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Preliminary Studies of Groundwater Potential and It's Distribution Patterns in the Gumuk at Jember

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***Abstract*—** *Gumuk is a natural phenomenon that occurs in East Java, especially in Jember. The existence of gumuk scattered in the district of Jember has mined intensively, causing their numbers have declined dramatically. Collecting data in this study conducted on each of the gumuk using waypoint on GPS device consisting of latitude and longitude coordinates. Waypoint data is modified into shapefile (shp) then it is processed using ArcView Gis 3.3. Based on our preliminary studies in 2 Subdistrict of Pakusari and Ledokombo identified as cumulate gumuk while in the subdistrict of Arjasa as spread gumuk. The groundwater potential in cumulate and spread gumuk need to be investigated so that further confirming the role of gumuks as a water storage. Groundwater potential estimated using self potential methods. The results obtained in the cumulate gumuk have potential value 2 mV to -14 mV, the goundwater potential in the gumuk can be assumed to be dominant. While on the spread gumuk, soil water anomaly uneven, only at some point. The groundwater potential in this gumuk less dominant than the cumulate gumuk. From this study could be concluded that the distribution of cumulate gumuk more abundant groundwater potential than spread gumuk.*

***Keywords*— gumuk, cumulate gumuk, spread gumuk, groundwater potential, self potential.**

I. INTRODUCTION

District of Jember Regency has unique and specific landscape, with the existence of gumuk. Gumuk is small hills composed of rocks and has a varying size (large and height). Gumuk is included in the C category of quarry mining with result stone plates, sand, and stone use as foundation whereas hill mostly consist of soil (Sulistyaningsih, et al,. 1997). The number of gumuk was never officially inventoried, but the number was estimated at more than 1000, so Jember District was also dubbed the "District of a thousand gumuk". According to the theory of Verbeek and Vennema (in Fariha, 2013), the existence of the gumuk in Jember occurred due to the eruption of Mount Raung in the past that drains lava. The lava flows are covered by volcanic material with a thickness of tens meters and erosion occurs on soft parts comprising volcanic sediments of thousands years to produce the topographic shape of the gumuk as it is today.

The existence of gumuk spreaded in Jember now has been much eroded and flattened to the ground. Many of those gumuks have been converted into residential and agricultural areas. In 1990, the housing construction began to proggres quickly in Jember and most of land included gumuk, flatened and use as housing contruction. Besides, gumuk also mostly mined result stone plates causing the number has been reduced drastically. According to Kepel (2000), in macro scale, gumuk numbering thousands plays an important role in the groundwater system in the downstream area because the existence of the gumuk mostly located in the upstream. On a micro scale, the gumuk plays a role for the surrounding area, evidenced by the emergence of springs around a portion of the gumuk, with varying discharges. Springs encountered in the gumuk area are generally seepage.

It is necessary to re-inventory the current number of gumuk with its geological conditions. The distribution can be obtained through GPS (Global Positioning System) used to determine the point of coordinates Latitude and Longitude coordinates in each gumuk. GPS is a navigation satellite system designed to provide three-dimensional position and speed and information about time(Abidin, 2006).

The condition of subsurface structure can be observed using self-potential method. Self potential method is one of the geophysical methods whose basic principle is measure static natural voltage which is in the group of points on the ground surface. This method can be used to determine an area that potentially minerals and metals. Background potentials are formed by the flow of liquids, biolistrik activity in plants and caused by differences in electrolyte concentrations in groundwater as well as other geochemical activities. The value of background potentials depends on the geological resources below the surface shown in table 1 below.

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Table.1: Type of SP anomaly from various mineral

Sources	Type of anomaly
Mineral Potentials	
Sulphide (*pyrite, chalcopyrite, pyrrhotite, sphalerite,* galena)	Negative ~ hundreds of mV
Graphite (*magnetite* and other electronically conducting minerals)	Negative ~ hundreds of mV
Coal	Negative ~ hundreds of mV
Manganese	Negative ~ hundreds of mV
Quarrtz veins	Positive ~ tens of mV
Pegmatites	Positive ~ tens of mV
Potensial Background	
Fluid steaming, geochemical reaction, etc	Positive +/- negative ≤ 100 mV
Bioelectric (plants, trees)	Negative ≤ 300 mV
Groundwater movement	Positive or negative up to hunderds of mV
Topography	Negative, up to 2 V

(Source : Reynolds, 1997).

Jardani et al (2006) in their research about self-potential signals associated with preferential groundwater flow pathways in sinkholes state that most of negative anomalies were located along the trend where sinkholes were identified from surface features. The sinkholes are organized along these ridges channel because these ridges high volumes of groundwater flow. Jinadasa and de Silva (2009) do research on resistivity imaging and self-potential applications in groundwater investigations in hard crystalline rocks. from their research, area of negative self potential anomalies correlate well with possibly areas of groundwater accumulations. Base on previous research and table 1, the groundwater potential in the gumuk can be identified using a negative self-potential anomaly.

There are two kinds of data acquisition technique in self-potential method that is fixed base and leap frog technique. In fixed base technique, one of the electrodes is fixed at one point and the other electrode is moved at each measurement, whereas in leapfrog technique the two electrodes are moved at each measurement. Both techniques are very effective for knowing subsurface structures, but leapfrog techniques are more cost-effective and time-efficient than fixed base techniques (Sharma, 1997). Goto et.al (2012) using leapfrog method in SP observation for investigation groundwater flow system in a nonvolcanic mountain slope. Onojasun (2015) also using leapfrogging approach in delineating groundwater contaminant plums using self-potential surveying method in Perth Area, Australia.

II. METHODS

The data were collected in 3 sub-districts, i.e. Ledokombo, Pakusari and Arjasa. Gumuk choosen as research location at those sub district are gumuk that still intact and had not been mined at all. Data acquisition in the using GPS to determine Latitude and longitude coordinates of the location and elevation of each gumuk. GPS survey data in the form point is usually processed by converting into segment data such as topographic contour data before further processing in the GIS. Latitude and longitude coordinat obtained from GPS device as waypoint. Waypoint data is converted to shapefile (shp) then processed futher using ArcView GIS. Last result as map of gumuk distribution in 3 sub-distrik which will become the reference in knowing the current position and condition of the gumuk.

Meanwhile, to know the potential of groundwater in the gumuk area is done by taking the line along the 200 m in the gumuk with each spacing 5 m for each line. The data acquisitin location for groundwater potential in Ledokombo sub district, taken in Lembengan Village with coordinates $8^{o}09'50"$ S dan $113^{0}43'054"$ E. While in Pakusari sub district taken in Subo Village with coordinates $8^{0}09'56,2"$ S dan $113^{0}46'16,5"$ E. The last location in Arjasa sub District, Biting Village with coordinates $8^{0}06'46,5"$ S dan $113^{0}46'09,4"$ E. Location taken, is expected to represent the area of the gumuk. Technique of data acquisition using leap frog technique. The data acquisition technique can be seen in Figure 1.

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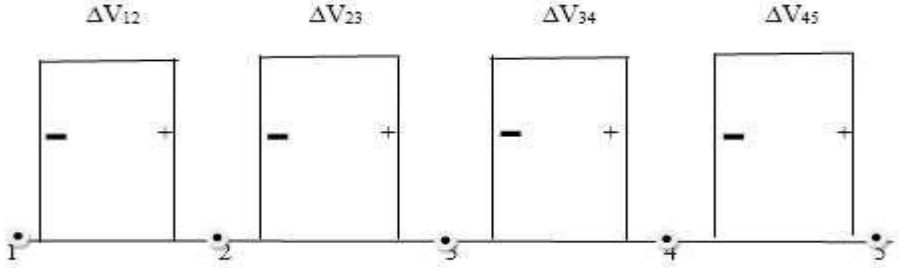

Fig.1: leapfrog technique in SP acquisition

where

ΔV_{12} : Potential difference value between point 1 and point 2
ΔV_{23} : Potential difference value between point 2 and point 3
ΔV_{34} : Potential difference value between point 3 and point 4
ΔV_{45} : Potential difference value between point 4 and point 5

In this research, we get the value of voltage in mV unit. The data is then processed in surfer 12 software so that it becomes a self potential contour map (equipotential map) that describes the groundwater potential of the research area.

III. RESULTS AND DISCUSSION

The maps of gumuk distribution patern done in 3 sub district in Jember shown di figure 2, 3 and 4 using ArcView GIS 3.3. GPS data survey generated in waypoint formulated by converting the data in the form of shapefile (shp). Data processing is done by combining the map of the location of the study area with the point coordinates of each gumuk by using the GIS method. From these data will be obtained map distribution of gumuk with a certain scale. In the map of gumuk distribution, the area of research is imaged with different colors., the road symbolized by the red colored lines and the village boundary symbolized by the black line that can be seen on the legend. The intact gumuk is imaged with blue dots while the gumuk being mined is imaged with red dots. The first research location is located in Ledokombo subdistrict consisting of several villages, namely Sukogidri, Sumberanget, Ledokombo, Lembengan, Lesung Source, Slateng, Suren, Sumberbulus, Karang Paiton, and Sumbersalak. Figure 2 is a map of gumuk distribution in Ledokombo subdistrict with scale 1: 125.000 with area of 146.92 km^2.

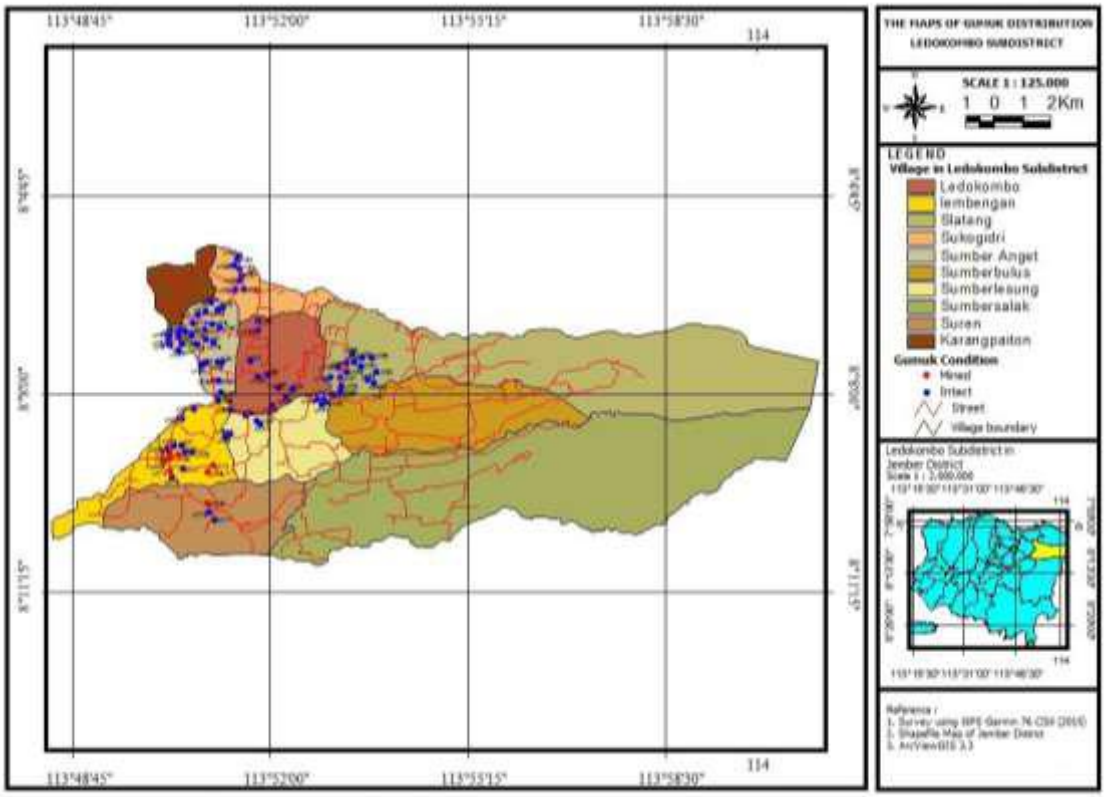

Fig.2: Map of Gumuk Distribution in Ledokombo Sub District

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Based on the results of the research described in table 2, the number of gumuk in Ledokombo subdistrict as 92 gumuk, consisting of 83 gumuk in intact condition and 9 gumuk being mined. The largest number of gumuk in this sub-district is in Sumber Anget Village which is 29 gumuk, consist of 28 gumuk in intact condition and 1 gumuk is being mined. While the fewest gumuk in Suren the village as 3 gumuk, consisting of 2 gumuk in intact condition and 1 gumuk being mined. Based on the geological map of Jember district, the rock formations in Ledokombo sub district consist of Raung rock, Argopuro Tuff, and Bagor Form.

Table.2: Number of Gumuk in Ledokombo Subdistrict

	Village	intact	mined	Rock formation
1	Sukogidri	8	-	Batuan Raung & Tuff Argopuro
2	Sumber Anget	28	1	Batuan Raung & Tuff Argopuro
3	Ledokombo	10	-	Tuff Argopuro
4	Lembengan	10	7	Tuff Argopuro
5	Sumber Lesung	9	-	Tuff Argopuro
6	Slaten	16	-	Form Bagor & Tuff Argopuro
7	Suren	2	1	Tuff Argopuro
8	Sumberbulus	-	-	-
9	Sumbersalak	-	-	-
10	Karang Paiton	-	-	-

The measured groundwater potency in the study location can be shown in the form of contour maps. The result of the potential contour of gumuk in Lembengan Village of Ledokombo SubDistrict is shown by figure 3 below:

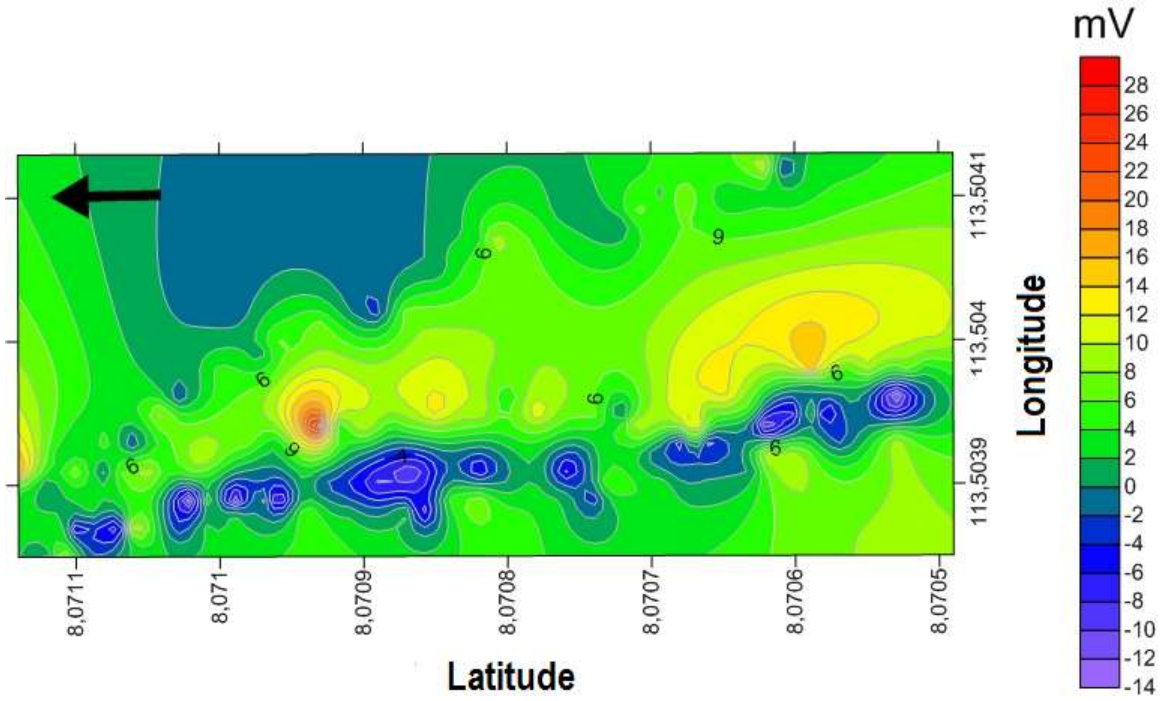

Fig.3: Map of contours potential distribution of gumuk in Lembengan Village, Ledokombo Sub District

Anomalies of groundwater potential in line 1 and 2 with coordinates 08º07'05" to 08º07'11" S and 113º50'39" E With a range of values from 0 mV up to -14 mV. Then there is also an anomaly of groundwater potential on line 4 with coordinates 08º07'09" to 08º07'10" S and 113º50'41" E potential value of -2 mV to -8 mV. The amount of groundwater potential in the research area is 15% of the research area.

The second research is located in Pakusari sub-district consisting of Bedadung, Patemon, Sumberpinang, Subo, Jatian, Pakusari and Kertosari villages. Figure 4 is a map of the gumuk distribution in Pakusari Sub District with scale 1: 60.000 and the area 29,11 Km^2. In Figure 4, can be seen that the distribution of gumuk in Pakusari sub-district is evenly distributed and the condition of the gumuk that is being mined is less than the gumuk under intact condition.

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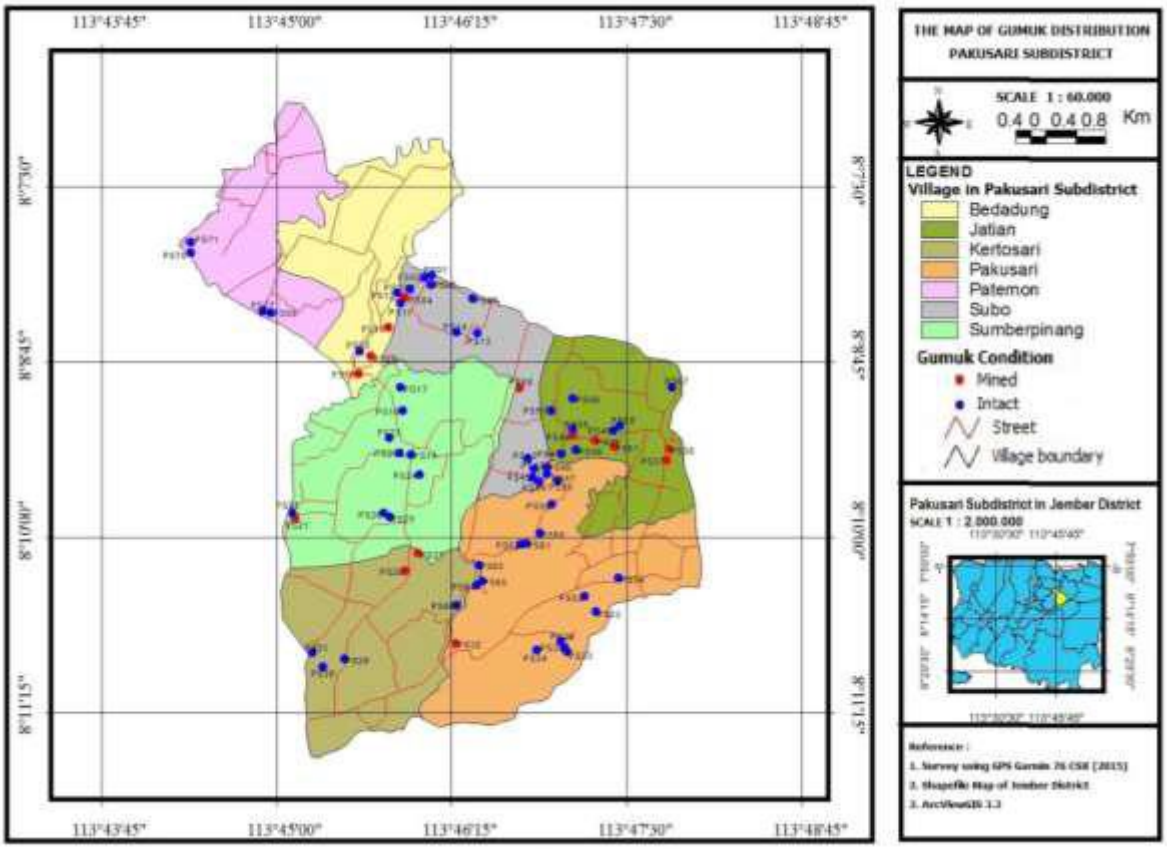

Fig.4: Map of Gumuk Distribution in Pakusari Subdistrict

The number of gumuk in Pakusari Sub-district is 71 gumuk, consisting of 56 gumuk in intact condition and 15 gumuk in mining process. In table 3 is seen that the largest number of gumuk in Pakusari Village is 18 gumuk consisting of 17 gumuk in intact condition and 1 gumuk in mined condition. While the fewest guduk in Patemon Village as 4 gumuk and in intact condition. Based on the geological map of Jember District the rock formations in Pakusari sub-district consist of Tuff Argopuro and Bagor Form.

Table.3: Number of Gumuk in Pakusari Sub District

No	Village	intact	mined	Rock Formation
1	Bedadung	2	3	Tuff Argopuro
2	Patemon	4	-	Tuff Argopuro
3	Sumberpinang	9	1	Tuff Argopuro
4	Subo	12	2	Tuff Argopuro
5	Jatian	8	6	Tuff Argopuro & Fom Bogor
6	Pakusari	17	1	Tuff Argopuro
7	Kertosari	4	2	Tuff Argopuro

The measured self potential at the research site can be displayed in the form of contour maps. The result of the potential contour of the spreading of dune in Subo Village of Pakusari District is shown by figure 1.5 below:

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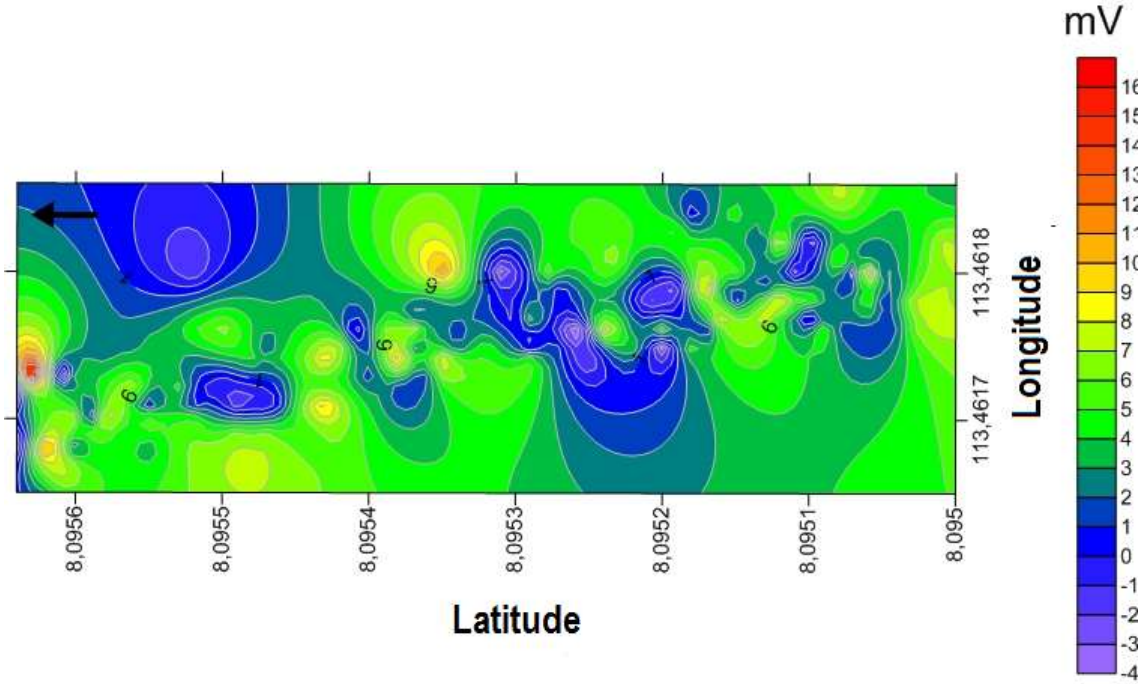

Fig.5: Map of potential contour distribution of gumuk in Subo Village Pakusari SubDistrict

At the gumuk in Subo Villages, pakusari subdistrict, some potensial groundwater potency were shown in 08º09'52" sampai dengan 08º09'53" S dan 113º46'18" E with range of potential value 2 mV to -4 mV. Groundwater potential areas is 24% of this research area.

The third location is in Arjasa Subdistrict, the result of its gumuk distribution is seen in Figure 6 with the scale of 1: 75.000 and the area of 43.75 Km^2.

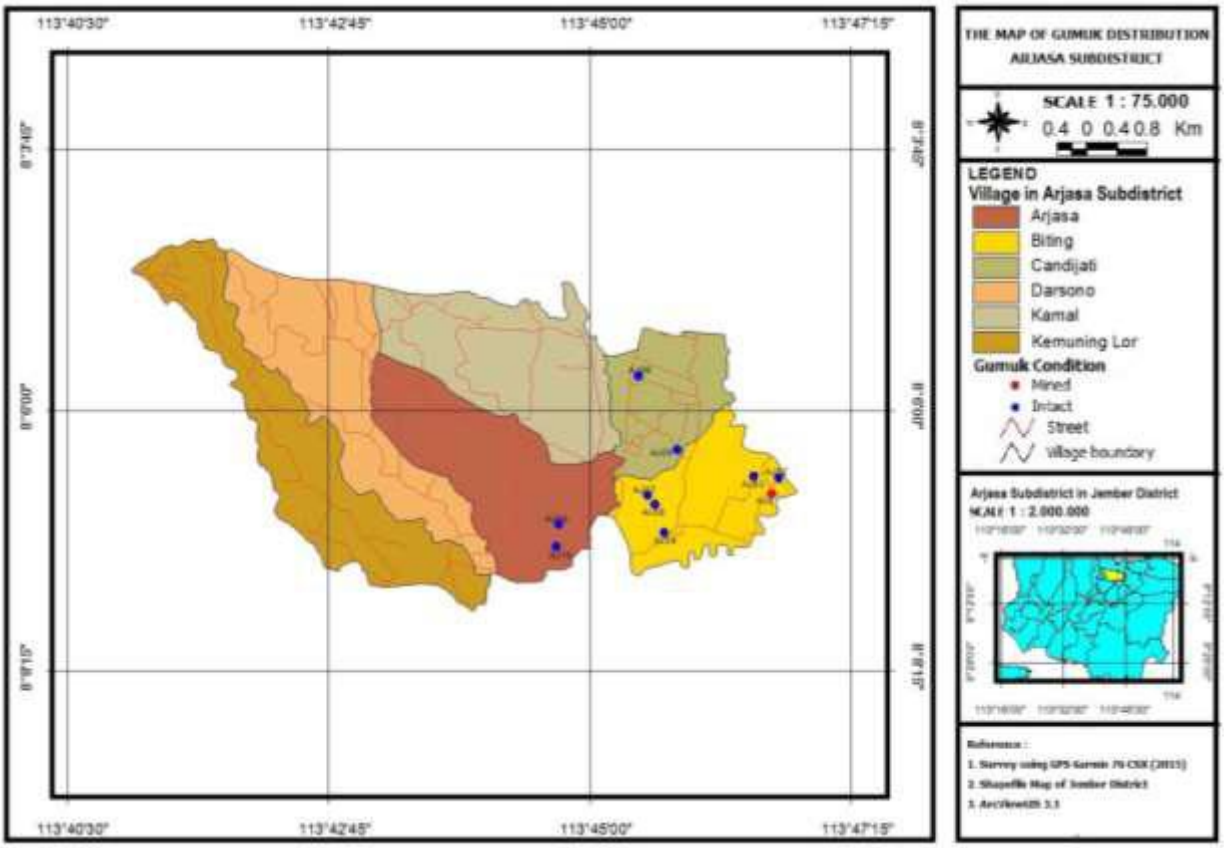

Fig.6: Map Distribution of Gumuk in Arjasa Sub District

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Based on table 4. the number of gumuk that is in District Arjasa as 10 gumuk, consisting of 9 gumuk in intact condition and 1 gumuk is being mined. The area where the distribution of the gumuk is located in 3 villages, Biting, Candijati, and Arjasa. This sub-district is a subdistrict that has the least number of gumuk compared to other sub-districts, this is because the gumuk in this region many have been mined, so the number of gumuknya decreases. Rock formations contained in the region are the formation of Bagor Form Stone, Argopuro Breccia, and Argopuro Tuff.

Table.4: Number of Gumuk in District Arjasa

No	Village	intact	mined	Rock Formation
1	Biting	5	1	Form Bagor, Breksi Argopuro, dan Tuff Argopuro
2	Candijati	2	-	Breksi Argopuro
3	Arjasa	2	-	Breksi Argopuro
4	Kamal	-	-	-
5	Darsono	-	-	-
6	Kemuning Lor	-	-	-

The results of the self potential contour of gumuk distribution in Biting Village, Arjasa Sub District is shown by Figure 5 below:)

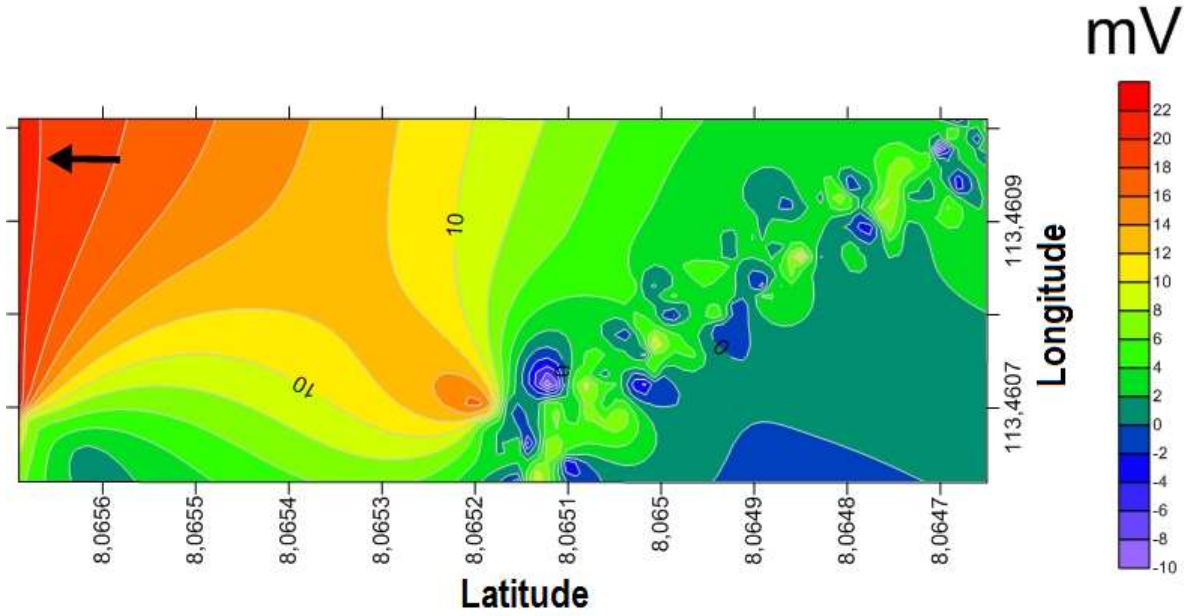

Fig.5: Map of potential contour distribution in Biting Village, Arjasa Sub District

The potential of groundwater in the spread of gumuk spread in the village of Biting Arjasa District has a range of values 0 mV to -10 mV, groundwater anomalies shown uneven in the gumuk area only at some point. The area of groundwater potential is 4% of the research area.

The number of gumuk in Jember district decreases due to switching function to residential areas and most of them have been mined. This lead to decreasing of spring water which are generally found around gumuk. Gumuk ecosystem, functionally play big role for human life, i.e forming a local hydrologic cycle that has an important role in creating a microclimate for agricultural landscape and preserve the water cycle. The hydrological cycle of the gumuk can be likened to a water reservoir capable of storing rainwater as an input and then drain to the area under it continuously. Therefore, Jember District Government should make spatial planning for non-existent of gumuk and can be developed into productive economic activities without destroying its formation

IV. CONCLUSION

Based on the measurement results of the gumuk distribution and the potency of groundwater obtained pattern of gumuk distribution divide into cumulate gumuk and spread gumuk. Gumuk is assumed to have a cumulate pattern if the distance between the gumuk not too far away and when viewed from a distance it will be seen forming a single gumuk. This type of gumuk based on

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research results are in Sub District Ledokombo and Pakusari. While the gumuk is assumed to have spread pattern if the distance between gumuk far enough and its position is not seen as one unity. This type of gumuk based on research results are in Sub District Arjasa. The results obtained on the cumulate gumuk have a potential range of 2 mV to -14 mV, so that the potency of groundwater in the cumulate gumuk can be assumed to be dominant. Whereas in the spead gumuk anomalous groundwater shown unevenly, in the gumuk area only at some point. Potency soilwater in gumuk spreads less dominant compared with cumulate gumuk.

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