

Hydrogeological Investigation of Thagaya-Myohla area, Yedashe Township, Bago Region

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Abstract

The study area is located in the Thagaya-Myohla Townships, Taungoo District, Bago Region. It is between North Latitude 19°16'4.8" N to 19°25'40.8" N and East longitude 96°12'57.6" E to 96°24'7.8" E and refers to one-inch topographic map of this area is No.94A/3 and 94A/7. It has tropical monsoon climate with average monthly rainfall of about 167mm (6.64 inches) which may reach as high as 471mm (18.56 inches) during rainy season. The major sources of employment include agriculture, horticulture and animal husbandry, almost 80% of the workforce. On the basis of geological conditions and stratigraphic position, three types of aquifers are found, younger alluvial aquifer and two older alluvial aquifers. In accordance with their morphological characteristics and occurrence, younger alluvial aquifer (Sittaung River valley deposit), older alluvial aquifer can be sub-divided into older alluvial aquifer unit I (Fan deposit from Bago Yoma) and older alluvial aquifer unit II (Fan deposit from Eastern Highland). The groundwater flow direction of the area is from west to east in the western part of the study area towards the Sittaung River and from east to west in the eastern part of the study area towards the Sittaung River. The water samples are collected from 15 wells and were subjected to analysis for chemical characteristics. Some water samples were found to be within in WHO guideline value. The iron values in the study area exceed the standard limit and other ions values fall under the permissible limits. The suitability of groundwater for irrigation was assessed from (TDS, EC, SAR, MAR, Na% or RSC). Most of the groundwater samples in this area fall in the suitable range for irrigation purpose.

Keywords: groundwater parameters, aquifer, drinking water, irrigation

Introduction

The study area is located in the Thagaya-Myohla Townships, Taungoo District, Bago Region. It is between North Latitude 19°16'4.8" N to 19°25'40.8" N and East longitude 96°12'57.6" E to 96°24'7.8" E and refers to one-inch topographic map of this area is No.94A/3 and 94A/7. It extends 16.9 km (10.5 miles) from east to west and 15.3 km (9.5 miles) from north to south. The total coverage area is about 259 square kilometers (99 sq.miles). The location and Tube well location map for water level measurement of the study area is as shown in Figure (1.a&b). Yangon-Mandalay car-road and rail-road are passing through this area. So, the study area is easily accessible throughout the year by car and motorcycle from Taungoo city.

Purposes of Study

- To assess the hydrogeological condition of the area
- To determine the chemical component and type of groundwater
- To evaluate the suitability of groundwater

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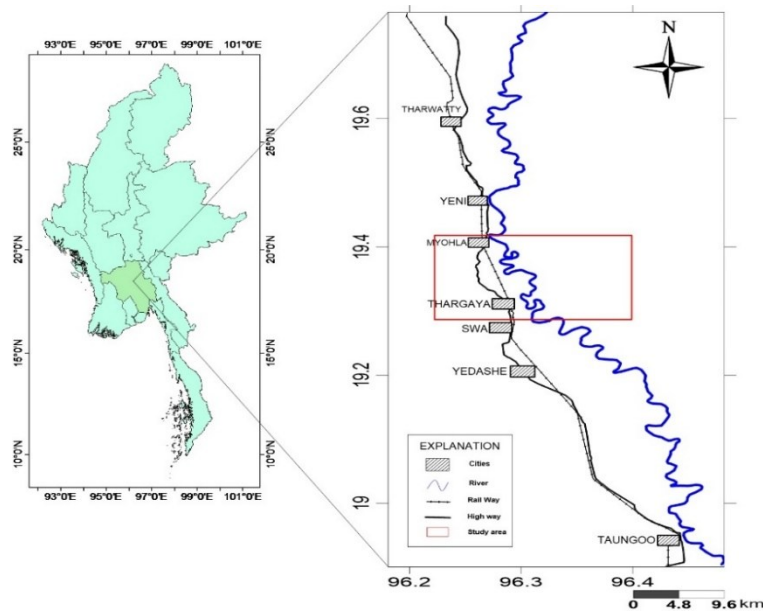


Figure.1(a) Location map of the study area

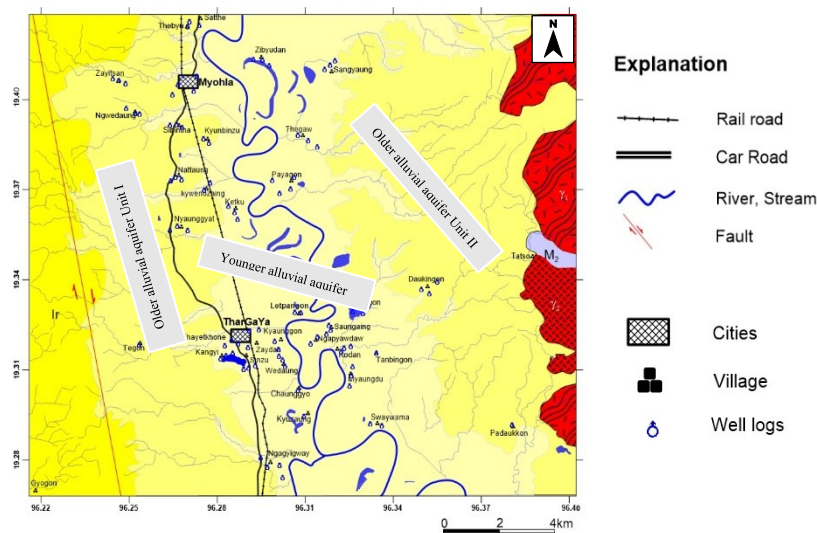


Figure.1(b) Tube well location map for water level measurement

Materials and Methods

The desk study, site investigation and laboratory tests had been made in the present study to know the distribution of type of aquifer, aquifer characteristics and water quality.

Desk study includes two steps, literature review on geology, hydrogeology and collection of the reports related to the present study area, and analytical methods and using satellite image.

The investigation will be made by traversing aided with one inch topographic maps. Most of the existing tube wells were visited. Aquifer sand samples and water samples would be collected to identify their characteristics. Measurement of water levels would be carried out by using water level indicator. The position of the wells would be measured by G.P.S. Water bearing horizon and lithology of the wells data from the local well drillers were taken into account and recorded.

Water sample were collected and analyzed for the physical properties (total dissolved solid, electric conductivity, pH, total hardness) and chemical properties (cations and anions) at chemical laboratory. Chemical analysis would be carried out in the laboratory and assessment of groundwater quality.

Result

Hydrogeological Investigation of Thagaya-Myohla area

Description of Aquifers

Based on the geologic and hydrogeologic condition of the Thagaya-Myohla Area, three aquifer units can be classified. The present study is emphasized on alluvial aquifer units because most of the tube wells were sunk in these units. Hence, in the study area two major types of aquifer are recognized as follow:

1. Younger alluvial aquifer (Sittaung River valley deposit)
2. Older alluvial aquifer Unit I (Fan deposit from Bago Yoma) and Unit II (Fan deposit from Eastern Highland)

Younger alluvial aquifer

This aquifer is lying in the western part and eastern part of Sittaung River. The areal extent of this unit is about 6.6 km from north to south in length and about 2.9km in width from east to west. This aquifer is made up of sediments deposited by Sittaung River. Thus, the thickness of this aquifer is varying from place to place. Also grain size of sediment is varying from place to place. The shallow aquifer is lying at the depths of 9.14m (30ft) to 18.3m (60ft) and medium aquifer type is lying at the depth 18.3m(60ft) to 27.4m (90ft) as shown in Figure (2.a). Discharge is about 700 gp/h from 2" diameter well (Static water level is at 16ft depth).

Older alluvial aquifer Unit I

This aquifer is lying between Sittaung River in the east and Bago Yoma in the west. The areal extent of this unit is about 6.4km from north to south is length and about 1.7km in width from east to west. This aquifer is made up of sediments deposited by Myohla Chaung, Sinthe Chaung, Ngakhonema Chaung and Chaungzauk Chaung as well as derived from Bago Yoma. Near the Bago Yoma the grain of sediment is coarse and towards Sittaung River it becomes finer. Older alluvial aquifer unit I is covered by yellow coloured clay. This unit is composed of sandy soil, yellow clay, clay soil, blue sand, yellow sand, whitish bluish and whitish yellowish sand. The shallow aquifer is lying at the depths of 9.14m (30ft) to 20m (65ft), medium aquifer type is lying at the depth 20m(65ft) to 26m (85ft) and deep aquifer 41.5m(136ft) to 63.4m (208ft) as shown in Figure (2.b). Discharge is about 800 gp/h from 2" diameter well (Static water level is at 12ft depth).

Older alluvial aquifer Unit II

This aquifer is lying between Eastern Highland in the east and Sittaung River in the west. The areal extent of this unit is about 5.8km from north to south is length and about 2.9km in width from east to west. This aquifer is made up of sediments deposited by Binbye Chaung, Ngazinyaung Chaung and Gweythe Chaung as well as derived from Eastern Highland. Near the Bago Yoma the grain of sediment is coarse and towards Sittaung River it becomes finer. Sand in this unit are mostly fine to coarse grained size. The shallow aquifer is lying at the depths of 9.14m (30ft) to 18.3m (60ft), medium aquifer type is lying at the depth 19m(61ft) to 26m (85ft) and deep aquifer 91.4m(300ft) to 110m (360ft) as shown in Figure (2.c). Discharge is about 400 gp/h from 2" diameter well (Static water level is at 13ft depth).

There are generally two directions of groundwater flow: one is in East to West direction in the eastern part and the other is in West to East in the western part of the study area. Finally, the groundwater discharges into the Sittaung River.

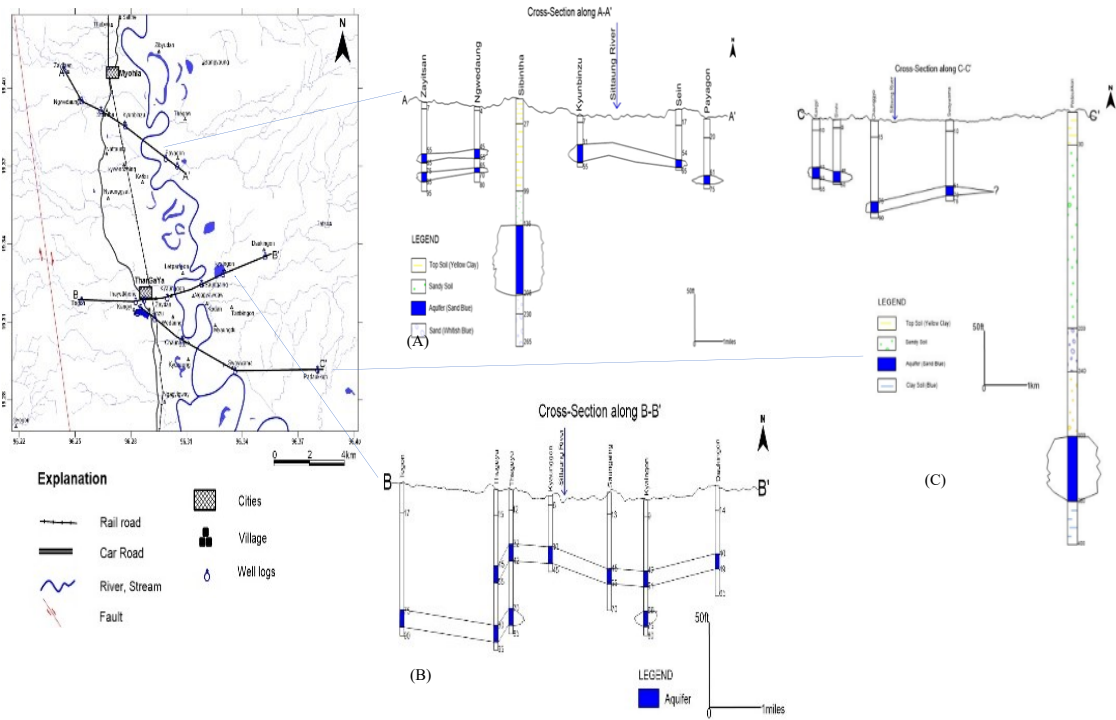


Figure.2. Cross-section of water bearing horizon of
 (a) older alluvial aquifer Unit I (Qa₁) along A-A',
 (b) younger alluvial aquifer (Qa₁) along B-B' and
 (c) older alluvial aquifer Unit II (Qa₂) along C-C'

Chemical Composition and Quality of Groundwater

Groundwater is not pure water because it usually contains dissolved mineral ions. Some of these dissolved minerals are essential for good health, but it may cause taste or odor problem if too abundant. Fifteen water samples were randomly collected over the entire area from hand-dug wells and tube wells. A typical chemical analysis includes the determination of Total Dissolved Solids (TDS), Electrical Conductivity (EC), Concentration of Hydrogen Ions (pH), Total Hardness (TH), Major Cations (Ca²⁺, Mg²⁺, K⁺, Fe⁺⁺ and Na⁺) and Major Anions (CL⁻¹, SO₄⁻², HCO₃⁻¹ and CO₃⁻²) (Table-1).

Chemical Analysis Data of Groundwater from Thagaya-Myohla Tube wells (ND= not detected)																	
Well No.	EC micromho/cm	TDS (mg/l)	pH	Concentration of ions in milligram per litre											Total Hardness	Total Alkalinity	Turbidity (NTU)
				Fe ⁺²	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	CO ₃ ⁻	HCO ₃ ⁻	SO ₄ ⁻²	Cl ⁻	As	Pb			
TM 1	90	60	5.8	0.4	0	2.84	5.61	0.48	ND	20	7.68	16	ND	0	16	20	0.4
TM 2	86	55	5.8	0.5	0.51	3.4	4.01	0.48	ND	20	7.68	15	ND	0.001	12	20	0.4
TM 3	90	60	5.8	0.3	0	2.07	4.01	2.4	ND	16	15.36	12	ND	0	20	16	0.3
TM 4	630	410	6.5	0.5	22.43	0.61	39.28	23.04	ND	16	34.56	172	ND	0.002	194	16	1.30
TM 5	410	270	6.5	0.3	0	2.94	24.85	14.88	ND	22	38.4	89	ND	0.002	124	22	0.15
TM 6	80	55	5.8	0.5	0	1.02	6.41	0	ND	16	15.36	12	ND	0.001	16	16	0.5
TM 7	270	180	6.5	0.6	12.4	2.37	10.42	5.28	ND	16	38.4	56	ND	0.002	48	16	7.3
TM 8	670	430	6.5	0.3	121	1.31	51.3	26.88	ND	46	19.2	95	ND	0	240	46	0.25
TM 9	600	390	6.5	0.4	0	0.64	62.52	18.72	ND	38	38.4	124	ND	0.001	234	38	3.1
TM 10	60	40	5.8	0.5	0	2.62	3.21	1.92	ND	12	7.68	10	ND	0	16	12	0.45
TM 11	620	400	6.8	0.5	4.35	21.41	63.33	26.76	ND	70	34.56	88	ND	0	270	70	0.25
TM 12	446.5	221	8.7	0.008	-	-	-	-	-	5	-	7	ND	-	5	-	8.76
TM 13	392.6	197	8.8	0.04	-	-	-	-	-	15	-	4	0.006	-	15	-	0.82
TM 14	102.9	519	7.5	0.2	-	-	-	-	-	255	83	140	ND	-	255	-	4.5

TM 15	133.7	66.9	8.1	0.3	-	-	-	-	-	55	1	7	ND	-	55	-	28.5
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Table (1) Result of hydrochemical analysis of water sample from tube well in the study area

Total Dissolved Solids (TDS)

In this study area, the highest value of TDS is generally 519mg/l, which is within the allowable drinking water standard of WHO (i.e.1000mg/l). So, it is found that all the groundwater in the study area are fresh water.

Electrical Conductivity (EC)

EC values of the study area is ranging from 60 micromho/cm to 630 micromho/cm which is within the allowable drinking water standard of WHO,i.e. 1500 micromhos/cm).

Concentration of Hydrogen Ions (pH)

pH value of the Thagaya, Thebyu and Sibintha village is 5.8, which is the acidic water because pH are less than 6.5. Padaukkon and Daukingon village, the pH values ranges from 8.6 to 8.8, which is alkaline water because pH are higher than 8.5. In Myohla and Tatso village, the pH values are 6.5, 6.8 and 7.2 respectively, which are within the allowable drinking water standard of WHO (i.e. 6.5-8.5).

Total Hardness (TH)

Hardness in water is between 5mg/l to 270mg/l, which are within the allowable drinking water standard of WHO (i.e. 500mg/l). Most of the samples are soft water, one sample no. (TM-5) is moderately hard water and also TM-4,8,9,11,14 are hard water of the study area.

Major Cations (Ca²⁺, Mg²⁺, K⁺, Fe⁺⁺, Na⁺)

Calcium value in the study area ranges from 0.16mg/l to 3.16mg/l, is lower than allowable drinking water standard of WHO (i.e. 75-200mg/l). Magnesium value is from 0.48mg/l to 26.76mg/l, which is lower than allowable drinking water standard of WHO (i.e. 30 to 150mg/l). Potassium concentration is ranging from 0.61mg/l to 21.41mg/l, which is within the allowable drinking water standard of WHO, (i.e. 200mg/l). Iron value is from 0.2mg/l to 0.6mg/l, iron content is lower than allowable drinking water standard of WHO (i.e. 0.5- 1.5mg/l). Distribution of sodium content is between 0.51mg/l to 121mg/l, which is within the permissible limit as WHO standard (i.e. 200mg/l).

Major Anions (CL⁻¹, SO₄⁻², HCO₃⁻¹, CO₃⁻²)

Chloride concentration in the study area range from 4mg/l to 172mg/l, which is lower than allowable drinking water standard of WHO (i.e. 200-600mg/l). Sulphate concentration in the study area varies from 1mg/l to 83mg/l, which is within the allowable drinking water standard of WHO (i.e. 400mg/l). Bicarbonate value in the study area ranges from 5mg/l to 255mg/l. Carbonate is not detected in the study area. WHO recommends a concentration of 200mg/l for potable water supply.

Arsenic (As)

The resulted of the water sample are not detected and except one sample (sample no.TM 13) in Daungingon village is found 0.006 mg/l, which is less than drinking water WHO guideline value (i.e.0.01mg/l).

Classificaton of Groundwater Types by Kurlov's Methods

The Kurlov's method is written by using ionic concentrations which are expressed in milliequivalent percentage. The highest amount of ion is expressed first and lesser ion in seconds and so on. The anions and cations are expressed above and under the line resembling as fraction. Eleven water samples from study area were used to know the groundwater types by Kurlov's method. According to the Kurlov's method, Chloride Calcium Magnesium (Cl Ca-Mg) type is major groundwater type.

Hydrochemical Ratios and Environment

Hydrochemical ratio shows the nature of the hydrochemical environments which more or less indirectly indicates the recharge and discharge conditions and the direction of the groundwater flow.

Chloride Bicarbonate Ratio (Cl/HCO₃⁻)

It suggests that the groundwater of these alluvial aquifer units contains higher Cl than HCO₃⁻. Most of the waters are found to be chloride water. The values of these ratios decrease towards the Sittaung River is noticed and not well reflected by groundwater of alluvial aquifers in the study area.

Calcium magnesium ratio (Ca⁺⁺/Mg⁺⁺)

At the younger alluvial aquifer (Qal), Ca⁺⁺ content is higher than Mg⁺⁺, as suggested by high Ca⁺⁺/Mg⁺⁺ ratio. It may be due to the chemical weathering from the eastern highland Ca⁺⁺/Mg⁺⁺ contour with the value of 5.2 is found at the Thagaya area and well reflected at the western part of the area. Groundwater of that area possess calcium as secondary salinity containing CaCl₂. Among these salts, calcium salts are more abundant than Mg salts.

Drinking Water

Most of the people obtain drinking water from private tube wells and I.W.U.M.D tube wells. According to the pH and Fe⁺⁺ analyses, some water samples contain high iron content. Treatment to reduce iron should be done in this area (Table-2).

Table (2) Composition with National and WHO Guideline Value for Drinking water

Well No.	pH	EC Microho/cm	Concentration of ions in milligram per litre										Remark
			TDS	Fe ⁺⁺	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺	CO ₃ ⁻	HCO ₃ ⁻	SO ₄ ⁻	Cl ⁻	
TM 1	5.8	90	60	0.4	ND	2.84	5.61	0.48	ND	20	7.68	16	Unsuitable
TM 2	5.8	86	55	0.5	0.51	3.4	4.01	0.48	ND	20	7.68	15	Unsuitable
TM 3	5.8	90	60	0.3	ND	2.07	4.01	2.4	ND	16	15.36	12	Unsuitable
TM 4	6.5	630	410	0.5	22.43	0.61	39.28	23.04	ND	16	34.56	172	Suitable
TM 5	6.5	410	270	0.3	ND	2.94	24.85	14.88	ND	22	38.4	89	Suitable
TM 6	5.8	80	55	0.5	ND	1.02	6.41	0	ND	16	15.36	12	Unsuitable
TM 7	6.5	270	180	0.6	12.4	2.37	10.42	5.28	ND	16	38.4	56	Suitable
TM 8	6.5	670	430	0.3	121	1.31	51.3	26.88	ND	46	19.2	95	Suitable
TM 9	6.5	600	390	0.4	ND	0.64	62.52	18.72	ND	38	38.4	124	Suitable
TM 10	5.8	60	40	0.5	ND	2.62	3.21	1.92	ND	12	7.68	10	Unsuitable
TM 11	6.8	620	400	0.5	4.35	21.41	63.33	26.76	ND	70	34.56	88	Suitable
TM 12	8.66	446.5	221.2	0.008	-	-	-	-	-	5	-	7	Unsuitable
TM 13	8.81	392.6	196.8	0.04	-	-	-	-	-	15	-	4	Unsuitable
TM 14	7.52	102.9	519.2	0.2	-	-	-	-	-	255	83	140	Suitable
TM 15	8.08	133.7	66.94	0.3	-	-	-	-	-	55	1	7	Unsuitable
National Guideline value	6.5- 8.5	1500	1000	0-1.5	200	200	75- 200	30- 150	-	200	400	200- 600	
WHO Guideline value	6.5- 8.5	1500	1000	0.3-1	200	-	75- 200	30- 150	-	-	200- 400	200- 600	

Groundwater Quality for Irrigation Water

Irrigation water are dependent on the type of plants, amount of irrigation water used, soil and climate, as some plants are highly sensitive to a certain concentration of an element in the irrigation waters. Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), Sodium Percentage (Na%), Residual Sodium Carbonate (RSC) are important parameters for determining the suitability of groundwater for irrigation.

Sodium Adsorption Ratio (SAR)

SAR measures relative concentration of sodium ions divided by the square root of one-half of the sum of calcium and magnesium ions in water sample. Where the ionic concentrations are expressed in meq. SAR values in water of the study area range from 0.06 to 3.41 (Table-3). Table (3) The classification of groundwater for irrigation base on SAR (after Richards, 1954)

Sr.No.	Quality of water	Limiting Values of SAR	Total No. of Samples (Out of Total 15 Samples)
1	Excellent (S1)	< 10	15
2	Good (S2)	18-Oct	-
3	Doubtful (S3)	18-26	-
4	Unsuitable (S4)	>26	-

Electrical Conductivity (EC)

The total concentration of soluble salts or salinity hazard in irrigation water can be express in terms of electrical conductivity. The value of EC in the groundwater samples of the study area ranges from 60 to 670 micromho/cm. This water can be used for irrigation(Table-4).

Table (4) The classification of groundwater for irrigation base on EC (after Richards, 1954)

Sr.No.	Quality of water	Limiting Values of EC (micromho/cm)	Total No. of Samples (Out of Total 15 Samples)
1	Excellent (C1)	< 250	7
2	Good (C2)	250-750	8
3	Doubtful (C3)	750-2250	-
4	Unsuitable (C4)	>2250	-

Residual Sodium Carbonate (RSC)

The concentration of carbonate and bicarbonate higher than the alkaline earth mainly calcium and magnesium concentration. The water quality may be diminished and affects agriculture unfavorably.

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{+2} + Mg^{+2})$$

Where all the irons are expressed in meq. The range of residual sodium carbonate of groundwater in the study area varies from -0.23 to -5.36 (Table-5).

Table (5) The classification of groundwater for irrigation base on RSC (after Richards, 1954)

Sr.No.	Quality water of	Limiting Values of RSC	Total No. of Samples (Out of Total 15 Samples)
1	Safe	< 1.25	15
2	Marginal	1.25-2.5	-
3	Unsuitable	>2.5	-

Magnesium Adsorption Ratio (MAR)

The value of MAR of groundwater in the study area varies from 12.36% to 49.67%. Indicating that about 15 water samples are within the acceptable limit of 50% (Table -6).

Table (6) Classification of groundwater for irrigation base on MAR (Ayers & Westoct, 1985)

Sr.No.	Quality of water	Limiting Values of MAR %	Total No. of Samples (Out of Total 15 Samples)
1	Suitable	< 50	15
2	Unsuitable	>50	-

Sodium Percentage (Na⁺%)

Sodium concentration is an important parameter of the groundwater quality for irrigation because sodium causes an increase in the hardness of the soil as well as a reduction in its permeability. The results of Na% in the study area varies from 0.35% to 52.60% (Table -7).

Table (7) Classification of groundwater for irrigation base on Na% (Wilcox, 1995)

Sr.No.	Quality of water	Limiting Values of Na%	Total No. of Samples (Out of Total 15 Samples)
1	Excellent	< 20	11
2	Good	20-40	3
3	Permissible	40-60	1
4	Doubtful	60-80	-
5	Unsuitable	>80	-

USSL Diagram for Irrigation Water Quality Evaluation

The USSL diagram best explains the combined effect of sodium hazard and salinity hazard. USSL diagram classification based on EC and SAR for irrigation. According to USSL diagram, about 7 samples are good (C₁S₁) and 8 samples fall medium to good (C₂S₁) classes (Table-8).

Table (8) USSL diagram classification based on EC and SAR for irrigation and shows the physico-chemical characteristic and irrigation suitability

Well No.	Cities	EC (micromho/cm)		S.A.R		Water Class	Quality of water	MAR%	RSC	Na%	Suitability for Irrigation
TM 1	Thagaya	90	C ₁	0	S ₁	C ₁ S ₁	Good	12.36	-0.31	18.53	Suitable
TM 2	Thagaya	86	C ₁	0.06	S ₁	C ₁ S ₁	Good	16.48	-0.23	31.3	Suitable
TM 3	Thagaya	90	C ₁	0	S ₁	C ₁ S ₁	Good	49.66	-0.39	11.75	Suitable
TM 4	Myohla	630	C ₂	0.7	S ₁	C ₂ S ₁	Medium to Good	49.15	-3.83	20.45	Suitable
TM 5	Myohla	410	C ₂	0	S ₁	C ₂ S ₁	Medium to Good	49.67	-2.46	2.96	Suitable
TM 6	Thebyu	80	C ₁	0	S ₁	C ₁ S ₁	Good	0	-0.31	7.54	Suitable
TM 7	Thebyu	270	C ₂	0.78	S ₁	C ₂ S ₁	Medium to Good	45.51	-0.83	38.6	Suitable
TM 8	Myohla	670	C ₂	3.41	S ₁	C ₂ S ₁	Medium to Good	46.34	-4.77	52.6	Suitable
TM 9	Myohla	600	C ₂	0	S ₁	C ₂ S ₁	Medium to Good	33.04	-4.61	0.35	Suitable
TM 10	Sibintha	60	C ₁	0	S ₁	C ₁ S ₁	Good	49.64	-0.31	17.4	Suitable
TM 11	Myohla	620	C ₂	0.12	S ₁	C ₂ S ₁	Medium to Good	41.05	-5.36	12.08	Suitable
TM 12	Myohla	446.5	C ₂	0	S ₁	C ₂ S ₁	Medium to Good	0	0	0	Suitable
TM 13	Myohla	392.6	C ₂	0	S ₁	C ₂ S ₁	Medium to Good	0	0	0	Suitable
TM 14	Myohla	102.9	C ₁	0	S ₁	C ₁ S ₁	Good	0	0	0	Suitable
TM 15	Myohla	133.7	C ₁	0	S ₁	C ₁ S ₁	Good	0	0	0	Suitable

Discussion and Conclusion

The study area is located in the Thagaya-Myohla Townships, Bago Region. Two types of aquifers are found, younger alluvial aquifer and older alluvial aquifers. The groundwater flow direction of the area is from west to east in the western part of the study area towards the Sittaung River and from east to west in the eastern part of the study area towards the Sittaung River. Three types of water bearing horizons; shallow aquifer is lying at the depths of from 30ft to 60ft, medium aquifer (from 60 to 90 ft), and deep aquifer (>90ft). TDS, EC, major cations and major anions were found within the permissible limit as WHO standard and National Guideline value. The pH of all water collected and analyzed are acidic water because pH value is less than 6.5 and alkaline water because pH is greater than 8.5. Some water sample are suitable for drinking because pH value is within 6.5-8.5. The iron values in the study area exceed the standard limit and other ions values fall under the permissible limits. Kurlov's method show that the Chloride Calcium Magnesium (Cl Ca-Mg) type is major groundwater type. $\text{Cl}^-/\text{HCO}_3^-$ ratio is not well reflected, and $\text{Ca}^{++}/\text{Mg}^{++}$ ratio is well reflected and also indicate that groundwater flows toward Sittaung River. Suitability of groundwater for irrigation was assessed from sodium adsorption ratio (SAR), electrical conductivity (EC), magnesium adsorption ratio (MAR), residual sodium carbonate (RSC) and percentage sodium (Na%). According to USSL diagram, all of the samples fall in the suitable range for irrigation purpose.

Acknowledgements

I am deeply indebted to Rector, Dr Soe Myint Aye and Pro-rector Dr Phyu Phyu Myint, Sagaing University for their kind permission and advice to carry out this research work. I would like to express big thanks to responsible personnel and local villagers in the study area. Finally, all my teachers from Geology Department, Sagaing University are highly thanked for their cooperation.

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