GROUNDWATER QUALITY ANALYSIS OF THE PHYU TOWNSHIP, BAGO REGION

Nay Nwe Myo[1], Min Han Nyein[2], Hnin Ei Hlaing[3]

Abstract

The study area is located between in the west of the Sittaung River and eastern parts of the Bago Yoma. It is lying between North Latitude 18º 24´ to 18º 30´ and East Longitude 96º 27´ to 96º 30´. The total coverage of the area is approximately 2322.42 square kilometers. Total population of the research area is about 257,273 (2019 Cencus). The drainage pattern of the study area is dendritic and parallel pattern. According to the pattern, the bedrock of the study area is shale and sandstone. Alluvial aquifer mainly composed of the research area. Alluvial aquifer mainly composed of the blue clay, blue sand, blue sandy clay and sand with gravel in some place. According to the well log data, its thickness is varying from 90-160 feet in one place to another. At well no.16, the groundwater yield from this unit is about 500 to 800 gallons per hour (gph) from 2" diameter tube well. The collected samples are analyzed at the Water Resources and Utilization Department (W.R.U.D) and Ministry of Agriculture and Irrigation Department, the cations and anions and TDS, EC, pH, total alkalinity and total hardness. According to the Piper method, water types can be classified by 3 types. There are Sodium Chloride, Calcium Chloride and Mix types. The pH values of water samples are ranging from 7.95 to 8.6. The electrical conductivity (EC) of groundwater samples is ranging from 210 to 800 µmhos/cm. TDS concentration is ranging from 120 ppm to 520 ppm. Sodium concentration is ranging from 5 ppm to 45 ppm. Calcium concentration is ranging from 9 ppm to 48 ppm and does not exceed the W.H.O standard (2011) of 200 mg/L. The value of iron in the research area is ranging from 0.0 ppm to 4.5 ppm. Bicarbonate concentration in the research area is ranging from 20 ppm to 92 ppm. The concentration of sulfate in the research area is ranging from 8 ppm to 70 ppm. The results of chemical data analyzed by the SSP% method, the SAR method and the MAR method show that some tube wells can be assessed suitable for use as irrigation water. According to the above methods and the WHO Drinking Water Standard, the data can assess whether the groundwater of the research area is suitable for drinking water, domestic use, and irrigation water, except that some tube wells are not suitable.

Keyword: SSP%, SAR and MAR

Location, Size and Accessibility

The study area is located between in the west of the Sittaung River and eastern parts of the Bago Yoma. The location map of the study area is shown in Figure (1). Geographically, the area is bounded by Oktwin Township in the north, Htantabin and Kyaukkyi Townships in the east, Kyauktaga Township in the South and Nattalin Township in the west. It is lying between North Latitude 18º 24´ to 18º 30´ and East Longitude 96º 27´ to 96º 30´. This area refers to the UTM Map and Map Sheet No. 1896-1, 5, 9 in UTM. The total coverage of the area is approximately 2322.42 square kilometers. Total population of the research area is about 257,273 (2019 Cencus).

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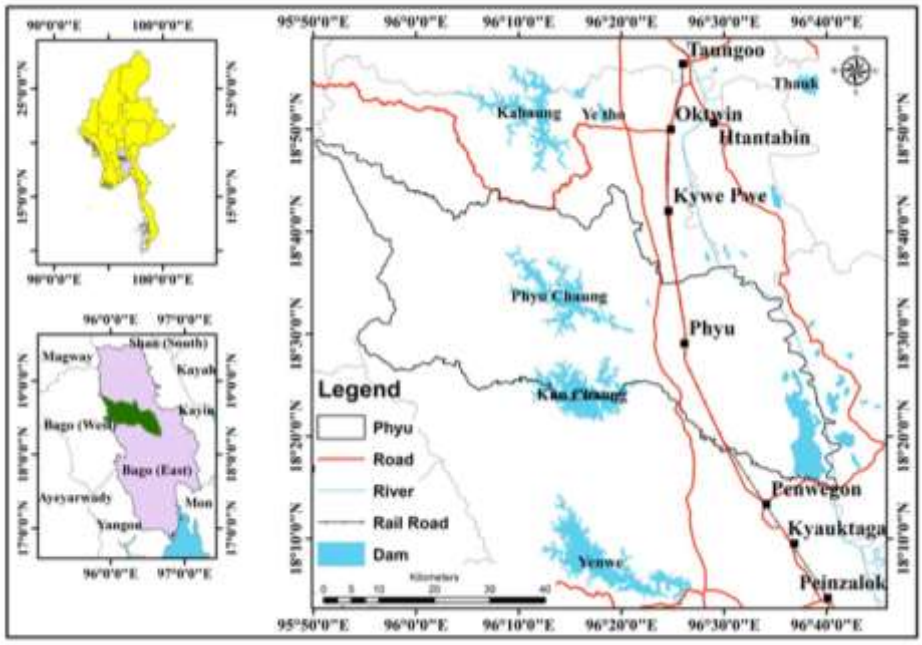


Figure 1. Location Map of the Study area

Purpose of the study

The purposes of this research are described as follows;

- To determine the chemical composition, quality and types of groundwater
- To access the groundwater quality for suitable sources of irrigation, domestic uses and industry use

Method of Study

Before commencement of this field work, the author tried to get information and literatures from available sources. Brittle plastic bottles have been prepared to bring back the water samples from the field for the analysis of their quality. The present research work consists of literature review, Geographic Information System (GIS) analysis, field investigation, and laboratory work. Method of study has two methods. There are Field Methods and Laboratory Methods.

Field Methods

During the fieldwork, the location of the well by G.P.S (Global Positioning System), the measurement of water level, well depth, well logging and collection of rocks and water samples, to set the information from the local people who need and well water were taken into the recorded.

Laboratory Methods

In the laboratory of Utilization of Water Resources Department, measurement of cations (Ca^{2+}, Mg^{2+}, Na^{+}, $K^{+,}$ and Fe^{2+}) and anions (HCO_3^-, SO_4^- and Cl^-), total dissolved solids (TDS), total hardness (TH), p^H and electrical conductivity (EC), smell, salinity, color, were made.

Previous Investigation

Most previous works in this study area emphasized on geology, hydrogeology and others. They are listed as follows:

Aye Aye Myint made “Environmental Geological Study of Taungoo and its environs” for Ph.D dissertation in 2009.

Bender, F., (1983) placed the study area into the Back Arc area of sedimentation in the Pegu Yoma and in the Sittaung Basin.

Kyaw Aung studied groundwater chemistry and water flow direction in the study area and made a study of the "Hydrogeological investigation of the groundwater of Taungoo-Oktwin area and Taungoo Town" for D.A.G. dissertation in 1979.

Kyaw Ye Aung made "Assessment of Groundwater Quality of the Oktwin Township, Bago Region" for M.Sc degree in 2016.

Thandar Aung made "Assessment of Groundwater Quality in Phyu Township, Bago Region" for M.Sc degree in 2016.

Thin Thin Khaing made "Analysis of poor drainage system and flood frequency during the rainy season in Taungoo" for M.Res.degree in 2005.

Wint Wint Htun studied Environmental Aspects of Kabaung Dam Project Area, Oktwin Township, Bago Division (East) "for M.Rse degree in 2005.

Zin Nwe Khaing studied "Assessment of Groundwater Quality in Taungoo Township, Bago Region" for M.Sc degree in 2016.

Drainage Pattern

Phyu of the main river is Sittaung. Phyu has many streams. All streams are freshwater type. The drainage pattern of the study area is dendritic and parallel pattern. According to the pattern, the bedrock of the study area is shale and sandstone. The drainage map of the study area is shown in Figure (2).

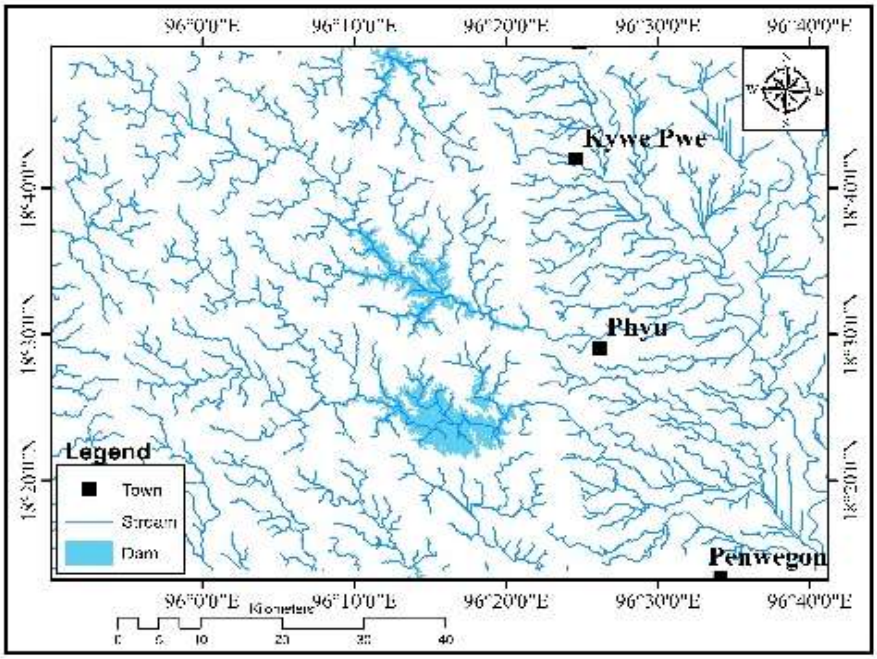


Figure 2. Drainage Map of the Study Area

Climatological Features

The climate data are based on the record of (Sources: The Department of Meteorology and Hydrology Kaba-Aye) for the period of 2011-2019. The monthly maximum temperature is high in April with 38.4 Cº and minimum temperature in January is only 15.9 Cº. The average monthly rainfall is 210 (mm). The monthly rainfall is high in Aug with 642 (mm).The relative humidity is

high in Aug with 96 %. The climatological condition of the study area is shown in Figures (3, 4, 5 and 6) respectively.

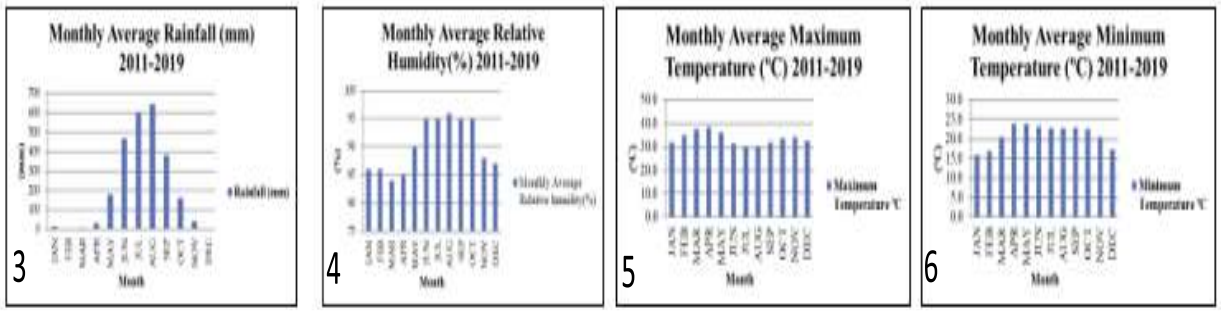


Figure 3. Monthly Average Rainfall, **Figure 4**. Monthly Average Relative Humidity, **Figure 5**. Monthly Average Maximum Temperature and **Figure 6**. Monthly Average Minimum Temperature

Regional Geologic Setting

The investigated area is located in the Pegu region, and the Bago Yoma area is situated in the eastern part of the Central Myanmar Tertiary Basin. Pegu Yoma is a morphological and geological unit about 400 miles (644 km) long and 40 miles (64.4 km) wide that generally strikes NNW-SSE lying between the Mogok Belt (Searle and Ba than Haq, 1964) and Shan Plateau (Eastern Highlands) to the east and Central Volcanic Line to the west. The study area lies between the right lateral Sagaing fault and the Papun fault (Soe Thura Tun, 2007).

In the study area, the Irrawaddy Formation is well exposed on both sides of the Yangon-Mandalay Highway, and the Pegu Group is widely distributed in the western part of the study areas. The regional geologic map of the study area is shown in Figure (7) and Table No. (1) Stratigraphic succession of the study area.

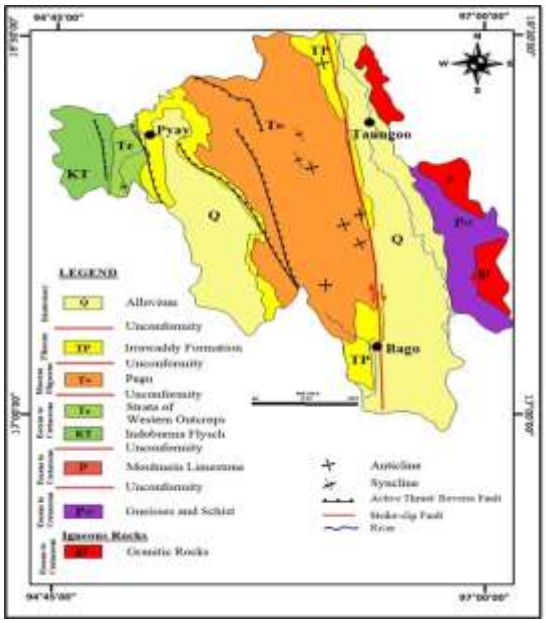


Figure 7. Regional Geologic Map of the Study Area, Source; (MGS 2014)

Table 1. Stratigraphic Succession of the Study Area

Geologic Age	Rock units	Lithology
Recent	Alluvium	clay loam and sandy clay, overburden soil, bluish brown, and yellowish brown in colour, moderately plastic and soft
Pliocene	Irrawaddy Formation	coarse current bedded and poorly consolidated buff color sandstone interbedded with gritty, pebbly beds, minor sandy clay and shale
Miocene	Pegu Group	light grey colour massive sandstones intercalated with grey shale and buff colour sandstones and siltstone
Late Cretaceous to Early Eocene	Igneous Rocks	Pegmatite dykes and quartzofeldspathic veins, Microgranite, Biotite granite, Porphyritic biotite granite

Hydrogeologic Characteristics of the Research Area

Collection of Data

One-inch topographic map was used in the collection of the water samples of the area under investigation. All water sample data are collected from the Water Resources and Utilization Department (W.R.U.D) and the Ministry of Agriculture and Irrigation Department.

Table 2 Chemical analysis of the research area

Tube Well No.	TDS ppm	EC µmho/cm	pH	TH ppm	TA ppm	Na ppm	k+ ppm	Ca2+ ppm	Mg2+ ppm	Fe2+ ppm	Cl- ppm	SO4= ppm	HCO3- ppm	Aquifer Types
P1	120	210	8.32	52	60	15	13	9	7	2	20	12	44	Alluvial
P2	400	640	8.58	166	112	45	38	36	18	1	120	34	92	Alluvial
P3	200	320	8.36	74	98	25	21	20	6	2.5	33	12	74	Alluvial
P4	200	320	8.7	68	72	26	22	14	8	1	45	14	52	Alluvial
P5	220	340	8.3	76	80	26	22	14	10	0.5	42	19	20	Alluvial
P6	160	270	8.32	90	86	11	9	20	10	3	22	17	52	Alluvial
P7	520	800	8.43	286	96	35	30	48	40	0.5	156	70	64	Alluvial
P8	300	470	8.39	112	96	35	29	22	14	3	74	28	76	Alluvial
P9	240	380	8.58	76	92	30	26	18	7	0	52	12	76	Alluvial
P10	160	250	8.34	104	70	5	4	21	13	2	22	23	58	Alluvial
P11	260	420	8.54	168	90	20	17	26	25	4.5	43	48	66	Alluvial
P12	220	340	7.95	74	84	21	23	12	11	2.5	43	18	64	Alluvial
P13	160	250	8.37	98	60	8.5	7	20	12	3	30	21	40	Alluvial
P14	240	380	8.34	92	92	29	24	16	12	0.5	45	23	64	Alluvial
P15	200	320	8.37	42	86	35	29	10	4	0	42	8	66	Alluvial
P16	220	350	8.37	118	78	15	13	15	19	2.5	43	34	66	Alluvial
P17	160	265	8.3	100	72	12	10	14	15	0	26	29	60	Alluvial

Aquifers

In the research area, alluvial aquifer mainly composed of the blue clay, blue sand, blue sandy clay and sand with gravel in some place. According to the well log data, its thickness is varying from 90-160 feet in one place to another. At well no.16, the groundwater yield from this unit is about 500 to 800 gallons per hour (gph) from 2" diameter tube well.

Classification of Piper Diagram (Piper 1944 and Hill 1940)

This method was proposed by Piper (1944) and Hill (1940). This method of the tri-linear diagram is widely used 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 diagrams are shown in Figure (8). According to the Piper method, water types can be classified by 3 types. There are Sodium Chloride, Calcium Chloride and Mix types.

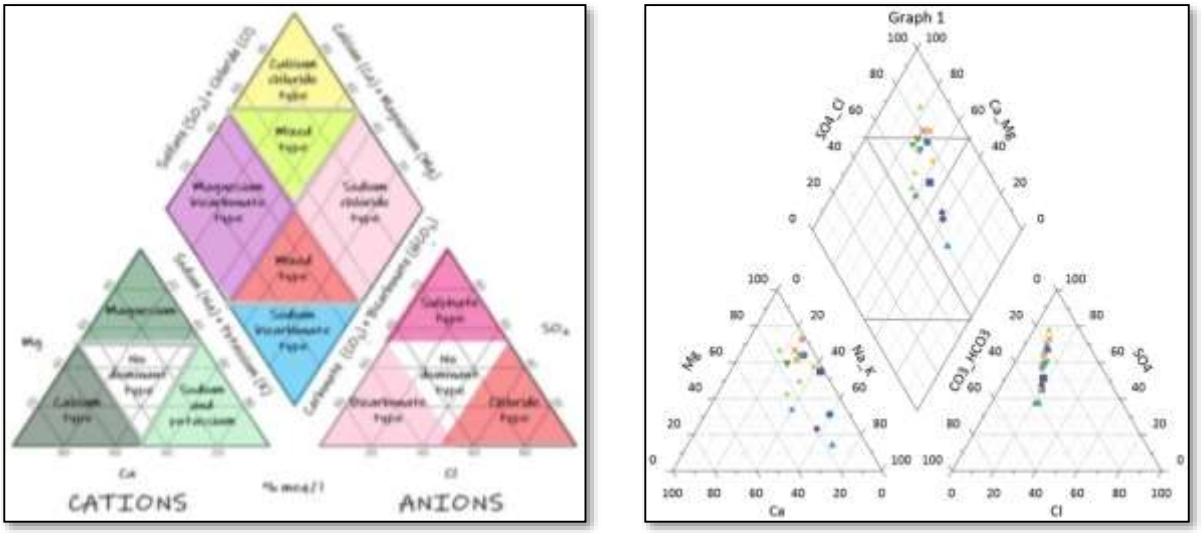


Figure 8. Classification of the Piper diagram, after Piper (1944) and by Hill (1940)

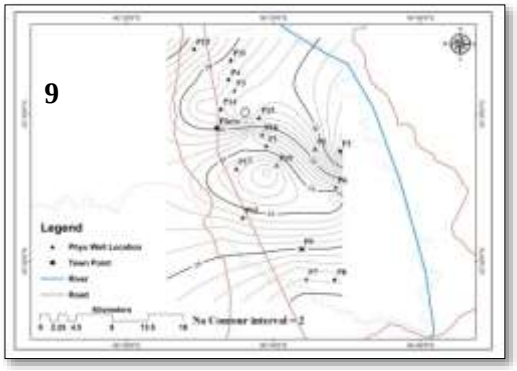
Chemical Analysis of the Groundwater

Chemical Analysis is important to specify the actual characteristics 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 are made in the laboratory.

In groundwater resources evaluation, the quality of groundwater is as important as its quantity. The chemical and physical constituents of groundwater determine its usefulness for municipal, commercial, industrial, agricultural and domestic water supplies.

Detail description of chemical composition of the study area

All water samples are collected from water Resources Department Yangon. The collected samples are analyzed for the cations (calcium Ca^{++} , Magnesium Mg^{++} , Iron Fe^{++} , Sodium Na^{+}, Potassium K^{+}) and anions Bicarbonate (HCO_3^{-}), Sulphate ($SO_4^{=}$) and Chloride (Cl^{-}) are represented shown in Figure. (9, 10, 11, 12, 13, 14, 15 and 16).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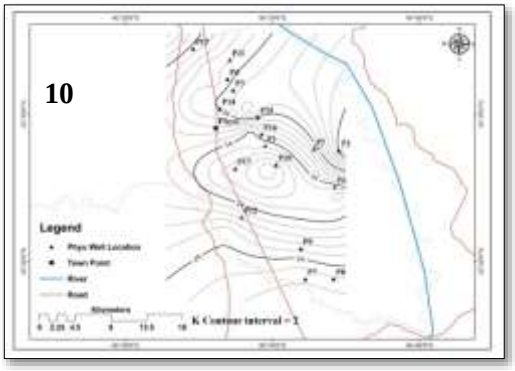
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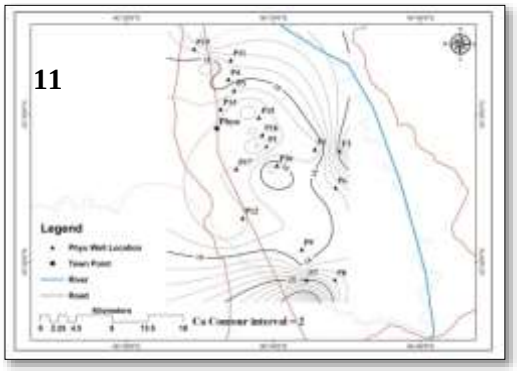
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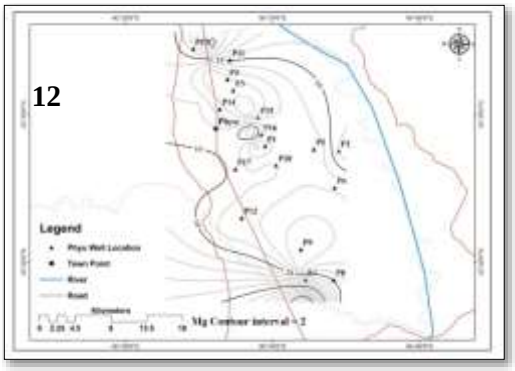
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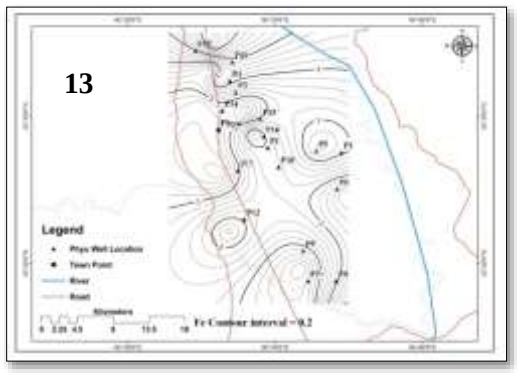
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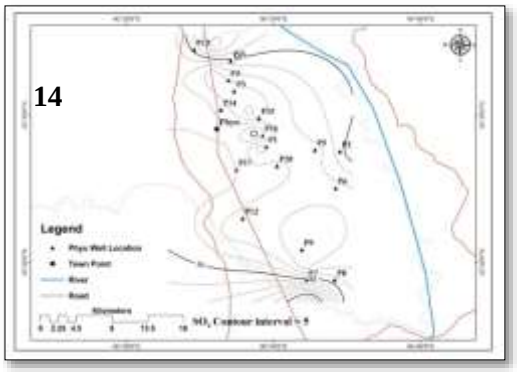
Fe Contour interval = 0.2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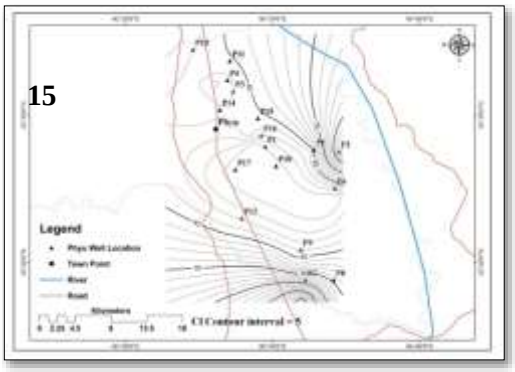
SO4 Contour interval = 5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Cl Contour interval = 5

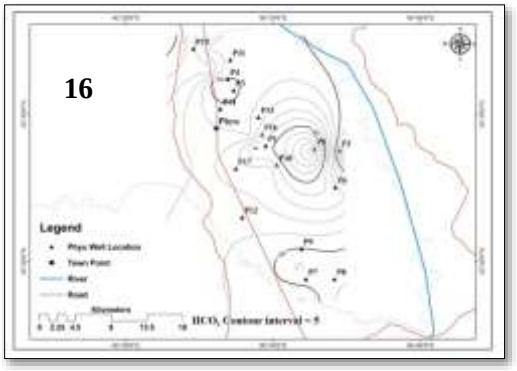

Figure 9. 10, 11, 12, 13, 14, 15 and 16. Distribution Map of the Major Cations and Anions in research area.

Domestic Purposes for Water Quality

The pH values of water samples are ranging from 7.95 to 8.6. The electrical conductivity (EC) of groundwater samples is ranging from 210 to 800 µmhos/cm. TDS concentration is ranging from 120 ppm to 520 ppm. Sodium concentration is ranging from 5 ppm to 45 ppm. Calcium concentration is ranging from 9 ppm to 48 ppm and does not exceed the W.H.O standard (2011) of 200 mg/L. The value of iron in the research area is ranging from 0.0 ppm to 4.5 ppm. Bicarbonate concentration in the research area is ranging from 20 ppm to 92 ppm. The concentration of sulfate in the research area is ranging from 8 ppm to 70 ppm. The water quality shows the domestic uses and drinking water of water quality in Table No. (3).

Table 3 Comparison with the study area and World Health Organization (W.H.O) Guideline Values for Drinking Water Quality Standard (2011)

Characteristics	Guideline value (2011)		The range obtained from groundwater	Remark
	Desirable	Max Permissible		
Calcium (mg/l)	75	200	9-48	Suitable
Magnesium (mg/l)	30	150	4-40	Suitable
Sodium (mg/l)	0	200	5-45	Suitable
Potassium (mg/l)	0	200	4–38	Suitable
Sulphate (mg/l)	0	250	8 – 70	Suitable
Chloride(mg/l)	200	250	20-156	Suitable
Iron (mg/l)	0.3	1	0 – 4.5	Unsuitable
TDS (mg/l)	0	1000	120-520	Suitable
pH	6.5	8.5	7.95 – 8.6	Potable
EC (micro mhos/ cm)	0	1500	210–800	Suitable

Agriculture purposes for Groundwater Quality

Agriculture is the basis of the Myanmar economy. The quality of water for irrigation is classified by Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR) and Soluble Sodium Percentage (SSP or Na %). The respective values of all water quality parameters are summarized in each table.

Sodium Adsorption Ratio (SAR) (Richardson, 1954)

Sodium Adsorption Ratio (SAR) is most commonly used to assess the suitability of irrigation water and classification based on the SAR values is expressed in Table No. (4). The SAR measures sodicity in terms of the relative concentration of sodium ions to the sum of calcium and magnesium ions in a water sample. Sodium concentration in water affects the deterioration of the soil properties reducing permeability. SAR is calculated using the following formula:

$$S.A.R = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$$

Table 4. Classification of Water based on the SAR

Type of water	SAR value	Classification
Low Sodium water	<10	Excellent
Medium Sodium water	10-18	Good
High Sodium water	18-26	Doubtful
Very High Sodium water	>26	Unsuitable

Where the ionic concentrations are expressed in meq /L. The result of the Sodium Adsorption Ration (SAR) is shown in the Figure. (17) and Table No. (6).

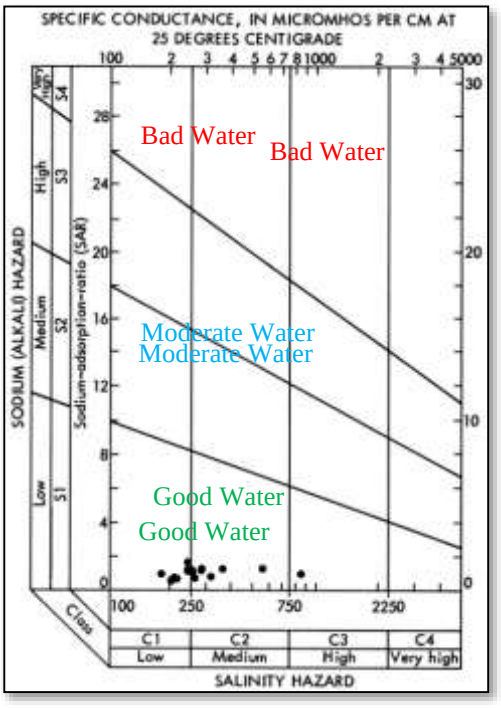

Figure 17. Sodium Adsorption Ration (SAR)

Magnesium Adsorption Ratio (MAR) (Raghunath, 1987)

The magnesium content of water is considered one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most water. More magnesium in water will adversely affect crop yield as the soil becomes more saline, Raghunath, H. M., (1987). The values of the magnesium adsorption ratio of each aquifer are tabulated in Table No. (6).

$$\text{M. A. R.} = \frac{\text{Mg2+}}{\text{Ca2+ + Mg2+}} \times 100$$

The value of the magnesium adsorption ratio of the research area ranges from 33 to 68 %. The acceptable limit of the magnesium adsorption ratio is 50 %.

Soluble Sodium Percentage (%) (Wilcox, 1955)

Sodium concentration plays an important role in the evaluation of groundwater quality for irrigation because sodium causes an increase in the hardness of the soil as well as a reduction in its permeability. The sodium percentage (Na %) is calculated using the formula given below:

$$\text{SSP} = \frac{(\text{Na} + + \text{K+})}{\text{Ca 2} + + \text{Mg2} + + \text{Na} + + \text{K} +} \times 100$$

The methods of classification of groundwater based on Na% (Wilcox,1955) is shown in Table No. (5). The result of the SSP% are shown in Table No. (6).

Table 5. Classification of Groundwater based on Na % (Wilcox, 1955)

(Na %) Percentage of Sodium	Classification
< 20	Excellent
20 - 40	Good
40 -60	Permissible
60 - 80	Doubtful
> 80	Unsuitable

Table 6. Summary Table for various methods of irrigation water quality in the Research Area

Tube Well No.	EC micro mhos/ cm	SAR	MAR%	SSP%
1	210	0.8	56	49
	Excellent	Excellent	Unsuitable	Permissible
2	640	1.2	45	47
	Good	Excellent	Suitable	Permissible
3	320	1	33	52
	Good	Excellent	Suitable	Permissible
4	320	1.1	49	56
	Good	Excellent	Suitable	Permissible
5	340	1.1	54	53
	Good	Excellent	Unsuitable	Permissible
6	270	0.4	45	28
	Good	Excellent	Suitable	Good

Tube Well No.	EC micro mhos/ cm	SAR	MAR%	SSP%
7	800	0.8	58	29
	Permissible	Excellent	Unsuitable	Good
8	470	1.2	51	50
	Good	Excellent	Unsuitable	Permissible
9	380	1.2	39	57
	Good	Excellent	Suitable	Permissible
10	250	0.2	51	13
	Good	Excellent	Unsuitable	Excellent
11	420	0.6	61	28
	Good	Excellent	Unsuitable	Good
12	340	0.9	60	50
	Good	Excellent	Unsuitable	Permissible
13	250	0.3	50	22
	Good	Excellent	Suitable	Good
14	380	1.1	55	51
	Good	Excellent	Unsuitable	Permissible
15	320	1.8	39	73
	Good	Excellent	Suitable	Doubtful
16	350	0.5	68	30
	Good	Excellent	Unsuitable	Good
17	265	0.5	64	29
	Good	Excellent	Unsuitable	Good

Results and Outcomes

The results of chemical data analyzed by the SSP% method, the SAR method and the MAR method show that some tube wells can be assessed suitable for use as irrigation water. PIPER method can be classified the water types, drinking water, domestic use and Irrigation water. Water Types can be analyzed into 3 water types. If high amount of Iron concentration, it can be reduced of amount with aeration methods and sand filtering methods. According to the above methods and the WHO Drinking Water Standard, the data can assess whether the groundwater of the research area is suitable for drinking water, domestic use, and irrigation water, except that some tube wells are not suitable.

Acknowledgment

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