STOCHASTIC GROUNDWATER FLOW A CASE STUDY IN PONTIAN

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To my beloved family.

Juma,at bin Idris

Norhanah binti Md. Danuri

Danuri binti Ramit

Norfarahin binti Juma'at

Mohd. Izzad bin Juma'at

Muhamad farhan bin Juma'at

Ammar ezzani bin Juma'at

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ABSTRACT

Groundwater is the nation's most importance sources. Therefore, it has motivated many researchers to study about groundwater. Nowadays, we have many researches done using stochastic model in groundwater flow. Hydraulic conductivity, K is one of the important parameters in groundwater. This research studied about groundwater property at Pontian, Johor. The secondary data consists of depth of water table and time taken for two different radius. From the secondary data, the values of hydraulic conductivity were obtained by using Earnst and Hooghout formula. From the calculation, the range of hydraulic conductivity is between $0.118\times10^{-3}cm/s$ to $6.948\times10^{-3}cm/s$ and it agrees that the hydraulic conductivity of peat soil is between $\times10^{-4}$ to $\times10^{-3}$. Besides that, this research also study the relationship between hydraulic conductivity as dependent variables with depth of water table and radius of auger hole as independent variables. Multiple linear regressions are used to analyze the relationship and it is shows that, the depth of water table and radius of auger hole affect the hydraulic conductivity significantly. Lastly, stochastic approach was used to describe the one dimensional, steady state and saturated groundwater flow and the exact solution is in the form of expected function of $J(s)$ which is the gradient of head potential.

ABSTRAK

Air bawah tanah merupakan sumber negara yang paling penting. Oleh itu, ia telah mendorong para penyelidik untuk mengakaji mengenai air bawah tanah. Pada masa kini, dapat dilihat banyak penyelidikan dengan mengkaji proses stokastic untuk air bawah tanah. Kekonduksian hidraulik, *K* merupakan salah satu parameter yang penting dalam alir air bawah tanah. Kajian ini mengkaji kekonduksian hidraulik air bawah tanah di Pontian, Johor. Data sekunder yang diperolehi mengandungi kedalaman aras air dan masa diambil bagi dua radius yang berbeza. Hasil dari pengumpulan data tersebut, nilai kekonduksian hidraulik, *K* diperolehi menggunakan formula Earnst dan Hooghout. Melalui hasil pengiraan, julat bagi kekonduksian hydraulic adalah diantara $0.118\times10^{-3}cm/s$ hingga $6.948\times10^{-3}cm/s$ yang menunjukkan kekonduksian hidraulik tanah gambut yang mempunyai julat diantara $\times10^{-4}$ hingga $\times10^{-3}$. Selain itu, kajian ini juga mengkaji hubungan antara kekonduksian hidraulik sebagai pemboleh ubah bergantung dengan kedalaman paras air dan jejari lubang gerimit sebagai pemboleh ubah bebas. . Oleh itu, model regresi linear berganda digunakan untuk mengkaji hubungan tersebut dan dapat dibuktikan bahawa kedalaman aras air dan jejari lubang gerimit mempengaruhi kekonduksian hydraulic secara signifikan.. Akhir sekali, penyelesaian stokastik digunakan untuk menyelesaikan persamaan air bawah tanah bagi satu dimensi, keadaan mantap dan tepu. Fungsi jangkaan stokastik yang terhasil adalah dalam bentuk fungsi jangkaan $J(s)$ iaitu kecerunan potensi kepala.

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q = specific discharge or flow rate Q, through cross sectional area A $\left[L/T\right]$

Q = flow rate $\left[L^3/T\right]$

A = cross sectional area through which flow occurs $\left[L^2\right]$

K = hydraulic conductivity

H = hydraulic head potential

K_s = hydraulic conductivity of the saturated soil (m/d)

Δy = average of level water in the hole (cm)

Δt = time interval (s).

C = factor depends on the depth of an impermeable layer below the bottom of the hole (S)

r = radius of the hole (cm)

y = average depth of the water level in the hole below the water table (cm)

D_1 = depth of water table (cm).

I_t = Ito stochastic integral

W = wiener process.

$X(.)$ = stochastic process

μ = drift coefficient of the stochastic differential equation

σ = diffusion coefficient

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

Groundwater is the nation's most importance sources. Therefore, it has motivated many researchers to study about groundwater. Nowadays, we have many researches done using stochastic model in groundwater flow. It is because, from Christakos et. al (1993), standard deterministic theories of flow and transport proven that it is quite inadequate when tested on natural phenomena since they do not involve with uncertainties in parameter that can lead to huge error. Therefore stochastic is alternative in studying groundwater behavior since it involved uncertainties parameter into groundwater flow. Stochastic model also provide theoretical and practical concepts to describe the combinations of complexities, heterogeneities in this phenomena.

Water is essential to human life and the largest source of fresh water is from underground. Therefore, the development of underground water has been made because the increasing demands for the fresh water and limiting supplies. Groundwater is a major source of industrial uses, agriculture and public uses. In order to maintain the groundwater supply, it is needed to protect the groundwater from contamination, resources depletion, and land subsidence.

Based on the USGS survey in 2013, about 40 percent of water used for the public supply and more than 97 percent provides for drinking water in the rural population who do not have access to the water supply systems. Besides that, for the agriculture industries, around 30 to 40 percent of water used comes from groundwater.

In Johor especially in Pontian the utilization of groundwater is at infancy stage. Pontian is one of the largest areas with peat soil type in Malaysia. Generally, the development of agriculture, industrial and urbanization activities will increase the demand for water supply. Current global environmental crisis which is flood in Pontian has reinforced the need for developing flexible mathematical model to obtain better understanding of the environmental problem. Therefore, in this research, stochastic model and analysis tools can help the environment scientist obtain more accurate information to be used in mitigating the adverse impacts and protecting this valuable resource. In addition, the analysis of groundwater flow is based on the structure of groundwater which consists of aquifer, soil type, porosity, permeability, head potential, and hydraulic conductivity.

1.2 Statement of Problem

Due to the rapid growth of population and irrigated agriculture has led the demand on water supply in Pontian. It is important issues so that deep knowledge about groundwater is important to manage the water resource efficiently. But the development of the groundwater system in Pontian is slow. Good mathematical model can help in decision making to manage water resource efficiency. Recently, deterministic model of groundwater has been used, but the uncertainties are not included which can lead to large error. Therefore, stochastic modeling can be used to study groundwater as the uncertainties are unavoidable in groundwater.

1.3 Objectives of the Research

The objectives of this research are:

1. To calculate value of hydraulic conductivity of peat soil.
2. To determine the effect of radius auger hole to the hydraulic conductivity

3. To model of one dimensional, steady state groundwater flow by incorporating stochastic approach.

1.4 Scopes of the Research

This research limits the scope area for the groundwater study is in Pontian, Johor. Besides that, peat soil is the type of aquifer in Pontian. In this study the model of hydraulic conductivity is constructed through multiple linear regressions. Besides that, the secondary data obtained consists of depth of water table and time taken for two different radius is collected by Abdullah (2006). Besides that, the groundwater flow equation of one dimensional, steady state, saturated is used to be solved by using stochastic method.

1.5 Significance of the Research

From this research, it can help in better estimation on the groundwater that will help environment scientist/specialist to design/manage groundwater resources more efficiently

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