CHEMICAL ANALYSIS OF THE GROUNDWATER IN MAYANGONE TOWNSHIO, YANGON REGION

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Abstract

The research area, Mayangone Township is situated on the Shwedagon-Mingaladon ridge. The topography of the research area is slight moderate rolling plain and it gently slope towards the west. This area is about 62.49 square kilometer. The research area is underlain by Recent to Pleistocene age valley fill deposit and Pliocene age Arzarnigon sand rocks. Arzarnigon sand rocks are medium to coarse-grained sand rocks, and sometime gritty. The sources of water supply are water from tube well and reservoir (Gyobyu reservoir). The main aquifer in western part is valley filled deposit and in the middle part it is Arzarnigon sand rock. The yield of valley filled deposit is 2000 to 4000 gallons per hour. pH is mostly about 7.77. TDS is 380 ppm. Total salinity is low and electrical conductivity (E.C) is always not more than 280 μ mho/cm. Iron content rising up to 6 ppm, is encountered. The concentration of chloride ion is widely distributed in most of the water of the studied region and the amount present in groundwater is relative higher than other anions. The results analyzed by KURLOV'S method and PIPER method can classified the water types. Groundwater is classified on the basic of total dissolved solid (T.D.S). According to WHO Drinking Water Standard, the groundwater of the research area is suitable for the drinking water.

Keywords: pH, TDS, groundwater, KURLOV's method and PIPER method

Introduction

The research area is lying at 20 to 60 feet above sea level. Population of Yangon City is dense. It lies on the bank of the Yangon River in the delta of the Irrawaddy. The main city area is situated between the Hlaing and Rangoon River on the west and the Pazundaung creek on the east at the southern extremity of a long narrow spur of the Bago Yoma.

Location and Size

Mayangone Township is situated in the northern part of the Yangon City. The research area lies at North Latitude 16° 49' 00" to 16°54' 30"and East Longitude 96° 5' 3" to 96° 11' 00". The area coverage is about 62.49 km^2(figure 1). The map index of the research area is 94 D/1 of one inch topographic map of Myanmar Survey Department.

Purpose of Research

The purpose of research includes the following:

(1) To obtain groundwater that is truly representative of the geologic formation.

(2) To investigate the chemical quality of the water.

(3) To research the characteristics of aquifer based on aquifer function.

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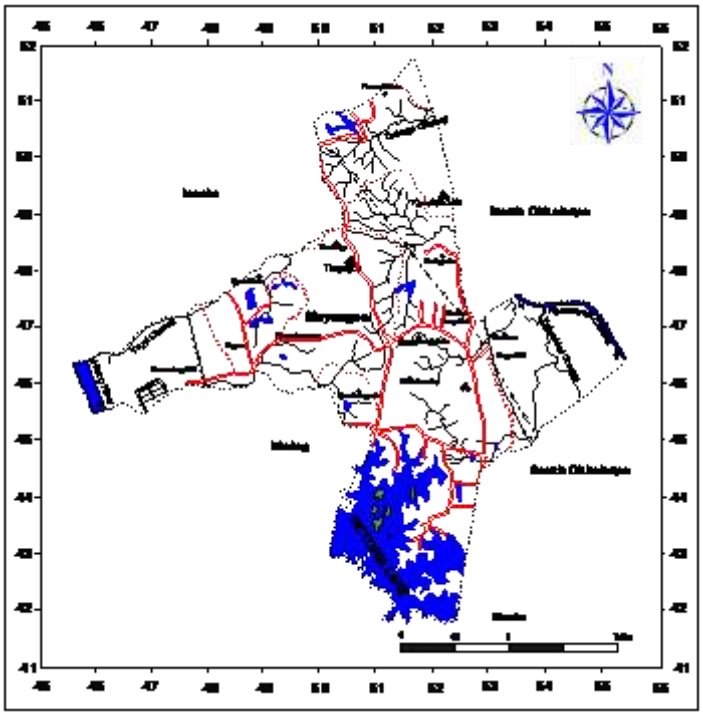


Figure 1 Location map of the research area

Methods of Study

Before commencement of the field work, the author visits to exit wells gathering of available data, such as relevant, topographic maps, meteorological data, pumping test data, recovery test data, well design and chemical data of groundwater in research area. These collected data are examined systematically and then they are reviewed and analyzed in the Water Resources Utilization Department. During the field, the measurements of water level, well depth, the position of wells by G.P.S are made. The step includes contouring of chemical analysis data and piezometric level setting up subsurface diagram of potential aquifers and presentation of chemical data using surfer version 8 computer processing programmed.

Topography

The topography of the area is marked by the presence of Shwedagon-Mingaladon Ridge, a north-south trending anticline. The research area is located at the southern end of the Pegu Yoma anticline where Miocene to Pliocene rocks crop out. The highest point of this range is central part of the area, whish is Junction area (8), with an elevation of between 30-60 feet above sea level. The research area is bounded by Insein Township, Hlaing Township, North Okkalarpa and South Okkalarpa at the north and east respectively and Kamaryut Township. The research area is sloping to the gently east and westwards. The eastern and western parts of the research area are the tidal affected area.

Drainage

Tidal action also takes place in the stream channel in the eastern and western part of the area. (e.g. Hlaing River and Ngamoeyeik Chaung). The water from the upper part of the research area drains the left and right side of the ridges and which into the Hlaing River and Ngamoeyeik Chaung River. The drainage pattern of the area is coarse dendritic or tree-like pattern (figure 2). Drainage pattern is important because the part of the drainage pattern indicate changes in under groundwater condition, type of rock and geologic structure.

Climate

The research area remains with the perimeter of tropical monsoon climate. Climate condition can be categorized into two seasons, the wet and the dry. Between mid October and mid May is a dry period known as inter monsoonal period when there are no monsoon winds. Yangon receives most of its rain during this season which usually last till October. The research area has a high mean temperature range of 30.4°C (figure 4a). It receives more than 559.6 mm of rain per annum. Annual mean evaporation is 3.647 mm per day (figure 4b) and annual rainfall is 92.3% of (figure 4c) at Kaba-Aye station.When the temperature is high; there is more evaporation and transpiration which reduces the amount of water in the river. The records of the Kaba-Aye meteorological station for the average monthly rainfall, temperature, evaporation and humidity during the period of 1999 to 2008 are shown in (figure 4d).

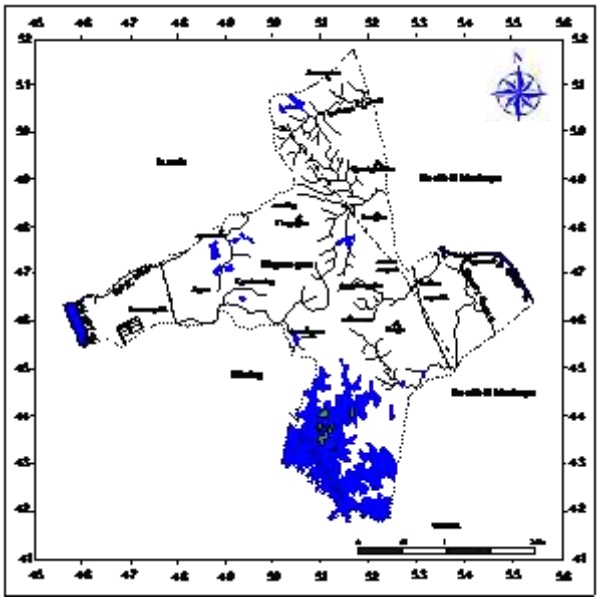
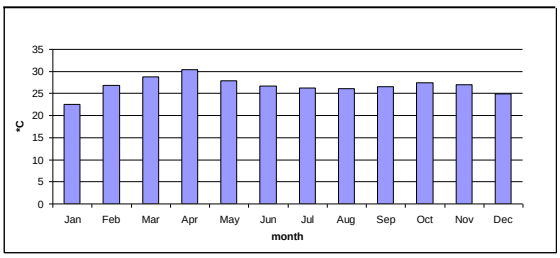


Figure 2 Drainage map of research area



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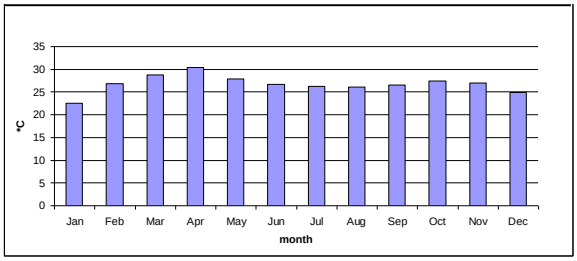

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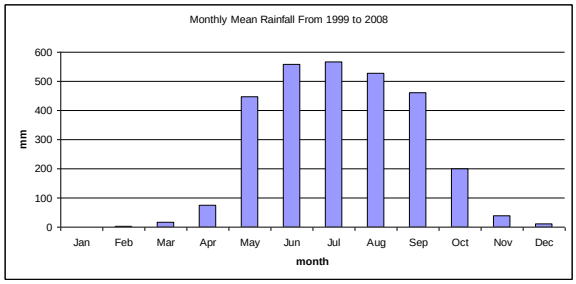

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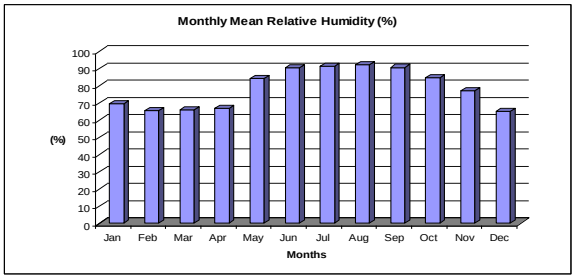

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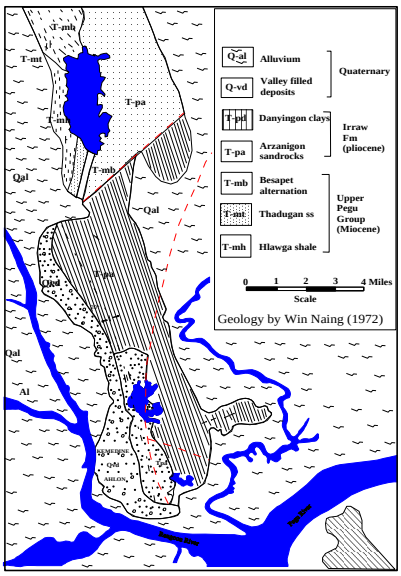
Figure 4 Climate condition of the research area a. mean temperature, b. mean evaporation, c. mean annual rainfall and d. mean humidity

Regional Geologic Setting

Yangon and its environs are underlain by thick Tertiary deposits and Quaternary deposits are shown in figure (5).

Pegu Group

Marine sandstones and shale of Oligocene (?) and Miocene age belong to Pegu Group. Hlawga shale of this group mainly consists of bluish grey silty shale and very fine-grained micaceous sand rock. Thadugan sandstone compose of bluish grey to brownish grey, fine to medium-grained, micaceous and argillaceous sandstone with ferruginous bands on the bedding planes. Besapet alternation is characterized by interbedded sequences of medium to very fine-grained, loosely cemented sandstone and shale. (Kyaw Tun , 1996).



After Win Naing (1972)

Figure 5 Geological Map of Yangon City

Irrawaddy Formation

The continental and marginal marine deposits of Pliocene belong to Irrawaddy Formation. It consists of massive, fine to medium-grained yellowish to yellowish brown micaceous sand rocks, sandy silt and shale. Shale is predominant at the upper horizon and sand beds are found at the middle and lower part. Iron rich hard bands of yellowish to red dish coloured are intercalated as inter layer. (Win Naing, 1972) This deposit composed of fine to coarse sand and gravel with yellowish coloured sometime clays lenses may interrupt the consistency of these beds. The alluvium deposit mainly consists of yellowish grey, bluish grey, brownish grey colored silts and clays. It may be about 50 feet thick. There is variation according to depositional environments.

Geological Structure

Yangon City Area constitutes ridge and low-land lying south Pegu Yoma between Sittaung delta in the east and Irrawaddy delta in the west. Regionally, the inclination of the eastern part is low angle or less than 30 degree. (Win Naing, 1972).En-echelon folding system of Yangon City is found as Hlawga Anticline, Yangon –Mingalardon Anticline, Thingangyun-Thanlyin Anticline and Twante Anticlines trending toward the south direction that is towards the Gulf of Mattaban. (Win Naing 1972).Three sets of faults are being identified in Yangon City area. Mingalardon Fault

and Danyingone Fault are found in the research area. Mingalardon Fault is the largest fault which is trending in NE-SW direction and the fault plane is estimated to be dipping southeast direction and downthrown to be at the eastern side. Another Transverse Fault divides two rock units of Irrawaddy formation and Pegu Group. (Win Naing, 1972)

Hydrogeologic Characteristics of Research

Collection of Data

One inch topographic map was used in collection of the water samples of the area under investigation. The collected samples were analyzed at Health Department. Tube-wells data were collected from the Water Resources and Utilization Department (W.R.U.D) and Ministry of Agriculture and Irrigation Department. Data of chemical analyzes of water samples were obtain from Health Department of Yangon City Development Committee (Y.C.D.C). The southern part of Mayangone area includes Inya Lake. There are two main types of lithology, i.e. there are Arzarnigon sand rocks and Danyingone clay, Irrawaddian Formation and in some places valley filled deposits. According to lithologic logs the water bearing horizons consist of yellow and blue coloured sand, sand with clay and gravel. According to well logs data the aquifer type is confined type. The depth of aquifer is ranging from 19 to 70ft from the ground surface.

Irrawaddy Aquifer

The distribution of the Irrawaddy aquifer blankets the whole research area. This formation includes two lithologic units: (i) Arzarnigon sand rocks and (ii) Danyingone clays. The valley-filled deposits and alluvium are found in eastern and western part of the research area. Arzarnigon sand rocks are overlain by Danyingone clays. According to well-log data from (W.R.U.D), Danyingone clays are found at the depth between 45ft and 200ft. The total area of distribution of the Danyingone clays approximately of the research area covered in middle portion.

Irrawaddian rocks mainly composed of siltstone, clay, shale and sandstone which generally dipping towards the east and the south with a very low angle. Arzarnigon sand rocks are made up of fine to coarse sand and sand with clay. Yield of the tube-wells vary from place to place is depending on the well's size, thickness of aquifer, well's design and well's development. The Danyingone clay unit is impervious and capable to produce small amount of water. The wells at the east of Shwedagon-Mingaladon ridge are shallow depths of 120 feet - 200 feet wells. In the northern part of the research area, the depth reaches up to 530 feet. The water bearing horizon of Irrawaddy Formation is encountered at the depth ranging between 60 feet and 530 feet. In the research area, well no. T5 with the depth yields 4000 gallons per hour from the depth 200ft. The well no. T 7 with the depth of about 530 feet which yield 500 gallons per hour.

Chemical Composition of Groundwater

The collected samples are analyzed at the Health Department of Y.C.D.C for the cations and anions and TDS, EC, pH, total alkalinity and total hardness.

Classification by KURLOV'S Method

The Kurlov's formula is written by using ionic concentrations that are expressed in milliequivalent percent (meq/l). The highest amount of ion is expressed first and lesser ion in second and so on. The anions are written above the line and cations are written below the line. The degree of mineralization (m) is placed in front of the format while pH, temperature, Fe^{++} etc., is placed behind. Based on Kurlov's Method, the chemical classification of groundwater types in the research area shows are 1.Chloride Bicarbonate -Magnesium-Calcium, 2.Chloride Sodium,

3.Chloride -Calcium –Sodium, 4.Chloride Sodium, 5.Sulphate Bicarbonate-Chloride-Calcium,6.Chloride Sodium-Calcium, 7.Chloride Bicarbonate-Sodium, 8.Chloride Magnesium-Calcium, 9.Chloride Calcium-Magnesium, 10.Chloride Sulphate-Calcium-Sodium, 11.Chloride Bicarbonate-Magnesium-Sodium, 12.Chloride Magnesium-Sodium, 13.Chloride Calcium, 14.Chloride Bicarbonate-Calcium, 15.Chloride Bicarbonate-Sodium-Calcium, 16.Chloride Sulphate-Sodium and 17.Chloride Sulphate- Sodium-Calcium

The water samples classified by KURLOV'S Method for Mayangone area describe as follow

T_1	$M\,0.1\frac{Cl_{59}HCO^{3}_{25}SO^{4}_{20}}{Na_{2.4}Ca_{38}Mg_{57}Fe_{1.24}}$	Chloride Bicarbonate Magnesium-Calcium
T_2	$M\,0.14\frac{Cl_{65}HCO^{3}_{22}SO^{4}_{13}}{Na_{58}Ca_{12}Mg_{24}Fe_{5}}$	Chloride Sodium
T_3	$M\,0.38\frac{Cl_{73}HCO^{3}_{18}SO^{4}_{13}}{Ca_{45}Na_{39}Mg_{15}Fe_{1}}$	Chloride -Calcium –Sodium
T_4	$M\,1.36\frac{Cl_{89}SO^{4}_{10}HCO^{3}_{0.9}}{Na_{72}Mg_{19}Ca_{7}Fe_{2}}$	Chloride Sodium
T_5	$M\,0.17\frac{SO^{4}_{37}HCO^{3}_{33}Cl_{30}}{MG_{49}Ca_{32}Na_{16}Fe_{3}}$	Sulphate Bicarbonate-Chloride-Calcium
T_6	$M\ 0.13\frac{Cl_{67}HCO^{3}_{18}SO^{4}_{15}}{Na_{46}Ca_{32}Mg_{20}Fe_{1}}$	Chloride Sodium-Calcium
T_7	$M\,0.16\frac{Cl_{51}HCO^{3}_{30}SO^{4}_{15}}{Na_{40}Ca_{23}Mg_{20}Fe_{7}}$	Chloride Bicarbonate-Sodium
T_8	$M\,0.19\frac{Cl_{64}HCO^{3}_{19}SO^{4}_{17}}{Mg_{49}Ca_{39}Fe_{8.9}Na_{1.6}}$	Chloride Magnesium- Calcium
T_9	$M\,0.14\frac{Cl_{70}HCO^{3}_{15}SO^{4}_{24}}{Ca_{32}Mg_{37}Na_{23}Fe_{7.5}}$	Chloride Calcium-Magnesium
T_{10}	$M\,0.13\frac{Cl_{49}SO^{4}_{25}HCO^{4}_{25}}{Ca_{62}Na_{28}Mg_{22}Fe_{2}}$	Chloride Sulphate-Calcium-Sodium
T_{11}	$M\,0.05\frac{Cl_{53}HCO^{3}_{26}SO^{4}_{19}}{Mg_{46}Na_{29}Ca_{14}Fe_{9.7}}$	Chloride Bicarbonate-Magnesium-Sodium
T_{12}	$M\,0.14\frac{Cl_{61}SO^{4}_{24}HCO^{3}_{14}}{Mg_{48}Ca_{44}Na_{6}Fe_{2}}$	Chloride Magnesium-Calcium
T_{13}	$M\,0.04\frac{Cl_{59}SO^{4}_{21}HCO^{3}_{19}}{Mg_{37}Na_{28}Ca_{19}Fe_{17}}$	Chloride Magnesium-Sodium
T_{14}	$M\,0.18\frac{Cl_{57}SO^{4}_{22}HCO^{3}_{20}}{Ca_{57}Mg_{32}Na_{12}}$	Chloride Calcium- Magnesium
T_{15}	$M\ 0.11\frac{Cl_{71}HCO^{3}_{20}SO^{4}_{9}}{Ca_{78}Mg_{12}Na_{9}Fe_{1}}$	Chloride Calcium
T_{16}	$M.06\frac{Cl_{56}HCO^{3}_{33}SO_{10}{}^{4}}{Ca_{72}Mg_{13}Na_{4}}$	Chloride Bicarbonate-Calcium
T_{17}	$M\,0.12\frac{Cl_{47}HCO^{3}_{17}SO^{4}_{8}}{Ca_{50}Na_{29}Mg_{18}Fe_{3}}$	Chloride Calcium-Sodium
T_{18}	$M\,0.17\frac{Cl_{62}HCO^{3}_{26}SO^{4}_{12}}{Na_{48}Ca_{33}Mg_{16}Fe_{2}}$	Chloride Bicarbonate-Sodium-Calcium
T_{19}	$M\,0.15\frac{Cl_{58}SO^{4}_{32}HCO^{3}_{20}}{Na_{42}Mg_{28}Ca_{24}Fe_{6}}$	Chloride Sulphate-Sodium
T_{20}	$M0.23\frac{Cl_{60}SO^{4}_{40}}{Na_{55}Ca_{35}Mg_{9}}$	Chloride Sulphate- Sodium-Calcium

Classification of Piper Diagram

This method is proposed by Piper (1944) and by Hill (1940). This method of tri linear diagram is widely use to depict chemical data and show the relative concentrations of the major cations (Ca^{+2}, Mg^{++} and K^{+}) and anions (CO_3^{-},HCO_3^{-},Cl^{-} and $SO_4^{=}$) . Cations are plotted on the left triangle and anions on the right triangle. Piper diagram are show in figure (5). Kurlov's method and Piper method are compared the result of the research area in groundwater types, which in table (1).

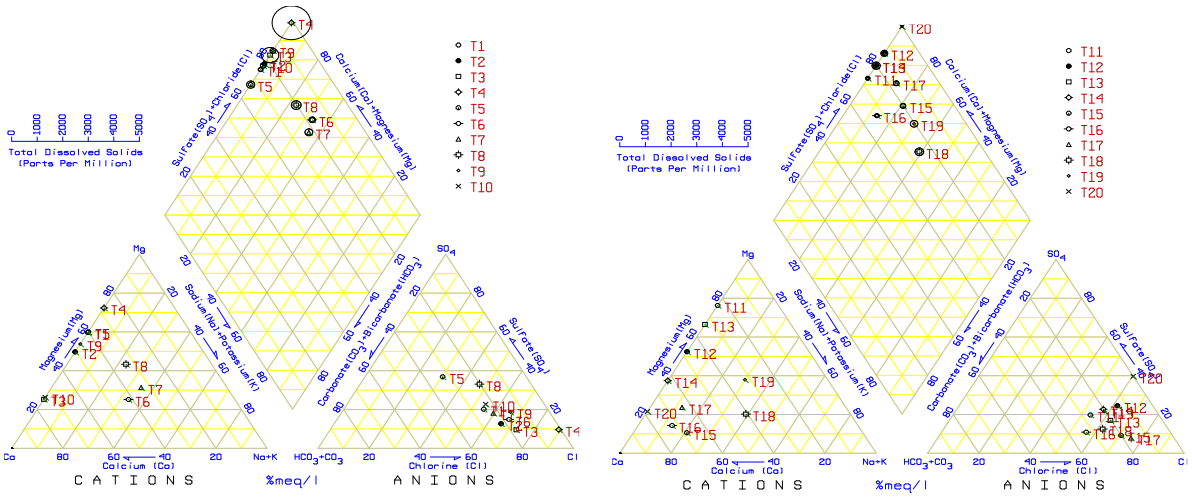


Figure 5 Classification of the Piper diagram

Table 1 Compares ion with Kurlov's method and Piper Method

Tube Well No.	Kurlov's Method	Piper Method
T_1	Cl HCO_3 Mg Ca	Ca Mg Cl
T_2	Cl Na	Ca Mg Cl
T_3	Cl Ca Na	Ca Cl
T_4	Cl Na	Mg Cl
T_5	SO_4 HCO_3 Cl Mg Ca	Ca Mg HCO_3 Cl SO_4
T_6	Cl Na Ca	Ca Mg Na Cl
T_7	Cl HCO_3 Na	Ca Mg Na Cl
T_8	Mg Ca	Ca Mg Na SO_4 Cl
T_9	Cl Ca Mg	Ca Mg Cl
T_{10}	Cl SO_4 HCO_3 Ca Na	Ca HCO_3 Cl
T_{11}	Cl HCO_3 Mg Na	Mg HCO_3 Cl
T_{12}	Cl Mg Ca	Ca Mg Cl
T_{13}	Cl Mg Na	Mg Cl
T_{14}	Cl Ca Mg	Ca HCO_3 Cl
T_{15}	Cl Ca	Ca Cl
T_{16}	Cl HCO_3 Ca	Ca HCO_3 Cl
T_{17}	Cl Ca Na	Ca Cl
T_{18}	Cl HCO_3 Na Ca	Ca Na Cl
T_{19}	Cl Na Mg	Ca Mg Na Cl
T_{20}	Cl SO_4 Na Ca	Ca Cl

Chemical Analysis

Chemical Analysis is important to specify the actual characteristic of groundwater. Determination of pH, total dissolved solids, T.D.S, electric conductivity E.C, dissolved cations of Na^+, K^+, Ca^{++}, Mg^{++} and Fe^{++} and dissolved anions of CO_3^-,HCO_3^-,Cl^- and $SO_4^=$ are made in the laboratory.

The pH values of groundwater show that all the water collected and analyzed are **"**potable water" because pH values fall in the range of 6.64 to 7.77 and the average pH value is 6.61. Total dissolved solids or salinity have been determined by TDS meter within 25°C to 30°C of room temperature. Total dissolved solid values fall in fresh water quality rang that is not more than 1000 ppm. The groundwater is fresh water according to K.A Gorrell classification. But of T.D.S of (T-4) is found to contain noticed that ranges 1360 mg/l. The E.C water is required to evaluate because it is very useful in accessing total salinity and concentrations of some of the major cations and anions. Correlation will be made between specific conductance, total dissolved solids, cations and anions. The result of the analysis of water samples fall in the range of from 40 μ mho/cm to 2100 μmho/cm.

Major Cations

Cations, which commonly contained in tube-wells including iron Fe^{++} cations have been determined. Common cations are calcium Ca^{++}, Magnesium Mg^{++}, Sodium Na^+ and Potassium K^+.Calcium ion concentration in groundwater of the research area falls in the range of 3.20 to 58.51 mg/l. The tube well T-3 is 58.51 ppm which displays a little bit rises in Calcium concentration than other tube-wells. Magnesium ion is very useful parameter in groundwater quality determination. In the research area, the value of Magnesium concentration is between 1.14 and 16.32 ppm. The concentration of Sodium ion in this studied area does not too differ from the remaining cations. The value of Sodium concentration is ranging from 1 to 29 ppm. Generally, the iron concentration in the research area is in the range of 0.3 to 6 mg/l. The value of iron concentration of tube well T_{10} reaches up to 6 ppm

Major Anions

Anions are playing a vital role in quality determination of groundwater. Only major anions of Carbonate (CO_3^-), Bicarbonate (HCO_3^-), Sulphate ($SO_4^=$) and Chloride (Cl^-) ions should be taken into account. In the studied area, there is no Carbonate concentration according to the analyzed result from the water sample of the research area. In all water samples from tube-wells in Irrawaddy aquifer Bicarbonate concentration is generally in the range of 8 to 70 ppm. Especially, the tube-well no. T_3 rises up to 70 ppm. The concentration of sulphate ion present is Irrawaddy aquifer usually shows the range between 3 and 48.96 mg/l. Moreover, the tube-wells no. T_9 is 48.96 ppm. The concentration of Chloride ion is widely distributed in most of the water of the studied region and the amount present in groundwater in relatively higher than other anions. Its concentration value is falling within the amount of 10 to 169 ppm. Chloride concentration of the tube wells no. T_3 is 169 ppm.

Drinking Water

Most of the people use drinking water and domestic water from the tube-wells. The standard proposed by WHO standard guideline for the drinking water is shown in compares with the obtained value of groundwater analysis from Mayangone Area. According to this table, generally the quality of groundwater is suitable to drink but T-4 is the brackish water is shown in table (2).

Table 2 WHO standard guideline for the drinking water in research area

Characteristics	Guideline value		The rang obtained from groundwater	Remark
	Desirable	Max Per-missible		
Calcium	75 mg/l	200 mg/l	3.2-58.51 mg/l	Good
Magnesium	30 mg/l	150 mg/l	0.8-43.2 mg/l	Potable
Sodium	0- mg/l	200 mg/l	0 –19 mg/l	Good
Potassium	0- mg/l	200 mg/l	0 –5 mg/l	Good
Sulphate	0- mg/l	400 mg/l	5.76 – 48.9 mg/l	Potable
Chloride	200 mg/l	600 mg/l	14 –590 mg/l	Rather
Iron	0.5 mg/l	1.5 mg/l	0 – 8 mg/l	Poor ,T_4
TDS	0- mg/l	1000 mg/l	65 – 1360 mg/l	But T_4 Brackish
PH	6.5 mg/l	9.2 mg/l	6.64 – 7.77	Potable
Hardness $CaCO_3$	0- mg/l	500 mg/l	15 –248 mg/l	Rather
Colour turbidity	5	20	-	Nil
Zinc	5 mg/l		-	Nil
EC	0- micro mho/cm	1500 micro mhos/ cm	0 – 2100 micro mhos/cm	Good water, But T_4 poor

Conclusion

The research area is underlain by Recent to Pleistocene age valley-filled deposits and Pliocene age Arzarnigon sand rocks. The valley-filled deposits are yellow to red, fine to coarse sand, gravel, yellow to red of lateritic soil and yellowish clay. The yield of valley filled deposit is 2000 to 4000 gallons per hour for 8 inches diameter well and the depth of water bearing horizon is ranging from 40 to 90 ft. The yield of Arzarnigon sand rocks is up to 3000 gallons per hour for 4 inches diameter well and the depth of water bearing horizon is ranging from 230 ft to 270 ft. The concentration of hydrogen ion (pH) is between 6.64 and 7.77. Mostly, total dissolved solids are always less than 380 ppm in the research area. Total salinity is low and electrical conductivity (E.C) is not more than 280 μ mho/cm. The concentration of Chloride ion is widely distributed in most of the water of the studied region and the amount present in groundwater relative higher than other anions. The analyzed results are classified by KURLOV'S method and PIPER method to indication the water types of groundwater of the research area. According to result of the chemical analysis data, the groundwater in Mayangone Township can be used for drinking water and domestic water.

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