Spatial Analysis of Environmental Water Quality in Coal Stockpile

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ABSTRACT

The location of mining is away from the coastline, so the coal stockpiles is needed. Stockpile serves as a temporary dump before the coal is transported through waterways to be marketed locally or abroad. The existence of the stockpiles is could adversely affect the environmental quality regarding air, water, and soil. The monitoring and management of environmental impacts is intended to minimize the impact arising from the existence and operations of coal buildup. The presence of liquid waste that comes from coal stockpile can lower the degree of acidity (pH value) and increase total suspended solid content (TSS), iron (Fe) and manganese (Mn) which when processed will not adversely affect the surrounding environment. The study aimed at mapping the spatial distribution patterns of pollutants in coal stockpile in order to know the quality of environment due to the presence and activity of the coal stockpile. Given the spatial analysis of environmental pollution, the long-term negative impacts due to the presence and the activity of stockpile can be reduced and preventive action can be done. The research begins by determining the coordinates of point samples, water sampling and laboratory analyzes. The results of measurement and analysis in a laboratory are used to make maps of the spatial distribution patterns of environmental quality. Water quality in acid classified stockpile locations around 3.4 with Fe content of 2.34 ppm and Mn content of 1.77 ppm, as well as 406 ppm of total suspended solid.

Keyword: spatial analysis, water quality, coal stockpile

1. INTRODUCTION

Coal stockpile is temporary shelter of coal before it is sent to consument and center of operational for a Coal Port. Coal which is mined from the mine site will be brought into the port of coal by road and then shipped to the consument. Stockpile serves as a buffer between the delivery and processing process, as well inventories, strategic and minimize short-term disruption or long term. It also serves as a mixing and distribution place by type of coal to conform with the request as required. Besides these purposes, the stockpile is also used to mix coal so the homogenization process as needed. Homogenization aims to prepare the products from one type of material in which fluctuations in coal quality and size distribution are equated. In the homogenization process there are two types of blending and mixing.

Stockpile management is the process of setting or procedure which consists of the quality setting of the coal in the stockpile buildup procedure. This is done as an effort to make coal produced can be controlled, both quality and quantity. In addition stockpile management is also intended to reduce the losses that may appear from the handling process or handling of coal in the stockpile, such as rain, dust in the dry season, or burnt caused of coal burnt in the stockpile. Coal stockpiling setting is very important because it is related with the

maintenance problems of quantity and quality of coal stacked in the stockpile.

Coal Stockpile at Muara Telang, Banyuasin Regency, South Sumatra, Indonesia, is one of the few existing stockpile at the Port of Tanjung Api Api region in the lowlands area which is affected by the tides. Stockpile location located at coordinates 02° 31'00.22"S – 02^o31'05.5"S 104° 48'00.7"E and 02° 30'37.6"S - 02° 31'24.3"S 104° 48'18.11"E –104° 48'20.6"E, with an area ± 61,09 Ha[1].

Coal stockpile at Muara Telang has flat topografi which is influenced by tide and wet tropical climate. Stockpile dimensions with a maximum height of stockpile ± 15 meters, with an angle of stockpile on conveyor belt, angle of repose stockpile which is formed about 25° – 30°, while angle stockpile which is pushed by bulldozer is 38° – 44°, grain size about 1-30 cm for coal from mine and 50-100 mesh for coal blending. The quality of coal in stockpile contain total moisture 30.19%, ash content 6.63%, volatile matter 41.05%, fixed carbon 40.28%, total sulfur 0.67% and calorific value 5926 kcal/kg.

Spatial analysis or spatial statistics includes any of the formal techniques which study entities using their topological, geometric, or geographic properties. Spatial analysis includes a variety of techniques, many still in their early development, using different analytic approaches and applied in fields as diverse as astronomy, with its studies of the placement of galaxies in the cosmos, to chip fabrication engineering, with its use of 'place and route' algorithms to build complex wiring structures. In a more restricted sense, spatial analysis is the techniques applied to structures at the human scale, most notably in the analysis of geographic data [2].

Complex issues arise in spatial analysis, many of which are neither clearly defined nor completely resolved, but form the basis for current research. The most fundamental of these is the problem of defining the spatial location of the entities being studied.

Classification of the techniques of spatial analysis is difficult because of the large number of different fields of research involved, the different fundamental approaches which can be chosen, and the many forms the data can take.

The definition of the spatial presence of an entity constrains the possible analysis which can be applied to that entity and influences the final conclusions that can be reached. While this property is fundamentally true of all analysis, it is particularly important in spatial analysis because the tools to define and study entities favor specific characterizations of the entities being studied. Statistical techniques favor the spatial definition of objects as points because there are very few statistical techniques which operate directly on line, area, or volume elements. Computer tools favor the spatial definition of objects as homogeneous and separate elements because of the limited number of database elements and computational structures available, and the ease with which these primitive structures can be created.

2. METHODS

Method of implementation of research conducted with field observations to map points that are in the water sample coal stockpile location by using GPS (Global Positioning System). With such a device would be recorded all the data x, y coordinates of the sample points are taken [3].

The water quality data were analyzed by the method of the coal stockpile descriptive. The results of the analysis are presented in the form of graphs and maps. Making maps of the spatial distribution is done by using GIS software with interpolation method. Spatial interpolation methods estimate the variables at unobserved locations in geographic space based on the values at observed locations. Basic methods include inverse distance weighting: this attenuates the variable with decreasing proximity from the observed location. Kriging is a more sophisticated method that interpolates across space according to a spatial lag relationship that has both systematic and random components. This can accommodate a wide range of spatial relationships for the hidden values between observed locations. Kriging provides optimal estimates given the hypothesized lag relationship, and error estimates can be mapped to determine if spatial patterns exist [4]. The method used in the formed of the spatial distribution maps with non-linear interpolation approach.

The model assumes that the weighting of the point value will allegedly be affected by the point value of other spatially adjacent. The essence of the model is to analyze the weighting of the observation point in a space adjacency that describes similarities between those points. The model is a model space weighting local, then search techniques (searching) which is used to set the number of observation points located in

the vicinity, or use the search technique within a specified radius.

Elevation value (z) for each point will be weighted by the square of the distance so that values close spatially will tend to affect the observed value at the point. This technique is known as Inverse Distance Weighting technique (IDW).

The process of analyzing the interpolation technique can be performed using Software Ilwys. Ilwys uses GIS techniques that integrate image processing capabilities, a tabular database and conventional GIS characteristics [5].

3. RESULTS

Water conditions in the coal stockpile location and stockpile activity is influenced by rainfall. The existence of coal stockpile activity will affect the quality of water for pH, TSS, and metals content.

To determine water quality in the stockpile location it will take sample of the water at several places/locations, namely in the drainage, trenches 3 and 4, settling ponds and in the Telang river. Water samples were analyzed in the laboratory and compared with the water quality standards based on by Governor Regulation No. 8 of 2012 standard quality to pH 6-9, TSS 200 ppm, metal content 9 ppm of Fe and metal content 4 ppm of Mn.

Surface water quality standards (water bodies) set at normal temperatures. High surface water temperatures ($>45^0$C) will affect the speed of chemical reactions as well as life in the water. Temperature changes show activity of biological chemistry in solids and gases in water. Decaying os at high temperatures can lower the solubility of oxygen in the surface water. Therefore the aeration process will inhibit degradation of organic matter. Furthermore it will give affect to kill biota in water bodies and also the vegetation tropical. However, the averaged water temperature of 25.5°C is a good indicator and suitable to conditions (lower than average air temperature). The average value of the temperature measured was still met the standard quality.

Dissolved oxygen is a basic requirement for plant and animal life in the water. Living being in the water depends on the ability of water to maintain the minimum oxygen concentration required for life. Fish are aquatic creatures that require the highest oxygen, then invertebrates and the smallest is the bacteria need oxygen. Minimum dissolved oxygen concentration for microbial life can not be less than 5 ppm. The concentration of dissolved oxygen is too low can result in fish (necton) and resulted in the rapid corrosion process because oxygen will bind hydrogen that coats the surface of the metal.

Acidity value (pH)

Normal water pH value is between 6-8, meanwhile the pH value is polluted, for example waste water varies depending on the type exhaust. The changes in acidity in wastewater 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. Waste water with a low pH is highly corrosive to steel and will cause corrosion on iron pipes. Environmental Quality Standards for the parameters of the surface water pH is 6-9. Furthermore, water is highly acidic or alkaline will result in disruption of marine life and even the equipment used. From Table 2 shows that almost all the locations showed low pH values (tends to be acidic) and beyond the environmental quality standards.
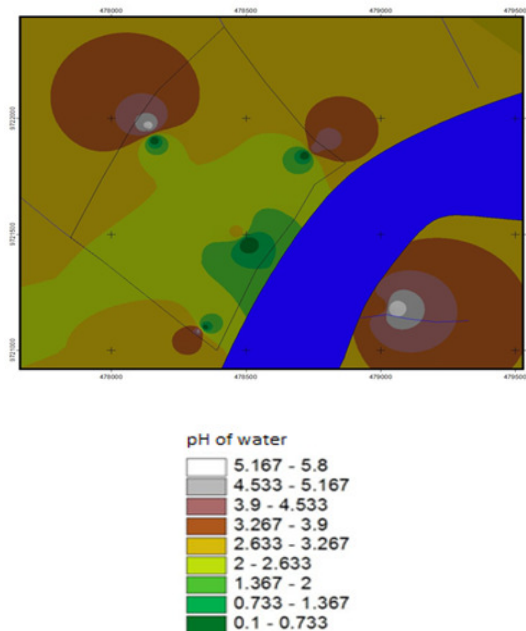

pH of water
- 5.167 - 5.8
- 4.533 - 5.167
- 3.9 - 4.533
- 3.267 - 3.9
- 2.633 - 3.267
- 2 - 2.633
- 1.367 - 2
- 0.733 - 1.367
- 0.1 - 0.733

Fig. 1. Map the spatial distribution of water pH at the site of the coal stockpile

Total suspended solids

The solids consist of organic and inorganic solids dissolved, and suspended sediment. This

material will settle to the bottom of water over time causing siltation in particular on surface water bodies receiving. Another consequence is the solid substances pose particular the growth of aquatic plants and can be toxic to other creatures. The number indicates the amount of sludge solids contained in the water [6]. 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 very low dissolved solids than the Environmental Quality Standard of 200 mg/L.

Solids composed of organic and inorganic solid materials were dissolved, precipitated, and suspended. Which include total suspended solids are sludge, clay, metal oxides, sulfides, algae, bacteria and fungi. This material will settle to the bottom of water which gradually raises special silting on the surface of the receiving water body. Another consequence of these solids cause the growth of certain aquatic plants and can be toxic to other creatures. The number indicates the amount of sludge solids contained in the water. Total suspended solids are generally removed by flocculation and filtration. Total suspended solids contribute to turbidity (turbidity) by limiting the light penetration for photosynthesis and visibility in the waters [5].

From the analysis of suspended solids, suspended solids content is high compared to the environmental quality standard, the concentration of suspended solids range from 249-355 ppm, indicating that the location of water samples containing suspended solids higher than 200 ppm of Environmental Quality Standards. From the map the spatial distribution of high TSS values seen across the Telang river are located in front of the pier and the waste storage ponds. The results of statistical tests also showed similar results where the correlation value reaches 93.7% and 100% confidence level (α <0.05) at 1% significance level, so the level is very significant. Map the spatial distribution of the pH value of water at the location of the coal stockpile can be seen in Fig. 2.

Heavy Metal and Toxic

Dissolved oxygen levels of the aquatic ecosystem in the vicinity of the study showed a relatively low value (less than 6 mg/L). Thus criteria, environmental quality aquatic ecosystems say less good or beyond the threshold standard.

Water is often contaminated with inorganic components, including heavy metals. Manganese (Mn) and iron are oxidized in water produced insoluble brownish color, which causes the water can not be used for domestic purposes and rocks containing compounds such as manganese and iron pyrite and hematite. In water bodies, iron (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.

The results of laboratory tests on water samples taken showed levels of iron (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 iron along the river.
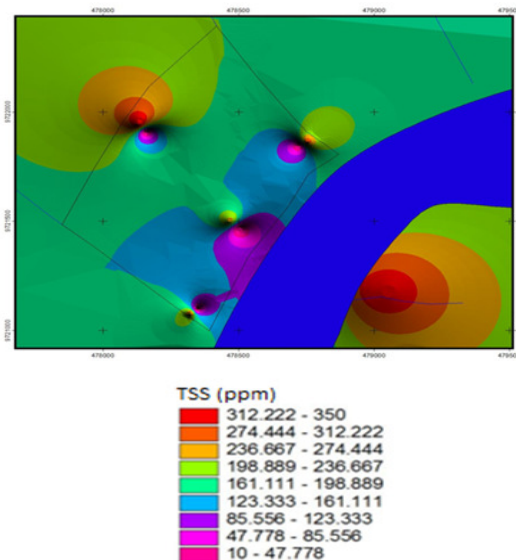

TSS (ppm)
- 312.222 - 350
- 274.444 - 312.222
- 236.667 - 274.444
- 198.889 - 236.667
- 161.111 - 198.889
- 123.333 - 161.111
- 85.556 - 123.333
- 47.778 - 85.556
- 10 - 47.778

Fig. 2. Map the spatial distribution of TSS in the water at the site of coal stockpile

Water is often contaminated by inorganic components, including heavy metals. Dangerous heavy metals are widely used in various purposes, therefore routinely produced on an industrial scale. Heavy metals in general as a mixture of iron (Fe), copper (Cu), total chromium (Cr), and aluminum (Al). Other metals were included in the heavy metal is manganese (Mn). Manganese (Mn) and iron (Fe) are oxidized in water and insoluble brownish color, which causes the water cannot be used for household and industrial use of water thus becomes limited. In general, the iron in the water can be:

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- Dissolved as Fe^{2+} (ferrous) or Fe^{3+} (ferry)
- Suspended as colloidal grains (diameter < µm) or greater, such as Fe_2O_3, FeO, $Fe(OH)_3$- Inlaid with organic substances or inorganic solids (such as clay).

Iron can be found in nature in the form of *pyrite* (FeS_2), *hematite* (Fe_2O_3), *magnetite* (Fe_3O_4), *limonite* [$FeO(OH)$], *goethite* ($HFeO_2$), and *ochre* [$Fe(OH)_3$].

In natural waters with a pH of about 7 and sufficient dissolved oxygen, ferrous ion which is easily soluble, oxidized to ferric ions. This oxidation occurs on the release of electrons. In contrast, the reduction of ferric into ferrous, electron capture occurs. Iron oxidation and reduction processes do not involve oxygen and hydrogen [7].

In the rare surface water Fe levels in excess of 1 ppm, but in the ground water, the levels of Fe can be much higher. In water that does not contain oxygen, such as ground water, iron is present as Fe^{2+} is enough solid dissolved, while the river water flowing and happening aeration, Fe^{2+} is oxidized to Fe^{3+} which is difficult to dissolve at pH 6-8 (solubility only under a few µg/L), it can even be Ferry hydroxide $Fe(OH)_3$ or one type of oxide that is solid and can settle. In river water, the iron is present as Fe^{2+} Dissolved Fe^{3+} and Fe^{3+} in the form of a colloidal organic compounds.

The results of laboratory tests on water samples taken at some point in the stockpile locations showed levels of iron (Fe) exists that exceeds the quality standards set (Quality Standar 7 ppm), whereas the levels of manganese (Mn) is still below the quality standard (Quality Standard 4 ppm). High Fe content is in the water area on the edge the location of the coal stockpile and water samples were taken people that live in the Telang river. From the statistical test results showed a correlation between the metals iron and manganese 21.4% and 76.1% for a location close to a stockpile that has a negative relationship with distance from the stockpile where the farther the distance from the stockpile the metal content decreases. This suggests the existence of a drainage channel at the location of the stockpile is very effective to minimize the spread of the metal from the waste into the waters. Map the spatial distribution of metal Fe and Mn in water can be seen in Fig. 3 and Fig. 4.

4. CONCLUSION

The quality of water is spatially mapped to perform the distribution pattern in the stockpile. In order to minimize the possible effects, the environmental management on the stockpiles area can be conducted with build a drainage which is connected to wastewater treatment plant
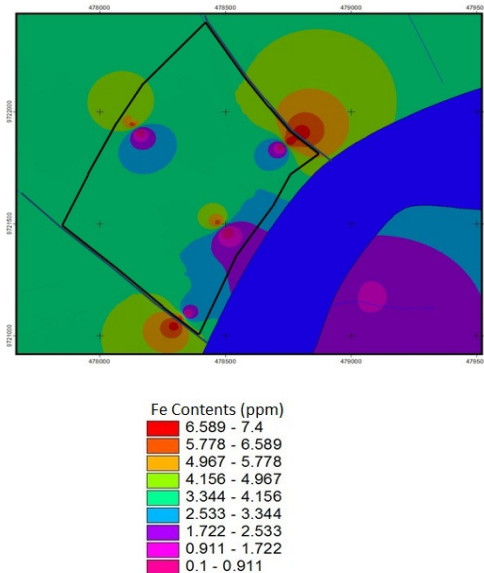

Fe Contents (ppm)
6.589 - 7.4
5.778 - 6.589
4.967 - 5.778
4.156 - 4.967
3.344 - 4.156
2.533 - 3.344
1.722 - 2.533
0.911 - 1.722
0.1 - 0.911

Fig. 3. Map the spatial distribution of Fe metal content in water

Mn Contents (ppm)
4.1 - 4.6
3.6 - 4.1
3.1 - 3.6
2.6 - 3.1
2.1 - 2.6
1.6 - 2.1
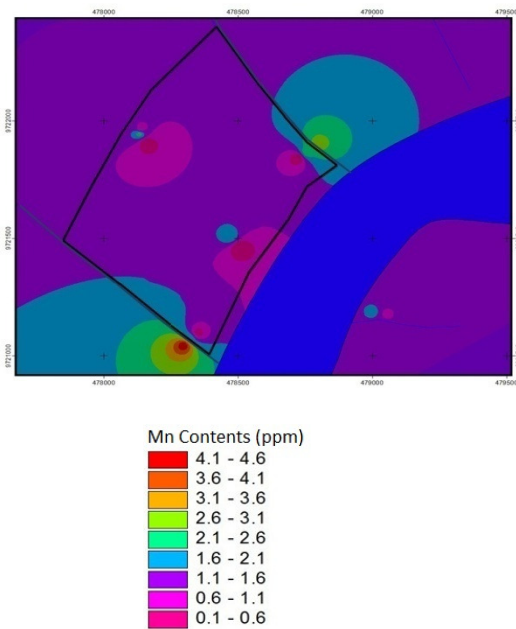1.1 - 1.6
0.6 - 1.1
0.1 - 0.6

Fig. 4. Map the spatial distribution of Mn metal content in the water

to prevent the movement of pollutants out the environmental of coal stockpile. Reduction of pollutants in the wastewater can be achieved by treatment the wastewater with using the map spatial distribution.

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