Geoelectrical Resistivity Methods as Basic Data for Development of The Quality of Groundwater Resources in Samboang Beach, South Sulawesi

Rahmat Hidayat, Sabrianto Aswad, Syamsuddin
Geophysics Study Program, Hasanuddin University

rahmatgeophysics@yahoo.com

Abstract

Bulukumba regency was covered with limestone zone, include Samboang Beach areas. Quality of groundwater was a serious problem at there, especially in dry season. A number of factors can affect the quality of a groundwater resources, such as contamination by saltwater intrusion. A 2D geoelectrical resistivity method was used for detecting and mapping occurrence of salt water in subsurface, Samboang Beach – South Sulawesi. The geoelectrical survey made up of line survey along 180 metres using Wenner configuration. The zone of brackish water is very clearly seen in the resistivity inverse model with position around 3.75 – 9.26 metres. This aquifer is referred to second aquifer. As the final result, a map with the possibility of salt/brackish and fresh water interface can be generated.

Keywords: Bulukumba, Brackish Water, Samboang Beach, Wenner Configuration.

Introduction

Water is among the nation’s most important natural resources, especially fresh water. It provides drinking water to urban and rural communities, supports irrigation and industry, sustains the flow of streams and rivers, and maintains riparian and wetland ecosystems. The importance of groundwater for the existence of human society cannot be overemphasized. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions.

A number of factors can affect the quality of a groundwater reservoir, such as contamination by saltwater intrusion or by toxic industrial chemic waste (Samsudin et al, 2007). These pollutants pose common environmental problems that have created the need to find suitable methods for monitoring the extent of such environmental damage (Bernstone et al, 1996).

The geoelectrical imaging method has been widely used in environmental and geotechnical investigation for more mapping of complex geological structures as it can delineate the resistivity distribution of such structures (Sultan, 2008). Geoelectrical imaging surveys aim to determine the physical properties on the plane delineated by injecting current along a different path and measuring the associated voltage drops.

In this paper, the efficiency of the geoelectrical imaging method in detecting salt/brackish-water within aquifer and investigating subsurface profiling is examined.

Geoelectrical Resistivity Theory

Geoelectrical resistivity is often first encountered in physics when discussing the resistance of an ideal cylinder of length L and cross-sectional area A of uniform composition. The resistivity \( \rho \) appears as the material-specific constant of proportionality in the expression for the total resistance of the cylinder,

\[
R = \frac{\rho \cdot L}{A} \tag{1}
\]

The total resistance \( R \) may be obtained experimentally through Ohm’s law, \( R=V/I \), where \( V \) is the potential difference between the ends of the cylinder and \( I \) is the total current flowing through the cylinder. Edge effects are not considered. The resistivity of the material, an intrinsic property of the material, is then related to experimentally measured extrinsic parameters by

\[
\rho = \frac{(V/I) \cdot (A/L)}{\text{K}} = R_{\text{app}} \cdot \text{K} \tag{2}
\]

In the second equation, the resistivity is given by the product of the apparent resistance \( R_{\text{app}}=V/I \) and a geometric factor \( K=A/L \), that carries information about geometry of the cylinder. This type of product of an apparent resistance and a geometry factor will appear again when the resistivity of the ground is determined.

For the Wenner array which is separated by equal intervals, denoted \( a \), the apparent resistivity is given by Telford et al., 1990:

\[
\rho_{\text{app}} = 2 \pi a (\Delta V/I) \tag{3}
\]

Methods

The purpose of geoelectrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. From these measurements, the true resistivity of the subsurface can be estimated. The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock.

The 2D electrical resistivity imaging surveys were performed at the proposed sites using the Geoelectrical
Single Channel Twin Probe Resistivity (G-Sound) resistivity meter (Fig. 1) and cables to which electrodes were connected at takeouts moulded on at predetermined equal intervals.

The Wenner arrays were used on Samboang Beach, Bulukumba Regency. The maximum line spreading was 180 metres in length. Data processing was conducted by a tomographic inversion scheme using the software RES2DINV (M. H. Loke, 2007). In this scheme, true resistivity distribution in the subsurface is obtained by a linearized least-squares inversion of apparent resistivity pseudosections acquired along profiles.

The result of geoelectrical resistivity data (after the processing) is presented in contour section of true resistivities (Fig. 2 & 3). In the section, the horizontal axis is the electrode spacing, and the vertical axis is the depth.

Results and Discussion

In Fig. 2, there was three model pseudosection such as measured apparent resistivity pseudosection, calculated apparent resistivity pseudosection, and inverse model resistivitv section. Value of the calculated apparent resistivity will be a start model for inversion process. This model will be compared with field data (measured apparent resistivity). If this value was very different, so this model will changed until near of field data.

In Fig. 3, this model had been included topography for every electrode and by resistivity contour subsurface model showed that the subsurface layer have influenced by intrusion of sea water. It was very clearly on model that have resistivity values between 0.12 – 2.62 Ωm in the layer of near surface. After that, dominant rocks in this research area is limestone. It was looked from resistivity model that showed resistivity values between 28.1 – 9154 Ωm. Vegetation around area measurements was grasses and coconut trees.

Resistivity model at distance between 125 – 170 metres showed that there was weathering zone of limestone because in their surface was alluvium. Maybe caused by weathering process of limestone and trees on this area.

Conclusion

Geoelectrical imaging method is very useful for subsurface and groundwater investigation in the study area. The zone of brackish water is very clearly seen in the resistivity inverse model with the position of around 8 metres of depth. The subsurface profile is very clearly imaged using the geoelectrical resistivity method. It can image the subsurface with brackish/salt water zone. It also can be used to predict the pattern of subsurface profile.

References


Figure 1. Geoelectrical Single Channel Twin Probe Resistivity (G-Sound) resistivity meter

Figure 2. Resistivity model (without topography)

Figure 3. Resistivity Invers Model (include topography)