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Determination Of Subsurface Aquifers and Distribution of Groundwater Table Depth in Wamena City, Jayawijaya Regency, Mountainous Papua Province

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ABSTRACT

This study was conducted to determine the existence of subsurface aquifers and the distribution of groundwater-surface depth in Jayawijaya Regency, Mountainous Papua Province. The background of this research is the need for optimal groundwater management in areas with high topography such as Wamena City. The method used was a geophysical survey with the Wenner-Schlumberger configuration resistivity geoelectric technique to identify the aquifer layer. Primary data was obtained through direct measurements using geoelectric devices and GPS, while secondary data was obtained from related literature. The results showed that there were free aquifers with a depth of 25-105 meters and depressed aquifers at a depth of 145-270 meters in various research locations. The distribution of this aquifer is highly dependent on local geological conditions, with the availability of groundwater quite high in some areas and minimal in other areas such as Kampung Sabulama and Wasawa. In conclusion, the resistivity geoelectric method is effective for mapping the distribution of aquifers, which can further be used as a basis for groundwater management in the study area.

Keywords: subsurface aquifer; geoelectric resistivity; groundwater management.

Introduction

Water is one of the main elements of the life of living things. Water is divided into two classifications, namely surface groundwater and subsurface groundwater (Akbar, Mahardhika, & Sari, 2023). Surface groundwater is water that is on the surface of the earth in the form of rivers, lakes, etc. Subsurface groundwater is groundwater that occupies cavities in rock layers or geological formations such as underground rivers, well water, etc. Subsurface groundwater can be found in water-saturated layers or aquifers (Zaenurrohman, Indrawan, & Permanajati, 2023).

The resistivity method is one of the geophysical methods used to determine the aquifer layer by utilizing the electrical properties of rocks (EFFENDI, 2021). The lack of proper utilization in the use of groundwater is a problem that is being experienced by the community in Wamena City, Jayawijaya Regency (Kristanto & Khafid, 2021). Topographically, Wamena City is in a fairly high area. The importance of using the resistivity geoelectric method is because this method is the only effective method to determine the conductivity properties of a layer. The existence of groundwater in a place is due to its geological conditions and rainfall (Kristanto & Utami, 2024). Groundwater is found below the surface of the ground, in a natural container called the Groundwater Basin (CAT). The analysis of the geometry and configuration of the groundwater aquifer system was carried out to find out the boundaries and constituent layers of the groundwater aquifer in more detail locally (ROMADHONA, SOEDARMO, & MUSSADUN, 2025). Using the Wenner-Schlumberger configuration resistivity geophysical method, this study aims to provide input, suggestions, and technical recommendations on groundwater management in Wamena City based on the creation of a conceptual model of the groundwater aquifer system. This can be used as a reference in groundwater basin-based groundwater management to meet the needs of clean water in the Wamena City area (Pulu, Mosey, Tongkukut, & Suoth, 2023).

(Dharmayasa et al., 2024) "Comparison of Ordinary Kriging and Inverse Distance Weighted Methods for Elevation Estimation in Topographic Data (Case Study: Topography of FMIPA Area, Mulawarman University)". This study examines the application of the ordinary kriging and IDW methods for elevation estimation in topographic data in the FMIPA area of Mulawarman University. The researcher wanted to find out if there was a difference in the results of elevation estimation in the topographic data in the FMIPA area of Mulawarman University using the ordinary kriging and IDW methods (Suhendar, Hadian, Muljana, Setiawan, & Hendarmawan, 2020). In addition, the researcher also wanted to find out what method was more accurate to use in estimating elevation in topographic data in the FMIPA area of Mulawarman University.

The conclusions obtained from this study are:

a. Based on the results of the cross-validation calculation, there was no significant difference between the results of elevation estimation in the topographic data in the FMIPA area of Mulawarman University using the ordinary kriging and IDW methods.
b. The ordinary kriging method provides more accurate estimation results compared to the IDW method. This can be seen from the RMSE value produced by the best model in the ordinary kriging method, which is 0.431 and 0.432 minimum when compared to the RMSE value produced by the optimal power parameter in the IDW method, which is 0.456.

(Maulana, Santosa, & Adji, 2023) "Groundwater Potential and Groundwater Use for Domestic Needs in the Limboto-Gorontalo Alluvial Plain, Gorontalo Province". The research method used is the survey method, namely by making observations and measurements directly in the field. The sampling technique used is systematic random sampling for geoelectric measurements and field hydrogeological data measurements

(Shoedarto, Tada, Kashiwaya, Koike, & Iskandar, 2022). Data analysis was carried out using an integrated approach between geology, PJ, and GIS-based geomorphology, as well as geophysical and hydrogeological approaches in the field.

The results of the study show that:

a. Hydrogelogically, the research location is the discharge area of the Gorontalo CAT system, the typology of the alluvial plain aquifer system, with the type of aquifer consisting of undepressed, semi-depressed, and depressed aquifer layers. The characteristics of the subsurface lithology of the study site generally show the cross-section between clay material (aquiklud), sand clay clay and clay sand (aquifer), and sand and gravel (aquifer). The type of lithology that constitutes an undepressed aquifer consists of sand with a resistivity value of 20-150 ohm-meters. The thickness of the aquifer is not depressed, especially in the western part of Lake Limboto is identified as having a relatively uniform aquifer thickness with an average thickness of 5 meters, while in the northern and southern parts, it is quite varied, namely from a thickness of 1.5 meters to a thickness of 27.5 meters,
b. Free groundwater potential zones consist of 4 (four) categories, namely high and very high potential zones, medium potential zones, and low potential zones spread across the northern and southern regions of the research location.
c. The free groundwater paving zone consists of 4 (four) paving zones, namely paving zone I (high class) with the characteristics of groundwater potential both in terms of quantity and quality, can be paved and utilized without limiting factors, paving zone II (medium class) has a fairly good groundwater potential in terms of quantity and limited quality potential locally, can be paved and utilized with supervision, and the paving zone III (low class) is a zone with a low quantity of groundwater, which can be paved very limited.

The objectives of this study are as follows:

1. To obtain the depth and thickness of the aquifer layer in Jayawijaya Regency,
2. Get a map of the distribution of aquifer depth in Jayawijaya Regency.

Method

The research method used is the survey method, which is a method of making observations and measurements directly in the field. The series of research activities includes several stages, starting from the preparation/pre-field stage, fieldwork, post-field, and the result stage designed by the research objectives. The location of the research is in Jayawijaya Regency, geoelectric measurement points are spread across Wamena City with a total of 23 test points.

Data Collection Techniques

To be able to analyze the determination of subsurface aquifers and the distribution of ground surface water depth, it is necessary to have data or theoretical information about basic concepts and adequate tools so that the need for data is very definitely needed in the data collection stage during the implementation of this research. The data that is used as a reference in the implementation and preparation of this thesis report can be divided into two types of data, namely:

Primary Data

Peripheral data is data taken directly by the researcher by digging up the source of the object being studied. Primary data is data obtained by taking data in the field, including measurements with geoelectric tools, and taking measurement coordinate points with Global Positioning System (GPS) tools.

Secondary Data

Secondary data is indirect data that is able to provide additional data and strengthen research. Secondary data is obtained from literature studies with the help of print media and internet media Secondary data is data obtained from previous research related to the use of natural materials in pavement thickness.

Results and Discussion

Geological Conditions of Jayawijaya Regency

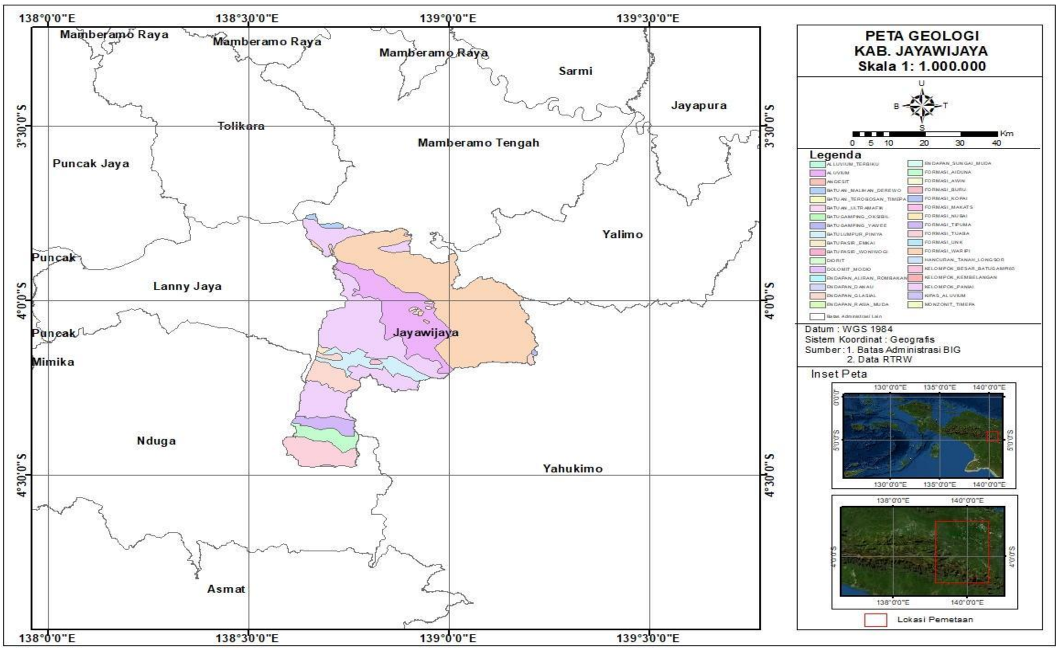

Figure 1 Geological Map

Based on geological maps, the basic condition of the soil layer structure in Jayawijaya Regency is an inseparable layer containing deep-sea facies, namely well-layered pelagic limestone, limestone inserts, napal, puritan, micro-crystalline limestone, and consists of reef facies, namely bioclastic limestone, limestone sea sedimentary rocks and limestone inserts. In most of the Jayawijaya area, especially in low-lying areas, the surface layer consists of alluvial rock distributions formed from sedimentary deposits by water that forms layers.

Geoelectric Data Interpretation

The interpretation of this data analysis is carried out from several field analysis data in a geoelectric cross-section. The results of this interpretation are presented in the form of a cross-section of type resistance, and a geoelectric interpretation of type resistance, as well as a map of the slip plane analysis of the subsurface lithological arrangement at the measurement site. To determine the lithology of rocks on the trajectory, data interpretation is carried out, the interpretation of this data goes through two stages, namely:

1. Qualitative interpretation

This interpretation was carried out to read a pattern of rock resistivity anomalies and then combined with the geology of the rock area and the data of the rock resistivity value, the result obtained from this interpretation is an overview of the subsurface geological structure of the research area.

2. Quantitative interpretation

This interpretation is carried out to analyze a resistivity anomaly pattern along a predetermined trajectory during qualitative interpretation. This interpretation is carried out based on the results of quantitative interpretation shadows. The results obtained are the anomalous parts of the subsurface geological structure that we want to interpret. In quantitative interpretation, there is ambiguity due to the variety of models that can be produced, which is due to the uncertain parameters of geometric factors, density of mass, and depth. Therefore, it is necessary to have supporting data in the form of geological data of the research area and other geophysical data.

Qualitative Interpretation of the Trajectories of the Research Area

According to the results of the correction of geological data, the research area is in a medium-high fracture. It is an inseparable layer that contains deep sea facies, namely well-layered pelagic limestone. In low-lying areas, the surface layer consists of a distribution of alluvial rocks formed from sedimentary deposits by water that forms the layer.

Quantitative Interpretation

1. Hurekama Village (WMX 1)

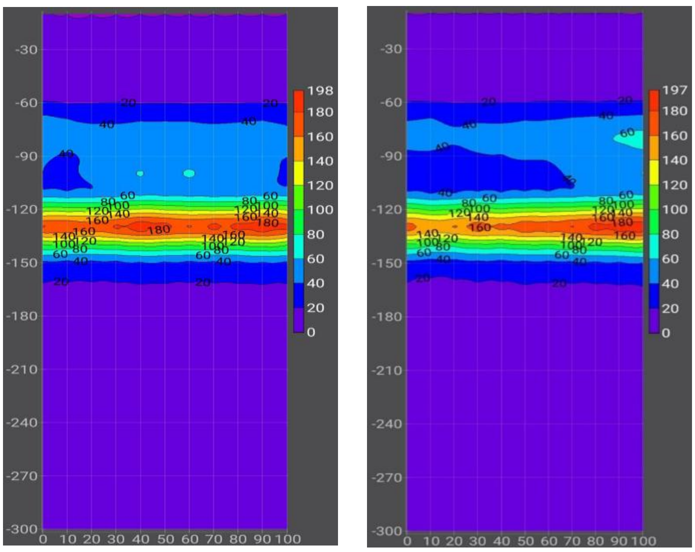

Figure 2 SEQ ARABIC 3 Stretch Pieces B1 & B2

The acquisition of Spans 1 and 2 of Hurekama village produced subsurface data as shown in figure 4.3. The results of the resistivity value readings in span 1 and span 2 show that at the geoelectric measurement location, there is a free aquifer at a depth of 0–60 m. Free aquifers are aquifers that are influenced by surface water sources such as rainwater and river water. This aquifer is greatly influenced by the weather, generally, free aquifers will have abundant water in the rainy season but decrease in the dry season.

The following aquifer layer is at a depth of 145 – 300 m. The presence of aquifers in the second layer has quite a large volume. The resistivity value of the aquifer in B1 and B2 is between 0 – 40 ohm, which is an aquifer of breccia rock with medium to high cracks.

The results of geoelectric measurements, lithological analysis, and resistivity values, showed that in all research locations, there were free aquifers with varying thicknesses ranging from 25 to 105 m calculated from the ground surface. Meanwhile, some locations such as Adventist clinics and free aquifer-like roads, are located 15-40 m from the ground level with a layer thickness ranging from 20-25 meters. This shows that the availability of surface groundwater in Jayawijaya Regency is quite high, except in the areas of Sabulama Village and Wasawa Village where there are no surface aquifers.

As for the depressed aquifer, it can be found at a depth varying between 145 – 270 m from the ground level with the thickness of the aquifer layer between 20 -65 m, with the deepest aquifer location found at the location of the cross monument, LMA, SD Kulitarek, Kampung Sabulama, Kampung Parema, and Kampung Wasama with the depth of the depressed aquifer at 245 - 270 m, while in other research locations the depth of the depressed aquifer is in the range of 145 – 165 m from the ground surface.

Aquifer Depth Distribution Map

The data obtained in the field are the location of the measurement points, the elevation of the groundwater level in two measurements, and the difference in the elevation of the groundwater level from the results of the geoelectric survey. Based on two measurement surveys conducted at the research site, there were differences in groundwater level elevation values. This is due to differences in hydrological conditions in each measurement survey. High rain intensity and long rain duration will increase groundwater level elevation. This event is part of the hydrological cycle, where groundwater is replenished from rainwater that enters the soil.

The data table of the survey results at the research site containing the groundwater level elevation is superimposed with the Survey Location Area Map, Wamena, Wesaput, and Hubukiak Districts, and the Wamena District Road Network Map, thus producing a map of the distribution of measurement points.

After that, interpolation was carried out using the Inverse Distance Weighted (IDW) method. In this study, the shape of the groundwater elevation contour map (equipotential line) is smooth and regular, making it easier to describe. The groundwater level elevation contour map is used as the main data in making groundwater flow patterns at the research site. The groundwater flow pattern was created using a second measurement survey because the number of measurement points was greater and the contour of the groundwater level elevation spread throughout the Wamena, Hubikiak, and Wesaput Districts.

Geoelectric Longitudinal Layout and Pieces

The stratigraphic depiction of the subsurface soil layer in the longitudinal direction aims to obtain an overview of the location, depth, and distribution of the aquifer of each survey area. From the results of the depiction, it can be seen that the type of soil layer on the surface, the waterproof zone/layer which is the layer before the aquifer, the depth of the aquifer, the slope, and the location of the aquifer along the longitudinal cut plane. In general, the position of the aquifer is at a depth of more than 150 m below the ground level. For the next time, the depth and position of the aquifer can be seen in the image of the longitudinal cut of the geoelectric test results in the attachment of the following page.

Conclusion

Based on the results of geoelectric measurements, lithological analysis, and resistivity values, shows that:

In Jayawijaya Regency, there are free aquifers with varying thicknesses ranging from 25 – 105 m calculated from the ground surface. Meanwhile, in some locations such as Adventist clinics and free aquifer-like roads, they are located 15-40 m from the ground level with a layer thickness ranging from 20-25 meters. This shows that the availability of surface groundwater in Jayawijaya Regency is quite high, except in the areas of Sabulama Village and Wasawa Village where there are no surface aquifers.

Depressed aquifers, can be found at depths varying between 145 – 270 m from the ground level with the thickness of the aquifer layer between 20 – 65 m, with the deepest depressed aquifer locations located at the location of the cross monument, LMA, SD Kulitarek, Kampung Sabulama, Kampung Parema and Kampung Wasama, which are found at a depth of 245 – 270 m while in other research locations, the depth of the depressed aquifer is in the range of 145 – 165 m from the ground surface.

Based on the map of the distribution of the depth of the aquifer and the layout of the aquifer cross-section, the position of the free aquifer is evenly distributed in Jayawijaya Regency except for several data collection points where there are no free aquifers. As for the distribution of depressed aquifers in Jayawijaya Regency extending for the north-south areas as a result of geoelectric testing at the observation point in Sinakma sub-district – Jl. Bayangkara – PU Workshop The pieces of depressed aquifers are found at a depth of 140 – 160 m with the thickness of the aquifer layer between 40 – 150 m, while for the observation point of Kampung Sabulama – Kampung Parema – Kampung Waysaput – Jalan Pikhe, the depressed aquifer is in an elongated position with a depth of 160 – 270 m with a thickness of 20–140 m of aquifer layer. For the northwest of Jayawijaya Regency, namely Jl. Pike – Jl. JB Wenas – Jl. Patimura, the distribution of the aquifer is evenly depressed along the track with an aquifer depth between 160 – 300 m. The east-west cross-section of the Sabulama village – LMA office yard shows the distribution of depressed aquifers with a small volume, the trajectory of the LMA-Sinakma Village office yard begins to show an increase in the volume of depressed aquifers, and the volume of aquifer distribution is evenly distributed in the slopes of Sinakma Village-Sinakma Old Regional Government with a depth of 140 – 300 m.

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