI 6989.2-2019
Amonia (NH4)	mg/l	<0,01	0.1	0.2	SNI 06-6989.19-2005
Biologycal Oxygen Demand (BOD)	mg/l	1.60	2	3	SNI 6989.72-2009
Phosfate (PO4)	mg/l	<0,01	0.2	0.2	SNI 06-6989.1.31-2005
Nitrat (NO_3)	mg/l	0.80	10	10	SNI 19-6964.7:2003
Phenolic Compounds	µg/l	<0,001	0.002	0.005	SNI 06-6989.21-2004
Cadmium (Cd)	mg/l	0.0022	0,01	0,01	SNI 6989.16-2009
Krom val. 6 (Cr^{+6})	mg/l	0.0028	0,05	0,05	SNI 6989.71-2009
Copper (Cu)	mg/l	0.0045	0,02	0,02	SNI 6989.6-2009
Lead (Pb)	mg/l	0.0016	0,03	0,03	SNI 6989.8-2009
Seng (Zn)	mg/l	0.0156	0,05	0,05	SNI 6989.7-2009
Mercury (Hg)	mg/l	<0,001	0.001	0,002	SNI 6989.78-2011
Iron (Fe)	mg/l	0.0498	0.3	-	SNI 6989.4-2009
Mangan (Mn)	mg/l	0.0056	0.1	-	SNI 6989.18-2009
Selenium (Se)	mg/l	0.0028	0.01	0,05	SNI 6989.5-2009
Arsen (As)	mg/l	0.0042	0.05	0.05	SNI 06-6989.54-2005
Cobalt (Co)	mg/l	0.0032	0,2	0,2	SNI 6989.68-2009
Sianida (CN)	mg/l	<0,001	0,02	0,02	SNI 6989.77-2011

Test Parameters	Unit	Test Results	Quality Standards		Test Method
			Class 1	Class 2	
Total detergent	mg/l	0.028	0.2	0.2	SNI 06-6989.51-2005
Fat Oil	mg/l	0.035	1	1	SNI 6989.10-2011
Microbiology					
Total Coliform	MPN/100 ml	15	1000	5000	SNI 01-3553-2006
Fecal Coliform	MPN/100 ml	0	100	1000	MPN

Clean water

From the results of monitoring and calculating the pollution index parameter rating (Ci/Li), it can be seen that almost all of the parameters measured still meet the requirements in accordance with the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 concerning Environmental Health and Water Health Standard Requirements for Hygiene and Sanitation. Therefore, to see the overall water quality, a clean water quality analysis is carried out using the pollution index (IPj) calculation method as shown in Table 3.

Table 3. Results of Clean Water Quality Measurements in the PT IUP area. Sumber Bumiputera

Test Parameters	Unit	Test Results	Quality Standards	Test Method
Physics				
Smell	-	Odourless	Odourless	Organoleptis
Taste	-	Flavourless	Flavourless	Organoleptis
Colour	Skala TCU	10	50	Perbandingan visual
*Total Dissolved Solids (TDS)	mg/l	165	1000	SNI 06-6989.27:2005
*Turbidity	NTU	0.80	25	SNI 06-6989.25:2005
*Temperature	^{0}C	26.40	Suhu udara ±3 ^{o}C	SNI 06-6989.23:2005
Chemistry				
*pH (Degree of Acidity)	-	8.04	6,5 - 8,5	SNI 6989.11:2019
Nitrat (NO_3)	mg/l	0.80	10	SNI 19-6964.7:2003
Nitrit (NO_2)	mg/l	<0,01	1	SNI 06-6989.9:2004
Hardness ($CaCO_3$)	mg/l	36.80	500	SNI 06-6989.12:2004
Flourida (F)	mg/l	0.0028	1.5	SNI 06-6989.29:2005
Total pesticide	mg/l	<0,001	0.1	Gas Cromatografi
Sulfat (SO^{4-})	mg/l	<10	400	SNI 6989.20:2009
Iron (Fe)	mg/l	0.0485	1	SNI 06-6989.49:2005
Mangan (Mn)	mg/l	0.0052	0.5	SNI 06-6989.41:2005
Cadmium (Cd)	mg/l	0.0022	0.005	SNI 06-6989.37:2005
Krom val. 6 (Cr^{+6})	mg/l	0.0029	0,05	SNI 06-6989.53:2005
Timbal (Pb)	mg/l	0.0018	0.05	SNI 06-6989.45:2005
Seng (Zn)	mg/l	0.0155	15	SNI 06-6989.43:2005
Mercury (Hg)	mg/l	<0,001	0.001	SNI 6989.78:2011
Selenium (Se)	mg/l	0.0026	0.01	SNI 6989.5-2009
Arsen (As)	mg/l	0.004	0.05	SNI 06-6989.54:2005
Sianida (CN^-)	mg/l	<0,001	0.1	SNI 6989.77:2011
Detergen as MBAS	mg/l	0.026	0.5	SNI 06-6989.51:2005
Organic Substances ($KMNO_4$)	mg/l	0.20	10	SNI 06-6989.22:2004
Microbiology				
Total Coliform	amnt/100 ml	15	50	SNI 01-3553-2006
Escherichia coli count	amnt/100 ml	0	0	MPN

Waste water

From the results of monitoring and calculating the pollution index parameter rating (Ci/Lij) it can be seen that almost all the parameters measured are still below the quality standards as required in Minister of Environment Regulation Number 09 of 2006 concerning Waste Water Quality Standards for Nickel Ore Mining Businesses as shown in Table 4.

Table 4. Results of Waste Water Quality Measurements (Pond Sediment) in the PT IUP area. Sumber Bumiputera

Test Parameters	Unit	Test Results	Quality Standards	Test Method
*pH (Degree of Acidity)	-	8.04	6-9	SNI 6989.11-2019
*Total Suspendid Solid (TSS)	mg/l	65.80	200	SNI 6989.3-2019
Iron (Fe)	mg/l	1.1823	5	SNI 6989.4-2009
Nikel (Ni)	mg/l	0.0781	0.5	SNI 6989.18-2009
Cadmium (Cd)	mg/l	0.0167	0.05	SNI 6989.16-2009
Krom val. 6 (Cr^{+6})	mg/l	0.0128	0.1	SNI 6989.71-2009
Copper (Cu)	mg/l	0.0184	2	SNI 6989.6-2009
Timbal (Pb)	mg/l	0.0109	0.1	SNI 6989.8-2009
Seng (Zn)	mg/l	0.8944	5	SNI 6989.7-2009
Cromium (Cr)	mg/l	0.0182	0.5	SNI 6989.17-2009
Cobalt (Co)	mg/l	0.0196	0.4	SNI 6989.68-2009

Soil Quality Monitoring

Soil quality monitoring is carried out to evaluate the management of environmental impacts due to mining activities and is directed at changes in the landscape and sedimentation that occur (Andshani et al., 2024; Pacetti et al., 2020; Rouhani et al., 2023). The results of the analysis of the physical and chemical properties of the soil are presented in Table

Table 5. Results of analysis of physical and chemical properties of soil in the PT Sumber Bumiputera area

Parameter Test	Unit	Test Results	Analysis Method
		TNH-MMM-01	
pH (H2THE)	–	5.88	pH-Meter
N-total	%	0.431	Kjedahl
P-available	ppm	12.80	Spectrophotometric
K-available	me/100g	16.90	AAS
Organic Ingredients	%	0.95	Spectrophotometric
Porosity	%	24.20	Gravimetry
Volume Weight	mg/l	1.268	Gravimetry
Permeability	cm/hour	22.50	Volumetric
Textures			Volumetric
*Look	%	45.80	
*Sand	%	5.80	
*Dust	%	48.40	
Type Substrate		Dusty Clay	

Information: TNH-MMM-01 = IUP location (S: 03^0 31′ 48.7″ E: 122^0 10′ 38,9″)

The condition of the chemical properties of the soil at the mine site at the observation sampling location shows that soil pH is in the neutral criteria, organic C is in the low range, total N is in the low range, available P is in low status and available K is in low status. Based on the results of the analysis of the quality of soil chemical properties, it shows that the level of soil fertility is still low. However, the reaction (pH) of the soil is in the neutral category so adding essential nutrients (fertilizer) will really help in increasing soil fertility so that plant growth is optimal.

The results of the analysis of the physical properties of the soil show that the soil porosity is low category, the soil permeability is slow, the volume weight of the soil is in accordance with mineral soils in general and the texture is dominated by the clay content binds a lot of water and nutrients. The physical condition of the soil is such that soil erosion and sedimentation easily occur at mining sites, especially mine reclamation sites. So, it is necessary to use the right plants for current field conditions.

Trend Evaluation

Air Quality

Noise

Monitoring results in the second semester of 2024 (Figure 2) show that noise values have decreased at mine sites and other locations. The noise value is still in good condition because it is below the specified quality standard threshold.

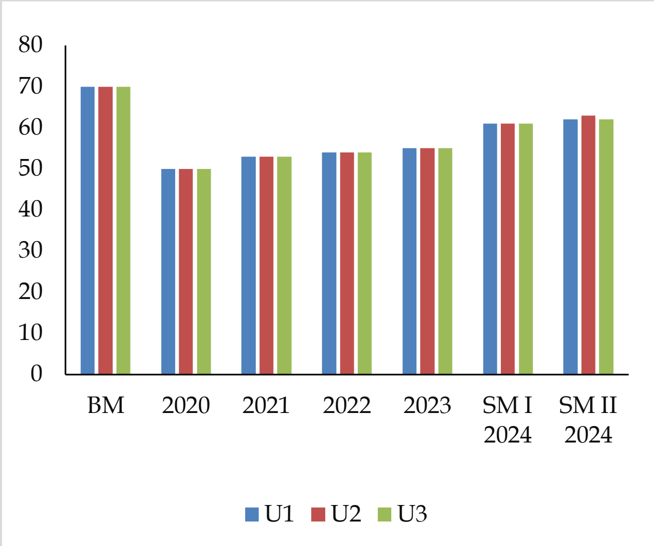

Figure 2. Noise data at the air quality monitoring station (U1 to U2) on monitoring the semester of 2020 to semester II of 2024

Sulfur Dioxide (SOx)

Monitoring results in the second semester of 2024 (Figure 3) show that SOx values in the mining area are generally below the environmental quality standard threshold. So, the air quality for SOx parameters is in very good condition.

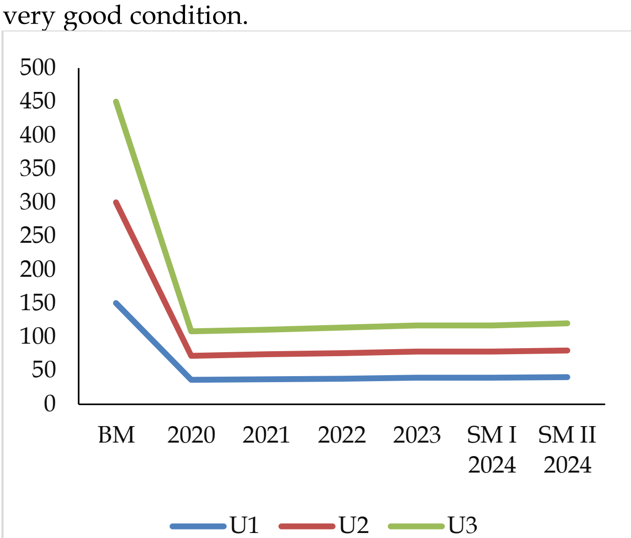

Figure 3. Sulfur dioxide data in station air quality monitoring (U-1 to U-4) on monitoring in 2020 until semester II of 2024

Nitrogen Dioxide (NOx)

Monitoring results in the second semester of 2024 (Figure 4) show that NOx values are generally far below the environmental quality standard threshold. So, the air quality for NOx parameters is in very good condition.

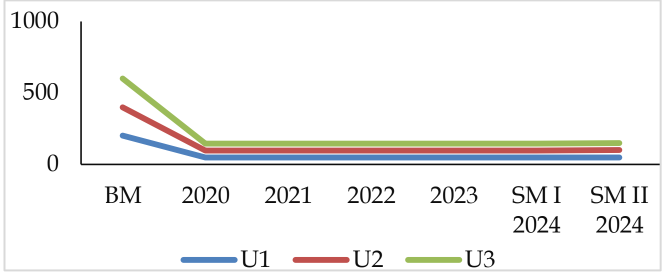

Figure 4. Nitrogen dioxide data in Station air quality monitoring (U-1 and U-3) in monitoring from 2020 to the second semester of 2024

Carbon monoxide (COx)

Monitoring results in the second semester of 2024 (Figure 5) show that COx values are generally far below the environmental quality standard threshold. So the air quality for COx parameters is in very good condition.

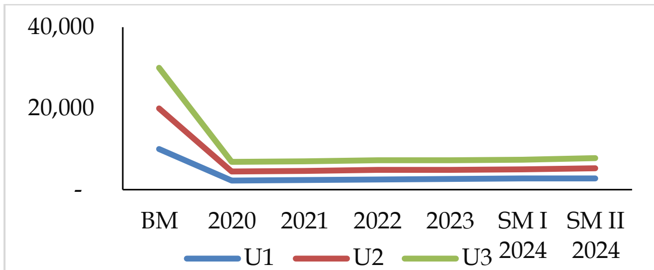

Figure 5. Carbon Monoxide Data in station air quality monitoring (U-1 and U-3) during monitoring from 2020 to the second semester of 2024**.**

Figure 6 shows that the carbon monoxide content in the previous semester was quite high compared to the quality standard, but in the second semester of 2024 it was far below the required threshold. This condition can be explained due to activities in the mining area of PT. Sumber Bumiputera is not working as it should.

Temperature (^oC)

Monitoring results in the second semester of 2024 (Figure 5) show that temperature values are generally the same as in previous years. Because the temperature value does not have a threshold value, a comparison of the optimal temperature conditions used by humans in general in tropical areas is used in the range of 26-43^{the} C. If this is used as a reference, the temperature conditions at the mining location and its surroundings are still in optimal conditions at certain times.

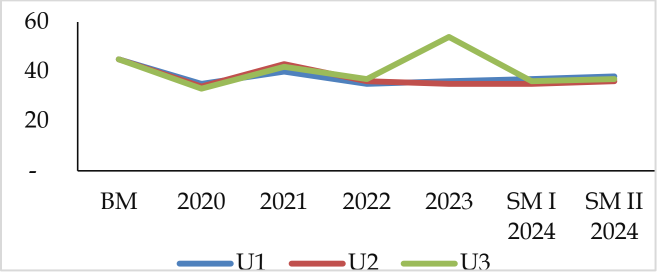

Figure 6. Temperature data in station air quality monitoring (U-1 and U-2) during monitoring from 2020 to the second semester of 2024.

Dust

Monitoring results in the second semester of 2024 (Figure 7) show that dust levels in the mine site area are generally far below the environmental quality standard threshold. So, the air quality for dust parameters is in very good condition.

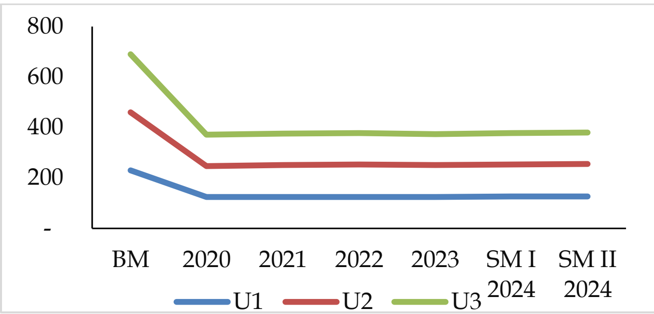

Figure 7. Dust Data in station air quality monitoring (U-1 to U-4) in monitoring from 2020 to semester II of 2024

PM 2.5

Monitoring results in the second semester of 2024 (Figure 8) show that PM 2.5 levels in mining areas is generally far below the environmental quality standard threshold. So, the air quality for PM 2.5 parameters are in excellent condition.

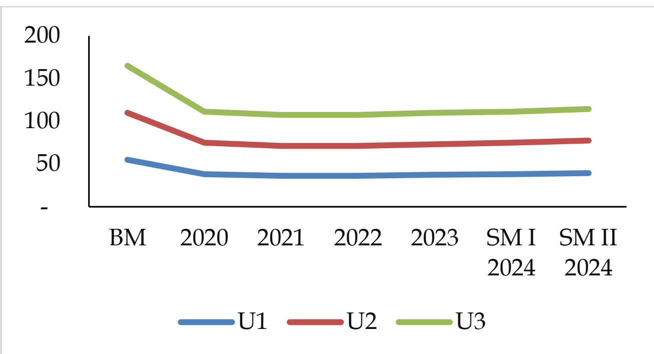

Figure 8. PM 2.5 and PM 10 data in station air quality monitoring (U-1 and U-2) in monitoring from 2020 to the second semester of 2024

Water Quality

Water quality status is described by the pollution index which is used to determine the level of pollution relative to permitted water quality parameters (Harahap et al., 2020; Şener et al., 2017). The Pollution Index can provide input to decision makers so they can assess water quality and take certain actions to improve water quality (Hossain & Patra, 2020; Ratnaningsih et al., 2018; Uddin et al., 2022).

Total Suspended Solid (TSS)

The results of surface water quality monitoring for TSS parameters in the first semester of 2024 (Figure 9) show that TSS values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

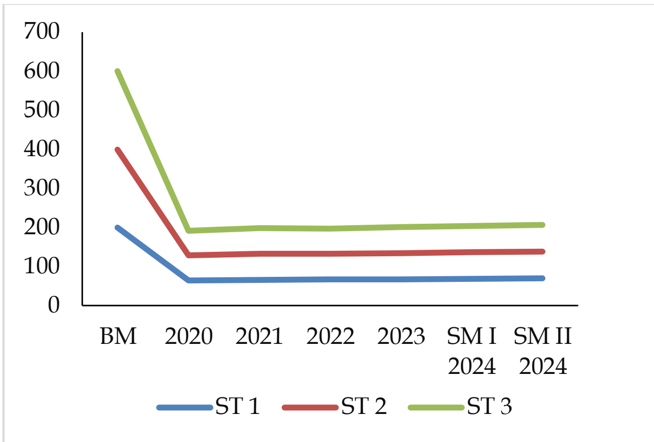

Figure 9. TSS data at station monitoring surface water quality during monitoring from 2020 to the second semester of 2024

Degree of Acidity (pH)

The results of surface water quality monitoring for pH parameters in the second semester of 2024 (Figure 10) show that the pH value was not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

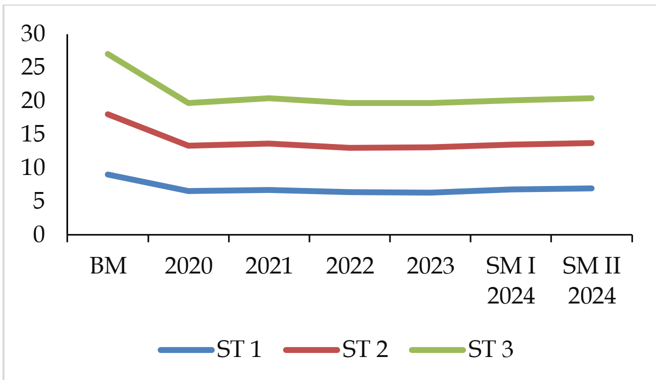

Figure 10. pH data at station monitoring surface water quality during monitoring from 2020 to the second semester of 2024

Figure 10 shows that there is an increase in pH this semester compared to the next semester even though there is no mining activity. It can be concluded that mining activities can affect the pH value of water. However, further observations are still needed in the following semesters.

Iron (Fe)

The results of surface water quality monitoring for Fe parameters in the second semester of 2024 (Figure 11) show that Fe values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

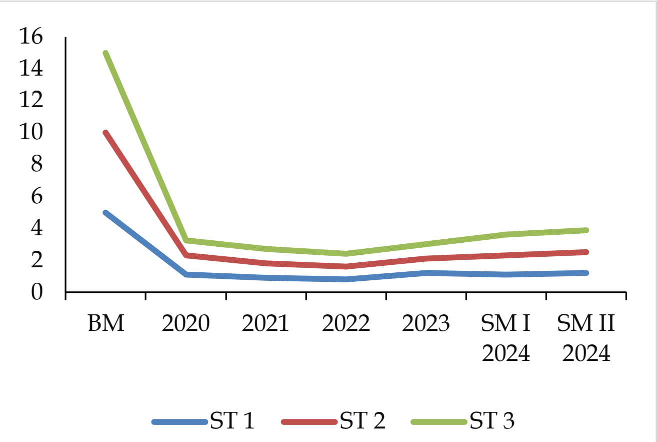

Figure 11. Iron data in station monitoring surface water quality during monitoring from 2020 to the second semester of 2024

Kobal (What)

The results of surface water quality monitoring for the Co parameter in the second semester of 2024 (Figure 12) show that Co values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

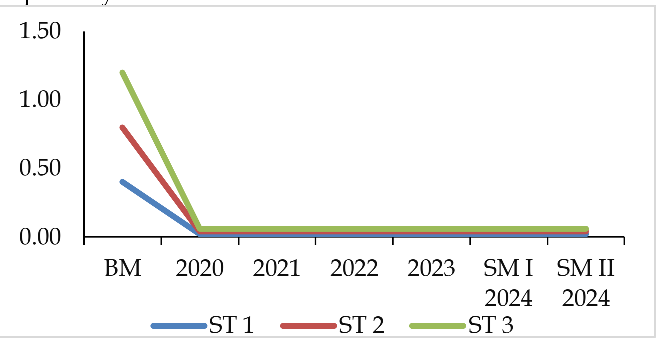

Figure 12. Cobalt data in station monitoring surface water quality during monitoring from 2020 to the second semester of 2024.

Lead (Pb)

The results of surface water quality monitoring for Pb parameters in the first semester of 2024 (Figure 13) show that Pb values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

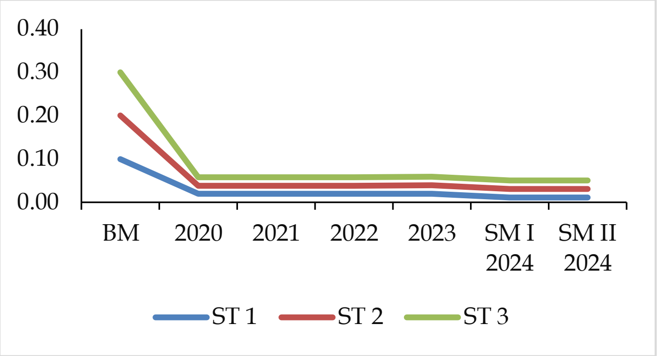

Figure 13. Lead data in station monitoring surface water quality during monitoring from 2020 to the second semester of 2024.

Zinc (Zn)

The results of surface water quality monitoring for Zn parameters in the second semester of 2024 (Figure 14) show that Zn values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

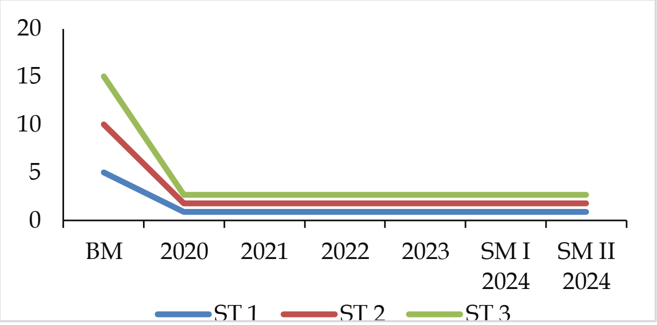

Figure 14. Zinc data on station monitoring surface water quality during monitoring from 2020 to the second semester of 2024.

Copper (Cu)

The results of surface water quality monitoring for Cu parameters in the second semester of 2024 (Figure 15) show that Cu values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

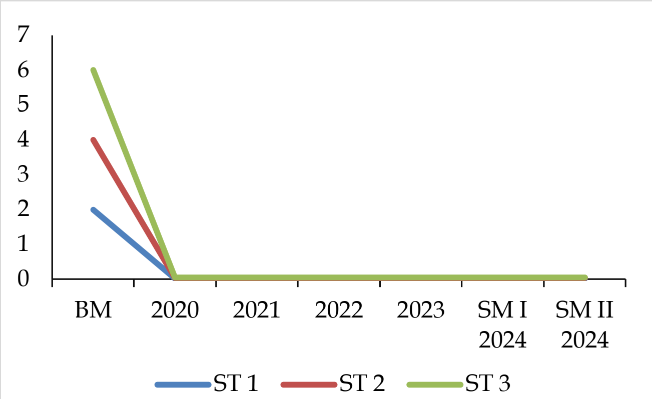

Figure 15. Copper data in station monitoring surface water quality during monitoring from 2020 to the second semester of 2024

Cadmium (Cd)

The results of monitoring surface water quality for Cd parameters in the second semester of 2024 (Figure 16) show that Cd values were not monitored due to the long dry season in the Southeast Sulawesi region, especially at the location point.

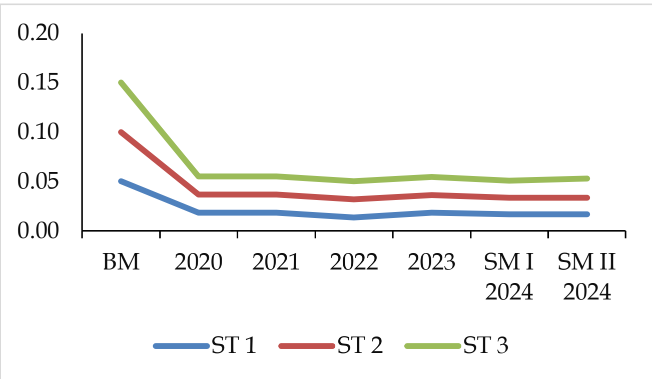

Figure 16. Cadmium data at station monitoring surface water quality during monitoring from 2020 to the second semester of 2024

Chromium (Cr^{+6})

Surface water quality monitoring results for the Cr parameter^{+6} in the second semester of 2024 (Figure 17) shows that the Cr^{+6} No monitoring was carried out due to the long dry season in the Southeast Sulawesi region, especially at the observation location.

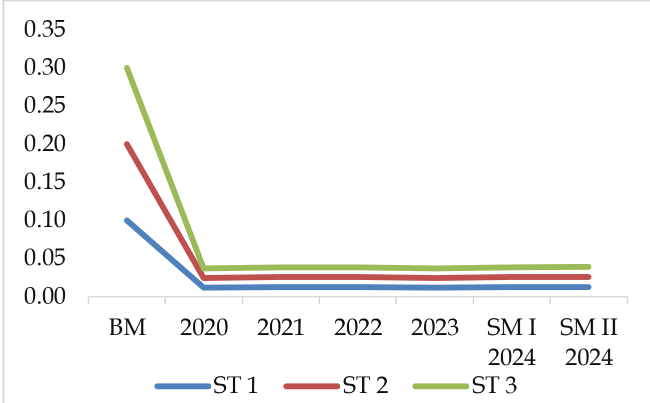

Figure 17. Chromium data (Cr^{+6}) Of station monitoring surface water quality during monitoring from 2020 to the second semester of 2024.

Soil Physical Quality

Soil physical quality as an environmental indicator in environmental monitoring due to mining activities at PT. Sumber Bumiputera was carried out on station observation. Considering that there are no environmental quality standards for soil physical parameters, the trend for each semester is used station the same observation. Trends in soil physical properties using data from the previous semester are presented in the following section, Figure 18.

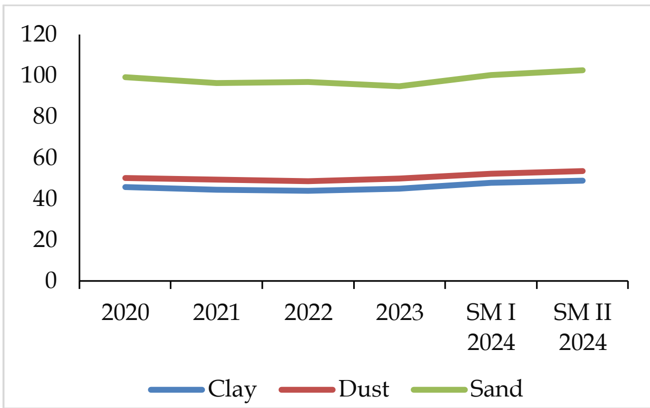

Figure 18. Data on physical properties of soil in station Soil quality monitoring in 2022 monitoring uses data from Semester II 2024

The results of monitoring the physical quality of the soil show that the texture does not experience much change because the character of the soil will not change even though various pressures and technologies have been applied to it. Likewise, the volume of land also did not experience significant changes. Soil porosity and permeability depend on the conditions for the presence of water in the soil. These two parameters relate to the vertical and horizontal entry of soil into the soil (Andayono & Palinto, 2023).

Based on the criticality level of the data, it was found that the environmental parameters monitored were below the required environmental quality standards. Thus, it can be said that environmental management and monitoring has complied with existing regulations and in accordance with the provisions in the RKL and RPL.

Conclusion

The findings of this study indicate that while PT. Sumber Bumiputera has implemented several environmental management strategies, such as land rehabilitation, waste management, and systematic monitoring of air and water quality. There remain significant areas for improvement. Strengthening community engagement, enhancing monitoring mechanisms, and ensuring stricter compliance with sustainability standards are crucial steps toward more effective environmental management. These findings have broader implications beyond North Konawe, as similar challenges exist in other mining-intensive regions. The study underscores the necessity for continuous environmental monitoring and adaptive management strategies to mitigate the negative impacts of mining activities. Practically, the results suggest that policymakers and industry stakeholders should develop more robust regulatory frameworks that integrate environmental sustainability into mining operations. Additionally, increasing community participation in environmental decision-making can enhance accountability and lead to more sustainable practices. Future research should explore the long-term effectiveness of these strategies and their applicability to other resource-extraction industries.

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Author Contributions
All authors have collaboratively contributed to every stage of this research, from conceptualization, data collection, analysis, and interpretation, to the final writing of this article. Each author has played an integral role in ensuring the accuracy and integrity of the findings presented in this study.

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Conflicts of Interest
The authors declare that there are no conflicts of interest related to this research. No personal, financial, or institutional factors have influenced the results or conclusions of this study.

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