Study on the Physico-Chemical Characteristics of Groundwater in Michika Town and Environs Northeastern Nigeria

A. G. Mohammed
Department of Geology,
Gombe State University,
Nigeria.

G.P. Singh
Department of Geology,
Gombe State University,
Nigeria.

A. Olasehinde
Department of Geology,
Gombe State University,
Nigeria.

A. D. Saidu
Department of Physics
UIICEST Bama,
Borno State, Nigeria

***Abstract-* An attempt to understand the water quality of Michika towns and Environs was carried out under the water quality index (WQI). Physico-chemical parameters of 15 water samples collected from both Hand-dug wells and Boreholes were determined using standard procedures. The values of WQI have been affected by concentration of dissolved Ca^{++}, Fe^{++}, and Cl^{-} in the water samples. The value ranges from 54.89 – 99.02 in the hand dug wells which indicate poor to very poor quality except Ghuzukwi. But all the value range for borehole sources indicates a good status with WQI range of 22.99 – 26.76. The quality of water sampled from well were not suitable for human consumption without proper treatment. Model average representations of each parameter for the area are also presented.**

***Index Terms*— Physico-chemical, Groundwater, Michika, Water Quality Index.**

I. Introduction

The study area lies within latitudes N10˚ 28' 063" and N10˚ 39' 407" and longitudes E13˚ 19' 505" and E13˚ 28' 393" Fig 1. The economic resources of Michika and its environs are mainly agricultural. The food crops grown include Maize, Rice and Guinea Corn while Cattle, Sheep and Goat rearing are also practiced. With the increase in population, agricultural activities and industrial growth in the area, there is much greater need for supply of adequate good quality water for the growing population for domestic, agricultural and industrial purpose. The various purposes to be served for water is determined by water quality standards set by the World Health Organization (WHO 2010) and other agencies concern. Water recourses have played critical and vital role throughout history in the growth and context which continue to be a factor of importance in the economic growth of all the contemporary societies. In societies like Nigeria with developing economics, the optimum development, efficient utilization and effective management of our water resources should be the dominant strategy for economic growth. But in recent year's unscientific management and use of this resources for various purpose almost invariably has created undesirable problems in its wake which includes water logging and salinity in the case of agriculture use and environment pollution of various limits as a result of mining, industries and municipal use.

Historically, availability of water resources has played major role in ancient civilization, and has underpinned the rate of growth of socio-economic development as well as the resulting quality of life. Literature indicates that the approaches to management of water resources is widely varied (Akujieze et al, 2003), and are also being transformed from the more traditionally approach which rely largely on physical solutions to a new concept that blends resource development with ecological concerns. The traditional water resources management approach which solely relies on sourcing of new reserves to mitigate increasing water demands caused by population increase and technological advancement (among others) is facing increasing opposition and claims of derogation (Asiwaju and Oladeji, 2001 Singh et al; 2013).

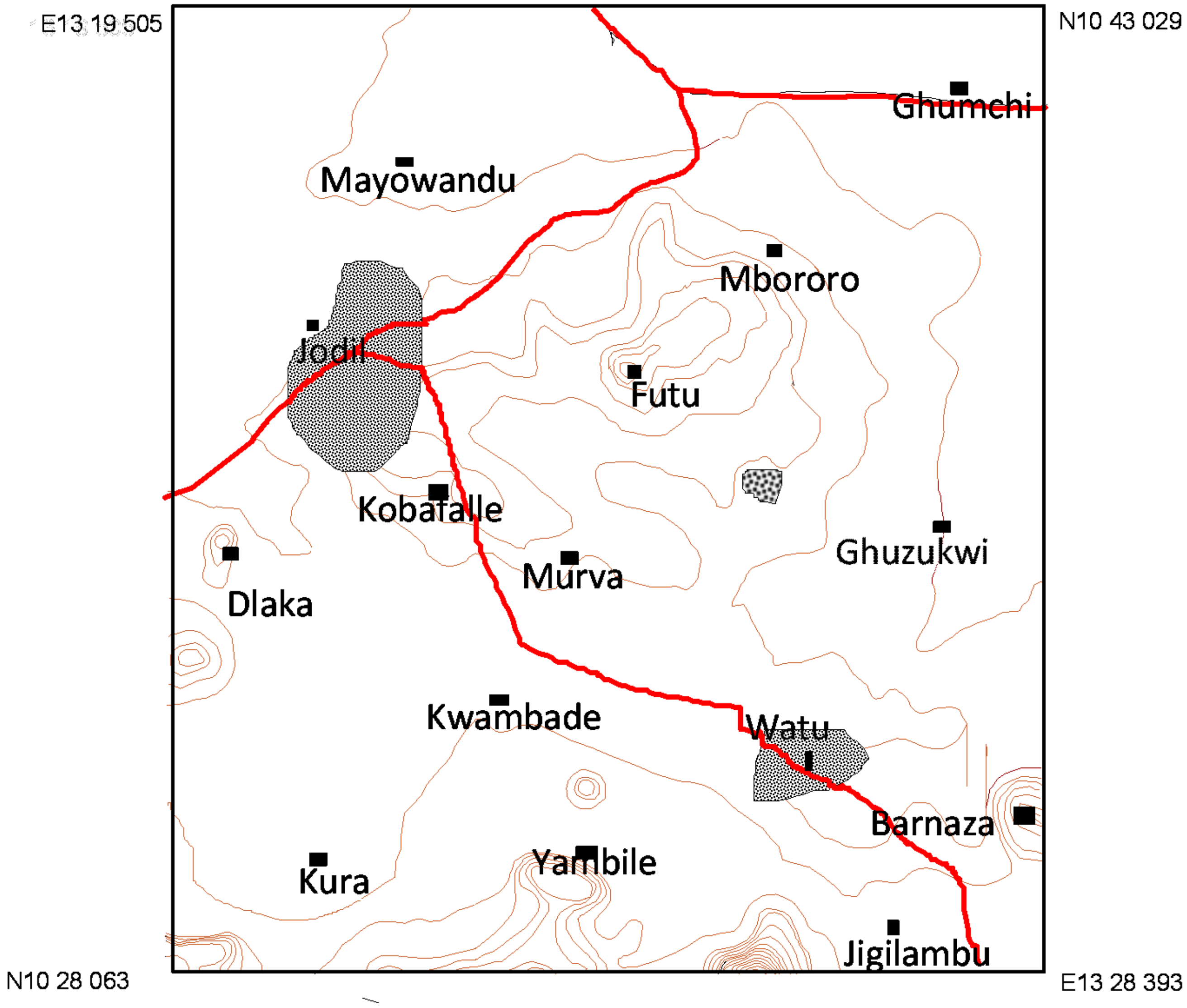

Fig. 1. Topographic Map of the Study Area.

A major tool in the assessment of water resources management scenarios is a model, due to its capability to enable decision makers to compare alternative actions and take management decisions to achieve efficient goals without violating specified constraints. However, the accuracy of any solution produced by a model is directly dependent on the input of the geo-hydrologic data and other boundary conditions that characterize the domain and the problem being solved. The reliability of the solution increases with increasing model discretization, but the detail and amount of the input data requirements also proportionally increases greatly. Water is one of the most indispensable resources and so is life. Water constitutes about 70% of the body weight of almost all living organism. Life is not possible on this planet without water. It exists in three states namely solid, liquid and gas. It acts as a media for both chemical and biochemical reactions and also as internal and external medium for several organisms. About 97.2% of water on earth is salty and only 2.8% is present as fresh water from which about 20% constitutes groundwater. Groundwater is highly valued because of certain properties not possessed by surface water 0 – 25 V. Good, 26 – 50 Good, 51 – 75 Poor and above 75 V. Poor .

II. MATERIALS AND METHODS

Sample Container: For sampling plastic bottles were used. Before sampling, bottles were soaked in HCl and rinsed twice with distilled water. Necks of the bottle were tightly sealed.

Sample Sampling: During the study, sampling was carried out at the fifteen different sites of Michika and surrounding villages. The sampling and analysis work for this study started in the month of January 2012 and extended up to September 2012. The sampling bottle was rinsed 2 to 3 times with the sample to be examined. The complete information was recorded about the source and the condition under which the samples were collected.

Water Analysis: During the present study groundwater sample were collected and analyzed for various physiochemical parameters to ascertain the characteristics of the groundwater of the study area. The water samples temperature, $_{P}$H and EC and TDS were determined at the point of sampling using a portable hand-held DC-powered Hanna HI88129 digital thermometer with a glass sensor. Others are estimated by the Standard Methods for groundwater using Hatch DR2000 direct reading spectrophotometer.

All the samples were examined to determine pH, EC, Potassium, Sodium, Calcium, Magnesium, Total Hardness, Nitrate, Fluoride, Iron and Chloride using standard methods.

TABLE I. GEOPHYSICAL DATA OF THE STUDY AREA

S/ No	Water Well	Coordinates	Elevation	P H	EC(us/cm)	Temp(0C)
1	**Watu**	N10˚36'250" E13˚21'904"	1690	7	146	26.6
2	**Jigilambu**	N10˚28'063" E13˚20'514"	1667	7	139	28.6
3	**Kura**	N10˚36'812" E13˚19'505"	1585	7	228	28.7
4	**Ghuzukwi**	N10˚36'968" E13˚25'494"	1670	5	164	28.5
5	**Ghumchi**	N10˚38'569" E13˚28'393"	1835	7	115	30.3
6	**Murva**	N10˚39'444" E13˚23'920"	1621	6	417	27.9
7	**Jodil**	N10˚38'447" E13˚23'583"	1670	7	312	26.7
8	**MayoWandu**	N10˚43'029" E13˚23'623"	1509	8	143	27.6
		AVERAGE	**1655**	**6**	**208**	**28.1**
	BORE HOLE					
9	**Barkanza**	N10˚34'411" E13˚23'107"	1879	7	213	30.1
10	**Yambile**	N10˚36'112" E13˚20'353"	1655	7	171	28.8
11	**Futu**	N10˚35'964" E13˚27'506"	2088	7	317	31.5
12	**Mbororo**	N10˚38'820" E13˚27'426"	1813	8	150	28.8
13	**Kwambade**	N10˚39'407" E13˚21'075"	1590	7	206	30.1
14	**Kobafalle**	N10˚38'913" E13˚20'202"	1546	7	152	26.6
15	**Dlaka**	N10˚37'311" E13˚24'247"	1763	7	256	29.6
		AVERAGE	**1762**	**6**	**173**	**29.4**

TABLE II. CHEMICAL PARAMETEROF THE STUDY AREA

WATERWELLS

(mg/l)

S/No	**TD S**		**Na**		**K**		**Ca**		**Mg**		**Fe**	**4**	**S0**	**Cl**	**N03**	**HC03**
			11.		4		15.		9.4				3.3			
1	95	8		.8		5		4			0.2	2		114	0.8	97.6
			23.		7		13.				0.1		4.7			
2	117	9		.3		4			9.6	8		4		259	2.7	314.3
			14.		5		12.		6.4		0.0		5.4			
3	101	9		.9		9		7		9		6		104	2.9	96.4
			13.		5		20.				0.0		0.0			
4	92	8		.1		2			7.3	8		7		94	1.5	97.6
			12.		4		24.		13.		0.1					
5	117	5		.7		9		6		4			4.6	118	0	87.3
			27.		5		12.				0.0		12.			
6	162	7		.4		9			7.4	9		1		140	2.6	96.4
			19.		5		13.				0.0		10.			
7	122	1		.4		8			8.1	7		6		126	2	74.3

8	116	21	6.1	90.1	15.6	0.08	0.4	116	1.3	134.2
Average	**115**	**18**	**6**	**25**	**10**	**0.1**	**5.2**	**18**	**2**	**125**
					BOREHOLES					
9	56	15	4.1	10.3	1.6	0.05	0	52	0	73.2
10	72	9.5	2.1	1.16	2.5	0.06	0.17	36	0.09	77.8
11	56	8.5	2.5	11.1	3.4	0.03	0	42	2.9	65.3
12	62	10.6	3.6	6.8	5.7	0.06	0.73	14	0	69.8
13	59	8.3	1.9	5.1	8.4	0.02	0	28	0.68	65.8
14	60	8.6	3.8	6.4	6.1	0.01	0.11	26	0.25	72.3
15	57	8.22	4.5	1.36	5.5	0.04	0	12	2.7	62.4
Average	**60.3**	**9.8**	**3**	**6**	**5**	**0.04**	**0.1**	**4**	**1**	**70**

Water Quality Index (WQI):

Water quality index is defined as a technique of rating water quality that provides the composite influence of individual water quality parameters in overall quality of water (Reza and Singh, 2010). It is an important technique in studying ground water quality (Tiwari and Misra, 1985; Singh, 1992; Rao, 1997; Misra and Patel, 2001). The calculation for the water quality followed the steps provided by Reza and Singh 2010. Where the weightage of 1^{th} parameter is given as

$W_1 = k/s_1$ …………………………………………………………………………… (1)

W_1 = the unit of weightage, s_1, the Recommended Standard for 1^{th} parameter (I = 1-6), k is the constant of proportionality. Individual quality is given by expression

$Q_1 = 100v_1/s_1$ ………………………………………………………………………. (2)

Q_1 is the sub index of 1^{th} parameter
v_1 is the monitored values of the 1^{th} parameter
s_1 is the standard or permissible limit of the i^{th} parameter.

$WQI = \sum_{=i}^{n} (Q_1W_1)/ \sum_{=i}^{n} W_1$ ……………………………………………… (3)

TABLE III. UNIT WEIGHTAGE OF PARAMETERS BASED ON THE WHO 2010 DRINKING WATER STANDARD

Parameters	Highest permitted Value for Water (s1)	Unit weightage (w1)
pH	8.5	0.03182477
EC	500	0.00054102
TDS	500	0.00054102
Ca	75	0.00360681
Mg	50	0.00541021
Fe	0.2	1.35255275
S04	250	0.00108204
Cl	250	0.00108204
N03	50	0.00541021
HC03	120	0.00225425

TABLE IV. : STATUS CATEGORIES OF WQI

WQI	Status
0 – 25	**V. Good**
26 -50	**Good**
51 – 75	**Poor**
>75	**Very Poor**

TABLE V. SUMMARY OF THE WQI FOR THE VARIOUS LOCALITIES

Hand dug wells			**Boreholes**		
S/No	Locality	WQI	S/No	Locality	WQI
1	Watu	99.02	9	Yambile	32.46
2	Jigilambu	78.83	10	Barkanza	36.76
3	Kura	60.36	11	Futu	35.15
4	Ghuzukwi	39.13	12	Mbororo	35.68
5	Ghumchi	66.26	13	Kwambade	35.68
6	Murva	54.89	14	Kobafale	35.68
7	Jodil	53.99	15	Dlaka	29.99
8	MayoWandu	80.92			

III. RESULTS AND DISCUSSION

The result of the Water Quality Index (WQI) has been presented in Table 5. The WQI for the Hand dug wells ranges from 53.99- 99.02. These values show low to very low qualities with exception of Ghuzukwi with the value 39.13. The higher values have been found to be due to higher concentration of Calcium, Iron and Chlorine. These probably indicate effective ionic leaching over local mining, sewage disposal and anthropogenic activities. The WQI for the boreholes are all good with ranges from 29.99 in Dlaka and 36.76 in Barkanza.

The result regarding the mean values of the various physico-chemical parameters of groundwater collected from all the hand dug wells and bore holes are given in the table 1. pH values (Fig 2) shows slightly acidic, the pH levels of the water supply points investigated are within the permissible range 6.5-8.5. All the groundwater samples are characterized by either a weakly acidic as in Ghuzukwi and Murva and slightly basic as in Barkanza and Mayo Wandu. The lowest P^H value is 5.4 in Ghuzukwi and is attributed to the discharge of acidic products in to this source by the agricultural and domestic activities and the highest pH value 7.7 was detected at Mayo Wandu. This is supported by the fact that the studies have shown that 98% all world groundwater are dominated by calcium and biocarbonate ions due to the limestone weathering in the studied area and underground water beds (Meybeck 2002.) Extreme pH values can affect the palatability of water. Most biological reactions are sensitive to variations in pH. For most of such reactions as well as for human beings, pH value of 7.0 is considered best and ideal.

The mobility of ions in solution can be clearly related with the total alkalinity. This is not surprising as the flow of water will be to the concentration of hydroxide ions (alkalinity) in the water. Highest EC values (Fig 4) of 417µs/cm is observed at (Murva) and the least value of 115µs/cm at (Ghumchi) in water wells and 317µs/cm (Futu) and 171µs/cm (Yambile) recorded the highest and least values of EC in the bore holes respectively. These two locations that recorded highest values of EC are situated at densely populated villages. Hence the relatively higher values may be associated to concentrated dissolved salts as a result of human activities, very low EC generally lower than MPL (1000µs/cm) in all the samples which is in turn a function of dissolved (ionizable) solids is recorded. This property is related to the hardness of water because the more dissolve ions (such as Ca^{2+}, Mg^{2+}, So_4^{2-}etc) that are present in a water sample the more will be its conductance and hence its hardness. Conductivity is an invariable indicator of range in to which Alkalinity and hardness values are likely to fall, and also of the order of dissolved solid contents of the water. TDS and conductivity can be used to delineate each other. Conductivity is proportional to dissolved solids they both show analogous trend in all the observations. The average TDS value (Fig 3) in the wells is 115mg/l with the highest value of 162mg/l at Murva and the least value of 92mg/l at Ghuzukwi while bore holes have a average values of 60.3mg/l with the highest value of 72mg/l at Yambile and the least value is 56mg/l at both Barkanza and Futu (Table 1). However the relatively higher values for water wells may be related to their exposure to air and environmental pollutants. It is however known that where TDS are high, the water may be “saline” and applicable parameter is “salinity” (WHO 2010). The potassium average value (Fig 5) is 6mg/l in hand dug well with a maximum value of 7.3mg/l in Jigilambu with a least value of 4.7mg/l in Ghumchi. While an average value of 3mg/l is shown by boreholes in the study area with a highest value of 4.5mg/l in Dlaka and a least value at 1.9mg/l at Kwambade. For the sodium (Fig 6) the average value of 18mg/l was obtained from hand dug well with a maximum value of 27.7mg/l in Murva and 11.7mg/l in Watu. While an average value of 9.8mg/l is shown by boreholes in the study area with the highest value of 15mg/l in Mbororo and a least value at 8.22mg/l at Dlaka. The result of this analysis shows an average value of 25mg/l in hand dug well with a maximum value of 90.1mg/l in Jodilanda and least value of 2.9mg/l in both Kura and Murva. While an average value of 6mg/l is shown by boreholes in the study area with a highest value of 11.1mg/l Futu with a least value of 1.16mg/l at Yambile. Magnesium (Fig 7) with average value of 10mg/l in hand dug well with a maximum value of 15.6mg/l in Mayo Wandu and a least value of 6.47mg/l in both Kura. While an average value of 5mg/l is shown by boreholes in the study area with a highest value of 8.4mg/l Kwambade with a least value of 1.6mg/l at Barkanza. An average value of 0.1mg/l for iron (Fig 8) was obtained in hand dug well with a maximum value of 0.2mg/l in Watu and a least value of 0.07mg/l in Jodil. While an average value of mg/l is shown by boreholes in the study area with a highest value of 0.06mg/l Yambile and Mbororo with a least value of 0.01mg/l at Kobafalle. The carbonate (Fig 9) average value of 125mg/l in hand dug well with a maximum value of 314mg/l in Jigilambu and a least value of 74.3mg/l in Jodil. While an average value of 70mg/l is shown by boreholes in the study area with a highest value of 77.8mg/l Yambile with a least value of 62.4mg/l at Dlaka. Chloride exists in all natural waters, the concentration varying widely and sometimes reaching a maximum in sea water (up to 35,000mg/dm^3). In fresh waters, the source include soils, rock formations, sea spray and waste discharge. Seawage contains large amount of chlorideas do some industrial effluents. Choride does not pose a health hazard to humans and the principal concentration is in relation to palatability. In table 1 and (Fig 11) the concentration of chloride in all the water samples were below the 250mg/l. The source of sulphate in under groundwater may be rocks and other geologic materials. Excess sulphate has a laxative effect especially in combination with Magnesium/or Sodium, Sulphates exists in nearly all natural waters. The concentrations vary according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals (Iron, Nickel, Copper and Lead). Iron Sulphides are present in sedimentary rocks from which they can be oxidized to Sulphate in humid climates, they later be leached in to water course so that groundwater are extremely high in Sulphates (WHO2010). The combination of Magnesium/Sodium with Sulphate will have an enhanced laxative effect of greater or less gravity depending on its concentration. At levels above 250mg/l water will begin to taste salty and will become increasingly objectionable as the concentration rises further, hence the objectionable level is recorded. Higher level may render fresh water unsuitable for agricultural irrigation (WHO 2010). In this work under groundwater sample none is above the maximum permissible (Fig 12) limit except at Jigilambu were the level of chloride ion reaches 259mg/l. Nitrates in soils may be soluble nitrates compounds or from run-off from inorganic fertilizers that may leach in to the wells (WHO 2010). In this research work the values ranges from 0mg/l to 2.9mg/l in hand dug wells with an average value of 1.3mg/l and range of 0 to 2.7mg/l in the boreholes with an average of 1mg/l (Fig 13). The levels of nitrate concentration are of interest for various reasons. Most importantly, high nitrate levels in water (above 50mg/l) for drinking water purposes will render them hazardous to infants as they induce the “Blue Baby” syndrome (Methaemoglobinaemia). The nitrates itself is not a direct toxicant but is a health hazard because of its conversion to nitrite. (WHO 2010)

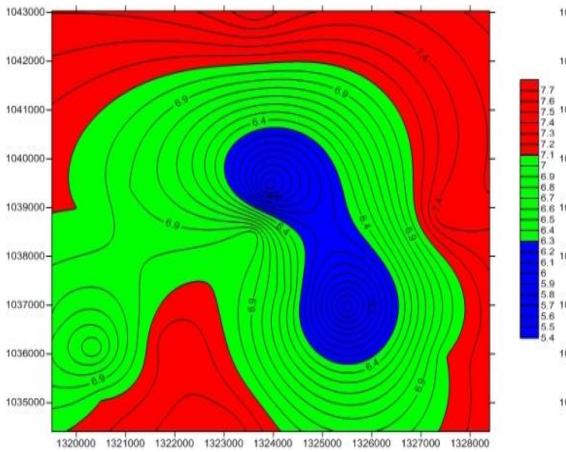

Fig 2: pH Values in the studied area

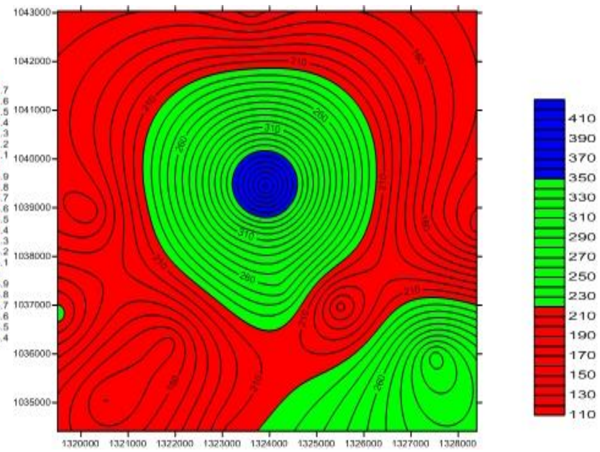

Fig 3: TDS Values in the studied area

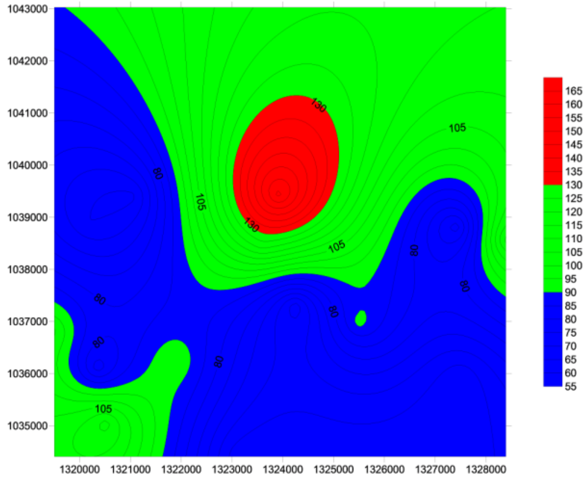

Fig 4: TDS Values in the studied area

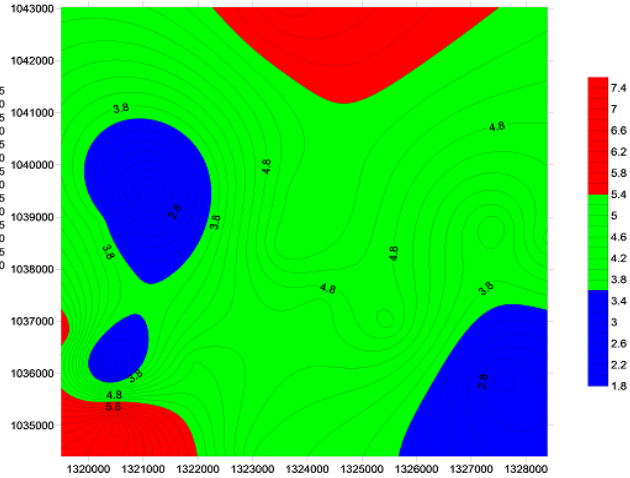

Fig 5: Potassium Values in the studied area

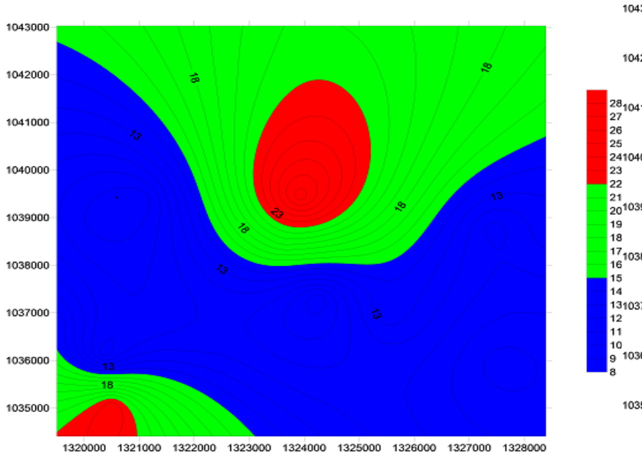

Fig 6: Sodium Values in the studied area

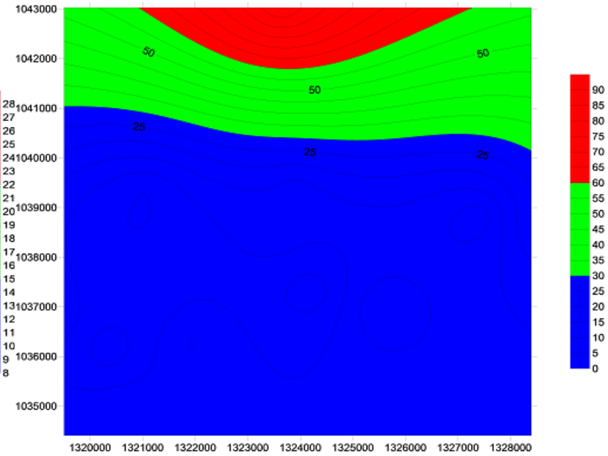

Fig 7: Calcium Values in the studied area

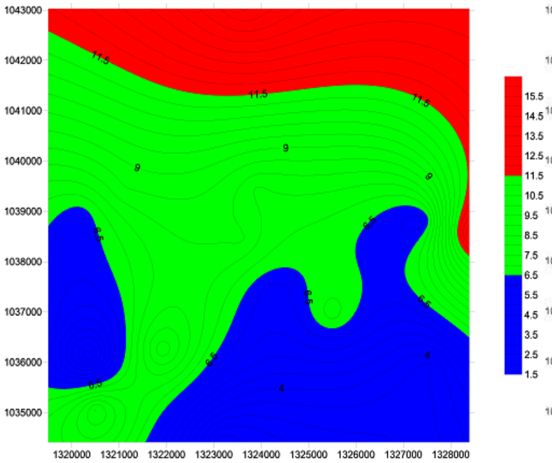

Fig 8: Magnessium Values in the studied area

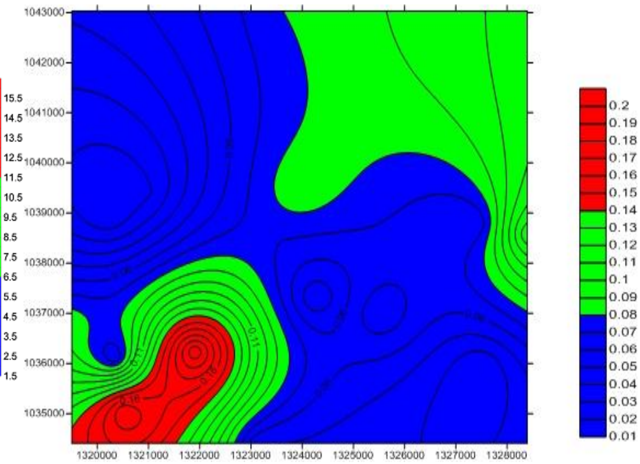

Fig 9: Iron Values in the studied area

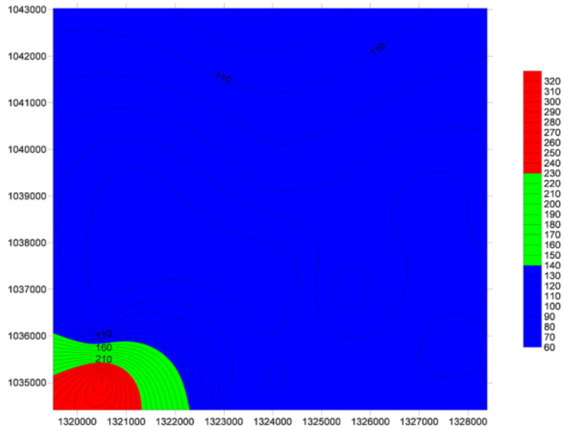

Fig 10: Carbonate Values in the studied area

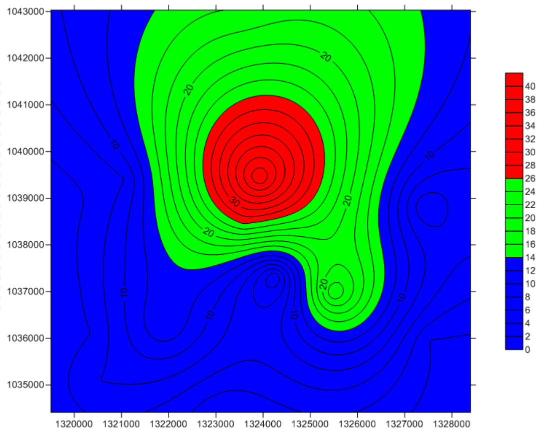

Fig 11: Chlorine Values in the studied area

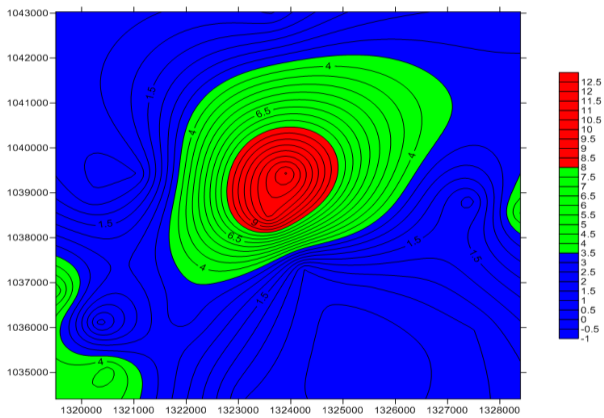

Fig 12: Sulphate Values in the studied area

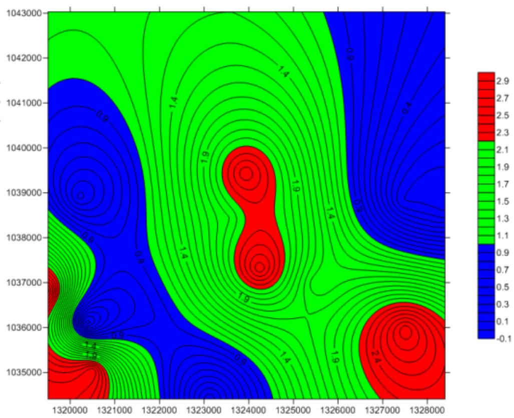

Fig 13: Nitrate Values in the studied area

IV. CONCLUSION

The values of WQI have attached by concentration of dissolved Ca+, Fe++, and Cl- in the water samples. But all the value range for borehole sources indicates a good status with WQI range of 22.99 – 26.76. The value ranges from 54.89 – 99.02 in the hand dug wells which indicate poor to very poor quality except Ghuzukwi. The quality of water sampled from well were not suitable for human consumption without proper treatment. Proper treatment of water's from hand dug wells must be treated before human consumption. It is recommended that the hand dug wells should be sited a distance away from the pit latrines to avoid infiltration and chlorine should also be treated where applicable. The utility of water at a simple acceptable low cost intervention at the point-of-use (house hold) level that are capable of improving the quality of water is also recommended.

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