# Acid Water Problem in Bukit Asam Coal Mine, South Sumatra, Indonesia

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**ABSTRACT**

With an average annual rainfall of more than 2800 mm runoff water is considered to be the main water problem faced by Bukit Asam Coal Mine. There is only a minor problem due to groundwater as the relevant aquifer consists of sandstone with low hydraulic conductivity, i.e. less than $10^{-7}$ m/s.

Water quality monitoring done periodically as a part of an environmental monitoring program has detected water with low pH. The problem is significant as it relates to a large amount of acid water in an abandoned pit in East Klawas which could be discharged to the nearby Enim river.

The acid water problem in Bukit Asam mine will be discussed. Since this problem has never been encountered before, the analyses to understand the acid generating process at present is based on very limited data. Further research is necessary, is being conducted and, at the same time, the appropriate method to handle the problem has to be developed to support an environmentally sound mining operation.

## INTRODUCTION

The Bukit Asam area is one of the important coal mine fields in Indonesia which has been mined since 1919. It lies in the country's richest coal region, South Sumatra, which is considered to have 51% of the Indonesian coal resources. In the 1980s Bukit Asam coal mine was re-developed as an integrated part of an energy development project including the development of a 2 x 400 MW coal fired power plant in Suralaya (West Java) and the improvement and development of a coal transport railway system of South Sumatra (see Figure 1).

Around 4.8 million tons of coal can be transported each year from Bukit Asam area through 400 km railway and sea transport to Suralaya to generate electricity for Java. It was planned that a continuous coal mine pit using bucket wheel excavators in Air Laya should fulfill the major part of the production. Due to operational constraints such expectation can not be realized. Some smaller pits have been developed around the Air Laya pit using shovels and trucks, at Klawas (East, Central and West) and South Muara Tiga (see Figure 2).

Such development has had its consequences especially in the water problems. The surface hydrology in the area has been extremely influenced by the mining activities. For example the natural drainage pattern in the dumping areas has been changed and some mined-out pits are

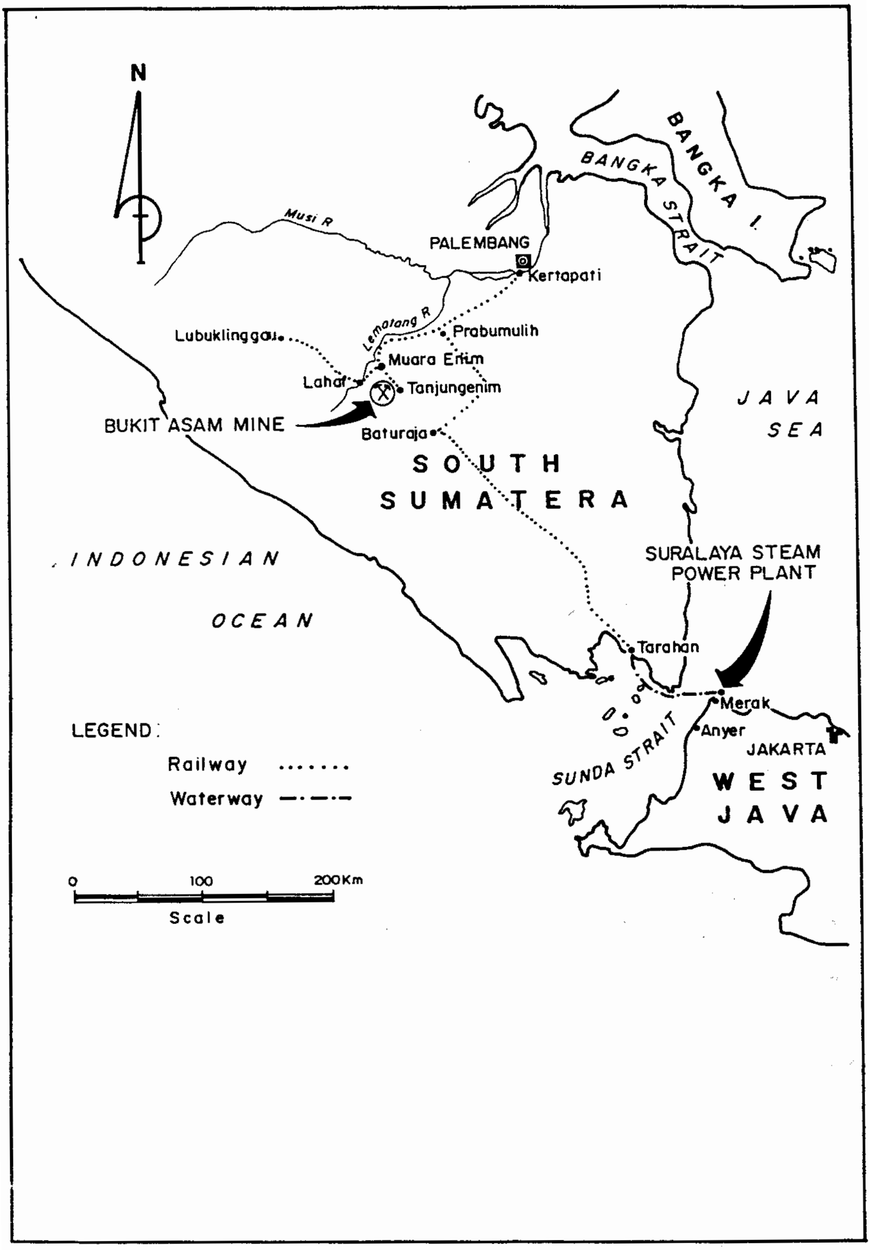


Figure 1
Location map

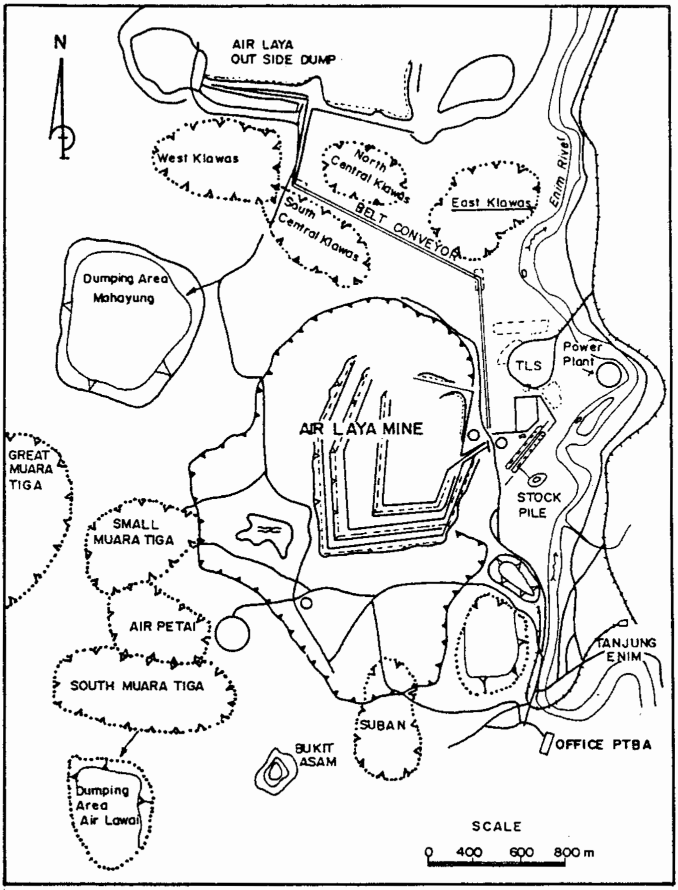


Figure 2
Bukit Asam Mine layout

filled by rain water. One problem which was not predicted before has been detected during the environmental monitoring, namely acid water drainage.

## COAL GEOLOGY

Coal in Bukit Asam is deposited in the South Sumatra Tertiary sedimentary basin, one of the main hydrocarbon basins in Indonesia, belonging to the Muara Enim Formation as the main coal bearing formation in this region. The area is characterized by magmatic intrusion activities which improved the coal quality as well as controlled the geological structural features.

There are three coal seams being mined in Bukit Asam, namely *Manggus* or A seam, which splits into two seams, A1 and A2, *Suban* or B seam, which in some mines also splits into two seams, B1 and B2, and *Petai* or C seam. The overburden and interburden consist of sandstone, siltstone and claystone (see Figure 3).

The coal quality distribution, especially in terms of calorific value, in the area is heavily influenced by the intrusion activities. Anthracitic coal is found in the area surrounding intrusive bodies, such as Bukit Asam andesitic hill, and the quality then decreases as the distance from the intrusive body increases. Typical quality of Bukit Asam coals is shown in Table 1. Most of the coal is classified as steam coal.

**Table 1**
**Bukit Asam coal quality (after Mangunwidjaya [2])**

| *Parameter* | *Steam coal* | *Dry coal* | *Anthracite* |
|---|---|---|---|
| **Total moisture (%) , ar** | 17 - 28 | 8 - 15 | 5 - 6 |
| **Inherent moisture (%), adb** | 7 - 15 | 2 - 7 | 1 - 3 |
| **Ash (%), adb** | 3 - 15 | 5 - 7 | 7 - 9 |
| **Volatile matter (%), adb** | 35 - 50 | 25 - 35 | 10 - 12 |
| **Fixed carbon (%), adb** | 45 - 55 | 55 - 65 | 80 - 82 |
| **Calorific value (kcal/kg)** | 5500 - 6500 | 6500 - 7500 | 7500 - 8000 |
| **Total sulphur (%)** | 0.3 - 1.0 | < 1.0 | < 1.0 |
| **HGI** | 50 - 65 | 50 - 65 | 50 - 65 |

## COAL MINING

The main pit in Bukit Asam area is Air Laya pit. It is a continuous coal mine using 5 bucket wheel excavators, each of which has a design capacity of 1300 bcm/h, in operation and 2 spreaders in the waste dumping area. The actual production of the pit is 2.3 million tons of coal per year.

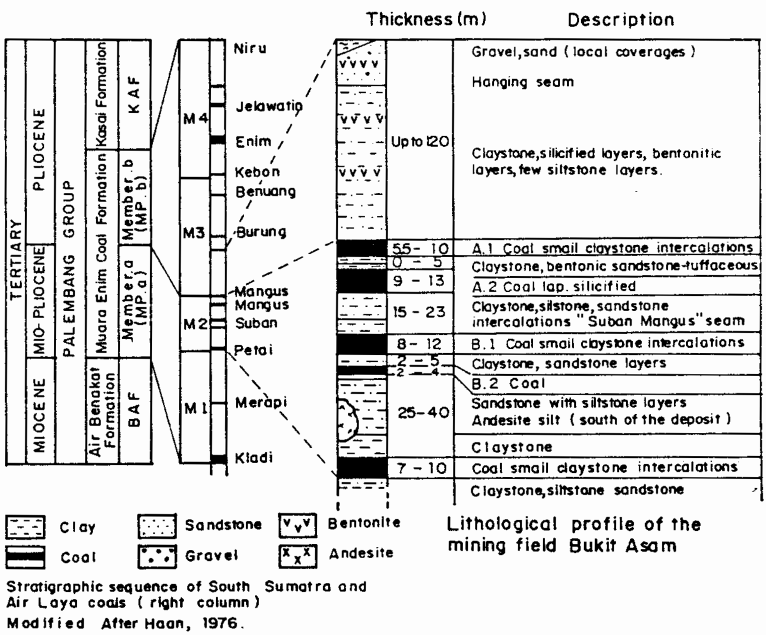


Figure 3
Lithological profile of Bukit Asam Mine

To achieve the production of minimum 4.8 million tpy, which is the consumption of Suralaya power plant, there must be other pits developed in the existing concession area. The operation of those pits should be independent to the Air Laya pit. Therefore, it has been decided to choose the shovel-truck combination in those pits. Such methods have the advantage in production flexibility as the pits are relatively small, with a lifetime of 2 to 5 years. The pits are Klawas (East, Central, West), South Muara Tiga, Small Muara Tiga and Suban. Some of them have already been mined out.

## HYDROLOGICAL CONDITION

The Bukit Asam mine lies between two rivers, Enim in the eastern boundary and Lematang in the west, each of them has a catchment area more than 1000 $km^2$. Most of the pits are located in the eastern part, close to the Enim river.

The climate in this area is characterized by the tropical weather condition with relatively constant temperature throughout the year and high humidity. Daily temperature ranges between 20° and 33° C. Rainfall is relatively high, annual data in the last ten years is between 2820 mm and 3832 mm. The lowest annual rainfall ever measured since 1948 is 1913 mm in 1963, and the highest was 4176 mm (in 1955). The monsoon controlls the climate, where northeast monsoon from November to March brings high rainfall and southwest monsoon from May to October gives a relatively dry season. Figure 4 shows the average monthly rainfall data for Bukit Asam mine.

Lithologically there is no potential aquifer up to the floor of Petai (C) coal seam, the lowest coal seam being mined. Sandstone between B2 and C seams is considered as the most permeable strata, although its hydraulic conductivity is mostly less than $10^{-7}$ m/s. The groundwater in this aquifer is too small to influence the mining activities (Gautama [1]).

## MINE WATER PROBLEM

Rain water is considered as the major water problem in Bukit Asam mine. High rainfall intensity and frequency require the proper handling of rain water especially to minimize the operational delay due to unworkable condition of the excavating front as well as unpassable slippery condition of haul roads. The erosion and the influence on the stability of the mine slopes is also a problem caused by the overland flow.

From the environmental point of view, the solids content of the drainage water is more critical as most of the overburden and interburden are composed of clayey material, whose erodibility is relatively high. Since the erosion in pit area cannot be avoided, sedimentation ponds are mandatory facilities to control the water quality before discharging to the river.

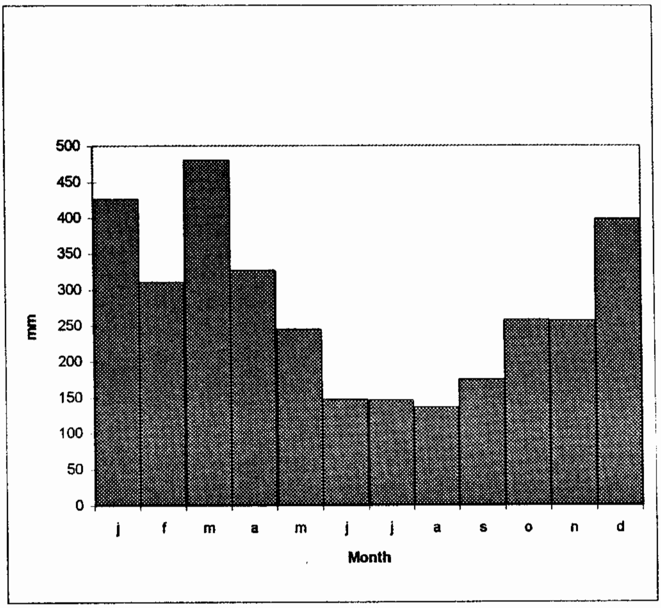


Figure 4
Average monthly rainfall in Bukit Asam Mine

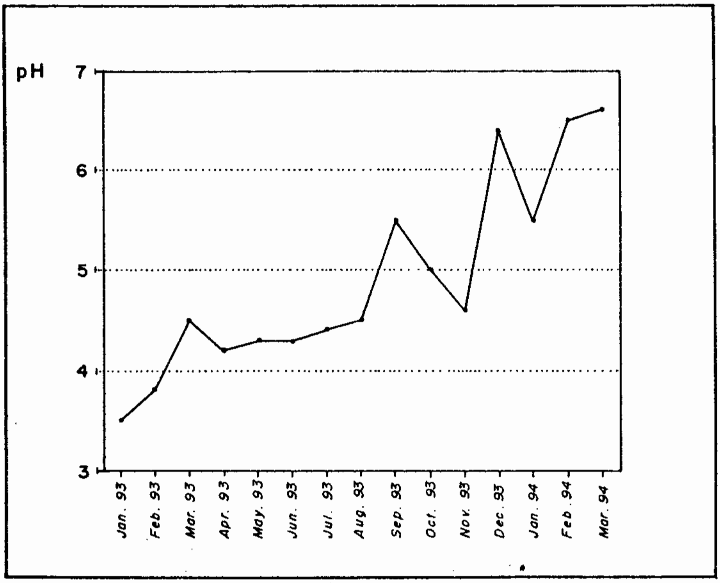


Figure 5
pH values of East Klawas water

## ACID WATER

To meet the environmental standard water quality monitoring has been done regularly in Bukit Asam mine. Water samples are taken from the rivers, sedimentation ponds, and other water sources. Every month more than 20 water samples are analysed in this environmental monitoring program. The monitoring results show that two parameters, total suspended solids and total dissolved solids, should be taken into account because these two parameters in most of the samples are usually higher than the standard allowable values.

Since 1992 attention has been directed to the water from an abandoned mine pit, East Klawas, because of its low pH. The East Klawas pit is an abandoned pit which worked for 5 years. After being mined out, the drainage activities were stopped and the pit allowed to fill with direct rainwater and runoff from the surrounding area. For months the water was collected without being discharge until the pit was full. The water volume now is estimated more than 500,000 $m^3$. Figure 5 shows the pH values of East Klawas pond from January 1993 to March 1994.

There are three major sources of acid mine drainage, after Miller & Murray [3] :

1. drainage from exposed mining faces in open pits;
2. runoff and seepage from waste rock dumps;
3. seepage from process tailings.

In Bukit Asam mine the possible sources of acid water are the first two mentioned above but the acid problem does not occur in all places. Most of drainage water from coal pits is more or less in neutral condition. The phenomena such as occurred in East Klawas was the only problem detected up to the present. There were actually ponds in Bukit Asam area which were abandoned mine pits. But low value of pH such as in East Klawas pond was never detected.

It seems that, because of exposure to air and water, pyrite in the coal and the overlying strata in the abandoned East Klawas pit oxidized, producing ferrous ions and sulfuric acid. This acid generating process (Sengupta [6]) is actually very complex and the content of sulphide minerals is not the only important factor in controlling the time of the acid generating process. It can be seen that although the total sulphur, either in the coal seam as well as in overlying strata, is low (see Table 1 & 2) the acid water in East Klawas pond was generated in a relative short time.

From the soil analyses, it has been identified that the waste strata in East Klawas area is more acid than in other places as shown in Table 2. Therefore, it is predicted that the sulphide minerals contained in the overburden strata in East Klawas are more acid generating and this is supported by the appropriate reaction environment. As the sulphur content of the coal seam itself is similar to the seam in other pits its role in the acid generating process seems not to be dominant.

Further research is necessary to understand the acid generating process in Bukit Asam mine. It is important for preventing and controlling the future acid water problem to support the environmentally sound mining operations. Such research is still being conducted.

**Table 2**
**Soil analyses (after PUSLITTANAK [5])**

| | KLAWAS | | | | | | OUTSIDE DUMP | |
|---|---|---|---|---|---|---|---|---|
| | Upper | | Middle | | Lower | | | |
| | I | II | I | II | I | II | I | II |
| pH | | | | | | | | |
| $H_2O$ | 3.00 | 2.83 | 2.67 | 2.87 | 2.95 | 3.22 | 3.6 | 4.3 |
| KCl | 2.88 | 2.72 | 2.60 | 2.83 | 2.83 | 3.08 | 3.5 | 4.2 |
| Organic matter [%] | | | | | | | | |
| C | 4.32 | 5.04 | 5.19 | 5.05 | 4.67 | 4.32 | 2.73 | 2.58 |
| N | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.08 | 0.05 |
| C/N | 43 | 46 | 52 | 51 | 47 | 43 | 34 | 52 |
| Cations [meq/100 g] | | | | | | | | |
| Ca | 3.73 | 6.49 | 8.51 | 7.48 | 8.38 | 8.89 | 7.35 | 7.07 |
| Mg | 3.83 | 8.59 | 10.61 | 13.93 | 7.66 | 11.98 | 11.05 | 11.37 |
| K | 0.09 | 0.09 | 0.07 | 0.10 | 0.11 | 0.14 | 0.09 | 0.30 |
| Na | 0.09 | 0.10 | 0.17 | 0.13 | 0.10 | 0.31 | 1.01 | 2.46 |
| Cation Exchange Capacity [meq/100 g] | 11.80 | 12.14 | 11.65 | 10.86 | 11.89 | 13.67 | 9.60 | 12.66 |
| Base Saturation [%] | 65.85 | 94.50 | 100 | 100 | 95.00 | 100 | 100 | 100 |
| Total Sulphur [%] | 0.10 | 0.12 | 0.10 | 0.12 | 0.12 | 0.14 | 0.27 | 0.19 |
| Free $Fe_2O_3$ [%] | 0.47 | 0.30 | 0.33 | 0.28 | 0.35 | 0.37 | 0.24 | 0.17 |
| Electric conductivity [mS/cm] | 1.48 | 2.49 | 3.19 | 3.38 | 2.50 | 2.71 | 2.82 | 2.45 |

Since it deals with a large amount of acid water, the priority was to identify an appropriate method to handle the problem. In the earlier monitoring program the values were lower than the later data because the pond was first being isolated from discharging to the river to avoid impacts on the aquatic biota. The addition of limestone to controll the pH seemed to be the only alternative but it was very costly to neutralize the whole water in the pond. More appropriate alternative is pond water management by controlling the water incharge, for instance runoff routing to the pond from the surrounding area, as well as controlling water discharge especially during the high water to allow dilution as the water entering the river . This alternative was applied and it was quite successful as shown by the increasing values of pH in the last four months.

## CONCLUSION

The mining activities in Bukit Asam area have a long history since their commencement in 1919. The present situation with the production capacity of more than 6 million tpy is actually the result of the mine re-development in the mid 1980s.

The problem of acid water in this area was never been heard of until approximately two years ago when during the regular environmentally monitoring program it was detected that the pH of water in East Klawas pond was low. The pond was actually a mined out pit filled with rainwater. Since it deals with a large volume of acid water, this problem became one of the environmental issues due to the mining activity in this area.

The oxidation of sulfuric matter, mostly pyrite, in the coal seam and overlying strata is believed to be the main source of this acid water generation. Unfortunately, sufficient data to analyze the acid water phenomena in Bukit Asam mine is not available at present because such problem was not predicted before. Therefore, in this stage the water and soil quality data is used in analyzing this phenomena. Further research is necessary to predict and prevent the generation of acid water in the future.

Pond water management seems to be the appropriate method to handle the acid water problem in East Klawas pond. Discharging the water is done only during high water, especially in the rainy season, in order to minimize the impact through dilution.

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