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Recycling Acid Mine Drainage into a Source of Clean Water

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Abstract **-** A good and sustainable source of water is needed to support coal mining operation. Therefore, it is essential for the company to make sure that a large quantity of water is always available. PT Putra Perkasa Abadi (PPA), a mine service company that is currently holding a contract with PT Borneo Indobara (the coal permit holder), recycles acid mine drainage (AMD) into a source of clean water to meet this need. This study aims to provide an alternative source of clean water by recycling AMD. In this study, AMD is pumped from the sump to the sediment pond to be chemically treated by using precipitation, flocculation, and coagulation methods. And then, it flowed through a pipe to the Water Treatment Plant (WTP) to be processed into clean water. The quality of clean water (i.e. pH, Total Dissolve Solids, and turbidity) complies with Ministry of Health of Indonesia Regulation No. 2 of 2023. The result shows that PPA was able to provide an estimated volume of 10.000 – 12.000 m^3 of clean water monthly. PPA was also able to eliminate the use of groundwater by implementing AMD recycling practices. Recycling AMD is proven to be a very effective alternative to provide a large amount of clean water supply to support coal mining operation in PPA.

Keywords**:** acid mine drainage, coal mine, clean water

1. Introduction

Overseeing the rapid economic growth in Asian countries, it is estimated a total of 7 billion ton of coal is required to fulfill the needs of electricity in Asia by 2030. It shows that coal demand in Asia will continuously increase over time. However, the bigger coal production activites may also produce bigger negative impacts on the environment, such as damage to natural habitat of flora and fauna, disrupting local ecosystems, land degradation, acidic water production, and air pollution. Consequently, coal mining activities must be conducted responsibly by adopting eco-friendly practices such as land rehabilitation after mining, waste management, and close supervision to the compliance of environmental standards [1].

PT Putra Perkasa Abadi (PPA) is a mine service company that is currently holding a contract with PT Borneo Indobara (the coal permit holder). It is located in South Kalimantan Province, Republic of Indonesia. Clean water is essentially needed by PPA to support its coal mining activities. It is needed for bathing, washing clothes, food preparation, washing heavy duty units, road watering, and other coal mining supporting activites. The number of PPA employees and their partners continuously grows over time. In 2023, the number of employees has reached a total of 5000 people. It is estimated that daily clean water need is 400.000 litres or approximately 10 – 12 million litres a month.

Continuous use of groundwater to meet the daily water needs is not a wise choice. In addition to the limited amount of groundwater, this is also in line with the government's expectations conveyed by the Minister of Public Works and Public Housing Mr. Basuki Hadimuljono regarding the optimisation of groundwater by promoting save yield, namely by conjunctive use [2]. In the efforts to optimise groundwater conservation, PPA innovates by recycling AMD into a source of clean water.

2. Methods

This study was conducted in PPA jobsite PT Borneo Indobara during January to December 2022. The data collection methods are field observation, water sampling, interviews with the in-charge staff, and laboratory analysis to check the quality of water. In addition, secondary data such as company procedures and environmental reports were also used and analysed to support the study.

2.1. Acid Mine Drainage Production

Acid mine drainage (AMD) is produced from rocks containing oxidised sulphide minerals [3]. It has low pH and other soluble toxic materials that may cause negative impact to the environment. Remediation is needed before the AMD is released to flow into the free water systems [1]

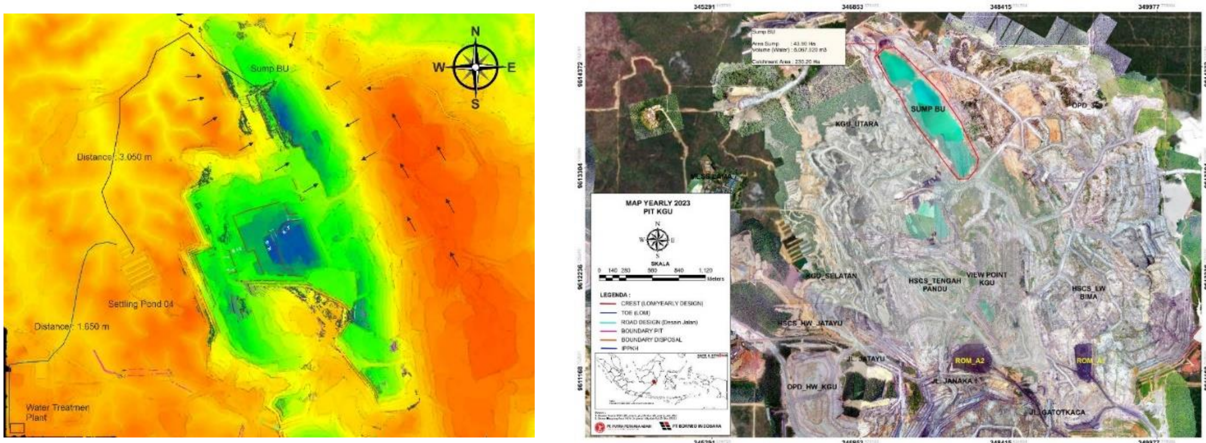
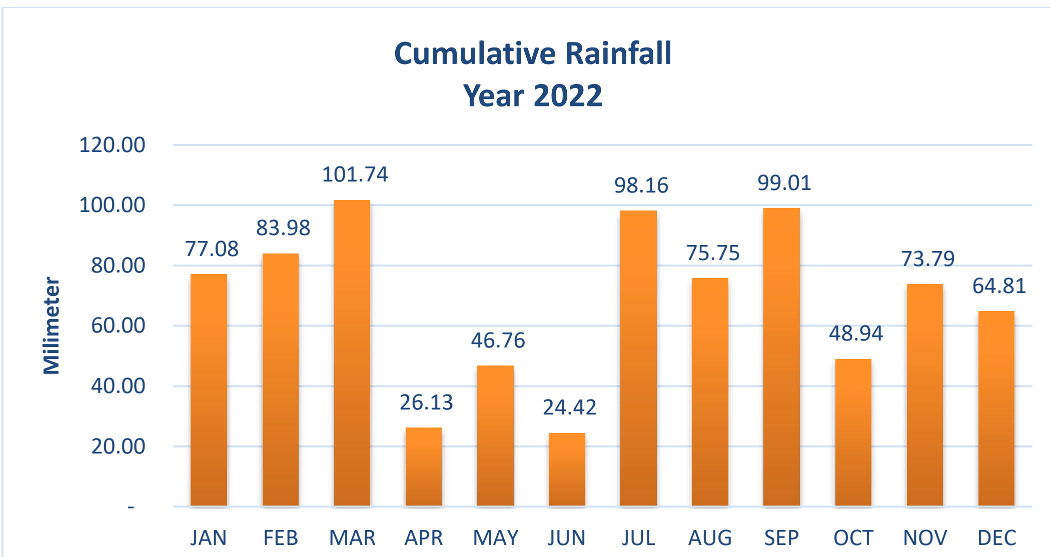


Figure 1. Map of rainfall and sump in mining pit area



Graph 1. Cumulative rainfall in Jan to Dec 2022

Figure 1 and graph 1 show the cummulative and distribution of rainfall in mining pit area during January to December 2022. Based on the data, the sump area is approximately 43,90 ha, the sump water volume is 5.067.020 m^3, and the rainwater catchment area that enters the sump is 230,20 ha. The high amount of rainfall and the large catchment area makes the pond filled with a large amount of water. Mining activity causing the water to become acidic. Thus, it needs further treatment.

2.2. Acid Mine Drainage Treatment

Acid mine drainage (AMD) is pumped from the sump, then flowed to the settling pond for further treatment. The treatment carried out is by using sedimentation, flocculation, and coagulation methods. After that, the water is then flowed to the water treatment plant (WTP) to be processed into clean water as shown in figure 3. The processing parts of WTP are:

1. Coagulation

   The first part is known as the coagulation basin. In this tub the water will be destabilised from colloidal/dirt particles. The destabilisation process can be done chemically by adding alum (aluminium sulphate) or physically by rapid mixing.

2. Flocculation
   Suspended solid particles and colloids or pseudocolloids in raw water that are naturally difficult to settle will be converted into larger particulate matter called called flocs which have a heavier specific gravity and larger particle size so that more easily separated from the water and settle out [5].
3. Sedimentation
   After the floc is formed (usually in the form of mud), the water will enter the sedimentation basin where the heavier specific gravity of the floc will automatically settle to the bottom of the basin and clean water can be separated from the mud.
4. Filtration
   Once the water is separated from the sludge, it will be filtered again to make it completely clean by entering the filtration basin by using silica sand, gravel, and activated carbon.
5. Disinfection
   After the treatment process is complete, an additional process of disinfection is carried out in the form of adding chlor.
6. Reservoir
   After the water has been treated, it will be put into a temporary shelter in the reservoir before being distributed to homes and buildings. To drain water, HDPE pipes and PVC pipes are used [4].

Table 1. Quantity of chemical use at the WTP

No	Type	Quantity	Dissolved Water	Discharged per Hour	Raw Water Flow Capacity
1	Alum	50 Kg	750 Litres	15 litres	20,000 litres
2	NaOH	50 Kg	750 Litres	8,5 litres	20.000 litres
3	Chlorine	3 Kg	750 Litres	20 litres	20,000 litres

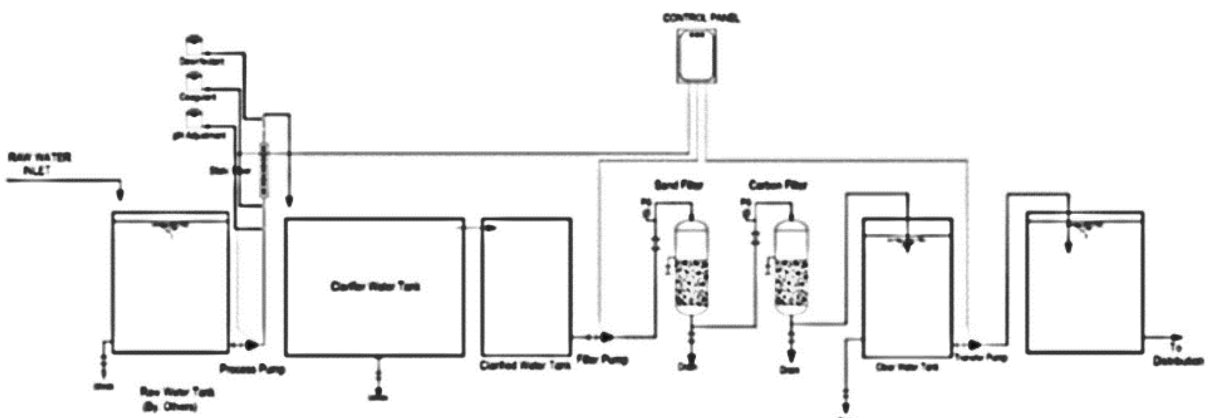


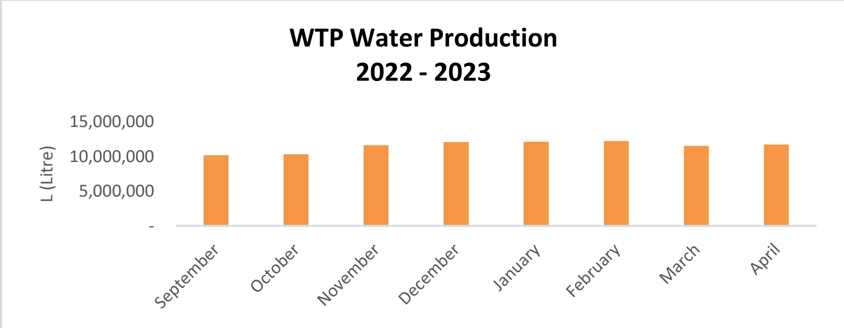
Figure 2. WTP process flow

3. Result & Discussion

Clean water that is produced from the WTP can be a sustainable option to fulfill water needs at PPA jobsite PT Borneo Indobara. Recycling AMD is proven safe to provide a source of water for sanitation. This innovation carried out by PPA is able to meet the daily sanitation water needs of employees and support mining activities.

3.1. Water Production

Graph 2 shows the amount of clean water produced from the WTP, ranges from 10-12 million litres. This data represents a large and constant amount of water when compared to the limited amount of groundwater reserves. PPA sees the abundant water source from acid mine drainage production as an opportunity to make a better use of it and also preserve groundwater. In addition, it can also reduce the risk of land subsidence due to groundwater extraction.



Graph 2. WTP Water Production Period Sep 2022-Apr 2023

3.2. Water Quality

In the Republic of Indonesia, clean water quality has to comply with the Ministry of Health of Indonesia Regulation No. 2 of 2023. Table 2 and figure 3 show that the quality and visual of AMD before treatment were not suitable for use. After treatment, the water looks clearer and the quality of the water complies with the reference standard. The quality of clean water produced from the WTP has pH 7,93, TDS 43,525 mg/l, and turbidity 0,84 NTU.

Table 2. Laboratory paramater of water before & after treatment

No	Parameter	Unit	Before	After	Quality Reference Standard	Mode Specification
1	Laboratory pH	-	5,96	7,93	6,5-8,5	SNI 6989.11.2019
2	Laboratory Temperature	°C	25	25	25±3	SNI 06-6989.23.2005
3	Dissolved Solids (TDS)	Mg/L	520	43,525	≤1000	SNI 6989.27-2019
4	Taste	-	Flavourless	No flavour	No flavour	-
5	Odour	-	Odourless	No flavour	No flavour	-
6	Colour	TCU	<0,012	<0,012	≤ 50	SNI 6989.80:2011
7	Turbidity	NTU	1,2	0,84	≤ 25	SNI 06-6989.25-2005
8	Dissolved Iron (Fe)	Mg/L	0,50	0,28	≤ 1	SNI 6989.84:2019
9	Dissolved Manganese (Mn)	Mg/L	3,12	0,03	≤ 0,5	SNI 6989.84:2019
10	Dissolved Zinc (Zn)	Mg/L	0,31	0,02	≤ 15	SNI 6989.84:2019
11	Dissolved Cadmium (Cd)	µg/L	1,37	0,14	≤ 5	SNI 06-6989.38-2005
12	Dissolved Lead (Pb)	µg/L	<1,307	<1,307	≤ 50	SNI 6989.46:2009
13	Mercury (Hg)	µg/L	<0,187	<0,187	≤ 1	TB-IK W-017 (MVU)

14	Detergent	Mg/L	<0,011	<0,011	≤ 0,05	SNI 06-6989.51-2005
15	Sulfate	Mg/L	24,1	11,1	≤ 400	SNI 6989.20-2019
16	Nitrate As N	Mg/L	3,6	3,2	≤ 10	SNI 6989.79:2011
17	Nitrite As N	Mg/L	0,005	0,005	≤ 1	SNI 06-6989.9-2004
18	Cyanide (CN)	Mg/L	<0,004	<0,004	≤ 0,1	SNI 6989.77-2011
19	Flouride (F)	Mg/L	0,71	0,023	≤ 1,5	SN1 06-6989.29-2005
20	Hardness (CaCo3)	Mg/L	272	32,9	≤ 500	SNI 06-6989.12-2004
21	Chloride	Mg/L	24,9	11	-	SNI 6989.19-2009
22	Total Coliform	CFU/100ml	0	0	≤ 50	APHA 9222 Membrane Filter 2017

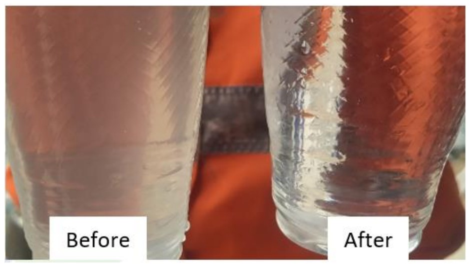


Figure 3. Visual appearance of wastewater before and after treatment

3.3. Cost Saving

The The utilisation of recycled water to meet clean water needs saving cost of soil drilling to obtain groundwater, with the amount of IDR 30.000.000 (or USD 2.000) each point. It also saving cost of groundwater use tax, with the amount of approximately IDR 60.000.000 (or USD 4.000) per month.

4. Conclusion

The implementation of recycling AMD into a source of clean water makes it possible for PPA to eliminate the use of groundwater. This innovation allows the water quality improvement and cost saving. The water produced from the WTP is sufficient to meet the daily needs of clean water for sanitation and support mining operation activities.

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