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| RESEARCH ARTICLE

Optimization of Mine Wastewater Treatment with Sump Water Circulation Treatment Method

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| ABSTRACT
The mining industry is one of the sectors that play an important role in the economy, but mining activities often produce hazardous waste for the environment, such as mine wastewater. This research aims to optimize mine wastewater management by applying the sump water circulation treatment method. This research uses an experimental research method in the PT Antereja Mahada Makmur mining area, which operates in the mining area of PT Multi Harapan Utama, Loa Kulu District, Kutai Kartanegara Regency, and East Kalimantan. Data collection techniques were carried out by field observation. The data that was collected is then analyzed qualitatively. The results showed a higher decline than planned in the remaining volume of sump 90. The impact of this decline was the achievement of the coal exposure target in November 2022. This shows that using the sump water circulation treatment method has successfully optimized the treatment of mine wastewater and has a positive impact on reducing the remaining volume of sump 90 so that the coal exposure target can be achieved effectively.

| KEYWORDS
Treatment, Wastewater, Mine, Circulation Treatment, Sump Water

| ARTICLE INFORMATION
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1. Introduction
The mining industry is one of the sectors that play an important role in the economy, but mining activities often produce hazardous waste for the environment, such as mine wastewater (Saleh & Wahyu, 2019). Acid mine drainage is a waste product that damages the environment due to mining activities. The source of this waste arises from the oxidation of pyrite minerals (FeS2) and other sulfide minerals that are exposed to the ground surface during the mineral mining process. Chemical and biological interactions of these minerals produce sulfate with significant acidity (Wahyudin et al., 2018). This high acidity, directly and indirectly, impacts environmental quality and the survival of surrounding organisms (Yusran, 2009).

Mine wastewater contains various hazardous chemicals such as heavy metals, acids, and other toxic chemicals. When this wastewater leaks or seeps into waters, it can contaminate clean water sources, disrupt aquatic ecosystems, and harm aquatic life (Herman, 2006). In addition, mining wastewater can also impact the company managing it, such as the submergence of overburden and coal reserves.

Figure 1. Sump 90 in October 2022

Figure 1 illustrates a situation where coal reserves and overburden are submerged in water. Progress in pumping water from sump 90 in the Sentuk Pit has encountered constraints that have resulted in optimization. This is due to the inability to continuously discharge water from settling pond 07 (SP07) to free water due to the excessively high Total Suspended Solids (TSS) value of the sump water (>37700 mg/l)*. This is despite the fact that the mining wastewater quality standard, according to East Kalimantan Regional Regulation No. 2 Year 2011, is ≤ 300 mg/L. If this situation continues, it could disrupt coal exposure in quarter 4 of 2022, where SR (Stripping Ratio) levels are expected to increase, which in turn could impact delays in achieving production volume targets and potentially affect overburden-related progress claims.

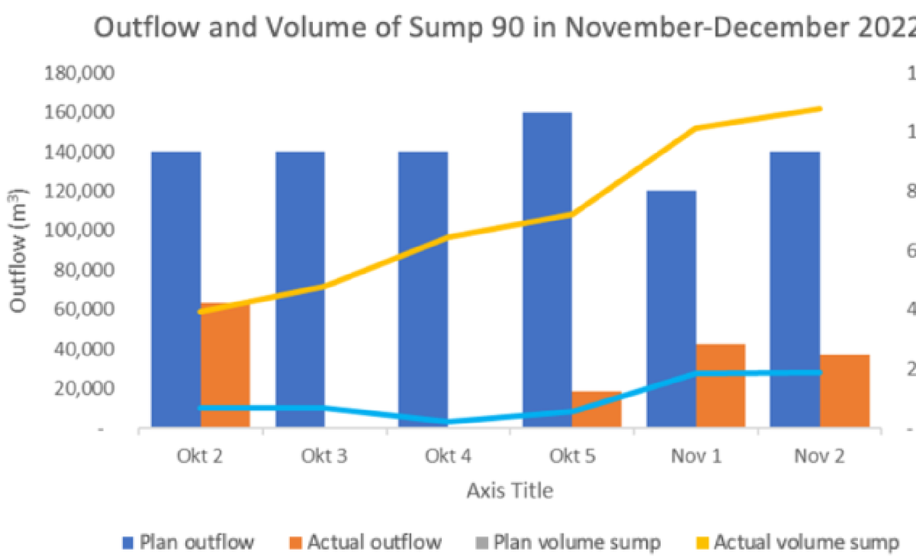

Figure 2: Outflow and Volume of Sump 90 October-November 2022

In Figure 2, the graph depicting the outflow and sump volume in the October-November 2022 period shows that the actual volume remaining is much larger than planned. The original plan was to have a sump water volume of 188,526 m3. However, the actual volume recorded was 1,076,939 m3, indicating a considerable difference between the plan and reality estimates regarding sump water management, indicating a problem in managing and controlling mine wastewater during this period.

Environmental pollution management is required by Law No. 32/2009 on Environmental Protection and Management. In this case, the management of pollution and damaging impacts on the environment is carried out to maintain the function and integrity of the environment (Suoth & Nazir, 2014). Efforts to implement this policy include optimizing mine wastewater treatment. This research aims to optimize mine wastewater management by applying the sump water circulation treatment method.

2. Method

This research uses an experimental research method. The experimental research method is a research approach designed to test hypotheses or cause-and-effect relationships between certain variables (Ramdhan, 2021). This research was conducted in the mining area of PT Antereja Mahada Makmur, which operates in the mining area of PT Multi Harapan Utama, Loa Kulu District, Kutai Kartanegara Regency, East Kalimantan. Data collection techniques were carried out by field observation. The collected data were then analyzed qualitatively.

3. Discussion

In this study, the outflow and volume of the sump in the October-November 2022 period were much larger than the actual volume remaining. The initial plan was to have a sump water volume of 188,526 m3. However, the actual volume recorded was 1,076,939 m3, indicating a considerable difference between the estimated plan and reality regarding sump water management, indicating a problem in managing and controlling mine wastewater in that period. Therefore, it is necessary to optimize wastewater treatment.

Optimization of mine wastewater treatment is an approach or effort to optimize the treatment process or treatment of wastewater generated from mining activities (Gunawan, 2006). One method for optimizing mine wastewater treatment is sump water circulation treatment. This method involves a water circulation cycle, in which sump (additional) water from various sources such as rainwater, groundwater, or surface water is collected, treated, and re-treated for use in various mining processes (Maulana, 2020).

The optimization of mine wastewater treatment aims to achieve several significant targets. First, achieving Coal Expose and Overburden Targets are key factors in the success of mining operations. Second, reducing the need for coagulant doses for wastewater treatment impacts the efficiency of the treatment process. Third, a reduction in the need for mud maintenance activities at SP 07 contributed to cost and resource savings. Finally, an increase in the Life Time of the Settling Pond to more than 14 days indicates an increase in the effectiveness of the management and maintenance of the settling pond. This optimization aims to realize more efficient, sustainable operations and positively impacts the environment and financial aspects of the company.

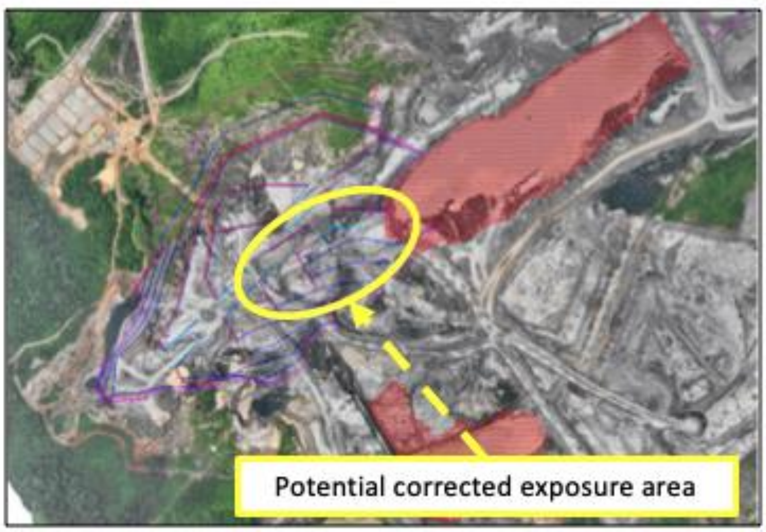

Figure 3. Potential Corrected Area

Taking into account the ongoing pumping conditions, by the end of November 2022, there is a change in the volume of sump 90, reaching 1,694,661 m3. In addition, there is a correction in the volume of exposed coal in seam 90 of 71,473 metric tons (mT). This shows that with the measures taken, the volume of water in sump 90 has changed significantly, and the volume of exposed coal in seam 90 has also been corrected, resulting in a more accurate volume calculation. These changes may indicate the effectiveness of the measures taken to regulate and manage water and coal resources at the site.

Figure 4. Before treatment

Improvement planning begins with the calculation of pre-treatment and treatment alum dosage requirements based on the results of jar test data and pumping plans:

Table 1. Calculation of pre-treatment and treatment alum dose requirements

Sample	TSS Value	Alum Dosage	Sedimentation Time	Effectiveness	Plan Wastewater Discharge	Alum Usage Target*	Target TSS Value for SP Inlet
Seam 90 -> Void 70 West	37.700 ppm	1,1 gram/Liter	72 jam	94,69%	1,577,060 Liters/hour (2 MF420 pumps)	35.000 Kg/day	≤2.000 mg/L
Void 70 West -> Inlet SP 07	2.000 ppm	0.14 gram/Liter	5 jam	92,50%	1,321,730 Liters/hour (1 MF380 pump and 1 MF420 pump)	3.750 Kg/day	<300 mg/L

Description: Pump running 20 hours/day

In the Improvement Planning table, two categories of samples are analyzed in calculating alum dosage requirements at the Pre-Treatment and Treatment stages. The first category, the Seam 90 -> Void 70 West sample, has a TSS (Total Suspended Solid) value of 37,700 ppm. The alum dosage applied was 1.1 grams per litre with 72 hours of sedimentation time. The effectiveness of using alum in reducing TSS reached 94.69%. The planned wastewater discharge for this category is 1,577,060 litres per hour using two pumps, type MF420. The target use of alum per day is 35,000 Kg to achieve a TSS value at the Inlet SP (Settling Pond) of no more than 2,000 mg/L.

Meanwhile, the second category, namely the Void 70 West -> Inlet SP 07 sample, has a TSS value of 2,000 ppm. The alum dose applied for this category is 0.14 grams per litre with a sedimentation time of 5 hours. The effectiveness of using alum in reducing TSS reached 92.50%. The planned wastewater discharge for this category is 1,321,730 litres per hour, using 1 pump type MF380 and one pump type MF420. The target use of alum per day is 3,750 Kg to achieve a TSS value at the SP Inlet of less than 300 mg/L. The existence of Void 70 West, which has an area of 8.6 Ha with the deepest point reaching 34 meters, is used as a sludge deposition area, and this can optimize the process of coagulant treatment activities because the depth of the void causes the active flow space for clean water to become more and the deposition process runs optimally so that the required alum dose can be reduced.

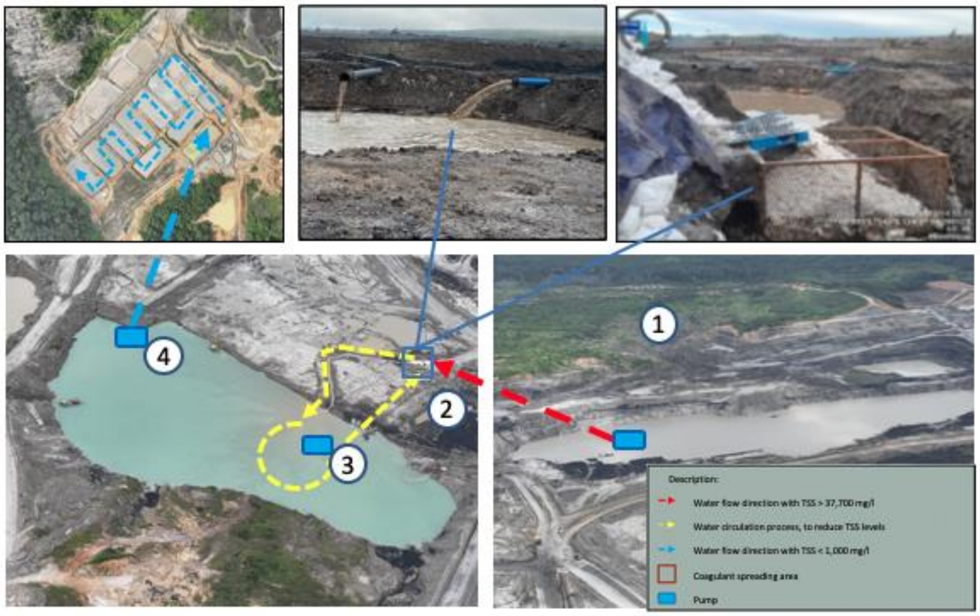

Figure 5. After treatment

Monitoring of Total Suspended Solids (TSS) entering Settling Pond 07 (SP 07) over a 3-month period revealed a significant reduction in TSS concentrations entering the SP after treatment. The improvement in the efficiency of the treatment process resulted in a significant decrease in the TSS content entering the SP. These results indicate that the remedial actions taken have had a positive impact in reducing pollution and improving the quality of wastewater entering SP 07 over the three-month monitoring period, as depicted in the following figure:

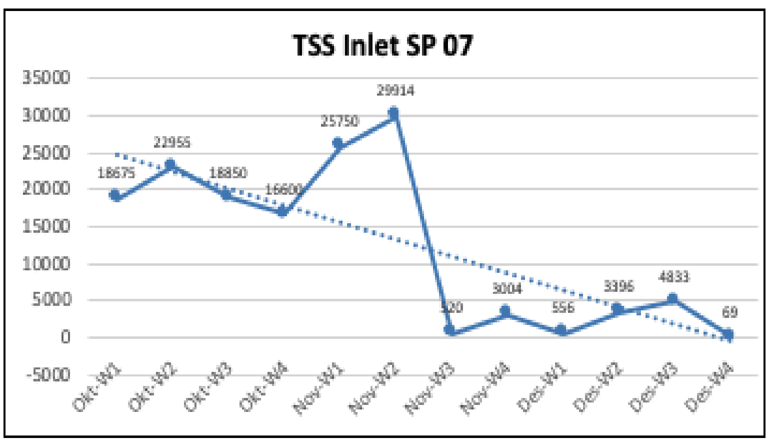

Figure 6. TSS Inlet SP 07

In the graph below depicting the amount of maintenance per month, it can be seen that there is an upward trend in the average life time of Settling Pond 07 (SP 07). This increase is in line with a significant decrease in the amount of maintenance required for the SP. In other words, as the average life time of SP 07 increases, there is a reduction in the need for routine maintenance. This indicates that the improvement in the quality and efficiency of wastewater treatment in SP 07 has successfully reduced the problems requiring maintenance and effectively extended the service life of SP 07.

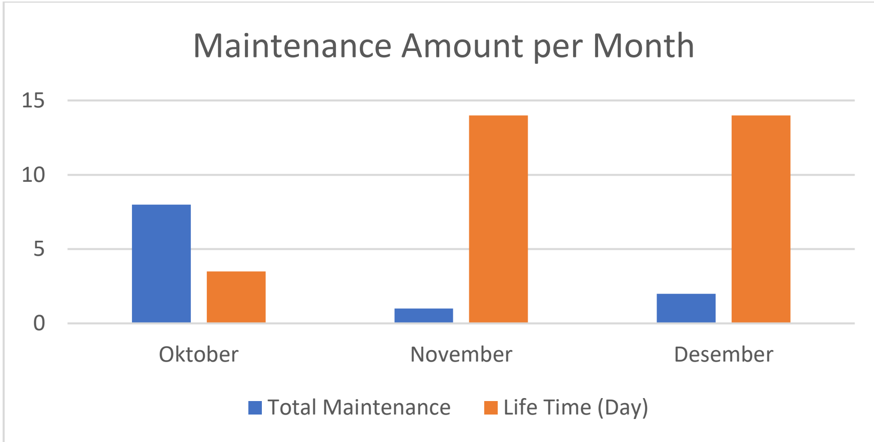

Figure 7. Number of Maintenance per Month

Analysis of the graph in Figure 8 shows that there is a decrease in the remaining volume of sump 90 that exceeds the predetermined plan. This indicates the effectiveness of the sump water circulation treatment method implemented. The positive impact of the decrease in the remain volume of sump 90 is the achievement of the coal expose target in November 2022 as planned. This means that the efforts to optimize mine wastewater treatment have provided the expected results and succeeded in maintaining the continuity of coal exposure at the desired level.

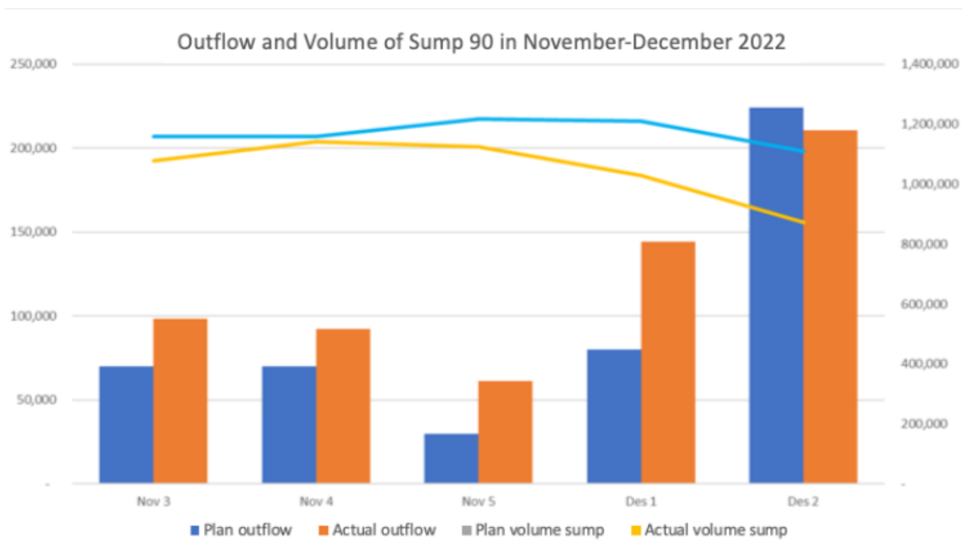

Figure 8. Outflow and Volume of Sump 90 in November-December 2022

The corrected exposure area can occur as a result of the implementation of the optimized sump water circulation treatment method. With the use of this method, the coal exposure area may be adjusted or corrected to meet the optimization objectives of the study. This may include a reduction, change in distribution, or increase in coal exposure in accordance with the established plan.

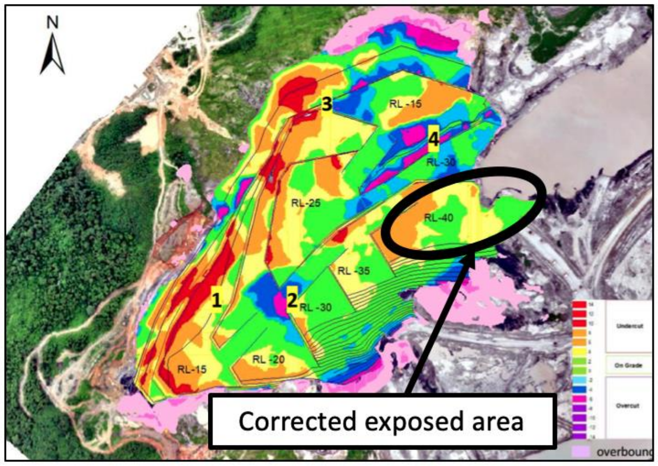

Figure 9. Corrected exposed area

In the Sentuk area for overburden, there is a comparison between the plan value of 6,954,716.80 and the actual value of 7,013,259.70. In addition, there is a calculation of the ACG (Actual-to-Plan Ratio) value of 100.8%. This indicates that there was an actual increase from the planned value for the Sentuk overburden area. While in the Sentuk area for coal expose, there is a plan value of 513,947.86 and an actual value of 512, 6699.45. The ACH (Actual-to-Plan Ratio) value in this area reached 99.8%, showing a decrease in the actual value from the plan in the Sentuk coal expose area.

Table 2: Comparison of Alum Dosage Requirements before Improvement

Stream	Average TSS Value	Alum Dosage	Wastewater Discharge	Alum Used	Mud Percentage
Seam 90 -> Inlet SP 07	37700 ppm	5 gram/Liter	541,460 Liter/hour (1 MF380 pump)	54.146 Kgday	76%

Description: Pump running 20 hours/day

Table 2 contains data that illustrates the conditions before corrective actions were implemented. This data refers to the flow from Seam 90 to Inlet SP 07, where it can be seen that the average TSS (Total Suspended Solids) value is 37,700 ppm. Under these conditions, the alum dosage used was 5 grams per liter, with a wastewater discharge of 541,460 Liters per hour regulated by one MF380 type pump. Alum usage under these conditions reached 54,146 Kg per day, and the percentage of sludge involved in the process was about 76%.

Table 3. Comparison of Alum Dosage Requirement after Improvement

Stream	Average TSS Value	Alum Dosage	Wastewater Discharge	Alum Used	Final TSS value generated
Seam 90 -> Void 70 West	37.700 ppm	1,1 gram/Liter	1,577,060 Liter/hour (2 MF420 pumps)	35.000 Kg/day	2.063 mg/L
Void 70 West -> Inlet SP 07	2.063 ppm	0.15 gram/Liter	1,321,730 Liters/hour (1 MF380 pump and 1 MF420 pump)	3.750 Kg/day	35 - 150 mg/L
				38.750 Kg/day	

Description: Pump running 20 hours/day

In the comparison table of alum dosage requirements after the improvement, there are significant changes in alum usage in the two streams discussed. First, in the flow from Seam 90 to Void 70 West, it can be seen that the average TSS (Total Suspended Solids) value before the improvement was 37,700 ppm. However, the alum dosage has been successfully reduced to 1.1 grams per liter after the improvement. The wastewater discharge regulated by two MF420-type pumps increased to 1,577,060 liters per hour. The use of alum under these conditions was successfully reduced to 35,000 Kg per day. The result is that the resulting TSS value reaches 2,063 mg/L.

Furthermore, in the flow from Void 70 West to Inlet SP 07, the average TSS value before the improvement was 2,063 ppm. After the improvement, the alum dosage applied was 0.15 grams per liter, with the wastewater discharge regulated by one MF380 pump and one MF420 pump, reaching 1,321,730 Liters per hour. Alum usage in this stream was reduced to 3,750 Kg per day. The result was that the resulting TSS value ranged from 35 to 150 mg/L. After the remedial action was taken, the final TSS value generated reached 38,750 Kg per day, demonstrating the remedy's effectiveness in reducing the amount of suspended solid matter in the wastewater.

Evaluation of the results of the cost study on pending volume and alum use efficiency resulted in significant findings. From the pending volume calculation, there is a potential pending volume of 967,029 Bcm, with a potential loss of revenue reaching Rp. 23,208,696,000. This is related to the overburden (OB) plan of 6,954,716 Bcm and the coal exposure plan of 513,947 mTon, and the potential loss of coal reached 71,473 mTon. Meanwhile, in the context of the cost efficiency of alum use, the calculation shows that the alum plan per day is 54,146 Kg with an alum plan cost of Rp. 216,584,000. However, the actual use of alum amounted to 38,750 Kg per day with an actual cost of alum of IDR 155,000,000. This results in a potential pending volume of alum usage efficiency of Rp. 61,584,000. This evaluation found that the amount of revenue that can be saved based on the comparison between pending volume and alum usage efficiency is Rp. 23,270,280,000. This finding shows that by optimizing the use of alum and reducing the pending volume, the company can save significant revenue.

4. Conclusion

The results revealed a decrease in the remaining volume of sump 90, which was higher than initially planned. The impact of this decrease was the achievement of the coal exposure target in November 2022. This result significantly contributed, especially to revenue savings of IDR 23,270,280,000. This finding shows that the implementation of the sump water circulation treatment method has successfully optimized the treatment of mine wastewater and has a positive impact in reducing the remaining volume of sump 90. Therefore, this ensures the effective achievement of the coal exposure target.

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Conflicts of Interest: The authors declare no conflict of interest.
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References

[1] Gunawan, Y. (2006). Peluang Penerapan Produksi Bersih Pada Sistem Pengolahan Air Limbah Domestik Waste Water Treatment Plant# 48, Studi Kasus di PT Badak NGL Bontang (Doctoral dissertation, program Pascasarjana Universitas Diponegoro).
[2] Herman, D. Z. (2006). Tinjauan terhadap tailing mengandung unsur pencemar Arsen (As), Merkuri (Hg), Timbal (Pb), dan Kadmium (Cd) dari sisa pengolahan bijih logam. *Indonesian Journal on Geoscience*, *1*(1), 31-36.
[3] Maulana, A. R. (2020). Perencanaan Teknis Geometri Sump Di Pit 1 Timur, Banko Barat, Jobsite TJMO, PT. Satria Bahana Sarana, Tanjung Enim, Sumatera Selatan (Bachelor's thesis, Fakultas Sains dan Teknologi UIN Syarif Hidayatullah Jakarta).
[4] Ramdhan, M. (2021). *Metode penelitian*. Cipta Media Nusantara.
[5] Saleh, L. M., & Wahyu, A. (2019). K3 pertambangan kajian keselamatan dan kesehatan kerja sektor pertambangan. Deepublish.
[6] Suoth, A. E., & Nazir, E. (2014). Penaatan Perusahaan Tambang Batubara di Kalimantan Timur terhadap Peraturan Air Limbah Pertambangan. *Ecolab*, *8*(2), 61-68.
[7] Wahyudin, I., Widodo, S., & Nurwaskito, A. (2018). Analisis penanganan air asam tambang batubara. *Jurnal Geomine*, *6*(2).