TIDAL EFFECTS ON GROUNDWATER CONTAMINATION AT PEKAN, PAHANG

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ABSTRACT

The meeting of coastal ground water and the sea is a unique and dynamic hydro geologic boundary phenomenon that has fascinated groundwater engineers and scientists for the past century. The variation of seawater level resulting from tidal fluctuations is usually neglected in regional groundwater flow studies. In this study the effects of seawater tidal on groundwater are investigated using geophysical together with conventional method. Comparative result between these two methods shown how tidal fluctuations effects groundwater in study area.

Keywords: tidal effect, groundwater, resistivity method, conductivity

INTRODUCTION

Tides are one of the most reliable phenomena in the world where the ocean waters will regularly rise and fall along our shores. Basically, tides are very long-period waves that move through the oceans in response to the forces exerted by the moon and sun. Tides originate in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface. When the highest part or crest of the wave reaches a particular location, high tide occurs; low tide corresponds to the lowest part of the wave, or its trough. The difference in height between the high tide and the low tide is called the tidal range. Effect from seawater tidal movement will influence the degree of salt-water intrusion and contaminant transport in groundwater.

The study area was located in the University Malaysia Pahang, Pekan campus (Figure 1). It was a reclaimed area situated at approximately 2 km distance from the shore. Geologically the study area (Fig. 2) is sited within the Quaternary sediment formations preliminary composed of marine and continental sediments which contain clay, silt, peat and gravel (Department of Mineral and Geoscience Malaysia, 1985).

Fig. 1. Location of study area from Google map

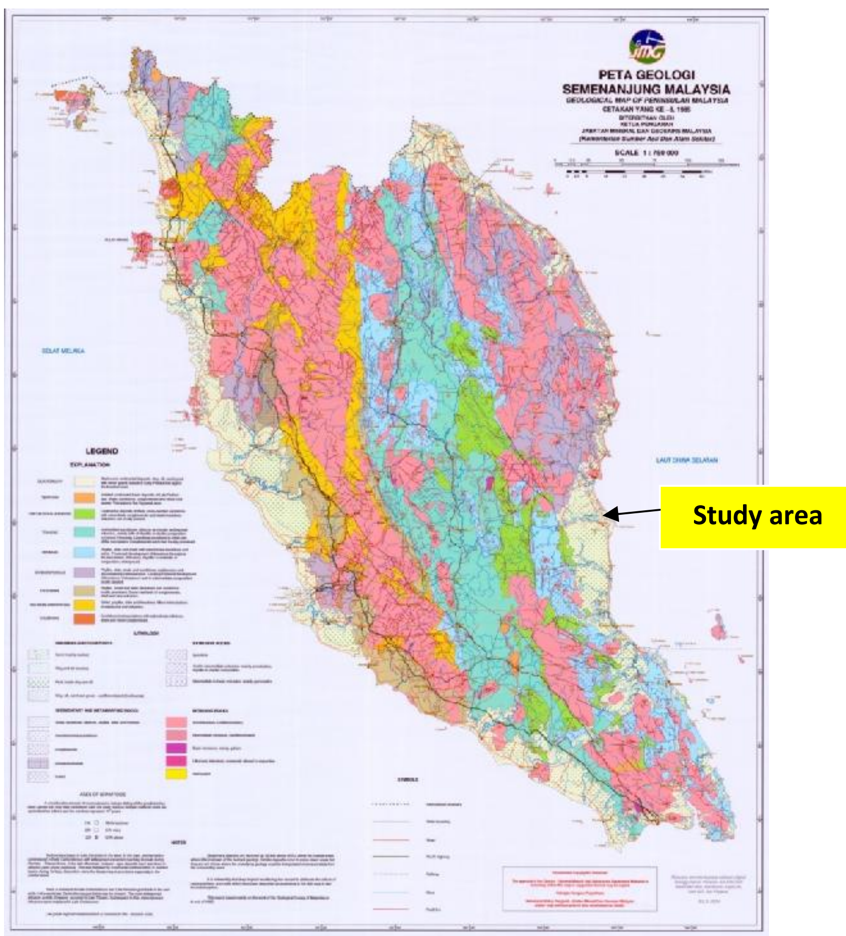

Fig. 2. Geological map of Peninsular Malaysia

The migration of saltwater into freshwater aquifers under the influence of groundwater development is termed as saltwater intrusion (Freeze and Cherry, 1979). Freshwater aquifers near the shore area may become saline due to sea level changes, reclamation of low-lying areas, fisheries activity and also tidal effect.

OBJECTIVE

The main objective of this study was to obtain reasonable assurance of tidal effect on saltwater intrusion in the study area. The electrical resistivity imaging (ERI) profile data of the ground subsurface were correlated with the variations of conductivity, salinity and total dissolved solids (TDS) data measurements of groundwater at two monitoring wells during high and low tide events. Base on the correlation between ERI and the physical parameter data variations, the volume of saltwater intrusion in the study area is most likely being affected by the fluctuations of sea level during tidal events. However, the results of this study could not be use to determine the cause of saltwater intrusion in the study area. Further study and investigation is needed in order to identify the possible sources and pathway of the saltwater intrusion.

METHODOLOGY

In this study, the ERI survey of the ground subsurface and in-situ physical parameter (conductivity, salinity and TDS) measurements of groundwater at two monitoring wells was conducted during both low and high tide events at the Sungai Pahang estuary. ERI is a survey technique designed for the investigation of areas with complex geology features; that involves the measurement of a series of resistivity profiles, using a computer program to control measurements between selected sets of an electrode array. The technique is very convenient and cost-effective for the measurement of resistivity profiles and delineating areas of different resistivity values. Since increasing separation provides information from increasingly greater depths, the measured apparent resistivity may be processed, to provide an image of true resistivity against depth. This technique was carried out to distinguish the resistivity value changes of material within the subsurface layer. This method is widely used to determine the depth and nature of an alluvium, boundaries and location of an aquifer and has been successfully being used in solving problems concerning groundwater issues such as in the determination of depth, thickness and boundaries of an aquifer (Zohdy, 1969 and Young et al., 1998), delineation of groundwater contamination zones (Rahman et al., 2004), delineation of groundwater aquifer (Umar et al., 2006).

The ERI method is based on the measurement of potentials between one electrode pair while transmitting DC between another electrode pair. ERI survey in field was conducted using Terrameter SAS 4000 system, LUND electrode selector system (ES464), multi-core cables and electrodes (60). The multi-core cables are rolled out and steel electrodes are connected to it at selected intervals, after which the data acquisition software automatically checks the electrode contact and scans through a pre defined measurement protocol (Dahlin, 2001). As the measurements are done automatically, configuration setting of the electrode array and others command has to be programmed according to the task considering depth of interest, data density and time spent.

In this study, Schlumberger's electrode arrays were applied and the arrangements of the array were shown below (Figure 3).

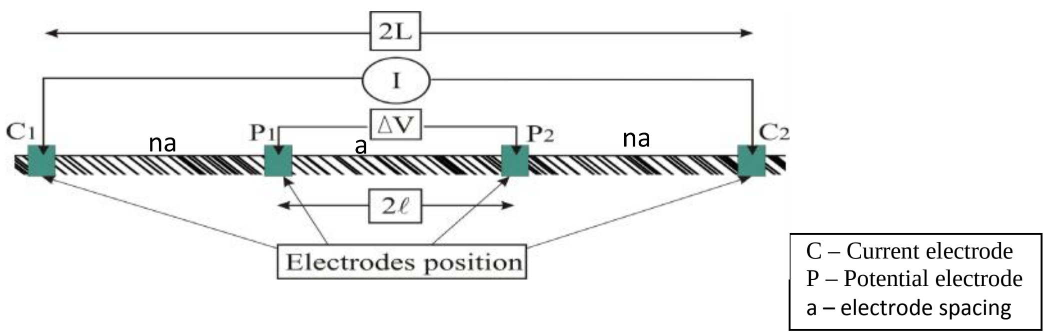

Figure 3: Schlumberger's electrode array

In this study, ERI method was performed twice during both high and low tide period. Both data was conducted on same survey line in order to record any variations in the resistivity profile measurements with respect to different tidal events. The physical parameter data (temperature, pH, salinity, conductivity, TDS etc.) of the groundwater at the two monitoring wells were measured using a portable multiparameter probe (HANNA HI9828). In this study, the conductivity, salinity and TDS values are selected for correlation study.

RESULT AND DISCUSSION

ERI profile results for UMP1 and UMP2 line survey of different tidal period

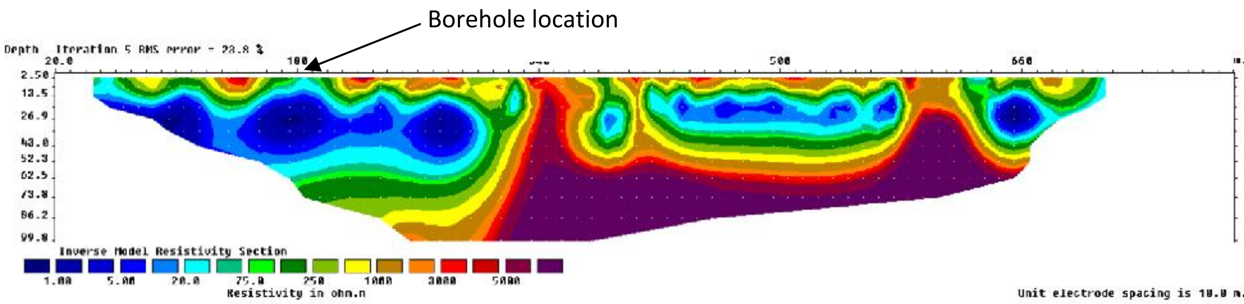

Fig. 4. ERI profile for UMP1

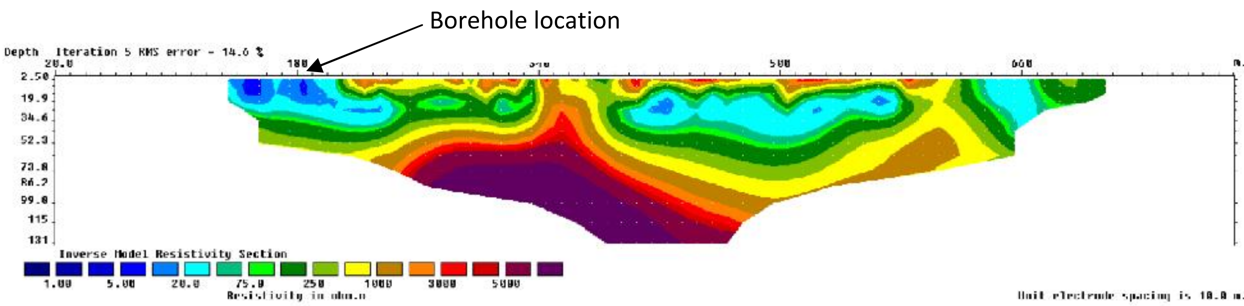

Fig. 5. ERI profile for UMP2

ERI profile survey for UMP1 was conducted during the high tide period while for UMP2; the survey was conducted during the low tide period. The tidal range magnitude during the survey was approximately 1.7 meter. The UMP1 profile (Fig. 1) result shows that the low resistivity value zone (< 30 Ωm) is located between 10 and 310 meter points of the survey line near the earth surface and within 10 to 60 meter depth level from the surface. The low resistivity value zone (± 20 Ωm) is apparent and consistent with the resistivity value of saltwater (Loke, 1999). Therefore, the ERI profile result for UMP1 indicates that, the seawater intrusion towards the mainland is most likely to occur during the high tide period. However, during low tide period, the low resistivity value zone located on the left side of the profile (Fig. 5) for UMP2 is relatively smaller compared to the UMP1 survey profile result. The reason for this is that, most likely, the volume of seawater intrusion moving towards mainland area during the low tide event is relatively smaller compared to the high tide event. Base on visual comparison, from both ERI profile, we can said that tides affect groundwater conditions in the study area.

The conductivity, TDS and salinity measurement of the groundwater were taken from two monitoring wells of different depth, shallow (UMP-A) and deep (UMP-B) boreholes. The *in-situ* measurements were recorded during both high and low tide period. The conductivity, TDS and salinity data of groundwater for the shallow borehole (UMP-A) indicates no significant difference for measurements taken during both tidal events (Table 1). However, the conductivity, TDS and salinity of groundwater at the deep borehole (UMP-B) recorded during high tide event is relatively higher compare to the low tide event (Table 2). This indicates that the saltwater intrusion is most likely to occur during high tide period in the deeper aquifer system in the study area.

Table 1
Shallow borehole UMP-A

Tidal event	Conductivity (µS/cm)	TDS (ppm)*	Salinity (PSU)**
High Tide (2.6m)	482	241	0.23
Low Tide (0.9m)	479	239	0.23

Table 2
Deep borehole UMP-B

Tidal event	Conductivity (µS/cm)	TDS (ppm)*	Salinity (PSU)**
High Tide (2.6m)	12612	6306	7.18
Low Tide (0.9m)	536	268	0.26

* partpermillion **Practical salinity unit

CONCLUSION

The ERI technique is one of the most effective geophysical methods for investigating the occurrence of saltwater intrusion. The preliminary result of the study shows that there is a possibility of saltwater intrusion in the deeper aquifer system of study area; however, due to limited data available we still cannot predict the source of this occurrence. Therefore, further study is needed in the future in order to understand more about the characteristic of the study area and also the source of saltwater intrusion.

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