Determination of Riverbed Filtration Potential as Water Supply Source using Geoelectrical Method

T B Mohamad Faizal1,2, A Mohd Nordin3, Y Nor Azizi1 and E Zaidi1

1Research Center for Soft Soils (RECESS), Institute Integrated Engineering, Universiti Tun Hussein Onn Malaysia 86400 Parit Raja Batu Pahat Johor Malaysia
2Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Hab Pendidikan Tinggi Pagoh, KM1, JalanPanchor, 84600 Panchor, Johor Malaysia
3School of Civil Engineering and Solid Waste Management Cluster, Universiti Sains Malaysia 14300 Nibong Tebal Penang Malaysia

Abstract. River bank filtration (RBF) is the influx of river water to the aquifer induced by a hydraulic gradient. Collector wells located on the banks in a certain distance from the river creates a pressure head difference between the river and aquifer, which induces the water from the river to flow downward through the porous media into the pumping wells. By applying this system of drinking water extraction, two different water resources are used where surface water from the river percolates towards the well; and groundwater of the surrounding aquifer is utilized. A study on the potential of RBF near the existing intake of Lembaga Air Perak at Sg Kampar was undertaken. Geophysical survey using resistivity traverses was made with 5 lines each on the right and left bank of the river. Three lines perpendicular and 2 lines parallel to Sg Kampar were investigated for possible water potential for RBF. The Wenner-Schlumberger configuration was chosen based on space provided in flatten areas and the depth of penetration interest in order to identify the presence of groundwater, stream-aquifer interaction and subsurface lithologies. Results from 2-dimensional profiles indicated that: (a) permeable soil saturated with water (possible groundwater and terrestrial sediments material) showed the resistivity value ranges of 0-150 ohm.m (b) semi permeable soil and weathered rock showed the resistivity value ranges of 200-1000 ohm.m and (c) impermeable soil and rock (unsaturated zone) showed the resistivity value ranges of 1000-7000 ohm.m.

1. Introduction
Geophysics study was conducted for determining the potential of using river bed filtration (RBF) system at water treatment plant of Kampar, Perak. The study was conducted as requested by Lembaga Air Perak (LAP) in order to determine the possibility of development RBF system for public water supply within this area. The geo-electrical method was used to determine the presence of groundwater, stream-aquifer interaction and as well as subsurface lithology [1,2]. The geo-electrical method indirectly compliments the conventional method such as borehole information, in order to correlate the lithology information and groundwater occurrence [3,4]. Furthermore, this method is more cost effective for subsurface investigations [4,5].
2. Methodology
The study area is located at the existing water treatment plant at Kampar, Perak. The exact location of the area was at longitudes E 101.164621° to E 101.162969° and latitudes N 4.371285° to N 4.372978°. From the observation, majority of topography in this area consists of flat area especially in flood plain of Kampar river and gradually elevated topography to the eastern direction.

Resistivity traverses were performed on 9th and 12th March 2018. The geo-electrical method that was carried out involved two-dimensional (2-D) imaging resistivity survey. The transverse survey distance was about 200 m which depends on the space provided in undulating area that was not more than 45 degree. The resistivity survey was conducted using the ABEM Terrameter SAS 4000, combined with ES 10-64 electrode selector. Eleven resistivity image profiles [L1(0m)-L1(200m), L2(0m)-L2(200m), L3(0m)-L3(200m), L4(0m)-L4(200m), L5(0m)-L5(200m), L6(0m)-L6(200m), L7(0m)-L7(200m), L8(0m)-L8(200m), L9(0m)-L9(200m), L10(0m)-L10(200m) and L11(0m)-L11(200m) see Figures 1] were measured across the area. For each profile, 61 electrodes were peg into the ground surface at the site. The survey traverses were oriented at N-S and W-E. The Wenner-Schlumberger array was used in this work. This array was chosen for the resistivity traverses because it gives a dense near-surface cover of resistivity data. Also, the array provides a good vertical resolution and can give a clear image of groundwater and sand-clay boundaries as horizontal structures [6]. The array was used for short distance of spacing in the area.

The data gathered in this survey were interpreted through the RES2DINV software to provide an inverse model that approximates the actual subsurface structure [7]. The starting model was then modified in such a way as to reduce the differences between the model response and the measured data. The differences were quantified as root-mean-squared (RMS) errors. This process continues iteratively until the RMS error falls within acceptable limits, usually below 10%, or until the change between RMS values calculated for consecutive iterations becomes insignificant [8]. The model with the lowest possible RMS errors, however, was not always the most appropriate one as it can show unrealistic variations in the resistivity model [9]. Finite difference method was used as the data includes topography.

Figure 1. Location of Sungai Kampar water treatment plant
3. Results and Discussion

Eleven profiles of two-dimensional (2-D) electrical imaging resistivity profiles were obtained from the surveys. Figures 2, 3, 4 and 5 showed the resistivity profiles located at the both side of Sg Kampar riverbank (Figure 1). The length of the survey line and depth of penetration ranges 200 with the depths of 40 respectively. In general, the 2-D profile obtained from the geo-electrical survey revealed three categories of geologic materials;

a) Permeable soil saturated with water (possible groundwater and terrestrial sediments material) with showed the resistivity value ranges of 0-150 ohm.m.

b) Semi permeable soil and weathered rock showed the resistivity value ranges of 200-1000 ohm.m.

c) Impermeable soil and rock (unsaturated zone) showed the resistivity value ranges of 1000-7000 ohm.m.

Three color codes (blue, green, and red) are used to denote the different geologic materials as representative in an inverse model (Figures 2, 3, 4 and 5). The summary of resistivity distribution as indicated in color codes versus material are used on this study is shown in Table 1.

Table 1. Summary of resistivity value interpretation

| No | Resistivity Value (Ωm) | Resistivity Legend | Interpretation |
|----|------------------------|--------------------|----------------|
| 1  | 0 ~ 150                | [10.0, 56.0, 100]  | Permeable Soil saturated with water (possible groundwater and terrestrial sediment materials) |
| 2  | 200 ~ 1000             | [200, 500, 1000]   | Semi permeable soil and weathered rock |
| 3  | 1000 and above         | [1000, 3000, 5000] | Impermeable soil or rock (Unsaturated zone) |

Figure 2. Inverse model for resistivity line for L1(0m)-L1(200m) at WTP Kampar area
Figure 3. Inverse model for resistivity line for L2(0m)-L2(200m) at WTP Kampar area

Figure 4. Inverse model for resistivity line for L8(0m)-L8(200m) at WTP Kampar area

Figure 5. Inverse model for resistivity line for L10(0m)-L10(200m) at WTP Kampar area

4. Conclusion

2-D resistivity images provided the information of permeable soil saturated with water that possible groundwater aquifer and terrestrial sediments material showed the resistivity value ranges of 5-150 ohm.m. Semi permeable soil and weathered rock showed the resistivity value ranges of 200-1000 ohm.m and impermeable soil and rock (unsaturated zone) showed the resistivity value ranges of 1000-7000 ohm.m. Terrestrial sediment material and highly fracture rocks presence in the study could be formed multilayer of aquifers as shown with variation of resistivity values presence in this study area. The boreholes information can be confirmed the presence of multilayer aquifers presence and
suitability of RBF method implements in the site area. This study suggested that the location of boreholes data should be concentrated at low resistivity values (10-150 ohm.m) zone rather than high resistivity value zone

References

[1] Zainal A M H, Madun A, Tajul B M F, Yusof M F, Zakaria M N and Rahmat S N 2017 Evaluation of unknown tube well depth using electrical resistivity method MATEC Web of Conferences 103, 07002 p 1-13

[2] Tajul B M F, Taib S and Hashim R 2009 Electrical imaging resistivity study at the coastal area of Sungai Besar, Selangor, Malaysia. Journal of Applied Sciences, 9 (16), p 2897-2906.

[3] Zainal A M H, Tajul B M F, Zawawi M H, Ali M, Madun A and Ahmad T S A 2015 Groundwater seepage mapping using electrical resistivity imaging Applied Mechanics and Materials 773, p1524-1534

[4] Tajul B M F, Ismail Z, Othman S Z, Taib S and Hashim R 2013 Use of time-lapse resistivity tomography to determine freshwater lens morphology, Measurement, 46, p 964–975.

[5] Zainal A M H, Saad R, Ahmad F, Wijeyesekera D C and Tajul B M F 2011 Application of geophysical methods in Civil engineering Malaysian Technical Universities International Conference on Engineering and Technology.

[6] Hamzah U, Yaacup R, Samsudin A R and Ayub M S 2006 Electrical imaging of the groundwater aquifer at Banting, Selangor, Malaysia, Environmental Geology 49, Issue 8, pp 1156–1162.

[7] Loke M H, Acworth I and Dahlin T 2003 A comparison of smooth and blocky inversion methods in 2D electrical imaging surveys. Exploration Geophysics Volume 34, Issue 3, pp 182-187.

[8] Batayneh A T 2006 Use of electrical resistivity methods for detecting subsurface fresh and saline water and delineating their interfacial configuration: a case study of the eastern Dead Sea coastal aquifers, Jordan, Hydrogeology Journal, Volume 14: p 1277–1283.

[9] Loke M H 2000 Electrical imaging surveys for environmental and engineering studies A practical guide to 2-D and 3-D surveys (Available online at www.geoelectrical.com/downloads.php). p 1-60.