RESEARCH ARTICLE OPEN ACCESS

Models of Leachate Movement to Ground Water System in Tamangapa Antang Landfill Makassar South Sulawesi Province

M. Fauzi Arifin[1], A.M. Imran[2], Muhammad Ramli[3], Mukhsan Putra Hatta[4]
[1](Doctoral Program of Civil Engineering, Faculty of Engineering, University of Hasanuddin. Email: inji.arifin@gmail.com)
[2](Department of Geological Engineering, Faculty of Engineering, University of Hasanuddin. Email: mudimran@yahoo.com)
[3](Department of Geological Engineering, Faculty of Engineering, University of Hasanuddin. Email: ramli@unhas.ac.id)
[4](Department of Civil Engineering, Faculty of Engineering, University of Hasanuddin. Email: mukhsan_hatta@yahoo.ac.id)

ABSTRACT
The landfill site Tamangapa Antang Makassar is the only one still in operation. Open dumping system is used in the early operation at waste management, but gradually this system is not used anymore. Volume of waste in the landfill until 2010 is predicted to be 9.582 m3/day. Such condition into environmental issues that must be considered from now on. Through this research there are several objectives that determine the geological and hydrogeological conditions Tamangapa area, groundwater flow patterns, analyze the direction of the distribution of leachate and effects on ground water systems in landfill sites Tamangapa, Antang. Geoelectric method used is the Wenner and Schlumberger configuration. Geoelectric analysis is based on the results of measurements and calculations using software RES2DINV 5:54, and combined with geological data in the form of direct observation in the field and leachate chemical analysis data. Several methods can be used to interpolate such as Trend, Spline, Inverse Distance Weighted (IDW) and Kriging. From the analysis of ground water flow is known that groundwater moving from the northwest to southeast direction and movement of leachate follow the direction of ground water flow.

Keywords - environment, geophysics, ground water, leachate.

I. INTRODUCTION

One important aspect in the management of municipal solid waste is a problem that if the leachate is not good management will lead to a serious threat to the environment, because the production of leachate will flow into the ground water and surface water as well. Leachate is the liquid flowing or 'soluble' from landfill, the composition of which varies depending on the age and type of landfill waste contained therein. This leachate usually contains bacteria and bacterial soluble or insoluble [1].

Landfill site Tamangapa Antang has area of approximately 10 hectares, which have been used since 1995 and actually designed to their needs during 10 years, but the fact that up to this moment this landfill site is still used, which means that almost 20 years old years. By looking at this fact can be assumed that this site has been environmental pollution that can cause effect on environmental sanitation in this area [2].

Pollution of shallow groundwater caused by the permeation of liquid waste from landfill, and can also contaminate wells surrounding population. This pollution has been felt by people around the landfill, especially for those who take advantage of the free groundwater as a source of clean water. Besides pollution of groundwater is also polluted the air with a pungent odor [3].

The large volume of waste in the landfill Antang in 1999 as much as 3.352,1 m3/day, while for 2001 the amount of garbage increased to 3.900 m3/day and in 2014 is predicted to be 13.640 m3/day. The total volume of waste will pollute the environment mainly on groundwater around the landfill. Such conditions into environmental issues that must be considered from now on [2].

II. RESEARCH PURPOSES

Consider the background and the formulation of the problems outlined above, the purpose of research are:

1. Knowing the Tamangapa Antang landfill local geological conditions.
2. Analyzing the distribution direction of leachate and its influence on groundwater systems in Tamangapa Antang landfill.
3. Modeling leachate movement against groundwater system Tamangapa Antang landfill.

III. RESEARCH METHOD

Method in research "Models of Leachate Movement to Ground Water System in Tamangapa Antang Landfill Makassar South Sulawesi Province" which were observed in the field as observe controlling factors and triggering factors. Controller factors are geology, structure, topography. Geoelectric data taken in the field as many as 4 point by using resistivimeter to know the shallow ground water position and lithology constituent research area. Observations and data retrieval of geoelectric data obtained in the field are collected as primary data to be processed in the form of reports on the results.

The methods of data collection are surface data retrieval and geoelectric data retrieval.

3.1 SURFACE DATA RETRIEVAL

Surface data retrieval research areas such as geological data such as descriptions of geomorphology, structure and lithology constituent research areas. Geomorphological observations focused on the shape of the topography and measuring the area of research.

3.2 GEOELECTRICAL DATA RETRIEVAL

Geoelectric data collection is done on 4 tracks measurements with each stretch along 150 meters. Each electrode spacing of 10 meters to know in detail the composition of material in areas of research that exist below the surface to see the value of resistivity of the resulting tool resistivitimeter. Resistivitimeter tool used is a multichannel use GeoRes software v3.1 b14 (Geo Restivity) and then analyzed using software RES2DINV. Examples of resistivity data retrieval using Geores software v3.1 b14 (Geo Restivity) are connected by means of a multichannel resistivitimeter in the research area.

3.3 DATA ANALYSIS

Data analysis stage is performed after the surface and geoelectric data retrieval, which include surface data analysis, groundwater chemical data analysis and geoelectric data analysis.

4.3.1 SURFACE DATA ANALYSIS

Surface data retrieval research areas such as geological data descriptions of geomorphology, structure and lithology constituent research areas. Geomorphological observations focused on the shape of the topography and measuring the area of research.

4.3.2 GROUNDWATER CHEMICAL DATA ANALYSIS

Data taken from leachate water in the landfill site Tamangapa Antang, acquired dominant compound in the leachate are nitrate (NO3 -N), sulfate (SO 4) BOD and COD. Qualitative data was analyzed by descriptive to provide a holistic picture of the state of the landfill.

4.3.3 GEOELECRICAL DATA ANALYSIS

The geoelectric data have been obtained in further processed accordance with the type of data. There are several methods that can be used to interpolate such as Trend, Spline, Inverse Distance Weighted (IDW) and Kriging. Each of these methods will yield results different interpolation. This post focuses the search observation point value of outcome models using IDW method and the results were again mapped using GIS. IDW is a simple deterministic method taking into account the surrounding point. Assumption of this method is the interpolation value to be more similar to the sample data that is closer than further away. Weights (weight) will change linearly according to the distance to sample data. This weighting will not be affected by the location of the data sample [4].

IV. RESULT AND DISCUSSION

4.1 REGIONAL GEOLOGY CONDITION

Geomorphology of research areas based morphometric approach, the research unit of the topography of the area has a slope ranging from 2%

to 7%, with the percentage of the slope angle of about 2°-4°. (Figure 1), so this area including wavy topography unit/sloping ramps [5].

Figure 1. Morphology of landfill sites Tamangapa

Stratigraphy research areas, which is reflected from the geological map of the study area consists of oldest to youngest can be divided into 3 units lithology includes in Tertiary lithology, the unit tuff, volcanic breccia and alluvial. Stratigraphy research area lithology encountered coarse tuff with fresh appearance showing brownish gray, weathered gray, pyroclastic texture, is silica (not reacting with HCl), the size of grains coarse ash, loose fabric, sorting bad, layered structure (N 42° E/12°), the mineral composition of biotite. The results of petrographic analysis of coarse tuff thin section (Figure 2) shows brownish yellow color, pyroclastic texture, mineral size (0.25 mm to 4 mm), shape angular - rounded, composed of mineral piroxene types augit (5%), mineral biotite (5-10%), quartz (10-15%), mineral plagioclase types andesin (5%), rock fragments (10%), volcanic glass (50-60%) and opaque minerals (5%). The name of rock 'Vitric Tuff'[6].

Figure 2. Outcrop view of coarse-grained tuff with colour light grey to yellow (left) and microFiguregraph view showing the mineral constituent (right).

The geological structure found in the area of research that is joint. Determination of the type of joint in the research area is determined by its shape. Based on joint irregular shape arrangement, is non-systematic joint (Figure 3).

Figure 3. Outcrop view of non-systematic joint on coarse tuff.

4.2 RESULT OF CHEMICAL GROUNDWATER ANALYSIS

Based on the results of laboratory analysis of data taken from the leachate in the area of Tamangapa Antang, acquired dominant compounds in the leachate are nitrate (NO3-N), BOD, COD, and sulfate (SO4). These compounds accumulate maximum at station 2 (Table.1).

Table 1. Results of Laboratory Analysis

RESEARCH RESULT					
Station	**Nitrate (NO3-N) (mg/l)**	**BOD (mg/l)**	**COD (mg/l)**	**Sulfate (SO4) (mg/l)**	**Water Source**
1	3.1	58	78.31	56.243	Leachate water
2	638.8	729	1.277,200	3,438. 10	
3	130.2	165	456	45.23	
4	251.9	126	403.495	57.41	
5	152.1	88	133.926	49.57	
6	9.091	9.26	11.224	8.58	Well water
7	14.31	1.52	2.48	13.69	
8	2.193	2.78	3.07	7.29	
9	8.387	6.19	25.233	22.60	
10	1,948	5,32	20,435	9,629	
11	15.795	2.07	4.163	8.58	

Source: Field Data 2014 and Analysis Results from Environmental Health Technical Center for Disease Control Class I Makassar

4.2.1 GROUNDWATER POLLUTION

The high levels of pollution in the study area due to the many existing waste disposal in landfill Tamangapa Antang. In this study, leachate as the main variables of this research were taken at an elevation of 8-16 meters above sea level. While on

well water as the independent variable in this study was taken at the station 6 at a depth of ± 10 m, at station 7 at a depth of ± 8 m, at station 8 at a depth of ± 10 m, at station 9 at a depth of ± 18 m, at station 10 at a depth of ± 10 m, at station 11 at a depth of ± 12 m.

4.2.1.1 POLLUTION ELEMENT NITRATE (NO3-N)

In the analysis of leachate samples were carried out at the station obtained the highest yield 1-5 there in station 2 with a value of 638.8 mg/l and the lowest is in station 1 with a value of 3.1 mg/l.

In the analysis of well water samples were carried out at station 6-11 obtained the highest yield is on station 11 with a value of 15.795 mg/l and the lowest is in station 10 with a value of 1.948 mg/l.

Accumulation of leachate water containing pollutant elements in the form of nitrate (NO3-N) in the study area is at station 2 and 4 are the areas with the scale of impact was high - with a value of 200 to 638.8 mg/l. This station is the peak area/dangerous zone where the most accumulated garbage found in the study area. While on station 1 is an area that is included in the scale the lowest impact to the value 1.953963161 to 10 mg/l of this area is a safe area.

Water wells were found in several stations 6, 7, 8, 9, 10 and 11 are still in the safe zone because it is below the threshold by decree of the Minister of Health Regulation. No. 416/Men. Kes/Per/IX/1990 where the exposure limit is 10 mg/l.

Nitrates in the direction of deployment of existing leachate location relative direction of research is the Northeast this case corresponds to the strike/bedding rock stance, namely Tuff. Pollution that occurred in the study area approximately 500 m from the outer limits of the landfill that has been determined by the government.

4.2.1.2 POLLUTION ELEMENT SULFATE (SO 4)

In the analysis of leachate samples were carried out at the station obtained the highest yield 1-5 there in station 2 with a value of 3438.1 mg/l and the lowest is in station 3 with a value of 45.228 mg/l.

In the analysis of well water samples were carried out at the station obtained the highest yield 6-11 there at station 9 with a value of 22.6 mg/l and is lowest at station 8 with a value of 7.29 mg/l.

Accumulation of leachate water containing pollutant elements in the form of sulfate (SO4) the study area is at station 2 is the area with high impact scale with values from 3000 to 3438.063 mg/l. This station is the peak area/dangerous zone where the most accumulated garbage found in the study area. While on station 6, 8, 10, and 11 is an area that is included in the scale the lowest impact to the value 7.295446396 to 400 mg/l. This area is a safe area.

Water wells were found in several stations 6, 7, 8, 9, 10, and 11 are still in the safe zone because it is below the threshold by decree of the Minister of Health Regulation. No. 416/Men. Kes/Per/IX/1990 where the exposure limits is <400 mg/l.

Direction of the spread of sulfate in the water leachate that is the location of research is relative towards the Southeast, it is in conformity with bedding rock slope direction, namely Tuff. Pollution that occurred in the study area about 50 m from the outer limits of the landfill that has been determined by the government.

4.2.1.3 POLLUTION ELEMENT BIOLOGICAL OXYGEN DEMAND (BOD)

In the analysis of leachate samples were carried out at the station obtained the highest yield 1-5 there in station 2 with a value of 729 mg/l and the lowest is in station 1 with a value of 58 mg/l.

In the analysis of well water samples were carried out at the station obtained the highest yield 6-11 there at station 6 with a value of 9.26 mg/l and the lowest is in station 7 with a value of 1.52 mg/l.

Accumulation of leachate water containing pollutant elements such as Biological Oxygen Demand (BOD) in the study area is at station 2 is the area with high impact scale with values from 600 to 728.993042 mg/l This station is the peak area/dangerous zone where the most widely encountered waste in the study area. While on station 7, 8, 10 and 11 is an area that is included in the scale with the lowest impact value 1.520625949 to 6 mg/l. This area is a safe area.

Water wells were found in several stations 7, 8, 10 and 11 are still in the safe zone because it is below the threshold by decree of the Minister of Health Regulation. No. 416/Men. Kes/Per/IX/1990 where the exposure limit is 1.52062 to 6 mg/l.

Direction of the spread of leachate BOD on existing research location is relative towards the Southeast, it is in conformity with bedding rock slope direction, namely Tuff. BOD occurrences in the region Tamangapa Antang contaminate approximately 1.5 km radius of the outer limits of the landfill that has been determined by the government.

4.2.1.4 Pollution element of Chemical Oxygen Demand (COD)

In the analysis of leachate samples were carried out at the station obtained the highest yield 1-5 there in station 2 with a value of 1277.2 mg/l and the lowest is in station 1 with a value of 78.31 mg/l.

In the analysis of leachate samples were carried out at the station obtained the highest yield 6-11 there at station 9 with a value of 25.233 mg/l and the lowest is in station 7 with a value of 2.48 mg/l.

Accumulation of leachate water containing pollutant elements such as Chemical Oxygen Demand (COD) in the study area is at station 2-4 is a region with medium-high impact scale with values from 1277.18811 to 400 mg/l. This station is the peak area/dangerous zone where the most accumulated garbage found in the study area. While on station 7, 8 and 11 is an area that is included in the scale the lowest impact to the value of 2.481146097 to 12 mg/l. This area is a safe area.

Water wells were found in several stations 7, 8 and 11 are still in the safe zone because it is below the threshold by decree of the Minister of Health Regulation. No. 416/Men. Kes/Per/IX/1990 where the exposure limit is 2.481146097 to 12 mg / l.

COD pollution level higher than the level of BOD pollution. This is because in Tamangapa, non-organic waste volume greater occurrences than the volume of organic waste. So as to affect the chemical elements dissolved bigger.

The direction of deployment of COD in leachate existing research location is relative towards Northeast and Southeast it is in conformity with the directions stance/strike and dip of rock bedding, namely Tufa. BOD occurrences in the region Tamangapa Antang contaminate approximately 1.5 km radius of the outer limits of the landfill that has been determined by the government.

4.3 Geoelectric Measurement Results

Geoelectric measurements were performed by using a multichannel geoelectric resistivity method Wenner configuration obtained four (4) track. Each measurement geoelectric long stretch of 150 m with 10 m spaced electrodes. Tracks 1 consists of 2 (two) line with the direction of the trajectory of South Southwest – North Northeast. Tracks 2 consists of three (3) line with the direction of the trajectory West Northwest - East Southeast. Tracks 3 consists of 3 (three) line with the direction of the trajectory West Northwest - East Southeast. Tracks 4 consists of 2 (two) line with the direction of the trajectory of South Southwest – North Northeast.

4.3.1 Tracks 1

Measurement of track 1 is located on the axis road Antang with coordinates 5°17’54,23” - 5°17’45,19” S, 119°48’82,06” - 119°48’86,09” E with direction South Southwest to North Northeast (Fig. 4).

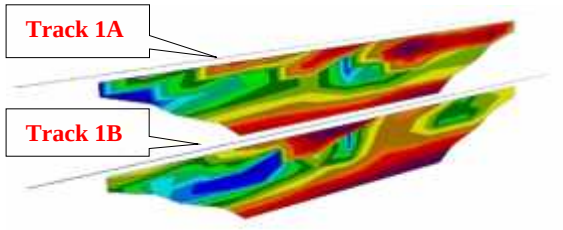


Figure 4. Geoelectric Inversion Section of resistivity line 1A and 1B

Based on rock resistivity value which is then adjusted to the lithology encountered on the location of the research, the study of rock making up the location is Tuff. Track 1A of the data can be interpreted position of the accumulation of water that has been contaminated is at a depth of 18.5 to 2.5 meters with resistivity values 0.348 Ω.m up to 1.62 Ω.m. While on the track 1B can be interpreted position accumulated contaminated water is at a depth of 2.5 meters to 14 meters and resistivity values up from 0,145 Ω.m to 1.34 Ω.m [7].

4.3.2 Tracks 2

Track 2 measurement located at a village on North of landfill Antang with coordinates of 5°17’22,25” - 5°17'30,63” S, 119°49’01,43” - 119°49’16,80” E with direction West Southwest to East (Fig. 5).

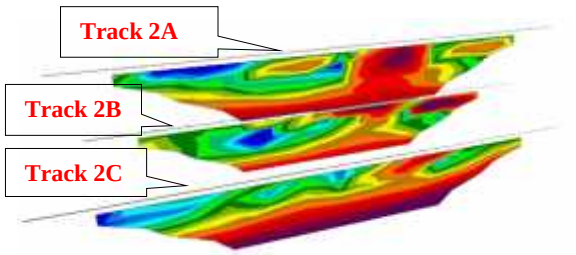


Figure 5. Geoelectric Inversion Section of resistivity line 2A, 2B and 2C

Based rock resistivity value which is then adjusted to the lithology encountered on the track 2 can be concluded that the lithology of research area constituent of Tuff.

From the data obtained on the track 2A can be interpreted position of the accumulation of water that has been contaminated is at a depth of 5.5 m to 22 m with resistivity values of 1.22 Ω.m to 4.37 Ω.m. Track 2B can be interpreted position of the accumulation of water that has been contaminated is at a depth of 7.5 m to 18.5 m and 12.8 m to 24.9 m with resistivity values 0.717 Ω.m up to 3.78 Ω.m, and on track 2C can be interpreted position of the accumulation of water that has been contaminated is at a depth of 2.5 m to 9 m and 7.5 m to 24.5 m with resistivity values 0.609 Ω.m up to 2.49 Ω.m [7].

4.3.3 TRACKS 3

Track 3 measurement located at a residential on Southwest of the landfill with the coordinates of 5°17'82,01" - 5°17'89,35" S, 119°48'01,12" - 119°48'88,08" E with direction West Southwest to Southeast (Fig. 6).

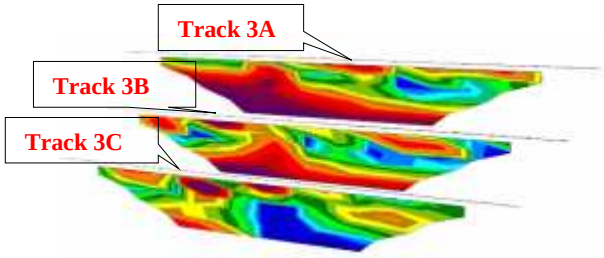


Figure 6. Geoelectric Inversion Section of resistivity line 3A, 3B and 3C

Based rock resistivity value which is then adjusted to the lithology encountered on the track 3 can be concluded tuff is the lithology constituent on the research area. From the data found on the track 3A can be interpreted position of the accumulation of water that has been contaminated is at a depth of 2.5 m to 12.5 m with resistivity values 0.477 Ω.m up to 1.58 Ω.m. While on the track 3B can be interpreted position of the accumulation of water that has been contaminated is at a depth of 2.5 m to 10 m and 7.5 m to 24.9 m with resistivity values 1.56 Ω.m up to 5.33 Ω. On track 3C position can be interpreted accumulation of contaminated water is at a depth of 7.5 m to 13 m with resistivity values 0,624 Ω.m up to 99.3 Ω.m [7].

4.3.4 TRACKS 4

Track 4 measurement located at an Islamic boarding school on southeast landfill Antang with the coordinates of 5°17'76,27" - 5°17'65,88" S, 119°49'49,51" - 119°49'42,85"E with direction West Southwest to Southeast (Fig. 7).

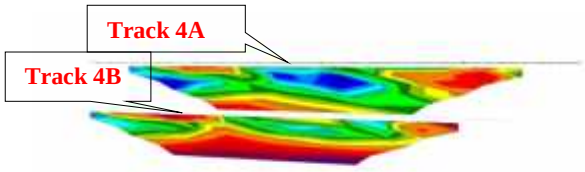


Figure 7. Geoelectric Inversion Section of resistivity line 4A and 4B

Based rock resistivity value which is then adjusted to the lithology encountered rock track 4 can be concluded constituent research sites are Tufa. Data obtained on the track 4A can be interpreted position of the accumulation of water that has been contaminated is at a depth of 18.5 m to 24.9 m with resistivity values 0.504 Ω.m up to 2.34 Ω.m. While on the track 4B data obtained can be interpreted position of the accumulation of water that has been contaminated is at a depth of 2.5 m - 23 m with resistivity values 0.210 Ω.m up to 80.0 Ω.m [7].

V. CONCLUSION

1 Regional geological Antang landfill waste lies in the wavy topography unit/sloping ramps with the percentage of the slope angle of about 2°-4°. Antang landfill area stratigraphy lithology encountered rough tufa ash coarse grain size, open containers, sorting bad, layered structure (N 42° E/12°) mineral composition of biotite.

2 Groundwater contamination has occurred in landfill waste, and chemical analysis has been conducted on the nitrate (NO3), sulfate (SO4), BOD and COD. From the analysis it is known that the four elements above the pollutant has exceeded the threshold that has been set by the

government.

3 Leachate movement patterns move in the direction of groundwater flow (advection process) that is from the Northwest to the Southeast.

REFERENCES

[1] Alzwar. M., 1988, *Pengantar Ilmu Gunungapi*. Nova, Bandung.

[2] Imran, A.M., 2005. *Perkembangan Polutan Dalam Air Tanah Pada Tempat Pembuangan Akhir (TPA) Sampah Antang, Kota Makassar, Provinsi Sulawesi Selatan.*

[3] Fauzi Arifin, M., 2001. *Tinjauan Geohidrologi Sebagai Salah Satu Pertimbangan Dalam Pemilihan Lokasi TPA Sampah*. Universitas Hasanuddin, Makassar.

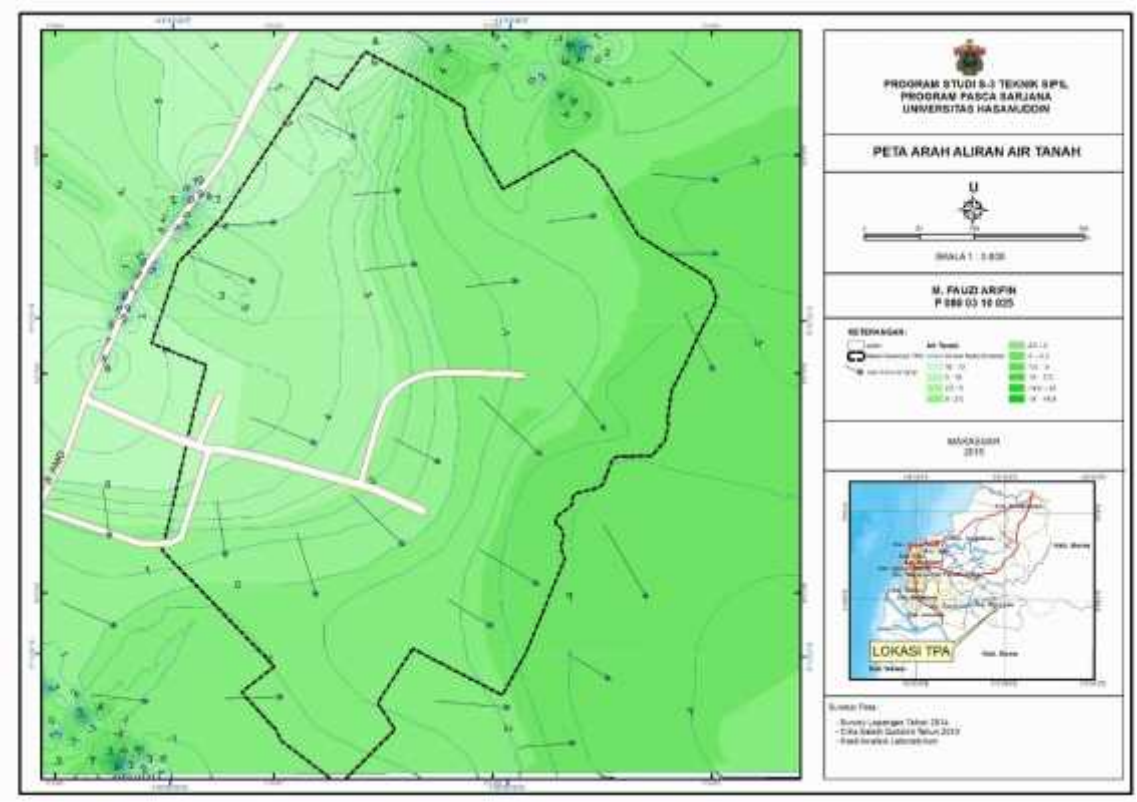
[4] Pramono, G. H., 2008, Akurasi Metode IDW dan Kriging untuk Interpolasi Sebaran Sedimen Tersuspensi di Maros Sulawesi Selatan, *Forum Geografi, Vol. 22, No. 1, Juli 2008*: 145-158.

[5] van Zuidam, R.A., 1985. *Aerial Photo Interpretation in Terrain Analysis and Geomorphologic Mapping*, Smith Publishers, The Hague, Netherlands.

[6] Pettijohn, F. J, 1975, *Sedimentary rocks 3th*, Harper & Row Publisher, New york, San Fransisco, London.

[7] Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A. 1990. *Applied Geophysics_Second Edition*, Cambridge University Press, Australia.

Attachment 1



Attachment 2