

Controlling factors of groundwater hydrochemistry in a small island's aquifer

^{1,2*}A. Z. Aris; ²M. H. Abdullah; ²A. Ahmed; ³K. K. Woong

¹Department of Environmental Sciences, Faculty of Environmental Studies, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

²School of Science and Technology, University of Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia

³Department of Environmental Science and Engineering, Gwangju Institute of Science and Technology, Gwangju, 500-712 South Korea

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ABSTRACT: Factor analysis was applied to the hydrochemical data set of Manukan Island in order to extract the principal factors corresponding to the different sources of variation in the hydrochemistry. The application of varimax rotation was to ensure the clear definition of the main sources of variation in the hydrochemistry. The geochemical data of dissolved major, minor and trace constituents in the groundwater samples indicates the main processes responsible for the geochemistry evolution. By using Kaiser normalization, principal factors were extracted from the data for each location. The analysis reveals that there are four sources of solutes: (1) seawater intrusion; (2) leaching process of underlying rock mediated by pH; (3) minerals weathering process and (4) dissolution of carbonate minerals characterized by high loadings of Ca, Zn and Mg. Such processes are dominated by the significant role of anthropogenic impact from the over abstraction of fresh water from the aquifer. Those factors contributed to the changes of the groundwater geochemistry behavior explain the effect of rising extraction of freshwater from the aquifer.

Key words: Factor analysis, groundwater, hydrochemistry, seawater intrusion, small island

INTRODUCTION

Groundwater of small island located in the tropical region, especially in Malaysia receives increasing stress such as contributed by anthropogenic factors. Over exploitation may cause the imbalance in the hydrological system. In such areas, groundwater is commonly the only water resources, and the most prevalent issue relevant is the quality of the groundwater. Groundwater quality deterioration could be due to seawater intrusion as a result of over exploitation. Since its existence has become the most important source of water supply for the small island's community, pumping from the upper phreatic zone is widely practiced. A case study was done on Manukan island. This island is under stress with the increasing number of tourist and human activities on the islands. Well known as diver's paradise, Manukan island received thousands of visitors a year and still increasing from year to year. While many atolls have been thoroughly

studied (Abdullah, *et al.*, 1997b; Abdullah and Musta, 1999; Abdullah, *et al.*, 2004; Abdullah and Aris, 2005), the hydrochemistry of Manukan island has rarely been reported. Located about 7.45 km (4.02 nautical miles) from Kota Kinabalu, Sabah, Manukan is one of the islands under Tunku Abdul Rahman Parks. This study was set to determine the controlling factor that significantly controls the chemistry of the groundwater in the island. All data were analyzed using factor analysis to investigate the principles of interaction of components and their integration into a system.

MATERIALS AND METHODS

Manukan island (5°57'-5°58' N and 115°59'-116°01' E), (Fig. 1) has an area of 206 000 m². Almost 80 % of the area is covered by forest in the high relief side, while the rest 20 % of the area is developed for tourism activities which are located on the low lying area of the island. Manukan island is the park's second largest island of Tunku Abd Rahman Parks

*Corresponding Author Email: zaharin@env.upm.edu.my
Tel.: +603 8946 7461; Fax.: +603 8943 8019