

IDENTIFICATION OF SEA WATER INTRUSION IN COASTAL AQUIFER OF TUMPAT AREA, KELANTAN USING ELECTRICAL RESISTIVITY IMAGING AND GEOCHEMISTRY METHODS

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Abstract

The present research focuses on seawater intrusion into groundwater in parts of Tumpat. Tumpat is to known city near to the shore line which is famous for coastal activities. Geologically the area is mainly comprised of quaternary alluvium all along coastal areas. In present study the integrated approach is applied using Electrical Resistivity Imaging (ERI) for 200 meter line and data collected using ABEM Terrameter LS with 42 electrode, 5 meter spacing and data process using software RES2DINV. The chemical methods which include insitu test (Salinity, TDS, TSS, Turbidity EC and pH) and laboratory experiments such as AAS and titration for chloride concentration in five well locations. Total five survey lines were conducted by applying Pole dipole and Wenner configuration. Based on resistivity profile, all five location of survey line showing seawater intrusion at approximately 30 meter depth. From the insitu chemical result, location 1 shows high salinity value owing to the proximity of the location near to the shore line.

Keywords: Seawater Intrusion, Resistivity, Chemical Parameter, Tumpat, Kelantan.

Introduction

Groundwater resources become demand of people living in Northern part of Kelantan. However, there are various groundwater pollution might affect health of them. The most crucial problems including seawater intrusion within groundwater aquifer. In coastal area, saline invasion is commonly happen and become major problem [1]. The present study for identify seawater intrusion was done by both geochemical test and geophysical survey in parts of Tumpat, Kelantan (Fig 1). Electrical Resistivity Imaging (ERI) is used to identify saltwater intrusion. The salinity sources and water intrusion easily identify by using

geophysical and geochemical.

Saltwater intrusion study take place in Tumpat town along with neighbouring location. There are five selected location for geochemical test and another five selected location for ERI survey along the shore line. This research is important for the people especially who are using groundwater as the main source of water. Peoples who is living in Northern part of Kelantan totally depend on groundwater for daily uses [2] and mostly using open well or dug well.

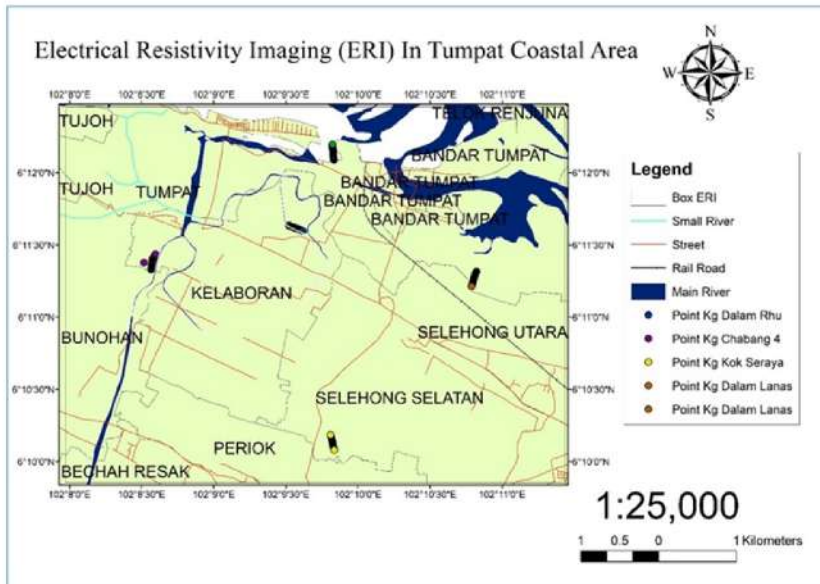


Figure 1. Sampling location map

Materials and Methods

The integrated method were used to determine groundwater quality and pollution. There are Electrical Resistivity Imaging (ERI) and Geochemistry. By combining these two methods, saltwater intrusion can be analysed accurately.

ERI method is beneficial because it can provide data beneath earth surface. For these survey. There are total five line survey in different location and distance from shore line. 200 meter line of survey data collected by using ABEM Terrameter LS associate 42 electrode,

42 clips, 2 main ERI cable with 5 meter interval clip. The data were processed by using Terrameter Toolbox and RES2DINV software.

Geochemistry test involved insitu and laboratory test. Physiochemical parameter were obtained which include salinity, EC, pH, TDS, turbidity. In situ test such as Salinity, TDS, Turbidity EC and pH. In addition, laboratory test also been done for Iron, Manganese, Copper, potassium and chloride.

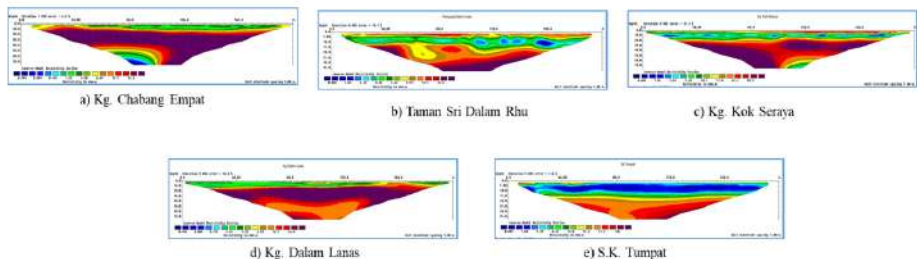


Figure 2. Result section of all locations. (a) Kg. Chabang Empat, (b) Taman Sri Dalam Rhu, (c) Kg. Kok Seraya, (d) Kg. Dalam Lanas, (e) S.K. Tumpat

Table 1. Summary of result and interpretation of all survey line location

No.	Location	Summary result
a.	Kg. Chabang Empat	0.190-0.380 ohm is suspected as saline water. 1.52-24.3 ohm suspected fresh water associated with saline water. 1.52-24.3 ohm is suspected as clay/sand/alluvium sediment. Saline intrusion in 60-70m depth. Configuration: Pole – dipole.
b.	Taman Sri Dalam Rhu	All showing intrusion. 0.846-5.37 ohm is low saline intrusion with depth 0-15 m and associate with surface water. 8.53-21.5 ohm is clay material associate with saline intrusion from low to high intensity. Depth 15-35m alluvium sediment associate with salt water. No fresh water. Configuration: Schlumberger.
c.	Kg. Kok Seraya	0.668-20 ohm is suspected as salt water from low to high intrusion with depth 0 – 20 m. clay particle with salt water found in depth 20-30m with 5.34-21.4 ohm. 85.5 ohm show fresh groundwater and may associate with clay sediment/alluvium with depth 30 to 70m. Configuration: Pole – dipole.
d.	Kg. Dalam Lanas	0.195-20 ohm show saline intrusion. 1.56-24.9 ohm suspected as sand/clay with saline water. No fresh water until depth 70m. 20.70m is may be clay and alluvium with saline intrusion. Configuration: Pole – dipole.
e.	S.K. Tumpat	No saltwater intrusion of ground water aquifer. Resistivity value 0.801-103 ohm. 0.801-20 ohm within depth 0-20m is surface saline water. Clay exhibit in depth 20 -35m with 25.6-103 ohm. Fresh water with alluvium can be found in depth within 25 – 35m with 51.3-103 ohm. Configuration: Schlumberger.

Result of insitu test

Figure 3 show graph of in situ analysis of all open well in different location and Table 2 shows result of insitu test.

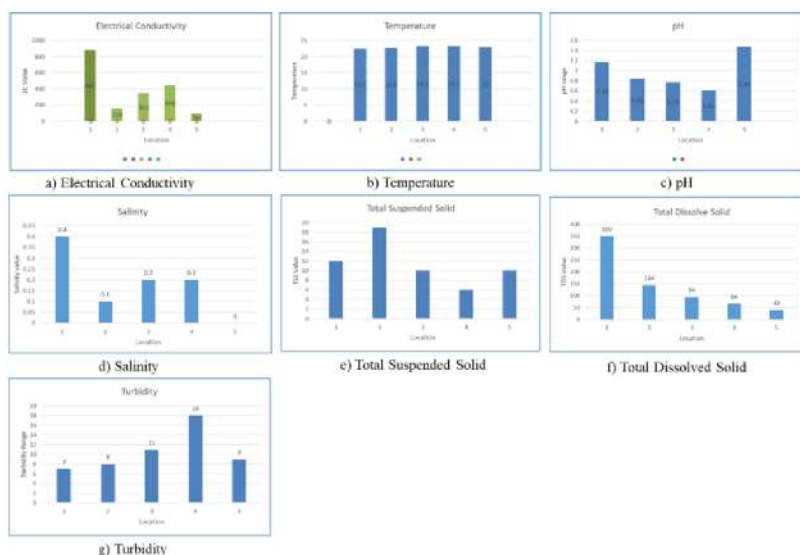


Figure 3. In situ test result of all location. (a) Electrical Conductivity, (b) Temperature, (c) pH, (d) Salinity, (e) Total Suspended Solid, (f) Total Dissolved Solid, (g) Turbidity

Table 2. Result of insitu parameter

No	Location	Electrical Conductivity (μS/cm) (750-2000)	Temperature (°C)	pH (5.5-9.0)	Salinity (ppt) (0.15-1.0)	Total Suspended Solid (50) (mg/L)	Total Dissolved Solid (1500) (mg/L)	Turbidity (NTU) (50)
1.	Kg. Jubakar Pantai	887	22.5	7.18	0.4	12	350	7
2.	Pekan Tumpat	343	23.2	6.77	0.2	10	144	8
3.	Kg. Chabang Empat	446	23	6.61	0.2	6	94	11
4.	Kg. Kelong	159	22.8	6.84	0.1	19	66	18
5.	Kg. Kok Seraya	94	23	7.48	0.0	10	40	9

Result of trace elements

Figure 4 show distribution of trace element of open well in five different location and chemical concentration of few ions is given in table 3.

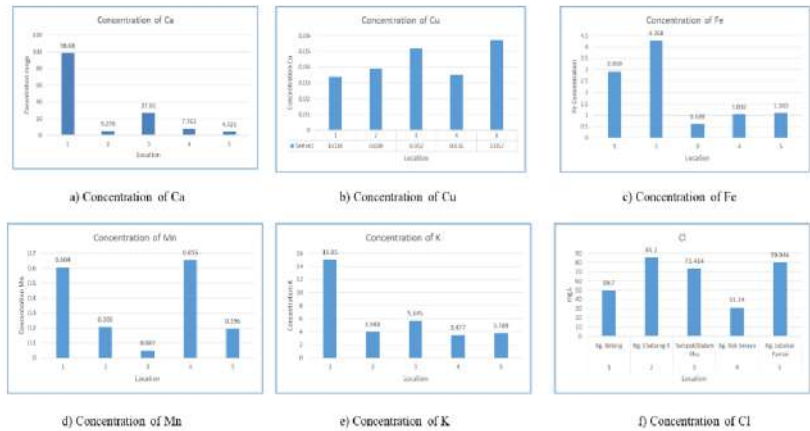


Figure 4. Distribution trace element result of all location. (a) Concentration of Ca, (b) Concentration of Cu, (c) Concentration of Fe, (d) Concentration of Mn, (e) Concentration of K, (f) Concentration of Cl

Table 3. Result of chemical concentration

No.	Location	Cu ²⁺ (mg/L) (1.0)	K ⁺ (mg/L) (30)	Mn ²⁺ (mg/L) (0.2)	Ca ²⁺ (mg/L) (200)	Fe ²⁺ (mg/L) (1.0)	Cl ⁻ (mg/L) (250)
1.	Kg. Jubakar Pantai	0.034	15.05	0.604	98.68	2.919	79.946
2.	Pekan Tumpat	0.039	3.983	0.205	5.276	4.268	73.414
3.	Kg. Chabang Empat	0.052	5.645	0.047	27.01	0.599	85.2
4.	Kg. Kelong	0.035	3.477	0.655	7.763	1.032	49.7
5.	Kg. Kok Seraya	0.057	3.798	0.196	4.521	1.103	31.24

Discussion

Generally, all the results from resistivity survey showing seawater intrusion. However, pole dipole configuration able to determine result of seawater intrusion into groundwater aquifer. Schlumberger configuration able to capture result of saline intrusion of surface water and first layer aquifer. Table 1 shows result of saltwater intrusion in 5 different location of survey line. In general resistivity value of seawater in alluvium is 0.2 ohm until 20 ohm and fresh water is about 50 until 150 ohm. Fresh water can easily be found in second aquifer with depth 30 meter and below. Second layer of aquifer contain depth of 20 meter and below [3]. The result shows seawater intrusion into all groundwater aquifer in first aquifer of Kg. Dalam Lanas and Kg. Chabang Empat showing high seawater invasion with resistivity value is more than 0.190 and 0.195 ohm. However, distance of Kg. Chabang Empat from shore line quite far than Kg. Dalam Lanas indicate the area is intruded by seawater massively. Depth of intrusion is 60 -70 meter in case of Kg. Kok Seraya which shows low resistivity value which is about 0.8 ohm. However, seawater intrusion can be identified in all locations in first layer of aquifer associate with gravel, sand and clay sediment.

In addition, the purpose of groundwater quality analysis were also performed in the locations which was close to resistivity survey line and this analysis supported resistivity result. Few insitu parameters analysed such as EC, pH, salinity, TDS and turbidity. Electrical conductivity values shows higher in Kg. Jubakar Pantai which is 887 micro siemen per centimetre. This is because the distance of the open well from shore line is to close and also similar results shows in S.K Tumpat. Kg. Chabang Empat and Bandar Tumpat. The pH value varies from 7.48 to 6.61 which basic to

acidic. Human activities such as agriculture affect pH value along with precipitation and infiltration during raining season when aquifer become recharge. However, all the values still in safe range and suitable to use. Another important parameter is salinity that measure how much groundwater affect by seawater. Salinity in Kg. Jubakar Pantai showing highest value which is 0.4 ppt among all location of open wells as the location is close to shore line with depth of open well around 3 meter. Bandar Tumpat and Kg Chabang Empat showing least saltwater intrusion as the location quite far from shore line. However, resistivity survey from Kg Chabang Empat showing high saline intrusion in depth of 60 until 70 meter which is second and third layer aquifer. The value of TDS show high in Kg. Jubakar which is 350 mg/L and Kg. Kok Seraya has the lowest value which is 40 mg/L. In addition turbidity also measures which shows high in Kg. Kelong around 18 NTU. This high turbidity values probably mostly of the wells are always open and not properly covered.

Some other parameter also analysed such as Cu, Fe, Mn, and Cl. The concentration of copper in all locations within permissible limit. Iron concentration in all location is too high and exceed permissible limit which is 1 mg/L. Bandar Tumpat shows highest value which is 4.268 mg/L followed by Kg Jubakar that is 2.919 mg/L. Others location is 1.0 mg/L. Based on iron concentrations the water from these wells not suitable for drink purpose. Manganese concentrations also shows high which is 0.65 mg/L in few locations and this concentration is beyond permissible limit that is 0.2 mg/L. The concentration of chloride in Kg Jubakar and Kg. Dalam Rhu shows 85.2 and 79.95 mg/L respectively. These high values probably the location is near to shore line.

Acknowledgements

The authors are gratefully acknowledged to all staff of Faculty of Earth Science, Universiti Malaysia Kelantan for providing the facilities to carry out this research.

The financial assistance is received from Fundamental Research Grants (R/FRGS/A08.00/00644A/002/2015/000228 and R/FRGS/A0800/00644A/003/2018/00556) is highly acknowledged.

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