IDENTIFICATION OF GROUNDWATER RESOURCEZONATION AND GROUNDWATER PROTECTION AREA IN BANYUWANGI REGENCY

Lena Sumargana, Djoko Nugroho, Budi Heru Santosa
Pusat Teknologi Pengembangan Sumberdaya Wilayah, Badan Pengkajian dan Penerapan Teknologi, Geostech, Kawasan Puspiptek, Serpong, Tangerang Selatan

lena.sumargana@bppt.go.id, djoko.nugroho@bppt.go.id, budi.heru@bppt.go.id

Abstract. Groundwater as water resources requires special attention in order to be utilized in a sustainable manner. Utilization of groundwater that does not consider ecological aspects have shown the negative impact that a decline in quantity and quality of groundwater and the environment as has happened in big cities in Indonesia. therefore to the protection of groundwater resources requires the Groundwater Protection Area. In this study conducted assessment to determine the Groundwater Protection Area in the regency of Banyuwangi as a protected area that will be accommodated in the Spatial Plan Banyuwangi. Components of the study consisted of the analysis of geology, topography, hydrology, climatology, and hydrogeology as input for determining the zoning of groundwater and aquifer potential of the basis for determination of the Groundwater Protection Area. Based geoelectric data, there are two layers of the aquifer, unconfined aquifer, the depth of this aquifer are so varied and the quality was good except for the south-southeast which is brackish; second is confined aquifer located in the north-east and the south, with the category of fresh water. By reference to the value of electrical conductivity of 5-30 μS/cm (Mandel, 1981) as a water catchment area for regional water catchment system located at an altitude between 280-800 meters above sea level. Groundwater Protection area is obtained by spatial analysis and weighting of the value of Land type, recharge area, land use and water balance; then produced three protection area categories, namely primary, secondary and development catagory. Primary Groundwater Protection area category is dominated by forests and plantations; confined aquifer zone is contributed by unconfined aquifer in the protected area above it.

Keywords: Groundwater Protection Area, geoelectricity, aquifer

1. Background

Water both surface water and groundwater is a vital thing that is needed by all living creatures, in some area this resources becoming a very strategic commodity. Utilization of groundwater that does not consider ecological aspects have shown the negative impact that a decline in quantity and quality of groundwater and the environment as has happened in big cities in Indonesia. it is necessary a study and regulation to preserve these groundwater resources. as a growing area of the eastern part of Java, Banyuwangi regency need Groundwater Protection area to keep groundwater resources remain protected and maintained, In this study conducted assessment to determine the Groundwater Protection Area in the regency of Banyuwangi as a protected area that will be accommodated in the Banyuwangi Spatial Plan. The existence of aquifer as a storage media need to be mapped. in order to utilization and protection can be optimally performed.

One method that can be used to identify the existence of the potential groundwater is geo-electric method (Sehah, 2016). This method can mapped distribution vertically dan laterally of aquifer. Recharge zones which let water into the aquifer need to know to facilitate the determination of which areas should be protected to keep the water into the aquifer.

Estimation of rainwater elevation that enters the aquifer can be done by doing a graphical analysis between electric conductivity value of water and elevation on some sample values at some elevation by looking at the value of electric conductivity between 5-30 μS/cm is regarded as a water recharge (Nugroho, 2003)

2. Data and Methods

Banyuwangi is the largest regency in East Java Province, Geographically is located between the 7° 43' – 8° 46'South and 113° 53' – 114°38' East and at an altitude of between 0 - >3000 meters above sea level. Landuse in this area is diverse with a predominance of forest, rice fields, plantations and settlements. Banyuwangi has an average rainfall of 108 mm per month with dry months of August, September and October.

Located in the east - southeast of Ijen Volcano, Banyuwangi regency stratigraphically composed of Tertiary sedimentary rocks, intrusion, volcanic rocks and sedimentary rock. Overall the area is dominated by quaternary sedimentary rocks coming from the volcano and alluvium (Sidarto, 1993).

Secondary data collected are a topographic map, administration map, Geological map, landuse map, climate data, soil map, demography data. Slope map, the sub-watershed map generated from topographic map.

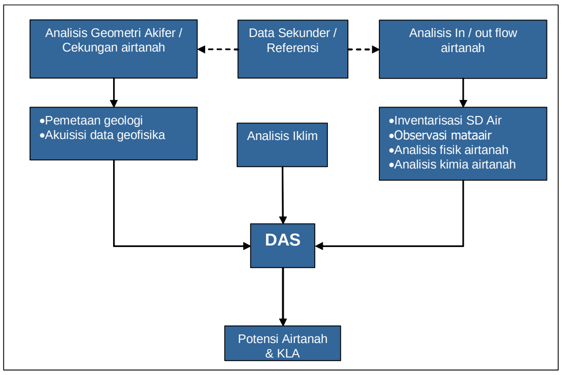

Figure 1. Reasearch Methods Flow

Observation and Measurement of Quality of water from springs and wells (Total Dissolve Solid, electric conductivity, temperature, chemical properties). Observation springs and wells, to determine the type of spring as reference material determination of the geometry of springs (Fetter, 1994), and determines the recharge area

Geoelectric measurument, aim to determine the composition depth and spread of subsurface rocks/soils based on the value of resistivity obtained.

Groundwater resources Zonation is obtained by determining the depth, thickness and distribution of the aquifer (unconfined and confined) based on data geoelectric and geologic field observations.

Making of isofreatik map that shows similarity level of groundwater based on measurement of groundwater table depth taken at several measurement points. This map aims to determine the depth of groundwater table, groundwater flow direction, and hydraulic gradient.

Calculation of balance water resources and hydrology analysis to determine the rainfall, evaporation and runoff as a parameter to determine the condition of a sub watershed, such as surplus water area, which will facilitate the management of water resources in each sub-watershed.
Calculation of the water balance of each sub-watershed is done by using the equation

$$PPT = ET + RCH + RO$$

Where, PPT = Precipitation, ET = Evapotranspiration, RCH = Addition of groundwater and RO = Run Off.

To calculate water consumption or Water Use, then apply the relationship:

$$RCH = BF + WU + TRS$$

Where BF = springs, WU = Water use, and TRS = Ground Water Transfer / Storage.

Water balance map compiled in order to obtain a map of the water balance surplus for each sub-watershed.Determination of recharge areas, based on the assumption that the physical and chemical properties of groundwater dependent on the condition of the physical properties and chemical composition of water that seep (rain water, river water, lake water, etc.) and the chemical processes that occur during the water circulating in the aquifer (Matthess, 1982). Assuming that the groundwater comes from rain water, then if the chemical properties of groundwater with rainwater almost equal it is interpreted that the groundwater aquifer had contact rainwater and relatively quick.

Based on analysis of the value of electric conductivity of groundwater and elevation on the southern slopes of case studies Merapi (nugroho, 2003), Figure 3 shows a graph of the relationship between electric conductivity of groundwater and elevation where the linear line indicate the trend significant relationship between the accumulation value of the electrical conductivity for each discharge elevation. The lower the elevation of a discharge, then relatively concentration values electrical conductivity higher.

Determination of groundwater protected areas carried out with spatial analysis and multi-criteria analysis of the recharge map, land use map, soil map, surplus area map and slope map, with scoring table-1 below.

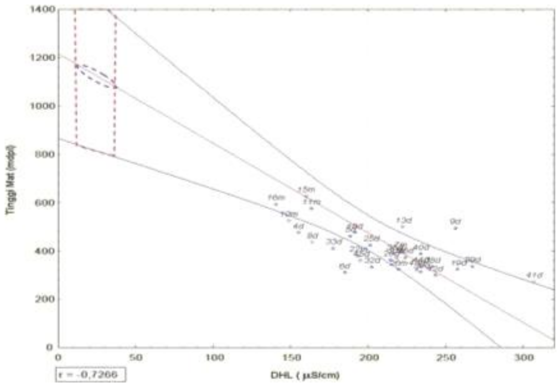

Figure 3. Relationships beetwen electric conductivity with groundwater levels (Nugroho, 2003)

Tabel-1. Weight and Scoring for determining groundwater protection area

Criteria	Weight	Sub-criteria	Score
Ground Water Recharge	40	200 mdpl – 800 m dpl	10
		< 280 m dpl or > 800 m dpl	5
Soils	30	Abu / pasir dan tuff batuan vulkan intermedier sampai basis	10
		Abu / pasir dan tuff batuan vulkan intermedier, tuff dan batuan vulkan masam, intermedier dan basis, tuff vulkan intermedier sampai basis	7.5
		Endapan liat dan pasir	5
		Batuan vulkan	2.5
		Endapan liat, batu kapur	0
Landuse	15	Hutan	10
		Perkebunan	7.5
		Belukar/semak	5
		Rumput	2.5
		Sawah, pemukiman, tanah berbatu	0
Water Surplus	10	> 450 mm	10
		> 260 – 450 mm	7.5
		> 160 – 260 mm	5
		< 160 mm	2.5
Slope	5	0 – 8 %	10
		8 – 15%	8
		15 – 25%	6
		25 – 45%	4
		> 45%	0

3. Results

3.1 Groundwater Resource Potensial Zone

Ground water resources potential zone is determined base on the distribution of aquifer map, that obtained from geoelectic survey, measuring water quality and geological observation. There is two type of aquifer in a study area, unconfined and confined aquifer, where confined aquifer deeper than unconfined aquifer, with depth and thickness vary. confined aquifer spread in south area.

The value of TDS (Total Dissolve Solid) value relatively increased when approaching the coast or towards discharge area. Base on classification Freeze and Cherry (1979) value of TDS of research areas between 70-920 ppm and classified into fresh water (0-1000 ppm). In figure 3 can also be seen concentrations of TDS and electric conductivity which are very high in the south area of research, This is due to the enrichment of Cl, since it is influenced by rock composistion.

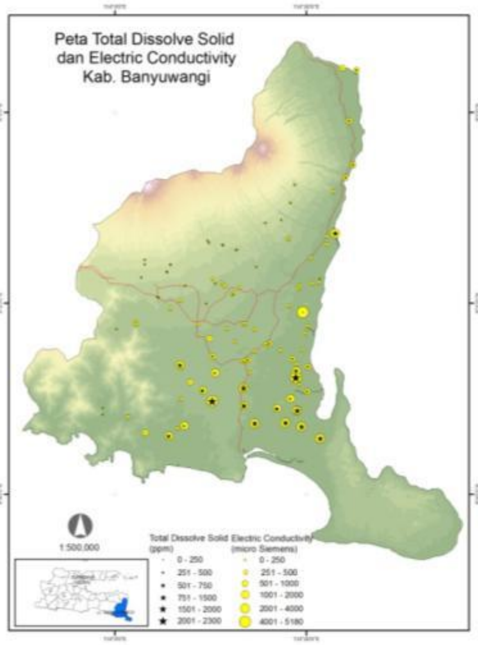

Figure 3, Total Dissolve Solid dan Electric Conductivity Map

Groundwater basin and the potential derived from observations of groundwater discharge, water chemistry value and results of geoelectric interpretation. The research area consists of two aquifers, the unconfined aquifer (aquifer 1) and confined aquifer (aquifer 2). In unconfined aquifer zone, the thicker aquifer is located in the east - southeast area (Figure 4), but based on the physical-chemical properties of any areas recommended to avoid utilization that is in the south-southeast, which is characterized by the high value of electric conductivity (Fig. 4). According to Mandel (1981) and Freeze and Cherry (1979) clasification are classified as category Brackish water, caused by sea water intrusion**.**

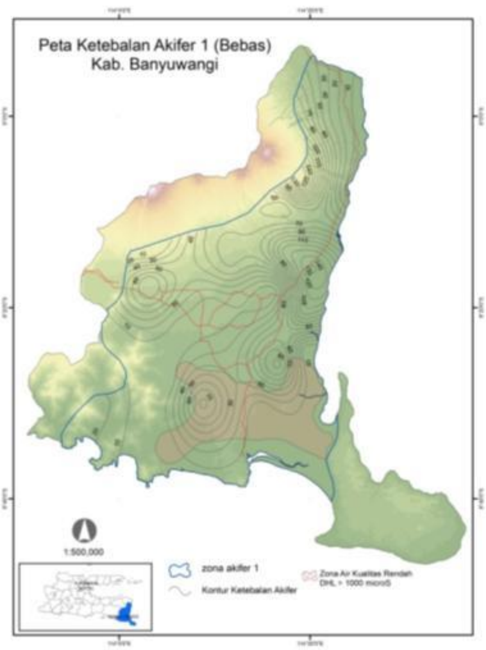

Figure 4. Map of the thickness of unconfined aquifer

Confined aquifer zone or aquifer 2 is also determined based on the result geoelectric survey data that has been verified by the depth of the drill found in the study area (Figure 5). The thickness of the confined aquifer is obtained by determining the position of the upper and lower limits based on interpretation of geoelectric data. Areas that have the potential aquifer pressure is on the southern part of the area of research and some regions in the north-east.

Groundwater potential zone of aquifer 2 is about 1,472,634,525 m2, with water quality classification from Freeze and Cherry (1979) and Mandel (1981) as a category of fresh water.

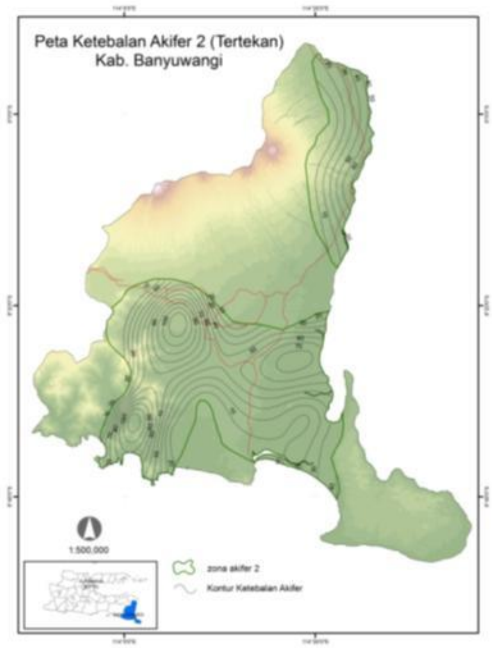

Figure 5. Map of the thickness of confined aquifer

3.2 Groundwater Protection Area

Recharge area is determined by analysis of water quality data and elevation for each sub-watershed. By determining projected line of electric conductivity values of rain water (5-30μS/cm) of a sample of elevations. Based on data from the graph below, figure6 and 7,the Recharge area at an elevation of 280-800 meters, an average minimum and maximum effective elevation of rainwater into the aquifer, the effective area as a recharge area for regional groundwater recharge. Delineate the elevation range of the recharge area of theisohiyet map (figure 8), the highest rainfall fell on the elevation ranges with 2400-2500 mm/year.

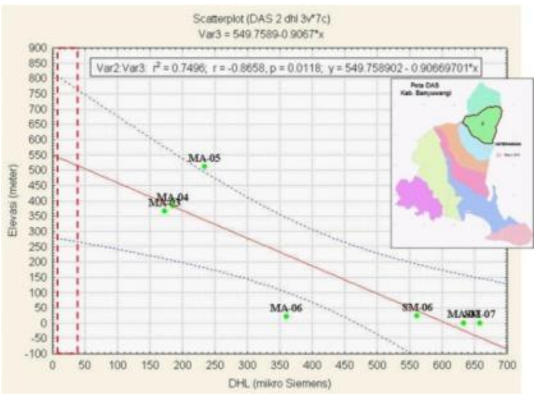

Figure 6. electric conductivity distribution of samples of some elevations in sub-watershed 2

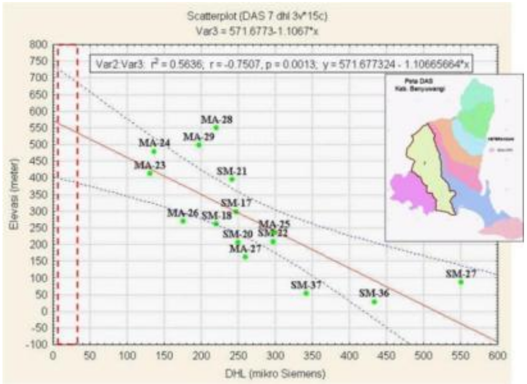

Figure 7. electric conductivity distribution of samples of some elevations in sub-watershed 7

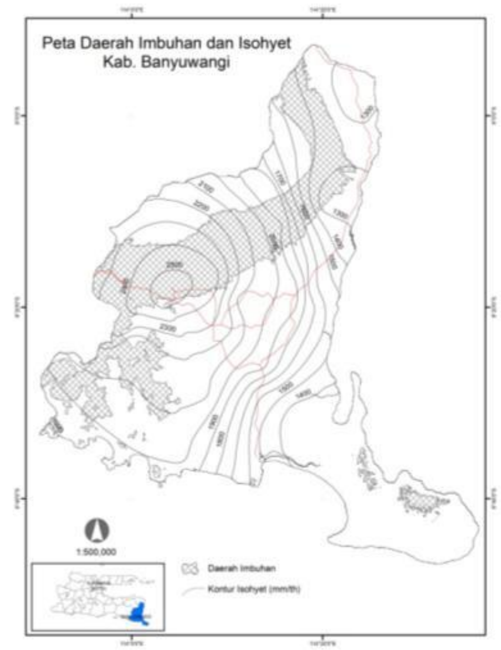

Figure 8. Groundwater recharge elevation and isohyet map

Identification of groundwater protection areas is determined by performing spatial analysis by means of overlaying of layer strongly associated with the determination of the recharge area ie soil type, landuse and water balance sub-watersheds, slope. Then with weights and scores that have been determined carried out spatial analysis of several thematic maps to determine groundwater protection areas.

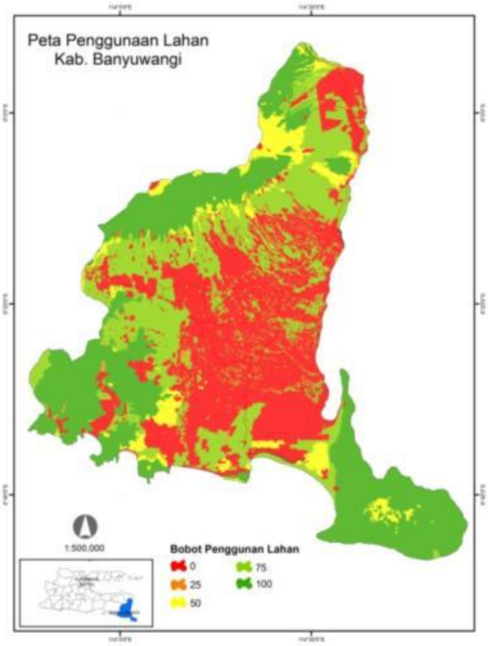

Figure 9. Landuse scoring map

There are three class protection: primery area, secundary area and development area (Figure 12). The primary area is a highly protected zone, in this area change of landuse is not allowed, dominated by forests and plantation, the surface water and rain water contribute recharge directly to the aquifer in these zones.

On Groundwater Protection Area map, in confined groundwater zone show that the confined aquifer in this zone contributed from unconfined aquifer on it, depend on the sustainability of that groundwater quality and quantity by keeping the catchment area in upstream.

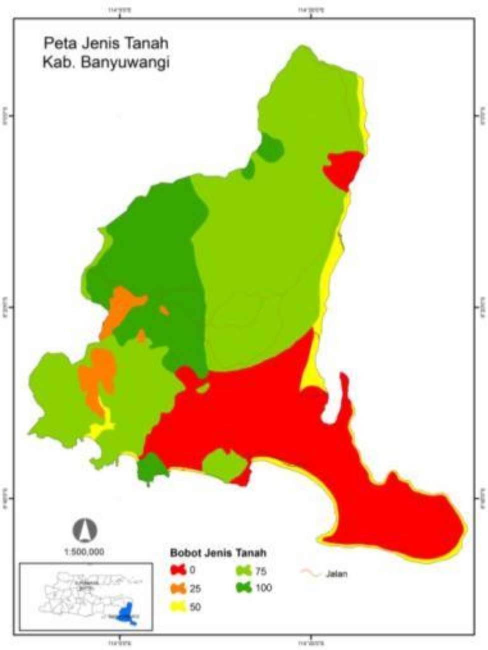

Figure 10. Soils scoring map

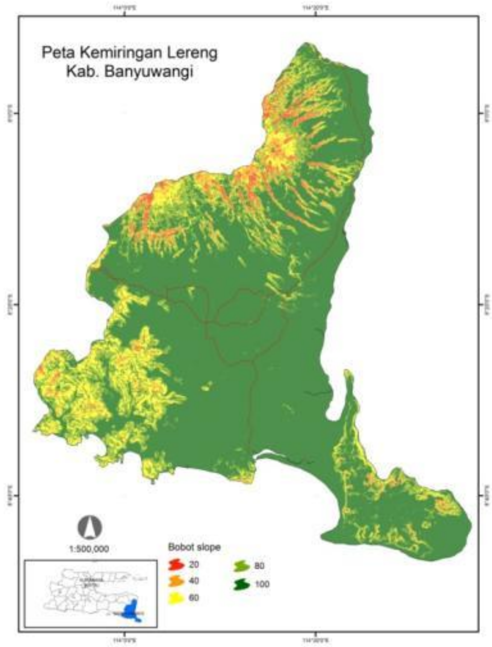

Figure 11. Slope scroring map

For areas with forested land use at this time, should be maintained as Alaspurwo forest area, despite the Grounwater Protection Area map is not the primary are, because of geological and morphological conditions that do not support, but this is an area of forest that have ecological functions.

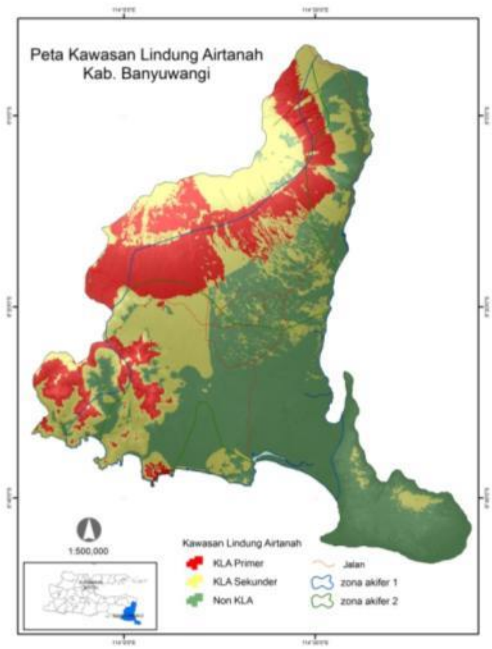

Figure 12. Groundwater Protection Area Map

4. Conclusions

- There are two types of aquifers, unconfined aquifer and confine the aquifer. the potential for groundwater areas are in the east - southeast for unconfined aquifer and in the south and the north-east for confined aquifer with good quality (fresh water), except in the east - southeast area there is a brekish quality water.

- Distribution of rainy days in a year in Banyuwangi uneven. So there is a limited supply of water in the dry season. This requires the good management of water resources so that people needs can be fulfilled throughout the year.
- Protected Areas Groundwater is done with spatial analysis of the layer that is intimately associated with groundwater, greatly assist local governments in managing the environment, primary groundwater protection area need to note the primary groundwater, by maintaining the quality and quantity and avoid of landuse change.

References

Sidarto, 1993, peta geologi regional Lembar Banyuwangi skala 1 : 100.000

Sehah, 2016, *Pendugaan Kedalaman Air Tanah Mengunakan Metode Geolistrik Konfigurasi Schlumberger di Desa Bojongsari Kecamatan Alian Kabupaten Kebumen,* Jurnal Neutrino Vol. 8, No. 2, April 2016

Mandel dan Shiftan, 1981, *Groundwater Resources Evaluation: Exploration and Exploitation*, Academic Press.

Fetter, 1980, *Groundwater Hidrogeology*, Prentice Hall,Inc.

Freeze, R. Allan and Cherry, John A., 1979. *Groundwater.* Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632

Mandel, S., 1981, Groundwater Resources, Academic Press, Inc., New York.

Matthess, 1982, *The Properties of Groundwater*, John Wiley & Sons, Inc.

Nugroho, D., Puradimadja, D. J., 2003., Penafsiran Zona Jenuh dan Tidak Jenuh Pada Akifer Bebas, Endapan Bahan Volkanik, Studi kasus Lereng Selatan Gunung Merapi (Kaliadem-Deles), Kab. Sleman, D.I. Yogyakarta dan Kab. Sleman, Jawa Tengah, Vol. 2 Proc. JCJ 2003, Dec 15-17 2003. p.571

Todd, D.K., 1980, *Groundwater Hydrogeology*, John Wiley & Sons, New York USA, 535p.

BRR-BPPT, 2006, *Geoinvestigasi Danau Aneuk Laot Pulau Weh NAD,* Laporan