Penerbit Akademia Baru

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage: www.akademiabaru.com/araset.html
ISSN: 2462-1943

Development of geological structure of Selangor basin using borehole lithology information

Open Access

Nur Hidayu Abu Hassan [1,*], Mohamed Azwan Mohamed Zawawi [1], Nur Sabrina Nor Jaeman [1]

[1] Department of Biological and Agricultural Engineering, Faculty of Engineering Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia

ARTICLE INFO

Article history:
Received 2 March 2017
Received in revised form 17 May2017
Accepted 20 May 2017
Available online 26 May 2017

ABSTRACT

The water shortage in Selangor Northwest Project rice granary areas has been growing concern. The increase in plant capacity and the El Nino phenomenon that hit Malaysia (1998 & 2016) has cause the main source of irrigation; surface water and rainfall, could no longer meet the needs of paddy. As a consequence, paddy productivity has becoming serious concern and urge for alternative irrigation water supply. At the same time, the use of groundwater as a source of alternative supply of irrigation water has started to get attentions. However, to determine the potential groundwater aquifer, preliminary study should be made in advance. Thus, the focus of this paper is to investigate the geological structure of the Selangor Basin by means analysis of borehole information. A total of 56 tube wells data were used to obtain layers of subsurface in the study area. By using groundwater modelling software (Visual MODFLOW), a model that represents an actual geological conditions has been made. A total of 6 subsurface layers have been identified. The result of study showed that, the geological formations of the study area mainly consist of three types; alluvium, sedimentary and metamorphic rock.

Keywords:
Selangor Basin, MODFLOW, irrigation, groundwater

1. Introduction

Selangor Northwest Project rice granary area which is situated in the state of Selangor Malaysia, has been considered as the most progressive and productive as well as developed scheme among eight other scheme. The total cultivated area for paddy crop is about 19, 000 ha. Generally, the scheme is practicing double cropping seasons, which is Wet Season (August – January) and Dry Season (February – July) [1]. However, the production only achieved half of the targeted yield (10 tonnes) with the 200 percent of cropping intensity [2].

The main dilemma that always afflict the scheme is the water deficiency in irrigation system. Lack in irrigation system's efficiency has resulted in poor water distribution. As the rice is very responsive to water stress [3], it thus will affect the crop yield in terms of quality and quantity. Till now, Malaysia

* *Corresponding author.*
E-mail address: hidayuhassan22@yahoo.com (Nur Hidayu Abu Hassan)

has experience several times of extreme weather that push the farmers to stalemate. Natural disaster, El Nino phenomenon (1998 & 2016) and upsurge in plant capacity has caused the main source of irrigation water supply cannot meet the needs of paddy; surface water and rainfall. Therefore, there is an urgent needs of finding alternative water supply for the irrigation system.

Hitherto, the use of groundwater as an alternative water supply in irrigation system has started to get attentions. In Malaysia, the use of groundwater in irrigation system is not common, since farmers believe that surface water is more reliable water supply. However, problem arise in the rice granary area at the study area since it is located near the coastline, where it is believed to have high potential of saline water intrusion if excessive pumping activities is done. In addition, due to active agricultural activities especially paddy cultivation, the shallow aquifer is feared to contain high percentage of nitrate due to fertilizer pollution.

Thus, even though groundwater compared to surface water is more dependable and viable sources, it is crucial for the groundwater to have proper abstraction with appropriate methods and technology. Anyhow, to locate the potential of groundwater aquifer, advance preliminary study need to be done accordingly. The presence studies shows lack of research in investigating the geological structure for groundwater abstraction purposes. The records in Department of Minerals and Geoscience, Malaysia until recent report only focusing in developing borehole with 30 m depth which is not suitable to interpret the whole geological structure of investigated area. Thus the focus of the paper is to investigate the geological structure of Selangor Basin by means analysis of tube well information to determine its geological formations. A groundwater modelling software was used to build up the model based on real condition.

2. Methodology

2.1 Site Description

Selangor Basin was chosen as the study area and located in Selangor, Malaysia as shown in Figure 1. The paddy cultivation area is marked by red circle. Preliminary study was carried out to determine the geological structure. Generally, for any particular area, geology condition is differ even though it is located in the same state. The Geology Map of Selangor Basin [6] as shown in Figure 2, asserts that there are different type of soil's media in study area.

The rice granary area are having difficulty in irrigation water supply since long time ago. The ideas of having wellfield in granary area is not a resolution since shallow aquifer is may be affected by saline water intrusion. While brackish water was found few kilometers from coastline and is not suitable for irrigation water supply. But freshwater in metamorphic rock that been found is believed to be better alternative water supply for irrigation rice granary area.

As reported in previous study [10], saline water can be detected 3 to 5 kilometer from coastline towards inland called as alluvial aquifer. While afterwards, brackish water is been identified before encountered to metamorphic rock aquifer which contain freshwater as red circled in Figure 2.

Fig. 1. Map of Selangor basin [6]

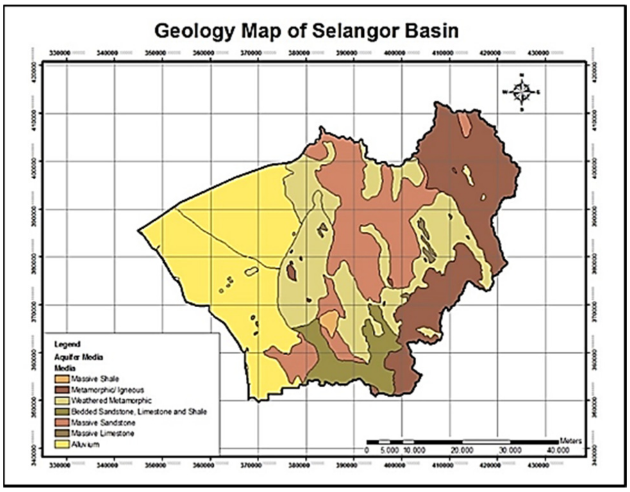

Fig. 2. Geology map of Selangor basin [6]

2.2 Tube Wells

Tube wells lithology information were analysed and used to develop subsurface layers including its thickness. Details of the tube wells information used were shown in Table 1. There are practically 56 tube wells with its location and elevation were used to construct the subsurface structure of the study area. Cross sectional tube well distribution map was then created as shown in Figure 4. The distribution map been organized according to the cross section from west to east as illustrated. This is to ensure the continuity of the soil layers.

The example of tube well lithology information from tube well KSG004M is shown in Figure 3. The information regarding the depth and layer of soil was used to complete the subsurface layer of the study area.

Table 1
Tube Wells Data Information

Tube Well	Location	X-coordinate	Y-coordinate	Elevation (m)
SB01	Parit 4, Sungai Burong, Sekinchan	740021	390134	6
SB02	Parit 10, Ban Canal, Sekinchan	734478	396488	8
SB03	Parit 14, Simpang Lima Sekinchan	731816	402606	7
SB04	Parit 6 Gambut Sungai Besar	728542	406093	13
SB05	Parit 9 Timur, Sungai Besar	727644	410093	5
SB06	Parit 13, Sungai Besar	731260	412491	4
SB07	Parit 8 Timur, Sungai Besar	724757	411453	5
SB08	Parit 15, Sungai Besar	733761	412881	1
BSBEW1 (MW1)	S. K. Binjai Jaya, Sungai Panjang, Sabak Bernam	736150	411017	7
BSBEW2 (TW1)	S. K. Binjai Jaya, Sungai Panjang, Sabak Bernam	736150	411017	7
BSBEW3 (TW2)	Masjid Othmaniah, Binjai Jaya, Sungai Panjang, Sabak Bernam	736520	411895	8
BSBEW5 (MW4)	Km 45.5 Sungai Besar - Tanjung Malim, Sabak Bernam	750029	404865	16
BSBEW6 (MW5)	Kampung Belia Dua, Sungai Panjang, Sabak Bernam	744041	410060	11
BSBEW7 (MW6)	Kampung Belia Dua, Sungai Panjang, Sabak Bernam	741285	410420	7
KSG001M	Bukit Talang Estate, Raja Musa Division	753630	380001	7
KSG004M	JPS Land Along Head Irrigation Canal Near Tanjung Karang	749446	383301	15
KSG005M	JPS Land Along Head Irrigation Canal Near Tanjung Karang	746808	385039	7
KSG007M	Tanjung Karang Forest Reserve Along Head Irrigation Canal	760897	395506	22
KSG008M	Tanjung Karang Forest Reserve Along Head Irrigation Canal	760624	399636	24
KSG009M	Tanjung Karang Forest Reserve Along Head Irrigation Canal	760225	403890	13
KSG010M	Gagasan Estate Sungai Panjang	748925	407339	9
KSG011M	Gagasan Estate Sungai Panjang	751456	404843	4
KSG019M	Agrotech Firm, Sungai Panjang	758091	405005	8
KSG020M	Sungai Panjang Estate	754339	404233	11
KSG021M	Sungai Panjang Estate	751456	404843	4
KSG023M	Tanjung Karang Forest Reserve Along Head Irrigation Canal	760740	401264	16
KSG035M	KDED Land	766277	378334	12
KSG036M	KDED Land	764021	378281	11
KSG037M	KDED Land	762119	377735	13
KSG038M	KDED Land	761931	377424	15
KSG039M	KDED Land	762119	377735	13
KSG041M	KDED Land, Batang Berjuntai	765128	376999	12
KSG040M	KDED Land, Batang Berjuntai	764871	378125	11
KSE02	Bukit Rotan-Ijok	761556	365713	11
KSE03	Kampung Parit Mahang	764560	365854	9
KSE06	Kampung Lubuk Jaya	756880	374202	10
KSE07	Kampung Baharu Pasangan	761891	373602	3
KSE08	Kampung Raja Musa	756614	377205	10
KSE09	Kampung Raja Musa	760621	376976	9

KSE10	Kampung Seri Makmur	765128	376999	12
KSE11	Kawasan Lombong Berjuntai	768458	377298	9
KSE13	Jalan ke Tanjung Karang	752858	377185	6
KSE14	Kampung Seri Tiram Jaya	750953	382307	9
KSE15	Ladang Sungai Selangor	758468	369753	10
KSE16	Ladang Sungai Rambai	762537	369725	13
BKSPZ1	-	755977	379204	21
BKSPZ2	-	755977	379204	21
BKSPZ05	-	762215	377104	9
BKSPZ06	-	762119	377735	13
BKSP07	-	762119	377735	13
BKSTW3	Taman Agro	762132	375231	8
BKSTW4	-	755977	379204	21
BHSEW 1	Kampung Orang Asli, Kuala Kerling	785085	391254	46
BHSEW2	Sekolah Kebangsaan Gedangsa	764553	413555	31
BHSEW3	MRSM, Kuala Kubu Bharu	797726	392700	72
BSBEH10	Pusat Perhilitan Badak, Sabak Bernam	760588	406146	15

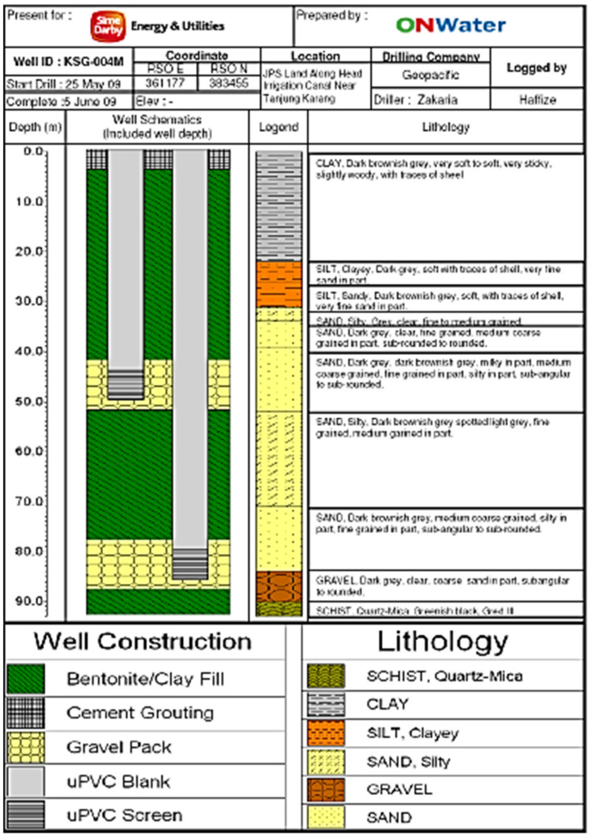

Fig. 3. Example of tube well lithology of tube well KSG004M, Sime Darby.

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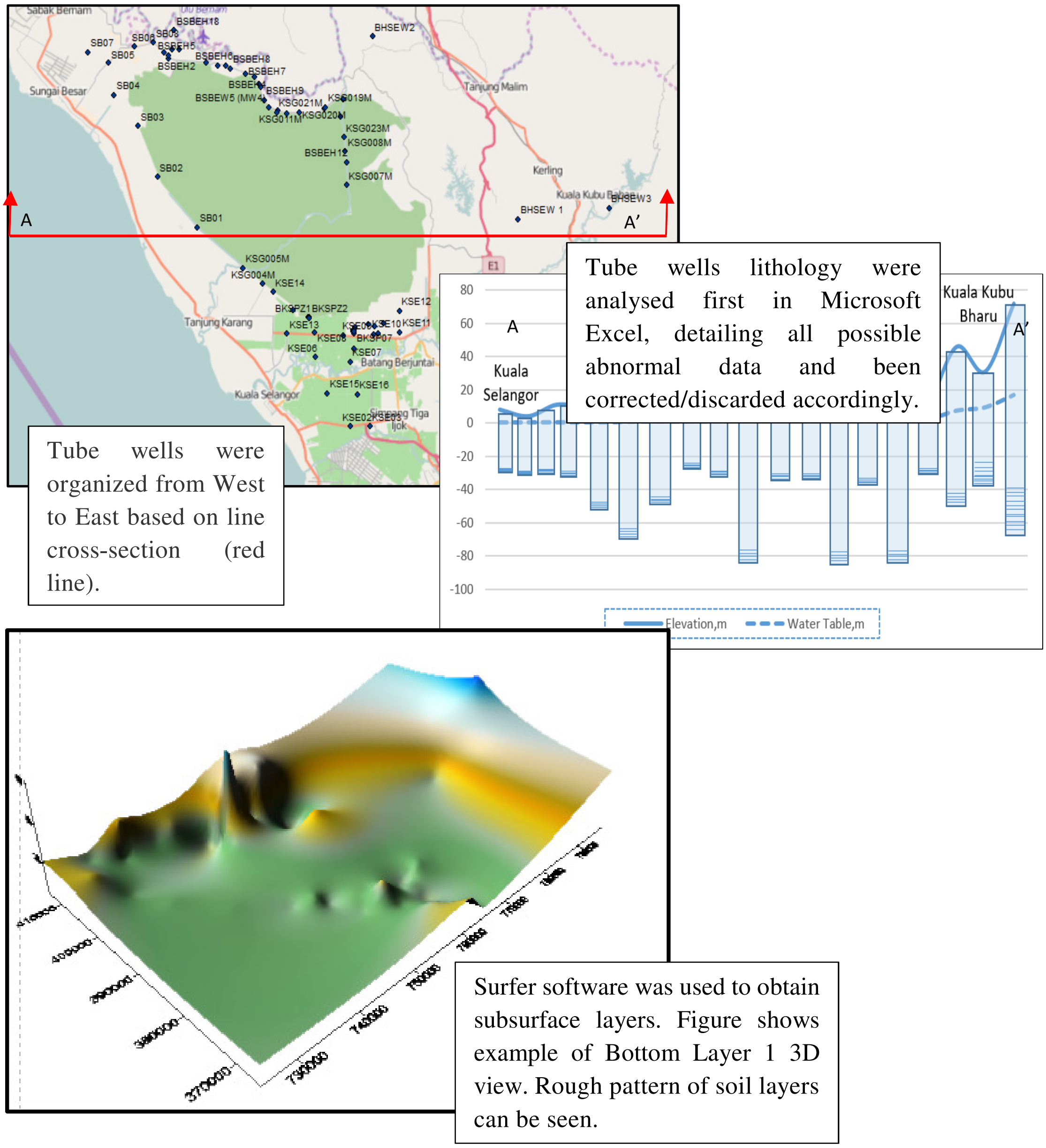

Fig. 4. Graphical method of analysing raw tube wells information

2.3 Geophysical Technique

Induced Polarization (IP) Survey has been conducted in verifying the precision of the similarities of borehole lithology. Blok F, Sawah Sempadan with coordinate of 383 203.36 m N and 749 339.95 m E has been chosen for comparison purposes with borehole KSG0004M lithology as in Figure 3.

Resistivity profile is shown in Figure 5, while Figure 6 gives description varies colour scheme for resistivity reading. Result of the IP Survey exhibit the existence of saltwater coloured as dark blue. At the depth of 1 to 25 m below ground surface, the presence of clay deposit are noticeable as coloured in blue to light blue. While alluvium which represent clay, silt, sand and gravel deposit can be seen through the depth of 25 to 90 m. Colour ranging from green to orange in the profile indicate the presence of alluvium layer.

The common theoretical resistivity reading for schist is about 20 - 104 ohm.m, however, the measured resistivity reading for schist through IP Survey which is 20 – 50 ohm.m overlapped with the alluvium resistivity reading which is 10 – 250 ohm.m. Thus, the soil type in resistivity profile could not be discernible between both schist and alluvium. Nevertheless, over the borehole lithology, the existence of schist is proven through the drilling process. Thus it can be deduced that the schist layer is presence at the bottom of investigated borehole.

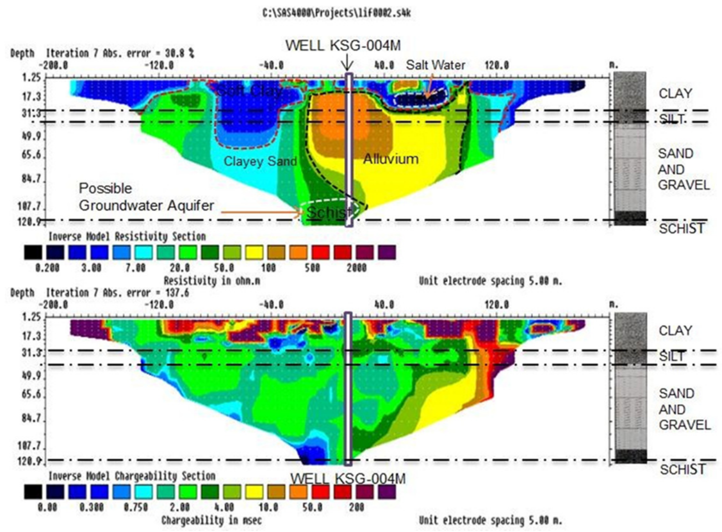

Fig. 5. Geophysical technique profile of Blok F, Sawah Sempadan

Fig. 6. General Color Scheme of Resistivity Value

Throughout the result of comparison between both boreholes KSG 0004M lithology with the IP Survey that been conducted at the same point location, it can be concluded that the analysis using well lithology is reliable.

2.4 Groundwater Modelling Software

In creating a geological structure of subsurface layers, raw data of tube wells information were analysed first before running in groundwater modelling software (Visual MODFLOW). The abnormal raw data were corrected or discarded accordingly. A model that represents an actual geological conditions has been made as shown in Figure 7. The modelling map's coordinate were 710,917 – 805,328 m, and y coordinate 358,955 – 417,262 m (area 944,411 x 58,307).

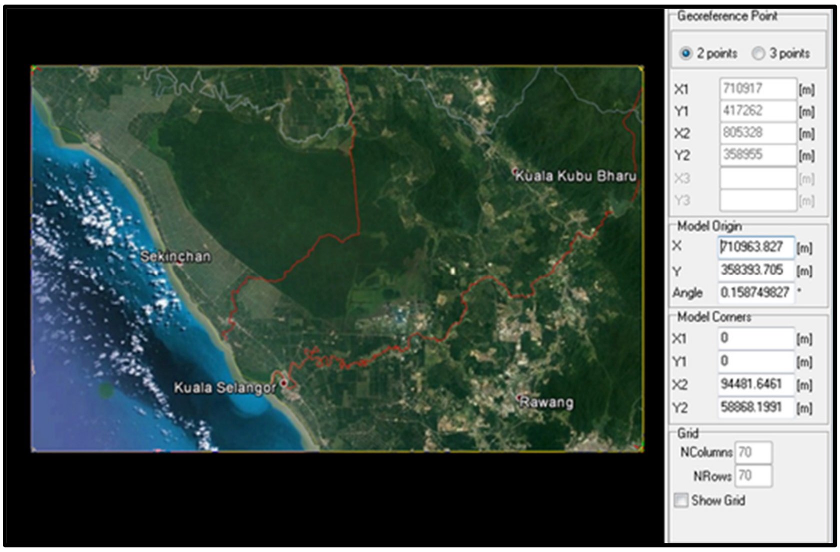

Fig. 7. Model domain based on real world georeferenced

3. Results and Discussion

By using groundwater modelling software, result of geological structure of subsurface layers with mainly composed of 6 layers, which were;

- Layer 1 – Clay
- Layer 2 – Alluvium
- Layer 3 – Sandstone
- Layer 4 – Shale
- Layer 5 – Schist
- Layer 6 – Impermeable rock

Kriging Interpolation Method was applied in the modelling, result shows there were different pattern of subsurface soil layers at different cross-section. Four cross-section shown in Figure 8 to 11 was properly cut out to show better view and understanding of geological formation in study area. Geological formations that stands out are alluvium, sedimentary rocks and metamorphic rocks.
Figure 8 cross-section A-A' shows alluvium layer in west area where shallow aquifer is found. The thickness of alluvium layer as circled is down to 40 to 43 m based on sea level. The layer thickness decline towards east as it goes to sedimentary and metamorphic rock. Previous study [11] have found that, abstraction of groundwater has proven that there is saline water intrusion. Thus, this shallow aquifer is not suitable to provide water supply in overcoming the water supply deficiency. To add on fertilizer pollution may diffused in shallow aquifer and may contain high percentage of nitrate. Figure 9 cross-section B-B', as circled, shows range of thickness depth 20 to 35 m layer of metamorphic rock. According to study [12], fractured schist have been found from depth of 27 m. Sample groundwater abstraction shows freshwater groundwater with acceptable quality parameter.

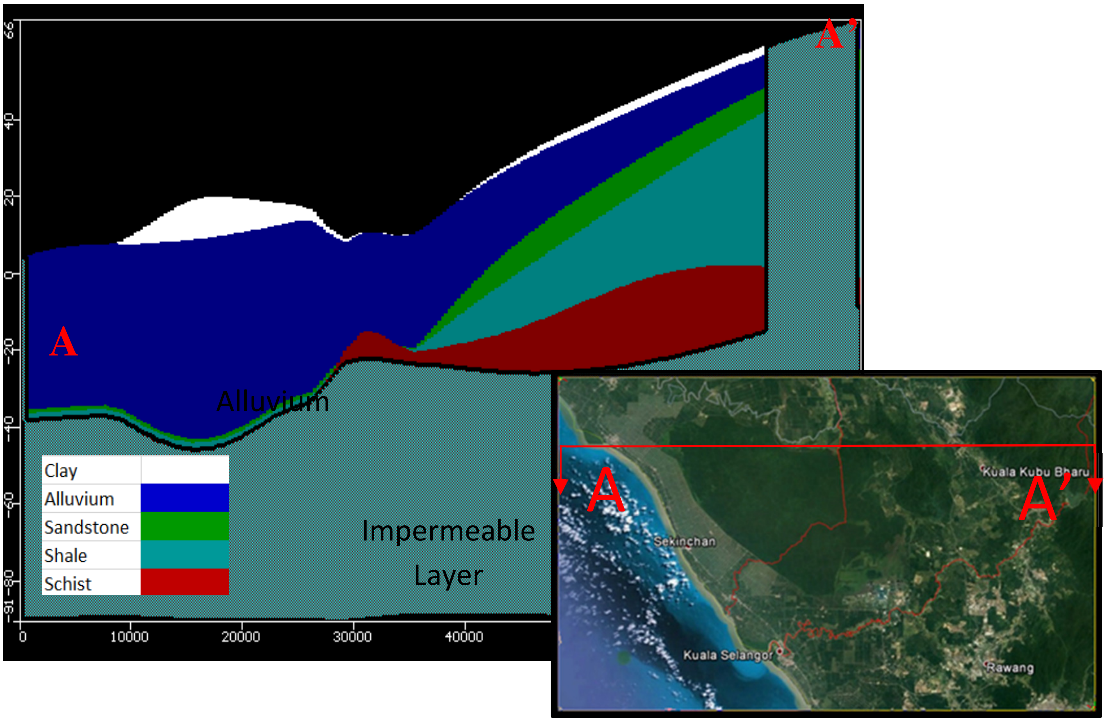

Fig. 8. Cross section A – A' of the soil layers

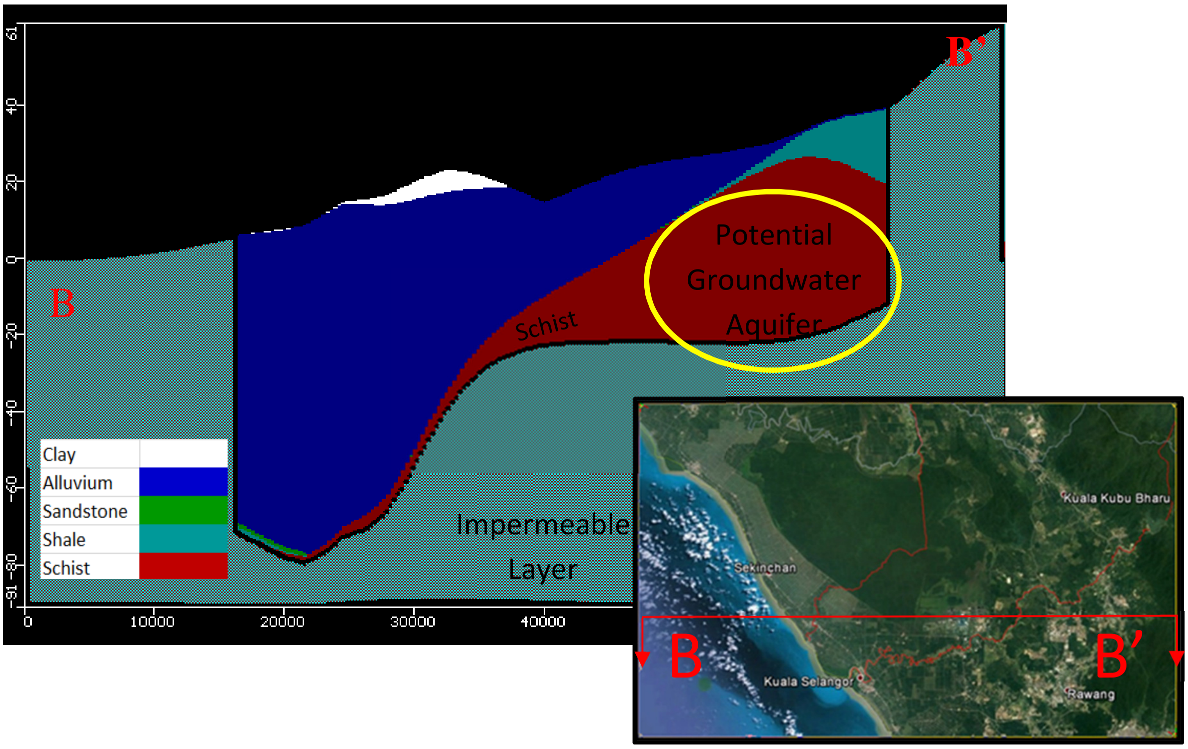

Fig. 9. Cross section B – B' of the soil layers

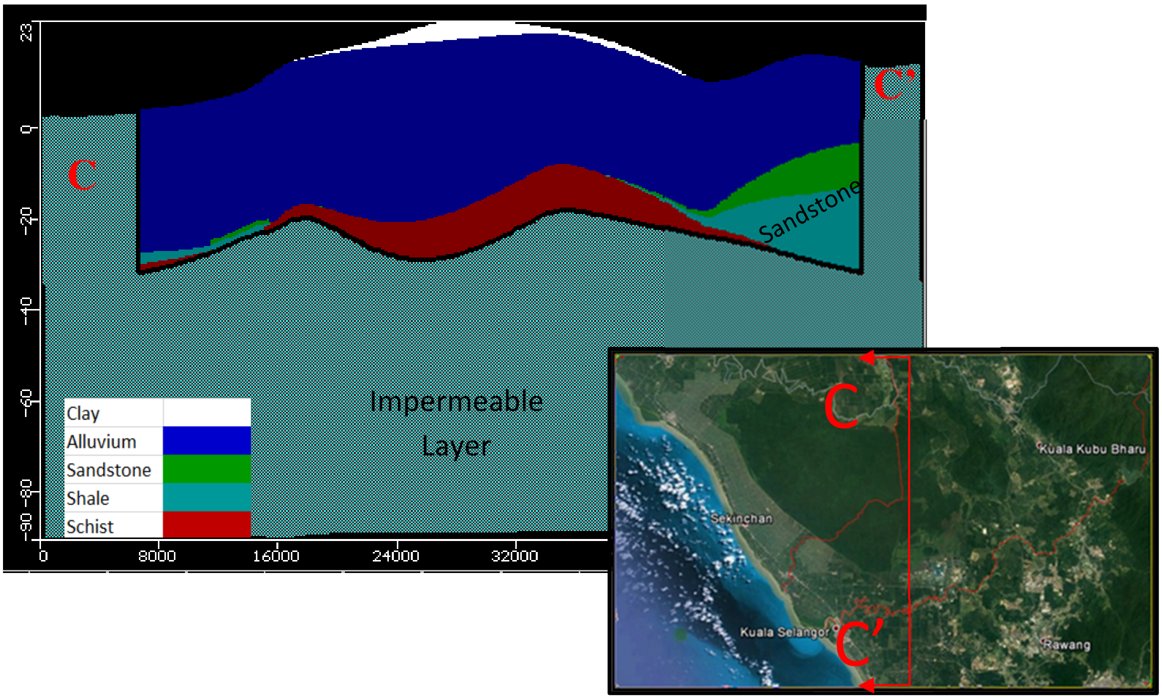

Fig. 10. Cross section C –C' of the soil layers

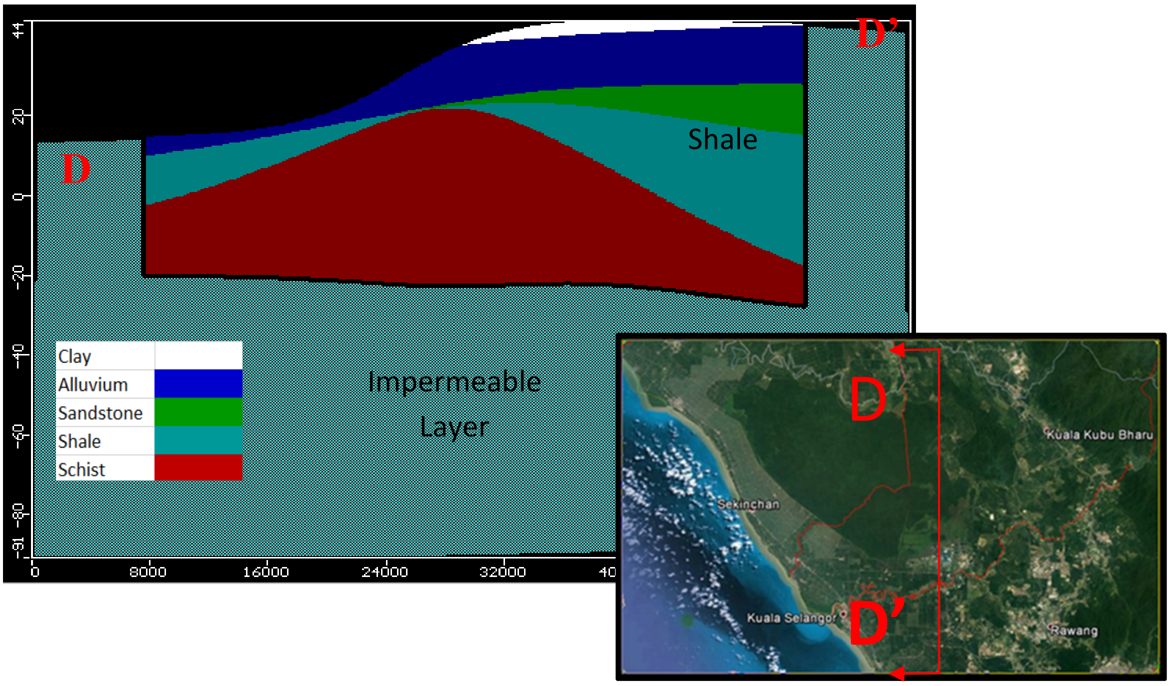

Fig. 11. Cross section D – D' of the soil layers

Figure 10 cross-section C-C' shows sedimentary rocks, sandstone lies. Study by [13] reported sandstone layer was found at depth of 21 m down to 40 m. However, test on groundwater abstraction on the tube well indicate limited of groundwater discharge. Result in Figure 11 cross-section D-D' indicate the location of shale. Previous study [13] shows fractured shale was found at depth of 41 m and may be another option for water supply. However, the groundwater needs to be rarefied by suitable method and technology due to contain of calcium bicarbonate.

4. Conclusion

This paper presents interpretation of Selangor Basin geological structure. The main geological formation in study area are alluvium, sedimentary and metamorphic rock. Metamorphic rock may contain freshwater that can be another best option for irrigation supply. However, further study need to be done to analyze the suitability of groundwater and best method of supplying the water supply.

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