Impact of Coal Mining Activity on Water Quality Mining Area at South Sumatera Province

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Abstract. This study aims to determine the impact of water quality on coal mining on mining areas. Monitoring of wastewater at coal mining area is conducted to determine the level of industry compliance to the quality standard of wastewater discharged to the environment. Monitoring for sampling was conducted on 3 locations of Lahat Subdistrict Puntang Village and Kandis Village (A1 and A2), Merapi Subdistrict Gunung Agung Village (B1 and B2) and Sungai Lilin Subdistrict Mekarjadi Village (C1 and C2). Parameter measurement was carried out in the field and laboratory. The results of the analysis were compared with Decree of Minister of Environment No 113 the year 2003 on the quality standard of coal mining wastewater. Based on the pH measurement of mining activity wastewater was in the range of 3.18 – 5.6, hence the pH had exceeded the required standard of 6 - 9. The Fe, Cu, Zn, Cr, Co, Hg parameters from the analysis were still below the standard of the quality required. Mn and Ni parameters, locations (A1 and A2), (B1 and B2) and C2 analysis result fulfilled the required quality standard of 0.01 Mn and 0.075 Ni, while the location (C2) exceeded the standard of 0.025 Mn and 0.085 Ni. While the concentration of Aluminum (Al) parameter in all locations was above the required standard of 0.05 ppm within the range 0.0557 - 1.219 ppm.

1. Introduction

South Sumatra has a total area of 109,254 km² and is the widest area in Sumatera Island which is about 22.0% of the total area of Sumatra or around 5.4% of the total area of Indonesia. The potential of coal in South Sumatra Province is known to account for approximately 85% of the total reserves contained in Sumatra or about 22.24 billion tons. In South Sumatra's program as a national energy barrier, coal energy is positioned as one of the alternative energy sources of post-petroleum. Coal mines are distributed Muara Enim, Banyuasin, Musi Rawas, Ogan Kumering Ulu, Ogan Kumering Ilir, and Lahat with coal production reaches 9,119,457 tons (BP3MD of South Sumatra Province, 2014)

Viewing data in the field there is no wastewater treatment at the mining site, where wastewater formed by Mining Acid Water (AAT) is flowed to the river and into the swamp area directly. If this issue is unhandled, due to the high accumulation of heavy metals in particular, it can damage environmental functions particularly water components. Water contaminated by high toxic heavy metals may have an impact on biota in water and public health using contaminated water through biomagnification entering the food chain and affecting humans[1], resulting in brain damage or the reduction of mentality process [2] and central nervous function [3], lower energy levels ([4], DNA damage [5], the change in gen expression [6], skin [7], muscle [8], blood composition [9], kidneys [10], liver [11],...
heart [12] and hematological damage [13,9]. While excessive exposure to heavy metals is released to the environment due to mining activities [4]. This has created a global problem, since heavy metals are non-biodegradable and can accumulate in living tissue, causing various diseases and disturbance in the food chain. It is also known that groundwater is the world’s most used drinking water supplies, the global population is 7 billion people (UNFPA, 2011), and while around 1.1 billion of them worldwide lack access to drinking water supplies, and 1.5 million occur deaths due to the utilization of unsustainable surfaces and groundwater [14]

Understanding the research background is conducted to investigate water quality in mining areas, informing the public, mining industries, and government. Thus, the community, government, and coal mining entrepreneurs can be cognizant of how much damage the environment surrounding coal mining, the government side is expected to make an effort to strengthen and implement regional regulations on environmental management, and local government should take firm action against coal mining activity either have mining licenses or illegal mining (without permission). In accordance with article 33 paragraph 3 of the 1945 Constitution that is: "The earth, the water and the natural wealth contained therein are controlled by the state used to the maximum for the prosperity of the people". However, the use of natural resources such as coal massively by not paying attention to the environment will result in negative impacts both short and long-term, resulting in mining impacts of ecosystem damage that can no longer function optimally.

2. Methods
2.1. Location of study
Three sampling points of the study were taken for this study, namely namely: Sungai Kandis and Sungai Puntang, Keban Village, the Subdistrict of Lahat (A1 and A2), the water of the Wastewater Disposal Facilities (WDF) and the swamp water of Gunung Agung village in the Subdistrict of Merapi Barat (Location of B1 and B2), and the pool water and the swamp water in the Subdistrict of Sungai Lilin, Musi Banyuasin Regency (C1 and C2).

![Figure 1. Location for taking Water Samples (Puntang Village, Gunung Agung Village and MekarJadi Village).](image-url)
2.2. Methods of study
The amount of water taken as a sample was 1 liter (20 bottles) of water put in Schott bottles that had been washed with nitric acid 20%. Before the bottles were filled with water samples, they were rinsed first with river water at the sampling locations, then water was cooled at 4°C to be brought to the laboratory and stored in the refrigerator until it was analyzed. The tests were conducted to detect pH, Total Suspended Residue (TTS) and heavy metals (Fe, Mn, Ni, Cu, Zn, Al, Cr, Co, and Hg). The sampling was done during the rainy season (February 2017). The sample of water used in this study was the water of the river and the swamp in the vicinity of the location of the study. The water samples were analyzed in the laboratory by using Atomic Absorption Spectrophotometer (AAS) with three tries. The data analysis was done by using One-way ANOVA which was followed by Duncan test to evaluate the significance of the P < 0.05.

3. Results and Discussion
The complete results of water quality analysis of both those performed in the field (in situ) and those carried out in the laboratory are presented in table 1.

Table 1. The results of analysis of water quality of the study site.

| Parameter | Unit | Quality Standard of Class I | Location A1(Lahat) | Location A2(Lahat) | Location B1(Merapi) | Location B2(Merapi) | Location C1(Muba) | Location C2(Muba) | Mean of Analysis Results |
|-----------|------|-----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|------------------------|
| pH        | -    | 6 - 9                       | 3.4                 | 3.6                 | 4.5                 | 5.6                 | 3.18                | 3.26                |                       |
| TSS       | mg/l | 50                           | 2                   | 19                  | 23                  | 53                  | 22                  | 27                  |                       |
| Fe        | mg/l | 0.3                          | 0.02                | 0.03                | 0.19                | 0.08                | 0.17                | 0.22                |                       |
| Mn        | mg/l | 0.1                          | 0.08                | 0.04                | 0.06                | 0.007               | 0.09                | 0.25                |                       |
| Ni*       | mg/l | 0.075                        | 0.05                | 0.01                | 0.03                | 0.03                | 0.021               | 0.085               |                       |
| Cu        | mg/l | 0.02                         | < 0.003             | < 0.003             | 0.006              | < 0.003             | < 0.003             | < 0.003             |                       |
| Zn        | mg/l | 0.05                         | 0.01                | 0.01                | 0.05                | 0.02                | 0.09                | 0.01                |                       |
| Al        | mg/l | 0.05                         | 1.03                | 1.03                | 0.567               | 0.557               | 1.0246              | 1.219               |                       |
| Vn        | mg/l | -                            | < 0.003             | < 0.003             | < 0.003             | < 0.003             | < 0.003             | < 0.003             |                       |
| Cr        | mg/l | 0.05                         | 0.03                | 0.03                | 0.01                | 0.01                | < 0.003             | < 0.003             |                       |
| Co        | mg/l | 0.2                          | < 0.03              | < 0.03              | < 0.003             | < 0.003             | 0.04                | 0.04                |                       |
| Hg        | mg/l | 0.001                        | < 0.0001            | < 0.0001            | < 0.001             | < 0.001             | < 0.0001            | < 0.0001            |                       |

*Source : Government Regulation No. 82 of the Year 2001 (PP No. 82 Tahun 2001)
* Ministerial Decree on the Environment No. 51 of the Year 2004 (Kepmen-LH No. 51 Tahun 2004)

3.1. pH (Degree of ionization)
The results of the Duncan test indicated that the pH value at C1 location was different from those of the other locations, with the highest value of 3.18. The same thing occurred at the location of B2 with the lowest value of 5.6. The results of analysis of pH levels indicated that the pH levels of water at the three (3) locations of the study were lower than those required quality standards specified in Ministerial Regulation on the Environment, the Ministerial Decree No. 82 of the Year 2001 on the Management of Water Quality and Water Pollution Control, the levels of pH range between 6 and 9.

3.2. Total suspended solid (TSS)
The results of the analysis of TSS using the Duncan test in the study location of A1 and A2 are the same, but they are different from those of the other locations. It is assumed as the result of the transfer of sediment originating from the location of the exploitation of coal mines and carried over into the waters of ponds and swamps.

3.3. Iron (Fe)
The results of the Duncan tests on the location of A1 and A2 and B1 and C1 are the same, but those of the location of B2 and C2 are different from those of other locations. This is because the heavy metals entering the aquatic environment will experience dilution as a result of the influence of tides, adsorption, and absorption by aquatic organisms [15]. The high content of iron (Fe) at the location of...
B2 and C2 was allegedly caused by the Fe content derived from the disposal of wastewater from the mining industry around the area of B2 which was discharged into the swamp and precipitated, while that of the C2 location was due to the fact that it was in the region of the Wastewater Disposal Facilities (WDF) which produced effluent from the stockpiles of coal. In a state of low pH, the iron present in the water is in the form of ferro ($\text{Fe}^{2+}$), and ferri ($\text{Fe}^{3+}$), in which ferri will settle and will not dissolve and be invisible in the water, resulting in water becomes colorless, odorless and tasteless. Iron levels in natural waters range from 0.05 to 0.2 mg/L. In the deep ground water with low oxygen levels, iron levels can reach 10 to 100 mg/L.

3.4. Manganese (Mn)
The results of Duncan tests revealed that there was a difference among the locations, except for the location of A1 and C1 which showed no differences. This is because the locations of A2, B1, B2, and C2 are the areas that experience low tide. The heavy metals which enter the aquatic environment will experience dilution as a result of the influence of the tides, adsorption, and absorption by aquatic organisms [15]. The excess of manganese (Mn) may cause chronic poisoning in humans which induces the weakness on the feet, the dull appearance of face muscles, and the continued impact of the manganese poisoning (Mn) in human, such as speaking slowly and hyperreflexia. Manganese effects occur mainly in the respiratory tract and in the brain. The symptoms of manganese poisoning are hallucinations, forgetfulness, and nerve damage [3].

3.5. Nickel (Ni)
Duncan tests at the locations of A2, B1, B2, and A1 reveal that the water in those locations does not have different levels of nickel (Ni), but they show differences in the locations of C2 and C1. This is because the location of C2 has the same characteristics as those of C1. Nickel is required by the body in small quantities, but when it is present in great amount, it can harm human health, because it can cause lung cancer, nose cancer, cancer of the larynx, prostate cancer, loss of balance, respiratory failure, birth defects, asthma and chronic bronchitis and damage to the liver and kidney function [15].

3.6. Copper (Cu)
The results of the Duncan test for the content of Copper (Cu) in three (3) locations did not reveal any difference for the locations of A1, A2, C1, and C2, but there were differences in the locations of B2 and B1. This is because the location of B1 and B2 are the same, and they got it from the wastewater runoff of the coal stockpile.

3.7. Zinc (Zn)
Zinc ion (Zn) in the water comes from waste the mining industry. This metal is important in the composition of enzyme metal and is toxic to the plants at sufficiently high concentrations. At the location of the study, the results of the Duncan test on the content of Zinc in the water at the locations of A1, C2, A2, B2 is not different, but it is different from that of the locations of B1 and C1. This is because the location of B1 is the location of the Wastewater Disposal Facilities (WDF) which gets it from the runoff of the wastewater from the coal stockpile, while the location of C1 is the stagnant pools of water which also gets it from the runoff of the wastewater.

3.8. Aluminum (Al)
The results of the Duncan tests for the content of aluminum in the water at the location of the study showed no difference among the locations of B2 and B1 and the locations of A1 and A2. While that of the location of C1 and C2 are significantly different from that of the other locations. This is because the location of the C1 was stagnant pool water originating from the wastewater runoff of the coal, while the location of C2 was the swamp water which was discharged from wastewater of the coal. Whereas the location of A1 and A2 was a flowing river, and there was wastewater effluent from the
coal mines, while the location of B1 and B2 was wastewater runoff from the Wastewater Disposal Facilities (WDF) of the coal stockpile.

3.9. Chromium (Cr)
Chromium is never found in nature as a pure metal. The main source of chromium is very few, namely rocks chromite \( \text{FeCr}_2\text{O}_4 \) and mic oxide \( \text{Cr}_3\text{O}_3 \). This study reveals that the results of the Duncan test on the concentration of chromium found in all three (3) locations show no difference among the locations of A1, A2, C1, and C2, but there are differences from those in the locations of B1 and B2, in which those of B1 and B2 have the same concentration of Chromium.

3.10. Cobalt (Co)
The results of the Duncan test at the location of the study showed that the average Cobalt (Co) content detected in the locations of B1 and B2 was the same, and so was that of the locations of A1, A2, C2, and C1. The human body requires a very small amount of a metallic element of Cobalt (Co) for the formation of red blood cells. Cobalt is a component of vitamin B12.

3.11. Mercury (Hg)
The result of Duncan test of mercury levels showed a striking difference at all three locations, in which the locations of A1, A2, and B1, B2 have lower mercury levels at <0.0001 mg / L, while those of the location of C1 and C2 were relatively high <0.001 mg / L. All components of the mercury including that in the form of alkyl that enters the human body continuously will cause permanent damage to the brain, liver, and kidneys. The effects of mercury toxicity in humans depend on the form of mercury composition, its entrance into the body and the duration of its development. As an example, the mercury in the form of Mercury Dichloride \( \text{HgCl}_2 \) is more toxic than that of Mercury Chloride \( \text{HgCl} \).

4. Conclusions
The results of water quality analysis of the three (3) location of the study in the mining areas of (Sungai Kandis and Sungai Puntang in the Keban Village in the Subdistrict of Lahat (Location of A1 and A2), the water of the Wastewater Disposal Facilities (WDF) and the swamp water of Gunung Agung village in the Subdistrict of Merapi Barat (Location of B1 and B2), and the pool water and the swamp water of Mekarjadi Village in the Subdistrict of Sungai Lilin, Musi Banyuasin Regency (Location C1 and C2) show that the parameters of pH and Aluminum (Al) exceed the quality standards specified in the Ministerial Regulation on the Environment, the Ministerial Decree No. 82 of the Year 2001 on the Management of Water Quality and Water Pollution Control, and the parameters of Nickel (Ni) at the location of C2 also exceed the standards.

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