BORNEO SCIENCE 3: 43 - 51, DEC. 1997

A PRELIMINARY GEOCHEMICAL STUDY ON MANUKAN ISLAND, SABAH

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ABSTRACT. *The study was carried out to determine the geochemical elements in the soil and groundwater in Manukan Island, Sabah. The major element contents in the soil are Mg, Ca, Si, and Al. The relatively higher concentrations of Mg and Ca in some water sampling stations may be due to the dissolution of carbonate minerals from the soil. The Cl content of the water shows higher than the drinkable standard.*

INTRODUCTION

The study of the geochemical composition of Manukan Island provides useful information of soil and water in the study area. The chemical composition of the study area would provide a preliminary information regarding the chemical contents of soil and groundwater. The presence of relatively high chloride concentration may be due to contamination from sea water. It is important to have a general understanding of mineralogy of the site because of the mineral content of soil and rocks may be to a large extent, controls the types of water. The water-bearing rocks exert a strong influence on groundwater quality, especially due to the solubility of the rocks.

Generally, an island is susceptible to sea water contamination particularly permeable sedimentary formation. So far, only a few such studies have been carried out in Malaysia in order to evaluate groundwater. In other parts of the world, there were several studies done on islands such as a group of islands in the Kingdom of Tonga (Furness & Helu, 1993), Malta islands (Government of Malta, 1979), and Canary islands in the north-west of African continent (Heras & Oiza, 1979), where there are increasing demand of water occur deterioration of groundwater quality.

The main objective of the present study is to determine the composition of soil and groundwater in Manukan Island to be a baseline data for further research.

Manukan Island is situated in the north-west coast of Sabah, Malaysia (Figure 1). It has an area of 206,000 m^2, and its 164,800m^2 area is covered by forest particularly on the high-relief side. This is one of the island of Tunku Abdul Rahman Marine Park. It is protected under the government's Parks Enactment of 1978. This island is famous for its sandy beaches and corals, and is opened to visitors. Geologically, the island consists of interbedded sandstone and shale classified as the Crocker Formation deposited during Late Eocene to Middle Miocene (Basir *et al.*, 1991).

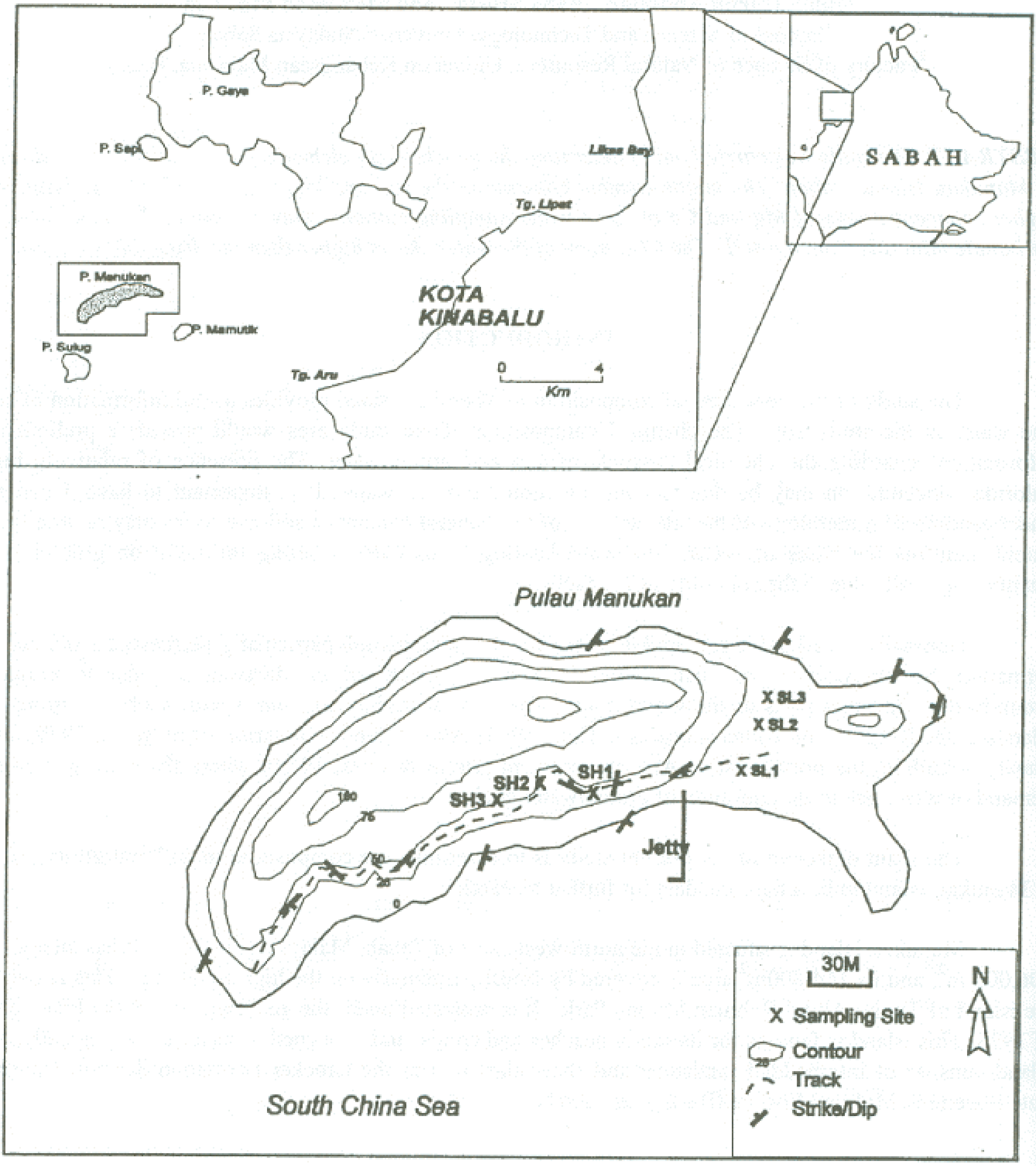

Figure 1: Location of the study area on Pulau Manukan Sabah

MATERIALS AND METHODS

Mineral and Soil Analysis

The soil samples were collected at 5cm and 50cm depths by using hand auger from three locations both from hillslope and lowland areas. For the purpose of analysis of elements and minerals, samples were dried, crushed and powdered using mortar. To identify the secondary minerals in soils, X-ray Diffraction (XRD) method was carried out by electronic Siemens Diffractometer D500 and Kristalloflexx 710/710H using Diffrac/AT software.

SiO_2, Fe_2O_3, Al_2O_3, MgO, MnO, CaO, Na_2O and K_2O were determined using X-ray Fluorescene (XRF) method with Philips PW 1480 X-ray digital and spectrometer controlled by the Digital software X44 microcomputer. The graph calibration method used Alphas on-line programme. Chloride was analysed using acid-soluble chlorine method (Jeffry & Hutchison, 1986). The loss on ignition (L.O.I) was obtained by heating samples at $1000^{\circ}C$ for 1 hour.

Hydrochemical Analysis

Groundwater samples were collected by the help of Wildco water sampler model-1120, from four existing wells on the island (Figure 1). The covered well has a diameter of 150 cm and depth 290 cm from the ground. Sampling was done during the tidal height range of 0.6 - 1.6 m.

In situ readings of conductivity and salinity were measured using HACH CO15 conductivity meter model-50150. WTW pH meter model pH320 was used for recording pH values. For analysing chloride, 100 ml of each sample was mixed with 0.1 ml, K_2CrO_4 indicator solution and titrated with standard 0.0141 N $AgNO_3$. Samples for analysis of Ca, Mg, and Si at laboratory were stored in clean bottles and preserved with nitric acid at $pH<2$ until their measurement using Atomic Absorption Spectrophotometer (AAS).

RESULT AND DISCUSSION

Geological Structure

The sedimentary rock of Manukan Island dips towards East - Northeast, i.e towards the low relief area, with dipping angles of 15° - 45° (Figure 1). The fold forms a slight symmetrical syncline in the low-lying area. Small scale normal faults and joint sets can be observed in several locations.

The island consists of clastic sediment of the Crocker Formation with interbedded sandstone and shale. On the upper sequence, the rock consists of interbedded thick sandstone and thin shale. The lower sequence consists of thick yellowish brown shale and dark grey in colour and, interbedded with black grey thin sandstone. The weathered sandstones are yellowish in colour, whereas the shales are brown and dark.

Soil Profile and Geochemistry

Soil profile and geochemistry are important to understand the chemistry of the phreatic zone of the island. The soil profiles of the island show a complete weathering zone from totally weathered-soils to fresh rocks, with varying thicknesses. In general, the profiles at lowland area (Figure 2A) are thinner compared to that of the hilly area (Figure 2B). The weathering profiles can be divided into 5 main zones based on the profiles modified from Thornbury (1965) and Samsudin (1981). While, zone 'O' contains degraded and undegraded organic matter of animal and plant wastes, the zone 'A' characterized by the mixture of humus and minerals that are resistant to leaching processes. Zone eluviation or accummulation of secondary minerals such as clay and sesquioxide are zone B. Area C is a zone that shows the characteristic of soil and rock or saprolite, whereas zone D is a fresh rock that consists of interbedded sandstone and shale layers. On the lowland, the sandstone has about the same thickness, with shale and carbonated coral deposits (Dca).

The abundancy of major and trace elements in the soils of the island are shown in Table 1. The most abundant major element in both lowland and hillslope areas is SiO_2. The hill has SiO_2 range of 72.51 - 90.89 %, whereas the lowland has 25.40 - 63.97 %. Generally, the bed rocks and soil consist of quartz embedded in sandstone. This was characterised by using XRD (Figure 3A & B). Quartz is a mineral that is resistant to weathering action and stays in the soil during the leaching processes. A small amount of SiO_2 might have been contributed by clay minerals such as kaolinite.

Table 1 Abundancy of major and trace elements in the soils of Manukan Island.

Samples / Elements	SL1 (3cm)	SL1 (50cm)	SL2 (5cm)	SL2 (50cm)	SL3 (5cm)	SH1 (5cm)	SH2 (5cm)	SH2 (50cm)	SH3 (5cm)	SH3 (50cm)
SiO_2 (%)	36.74	48.65	54.94	25.40	63.97	72.51	90.89	90.49	91.01	86.86
Al_2O_3 (%)	1.11	1.95	1.95	0.27	2.15	11.76	3.80	4.36	3.86	6.08
Fe_2O_3(T) (%)	0.30	0.54	0.58	0.12	0.65	5.21	1.09	1.24	1.15	1.84
MnO (%)	0.01	0.01	0.01	0.01	0.03	0.01	0.00	0.01	0.01	0.01
MgO (%)	0.27	0.15	0.11	0.07	0.14	0.77	0.08	0.08	0.18	0.22
CaO (%)	31.63	24.65	21.02	39.18	15.94	0.03	bdl	bdl	bdl	bdl
Na_2O (%)	.0.59	bdl	0.08	bdl	0.02	bdl	bdl	bdl	bdl	bdl
K_2O (%)	0.18	0.18	0.27	0.08	0.23	1.92	0.41	0.45	0.44	0.67
L.O.I (%)	28.29	23.49	2025	34.19	16.05	8.44	3.50	3.01	3.73	3.80
Cl^- (ppm)	0.05	0.03	0.10	0.10	0.05	0.16	0.012	0.008	0.02	0.013
TOTAL (%)	**99.26**	**99.82**	**99.39**	**99.39**	**99.33**	**101.14**	**100.09**	**99.95**	**100.72**	**99.86**

*bdl: below detectable limit

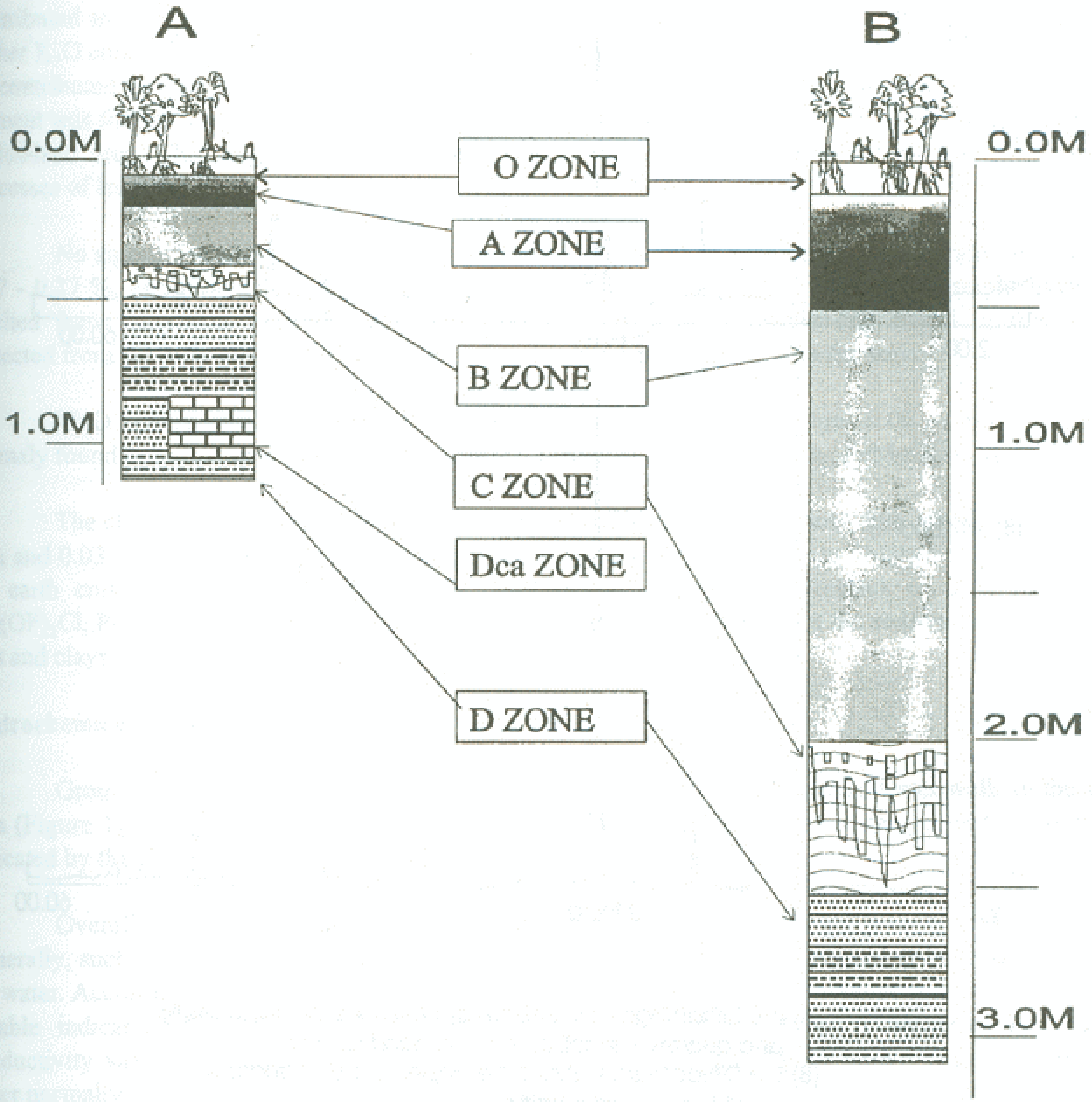

Figure 2: The soil profiles of the lowland area (A) and the hilly area (B) in Pulau Manukan Sabah

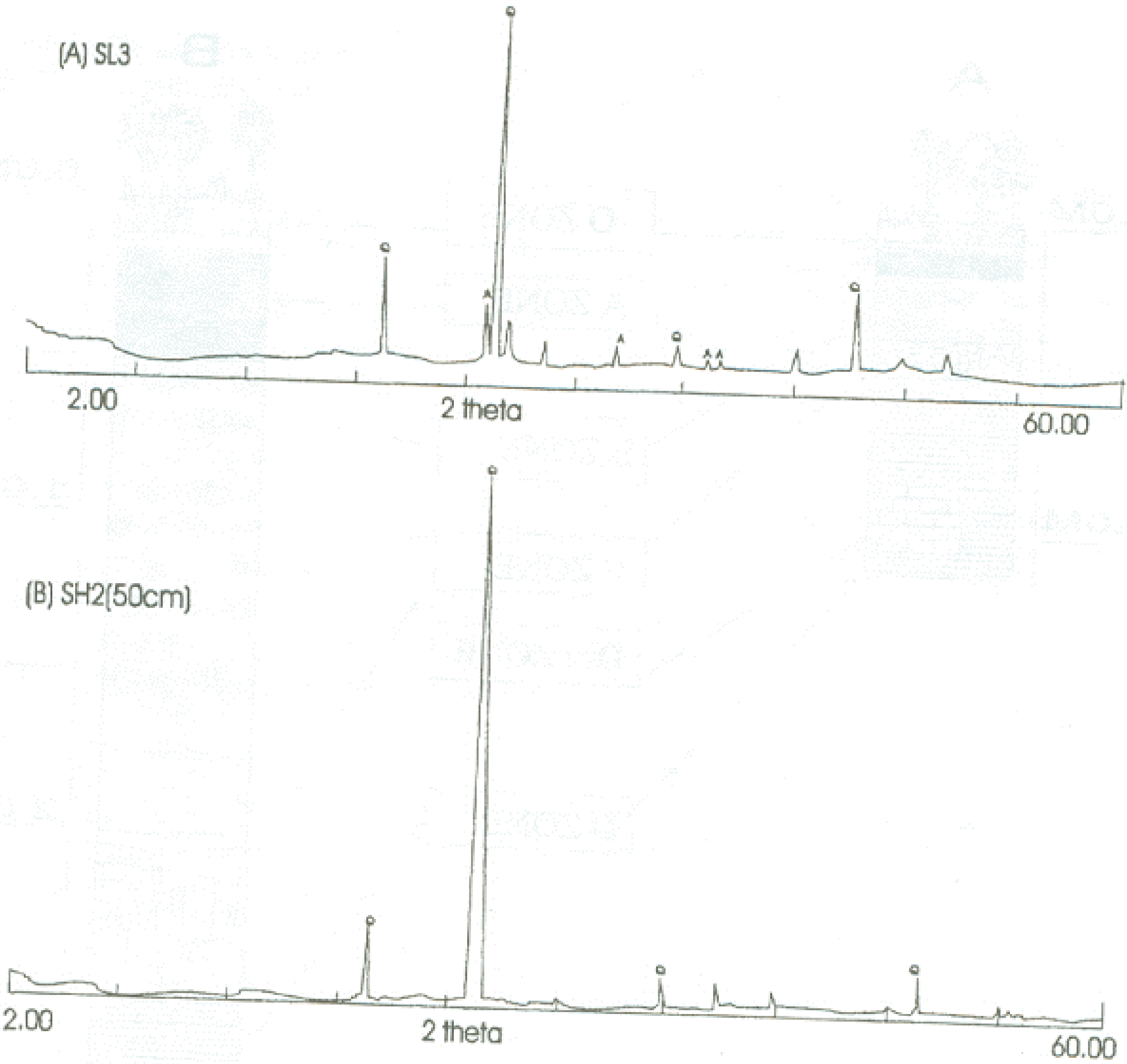

Figure 3: (A) The Diffractogram shows the appearance of aragonite(A) and quartz(Q) in soil from the lowland locality
(B) The Diffractogram shows the appearance of quartz (Q) in soil from the hill locality

The profile on the hill has higher concentration of Al_2O_3 compared to the lowland, i.e. 3.80 - 11.76 % and 0.27 - 2.15 %, respectively. Such difference might be due to the content of clay and muscovite minerals found in the higher relief. Relatively, the content of Fe_2O_3 also higher in the hill compared to the lowland as shown by Table 1. Mineral iron oxide and iron carbonate might responsible for the formation of Fe_2O_3 in this soil.

The higher range of concentration of CaO in the lowland soils, i.e. 15.94 - 39.18 % is mainly attributed to carbonate minerals as indicated by Figure 3A. The dissolution of such mineral might have contributed to the high concentration of Ca in the water samples. The soils on the hilly area contains higher K_2O concentration of 1.92 - 10.41%, and lowland soil of 0.08 - 0.27 %. Such concentrations might be contributed by the presence of muscovite mineral and salts in the soils. The concentration of Na_2O element was found to be below detectable limit in soil on the hilly area, but the value was less than 0.59 % in lowland area. This might be mostly due to the feldspar mineral that might have experienced the processes of leaching.

No significant difference was found for the MgO in soils in both profiles. Generally, it's range is 0.07 - 0.27 %, except at one of the locations on the hillslope which has 0.77 %. MgO might have been leached from magnesite [$MgCO_3$] and dolomite [$CaMg(CO_3)_2$]. However Mg found in this sample collected from the hilly area might have been present in the mineral chlorite in the soils.

MnO concentrations in both profiles are low. Its concentration ranges 0.00 - 0.03%, which is normaly found in sediment. Its presence is probably attributed to either $MnCO_3$, $FeMnO_3$ or MnO.

The chloride concentration is very low in both profiles that varies from 0.008 - 0.16 % on the hilly area and 0.03 - 0.100 % in the lowland area. Such values are almost similar to chloride concentrations in the earth crust i.e. 0.05 % (Mielke, 1979). The chloride is normally presents in minerals such as $Ca_2(OF)_2Cl$, $Pb_2CO_3Cl_2$ and NaCl are formed and on leaching it is absorbed by the sediments of mud rocks, silts and clays.

Hydrochemical Study

Groundwater sampling was limited in this study due to the limit of groundwater wells in the study area (Figure 1). Geochemistry data shows the groundwater in the study area is categorised as neutral as indicated by the pH values of 6.8 - 7.2 (Table 2).

Overall conductivity readings of the groundwater fall within the range is more than 1.1 mS/cm. Generally, such conditions are derived from the concentrations and types of dissolved materials present in the water. According to Roscoe (1990), conductivity is a good measure of the relative mineralization, and a reliable indicator of relative differences in water quality between different aquifers. The current conductivity values recorded on the island exceeded the level of good fresh water. Good quality fresh water normally has the conductivity value of about 0.05 mS/cm; whereas sea waters are around 60 mS/cm.

Magnesium and calcium are main cations usually found in natural waters (Pitter, 1993), but their concentrations are usually less than 50 mg/l and 100 mg/l, respectively (Todd, 1980). The magnesium and calcium in the groundwater of the study area show normal concentration.

The relatively high concentrations of silica in the range of 2.4 - 15.9 mg/l found in the groundwater reflect its existence as major component in the soils of the island (Table 1).

Table 2 The mean values of physical and chemical contents in groundwater samples collected from the study area.

	Sampling Sites		
Parameters	**SL1**	**SL2**	**SL3**
pH	6.9	7.2	7.0
Conductivity (mS/cm)	2.4	2.0	2.2
Magnesium (mg/l)	30.2	36.5	34.1
Calsium (mg/l)	63.9	81.2	79.8
Silica (mg/l)	4.5	6.4	9.4
Chloride (mg/l)	574.0	749.0	421.5

Chloride content shows relatively higher than drinkable standard, which may be explained due to an early stage of contamination from the sea water.

CONCLUSION

In the light of this study the following conclusion can be drawn. First, the study area is underlain by clastic sediment of Crocker Formation, which consist of sandstone, shales, and an interbedded sandstone shales. Generally, groundwater found in highly fractured sandstone. Second, geochemical data indicates that the chloride content in groundwater is higher than soil which may be due to contamination from sea water.

ACKNOWLEDGEMENT

The authors would like to thank the Director of Sabah Parks (Datuk Lamri Ali) for the permission to carry out research on Manukan Island. Thanks are also due to, the Deputy Director of Sabah Parks (Mr. Francis Liew) and the staff of the Parks stationed on the island for their good cooperation during the research. Many thanks are dedicated to Mr. Aziz Ngah, Mr. Zahari Hussain and Mr. Yaakūb Othman for their technical assistance in the XRF, XRD operations and chloride analyses of soil samples, respectively.

It is acknowledged that this research was financially supported by IRPA (Intensification of Research in Priority Areas) grant no. 9510 awarded to Prof. Madya Dr. Ridzwan Abdul Rahman of Borneo Marine Unit of Universiti Malaysia Sabah.

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