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Geohydrological Investigation of Garbage Final Disposal Site (Case Study of Tamangapa Antang Site of Makassar, South Sulawesi Province)

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Abstract

Administratively, the study area is included in the Municipality of the District of Manggala Makassar, South Sulawesi Province. Geographically, this area lies in $5^0$10'16,776"-$5^0$11'6,1284" south latitude and $119^0$29'6,128"-$119^0$29'49,1912" East Longitude. Through this research there are several objectives designed to achieved namely to determine the geological and geomorphological conditions of Tamangapa area, the groundwater flow direction, and the impact of pollution caused. To determine the condition of the natural system that is used as the basis for determining the distribution of leachate and distribution of correlation mapping, the geological and hydrogeological.survey was conducted. The survey includes observation of morphological conditions, lithology, geological structure and hydrogeological and geoelectrical survey which include groundwater level measurements, analysis of water samples soil and permeability measurements in the field. Groundwater conditions in the study area does not meet the quality standards and the impact on public health conditions, one of which is diarrhea and itching.

Key words: groundwater, leachate, environment, geohydrology

1. INTRODUCTION

Makassar city has been experiencing rapid development, which is affecting an increasing production of waste in the city. Production of waste in the city of Makassar is continuously increased dramatically.

Makassar government policy for Garbage Final Disposal method is termed as Controlled Landfill Land (Controlled Landfill). The Principles of Controlled Landfill Land processing method is garbage that has piled up is covered periodically with a layer of soil and then the trash is levelled and compacted.

Effective use of such methods should consider the physical condition of the landfill, waste types and characteristics, funding capabilities and supporting infrastructure. Without considering these aspects will lead to pollution of the surrounding environment, such as the formation of leachate seepage can contaminate the surface water and shallow ground water, and air pollution, as well as land pollution. The indications are more emphasized from the previous study conducted at the Tamangapa garbage disposal

site by [1] who concluded that the seepage of leachate out of the landfill waste that pollutes the groove forming a flow that pollute the surface water and shallow groundwater around the landfill.
The process produces a landfill leachate (leachate) that seeps into the ground or flows on the surface of the ground. Leachate is formed through the transfer of waste material is buried in the soil by ground water, storm water and wastewater disposal through this pile of garbage. The liquid are toxic and can contaminate ground water. Generally a leachate could have COD, high BOD, TDS, TOC, salt compounds such as chlorides, nitrogen compounds and various heavy metals, [2].
Correspondingly, a research conducted by [1] showed that some wells around the garbage disposal site of Makassar city produces bad smells. [1] further concluded that the well water quality conditions around the garbage disposal site of Makassar relatively is smelly and discolored especially wells within approximately 100 meters of the landfill sites. Considering the type of waste and groundwater quality in the city of Makassar, the researchers therefore initiated a research titled "Overview of geohydrology of Waste Disposal Site (Waste Landfill Case Study of Antang), District of Manggala, Makassar, South Sulawesi.

2. PURPOSE AND OBJECTIVES

Investigating the direction of flow and rate of shallow groundwater contamination caused by seepage of garbage disposal site of Tamangapa, Antang. Investigating the impact of water pollution on public health conditions in the study area.

3. RESEARCH METHODOLOGY

To resolve the direction of movement of leachate in the groundwater at the garbage disposal site of Antang Makassar, the results of this analysis are distinguished based on the objectives to be achieved in this study, namely:
Spatial analysis to determine the distribution and aquifer layer thickness as well as the controlling factor on modeling groundwater flow and leachate movement in the study area by means of:

a) Data Inventory of wells in the study area included the location, depth, water table, and lithological composition.
b) Making Maps of the correlation between wells in the garbage disposal site of Antang.
c) Making a geological cross section of the northwest direction - southeast based on the data of geoelectrical analisis and core analysis to determine the condition of the subsurface area the research area.
d) Determination of geohydrological and hydrological parameters to map the groundwater flow and contaminant movement.

4. RESULTS AND DISCUSSION

4.1 Local Geological Condition of Antang, Makassar

Antang garbage disposal site is located on the slopes of the slightly flat terrain hills of Tamangapa southern valleys flanked by two north-south trending ranges. The elevation ranges of height of 16 m to 20 m above sea level with a natural slope between 15% to 25% and were regionally toward the east.
Morphographic approach is carried out through direct observation in the field and the area has a flat topography appearance. Based on the results of data processing and morphometric characteristics and a description of this area, the relief in the form of plain, (photos 1).
Based on the morphometry approach, topography of the study area has a unit slope ranging from 0% to 2%, with the percentage of the slope angle of about 0^0-2^0. So this area include a flat terrain, [3].

Photo 1. Shows a sloping plain on the morphology of the landfill waste Antang.

Stratigraphy of the study area, which is reflected in the geological map of the study (Photos. 2B). comprise of coarse tuff lithology encountered with fresh appearance showing brownish gray, weathered of gray color, texture of pyroclastic, is silica, grain size of coarse ash, open texture, poorly sorted, structurally layered (N48^{o}E / 10^o) , mineral composition of biotite. Based on the classification of volcanic rocks, these rocks are classified into coarse tuff.
The results of petrographic analysis of thin section of coarse tuff (Foto.2A), generally the coarse tuff has a brownish yellow color absorption, interference color blackish gray, pyroclastic texture, form of sub-angular grains - sub-rounded, grain size <0.01 to 2.1 mm. The composition type of material composed of andesine plagioclase (0-6%), pyroxene types is augite 0-12%, opaque minerals (0-5%) and volcanic glass (0-80%). Based on the classification of pyroclastic rocks, the rock is named "Vitric Tuff" , [4]

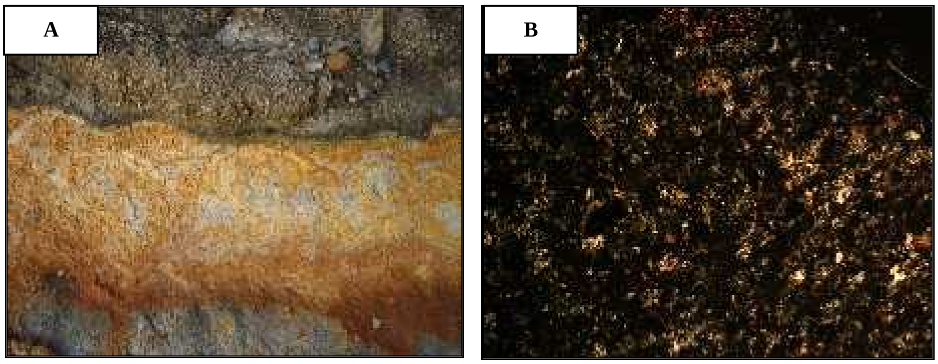

Photo 2. Shows a rough tufa rock as the bedrock landfill waste Antang (A), and the appearance of coarse tuff incision micrograph (B).

4.2. Geohydrological Condition of The Research Area

Geohydrologic conditions Antang landfill area is included in the free aquifer or aquifer system of not depressed. Aquifers are not depressed are at a depth of ± 30 meters and composed of volcanic breccia unit along with its weathering characteristics that have permeability (K) of 9.5 x 10-4 to 1.5 x 10-4 cm / s. The spread of the aquifer covers the entire area of research and ground water level varies from -3.8 to -10 meters below ground level. The depth of ground water also depends on the local topography with

seasonal fluctuations ranging between 1-2 meters in accordance with the landscape topography, there is a two-way flow of free land that is to the southeast and western slope hydrology power by more than 2%. Judging from its regional conditions, groundwater flow at this location is part of the flow system that accumulates in Makassar basin, which is used as a source of drinking water.
Infiltration at this location has a value of permeability (k) of 10-3 to 10-4. Complete data on the lithology of Tamangapa Antang, are shown in Table 1.

Table 1 Description of Rocks and Permeability Field

Depth	**Lithology**	**Permeability (cm/s)**
0 – 0,3	Overburden	-
0,3 – 7,5	Clay	$9,5 \times 10^{-4}$
8,5 – 22	Volcanic Breccia and Andesite Boulder	$5,81 \times 10^{-4}$ s/d $3,2 \times 10^{-4}$
22 – 27,5	Sandstone and Silt Intercalation	$2,4 \times 10^{-5}$
27,5 – 30	Volcanic Breccia	$1,6 \times 10^{-5}$

Source: Office of Mines and Energy of South Sulawesi 2008.

4.3 Groundwater flow direction (Shallow Groundwater)

Basically it is the nature of water to flow from a high place to a lower place because of the gravitation. Therefore elevation and lithology and position of the research area strongly influence the direction of groundwater flow. In the study area the bearing of rock layer is (N48^{o}E / 10^o).
In the cross-section profile of A1 - A2 (V: H = 10: 1) passing through site no 10, 8, and 9, where the depth of the site 10 ± 10 M with elevation of 5.67 meters above sea level, correlated with site No.8 with a depth of ± 10 M, the elevation is 4.25 meters above sea level elevation, and station No. 9 with a depth of ± 18M, the elevation is 8,39 m above the sea level. We can see the direction of water flow relatively to the East heading towards Station No. 9.

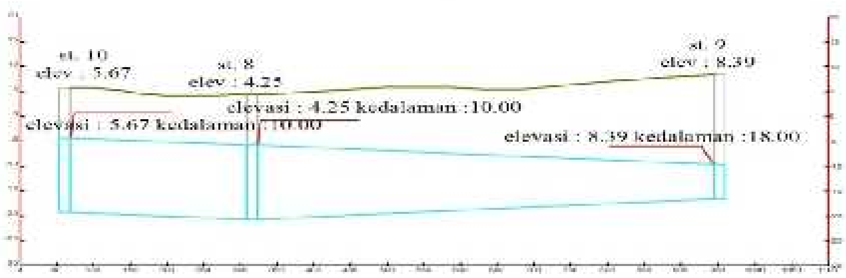

Fig 1. Cross-section A1 - A2 (V: H = 10: 1)

In cross-section profile of B1-B2 (V: H = 10: 1) passing through site stations No.10, 7, and 11, site No.10 stations where the depth is ± 10 M with elevation of 5.67 meters above sea level, correlated with station No. 7 with a depth of ± 8 M , elevation of 14.30 meters above sea level, and station No.11 at a depth of ± 12M, elevation 15.80 above sea level.

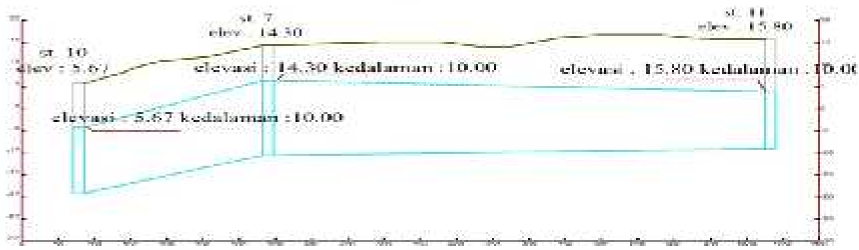

Fig 2. Cross-section B1 - B2 (V: H = 10: 1)

We can see there are two properties of water that is always due to the lowest point and is supported by the position of the rock so that the water flow direction leads towards relatively Southwestern (from station No.7 to No. 10) and relatively towards Northeast (from station No.7 to station No.11) .

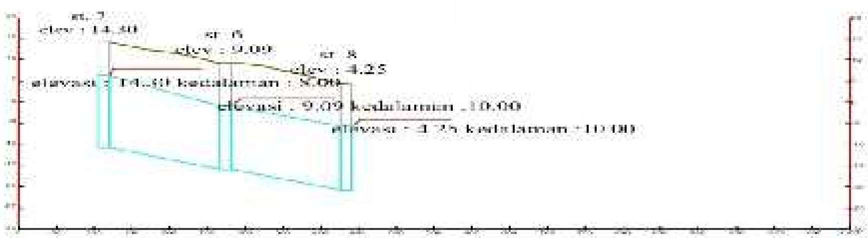

Fig 3. Cross-section C1 - C2 (V: H = 10: 1)

In cross-section profile of C1 - C2 (V: H = 10: 1) passing through the station No.7, 6, and 8. Station No.7 has a the depth of ± 8 M with 14:30 above sea level, correlated with station No.6 with a depth of ± 10 M, elevation 9.09 meters above sea level, and station No.8 with a depth of ± 10 M, 4.25 meters above sea level elevation. We can observe that the direction of the water flow towards relatively to South-Southeast heading to station No.8.

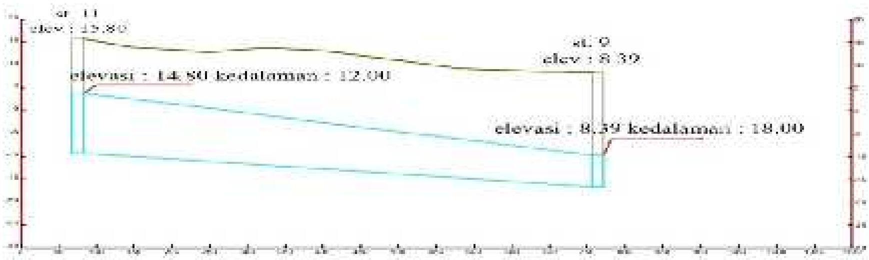

Fig 4. Cross-section D1 - D2 (V: H = 10: 1)

In cross-section profile of D1 - D2 V: H = 10: 1) passing through the station No.11, and 9, where the depth of the station No.11 is ± 12 M with elevation of 15.80 meters above sea level, station 9 is correlated with the depth of ± 18M and elevation of 8.39 meters above sea level. We can see the direction of the flow of water relatively to the Southeast towards station No.9.

Figure 1. Groundwater flow maps of Antang GFD

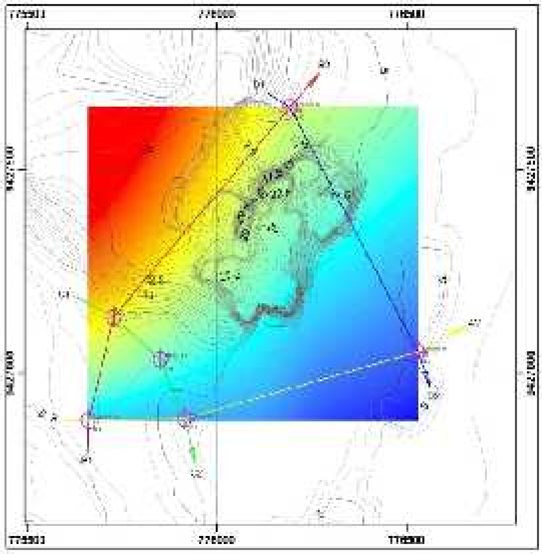

Figure 2. Shallow Groundwater Correlation Map

4.4 Groundwater Quality

At the Antang GFD area, data was collected to measure the quality of shallow groundwater, leachate based movement direction follows the direction of the position of rocks, geomorphology, and topography. The laboratory tests were conducted at the Center of Environmental Health Engineering Makassar Class I include: pH, BOD, COD, Nitrate and Sulfate.
Shallow groundwater wells in the vicinity of Antang, GDS mostly have experienced contamination by the contents of various elements and compounds, (see Table. 2).

Table 2. Results of Chemical Analysis of Shallow Well Water Samples

Station	Well Depth	pH	BOD	COD	Nitrate	Sulphate
6	10	5.33	9.26	11.224	9,091	8,584
7	8	4.99	1.52	2.48	14,310	13,689
8	10	6.3	2.78	3.07	2,193	7,289
9	18	5.82	6.19	25.233	8,387	22,599
10	10	5.65	5,32	20,435	1,948	9,628
11	12	6.31	2.07	4.163	15,795	8,581

Shallow Groundwater Quality Analysis of each station.

4.5 Shallow groundwater quality analysis for each station

4.5.1 Shallow groundwater wells (Station No. 6)

At station No.6 well is ± 10 m depth, water pH is 5.33 where the maximum limit of 6.5 to 9.0 when compared with the content of the well water ph at station 6 is still below the allowed water quality standards. The BOD content of 9.26 mg /l, COD of 11,224 mg /l, Nitrate of 9,091 mg /l and sulfate of 8,584 mg /l which content follow the pattern of groundwater flow direction of the slope of the bedding of coarse tuff bedrock. General direction of the slope of the rock layers are ($N48^0E$ / 10^0), which is trending towards northwest-southeast.

From the results of the laboratory analysis it can be concluded that the shallow well water located at station No.6, considered to be unfit to drink, because the pH of the water is below the allowed water quality standards.

Similarly, BOD, COD and elements of Nitrate (NO3) and sulfate (SO4) are still present in the groundwater at station No.6, can be categorized as water unfit for consumption and can affect health.

4.5.2 Shallow groundwater wells (Station No.7)

At station No.7 the well is ± 8 m depth, water pH of 4.99 where the maximum limit of 6.5 to 9.0 when compared with the content of the well water ph at station No.7 is still below the allowed water quality standards. The BOD content of 1.52 mg /l, 2.48 mg of COD /l, Nitrate of 14,310 mg /l and sulfate of 13,689 mg /l which the existence follow the pattern of groundwater flow direction of the slope of the bedding of coarse tuff bedrock. General direction of the slope of the rock layers are ($N48^0E$ / 10^0), which is trending northwest-southeast.

From the results of the laboratory analysis it can be concluded that the shallow well water located at station No.7, considered unfit to drink, because the pH of the water is below the allowed water quality standards.

Similarly, BOD, COD and elements of Nitrate (NO3) is quite high and Sulfate (SO4) is still present in the ground water at station No.7, can be categorized as water unfit for consumption and can affect health.

4.5.3 Shallow groundwater wells (Station No.8)

At station No.8 the well is ± 10 m depth, water pH of 6.3 where the maximum limit of 6.5 to 9.0 when compared with the content of the well water ph at station No.8 is still below the allowed water quality standards. The BOD content of 2.78 mg /l, COD of 3,070 mg /l, Nitrate of 2,193 mg /l and sulfate of 7,289 mg/l which the occurrence follows the pattern of groundwater flow direction of the slope of the bedding of coarse tuff bedrock. General direction of the slope of the rock layers are ($N48^0E$ / 10^0), which is trending northwest-southeast..

From the results of the laboratory analysis it can be concluded that the well water shallow located at station No.8, considered unfit to drink, because the pH of the water is below the allowed water quality standards.

Similarly, BOD, COD and elements of Nitrate (NO3) is quite high and Sulfate (SO4) is still present in the ground water at station No.8, can be categorized as water unfit for consumption and can affect health.

4.5.4 Shallow groundwater wells (Station No. 9)

At station No.9 the well is ± 18 m depth, water of pH of 5.82 where the maximum limit of 6.5 to 9.0 when compared with the content of the well water ph at station 9 is still below the allowed water quality standards. The BOD content of 6.19 mg/l, COD of 25,233 mg/l, Nitrate of 8,387 mg/l and sulfate of 22,599 mg/l which the occurrence follows the pattern of groundwater flow direction of the slope of the bedding of coarse tuff bedrock. General direction of the slope of the rock layers are ($N48^0E$ / 10^0), which is trending northwest-southeast.

From the results of the laboratory analysis it can be concluded that the well water shallow located at station No.9, considered unfit to drink, because the pH of the water is below the water quality standards are allowed.
Similarly, BOD, COD and elements of Nitrate (NO3) is quite high and Sulfate (SO4) is still present in the ground water at station No.9, can be categorized as water unfit for consumption and can affect health.

4.5.5 Shallow groundwater wells (Station No.10)

At station No.10 the well is ± 10 m depth, water pH of 5.65 where the maximum limit of 6.5 to 9.0 when compared with the content of the well water ph at station 10 is still below the allowed water quality standards. The BOD content of 5.32 mg/l, COD of 20,435 mg/l, Nitrate of 1,948 mg/l and sulfate of 9.628 mg/l which the occurrence follow the pattern of groundwater flow direction of the slope of the bedding of coarse tuff bedrock. General direction of the slope of the rock layers are ($N48^0E$ / 10^0), which is trending northwest-southeast.
From the results of the laboratory analysis it can be concluded that the well water shallow located at station N0. 10, considered unfit to drink, because the pH of the water is below the water quality standards are allowed.
Similarly, BOD, COD and elements of Nitrate (NO3) is quite high and Sulfate (SO4) is still present in the ground water at station No.10, can be categorized as water unfit for consumption and can affect health.

4.6 Groundwater Pollution Impact against Public Health in Nearby Antang Garbage Disposal Site.

Antang garbage disposal site is a catchment area (recharge) which is based on the geohydrological condition. Through this, leachate emanating from the garbage can flow directly into groundwater system through bedrock layer of the garbage disposal site area. From the description above, and based on the results of chemical analysis of water samples (see Table 2), it can be concluded that the groundwater conditions in the study area does not meet the environmental quality standards. The real health impact is felt by the people in the vicinity of the garbage disposal site, in the form of diarrhea and itching.

CONCLUSION

The existence of some chemical elements carried along with the leachate from the Antang garbage disposal site has caused shallow groundwater (wells) pollution. This pollution is due to the direction of groundwater flow with a slope of rock strata with relatively high permeability.
Contaminants have polluted people's wells and caused the ground water in the area of Antang garbage disposal site does not meet the allowed water quality standards to be consumed.

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MAP ANNEX

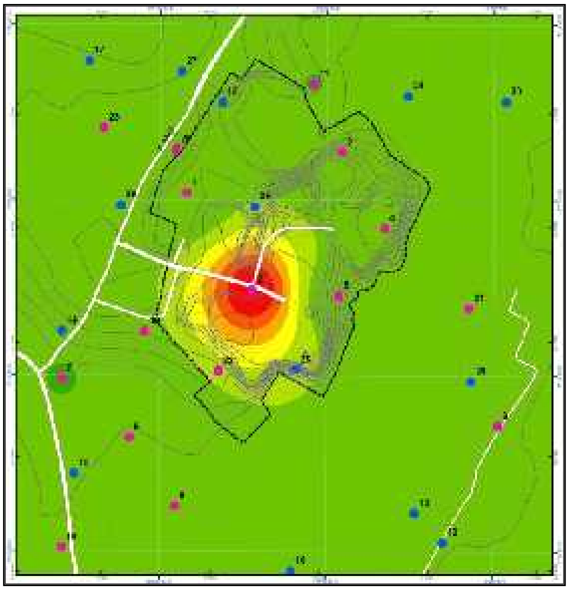

Figure 3. **BOD** Distribution Map

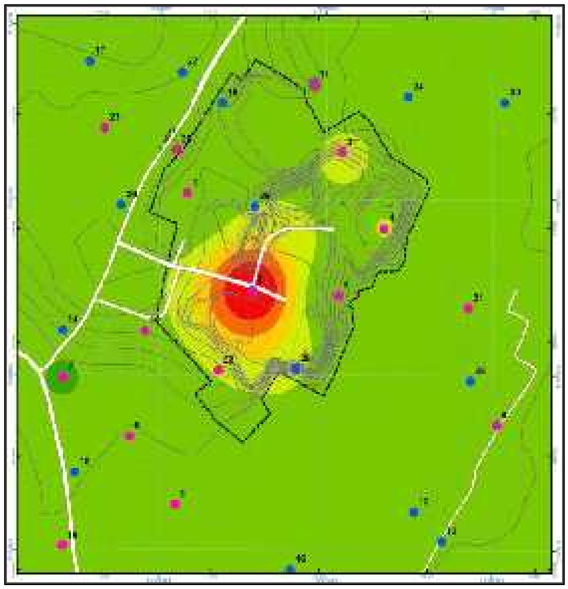

Figure 4. **COD** Distribution Map

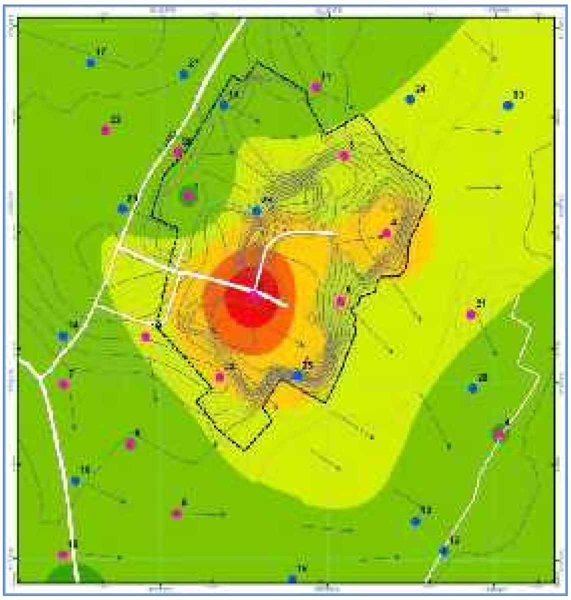

Figure 4. **Nitrate** Distribution Map

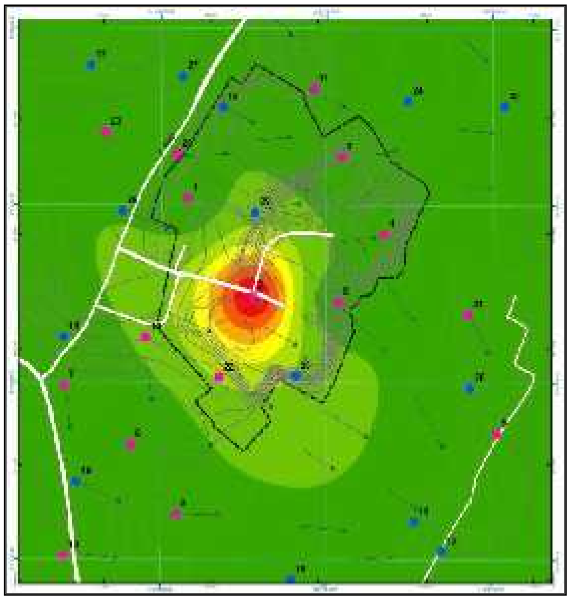

Figure 5. **Sulphate** Distribution Map