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2013 J. Phys.: Conf. Ser. 423 012053

(http://iopscience.iop.org/1742-6596/423/1/012053)

Evaluation of environmental effect of coal stockpile in Muara Telang, Banyuasin, Indonesia

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Abstract. Stockpile commonly serves as a temporary dump before the coal is transported through the waterways. This study investigated the effects of coal stockpiles on the surrounding environment: air, water, and soil. The location of the study is in the estuary of Telang, South-Sumatra, Indonesia, which is located at the edge of the river of Telang and close to the residential community. The monitoring of the environmental impact from the stockpile is intended to conduct an environmental assessment owing the existence and operations of coal accumulation. Enviromental impact analysis was conducted based on the value of the effluent, air pollution (dust), soil and water by determining the parameters of the coal wastewater pH, total suspended solid, ferrous dan ferrous metals contents. The results indicate that the total suspended particulate, total suspended solids, noise level, ferrous metal and manganese metal were 10-14 μg/Nm^3, 249-355 mg/L, 41.3 to 50.3 dBA, 6.074 to7.579 mg/L, and 1.987 to 2.678 mg/L, respectively. Meanwhile the pH of water and soil were 3 to 4 and 2.83 to 4.02 respectively. It is concluded that the pH value are beyond the threshold standard.

1. Introduction

World coal consumption in recent years has increased very rapidly. In 2007, world consumption reached 5,522 million tons, showing an increase of about 3.5% per year [1]. In the world coal trade, Indonesia plays an increasingly important over the years as a producer or exporter. In 2007, Indonesia was in seventh position as a coal producers which contributes up to 4.2% of the total world productions. On the other hand, as an exporter of coal Indonesia was in the second position with a total export capacity of 202 million tonnes [2]. South Sumatra has the potential coal resources. The total coal resources are about 22,240 billion tonnes or 41.5% of the total national reserve. The need for coal in South Sumatra is increasing with an average of about 5.06% annually [3].

Location of mining away from the coastline causing more expensive transportation costs. In order to reduce the cost, the transportation system was adjusted to a combination of land and sea transport. Coal from the mines is transported by road to the place of coal accumulation (stockpile) to further transported by barges. Stockpile serves as a temporary dump before the coal is transported through the waterways to be marketed at home and abroad. As the potential impacts by the opening of international port of Tanjung Api-Api, it is strongly effected to the potential development of coal stockpile area.

The coal stockpile in Muara Telang is one of the few existing stockpile in Tanjung Api-Api, which is commonly located in wetland areas affected by tides. The stockpile is located at (02^{o}31'00.22" S - 02^{o}31'05.5"S 104^{o}48'00.7" E) and (02^o 30'37.6"S - 02^{o}31'24.3"S 104^{o}48'18.11"E - 104^{o}48'20.6"), with

an area of about 61.09 hectares. The location is on the estuary of the Musi River where tidal variation ranging from 1.0 to 3.0 meters. The tidal effect is higher in this region compared to the influence of rainfall. In addition, altitude varies from 0.5 m to 2.0 m above sea level [4]. The stockpile location is very strategic because it can be passed by a barge as a transporter of coal to consumers. Although the location of the stockpile is far from the main road of the Tanjung Api Api and settlements, activities in the stockpile generate significant dust disturbing the surrounding community [5].

Suspended solids from the run-off in the coal stockpile are at levels of above 2,000 ppm even at 10,000 ppm. The existence of liquid waste from coal stockpile can reduce the degree of acidity (*pH*) and increase the content of total suspended solids (*TSS*), ferrous (*Fe*) and manganese (*Mn*) [6]. Relatively high suspended solids will reduce the penetration of light or sunlight into the water thus affecting the regeneration of oxygen in photosynthesis. On the other hand, high concentration of the *Fe* may affect the lives of aquatic organisms and may cause rust on the equipments made of metal. Meanwhile, the *Mn* metals are toxic at high concentrations. *pH* value of the water that is not in the normal range may affect organisms in the water, such as fish and other animals. In addition, an abnormal pH is corrosive to metals resulting in rust [7].

Monitoring the environmental impact on the stockpile is intended to conduct an environmental assessment of the impact arising due to the existence and operations of coal accumulation. The analysis was corresponded to the value of the effluent, air pollution (dust), soil and water by refering at the parameters of the coal wastewater *pH*, *TSS*, ferrous and manganese metals [8].

2. Method of Study

Data were collected from primary data and secondary data. Primary data obtained from the measurements of samples in the laboratory while secondary data were several reports from related study such as the analysis of the environmental impacts of coal stockpile in Muara Telang.

3. Results and Discussion

3.1 Air quality

Air quality parameters are including the temperature, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), total suspended particulate (TSP), and noise [9].

3.1.1 *Temperature*

Air temperature measurements are required, in which the gas content in the air is inversely proportional. At low temperatures, the concentration of gas pollutant in the air is considerably high (floating near the surface of the earth), while the air temperature increases, the gas in the lower air pollutants (gas rises into the atmosphere). The temperature of the air in coal stockpile locations ranged from 29.8 to 31.8^{o}C.

3.1.2 *Carbon Monoxide (CO)*

Carbon monoxide is a toxic gas that is colorless, odorless, and has no taste. This component has a weight of 96.5% of the weight of the water and does not dissolve in water. Carbon monoxide is present in nature formed from one of the incomplete combustion of the carbon or carbon-containing components, the reaction between carbon dioxide and carbon-containing components at high temperatures, the carbon dioxide will decompose into carbon monoxide and oxygen.

Several studies have shown that the effect of CO on plants is usually not seen in practice. Whereas, the effect of CO on humans at high concentrations can cause death, whereas contact with CO at relatively low concentrations (30,000 ppm or less) can be detrimental to health. In addition, the effect of CO on the human body is mainly caused by the reaction of CO with hemoglobin (Hb) in the blood.

The results of measurements taken at four sampling points indicate that the CO level is below the established standards of 77-124 μg/Nm^3. We note that the CO concentration in the residential location is generally derived from the motor-vehicles activities and household activities.

3.1.3 *Sulfur dioxide (SO_2)*

Pollution by sulfur dioxide is mainly caused by two components of sulfur forms a colorless gas, namely sulfur dioxide (SO_2) and sulfur trioxide (SO_3), in which both are called as sulfur oxides (SOx). Sulfur dioxide has a characteristic pungent odor and non-flammable in air, while the sulfur trioxide is a component that is not reactive. SO_2 in the air always produced in large quantities, while the amount of SO_3 formed varies from 1-10% of the total SOx.

SO_3 in the air in the form of gas is possible only if the concentration of water vapor is very low. If the water vapor present in sufficient quantities, SO_3 and water vapor will soon join to form droplets of sulfuric acid (H_2SO_4) with the following reaction:

$SO_3 + H_2O \longrightarrow H_2SO_4$

The normal components contained in the air is H_2SO_4 not SO_3. But the amount of H_2SO_4 in the atmosphere is more than the result from SO_3 emissions. This suggests that there is other mechanism producing H_2SO_4 in the environment. After being in the atmosphere, SO_2 is converted into SO_3 (later to become H_2SO_4) by photolytic processes and catalytic. The total amount of SO_2 oxidized into SO_3 is influenced by several factors including the available water, intensity, time, and distribution of sunlight spectrum.

SOx influence on plants can be affected by two factors, namely the effect of SO_2 concentration and contact time. While, the effects of high concentration SOx on humans and animals is irritation of the respiratory system. We conducted measurement at four sample locations (*see* Table 1). The results show that the concentration of SO_2 about 5.26 to 30.26 μg/Nm^3, which is below the standards (900 μg/Nm^3).

3.1.4 *Nitrogen oxides (NOx)*

Nitrogen oxides (NOx) are a group of gases in the atmosphere of gas nitric oxide (NO) gases in the atmosphere. Although other forms of nitrogen oxides exist, but these two gases are most commonly found as an air pollutant. Nitrogen oxide is a gas that is colorless and odorless, whereas nitrogen dioxide has a reddish-brown color and pungent. Out measurement at four sample locations indicate that the concentration of NOx is about 2.08 to 21.73 μg/Nm^3, which is below the threshold standard.

3.1.5 *Total suspended particulate*

Dust particles generally contain a variety of different chemical compounds with different sizes and different shapes, depending on where the source emission. Naturally particulate dust can be generated from dry dust carried by the wind or derived from a volcanic activities. Particulate dust drift is also produced from the combustion of coal. The coal combustion is not perfect in such that the forming aerosol compound of tar beads. Compared with the burning of coal, oil and gas combustion generates fewer particulates floating dust. Motor-vehicle density can increase the total emission of black smoke particulate dust [9].

Size of dust particulate solid or liquid form in the air depends on the size. Size of dust particulates that endanger health generally range between 0.1 to 10 microns. In general, the size of about 5 microns of particulate dust is airborne particulate matter that can go directly into the lungs and settles in the alveoli. This situation does not mean that the size of particulates greater than 5 microns are not dangerous, because the larger particulates may interfere with the upper respiratory tract and cause irritation. This situation will worsen if the synergistic reaction with SO_2 gas contained in the air which comes from the activity of stone crusher and unloading coal. Besides particulate dust that floated and fluttered in the wind will cause irritation to the eyes and can impede penetration eye (visibility). The existence of spills of toxic metals contained in particulate dust in the air is the greatest danger to health. In general, the polluted air containing hazardous metals only about 0.01% to 3% of all particulate dust in the air. However, these metals can be cumulative and possibly synergistic reaction occurs in the body's tissues [10].

The results of measurements taken at four sample locations show that the content of particulate dust is10-44 μg/Nm^3 and it remains below the established standards.

3.1.6 *Noise*

Noise in occupational health is defined as hearing voices. It can reduce both quantitatively (increased hearing threshold) and qualitatively (narrowing of the spectrum of hearing), factors related to the intensity, frequency, duration and timing pattern. Noise is measured with a sound level meter. With the mechanism of action, if any object vibrates, it will lead to changes in air pressure that can be captured by these tools, will move the meter pointer.

Noise causes various disorders on society, labor and animals around him. Noise can cause disruption, such as impaired physiological, psychological, communication disorders and deafness, or there is classification of disorders such as auditory disorders, such as disruption of hearing and non-auditory disturbances such as impaired communication, health hazards, decrease work performance, fatigue and stress.The results of conducted noise level measurements at four samples locations, the noise level is between 41.3 dBA to 50.3, still below the threshold standard.

The results of measurements taken at several locations in the stockpile area shown in Table 1. It is shown that the temperature has no significant difference, where the measurement takes place when the air temperature is quite bright.

Table 1. The results of measurements of air quality and noise levels in the coal stockpile.

No.	Parameter	Unit	Measurement Results				Threshold Standard[a]
			U-1[d]	U-2[e]	U-3[f]	U-4[g]	
1	Air temperature	^{o}C	29.8	30.6	31.8	30.5	-
2	CO	µg/Nm^3	77	124	92.4	90.2	30.000
3	SO_2	µg/Nm^3	5.26	30.26	10.16	10.10	900
4	NO_2	µg/Nm^3	2.08	21.73	6.55	6.50	400
5	TSP	µg/Nm^3	12	14	11	10	230
6	Noise	dBA	45.9	50.3	44.8	41.3	55[b] 70[c]

[a] South Sumatra Governor Regulation No.6 of 2012 [11]
[b] For residence area
[c] For industrial area
[d] Coal stockpile location
[e] Sri Tiga village
[f] Telang riverside
[g] Karang Anyar village

3.2 Water quality

Water quality can be seen from the physical and chemical parameters. Consequent changes in the physical parameters is seen from the water surface, water temperature and dissolved solids. The solids consist of organic and inorganic solids and suspended sediment. This material will settle at the bottom of water over time causing siltation of water bodies. Another consequence of this solid is a growth of toxic aquatic-plants that can influence other organisms. The number indicates sludge solids contained in the water. Chemical parameters include the level of acidity (*pH*) and heavy metals [12].

3.2.1 *Water temperature*

The standard surface water is set at normal temperatures. High surface water temperatures (>45^{0}C) will affect the speed of chemical reactions as well as lifes in the water. Temperature changes show activity of biological chemistry in solids and gases in water. The potential decay that occurs at high temperatures can cause the solubility of oxygen in the surface water. It is set to reduced, so that the process of aeration is needed in order to degrade organic matter that is inhibited. Furthermore, we will give effect to turn off the water biota in water bodies and vegetation lethal hit. Thus, the water temperature averaged 26.5°C is a good indicator, and in accordance to the conditions of the tropics. The average value of the temperature measured was still met the quality standard.

3.2.2 *Total suspended solids*

The solids consist of organic and inorganic solids dissolved, and suspended sediment. This material will settle at the bottom of water over time causing siltation in particular on surface water bodies. Another consequence is that the solid substances could pose a growth of particular aquatic plants that can be toxic to other creatures. The number indicates the amount of sludge solids contained in the water [12]. From the analysis of dissolved solids, dissolved solid substances classified as very high compared to environmental standards, the concentration of dissolved solids ranging from 249-355 mg/L, indicating that the location of water samples containing high dissolved solids than the Environmental Quality Standard of 200 mg/L.

3.2.3 *Acidity value (pH)*

Normal water *pH* value is between 6-8, while the polluted water such as waste water, has various pH depending on the type of exhaust. The changes in the acidity of the waste water either to the alkaline (higher *pH*) or to the acid (lower *pH*) would greatly disrupt the lives of fish and aquatic animals in the vicinity. In addition, waste water having very low *pH* is highly corrosive to steel and ferrous pipes. From Table 2, we found that almost all of the locations show low *pH* values (tends to be acidic) and beyond the environmental quality standards.

Table 2. Analysis data of river water.

No.	Parameter	Unit	Analysis Results				Threshold Standard[a]
			U-1[b]	U-2[c]	U-3[d]	U-4[e]	
1	Temperature	^{o}C	26.5	26.5	26.5	26.5	-
2	pH	-	3.08	4.59	4.48	4.94	6-9
3	Total Suspended Solid	mg/L	249	310	355	289	200
4	Dissolved Ferrous	mg/L	6.074	7,579	6.551	6.505	7
5	Dissolved Manganese	mg/L	2.059	2.556	2.678	1.987	4

[a] South Sumatra Governor Regulation No.8 of 2012 [14]
[b] Main trench location
[c] Trench 3 location
[d] Telang river location
[e] Trench 4 location

3.2.4 *Disolved oxygen*

Dissolved oxygen is a basic requirement for plant and animal life in the water. Living beings in the water depends on the ability of water to maintain the minimum oxygen concentration required for life. Fish are aquatic organism that require the highest oxygen, followed by invertebrates. Bacteria are the aquatic organism that need the smallest amount of oxygen. Minimum dissolved oxygen concentration for microbial life can not be less than 5 ppm. Very low concentration of dissolved oxygen can cause a death on fish and results in a rapid corrosion process [13]. Dissolved oxygen levels of the aquatic ecosystem in the vicinity of the study showed a relatively low value (less than 6 mg/L). Thus we may conclude that the aquatic ecosystem in the study area is not good or the aquatic organism because its concentration is below the threshold standard.

3.2.5 *Heavy metal and toxic*

Water is often contaminated with inorganic components, including heavy metals. Manganese (*Mn*) and ferrous (*Fe*) is oxidized in water and insoluble brownish color. The contaminated water can not be used for domestic purposes and rocks containing compounds such as manganese and ferrous pyrite and hematite. In water bodies, ferrous (*Fe*) from the corrosion of heavy equipment and water pipes, metal materials as electrochemical reactions occurring on the surface. Water containing dissolved solids having electrically conductive properties to accelerate corrosion [8].

The results of laboratory tests on water samples show that the level of ferrous (*Fe*) in all locations are above the specified standards. This could be possible due to the oxidation of the pipes or objects that contain elements of ferrous along the river.

3.3 Soil quality

The process of soil formation in Muara Telang strongly influenced by the water (alluvial processes), with additional influences could be the intrution of saltwater or flooding tide in some areas. The condition of the soil in the area of activity is a thin peat marshland. Generally alluvial soil types with shrub land cover with gelam (*Melaleuca cajupati P*), palm, grass marsh tidal areas. Typology of ecosystem study area is peatland ecosystems, wetlands or marshy ground. Typology can be classified into a tidal marsh ecosystem. Ecosystems are usually located on the banks of the great rivers that form the ecosystem of freshwater peat swamp forest with water conditions affected by brackish.

3.3.1 *Physical properties of the soil*

Based on the interpretation of Land and Land Unit Map, published by the Agency for Survey and Mapping (Bakosurtanal) and Research Center of Land and Agro-climate Bogor [15], the coal stockpile area in the village of Muara Telang has alluvial soils. Based on the description of the physiographic, generally fall into three land units, namely:

- Land back swamp (marsh behind) beaches with fine sediments, flat (generally, 3%), dominated by swamp vegetation, forests and shrub gelam (*melaleuca cajupati P*), formed from parent material refined marine sediments from the quarter and some regions have been opened / created fields and some are still in the form of shrubs are still flooded. Alluvial soil found in both study sites in the rice paddies and natural land where there is a difference in the nature of morphologic.
- Tidal plains, mangrove vegetation, sediment smooth, flat (slope <3%).
- Peat land, with the thickness of 10-80 cm, formed from deposits of organic materials, drainage obstructed. Soil fertility is generally low to moderate, easy to shrink the physical properties not turn when in drainage, highly flammable when dry, and has a low mineral soil.

3.3.2 *Chemical properties of soil*

Observations were made at three points representing the existing land units, at ditch 4, ditch 3, and the center of the land. Composite sampling is done at a depth of 0-50 cm. Laboratory analysis of the soil chemical and physical properties is shown in the Table 3.

Table 3. The analysis of physical and chemical properties of soil.

No.	Parameter	Unit	Criteria		
			P-1[a]	P-2[b]	P-3[c]
A.	Chemical properties				
1	pH	Unit	4.02	2.83	2.72
2	C-organic	%	12.67	6.00	8.62
3	N-total	%	0.62	0.24	0.32
4	P-total	mg/L	0.049	0.022	0.023
5	K	me/100g	0.20	0.22	0.18
B.	Physical properties				
6	Porosity	%	45.55	54.23	41.55
7	Permeability	cm/hour	0.22	0.55	0.35
8	Texture: sand	%	15.94	17.77	19.24
	dust	%	37.25	35.21	31.12
	clay	%	46.31	47.02	49.64

[a] Trench 4 location
[b] Trench 3 location
[c] Coal stockpile location

Based on the results of the analysis as shown in Table 3, it is known that the chemical condition of the soil fertility is low to moderate, where the soil has a high acidity (low *pH*) is 2.38 to 4.02. Soil acidity (*pH*) is one of properties that affects absorption of nutrient elements by plants and it is an indicator of toxic elements that affect the growth of microorganisms. The content value of N, P, K total is low to very low, but it has swapped a relatively moderate base and C-organic content classified as moderate. The physically soil at the stockpile locations as low to moderate, with relatively moderate to high porosity, bulk density, and generally low to moderate clay fraction which is dominated by the component. Based on the chemical soil fertility, the fertility rate in the coal stockpile are relatively low.

4. Conclusion and recommendation

Coal stockpile activities have an impact on the surrounding environment. Location of stockpile in the river will have an impact on surface water and soil quality. Unloading-coal activities at the port also cause noise and influence the air quality at the site of stockpile. Air quality parameters including temperature, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxide (NOx), total suspended particulate and noise. Water quality is affected by temperature, *pH* value and metal content of ferrous and manganese. The low *pH* value of the soil will interfere with fertility soil in the stockpile.

The presence of high total suspended solids and ferrous metal content in Telang River causes effluent from the coal stockpile should be processed before it is discharged. Coal stockpile management system must consider the characteristics of coal stockpile in Muara Telang, Banyuasin.

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