ESTIMATION OF IMPACT OF ARTIFICIAL GROUNDWATER RECHARGE IN SMALL ISLANDS USING A NUMERICAL MODELLING APPROACH

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Degree of Master of Science

Department of Civil Engineering

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in text.

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P. Rubyhanusha Date

The above candidate has carried out research for the Master's thesis under my supervision.

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Dr. R.L.H.L. Rajapakse Date

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ABSTRACT

Estimation of Impact of Artificial Groundwater Recharge in Small Islands using a Numerical Modelling Approach

There are many small islands all over the world, which face scarcity of drinking water due to low rainfall, high evaporation rate, absence of surface water and salinity in groundwater. Island width, amount of recharge, pumping rates and aquifer properties are the governing factors of freshwater lens volume. Only a certain percentage of rainfall will percolate naturally into the ground and remaining rainwater will reach the sea without recharging the ground. In addition to natural recharge, artificial recharge can be used to increase the freshwater lens volume. In order to identify the effect of artificial recharge in the freshwater lens, the existing conditions of the aquifer and the volume of groundwater should be identified. It can be identified by using geophysical investigations, algebraic models or numerical models.

The objective of this study is to identify the impact of artificial recharge on aquifer condition and groundwater table in small islands by using a numerical modelling approach.

Three islands in the Maldives, namely Dharavandhoo, Henbadhoo and Bodufolhadhoo, which face scarcity of drinking water, were selected for this study. A two-dimensional numerical model was developed by using SUTRA (Model for 2D or 3D Saturated-Unsaturated, Variable-Density Ground-Water Flow With Solute or Energy Transport) with ModelMuse as graphical user interface (GUI). The model simulates the seawater-freshwater interface by using the following approach. Island undergoes a prolonged drought, which causes the water inside the island to become fully saline due to saltwater intrusion. Later, rainwater recharge to the island starts which drives out seawater, raise the water level on the island, and finally a constant freshwater lens develops over time. In the present study, the freshwater level and seawater-freshwater interface level in each island were measured by using electromagnetic surveys (Model: ABEM Terrameter SAS 1000), and aquifer properties were obtained from the literature and in-situ testing. Holocene aquifer hydraulic conductivity was calibrated until the percentage difference between simulated freshwater lens volume and observed freshwater lens volume is less than ±10%. The impact of artificial recharge was identified by increasing the recharge rate in the model by 5% and 10% of annual rainfall and simulating the previously calibrated model, presuming that artificial recharge can be increased to facilitate an additional recharge of 5–10% of annual rainfall.

Observed seawater-freshwater interfaces of the islands in most transects were in lens shape as expected, but interfaces in certain transects have clear upconing effect at particular locations due to over-pumping. The calibrated Holocene aquifer hydraulic conductivity values range from 25 m/day to 45 m/day, which is in the same order of magnitude for atoll island Holocene aquifer hydraulic conductivity values presented in previous studies. The analysis of the effect of artificial recharge indicates that the freshwater lens thickness and volume significantly increased with artificial recharge. With a 5% of annual rainfall as artificial recharge, the freshwater lens thickness of Dharavandhoo, Henbadhoo and Bodufolhadhoo islands increased from 5.2 m to 6.9 m (33%), 2.6 m to 4.0 m (54%) and 1.5 m to 2.7 m (80%), respectively and with a 10% annual rainfall as artificial recharge, it increased to 8 m (53%), 4.9 m (88%) and 3.4 m (127%), respectively.

Based on these results, it can be concluded that the model developed can be effectively used in quantifying the effect of artificial recharge on groundwater volume and artificial recharge will be a sustainable solution to overcome the scarcity of drinking water in small islands.

Keywords: Atolls, Freshwater lens, Maldives islands, SUTRA - Model Muse

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