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Research Paper

Utilization Study of Void Mine For Sustainable Environment of The Limestone Mining Sector at PT Semen Baturaja (Persero) Tbk

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Abstract
Event open-pit mining methods in the exploitation of limestone by PT Semen Baturaja (Persero) Tbk cause depletion of water, air, and soil. At the end of mining activities will leave ex-mine land in the form of void and non void (empty land). Reclamation and Postmining must be carried out by the company according to the mandate of Government Regulation No. 78 year 2010. Reclamation and activities on ex-non void mines can be revegetation activities, while void can be used as reservoirs for raw water sources. The aim is to maintain the sustainability of natural resources and water in the limestone mining environment. The research aims to determine the condition of void water produced from limestone mining activities for a sustainable environment. The method used in this study is using the pollution index method. The results showed that the water in the sump inlet and quarry outlet mild pollution. Pollution index at the location of the limestone mine sump inlet worth 2.14 and for oulet quarry worth 2.07. This shows that mine void water is not feasible to be used as raw water, so water treatment needs to be done so that it meets the established quality standards. If void water comply the prescribed quality standards, environmental sustainability in the limestone mining sector can be achieved during the life of the mine, post mining, until after the post-mining period.

Keywords
Water Void, Pollution index, Limestone Mining, Sustainable Environment

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1. INTRODUCTION

The open pit mining method carried out by PT Semen Baturaja (Persero) Tbk at the end of mining will leave ex-mine land and void. Voids are formed due to overburden deficit which causes closing of the pit can not be recovered such that formed the baseline condition (Yunandar, 2012). Voids are classified into three class, namely (a) existing void, are voids in the mining area during the operation of the mine; (b) void residuals, are voids that occur during mine closure; and (c) final void, is a void formed after the end of all mine production operations or the end of mine operational life (Juniah, 2014). PT Semen Baturaja (Persero) Tbk is obliged to conduct reclamation and post-mining activities on ex-mining land as mandated by the laws and regulations of the Republic of Indonesia. Reclamation and post-mining activities in the form of revegetation activities are carried out on ex-mine land (non void) for the sustainability of limestone mining environment. The same thing must be done for ex-mine holes (void) by utilizing these voids for other uses. It also aims to achieve sustainable environmental development which is a necessity for countries that want environmental sustainability (Juniah et al., 2018).

Reclamation can be done in the form of revegetation and / or other designation (residential area, tourism, water source, and place of cultivation) (ESDM, 2014). The use of voids has been carried out by several mining companies both in Indonesia and abroad. Void coal mines are used as a source mine drinking water / raw water in West Virginia at Kansas USA, mines in South Africa and PT Adaro (AustralianGovernment, 2016; Juniah, 2013), freshwater aquaculture (Moersidik and Setyo, 2014; Juniah, 2013), voids of PT Semen Padang limestone quarries will be utilized for water ponds or reservoirs in post-mining (Yose, 2018). Void that holds water can develop functions into a kind of catchment area (Iriadenta, 2010). If voids are formed in a large size, it can be used as a reservoir that can be used as a provider of water resources, especially in the dry season. the reservoir is useful to reduce the risk of floods because it reduces the volume of runoff water flowing and contributes to the discharge water of the nearest river. The void water can be utilized as raw water, freshwater aquaculture, tourism, micro hydro power plants, and so on. This study will examine the utilization of voids limestone mines at PT Semen Baturaja (Persero) Tbk for allotment of reservoirs that are used as raw water sources. The utilization of the voids of the limestone mine as a provider of raw water sources has been supportive in efforts to establish a sustainable environment which will benefit for current and future generations. The use of voids as reservoirs has proven that the post mining environment of limestone has an environmental function, namely as a provider of natural resources in the form of water resources, and as a giver of aesthetics where the void is managed to become a reservoir (Juniah, 2018).

The use of voids must be managed properly, including (ESDM, 2018):

a slope stabilization;
b void security;
c recovery and monitoring of water quality and management of void water according to its designation; and
d void maintenance.

One of the void management activities is the monitoring of void water quality according to its designation. This research is utilizing voids as a source of raw water. Therefore, it is necessary to study the quality of water entering and leaving the mine to find out whether it comply environmental quality standards. The water contained in the reservoir can be used as a source of raw water if the water quality has supplied the quality standards permitted by regulations, that is government regulations No. 82 of 2001 for class I, Minister of Health Regulation Number 492 / MENKES / PER / IV / 2010 about Drinking Water Quality Requirements and Minister of Health Regulation Number 416 / MEN.KES / PER / IX / 1990 about Water Quality Requirements and Supervision. Therefore, the water treatment must be done in order to meet the quality standards. Water quality criteria are classified into 4 classes as follows (GovermentRegulation, 2001).

a First class, water for which the designation can be used for drinking water, and / or other designation which requires the same water quality as that;
b second class, the water for which the designation can be used for water recreational infrastructure/facilities, cultivation of freshwater fish, livestock, water for irrigating plantations, and / or other designations which require water quality that is the same as those uses;
c third class the water for which the designation can be used for the cultivation of freshwater fish, livestock, water for irrigating plantations, and / or other designations that require water quality that is the same as those uses;
d fourth class, the water for which the designation can be used to irrigate crops, and / or other designations which require water quality that is the same as those uses.

Testing of mine void water quality has also been carried out by several researchers. Chemical studies of used water void from PT Kaltim Prima Coal mines in East Kalimantan that can be used for various water uses for class II water quality (Santoso and Dwi, 2018).

Water quality test results due to limestone mining in North Germany found a high content of calcium, bicarbonate, sodium and chloride salts in river water and also in limestone mining in Madukkarai India there was a decrease in water quality which exceeded the standard limit for water quality parameters such as total dissolved solids, total hardness and chloride (Lamare and Singh, 2016). Voids can be utilized if the water quality is below the specified water quality standard. Quality standards are measures of limits or levels of living things, substances, energy, or components that exist or must exist and / or pollutants which are tolerated in the presence of water (GovermentRegulation, 2001). The level of water quality conditions that indicate polluted conditions or good conditions in a water source within a certain time by comparing with the water quality standards specified will indicate the status of the water quality (Baitullah, 2015). Determination of water quality status can use the pollution index method. Management of water quality on the basis of the Pollution Index (PI) can provide input to decision makers to be able to assess the quality of water bodies for an allocation and take action to improve quality if there is a decrease in quality due to the presence of polluting compounds.

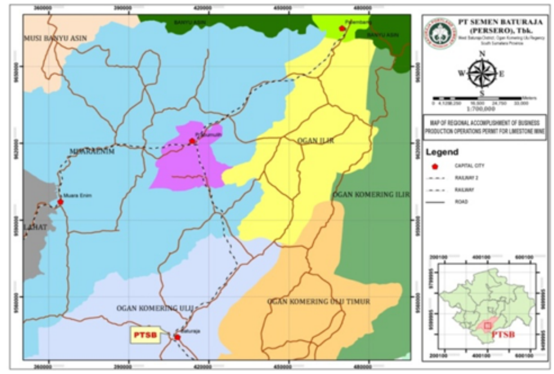

Figure 1. Map of Research Location (PT.Semen Baturaja (Persero) Tbk, 2018a)

2. EXPERIMENTAL SECTION

2.1 Material

This research was conducted in existing mining block PT Semen (Persero) Tbk, Ogan Ulu, South Sumatra Province. This study took samples of water for testing water quality. Water sampling is carried out on water in the inlet and outlet of the existing mine site with consideration to knowing the condition of the water entering the former limestone mining and the condition of the water coming out into the environment. The research location is shown in figure 1.

2.2 Method

The water samples taken were then carried out laboratory tests on the physical and chemical characteristics of water. The next step is analyzing water quality using the pollution index method based on the Decree of the Minister of Environment Number 115 of 2003 concerning Guidelines for Determining the Status of Water Quality.

$$PI_j = \sqrt{\frac{(\frac{C_i}{L_{ij}})^2_M + (\frac{C_i}{L_{ij}})^2_R}{2}} \quad (1)$$

where:

PIj = Pollution index for designation (j)
Lij = Concentration of water quality parameters
Ci = Concentration of water quality parameters
(Ci/Lij)R = value (Ci/Lij) on average
(Ci/Lij)M = value (Ci/Lij) on maximum

The pollution index method can directly connect the level of contamination with whether or not the water can be used for certain uses and with certain parameter values. Determination of river water quality status can be seen based on the pollution index criteria as follows.

- $0 \leq PI_j \leq 1.0$ comply quality standard (good condition)
- $1.0 < PI_j \leq 5.0$ mild contamination
- $5.0 < PI_j \leq 10$ medium contamination
- $PI_j > 10$ heavy contamination

3. RESULTS AND DISCUSSION

PT Semen Baturaja (Persero) Tbk conducts limestone mining using the open pit method. Limestone business uses 2 methods of demolition, namely surface miner and blasting. The stages of limestone mining operations of PT Semen Baturaja (Persero) Tbk are as follows.

a Land Clearing
Land clearing activities include clearing scrub, make the pioneer, and brought water.

b Stripping the Cover Land
excavators used in stripping the cover land. Cover layer in the form of top soil and soft rock.

c Demolition
The method of demolition of limestone carried out by PT Semen Baturaja (Persero) Tbk in this existing mine consists of two methods, that is a method without blasting with a surface miner mechanical digging device and blasting with an excavator class 30T mechanical digging device. Blasting method is carried out at the location of sediments located far from the location of community settlements, so as to dismantle using the surface miner method. This aims to ensure that mining operations remain environmentally and economically sustainable.

d Loading
The loading excavator used was 1 unit excavator class 20 T for digging and loading top soil, 1 unit excavator class 30 T for digging and loading overburden and limestone, and 1 wheel loader unit to collect the resulting material by Surface Miner class 500 T.

e Transportation
The conveyance used is dumptruck class 30 T. The results of limestone mining are transported using dumptruck to the crusher. The mine distance and crusher are estimated to be between 0.5 - 1.5 km.

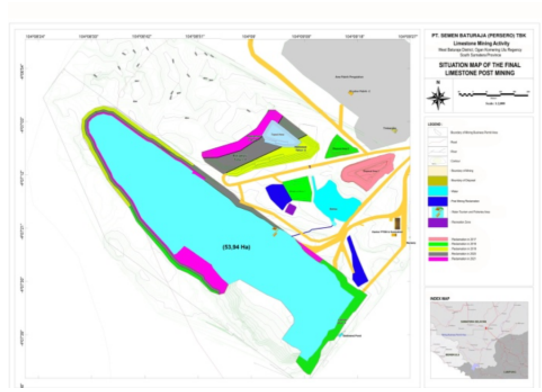

Figure 2. Situation Map of the Final Limestone Post Mining (PT.Semen Baturaja (Persero) Tbk, 2018b)

Limestone mining activities have an impact on decreasing water, air and soil quality, forest degradation and also water availability (Lamare and Singh, 2016). Open mining activities can cause disruption of the water system in the mining area itself and can even extend to the surrounding area Juniah and Rahmi (2017). Based on PT Semen Baturaja (Persero) Tbk Post Mining Plan document, it is known that at the end of limestone mining activities will leave ex-mining land in the form of vacant land and void holes as shown in figure 2. The area of void that will be formed 53.94 hectare. The appropriate reclamation and post-mining plan must be prepared by PT Semen Baturaja (Persero) Tbk so that the sustainable environment of limestone mining is achieved. The three environmental components that must be aligned for environmental sustainability are the natural environment in the form of water resources, the artificial environment (built environment) in the form of reservoirs, and the social environment is the people living around the former mining area (Juniah and Sastradinata, 2017). Efforts that can be made to achieve this harmony make the right technological approach in dealing with possible disruptions in efforts to utilize mine void according to its designation (Dariah et al., 2010).

This study examines the use of voids for the designation of reservoirs that are utilized as raw water sources. Raw water for drinking water is water that can be processed into suitable water as drinking water by processing it simply by filtration, disinfection and boiling (GovermentRegulation, 2001). This needs to be done because water is one of the key parameters of supporting human life and environmental governance systems (Juniah, 2013). This study takes the example of surface water on the sump inlet and quarry outlet to be tested for physical and chemical parameters. with consideration to knowing the condition of the water entering the former limestone mining and the condition of the water that comes out into the environment. The results of laboratory analysis and testing of surface water quality at the existing mining activities of PT Semen Baturaja (Persero) Tbk taken at the sump inlet and quarry outlet are presented in table 1.

Table 1. Test Results of Water Quality Laboratory of PT Semen Baturaja (Persero) Tbk

	Parameter	Unit	EQS*)	Hasil Inlet	Hasil Out-let
	A. Physics				
1	Temperature	°C	Dev	25.4	26.8
2	TDS	mg/L	1000	31	20
3	TSS	mg/L	50	22	17
	B. Anorganic chemistry				
1	pH	#	9-Jun	6.07	6.07
2	Iron	mg/L	0.3	0.12	0.08
3	Mangan	mg/L	0.1	0.05	0.05
4	Barium	mg/L	1	0.001	0.001
5	Copper	mg/L	0.02	<0.003	<0.003
6	Zinc	mg/L	0.05	0.03	0,001
7	Total chrome		0.05	<0.018	<0.018
8	Cadmium	mg/L	0.01	<0.0015	<0.0015
9	Mercury	mg/L	0.001	<0.0001	<0.0001
10	Lead	mg/L	0.03	<0.003	<0.003
11	Arsenic	mg/L	0.05	<0.0009	<0.0009
12	Selenium	mg/L	0.01	<0.0012	<0.0012
13	Cyanide	mg/L	0.02	0.004	0.002
14	Cobalt	mg/L	0.2	0	0
15	Flouride	mg/L	0.5	0.25	0.17
16	Free Ammonia	mg/L	0.5	0.33	0.32
17	Nitrate	mg/L	10	2.92	2.9
18	Nitrite	mg/L	0.06	0.18	0.174
19	BOD	mg/L	2	2.62	2.51
20	COD	mg/L	10	19	15
21	DO	mg/L	6	2.07	2.01
22	Sulfide	mg/L		<0.03	0
	C. Anorganic chemistry				
1	Oil and Fat	mg/L	1000	0.19	0.13
2	Phenol	mg/L	1	0	0

Note: Environmental Quality Standards Government Regulation No. 82 of 2001 Class I

Water inlet and outlet quality test results when compared to EQS Government Regulation No. 82 Year 2001 for class I shows that water conditions are contaminated. Based on the calculation of water quality status using the pollution index method, it was found that the water quality at the sump inlet and limestone quarry outlet of PT Semen Baturaja (Persero) Tbk was in a mild polluted state. The status of water quality here means the level of water quality conditions that indicate polluted conditions or good conditions in a water source within a certain time by comparing with the specified water quality standard. Pollution index at the location of the limestone mine sump inlet worth 2.14 and for quarry oulet worth 2.07.

Based on Table 1, it can be seen that the water contained in the sump inlet and limestone quarry outlet of PT Semen Baturaja (Persero) Tbk needs to be handled or reprocessed so that it can be used as raw water. This can be seen from several inorganic chemical parameters that are above the water quality standard set by government regulations. The chemical parameters in the form of Biochemical Oxygen Demand (BOD) in the inlet and outlet are above the prescribed quality status (2 mg / L), which are 2.62 mg / L and 2.51 mg / L. BOD is the amount of oxygen needed by microorganisms to decompose biologically organic matter (Aziz et al., 2013). Chemical parameters in the form of Chemical Oxygen Demands (COD) in the inlet and outlet are above the predefined quality status (10 mg / L) which is 19 mg / L and 15 mg / L. The COD value indicates the degradation of organic and inorganic materials, which is expressed by the amount of oxygen needed for the degradation process. The same thing happened to the chemical parameters in the form of Nitrite as N in the inlet and outlet above the predetermined quality status (0.06 mg / L) which is 0.180 mg / L and 0.174 mg / L. Large amounts of nitrite binds oxygen in water which results in water deprived of oxygen. Water pollution in the inlet and outlet is allegedly caused by waste generated from limestone mining activities. Organic and inorganic compounds found in limestone when mining is lifted to the surface, thus affecting water quality found in inlets and outlets. Therefore, it is necessary to do a water treatment of water void in the limestone quarry so that it can be used as raw water.

After the right water treatment is carried out so that it meets the established quality standards, the void water can be used as raw water. The use of mine void water as raw water is expected to be felt during the limestone production period, during post-mining (5 years), and after post-mining (mine closure). Utilization of mine void water as raw water can prevent water pollution after post-limestone mining because water is still managed to meet water quality standards in accordance with applicable laws and regulations. This will have implications for environmental sustainability in the limestone mining sector. Environmental sustainability here means that the environment (void) as a provider of raw water resources for the internal life of the company in particular and the community around the mine in general during the life of the mine, post mining, until after the post-mining period.

4. CONCLUSIONS

PT Semen Baturaja (Persero) Tbk's current void water cannot be utilized as raw water. This is because the quality of the quality of PT Semen Baturaja (Persero) Tbk limestone mine water (inlet sump and quarry outlets) is in mild pollutant status, with a pollution index at the location of 2.14 limestone sump mine inlets and for quarry sale worth 2.07. The chemical parameters of water that must be managed properly so that void water can be used as a source of raw water are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrite as N because it is above the predetermined quality standard.

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