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DEVELOPMENT OF A HYDROGEOLOGICAL CONCEPTUAL MODEL AND GROUNDWATER MODELING FOR THE SELANGOR BASIN, MALAYSIA

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By

NUR HIDAYU BINTI ABU HASSAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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June 2018

Chairman: Mohamed Azwan Mohamed Zawawi
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Exploitation demand in surface water for various purposes in Malaysia has been gradually increasing. This issue is very concerning as it involve large scale purposes; especially in agricultural activities and industrial purposes. Hence, it is important to acknowledge the need of a sustainable alternative water supply.

Groundwater as water supply is not common in Malaysia. The lack of research and expertise on groundwater aquifer area has led to minimal usage of groundwater. Despite of the limited data information available, this study intends to develop a groundwater flow model within the interest area. However, to achieve this goal, it is important to determine the geological condition of the study area and develop a proper hydrogeological conceptual model to represent the accurate real world conditions and then do a simulation to observe the natural groundwater pattern.

The geological condition was determined by the borehole log lithology, and the applicability of the lithology has been confirmed by the geophysical study. A total of six layers which were silty clay; sand and gravel; sandstone; shale and schist with solid granite underlain the subsurface formation as bedrock.

The development of hydrogeological conceptual model requires several model input to be included; hydrological data, meteorological data and necessary boundary conditions. Calibration of conceptual model was made with correlation coefficient 0.975 and normalized RMS with 14.18%. Validation of model cannot be made because it requires two set of data with different time period. However, validation should not be seen as end process but as the entire process involved.

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Groundwater flow mass balance graph has been determined. Input parameters that effects the flow were constant head, river leakage, recharge and ET.

Simulation of groundwater flow model gives water table elevation contour and groundwater flow direction. The movement of groundwater direction can be observed flowing from higher hydraulic gradient (high water table elevation) towards lower hydraulic gradient (low water table elevation).

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Sarjana Sains

PEMBANGUNAN MODEL KONSEPTUAL HIDROGEOLOGI DAN MODEL AIR BAWAH TANAH BAGI KAWASAN LEMBANGAN SELANGOR, MALAYSIA

Oleh

NUR HIDAYU BINTI ABU HASSAN

Jun 2018

Pengerusi: Mohamed Azwan Mohamed Zawawi
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Permintaan dalam mengeksploitasi air permukaan bagi tujuan-tujuan tertentu di Malaysia semakin meningkat. Isu ini sangat membimbangkan kerana ianya melibatkan industri skala besar; terutamanya dalam aktiviti pertanian dan perindustrian. Oleh itu, adalah penting untuk mencari sumber air alternatif yang mampu menampung bekalan yang berterusan.

Penggunaan air bawah tanah sebagai sumber bekalan air adalah kurang dipraktikkan Malaysia. Kurangnya penyelidikan dan kepakaran mengenai corak sistem akuifer bawah tanah telah menyebabkan penggunaan air bawah tanah yang minimal. Oleh yang demikian, dengan maklumat data adalah terhad, kajian ini memberi tumpuan untuk membangunkan model air bawah tanah dalam kawasan kajian. Walau bagaimanapun, untuk mencapai matlamat ini, adalah penting untuk menentukan struktur geologi kawasan kajian dan membangunkan model konseptual hidrogeologi yang tepat bagi mewakili keadaan dunia sebenar. Struktur geologi yang ditentukan oleh litologi telaga, dan penerapan litologi telah disahkan oleh kajian geofizik.

Keadaan geologi tanah telah ditentukan oleh log telaga, dan penerapan litologi telah disahkan oleh kajian geofizik. Sejumlah enam lapisan telah dikenal pasti iaitu tanah liat; pasir dan kerikil; batu pasir; syal dan schist dengan granit bersifat pepejal sebagai batuan dasar.

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Pembangunan model konseptual hidrogeologi memerlukan beberapa input parameter untuk diambil kira; data hidrologi, data meteorologi dan syarat sempadan yang diperlukan. Penentukuran model konseptual dibuat dengan pekali korelasi 0.975 dan RMS dinormalisasi dengan 14.18%. Pengesahan model tidak boleh dilakukan kerana ianya memerlukan dua set data dengan tempoh masa yang berbeza. Walau bagaimanapun, pengesahan harus tidak dilihat sebagai proses akhir tetapi sebagai keseluruhan proses yang terlibat. Graf baki jisim air bawah tanah telah ditentukan. Parameter yang memberi kesan aliran aras air malar, kebocoran sungai, pengisian air bawah tanah dan ET.

Simulasi model aliran air tanah memberikan kontur ketinggian jadual air dan arah aliran air bawah tanah. Pergerakan arah bawah tanah dapat diperhatikan mengalir dari gradien hidraulik yang lebih tinggi (elevasi ketinggian air tinggi) ke arah kecerunan hidraulik yang lebih rendah (ketinggian meja air rendah)

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In the name of Allah, Most Gracious, Most Merciful
Have We not uplifted your heart for you O Prophet;
Relieved you of the burden;
Which weighed so heavily on your back;
And elevated your renown for you?
So, surely with hardship comes ease;
Surely with that hardship comes more ease;
So once you have fulfilled your duty, strive in devotion;
Turning to your Lord alone with hope.

[Al-Sharh, 1:8]

All praises to Allah who has guided His servant through ups and downs of this journey.

To En Mohamed Azwan Mohamed Zawawi.

To my beloved *Ibu* and *Ayah*.

To all who always with me.

This is for you….

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I certify that a Thesis Examination Committee has met on 26 June 2018 to conduct the final examination of Nur Hidayu binti Abu Hassan on her thesis entitled "Development of a Hydrogeological Conceptual Model and Groundwater Modeling for the Selangor Basin, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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Declaration by graduate student

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Name of Member of Supervisory Committee: Ahmad Fikri Abdullah

Signature: ______________________________
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CHAPTER 1

INTRODUCTION

1.1 Background Study

Surface water and groundwater are mainly two major water sources for public consumption. According to statistic by Food and Agriculture Organization (FAO) 1999, 97% of surface water was used for particular importance, while the other 3% was from groundwater. Dependency on surface water regardless for any sector from time immemorial however, facing same issue that remains unresolved; water deficiency. Again statistic report from FAO, 2016 affirms that mostly utilization of water sources in 2005 in Malaysia comes from industry 36%, while 34% are from irrigation and livestock, while another 30% is from municipalities' purposes.

The increasing water demands among sectors have gradually pressure on the surface water in terms of quality and quantity. Worst comes to worst, natural disasters such as floods and droughts that hit Malaysia seasonally has led to major water scarcity as surface water can be easily influenced by environmental harm. Indeed, Malaysia receive rainfall throughout the year which roughly estimated about 2,300 mm. However, with the abundant amount of rainfall compared to other countries, the quantity is still insufficient to support water demand in any industries or agricultural purposes.

Nonetheless, the exploitation of groundwater in Malaysia for any purposes is still not fully utilized. According to FAO, 1999, groundwater abstraction for domestic sector is about 60-65% while 30-35% is abstracted for industry purposes and the last 5% is for irrigation. This suggests that society is not aware of the abundance amount of groundwater exists in Malaysia. As specified by Alberto et al., 2006 cited from Fauzie et al., 2013, groundwater sources has a more reliable supply, lesser vulnerability to drought and is more accessible for individual use in comparison with traditional surface water supply.

However, in order to harness groundwater to the fullest, a complete hydrogeological conceptual model need to be developed in order to observe groundwater flow system thoroughly. In general, a conceptual model is referred as a graphical representation of overall groundwater flow system that relates with geological, hydrogeological, and hydrological data which is simplified into block diagram or sometimes cross section as reported by Anderson & Woessner, 1992. While Barnett et al,. 2012 has ascertain the importance of developing a groundwater flow model which was relates to understand the groundwater system within the interest study area; exploring more alternative management

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approach; establish reliable estimation of groundwater budgets; forecast future outcome of groundwater in different scenarios; and verifying future data information needed. Nevertheless, the basic of developing the groundwater flow model was investigating the subsurface geological formation within the area of interest. A proper determination of subsurface geological formation give thoroughly view of subsurface layer characteristics which includes thickness of each soil/rock layer and depth of each soil/rock layer.

1.2 Problem Statements

The study is localized in western region of Selangor Basin area. The scope of the study is to develop the hydrogeological conceptual model to observe the groundwater flow system under natural condition.

A conceptual model development is crucial in investigating the system of groundwater flow. However, a clear and thoroughly view of subsurface geological formation need to be done by using borehole log in comparison with geophysical study. Both undertaken methods are needed in determination of subsurface layer in interest study area, thus developing a groundwater conceptual model then is easier. Nevertheless, in recent study, there is still lack in research/information regarding the subsurface geological formation in study area.

1.3 Objectives of Study

The main objective of this study is to establish hydrogeological conceptual model of Selangor Basin. The specific objectives are:

1. To investigate the subsurface geological formation using borehole log data information at Selangor Basin area.
2. To develop the conceptual model of the study area.
3. To simulate the groundwater flow model under natural condition.

1.4 Scope and Limitations

The scopes of the analysis are as below:

i) To determine subsurface geological formation

Determination of subsurface geological formation at study area is rather difficult due to the insufficiency of information data and research done by previous researchers. Most tube wells information obtained are focusing on west region of study area in comparison to the East region.

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ii) To develop hydrogeological model

Hydrogeological model of Selangor Basin needs to be developed in order to create a model that can represent real world condition. Long term observational results can be obtained over the model. The logic behind this is; developing a model, it will give an additional insight into the complex system behavior of the beneath subsurface media, as well as assisting in building a conceptual understanding.

The limitations of the analysis are as below:

i) Developing a subsurface geological formation at study area needs proper methods which are the observations from tube well lithology and geophysical study. However, in most lithology, the depths are not suitable for interpolation purposes in order to determine the actual layer at that particular point. While geophysical study needs experts and knowledge in determining the exact line to be tested on.

ii) Developing a hydrogeological model of Selangor Basin involves an expansive extent. The data needed to fullfil the objective of the research are lacking, thus it is feared that it will be insufficient in order to develop a conceptual model.

1.5 Thesis Overview

This thesis contains five chapters. Chapter 1 is an introduction to the thesis, providing a background study, problem statements, objectives of study, and scope and limitations. Chapter 2 contains a literature review on several topics that are related to research project. Literature review on Geophysical Investigation, Visual MODFLOW are provided in Chapter 2. Besides, a summary of previously published articles is discussed in Chapter 2. Chapter 3 provides a description of study area as well as the methodology used in this study. Study area, data acquisition and data analysis are discussed in this chapter. Chapter 4 contains the results and discussions of the subsurface geological condition as well as the development of groundwater modeling. The conclusion and recommendation of study are discussed in Chapter 5. Additional figures for this thesis are provided in Appendices.

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