Assessment of Groundwater Vulnerability in Coal Mining Areas Using the DRASTIC Method

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ABSTRACT

This research is focused on knowing how vulnerable the ability of groundwater is to be affected by mining activities. Supporting analysis includes mine design using the stripmine method and research on hydrological and hydrogeological characteristics. Field activities include observation, measurement, testing of groundwater potential with the slugtest method in the study area. Testing of groundwater potential is carried out based on 6 core drill holes, namely GT-01, GT-02, GT-03, GT-04, GT-05, GT-06. Analysis of this study uses the DRASTIC method as a weighting and valuation method. In the DRASTIC method of groundwater vulnerability influenced by several factors, namely, the depth of the groundwater, rainfall, topography (slope), lithology, soil texture and hydraulic conductivity. The types of aquifers found in the study area were free aquifers with a depth of 3.15 – 4.7 m, divided south while aquifers were depressed with a depth of 12.1 - 55.5 m in the northern and central parts. The index value varies when the minimum rainfall is 72-146 with a low level vulnerability and when rainfall is high 96-165 the level of vulnerability is low to high, then the effect of mining activities is the cutting off of aquifer layers.

Keywords: *DRASTIC Index, groundwater, aquifer.*

I. INTRODUCTION

The research area is located in the coal mining business permit area located in Darmo village, Lawang Kidul sub-district, Muara Enim regency South Sumatra Province, groundwater problems are very important because groundwater becomes the needs of the community around the first site, due to mining activities in the research area disturbing the water system and the surrounding environment, the purpose of this study is determine the type of aquifer and the direction of groundwater flow, calculate the DRASTIC index value, analyze groundwater vulnerability to the planned mining activity and make zonation maps of groundwater vulnerability as material for mining activity planning analysis.

II. METHOD

The first stage of this research is by conducting a study of literature in the library and company archives beforehand, then conducting field activities which include observing the measurement of groundwater potential testing by slugtest method, this test was carried out on 6 core drill holes namely, GT-01, GT-02, GT-03, GT-04, GT-05, GT-06, then carried out analysis with the DRASTIC method, following the research flow diagram.

Figure 1. Research Flow Diagram

III. RESULT AND DISCUSSION

1. Characteristic of rainfall

Rainfall is very influential on groundwater conditions at the study site because the size of the rain will affect the magnitude of infiltration and percolation.

Figure 2. Rainfall chart

2. Aquifer Characteristic

The aquifer media in the study area that has the ability to store groundwater is sandstones and gravel sand. Identification of the thickness of aquifer from 6 drill hole data in the study area is 3.10 m – 41.5 m with free and depressed aquifer types. The interpretation of drill holes GT-01, GT-04, GT-05 and GT-06 is found at the depth of 0 m – 22.7 m and 0 m – 12.1 m. the free aquifer layer in the GT-02, and GT-03 is at the depth of 4.70 m – 12.20 m and 3.15 m– 27.1 m, while the depressed aquifer layer is at the depth of the interpretation of the GT-01, GT-04, GT-05, GT-06, namely 22.7 m - 25.7 m, 15.3 m – 18.4 m, 12.10 m – 15 m, and 55.5 m – 87 m.

Testing the potential of groundwater in the field is done by the slugtest method and then observing the groundwater level at each drill hole location.

3. Coefficient of Permeability (*k*)

From the existing drill log data, the lithology of the investigation area can be identified as sandstone layers both in the overburden and interburden layers, installation of pipes in the bore holes is carried out on the drill hole until the groundwater level rises, after that the slug test is tested using a piezometer and records the groundwater drop data and the time of its decline. The test result are processed until the permeability coefficient value is obtained between 1.331×10^{-5} m/s – 7.454×10^{-7} m/s, that is as follows

$$k = 0.133.(\Delta S).\{(Rc)^2/L\} \quad (1)$$

1. GT-01= 1.958×10^{-6} m/s = 0.1692 m/day
2. GT-02= 1.891×10^{-6} m/s = 0.1634 m/day

3. GT-03= 9.653×10^{-7} m/s = 0.0834 m/day
4. GT-04= 4.982×10^{-6} m/s = 0.430 m/day

5. GT-05= 1.331×10^{-5} m/s = 1.150 m/day
6. GT-06= 7.354×10^{-7} m/s = 0.0635m/day

4. Transmissivity (*T*)

The value of transmissivity (T) is defined by a number stating the rate of water flow through the unit of area of aquifer per unit time. The transmissivity value is directly proportional to the hydraulic conductivity and thickness of the aquifer. Transmissivity values can be calculated after the permeability coefficient value is obtained from the results of the slug test on each bore hole. The value of transmissivity can be obtained using the equation:

$$T = k.b \quad (2)$$

1. GT-01:
   $(1.958 \times 10^{-6} \times 34.50)\ m^2/s = 6.755 \times 10^{-5}\ m^2/s$
2. GT-02:
   $(1.891 \times 10^{-6} \times 49)\ m^2/s = 9.2659 \times 10^{-5}\ m^2/s$
3. GT-03:
   $(9.653 \times 10^{-6} \times 24)\ m^2/s = 2.316 \times 10^{-4}\ m^2/s$
4. GT-04:
   $(4.982 \times 10^{-6} \times 3.1)\ m^2/s = 1.544 \times 10^{-5}\ m^2/s$
5. GT-05:
   $(1.331.10^{-5} \times 2.9)\ m^2/s = 3.861 \times 10^{-5}\ m^2/s$
6. GT-06:

   $(7.354 \times 10^{-7} \times 31.50) m^2/s = 2.316 \times 10^{-5}\ m^2/s$

5. Storage Coefficient (*S*)

Storage coefficient is the volume of water that can be released or storage per unit surface area of aquifer per unit head change on the surface and the calculation uses equations [5]:

$$S = 3.28 \times 10^{-6} \times b \quad (3)$$

So that the storage coefficient values of each test well can be obtained as follows:

1. GT-01:
   $3 \times 10^{-6} \times 34.50 = 1.035 \times 10^{-4}$
2. GT-02:
   $3 \times 10^{-6} \times 49 = 1.47 \times 10^{-4}$
3. GT-03:
   $3 \times 10^{-6} \times 24 = 7.2 \times 10^{-5}$
4. GT-04:
   $3 \times 10^{-6} \times 3.1 = 9.3 \times 10^{-6}$
5. GT-05:
   $3.10^{-6} \times 2.9 = 8.7 \times 10^{-6}$
6. GT-06:
   $3 \times 10^{-6} \times 31.50 = 9.45 \times 10^{-5}$

6. Groundwater Flow Contour

The direction of groundwater flow is determined by the three point problem method [6]. The direction of groundwater flow will always be perpendicular to 90º to the contour of groundwater and the flow from the high to low contours, the data used is the measurement of groundwater elevation from 6 drill holes obtained from the test result slugtest. The direction of groundwater flow is based on each groundwater surface depth (MAT) interpolation at each sampling location.

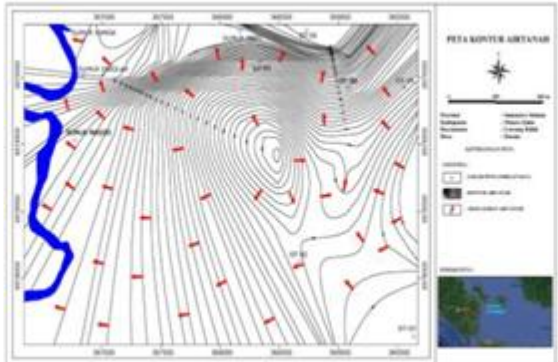

Figure 3. Groundwater Contour Map

7. Groundwater Vulnerability Analysis

The level of vulnerability of groundwater is based on the weighting of the rating and the load of the DRASTIC method, after determining all the required parameters, then the parameter is classified and given a rating value and multiplied by weighting factors/ factor to get the DRASTIC index value. The DRASTIC index is divided into 5 classes, the higher the DRASTIC index indicates the level vulnerability otherwise a small index indicates a low level of vulnerability.

Table 1. Groundwater Vulnerability on Minimum Rainfall

No	Hole ID	Index DRASTIC	Vulnerability
1	GT-01	90	Low
2	GT-02	146	Middle
3	GT-03	136	Middle
4	GT-04	82	Low
5	GT-05	97	Low
6	GT-06	72	Very Low

Table 2. Groundwater Vulnerability on Maximum Rainfall

No	Hole	Index DRASTIC	
1	ID	114	Vulnerability
2	GT-01	165	Low
3	GT-02	160	High
4	GT-03	106	High
5	GT-04	121	Low
6	GT-05	96	Middle

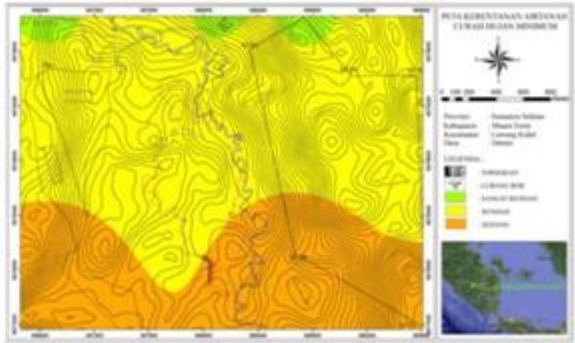

Figure 4. Groundwater Vulnerability on Minimum Rainfall Map

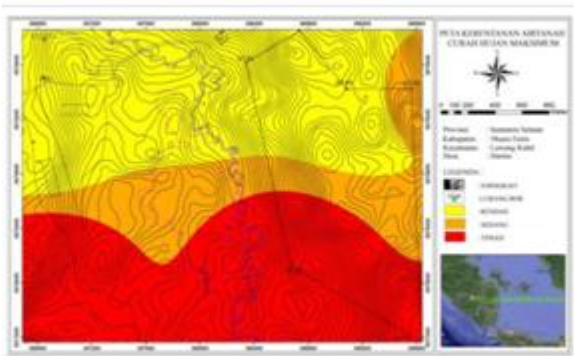

Figure 5. Groundwater Vulnerability on Minimum Rainfall Map

IV. CONCLUSION

1. There is a need for special drilling hole data for this study which covers the area of IUP so that the analysis of this research can cover all mining planning activities.
2. It is better to do an additional study related to groundwater quality and groundwater handling in the mining activity plan at the research site.

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