



Analysis the Effect of Physical Parameters on Groundwater Salinity in the KEK Mandalika Lombok

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Abstract

KEK Mandalika is located in a coastal area which is very vulnerable to changes in the quantity and quality of groundwater due to seawater intrusion. This study aims to detect the presence of aquifers (groundwater), seawater intrusion and analyze the effect of physical parameters to determine groundwater quality in the KEK Mandalika area. The physical parameters used are: resistivity, conductivity, Total Dissolved Solid (TDS) and salinity. The resistivity value was obtained using the geoelectric resistivity method with 10 lines using a dipole-dipole configuration, while the other parameters were obtained through 10 samples of well water which were located adjacent to the geoelectric line. Resistivity geoelectrical data processing using *Res2Dinv software*, *Surfer13 software* to observe the spread of each parameter and perform regression analysis to see the effect of resistivity, conductivity, TDS on salinity. The results obtained are geoelectric resistivity in the form of an aquifer layer around the KEK Mandalika at a depth of (2 – 12) meters with resistivity values ranging from (0 – 2257) Ω m. The results of groundwater samples are: conductivity with values ranging from (1.02 – 20) mS/cm, TDS with values ranging from (67.3 – 3070) mg/L and salinity with values ranging from (0.05 – 2.07) ppt. The effect of conductivity, TDS on salinity is directly proportional, while the effect of resistivity on salinity is inversely proportional. Most of the KEK Mandalika area is likely to experience seawater intrusion, especially in the Eastern region.

Keywords: Geoelectric resistivity; water physical parameters; seawater intrusion; KEK Mandalika

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INTRODUCTION

Water is one of the natural resources that are needed in life. Water generally includes groundwater and surface water (Amri, 2018). One of the most used water in life is shallow groundwater in the form of wells. Shallow groundwater is groundwater that is above the first impermeable layer which is not too deep below the surface (Rohmah et al., 2018). Therefore, shallow groundwater is easy to obtain but also easy to be contaminated by leaks or pollutants.

The KEK (*Kawasan Ekonomi Khusus*/Special Economic Zone) Mandalika is an area on the Southern coast of Lombok - Indonesia which is undergoing rapid development. One of the basic needs in the process of building and managing facilities is the availability of clean water. Geologically, this area is an alluvial land (Mango et al., 1994) which has high porosity so that it is easily contaminated with pollutants (Kazakis et al., 2016; Tomozawa et al., 2019; Laode et al., 2020). The problem that commonly occurs in coastal areas is the contamination

of groundwater with seawater, otherwise known as seawater intrusion. If intrusion occurs, groundwater will taste salty which will have an impact on changes in the quality and quantity of groundwater (Sunaryo et al., 2018; Indriastoni and Novi, 2014).

The existence or changes in groundwater due to seawater intrusion can be identified by investigating subsurface structures. The investigation can be carried out using geophysical methods, namely the geoelectric resistivity method. In general, this method utilizes the difference in resistivity of subsurface rocks. By using the geoelectric resistivity method, the position of the aquifer layer as a water carrier can be determined based on the resistivity value of the rock. This method is very popularly used in the fields of hydrology and the environment (Sunaryo et al., 2018; Susilo and Fitriah, 2018; Kamal et al., 2020; Santoso, 2018).

In addition to investigating the subsurface, changes in groundwater can be investigated using physical parameters such as conductivity, TDS (Total Dissolved Solid) and salinity (Khairunnas and Gusman, 2018; Hilmi et al., 2021). The physical properties of water are one of the parameters to determine water quality. This is because not all groundwater can be used to meet daily needs. Therefore it must pay attention to the parameters of water quality standards so that it is suitable for consumption.

Based on these problems, it is necessary to conduct a study to detect the presence of aquifers (groundwater) and seawater intrusion using the geoelectric resistivity method and analyze the effect of physical parameters such as conductivity, TDS and salinity to determine groundwater quality in the KEK Mandalika area.

METHOD

Research location

This research was conducted in KEK Mandalika, Pujut District, Central Lombok Regency. Geoelectric data retrieval of the dipole-dipole configuration was carried out for 10 lines. The line is made adjacent to the location of the well around the KEK Mandalika area to detect the presence of surface water aquifers. An overview of the research location is presented in Figure 1.

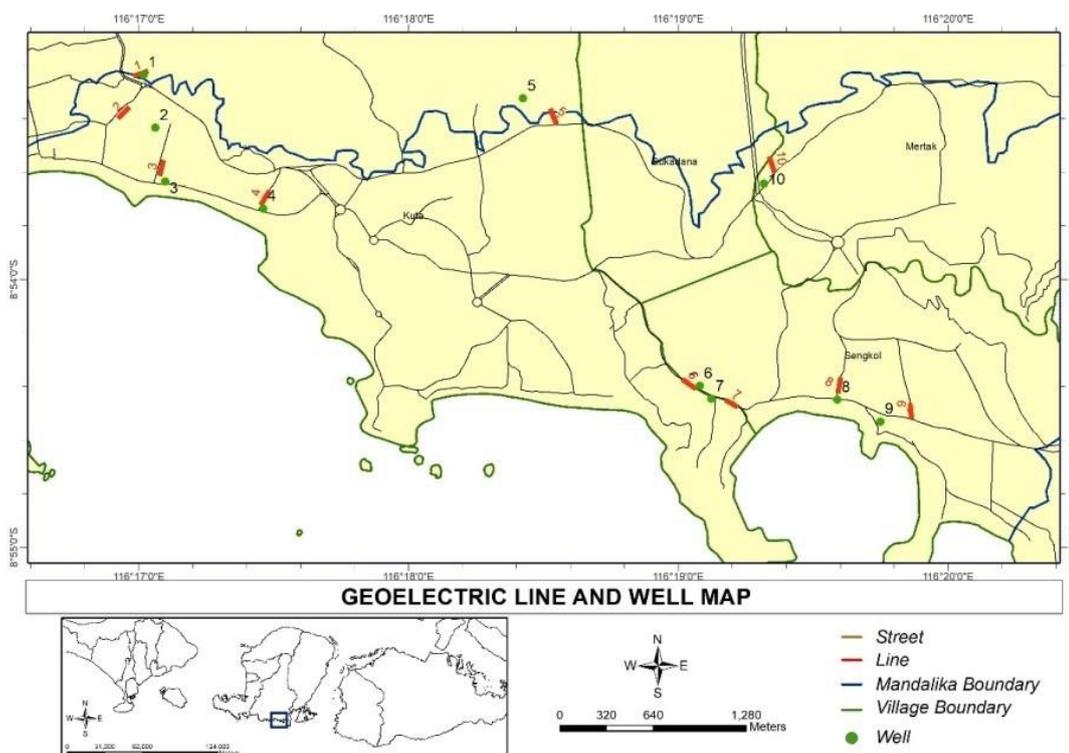


Figure 1. Research location

Groundwater sample analysis

Groundwater sample testing was carried out on 10 sample wells which were located close to the geoelectric resistivity lines, so that the analysis of the parameters could be correlated with each other. The physical parameters measured in groundwater samples are conductivity, TDS and salinity using an EC meter (Electrical Conductance) 9000 Model. The geographical position of the groundwater sampling location is presented in Table 1.

Table 1. Geographical location of research area

Nu.	Location	Easting	Northing	Well water level
1	Well 1	421203.8	9017297	3.89
2	Well 2	421314.4	9017171	2.93
3	Well 3	421382.1	9016801	2.7
4	Well 4	422048.3	9016615	3.2
5	Well 5	423806.9	9017375	4
6	Well 6	425016.1	9015402	2.5
7	Well 7	425098.5	9015343	1.9
8	Well 8	425951.8	9015309	2.1
9	Well 9	426247.3	9015143	2.4
10	Well 10	425506.6	9016958	2.1

Geoelectrical resistivity survey

The principle of the resistivity method is to inject electric current into the earth through current electrodes (C1 and C2) and the response is received in the form of an electric potential difference measured through a pair of potential electrodes (P1 and P2) (Obikoya and Bennell, 2012). From the measurement results in the form of electric current (I) and potential difference (ΔV), it can be obtained that resistivity variations in the layer below the measurement point (Khalil and Santos, 2013). Measurement of resistivity used a resistivity meter G-Sound Geocis 12x2 Volt battery with a line length of 120 meters. The electrode configuration used in the measurement is a dipole-dipole configuration. The advantage of the dipole-dipole configuration is very good for penetration depth and changes with time. The sensitivity of this method is high for the horizontal direction and medium for the vertical direction. Thus, this configuration is very good for horizontal mapping surveys (As'ari, 2016). This study used a space between the electrodes (a) 5 meters, and integers (n) 1-10. The electrode positions of the dipole-dipole configuration are presented in Figure 2.

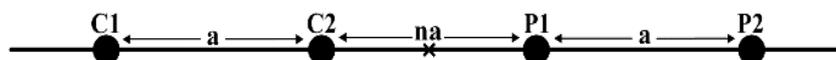


Figure 2. The position of dipole-dipole configuration electrode (Telford et al., 1990).

The geometry factor of the dipole-dipole configuration is shown in equation 1.

$$K_d = \pi n(n + 1) - (n + 2)a \quad (1)$$

The measurement results from the geoelectric resistivity method are apparent resistivity values. Pseudo-resistivity (ρ_a) is defined as:

$$\rho_a = \frac{\Delta V}{I} K_d \quad (2)$$

Where, ρ_a is the Pseudo-resistivity (Ωm), K_d is the dipole-dipole configuration, I is the current (Ampere), ΔV is the potential difference (Volt). Data processing using Res2Dinv software obtains the final result in the form of a cross-section of resistivity values that vary laterally with depth

Analysis of the relationship between variables

The results of the conductivity, TDS and salinity laboratory tests were then made a simple linear regression graph to see how closely the relationship between variables was. Linear regression is a measuring tool that is also used to measure the presence or absence of correlation between variables. Simple linear regression only involves two variables (variables X and Y) (Hasan, 2001), and the coefficient of determination is as follows.

Simple linear regression equation

$$Y = a + bX \tag{3}$$

Y = Dependent variable

X = Independent variable

a = Intercept

b = Regression coefficient or slope

Determination coefficient

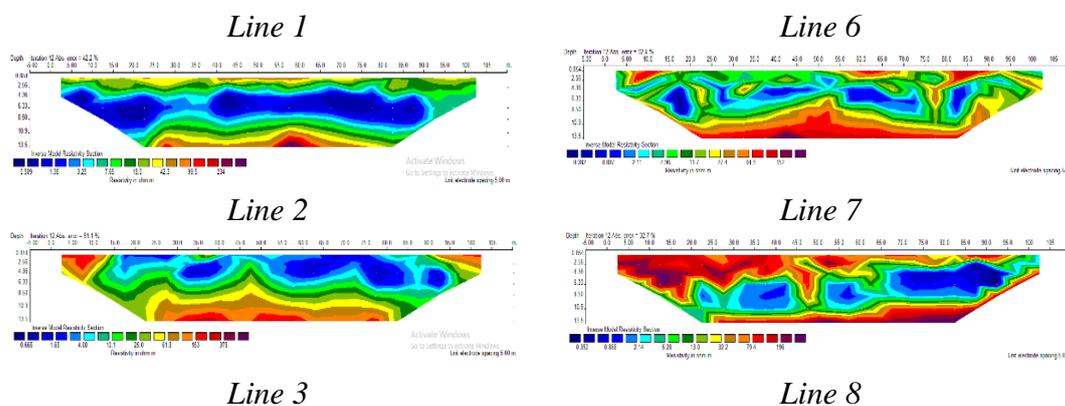
The determination coefficient (R^2) is part of the total diversity of the dependent variable (Y) which can be explained by the diversity of the independent variable (X). This coefficient is calculated by squaring the correlation coefficient. The interpretation of the coefficient of determination can be seen in Table 2 (Hastono, 2006).

Table 2. Interpretation of the determination coefficient (R^2) value

Nu.	R^2	Interpretation
1	0,00 – 0,25	No relationship/weak relationship
2	0,26 – 0,50	Medium relationship
3	0,51 – 0,75	Strong relationship
4	0,76 – 1,00	Very strong/perfect relationship

RESULTS AND DISCUSSION

One of the studies conducted is a geoelectric resistivity study for mapping the underground surface and groundwater sources (aquifers). The following is the result of Res2dinv processing for each line showing a 2D cross-section of the subsurface layer as shown in Figure 3.



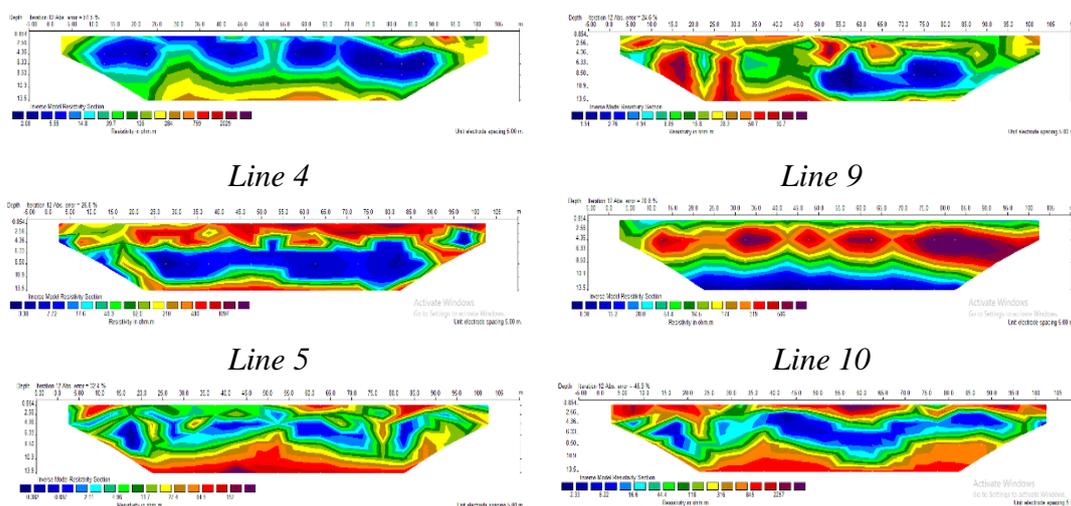


Figure 3. The Res2Dinv results (2D subsurface section)

Based on the results of Res2Dinv processing, the aquifer layer is located at a depth of (2 - 12) meters below the surface marked by light blue and dark blue with a resistivity value range between (0.5 - 16.6) Ωm . Then, the cross section of the aquifer layer is interpolated to form a distribution map to see the distribution of the aquifer, as revealed in Figure 4.

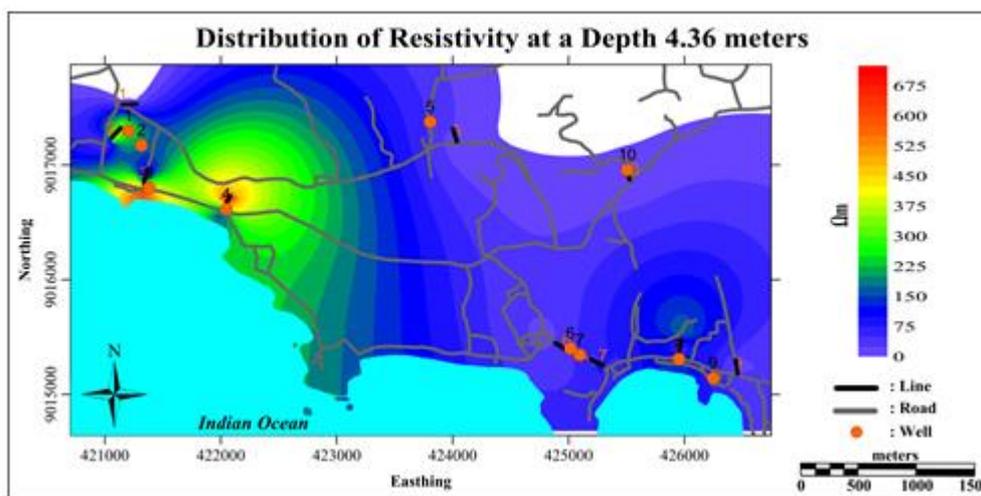


Figure 4. Distribution of resistivity

Based on Figure 4, it can be seen that the distribution of high resistivity values is located in the west, precisely on the 4th line marked with green to yellow colors with a resistivity value range (240 – 540) Ωm and decreases towards the east towards lines 6, 7, 8, 9 and 10 marked in dark blue with a range of values (60 – 240) Ωm . Some locations that have a fairly low resistivity value are located in the East region, this indicates that the East region has a fairly high intensity of seawater intrusion compared to the West region. The Eastern region is dominated by pond plains that have salt water pools.

In addition to the resistivity value using the dipole-dipole geoelectric method, measurements of TDS parameters, conductivity and salinity were also carried out to study seawater intrusion into the aquifer layer in KEK Mandalika and its surroundings based on well water samples. TDS is an indicator of seawater intrusion that shows the amount of dissolved solids in water, one of which is the amount of dissolved salt. Another parameter used to identify the type of water is conductivity, conductivity indicates the ability of water to

carry an electric current, the more dissolved salt content the higher the conductivity. The next parameter used in identifying the type of water is salinity. Salinity indicates the level of salinity that is affected by dissolved salt.

The results of this study indicate that groundwater quality varies at each well sample point. The highest concentrations of TDS, conductivity and salinity were found at sample points of well 9, which were 20 mS, 2.07 ppt and 3070 mg/L, respectively, the distance of sample point 1 from the shoreline was 139 m. While the smallest concentrations of TDS, conductivity and salinity were found at the sample points of Well 2, namely 1.02 mS, 0.05 ppt and 67.3 mg/L, the distance of sample point 1 from the shoreline was 463 m. The value of the complete well sample can be seen in Table 3.

Table 3. The results of well water samples based on physical parameters

Well	Conductivity (mS)	Salinity (ppt)	TDS (mg/L)
1	2.33	0.11	160
2	1.02	0.05	67.3
3	1.41	0.07	92.8
4	2.73	0.13	188
5	1.78	0.09	120
6	2.02	0.09	133
7	2.3	0.12	162
8	1.9	0.1	134
9	20	2.07	3070
10	1.8	0.08	118

The distribution of TDS parameter values, conductivity and salinity can be seen on the distribution contour map created using Surfer 13 software, as shown in Figure 5.

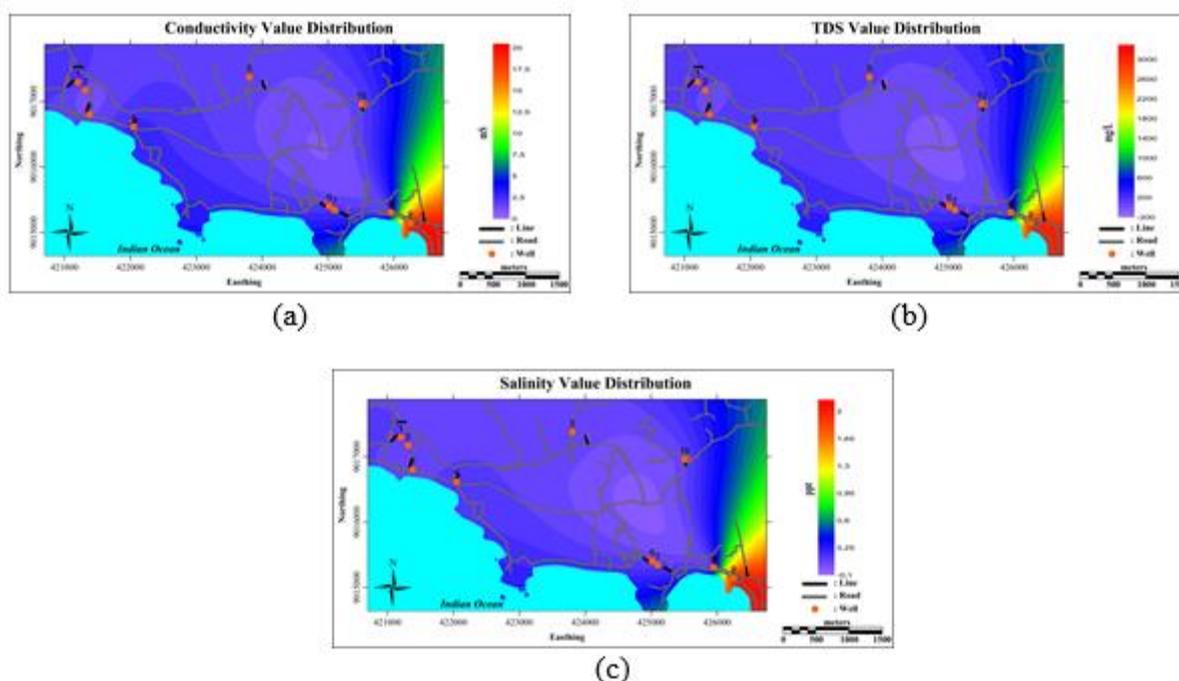


Figure 5. Parameter value distribution map; a) conductivity, b) TDS, and c) salinity

From the TDS contour map, the conductivity and salinity distribution can be seen visually to what extent the aquifers in the KEK Mandalika area and its surroundings are experiencing an intrusion process. Based on the map, it can be seen that the further away from the coastline, the color becomes green and indicates a lower TDS value. Areas with high TDS values are caused by the influence of seawater entering the aquifer which is quite

large. In accordance with the reality on the ground that the area with the highest value of the intrusion rate is the area that is directly opposite the sea.

Furthermore, to see the relationship between parameters, a simple linear regression graph was made. The results of linear regression analysis of the relationship between TDS, conductivity, and salinity are shown in Figure 6.

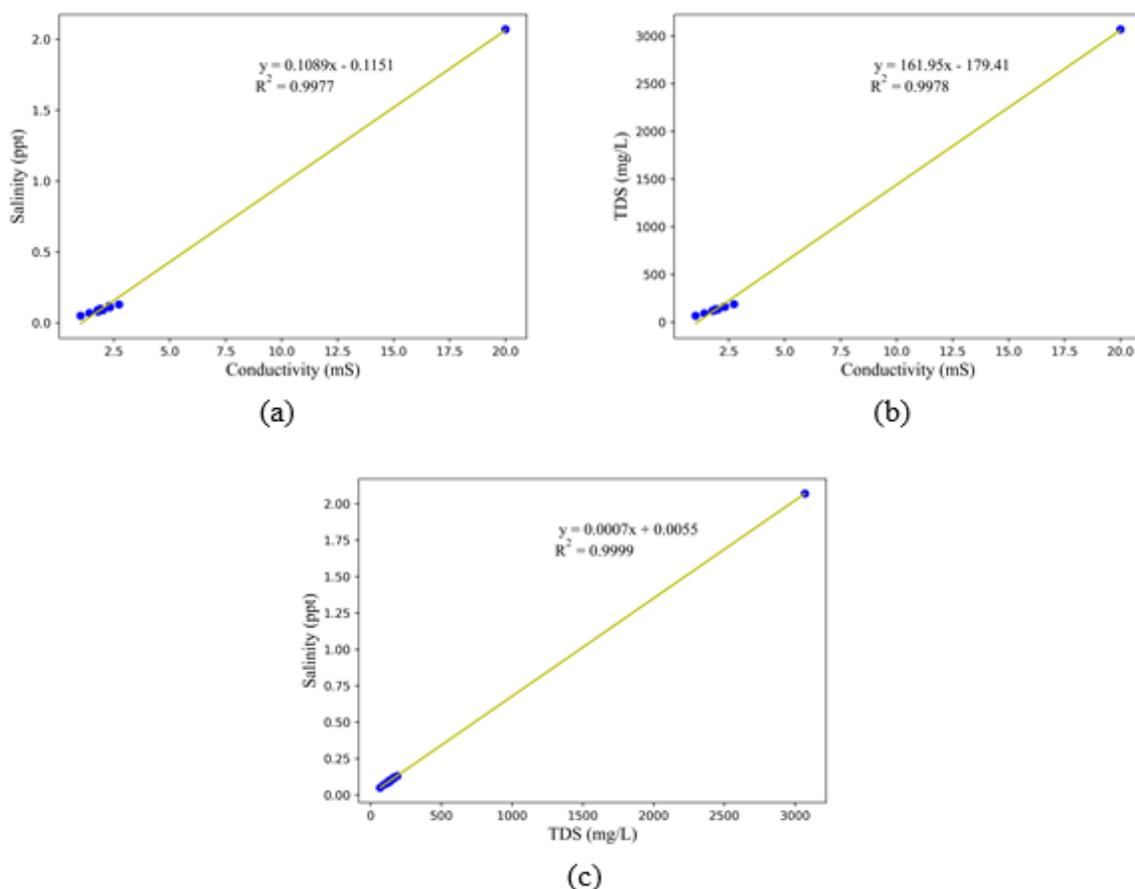


Figure 6. The results of linear regression analysis; a) correlation of conductivity and salinity, b) correlation of TDS and conductivity, and c) correlation of TDS and salinity.

Figure 6a is a graph of the relationship between conductivity and salinity. From the regression equation, the coefficient of determination (R^2) is 0.99668, which means that the conductivity value greatly affects salinity. The higher conductivity represents higher salinity, meaning that the salinity level is greater. Figure 6b shows the relationship between TDS and conductivity. The correlation between positive linear regression with the coefficient of determination (R^2) is 0.9978, indicating that the greater the conductivity value, the greater the TDS value. Likewise with Figure 6c which shows a graph of the relationship between TDS and salinity. The correlation between positive linear regression with a coefficient of determination (R^2) is 1, which means the TDS value greatly affects the salinity value (Khairunnas and Gusman, 2018). Higher TDS represents higher salinity value (concentration of ions/salts) (Nurrohman et al., 2012).

The comparison between the resistivity and salinity values was evaluated based on the comparison of the distribution of values in Figure 4 and Figure 5c. The correlation between the resistivity value and salinity is inversely proportional. If the resistivity value is high, the salinity value is low. This is in accordance with that obtained in the West region where the conductivity value is small which is indicated by a purple color with a range of conductivity values ranging from (1- 3.2) mS, TDS values ranging from (475 – 1150) mg/L, and salinity values ranging from (0 – 0.6) ppt and the larger towards the East region is marked in blue to

red with a conductivity range between (5.4 – 18.6) mS, for TDS values ranging from (1150 – 3175) mg/L and for salinity values ranging from (0.6 – 2) ppt.

CONCLUSION

Based on the results of resistivity geoelectrical data, the aquifer layer in the KEK Mandalika area is found at a depth of (2 – 12) meters below the surface and resistivity values range from (0 – 2257) Ω m. The results of the analysis of groundwater samples obtained conductivity values ranging from (1.02 – 20) mS, TDS values ranging from (67.3 – 3070) mg/L and salinity values ranging from (0.05 – 2.07) ppt. The effect of conductivity, TDS on salinity based on simple linear regression analysis is directly proportional. Meanwhile, the effect of resistivity on salinity is inversely proportional. Most of the KEK Mandalika area is possible to experience seawater intrusion, especially in the Eastern region.

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