ANALYSIS ON THE GROUNDWATER QUALITY OF HPA-AN TOWN

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Abstract

This paper presents the water quality of tube-wells in Hpa-An Town located in the southern continuation of Eastern Highland. In the area, different water sources are found with high content of chemical parameters that are harmful for human health. Most of town dwellers consume shallow tube-well water. It is important to know the quality of tube-well water and thus samples of tube-wells water extracted in different parts of the town are studied. The objectives of this paper are to explore the spatial variation of water quality in the study area, to find out the relationship between selected water quality parameters and tube-well depth and to assess the impact of ground water quality on local people. The data on groundwater consumption and local people's perception were collected through field observation, structured interviews and departments concerns. Inverse Distance Weighted (IDW) are used to analysis the parameter of pH, Salinity, Total Dissolved Solid, Turbidity, Total Hardness, Calcium, Magnesium, Chlorine, Iron and Salinity. To assess the correlation between spatial variation and water quality parameters (six pairs – Total Dissolved Solid and Electrical Conductivity, Salinity and Electrical Conductivity, Salinity and Total Dissolved Solid, Calcium and Total Hardness, Calcium and Magnesium, Total Hardness and Magnesium) Pearson's Correlation Coefficient Method, Scatter Diagram Analysis (R^2) is used. Hierarchical Cluster Analysis (SPSS, Ward Method) is used to identify the spatial variation of water quality of study area. The test results indicate that Turbidity, Iron and magnesium contents are higher than the acceptable level of WHO (2017) and Myanmar National Drinking Water Quality Standard (MNDWQS-2006). In addition, test results of pH value are lower than the permissible level of WHO and MNDWQ Standards. All groundwater samples are not suitable for drinking and cooking purposes.

Keywords: Spatial variation of water quality, Inverse Distance Weighted (IDW), Scatter Diagram Analysis (R^2), Hierarchical Cluster Method (SPSS, Ward Method), tube-well water

Introduction

Water is necessary for human beings and living thing. Freshwater comprises just 2.5% of the total global water, 68.7% of this freshwater is in the form of ice and glaciers; 30.1% forms groundwater; and 1.2% forms surface water (Gleik, 1993). The available of sufficient portable water is important for any area. Safe water is one of essential component or need for healthy living (WHO guidelines for drinking water quality-NCBI). The groundwater surface is not affected either by natural or human influence. Most of the water is directly obtained from ground water, the least from the rain water. Hpa-An Town is located in the southern part of Kayin State in Myanmar.

Hpa-An Township is located on the eastern bank of the Thanlwin River and the soils near Hpa-An Town are waterlogged swampy soils, lateritic soils and soils formed by erosion of the limestone. Hpa-An Town was selected to study the water quality because people living in Hpa-An Town use water from Thanlwin River, shallow tube-wells and some deep tube-wells. Water is essential for daily consumption and uses. Most of the people use water from shallow tube-wells for domestic purposes. Water is extracted by pumping from the depth between 6 metres (18 ft) to 20 metres (60 ft). Because of nearness to Thanlwin River, low flat land areas, waterlogged

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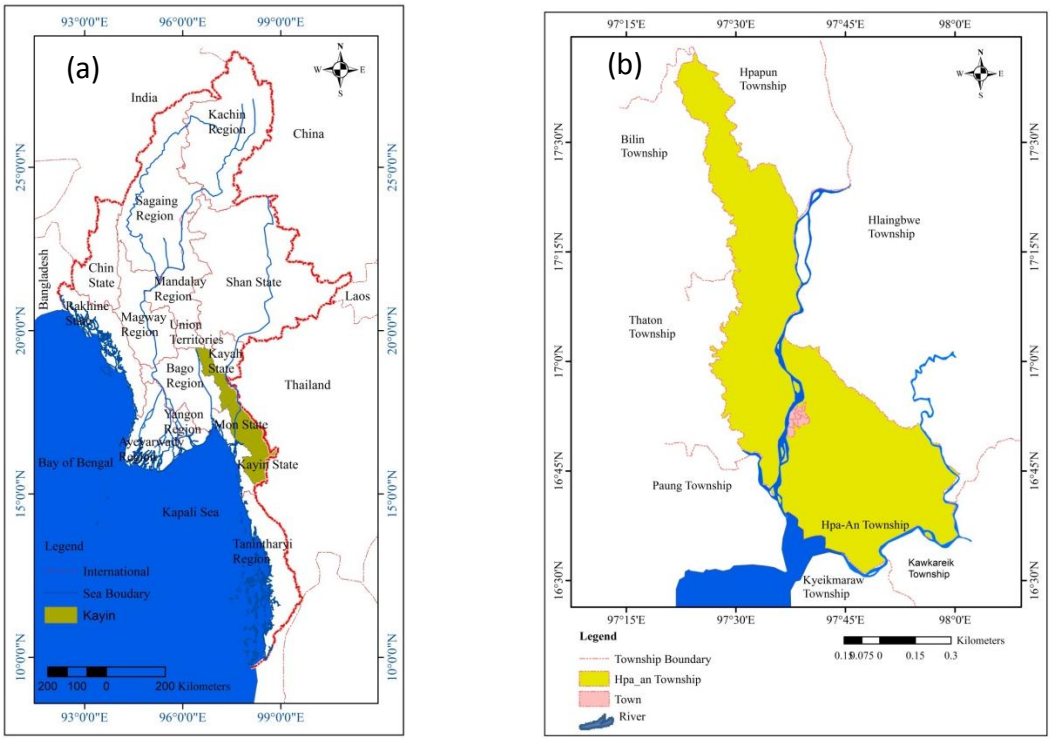
swampy soils and being underlain by old limestone, it necessary to assess the water quality for sharing the knowledge of water quality and to point out the health impacts caused by water used in the area. Therefore, chemical contents were checked to present the suitability and unsuitability for drinking and domestic consumption of the tube-well water, and spatial variation of water quality is presented from the geographical point of view.



Sources: Survey Department, Yangon and Topographic map (1:50000)

Figure 1 (a and b) Location of Study Area

Study Area

Hpa-An is situated between north latitudes 16°.50' 0" and 16°.55' 0" and east longitudes of 97°.36' 50" and 97°40' 20". Hpa-An Town area is located in the central part of Hpa-An Township, southern part of Kayin State. It is the capital of Kayin State. It lies in the eastern bank of Thanlwin River and low-lying floodplain area of Thanlwin River. It has an area of 25.89 square Kilometers (10 square miles) and it is composed of nine wards. Generally, it is 16.7 metres (50 ft) above the sea level. The western flat plain is low-lying area. The underlying rocks of the range and uplands are old limestone, granite and metamorphic rocks. There are also limestone hills such as Zwegabin taung near Hpa-An.

Three types of soils are found in the study area. These are meadows, lateritic and waterlogged swampy soils. Soils and geological structure of an area have great impact on groundwater quality.

Methodology

Both primary and secondary data are used. The study on water quality of tube-wells is based on data from the Water Resource and Environmental Conservation Department, Hpa-An Township, Kayin State. Primary data for water samples were collected in the period on 8 April 2019. These water samples were firstly collected and then tested in ISO-TECH Laboratory, Insein Township, Yangon Region, Myanmar. The data were assessed by the WHO Standard (2017) and Myanmar National Drinking Water Quality Standard (MNDWQS-2006). Spatial variation of aquifers' depths and water quality parameters were identified by Scatter Diagram Analysis (R^2). GIS (Arc Map 10.1) was applied for spatial variation of tube-well map of the study area. Twenty sample points of ground water tube-well were collected from Hpa-An Town. These water samples were taken depending on Wards area and densely populated places of all wards. The depths of tube-wells range from 6 metres (18 ft) to 20 metres (60 ft).

Aim

The main aim of this research is to make an analysis and assessment of the spatial variation of water quality in Hpa-An Town, based on chemical parameters from the geographic point of view.

Objectives

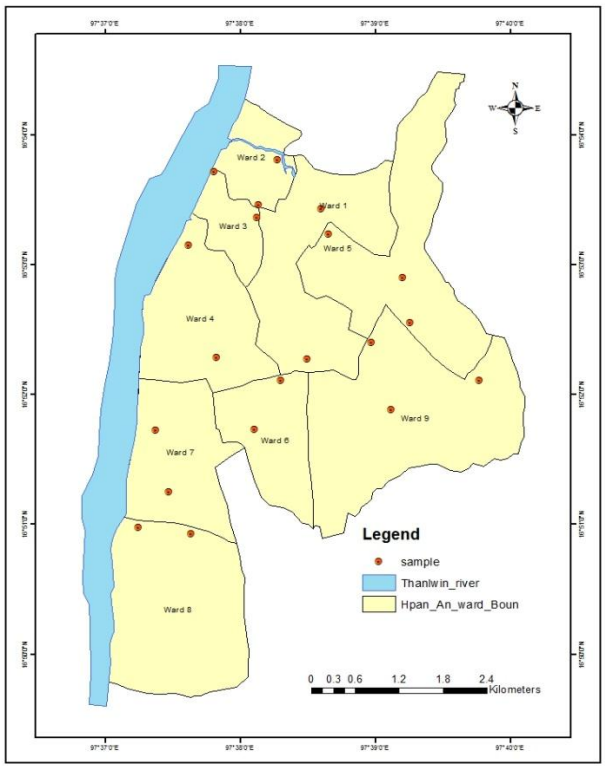
The main objectives are:

- To explore the spatial variation of water quality in the study area.
- To find out the relationship between selected water quality parameters and tube-well depth.
- To assess the impact of ground water quality on local people.

Spatial Variation of Groundwater Quality in Hpa-An Town

To measure the spatial variation of groundwater quality in study area, 20 sample water bottles are collected from nine wards to identify 10 chemical parameters. Collected water samples are based on different depths of tube-wells from the layers of swampy soil (3.3metres - 10metres) and sandy soil (10 metres-21.6 metres). These lead to represent the quality of groundwater for Hpa-An Town. The test results of chemical parameters are presented together with WHO standard (2017) and Myanmar Drinking Water Quality Standard (MDWQS-2006).

In this study, the chemical test and physical test are mainly used to analyze the content of Total Dissolve solid, Electrical Conductivity, pH, Salinity, Calcium, Iron, Magnesium, Chlorine, Turbidity and Total Hardness. Water quality is a description of the chemical contents, physical and biological characteristics of water, usually in respect to its suitability for drinking, cooking and other purposes.



Source: Field Survey

Figure 2 Groundwater Sample Points in Study Area

Assessment on the Tested Results of Groundwater Quality

Water quality standard is a level for a water constituent which ensures acceptability of the water to consumers and also safe to drink or use in cooking and bathing.

pH

The pH of the water is the measurement of the acidity or alkalinity of the water. pH value ranges between 6.5and 8.5 is generally suitable for drinking. In this study area, all of the tested tube-well waters belong to the value of pH range between 4.4 and 6.9. A pH of 7 is neutral, under 7 is acidic and over 7 alkaline. According to the results most of tube-well waters are below the range of WHO (2017) standard and Myanmar National Drinking Water Quality Standard (MNDWQ-2006) and are high in content of acid throughout the year. Therefore, water tested in the study area is slightly acidic.

Total Dissolved Solid (TDS)

TDS is the proportion of solid in water. It includes carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions and other ions. In the study area, the test results of total dissolved solid ranges between 78 ppm and 302 ppm. Ward 5 and Ward 3 are with the lowest value of total dissolved solid. Ward 1, Ward 2, Ward 4, Ward 6, Ward 7, Ward 8 and Ward 9 have high value of total dissolved solid. According to the value of WHO standard and MNDWQS (General Accepted=500 ppm), tube-well's water of the study area is located within the accepted level all year round. TDS is directly related to the purity of water and the quality of water purification systems.

Turbidity (NTU)

Turbidity refers to water clarity. Turbidity includes clay, silt or mud in the water. In the study area, the tested turbidity results range between 5 NTU and 24 NTU respectively. The highest concentration of turbidity value is in Ward 3, Ward 5, and Ward 8.The lowest value of NTU is concentrated in the Ward 1, Ward 2, Ward 4, Ward 6, Ward 7, and Ward 9.In comparison with to the 5 NTU of WHO standard value, the test value of most of the wards are high. This result indicates high turbidity in tube-wells in the study area. Although turbidity does not represent a health condition, it can protect harmful bacteria from disinfection processes.

Total Hardness

Total hardness is the sum of the calcium and magnesium concentrations. Water hardness is a measure of the capacity of water to precipitate soap. In the study area, total hardness of tube-wells belong to within the range of 14 mg/ L to 396 mg/ L .The highest value of total hardness is found in Ward 2, Ward 8, and Ward 9. The lowest value of total hardness is observed in Ward 6 and Ward 5. The permissible value of WHO and MNDWQ Standard is 500 mg/ L. Therefore, total hardness of tube-wells in Hpa-An Town is in the range of WHO and MNDWQ standard levels.

Calcium

The presence of calcium in water results from deposition of limestone, dolomite, gypsum and gypsiferous shale. Calcium is necessary for proper bones, shells and teeth formation. According to test results, the value of calcium parametres ranges between 6 mg/ L and 120 mg/ L in the study area. The lowest value of calcium is at Ward 6 and Ward 1. All of the tested results of the tube-wells in Hpa-An Town are within WHO and MNDWQ standard levels.

Magnesium

Magnesium is an essential element in chlorophyll and in red blood cells. It is an essential element for the life function of all plants and animals. The results of Magnesium content of tube-wells lay range between 8 mg/ L and 276 mg/ L in the study area. The highest Magnesium value is found in Ward 2, Ward 8 and Ward 9. According to WHO and MNDWQ standards, the value of the three wards is higher than permissible level (150 mg/ L). It indicates more calcium content in water. The lowest values of Magnesium are found in Ward 6, Ward 5 and Ward 3.

Chlorine

Chlorine is an important chemical in water purification. Chlorine is found in water. According to chemical test, the values of Chlorine content range between 3 mg/ L and 190 mg/ L. The highest values of chlorine are detected in Ward 1, Ward 2. The remaining wards are of the lowest values of chlorine content in Hpa-An.

Iron

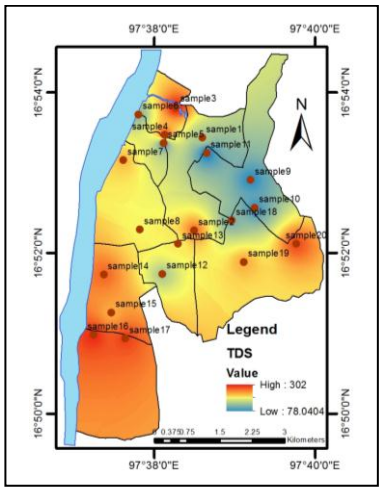
The high iron levels in water can cause staining in plumbing, laundry, cooking utensils and colors to foods. But it is an important component of hemoglobin and essential elements for all living things. In the study area, the values of tested Iron content lie within the range of between 0.26 mg/ L and 0.66 mg/ L. As a result of the test, the values of Iron in Ward 3 and Ward 7 are higher than the permissible WHO's standard level. In addition, a slightly higher value of Iron is found in the remaining wards.

Salinity

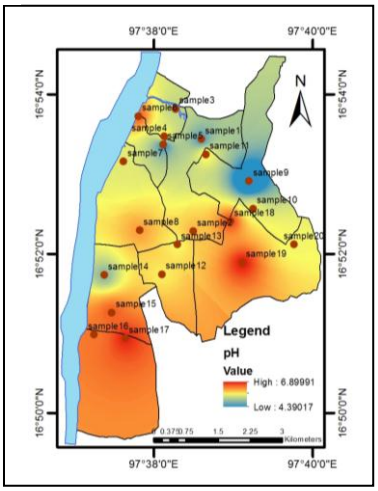
Salinity is a measure of the content of salts in soil or water. Salts are highly soluble in surface and groundwater. Excessive amounts of dissolved salt in water can affect drinking water

and ecosystem. The salinity values of water samples from Hpa-An Town are range from 0 ppt to 0.2 ppt. All of the test results of every wards are low in salinity value is compare with the WHO and MNDWQ standard levels.

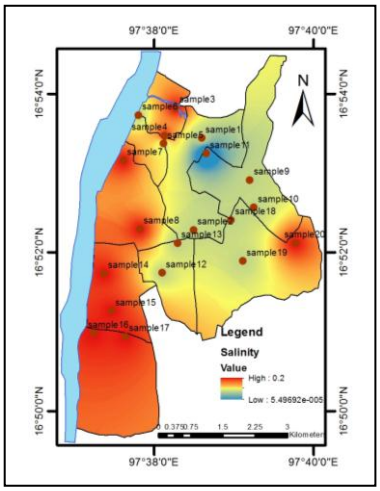
(a) Total Dissolved Solid



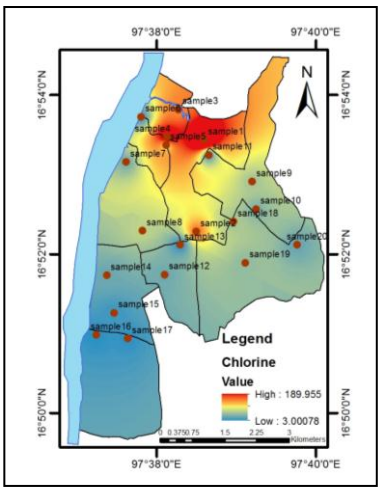
(b) pH Value



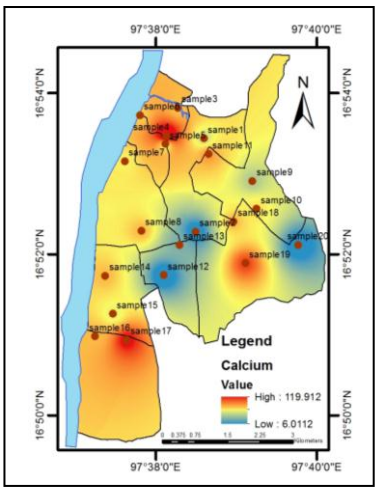
(c) Salinity Value



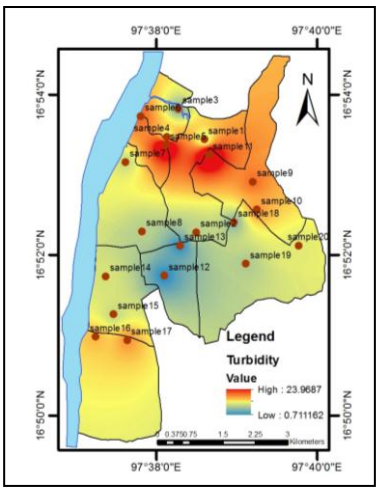
(d) Chlorine Value



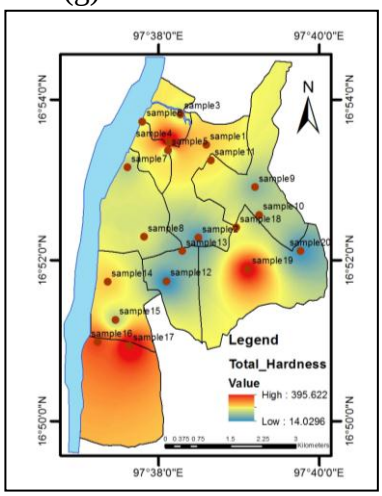
(e) Calcium Value



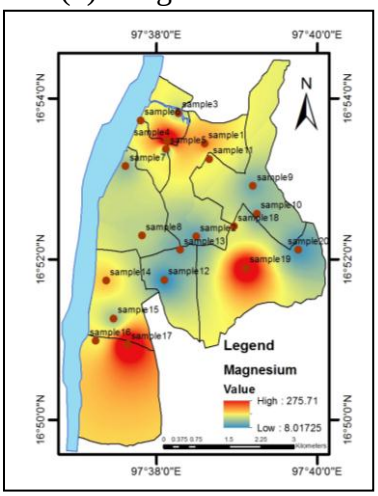
(f) Turbidity Value



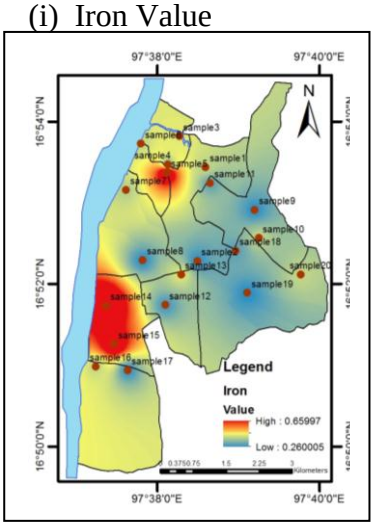
(g) Total Hardness



(h) Magnesium Value



(i) Iron Value



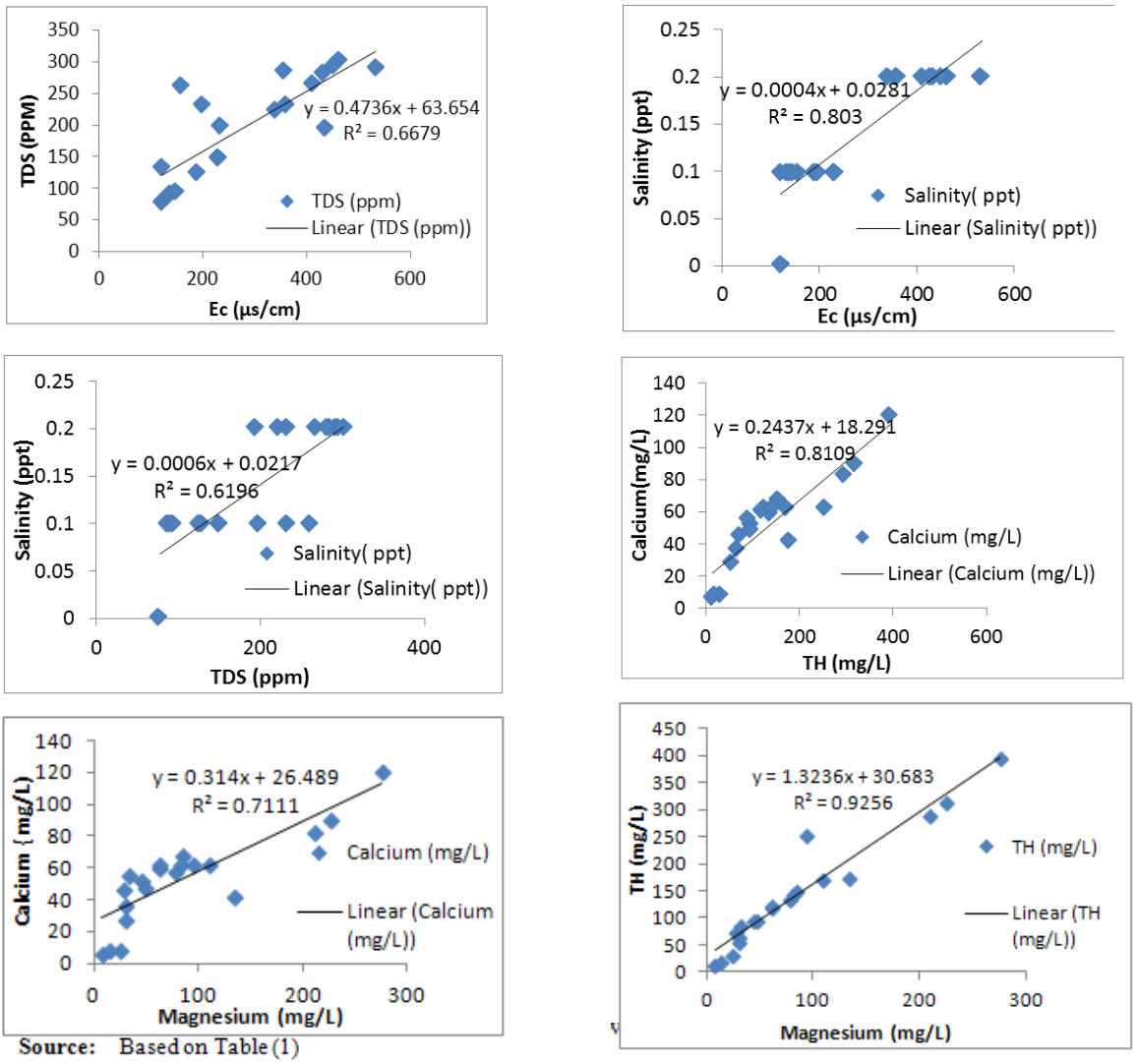
Sources: Based on Field Observation and Tested Result (ISO-TECH)

Figure 3 (a - i) Chemical Parameters of Hpa-An Town

Analysis on the Groundwater Quality in Hpa-an Town

Spatial variation of water quality parameters is assessed by Scatter Diagram Analysis (R^2).This method works out on the correlation between selected water quality parameters of the study area. The variables used in the groundwater quality for Scatter Diagram Analysis are shown in figure (4).

Among the ten chemical parameters, six chemical parameters including (Total Dissolved Solid, Electrical Conductivity, Salinity, Total Hardness, Calcium and Magnesium) have directly highest positive correlation between each other in study area. The values of Total Dissolved Solid and Electrical Conductivity have direct correlation with R^2 value of 0.667 in Scatter Diagram. Salinity and Electrical Conductivity values are directly correlated with R^2 value of 0.803.The positive correlation between Salinity and Total Dissolved Solid is highest with 0.619, between Calcium and Total Hardness with 0.810, between Calcium and Magnesium with 0.711 and between Total Hardness and Magnesium value with 0.925. The rest of chemical parameters are low in correlation coefficient values. As the R^2 value is less than 5, correlation coefficient value is rather low. The above - mentioned results show that there are positive and negative correlations between the parameters of water quality. Therefore, the correlation level is rather weak, as correlation coefficient values are much less than 5.0.



Source: Based on Table (1)

Figure 4 Correlation between Chemical Parameters

Table 1 Pearson's correlation significant results

	Depth	TDS (ppm)	Ec (µs/cm)	pH	Salinity(ppt)	Calcium (mg/L)	Chlorine (mg/L)	Turbidity (NTU)	TH (mg/L)	Mag (mg/L)	Iron (mg/L)
Depth	1	0.080	0.270	0.134	0.289	0.400	-0.050	0.033	0.481*	0.381	0.302
TDS (ppm)	0.080	1	0.817**	0.379	0.787**	0.199	0.073	-0.503	0.393	0.381	0.025
Ec (µs/cm)	0.270	0.817	1	0.196	0.896**	0.340	0.123	-0.418	0.405	0.343	0.104
pH	0.134	0.379	0.196	1	0.172	0.312	-0.315	-0.293	0.380	0.351	-0.276
Salinity(ppt)	0.289	0.787**	0.896**	0.172	1	0.233	-0.012	-0.386	0.270	0.214	0.226
Calcium (mg/L)	0.400	0.199	0.340	0.312	0.233	1	0.134	0.166	0.901**	0.843**	-0.059
Chlorine (mg/L)	-0.050	0.073	0.123	-0.315	-0.012	0.134	1	-0.134	0.246	0.340	-0.094
Turbidity (NTU)	0.033	-0.503*	-0.418	-0.293	-0.386	0.166	-0.134	1	0.030	-0.043	0.247
TH (mg/L)	0.481*	0.393	0.405	0.380	0.270	0.901**	0.246	0.030	1	0.962**	0.247
Mag (mg/L)	0.381	0.381	0.343	0.351	0.214	0.843**	0.340	-0.043	0.962**	1	-0.195
Iron (mg/L)	0.302	0.025	0.104	-0.276	0.226	-0.059	-0.094	0.247	-0.163	-0.195	1

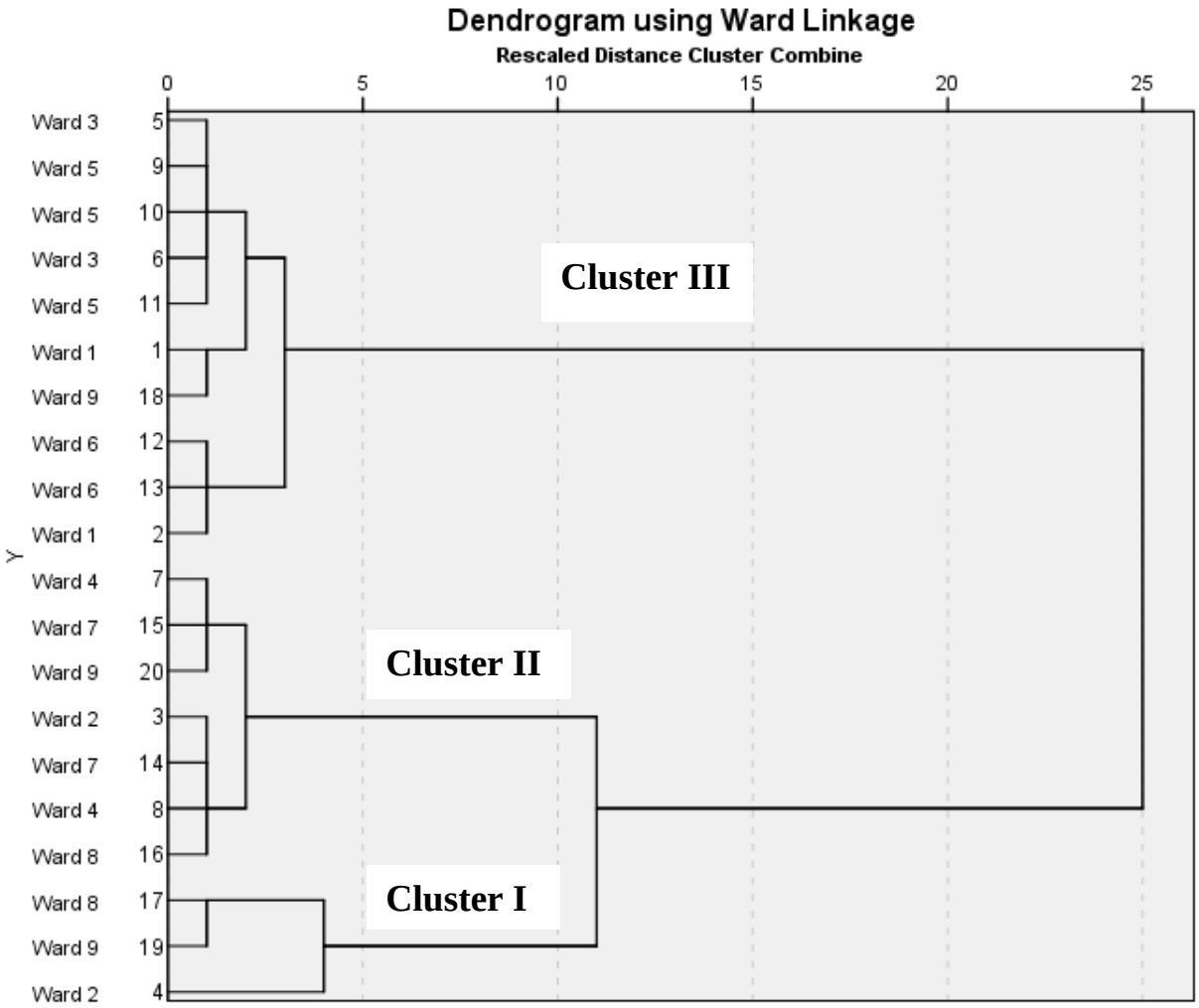
* Correlation is significant at the 0.05 level (2- tailed)
** Correlation is significant at the 0.01 level (2- tailed)

Source: Tested results of laboratories

Table 2 Sample Points Location and Water Quality Value

Ward	Sample	Depth (ft)	Temp (c°)	PH (P H)	Ec (µs/cm)	TDS (ppm)	Turbidity (NTU)	Iron (mg/L)	Calcium (mg/L)	TH (mg/L)	Chlorine (mg/L)	Mag (mg/L)	Salinity (ppt)
Ward 1	S1	40	28.84	5.3	231	150	6.5	0.34	42	176	190	134	0.1
Ward 1	S2	18	27.98	6.3	156	260	5.7	0.26	8	32	80	24	0.1
Ward 2	S3	24	27.97	5.76	464	302	3.6	0.36	60	122	75	62	0.2
Ward 2	S4	45	28.75	6.2	534	292	5.4	0.28	120	396	135	276	0.2
Ward 3	S5	38	29.11	5.09	138	90	24	0.63	46	74	52	28	0.1
Ward 3	S6	45	29.01	6.65	125	130	13.2	0.34	58	136	6	78	0.1
Ward 4	S7	23	28.22	5.92	343	223	6.1	0.33	52	96	17	44	0.2
Ward 4	S8	38	28.45	6.4	436	195	5.4	0.26	62	124	34	62	0.2
Ward 5	S9	38	28.39	4.39	135	88	12.8	0.26	36	66	28	30	0.1
Ward 5	S10	22	28.99	5.95	147	95	11.5	0.34	56	88	19	32	0.1
Ward 5	S11	24	28.34	6.09	121	78	21.6	0.28	68	152	7	84	0
Ward 6	S12	45	29.48	6.09	230	150	0.71	0.27	6	14	15	8	0.1
Ward 6	S13	24	28.65	6.04	234	200	0.8	0.36	28	58	4	30	0.1
Ward 7	S14	52	28.58	5.53	410	267	6.7	0.66	62	172	15	110	0.2
Ward 7	S15	50	28.43	6.66	360	233	6	0.58	48	96	6	48	0.2
Ward 8	S16	60	28.72	6.57	454	295	10.3	0.34	62	256	3	94	0.2
Ward 8	S17	45	27.77	6.87	357	286	11.5	0.26	90	316	4	226	0.2
Ward 9	S18	40	27.46	6.74	190	124	3.8	0.28	62	144	29	82	0.1
Ward 9	S19	33	27.5	6.9	200	232	5	0.26	82	292	23	210	0.1
Ward 9	S20	23	27.68	6.01	430	280	7	0.34	8	22	14	14	0.2

Sources: Based on Field Observation and Tested Result (ISO-TECH)



Source: Based on Table 2

Figure 5 Dendrogram of Cluster Analysis by Using Quantitative Variables of Sample Points

According to Cluster analysis, the sample points within the study area can be classified into three groups based on the variables of water quality. Among the 20 sample points, Thida Street in the north of Ward 2, Myitta Street in the west of Ward 9 and Min Ye Kyaw Swa Street of Ward 8 are included in Cluster I. The three tube-wells have higher content of conductivity, calcium, total hardness, magnesium and salinity with the depth of over 13.3 metres (40 ft). The chemical values are lower than the permissible value of WHO and MNDWQ Standards.

Cluster II includes seven tube-wells. These are Shweki 6th Street of Ward 8, Pagoda Road of Ward 2 , Shwe Pyithar 3rd street of Ward 9, Patauk Street and Thudunu Street of ward 4 and Saw San Si Phoe Street and Tha khin Mya Street of Ward 7 with a depth of between 7.7metres (23ft) and 20 metres (60ft). Among these Wards, Ward 7 and Ward 8 near the Thanlwin river have a depth of over 16.7 metres (50 ft). The waters of these tube-wells are high in calcium, total hardness, magnesium, salinity, iron, conductivity and total dissolved solid.

There are ten tube-wells between the depth of 6 metres (18ft) and 15 metres (45ft) in Cluster III. Among these, three tube-wells in the Hlartabyin Street of Ward1, Nilar Street and Pyitaw Aye Street of Ward 6 are high in chlorine content, it is lower than acceptable value of WHO and MNDWQ Standards. It means that water of these areas is suitable for consumption.

Water sample from Warsooo Street in Ward 9 only is highest pH level. But, after assessing by using WHO and MNDWQ Standards, the water is within acceptable range. Other chemical contents are lower than the standard value and thus the water is suitable for drinking and domestic uses.

The six tube-wells are located in Padonmar Street of Ward-1, Aungnan 4th Street, Bogyoke Street and U Yin Street in ward 3. In these areas, Chlorine and turbidity is higher than other sample areas. Therefore, water in these areas is suitable only for consumption.

Findings and Conclusion

In the study area, based on tested values of chemical parameters and Cluster Analysis, the results show that calcium content is low in the water within the study area. The low content of pH and high content of turbidity, iron and magnesium are found in Hpa-An Town. According to WHO and MNDWQ Standards, water samples from tube- wells in 7 Wards: , Ward 2, Shwebo Street of Ward 3, Ward 4, Ward 5, Ward 6 and Warso Oo 4th Street in Ward 9, out of nine wards are low in pH value. Water in these areas is lower than the permissible pH value of between 6.5 and 8.5 and it is acidic. Therefore, it is not suitable for drinking in this area. As the water contains high acid content and iron, the water is hard and more soap is needed in bathing and washing. The above-mentioned low quality of water can cause ill-health to residents of the respective area. Turbidity is higher than WHO and MNDWQ Standard and due to higher than maximum permission level, it is unsuitable for drinking.

The depth of the tube-wells varies from 7.7 metres (23 ft) to 20 metres (60 ft) in Ward1, Ward 2, Ward 3, Ward 4, Ward 5, Ward 7, Ward 8 and Warso Oo 4th Road in Ward 9 located near Thanlwin River. The groundwater in these wards is unsuitable for drinking because of high turbidity content. It can be used after boiling and filtering. If untreated water is consumed in the long-term, local people can get typhoid and diarrhoea.

Although the value is lower than MNDWQ Standard, the water samples are high in iron content in Hlartabyin Street of Ward1, Bogyoke Road in Ward 5, Ward 6, Warso Oo 4th Street in Ward 9 and Ward 2, Ward 3 and Ward 7. Among these wards, tube wellwaters in Ward 2, Ward 7, Ward 8 and Ward 9 have high iron content. Therefore, it is unsuitable for drinking and it has negative impacts on health of the local people.

The areas having high magnesium content are Pagoda Road in Ward 2, Shwekin 6th Street Ward 8, Shwepyithar 3rd Street Ward 9 near Kyarin Mt and calcium contents are higher than WHO and MNDWQ Standards and so the water is unsuitable for drinking and cooking. The water can cause crust in cooking pots leading to carcinogenic affect to local people.

Summing up, except pH, turbidity, iron and magnesium, water in the area is lower in total dissolved solid, calcium, chlorine, salinity, conductivity and total hardness according to with WHO and MNDWQ Standard. Although there is no waste materials from factories and farmland in area that use high chemical fertilizer, pH, turbidity and iron content vary from one place to another. Where the water is acidic, high in iron and turbidity content, water is not suitable for cooking and drinking to the local people in this area. According to interview and field observation, local people depend on bottled purified water for drinking and cooking purposes. Waters extracted from their own tube-wells are used for domestic purposes. To get thorough understanding on quality of water suitable for local people in Hpa-An Town, bacteriological test

is also needed to be conducted. Therefore, it is important to know the actual quality of groundwater for the town dwellers. To free from negative health impacts caused by using the low quality water of shallow tube-well, educative talks should be conducted to raise awareness of the local people; deeper tube-well should be sunk; the department concerned should distribute pamphlets, erect bill-boards related to the quality of groundwater in different areas of the town.

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