

EVALUATION OF SEAWATER INTRUSION IN SHALLOW AQUIFER OF KEMUMIN, KOTA BHARU USING INTEGRATED GEOPHYSICAL & GEOCHEMICAL METHODS

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Abstract

This study focuses on evaluation of seawater intrusion in shallow aquifers of Kemumin, Kota Bharu that is located near the shoreline. Seawater intrusion in shallow aquifers can pose serious issue as it can cause contamination of groundwater. Therefore, integrated approach is applied using Electrical Resistivity Imaging (ERI) method which include using ABEM Terrameter LS of 200 meter line with 41 electrodes and 5 meter spacing to produce a 2D imaging of the subsurface using RES2DINV software. The aforementioned method was integrated with in situ geochemical analysis to gather data with the parameters such as pH, temperature, salinity, turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Electrical Conductivity (EC) and laboratory analysis using Atomic Absorption Spectroscopy (AAS) and titration analysis at five well locations. A total of three resistivity survey lines were conducted by applying Wenner, Schlumberger and Pole-dipole array. Based on resistivity profile, only two locations of survey line showing seawater intrusion at approximately 5 to 20 meter depth. Based on salinity results, the samples collected near the shoreline (AT1, AT3, AT7 and AT8) show high salinity values but based on other chemical parameters all the groundwater samples are safe to use and within the permissible limit of the National Guideline of Raw Water Quality Standards by Ministry of Health, Malaysia.

Keywords: Seawater Intrusion, Shallow Aquifer, Kelantan.

Introduction

Seawater intrusion is a type of groundwater contamination especially near the shorelines area or coastal aquifers by interfering its chemical equilibrium and physical properties. The essential hindering impacts of seawater intrusion are decrease in the accessible freshwater supply volume and tainting of production wells, whereby under 1% of seawater (approximately 250 mg/L chloride according to world health organization [1] which renders freshwater unsuitable for drinking. Currently, total groundwater consumption is 134

MLD, which represents about 41% of total water production in the water treatment plants of AKSB. The 2.5 percent increase per year suggests that demand for potable groundwater would be around 210 MLD in 2020, rising to 270 MLD in 2030 (Rainhill Consulting Sdn. Bhd., 2011). Due to this, it is imperative to monitor the seawater intrusion into freshwater aquifer as it causes a decline in the quality of the groundwater according to appropriate standard usage

Materials and Methods

This preliminary study were done around in Kemumin, parts Kota Bharu, Kelantan (Fig 1) and focus lectrical resistivity and chemical parameter. The electrical resistivity imaging was conducted using ABEM Terrameter SAS 4000 where 41 electrode were arranged in a straight line and connected to a multicore cable. The field survey was conducted along three profiles where the length of each profiles is 200 m with an electrode spacing of 5 meter. The data then were processed using RES2DINV software to obtain two-dimensional (2D) resistivity profiles

for interpretation. In addition, in-situ hydrochemical analysis were also performed in order to monitor a few physical parameters such as EC, TDS, TSS, temperature, pH, turbidity, salinity as well as laboratory analysis using Atomic Absorption Spectroscopy (AAS). data and also in situ chemical parameters data collected to support the results obtained by the ABEM Terrameter LS. This is all part included in the integration of methods used to complete these investigations.

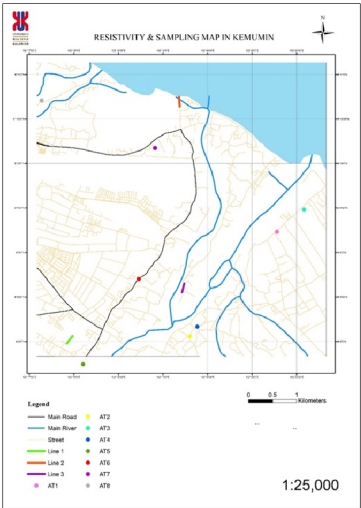


Figure 1. Sampling Location map

Results

Resistivity Surveys

Three survey lines were conducted to represent seawater intrusion. All lines are given below.

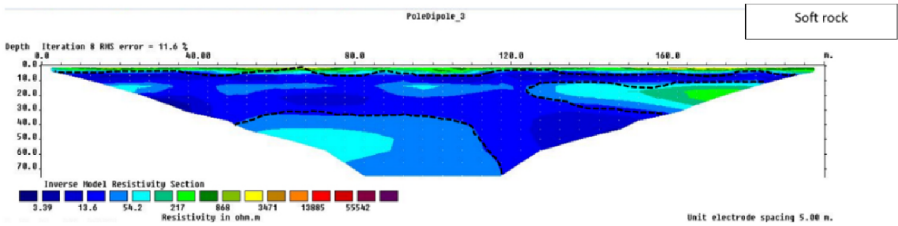


Figure 2. Resistivity survey line 1

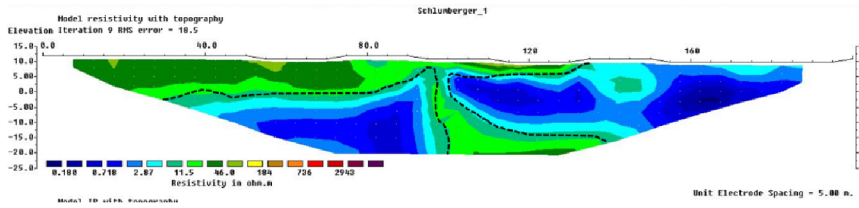


Figure 3. Resistivity survey line 2

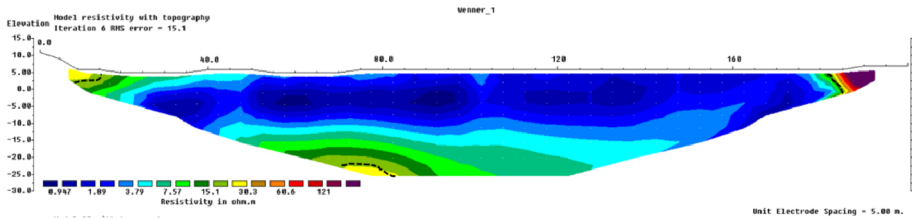


Figure 4. Resistivity survey line 3

Figure 2 shows minimum resistivity value in this survey line is 3.39 Ωm and the highest value is 55,542 Ωm with depth of about 70 meters. Based on the resistivity value shown, there is saline water presence as the minimum value of resistivity below than 20 Ωm . It means that groundwater already started to turn saline even though the area is far from the shoreline and this intrusion probably due to high amount of groundwater extraction.

Minimum resistivity value in Figure 3 shows in survey line 2 is 0.18 Ωm and the highest value is 2,943 Ωm with depth of about 20 meters.

Based on result in Figure 2, there is saline water presence as the minimum value of resistivity was below than 20 Ωm . This value indicate the range of saline water intrusion for 0.18 Ωm to less than 20 Ωm . Based on this value, the aquifers already contaminated.

Minimum resistivity value in survey line 4 is 0.947 Ωm and the highest value is 121 Ωm with depth of about 25 meters. Based on the Figure 3, there is small value from 0.947 Ωm shows of saline water presence as the minimum value of resistivity was below than 20 Ωm .

In Situ Chemical Parameters

All water samples analysis results given in Table 1, 2 and 3.

Sample Name	Type of water sample	Latitude, N	Longitude, E	Elevation above sea level	Distance from shoreline
AT1	Boring well	6.153852	102.3379	5 m	1.9 km
AT2	Boring well	6.13429	102.321725	9.7 m	4.24 km
AT3	Boring well	6.158035	102.343035	14 m	0.9 km
AT4	Dug well	6.136083	102.323089	5.5 m	4.05 km
AT5	Boring well	6.129023	102.301557	9.9 m	5.90 km
AT6	Dug well	6.145016	102.312147	7.5 m	3.85 km
AT7	Dug well	6.169551	102.315189	6.6 m	1.28 km
AT8	Boring well	6.178448	102.293969	6.0 m	1.15 km

Table 2. In situ physical parameters of collected water sample in study area

Sample	pH range	Temperature, °C	TDS, mg/L	TSS, mg/L	Turbidity	Salinity, ppt	EC, $\mu\text{S}/\text{cm}$
AT1	6.75	20.4	453	169	5.67	6.2	99
AT2	7.2	19.7	514	40	4.87	7.2	112
AT3	6.52	30.57	103	179	0.47	8.1	159.8
AT4	5.81	31.24	102	122	9.9	0.1	156.9
AT5	5.93	33.61	142	135	8.79	0.1	219.6
AT6	6.19	30.33	321	20	9.99	0.2	494.0
AT7	4.2	31.66	951	178	0.47	5.8	146.2
AT8	6.54	31.71	156	67	1.86	5.3	241.1

Table 3. Chemical concentrations of groundwater samples in mg/l

Sample	<i>C u</i> ⁺	<i>F e</i> ⁺	<i>K</i>	<i>M n</i> ⁺	<i>N a</i>	<i>C l</i>
AT1	0.031	1.384	3.199	0.040	5.360	47.85
AT2	0.048	0.718	22.93	0.129	50.26	42.6
AT3	0.042	2.650	41.33	0.071	777.2	44.02
AT7	0.052	2.168	3.143	0.378	43.74	36.50
AT8	0.027	0.267	5.650	0.341	6.889	49.27

Discussion

Based on the in situ parameters, a few deductions can be made to justify the resistivity data. Total Dissolved Solids (TDS) of water samples around Kemumin, Kota Bharu varied from 453 mg/L to 514 mg/L with the average value of 362.25 mg/L and all samples within permissible limit of MOH. Among all the collected water samples, AT7 shows the highest value of 514 mg/L compared to other water samples. The amount of TDS in these samples varied may be affected by types of minerals that make up the aquifers, the length of time which water is in contact with the minerals and chemical state of the groundwater. Electrical conductivity (EC) in the study area recorded from 494 μ S/cm to 99 μ S/cm. AT6 shows the highest value which is 494 μ S/cm. The salinity values ranges between 0.1 to 8.1 ppt. AT3 recorded the highest value of salinity due to its very close distance to the ocean while AT4, AT5 and AT6 recorded the lowest value of salinity which are still within the permissible limit according to MOH.

Concentrations of iron in study area ranged from 2.65 mg/L to 0.267 mg/L. The average of the iron ions concentration was 1.437 mg/L. Based on Table 3, only samples number AT2 and AT8 showed iron below the permissible limit compared to other samples which exceeds more than 1.0 mg/L. High concentration of Fe

probably due to presence of old pipes used for plumbing that contaminates the groundwater.

Manganese ions concentrations in study area ranged from 0.04 mg/L to 0.378 mg/L with the mean value of 0.192 mg/L. Sample AT7 and AT8 show high manganese ion concentration which is more than permissible limit and it is not safe for drinking purpose. The high concentration of manganese ion are probably due to contaminants that seeps into the ground. The range of sodium ions concentration of water samples ranges from 5.36 mg/L to 777.2 mg/L with overall average concentration of 176.69 mg/L of sodium ions. As shown above, AT3 has the highest value of sodium ions which is 777.2 mg/L which is more than permissible limit that clearly shown seawater intrusion. This result also supported by other parameters such as salinity that also show high value in the same samples. Presence of chloride ions are the one of the best indicators to detect seawater intrusion as the main component of salt water is NaCl. Based on Table 3, all the samples are still within the permissible limit which does not exceed 250 mg/L and still safe for consumption. Based on resistivity data, the result shows there are indicators of seawater intrusion supported by geochemical result of groundwater samples.

Conclusion

As conclusion, a few groundwater samples are not safe and not suitable for usage of all purposes in daily life as the data collected was compared to the Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia. Based on the result obtained from Electrical Resistivity Imaging (ERI) survey, there is quite distinct border in which the seawater

and freshwater interface occurred at 2 to 3 kilometers from the shoreline. This statement can be justified by the resistivity profile shown in Survey Line 2 and resistivity survey line 3 show a small amount salinity presence inside its shallow aquifer which can be supported by data collected from nearest groundwater well (sample AT4 and sample AT6).

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