STUDY ON GROUNDWATER POTENTIAL AS ALTERNATIVE WATER SUPPLY IN KUANTAN AND BENTONG, PAHANG

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ABSTRACT

The knowledge of groundwater resource in Pahang is low compared to the other state because Pahang received a large amount of rainfall each year which are between 2032 mm to 2540 mm. Consequently, the demand for groundwater is very low. Despite this, development of groundwater needs to be done to supply water to the public demand and to avoid the lack of water in the dry season. Aware of this fact, two areas in Pahang which are Kuantan and Bentong were selected as study areas. The study involved analysis of data pumping test collected from Mineralogy and Geoscience Department Pahang. The type of aquifer of both places is unconfined aquifer. In this study, Mineralogy and Geoscience Department have provided sufficient data for the analysis of this aquifer. The data collected are constant rate pumping test data, recovery pumping test data and step pumping test data. The study has found that, both of study areas have different geology which Kuantan is sand and gravel while Bentong is rock. Hydraulic conductivity, K for Kuantan is in region 700m/day to 2500m/day and Bentong is in region 1m/day to 3 m/day. Tranmissivity, T of aquifer in Kuantan is in region 3000 m^2/day to 9000 m^2/day and Bentong is in region 4 m^2/day to 12m^2/day. Besides that, the well efficiency, E_w in Kuantan shows a high efficiency than Bentong which the value is 89% and 47.42% respectively. Furthermore, Average iron content in groundwater in Kuantan is 5 ppm exceeding the maximum iron content as stated in Ministry of Health Malaysia Standards. However iron content in this well can be reduced by river infiltration through the well. While water quality in Bentong shows the value for each element is acceptable in Ministry of Health Malaysia. From this study, the results indicated that Kuantan area has a potential for groundwater development in Pahang compared to Bentong area.

ABSTRAK

Maklumat berkenaan dengan sumber air tanah di Pahang adalah rendah berbanding dengan negeri lain kerana Pahang menerima jumlah hujan yang besar yang mana antara 2032 mm hingga 2540 mm. Walaupun demikian, pembangunan air bawah tanah perlu dibangunkan untuk membekalkan air untuk keperluan masyarakat dan untuk mengelakkan kekurangan air di musim kemarau. Menyedari fakta ini, dua kawasan di Pahang iaitu Kuantan dan Bentong dipilih sebagai daerah kajian. Kajian ini melibatkan analisis data ujian pengepaman dari Jabatan Mineral dan Geosains Pahang. Jenis akuifer untuk kedua-dua tempat adalah akuifer tidak terkurung. Dengan demikian pengiraan yang terlibat dalam analisis ini adalah menggunakan kaedah akuifer tidak terkurung. Dalam kajian ini, Jabatan Mineral dan Geosains telah memberikan data yang cukup untuk digunakan dalam analisis akuifer.Data yang diberikan adalah data pengepaman kadar tetap, data ujian pemulihan dan data uji pengepaman pelbagai langkah. Kajian ini telah mendapati kedua-dua kawasan kajian tersebut adalah mempunyai geologi berbeza iaitu Kuantan adalah pasir dan kerikil, sedangkan Bentong adalah batu. Kekonduksian hidraulik, K bagi Kuantan dalam lingkungan 700m/hari hingga 2500m/hari dan Bentong adalah dalam lingkungan 1m/hari hingga 3m/hari. Manakala terusan akuifer, T di Kuantan di dalam lingkungan 3000 m^2/hari hingga 9000 m^2/hari dan Bentong dalam lingkungan 4 m^2/hari untuk 12m^2/hari. Selain itu, kecekapan telaga di Kuantan menunjukkan kecekapan yang tinggi dari Bentong yang mana nilai masing-masing adalah 89% dan 47,42%. Selanjutnya, kandungan besi dalam air bawah tanah di Kuantan adalah 5 ppm yang mana melepasi kadar besi dalam Piawai Kementerian Kesihatan Malaysia. Namun kadar besi dalam hal ini dapat dikurangkan oleh penyusupan air sungai melalui perigi. Manakala, kualiti air di Bentong berdasarkan nilai tiap-tiap unsur diterima di Jabatan Kesihatan Malaysia. Dari kajian ini, keputusan menunjukkan Kuantan mempunyai potensi bagi pembangunan air bawah tanah di Pahang berbanding kawasan Bentong.

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LIST OF ABBREVIATIONS

B.O.D	Biochemical Oxygen Demand
n_T	Total porosity
V_v	Volume of voids
V_s	Volume of solids
V_T	Total volume
dh/dr	Hydraulic gradient (slope of piezometric head, h at distance r from the pumped well)
E_w	Well efficiency
b	Thickness of aquifer (m)
B	Linear well-loss coefficient
C	Non-linear well-loss coefficient
D	Height of aquifer (m)
K	Hydraulic conductivity of aquifer
Q	Pumping rate
r	Distance of piezometer from well
S	Storage coefficient
s	Drawdown or drop of water level during pumping test
s'	Residual drawdown or rise of water level during pumping test
T	Transmissivity
t	Time since beginning of pumping
u	Dimensionless parameter
W (u)	The well function of u

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CHAPTER 1

INTRODUCTION

1.1 General

Water is the clear liquid that falls as rain and forms part of the hydrological cycle and is continuously moving through this cycle (Steel, 2003). Water is one of the Allah s.w.t creations which are very valuable to the human in daily life. In general, water is one of the needs which are very important in live. Without water, all the living thing such as human, animal and plants will die. It is because we need water for drinking, cooking, watering plants and so on everyday (Yusliani, 2006).

Groundwater is water below the ground that is found in the spaces between particles of rock and soil, or in crevices and cracks in rocks. It is stored and moves slowly through formations called aquifers. According to Ward and Robinson (2000) in saturated zone the pose spaces are almost completely filled with water and the pressure of water is equal to or greater than atmospheric pressure. Groundwater moves through porous geologic materials under the force of gravity or sometimes by the sheer weight of atmospheric pressure. This movement continues downward until an impervious layer of rock, shale, clay or other water tight formation is encountered.

These geologic barriers can cause localized area to remain completely saturated with groundwater, sometimes up to the land surface.

When rain falls to the ground, the water does not stop moving. Some of it flows along the land surface to streams or lakes, some is used by plants, some evaporates and returns to the atmosphere, and some seeps into the ground. Water seeps into the ground much like a glass of water poured onto a pile of sand. As water seeps into the ground, some of it clings to particles of soil or to roots of plants just below the land surface. This moisture provides plants with the water they need to grow. Water not used by plants moves deeper into the ground. The water moves downward through empty spaces or cracks in the soil, sand, or rocks until it reaches a layer of rock through which water cannot easily move. The water then fills the empty spaces and cracks above that layer. The top of the water in the soil, sand, or rocks is called the water table and the water that fills the empty spaces and cracks is called ground water (USGS, 2005).

An aquifer is an area that contains enough groundwater to be pumped to the surface and used for drinking water, irrigation, industry, or other uses. An aquifer may be a few feet or several thousand feet thick, and less than a square mile or hundreds of thousands of square miles in area (ADEC, 2009).

The amount of water an aquifer can produce depends on the volume of the soil and rock in the saturated zone, the size and number of the pores and fractures that can fill with water, and the permeability of the soil or rock. Water-filled porosity is a measurement of the amount of water a material can store, and permeability is a measure of how well the water can move through the material. Material such as silt or clay has high water-filled porosity it can store a lot of water but low permeability. Bedrock usually has low water-filled porosity, it can only store water in cracks and low permeability (ADEC, 2009).

1.2 Problem Statement

Groundwater development in Malaysia is lagging because there is a failure to recognize the vast potential of the invisible groundwater resource, compare to other countries like Thailand that used 80% of groundwater, China (78%), Austria (98%), Denmark (100%), Malaysia only used less than 2%. The wise use of groundwater resources can play a significant role in supplementing the nation's water supply requirement and reducing the impact of drought in both urban and rural environments (Douglas, 2009).

The importance of groundwater is not restricted to the quantities in which it is used, but also to the particular people it serves and the areas where it is used. Rapid development in the country results in an increased demand for water supply in recent years. Alternative source of water was also sought out among them in groundwater. The National Economic Action Council (1998) in the National Economic Recovery Plan has identified groundwater as one resource that has great potential to be developed. Regarding to that, it is very important to gain information from a groundwater potential area (Steward, 2009).

Surface water source tend to be turbid and typically contain higher concentration of colloidal and microbiological material than ground water source. Ground water source generally have higher initial quality and tend to require less treatment than surface water source, making ground water sources a good choice for small water system. In fact, most small systems already use in ground water sources. Before installing new treatment system, small utility using surface water might seek a ground water source, or a utility using a poor ground water source might develop a new well in an alternative location or use a deeper aquifer by extending the depth of a well or drilling a deeper one. In either case, if alternative sources of high-quality raw water are not available, the utility might seek a source of treated water from a water utility that has an adequate supply of water and is located close enough to extend a transmission main at an affordable cost. If such options cannot be found, however, then the utility needs to explore adding additional treatment systems (NAS, 2008).

1.3 Objective of Study

The main objectives of this study are:

I. To determine soil properties, physical properties and water quality for Kuantan and Bentong area.

II. To propose a potential area for groundwater development in Pahang.

1.4 Scope of study

The study involved analysis of data from Mineralogy and Geoscience Department Malaysia Pahang (JMG). The chosen areas of studies are Kuantan and Bentong. The geology for both of this area is different where Kuantan is major in sand and gravel while Bentong is major in rock. But the recharge of groundwater is different.

1.5 Location of Study

Pahang is the third largest state in Malaysia, after Sarawak and Sabah, occupying the huge Pahang River river basin. The Pahang River basin is located in the eastern part of Peninsular Malaysia between latitude N 2° 48' 45" and N 3° 40' 24" and between longitude E 101° 16' 31" and E 103° 29' 34". While the latitude of Pahang is N 3° 48' 0" and longitude E 103° 20' 0". Pahang's tropical monsoon climate brings with it a uniform temperature of 21°C to 32°C throughout the year. The months of January through April are dry and warm, while the months of May to December are wettest. Average rainfall each year falls between 2,032 mm to 2540 mm, with a high humidity between 82-86 percent. In this study, Kuantan and Bentong have been selected. The location of study area is shown in Figure 1.1.

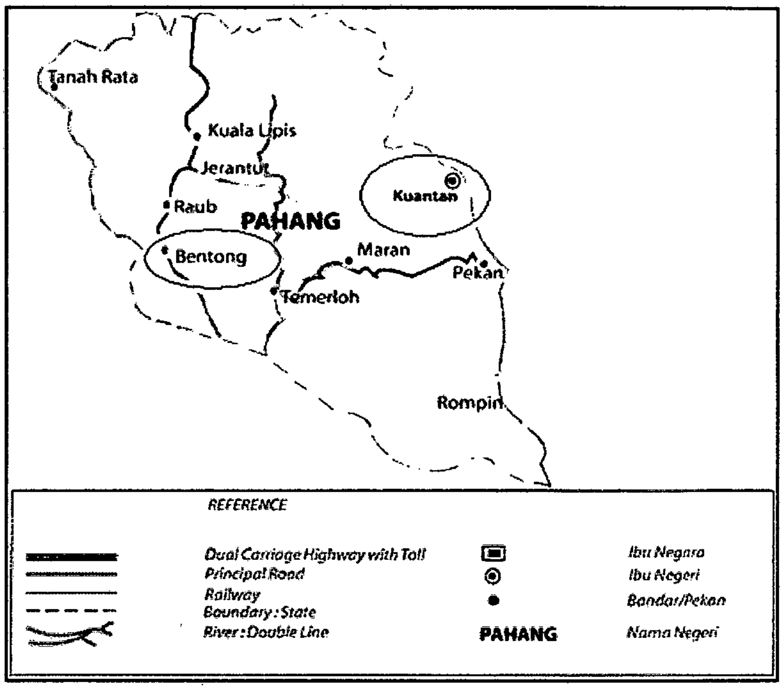

Figure 1.1: Location of study area: Kuantan and Bentong.

(Web Sawadee Co.,Ltd, 1998-2004).

1.6 Significant of Study

There are several valuable benefits expected by implementing this study. This study will improve the living standards of human using safe water supplied from wells which also can supply water even during the dry season. It's because groundwater development has for a long time provided drinking water to urban and rural population of developed and developed countries. Currently, groundwater is estimated to provide about 50% of the world drinking water supplies. There are also good economic reasons for widespread dependence on groundwater. In its natural state groundwater is usually of excellent quality and can be used with no costly treatment or purification. So it is saving the cost of transporting and treatment for the water.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Groundwater forms part of the natural water cycle and constitutes a major portion of the cycle. Groundwater is present in various types of geological formation and occurs in permeable geologic formation called aquifers which can store and transmit water. In most parts of Malaysia, groundwater resources are underutilized. (Jasni et al., 2006)The use of groundwater for domestic purpose is mainly confined to rural areas where there is no piped water supply except in Perlis and Kelantan, where groundwater is being significantly utilized for public water supply.

In Malaysia groundwater potential is mainly in alluvial aquifers and hard rock aquifers. Alluvial aquifers mainly compose of gravel, silt, sand and clay are the most productive and are situated along rivers in the coastal plains. Hardrock aquifers can be limestone aquifers and fractured rock aquifers. Alluvial aquifers and limestone aquifers typically are most productive, while fractured rock aquifers (made up of various sedimentary, metamorphic and igneous rocks) are comparatively poor yielding (Jasni et al., 2006).

2.2 Formation of Groundwater

The hydrologic cycle is a constant movement of water above, on, and below the earth's surface. It is a cycle that replenishes ground water supplies. It begins as water vaporizes into the atmosphere from vegetation, soil, lakes, rivers, snowfields and oceans which a process called evapotranspiration.

The life on earth s greatly influenced by the planet unending moisture cycle termed as the hydrologic or water cycle. The cycle has neither a beginning nor and end, but the concept of the hydrologic cycle commonly begins with the water of oceans, since it covers about three-fourth of earth surface. The water vapor rises into the sky and form clouds. The moisture lifted from earth surface condenses and fall back to earth as rainfall. The various forms of precipitation fall on the land are highly important for man to carry out agricultural activities. The entire water cycle is ruled by sun (Raju, 2004).

As the water vapor rises it condenses to form clouds that return water to the land through precipitation such as rain, snow, or hail. Precipitation falls on the earth and either percolates into the soil or flows across the ground. Usually it does both. When precipitation percolates into the soil it is called infiltration and when it flows across the ground it is called surface runoff.

Surface runoff eventually reaches a stream or other surface water body where it is again evaporated into the atmosphere. However infiltration moves under the force of gravity through the soil. If soils are dry, water is absorbed by the soil until it is thoroughly wetted. Then excess infiltration begins to move slowly downward to the water table. Once it reaches the water table, it is called ground water. The groundwater formation is illustrated in Figure 2.1.

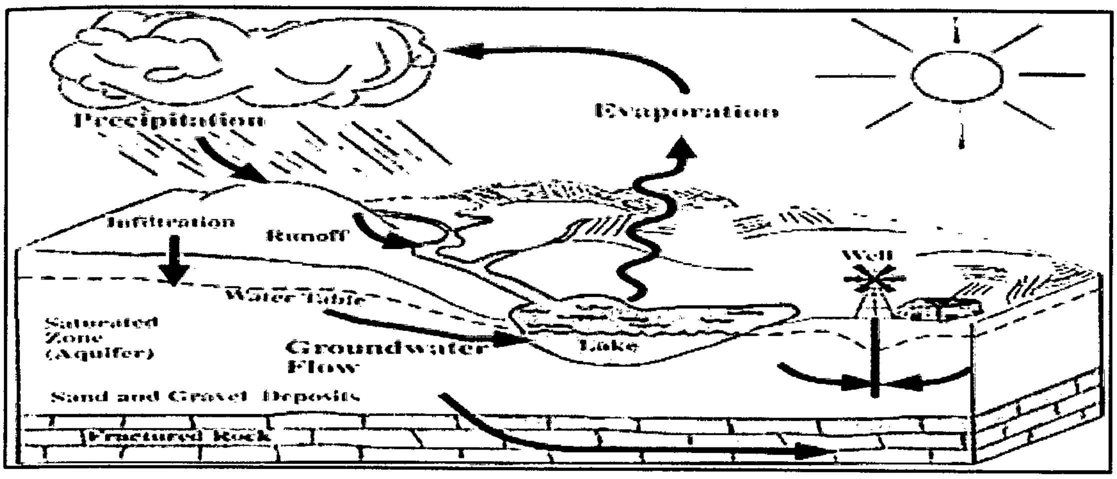

Figure 2.1: Formation of groundwater. (Fetter, 2006-2007)

The rapidity of infiltration depends on the permeability and porosity of soil. During infiltration, water will move downwards (due to gravity force) and fill the voids. In permeable soil i.e. sandy and alluvial soil, water infiltrates faster due to its higher volume of voids. Compared to impermeable soil i.e. clay and silt, small pore spaces retard infiltration. Otherwise in permeable soil, infiltration happens continuously and only stops once the voids in the ground are full with water (Bell, 1993).

According to Thomas (2005) most of the precipitation that reaches the ground surface is absorbed by the surface layer of soil. The remainder, once any depression storage has been filled, will flow over the surface as overland flow, reaching the stream channels quite quickly. The water that infiltrates into the soil may subsequently be evaporated, or flow laterally close to the surface as through flow, or else it may percolate under gravity to the groundwater body. Groundwater is water found within the pore spaces of geologic material beneath the surface of the earth. It exists in saturated layers of sands and gravels, in certain types of clay material, and in cracks within crystalline rock.

2.3 Groundwater Terminology: Aquifer, Aquitard and Aquiclude

To conduct and analyze the pumping test data, it is necessary to understand basic terminology for this profession. These other basic concepts are described in many ground water text books. Hydrogeological terms relevant to the aquifer are described in this section. Geologic unit are described by their lithology, origin or mineral content. An aquifer is defined as a saturated permeable geological unit that is permeable enough to yield economic quantities of water to wells. The most common aquifers are unconsolidated sand and gravels, but permeable sedimentary rocks such as sandstone and limestone, and heavily fractured or weathered volcanic and crystalline rocks can also be classified as aquifers (Kruseman et al., 1990).

An aquitard is a hydrostratigraphic unit that does not transmit sufficient water to support a well, but does not store and slowly transmit water from one aquifer to another. When taken over a large area, the volume of water movng from the aquitard to the aquifer can be significant. Aquitard which bound aquifer are often called confining layers or beds. An aquiclude is defined as a geological unit that cannot transmit significant quantities of water under ordinary hydraulic gradient. The term leaky confining layer is often used instead of aquiclude. Most hydrostratigraphic unit are usually aquifer or aquitard. Aquicludes are rare since even low permeability units such as clays and tills can have enough fissures or fracture to allow the leakage of some water to adjacent aquifers. An aquifer in one area, such as a thin silt, could be classified as an aquitard in another area where it occurs within coarse sands gravels (Hall, 1996).

2.4 Aquifer Types

Aquifer is classified into three categories which is confined, unconfined and leaky aquifer. They may also called by a stratigraphic names, but our interest is in the analysis of pumping test is controlled by following three categories

2.4.1 Confined Aquifer

A confined aquifer is bounded above and below by an aquiclude. In a confined aquifer, the pressure of the water is usually higher than that of the atmosphere, so that if a well taps the aquifer, the water in it stands above the top of the aquifer, or even above the ground surface. We then speak of a free-flowing or artesian well (Kruseman et al., 1990).

2.4.2 Unconfined Aquifer

An unconfined aquifer also known as a water table aquifer, is bounded below by an aquiclude, but is not restricted by any confining layer above it. Its upper boundary is the water table, which is free to rise and fall. Water in a well penetrating an unconfined aquifer is at atmospheric pressure and does not rise above the water table (Kruseman et al., 1990).

2.4.3 Leaky Aquifer

A leaky aquifer also known as a semi-confined aquifer, is an aquifer whose upper and lower boundaries are aquitards, or one boundary is an aquitard and the other is an aquiclude. Water is free to move through the aquitards, either upward or downward. If a leaky aquifer is in hydrological equilibrium, the water level in a well tapping it may coincide with the water table. The water level may also stand above or below the water table, depending on the recharge and discharge conditions (Kruseman et al., 1990). The unconfined and confined aquifer is illustrated in Figure 2.2.

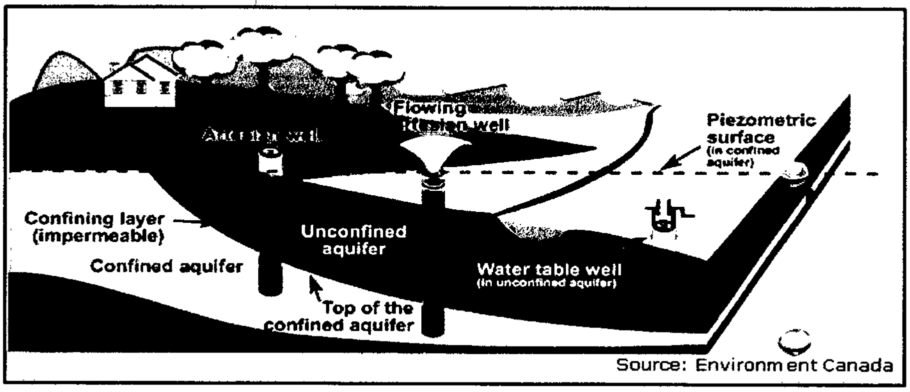

Figure 2.2: Confined and unconfined aquifer (Environment Canada, 2009)

2.5 Physical Properties

In describing the flow to a pumped well, various physical properties and parameters of aquifers and aquitards appear. These will be discussed below.