

Review on Rock Aquifers Researches Conducted in Malaysia

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Abstract. The exploration of groundwater in Malaysia was not very welcomed due to few misconceptions such as it is very expensive to extract, could give negative impacts to the environment and not reliable. Yet, in recent times, rock aquifers such as limestone, sedimentary rocks, volcanic rocks, igneous rocks and metasedimentary rocks are being explored. This paper aims to review the researches that have been carried out on rock aquifers in Malaysia. In general, the topics studied were potential zonation, groundwater quality and quantity, occurrence and flow of groundwater as well as characterization of rock aquifers. The highest yielding aquifer was metasedimentary rock aquifers meanwhile the quality was good in general. Most of the aquifers were having neutral pH values and the total dissolved solids more than 100 mg/l. Moreover, granitic aquifers contained more hardness than the metasedimentary rocks. The iron content in the aquifers was higher than the limit set by World Health Organisation which is 0.3mg/l while salinity of aquifers were not tested in many aquifers. It can be vividly seen that many research were focused on quality. Hence, more researches on characterization of rock aquifers must be done for proper understanding on occurrence, flow and recharge.

1 Introduction

The main water resource that intensely being used in Malaysia is the surface water eventhough the country is rich with other water resources like groundwater. The groundwater extraction is not embraced in here due to few misconceptions. The misconceptions are groundwater is limited, contaminated, not reliable, difficult to extract, expensive to drill and could cause harm to environment [1]. The other factors preventing exploration of groundwater are budget constrain and insufficient strategic plan for groundwater development. However, in the year 2016, the government has decided to integrate aquifer systems in water supply system up to 30% by the year 2030 [2]. It is considered a huge milestone in Malaysian water resources management. Recently, more rock aquifers are being explored in Malaysia.

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2 Literature review

Rock aquifers are explored to a certain extent in almost all the states in Malaysia. The common types of rock aquifers are limestone, metasedimentary rock aquifers, sedimentary rock aquifers, volcanic aquifers and igneous rock aquifers [1, 3, 4]. First, the metasedimentary rock aquifers, sedimentary rock with volcanic tuff aquifers and granitic aquifers were found in Negeri Sembilan [5]. The purpose of the study was to carry out fracture analysis and around 71 wells were drilled. Metasedimentary rock aquifers were drilled to a maximum depth of 187m with an average depth of 125m which produced a maximum yield of 960m³/day. As for the quality, Total Dissolved Solid (TDS) was 111mg/L, hardness was from 52 to 97 mg/L and iron content (Fe) was 5.09. Next, sedimentary rock with volcanic tuff aquifers were drilled to a maximum depth of 200m with an average depth of 163m which produced a maximum yield of 1264m³/day. On the other hand, Granitic aquifers were drilled to a maximum depth of 138m with an average depth of 100m which produced a maximum yield of 650m³/day and average yield of 400m³/day. As for the quality, pH value was 7.2, TDS was 170mg/L, hardness was from 43 to 152 mg/L and Fe was 0.98. The end results of this study were fracture orientations were linked to rivers and the fracture pattern followed the regional structural trend of the Main Range Granite.

The characteristics of groundwater in granitic and metasedimentary fractured rocks at West Coast Malaysia were determined [6]. Around 133 wells with depth between 100 and 200m were studied. The Metasedimentary rock aquifers produced an average of 400m³/day while Granitic aquifers produced an average of 300m³/day. The pH was 6.5, TDS was 120mg/L and Fe was 1.5mg/L when tested for quality. Furthermore, groundwater quality of interbedded sandstone, shale and mudstone at Shah Alam was studied [7]. The groundwater samples were collected from 31 wells which were more 100m in depth and tested for quality. It was found that the geology of study area controlled the catchment area and quality of groundwater was good. Yet, it was forecasted that the aquifer could contaminate if pollution occurred locally. Next, the research on quantity and quality of metasedimentary rock aquifers around Melaka, Negeri Sembilan, Selangor and Kedah was carried out [8]. Around 58 wells were studied with maximum depth of 201m and average depth of 146m. The maximum yield was 890m³/day while the average yield was 381m³/day. In addition, the samples collected had TDS from 100 to 150 mg/L, hardness lesser than 60mg/L and Fe of 2.39.

Moreover, mapping of potential aquifer in Selangor and Negeri Sembilan using remote sensing and GIS technique was done [9]. Geology of the study area was granite, sedimentary rocks with volcanic intercalation and metasedimentary rocks. When validated the map using wells, the results showed an accuracy of 84.74 %. In addition, the wells produced more than 264m³/day. Later, the study on potential aquifer zonation in Kedah and Perlis was carried out [10]. The lithology of Kedah was Chert while the lithology of Perlis was and crystalline limestone, mudstone and semi-consolidated gravel. Around 16 wells were drilled to validate the prediction and it was accurate up to 81.25%. The maximum yield was 632m³/day while average was 230.88m³/day. Next, the factors influencing groundwater chemistry was studied at Kapas Island, Terengganu [11]. Around 18 wells were drilled for this purpose. The samples showed pH value was 6.9, TDS was 988.3 and salinity (Sal) was 0.9 when tested. It was found that seawater intrusion, weathering, redox reaction and anthropogenic pollution greatly effect the quality of aquifers in this island.

A study on hydraulic and contamination stress in metasedimentary rock aquifer at Shah Alam was conducted as well [12]. It result showed that the aquifer was prone quality stress as only limited contamination occurred in the study area. However, the pumping can effect the quality stress further. In addition, groundwater quality study was carried out in Kajang

for granitic and shale aquifer and in Semeniyh for granitic aquifer [13]. The wells were drilled up to 160m in granite and 64m in shale. The aquifers in Kajang showed pH of 7.5, TDS of 276mg/L and Fe of 1.17mg/L. On the other hand, the aquifers in Semeniyh showed pH of 6.38, TDS of 372mg/L and Fe of 0.71mg/L. This study concluded that the urbanization in these study areas have effected the quality of groundwater apart from surface water. Finally, the limestone aquifer in Niah Great Cave, Sarawak was found out to have pH value of 7 [14]. This study was conducted to determine the occurrence, morphology and hydrogeochemistry of epiphreatic caves. Table 1 shows the summary of researches conducted on rock aquifers in Malaysia.

Table 1. Summary of researches conducted on rock aquifers in Malaysia

Source	Geology	Location	Research purpose	Decription									
				No. of wells	Depth of well(m)		Quantity (m3/day)			Quality			
					Max	Avg	Max	Avg	pH	TDS	Hardness	Fe	Sal
[5]	Metasedimentary rocks (Schist,Phyllite, Marble and Gneiss)	Negeri Sembilan	Fracture analysis	71	187	125	960	-	-	111	52-97	5.09	-
					200	163	1264	-	-	-	-	-	-
					138	100	650	400	7.2	170	43-152	0.98	-
[6]	Metasedimentary rocks	West Coast of Peninsular Malaysia	Characteristics of groundwater	133	-	100-200	800	400	6.5	120	-	1.5	-
	Granite rocks				-	-	300	-	-	-	-	-	

[7]	Interbedded sandstone, shale and mudstone	Shah Alam	Groundwater quality	31	-	>100	600	250-350		<100	-	-	-	-
[8]	Metasedimentary rocks	Melaka Negeri Sembilan Selangor Kedah	Determining quantity and quality of groundwater	58	201	146	890	381	-	100-150	<60	2.39	-	-
[9]	Metasedimentary rocks (Schist, Phyllite, Marble and Gneiss)	Selangor - Negeri Sembilan	Potential mapping of aquifer	68	-	-	-	>264	-	-	-	-	-	-
	Sedimentary rocks with Volcanic intercalation (Shale and Tuff)													
	Granite													
[10]	Chert	Kedah	Potential zonation of aquifer	16	-	-	632	231	-	-	-	-	-	-
	Crystalline Limestone, Mudstones and Shale and Semi-consolidated gravel, sand and clay with thin fold of lignite	Perlis												

[11]	Mostly Carbonaceous interbedded with sandstone, siltstone, mudstone and shale	Kapas Island, Terengganu	Evaluation of factors influencing the groundwater chemistry	18	-	-	-	-	6.9	988	-	-	0.9
	Shaly siltstone, conglomerate with quartzite siltstone and weathered tuff												
[12]	Metasedimentary rocks	Shah Alam	Hydraulic and contamination stress	44	136	576	-	7.66	835	2.4	-	-	-
[13]	Granite	Kajang	Groundwater quality	2	160	-	120	7.5	276	1.17	-	-	-
	Shale			1	64	-	-	6.38	372	0.71			
	Granite	Semeyih		2	160	123							

[14]	Limestone	Niah Great Cave, Sarawak	Occurrence, morphology and hydrogeochemistry of epiphreatic caves	-	-	-	-	7	-	-	-
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3 Discussion and conclusion

The study of rock aquifers in Malaysia are focusing on potential zonation, groundwater quality and quantity, occurrence and flow of groundwater as well as characterization of rock aquifers. However, it can be vividly seen that more focus was given to groundwater quality. Remote sensing and GIS were successfully used to map potential aquifer. The problems of these technique are the exhausting selection of criteria and if wrongly chosen, it would mislead the results [15]. As for groundwater quality, the pH, TDS, salinity, Hardness, and Iron content were typically tested. In general, the pH value of most of the aquifers were between 6 to 7. Aquifer with highest TDS recorded was Sedimentary rock aquifers followed by Metasedimentary rock aquifers and Granitic aquifers. However, almost in all aquifers the iron content is higher than the limit set by World Health Organisation a (WHO) which is 0.3mg/L. This could be due to higher weathering process occurred in tropical climate. In addition, the hardness was lesser than 150mg/L in rock aquifers. On the other hand, the metasedimentary rock aquifers had the highest yield followed by Limestone, Sedimentary rock aquifers, Volcanic aquifers and Igneous rock aquifers.

Furthermore, the characterization of groundwater carried out by Azie [6] focused on well drilling and hydrochemistry of aquifers. This clearly shows that more the tropical aquifers in Malaysia are not explored widely. The hydrodynamic properties of rock aquifers are definitely not forthright and results are volatile due to its native heterogeneity. There is difficulty in determining yield from one unique parameter as the parameters influencing rock aquifer vary in every geologic setting [16]. There is deficiency of knowledge in understanding occurrence, movement and recharge of groundwater in tropical aquifers. So far, factors such as fracture pattern, seawater intrusion, weathering, redox reaction and anthropogenic pollution were found to influence the quality and quantity of aquifer. Yet, further characterization of rock aquifers in terms of geology, hydrogeology, geophysics and geohydraulics should be done for better exploration and development of rock aquifers in Malaysia. Finally, the major threat of aquifer which is contamination due to geogenic and anthropogenic processes must be studied too.

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