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HYDROGEOLOGICAL MODELLING OF CONTAMINATED AREA IN TEGAL, INDONESIA

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ABSTRACT

Small and Medium Enterprises metal smelting in Tegal has been existed since more than 50 years ago. This metal smelting process produces heavy metal waste such as zinc, iron, alumunium and cooper which exceed the limit and contaminate the water. These hazardous and toxic wastes are disposed directly into the environment without adequate treatment to remove harmful compunds, thus alleged to have a high level of pollution to groundwater and surface water. The aim of the study is to obtain geological and hydrogeological condition of the study area, so that would be obtained the groundwater impurity pattern in the study area. In addition, this study also aims to determine the quality of groundwater based on physical and chemical characteristics of groundwater, determine the effect on the quality of groundwater contamination, and also to predict the extent to which contaminants have spread. The method used in this study was done by geological mapping, hydrogeological mapping, geoelectricity syrvey and lab test results. The result of the study is to create hydrogeological modelling that could be used to determine the extent of groundwater contaminatino and also to predict how it will affect the pollution in the surrounding area within the next few years.

INTRODUCTION

Pasarean and Lemah Duwur village are located in Adiwema Subdistrict, Tegal District. It is the central of Small and Medium Enterprise metal smelting. All metal smelting activities which have been existed in 50 years thus pollution rate on this area exceed the limit. Based on AMDAL, number of industrialist metal industry in Pasarean Village (2007) was recorded about 300 people. Currently, around 150 people do smelting activities, galvanized, elektroplanting, manufacture of electrical grounding, and other metal processing activities.

Nowadays, the construction industry is growing up rapidly in the world, including in Indonesia, which is a developing country. These developments must be in accordance with sustainable development, which consider the carrying capacity of the existing environment. One of the principle of sustainable development is to implement efficiency and conservation of natural resource, reduce the waste and used energy. Growing industry today can no longer well controlled, on one hand this is a revival of the community's economy, but on the other hand is a lack of attention to environmental concern such as groundwater.

The necessity of clean water increases in accordance with population. Along with the increase of population and industrial activities of households as well, it will also increase the amount of waste. Management of hazardous and toxic waste by throwing directly into environment will provide a high impact for existence of pollution of groundwater and surface water.

In connection with activities of metal smelting industry in Tegal, Central Java, which has resulted in hazardous and toxic wastes, among others, in the form of slag, it needs observation and scrutiny the quality of groundwater which has been a source of public drinking water. The waste is managed in a manner disposed of directly into the environment without hoarding equipped with adequate facilities. The existence of a pile of hazardous and toxic waste had been feared contaminating groundwater and bad for public health in the future. In various news reports, they pointed out there is correlation between the health of the local villagers with the condition of the groundwater used as drinking water.

This study was conducted to determine the condition of the subsurface rock layers associated with the type, depth and thickness and its distribution, especially the aquifer layer thus there will be clear understanding of the areas supported contamination of groundwater flow system. This study also aims to obtain a clear hydrogeological model of the area of contamination and symptoms in the study area.

METHODOLOGY

The research is performed by two steps i.e. mapping, includes geoelectricity survey, geological and hydrogeological mapping , and laboratory analysis. To achieve the purpose of this study, the research carried out field investigations in a form of shallow drilling on several locations, and laboratory analysis to determine the chemical constituents of groundwater. The result will be analyzed using a software called *rockwork* and will be made as hydrogeological modelling.

RESULT AND DISCUSSION

The result of shallow drilling from the surface to a depth of 11 meters in the study area showed stratigraphy, which is the character of rock and soil into aquifer in the study area can be seen.

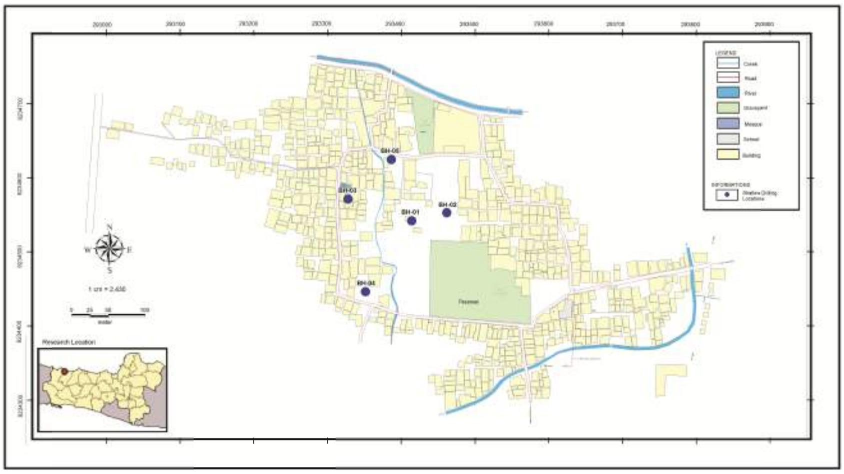

Figure 1.Drilling location map

Table I. Shallow drilling location

Location		
Name	**Easting (m)**	**Northing (m)**
BH-01	293414,02	9234524,58
BH-02	293461,84	9234535,83
BH-03	293327,36	9234553,66
BH-04	293351,73	9234428,44
BH-05	293386,06	9234607,42

Description of the Drilling Result

For the central part of the bore hole 1 (BH-1) with a description at a depth of 0 to 2,5 meters composed of the waste dumps of industrial activities that are gray to black . Depth of 2,5-3 meters in the form of ground coverings, dark brown, containing peat, and fine grained sandstone containing clay that is loose, and the third layer at a depth of 3-5 meters in the form of fine grained sandstone, shaped rounded to subrounded mudstone containing colored brown yellowish.

To the east of that bore hole 2 (BH-02) with a description of the depth of 0,5 meters above the ground cover composed, dark brown, containing peat, depth of 0,5-5 meters composed of yellowish brown mudstone lack the peat, and from a depth of 5-7 meters is fine grained sandstone, rounded shape to subrounded mudstone containing loose colored brown.

To the west is the bore hole 3 (BH-03) with a description at a depth of 0,5 composed of the waste dumps of industrial activities such as metal casting result is gray to black, 0,5 meters thick underneath a ground coverings, dark brown, containing peat, fine-grained sandstone that is loose, and the bottom layer at a depth of 1-4 meters is fine grained sandstone, shaped rounded to subrounded mudstone containing loose colored brown.

To the south is bore hole 4 (BH-04) with a description at a depth of 4 meters above the ground cover composed, dark

brown, containing peat. Below are 2 meters thick brown mudstone containing fine sandstone. And from the depths of 6-11 meters is fine grained sandstone, rounded to subrounded colored shaped cokleat.

To the north is to bore hole 5 (BH-05) is a form of industrial activity waste dump results foundry 1,5 meters thick, at depths below 1,5 to 3 meters a brown mudstone bedding, and the bottom at a depth of 3 to 7 meters is layers of fine sandstone, gray.

Water Contamination

From samples of groundwater and soil from the embankment area of research has been carried out laboratory analysis to determine the content of contaminants contained therein. The result of the laboratory analysis can be seen in the following tables:

Table 2. Result of chemical analysis of soil stockpiles

	Bore Hole					Normal Limits*	
	BH-01	**BH-02**	**BH-03**	**BH-04**	**BH-05**	Category I - II	Category III
Arsen	0.05	1.50	1.93	1.85	0.21	300	30
Barium	479.00	1109.00	90.80	89.40	128.00	-	-
Cadmium	9.34	5.44	4.77	4.58	7.09	50	5
Chromium	155.00	13.70	16.80	11.80	52.70	2500	250
Copper	5323.00	75.80	249.00	83.20	2925.00	1000	100
Cobalt	18.20	19.20	16.60	18.60	21.80	500	50
Lead	14243.00	97.60	496.00	105.00	7843.00	3000	300
Mercury	0.17	0.10	0.15	0.12	0.37	20	2
Molybdenum	1.00	1.00	1.00	1.00	1.00	400	40
Nickel	1336.00	25.80	17.30	15.30	256.00	1000	100
Tin	33.90	30.00	30.00	30.00	3.27	500	50
Salenium	10.00	2.00	2.00	2.00	2.00	100	10
Silver	1.03	10.00	0.25	10.00	1.36	-	-
Zinc	50851.00	695.00	393.00	356.00	29876.00	5000	50
Cyanide	2.00	2.00	2.00	2.00	2.00	500	50
Flouride	18.40	10.00	10.00	10.00	10.00	4500	450

*Kep-04/BAPEDAL/09/1995about the procedure for processing the results stockpiling requirements, processing requirements and the former location of the accumulation of hazards and toxic materials.

Result of soil chemical analysis in Table II and Table III it can be seen that the bore hole-I (BH-01) content of Cu, Pb, Ni and Zn exceeded the threshold limit and has been entered in the normal category I-II and for Cd has exceeded the limit normal category I-III. The content of Cu is worth 5.323 mg/kg, exceeding the normal limit of category I-II of 1000 mg/kg. The content of Pb is content with very high value ie 14.243 mg/kg, the normal limit of 3.000 mg/kg. Nickel content of 1.336 mg/kg, and the content of Zinc is almost 10 times the normal limit, reaching 50.851 mg/kg of normal limit of 5.000 mg/kg. Cadmium content of which exceeds the normal limit of 9,34 mg/kg of normal limit of 5 mg/kg.

To bore hole 2 (BH-02) contains a large concentration of contaminants with zinc values were 695 mg/kg exceeded the limit normal category III. While the value of other elements relative to normal. Bore hole 3 (BH-03) showed the value of copper, lead and zinc are relatively high, exceeding the normal limit of category III.

On bore hole 4 (BH-04) contains a large concentration of contaminants with zinc values were 356 mg/kg. While other elements relative to normal values. While for bore hole 5 (BH-05) showed the value of copper, lead, and zinc were very high, exceeding the normal limits of category I-II. With a copper content of 2.925 mg/kg, lead levels 7.843 mg/kg, and zinc content value of 29.876 mg/kg. Levels of cadmium and nickel are also very high exceeding the normal limits of category I-III with value levels cadmium 7,09mg/kg and nickel 256 mg/kg.

Table 3. Result of chemical analysis of groundwater (BH-2, BH-3, BH-4)

	Bore Hole		
	BH-2	**BH-3**	**BH-4**
Arsen	<0,001	<0,001	<0,001
Mercury	<0,001	<0,001	<0,001
Chromium	<0,05	<0,05	<0,05
Lead	<0,01	<0,01	<0,01
Copper	0,07	<0,03	<0,03
Cadmium	0,01	<0,003	<0,003
Zinc	160	<0,008	<0,008

* PP No. 20/1990 about Water Pollution Control

For the result of the chemical analysis of groundwater samples in Table IV borehole 2 (BH-02), the water sample bore hole 2 (BH-02) shows the content of cadmium and zinc are high. For bore hole 2(BH-02) has had a cadmium content exceeds 0.005 mg / L of 0.01 mg / L, while for the content of zinc is 160 mg / L.

Table 4. Result of chemical analysis of groundwater (BH-2, BH-3, BH-4)

	Bore Hole		
	BH-2	**BH-3**	**BH-4**
Arsen	<0,001	<0,001	<0,001
Mercury	<0,001	<0,001	<0,001
Chromium	<0,05	<0,05	<0,05
Lead	<0,01	<0,01	<0,01
Copper	0,07	<0,03	<0,03
Cadmium	0,01	<0,003	<0,003
Zinc	160	<0,008	<0,008

The result of hydrogeological modelling is shown by two pictures below. It describes such as direction of the contaminant underground water, depth of the contaminant water, and lithological around the aquifer system.

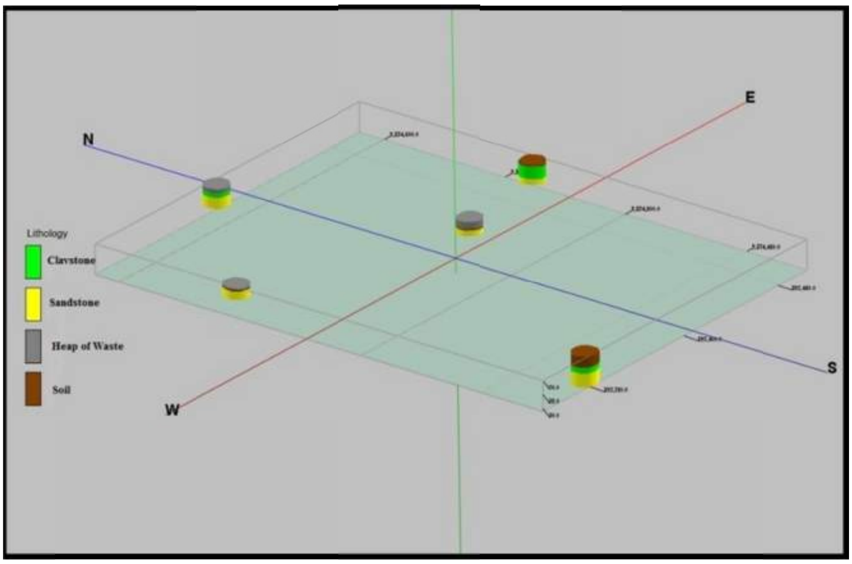

Figure 2.Modelling drill

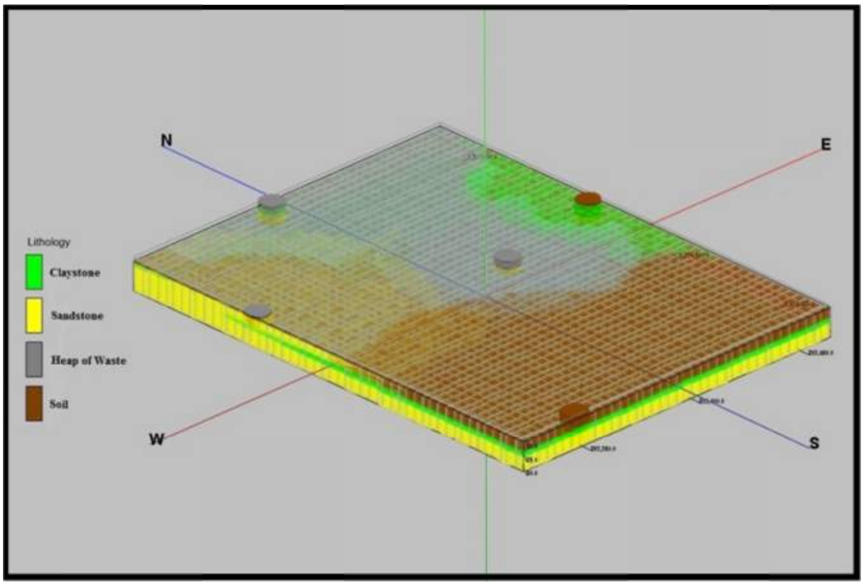

Figure 3. Modelling lithology

Inventing of hydrogeological modelling of contaminated area is intended to obtain information about condition of the study area after the groundwater has been contaminated. It also determine the quality of groundwater that has been contaminated by sewage based on the chemical characteristics of groundwater in the study area.

CONCLUSION

Based on observations of the geological conditions and geoelectric measurements in the field can be summarized as follows:

1. In general, conductivity in these areas have relatively low to medium value. This is due to the geological conditions of the area is dominated by sandstone and alluvium on the bedding top and on the bottom of a relatively well consolidated
2. Waste contaminant found in varying depths. It found on the surface in the form of a heap and below it until it reaches a depth of about 20 m
3. The existence of waste in the survey area can be sustained. It has the distribution pattern of North-South trending
4. Areas of central and western part of the Pasarean village dominate the spread of pollutant waste

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