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Research Article

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An Assessment of the Suitability of the Groundwater of Michael Okpara University of Agriculture, Umudike for Agricultural Purposes

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Abstract The study is focused on the groundwater of Michael Okpara University of Agriculture, Umudike in order to determine the suitability for agricultural purposes. Groundwater samples were collected from eleven strategic boreholes within the University campus during dry season, and were analyzed for physico-chemical parameters such as pH, EC, TDS, sodium, potassium, calcium, magnesium, chloride, sulphate, and nitrate. The calculated values of Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) indicate that the groundwater samples if used for Agricultural (irrigation) purposes are excellent in quality. A plot of the US Salinity diagram suggests that the the groundwater samples are good for irrigation.

Keywords Physico-Chemical Parameters, Groundwater, Sodium Adsorption Ratio, Irrigation, US Salinity Diagram

Introduction

Michael Okpara University of Agriculture, Umudike (MOUAU) is situated in Ikwuano area of Abia State, Nigeria. Also located in Umudike is the National Root Crop Research Institute.

Umudike area and its environs play hosts to major academic / research institutions in Abia State including the prestigious Government College Umuahia, the Umuahia campus of Abia State University, and the study centre of the National Open University of Nigeria.

The proximity of these institutions to one another including the Umuahia Industrial Market has added to an increase in the population of the area.

Rapidly increasing population, rising standards of living and exponential growth in industrialization and urbanization tends to add pressure on natural resources.

All sustainable resources are under pressure, the land is fixed but there is continual increase in infrastructure.

This reduction in available land due to increasing infrastructure will in the long run affect the agricultural productivity of the area. Empty plots of land being used for agricultural activities are fast disappearing, so there is need to optimally use the available ones for sustainable agricultural practices.

A solution to this is the commencement of all seasonal cropping [1]; to achieve this, groundwater could still be relied on to augment for surface water supply especially during the dry season.

Since the study area has huge groundwater potential [2]; It is therefore essential to assess the quality of the groundwater of MOUAU and the environs for sustainable agricultural practices.

Location / Geology and Physiography of the Study Area

There are about 11 different geologic Formations in Abia State of Nigeria but the Benin Formation of the Cenozoic Niger Delta covers almost half of the entire state.

Geologically, the study area Michael Okpara University of Agriculture, Umudike (MOUAU) is situated in the Benin Formation of the Cenozoic Niger-Delta basin of Nigeria (Fig. 1). The area is part of the oldest surface outcrop of the Cenozoic eastern Niger-Delta basin because it is situated immediately after the Bende-Ameki Formation of the Anambra basin.

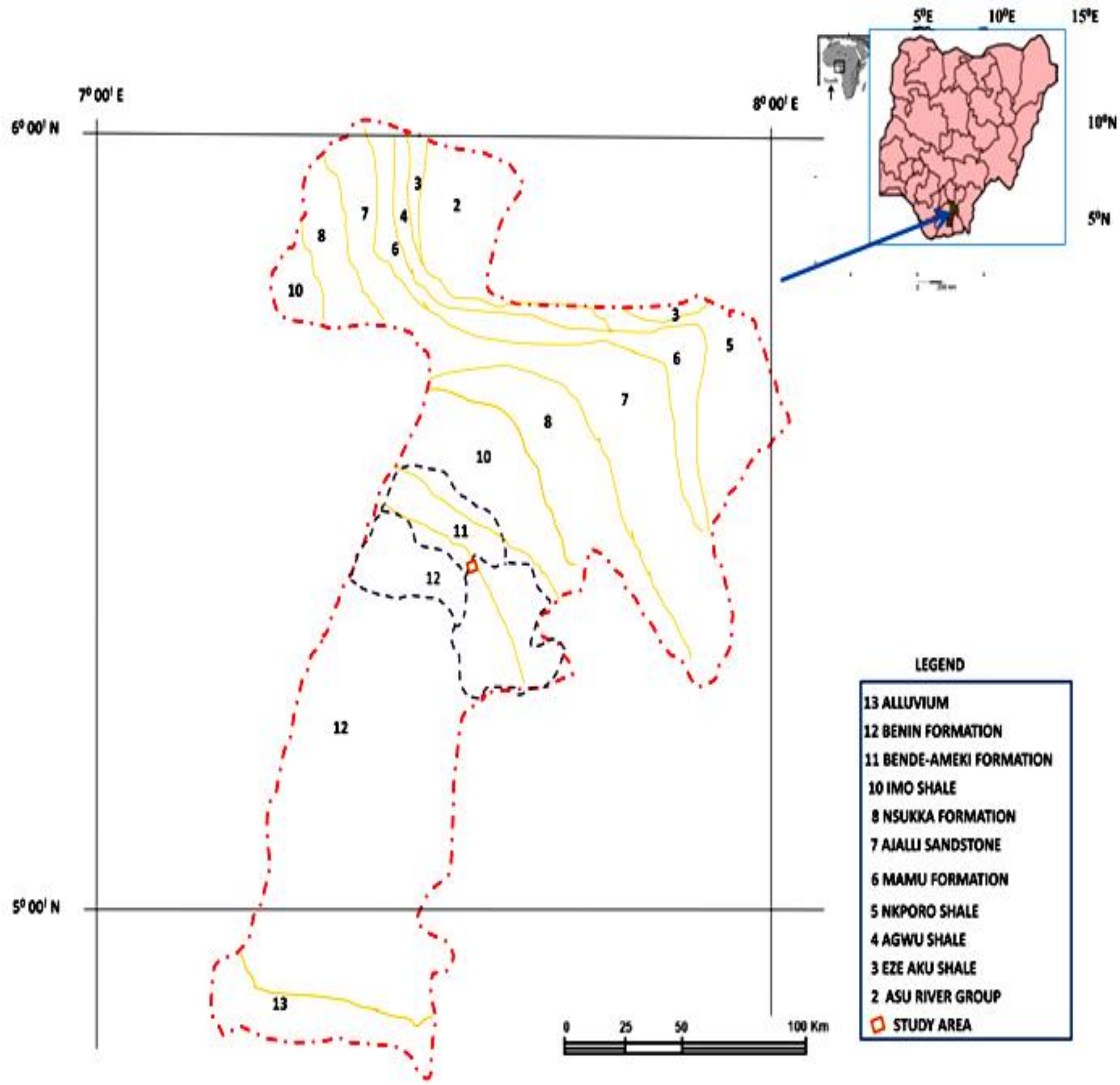

Figure 1: Geologic map of Abia State showing the Ikwuano-Umuahia Areas and the study area (Modified after Geological Survey of Nigeria (GSN), 1985).

The study area (Michael Okpara University of Agriculture, Umudike) lies within latitudes 5^0 28' and 5^0 29' N and longitudes 7^0 32' and 7^0 33'E (Fig 2). It is part of the sub-equatorial belt with its' wet season from Mid-April to October and dry season from November to Mid-April, and has double maxima rainfall peaks in July and September. The area is characterized by high temperatures of about 29^0 – 31^0C and high relative humidity values of over 70%.

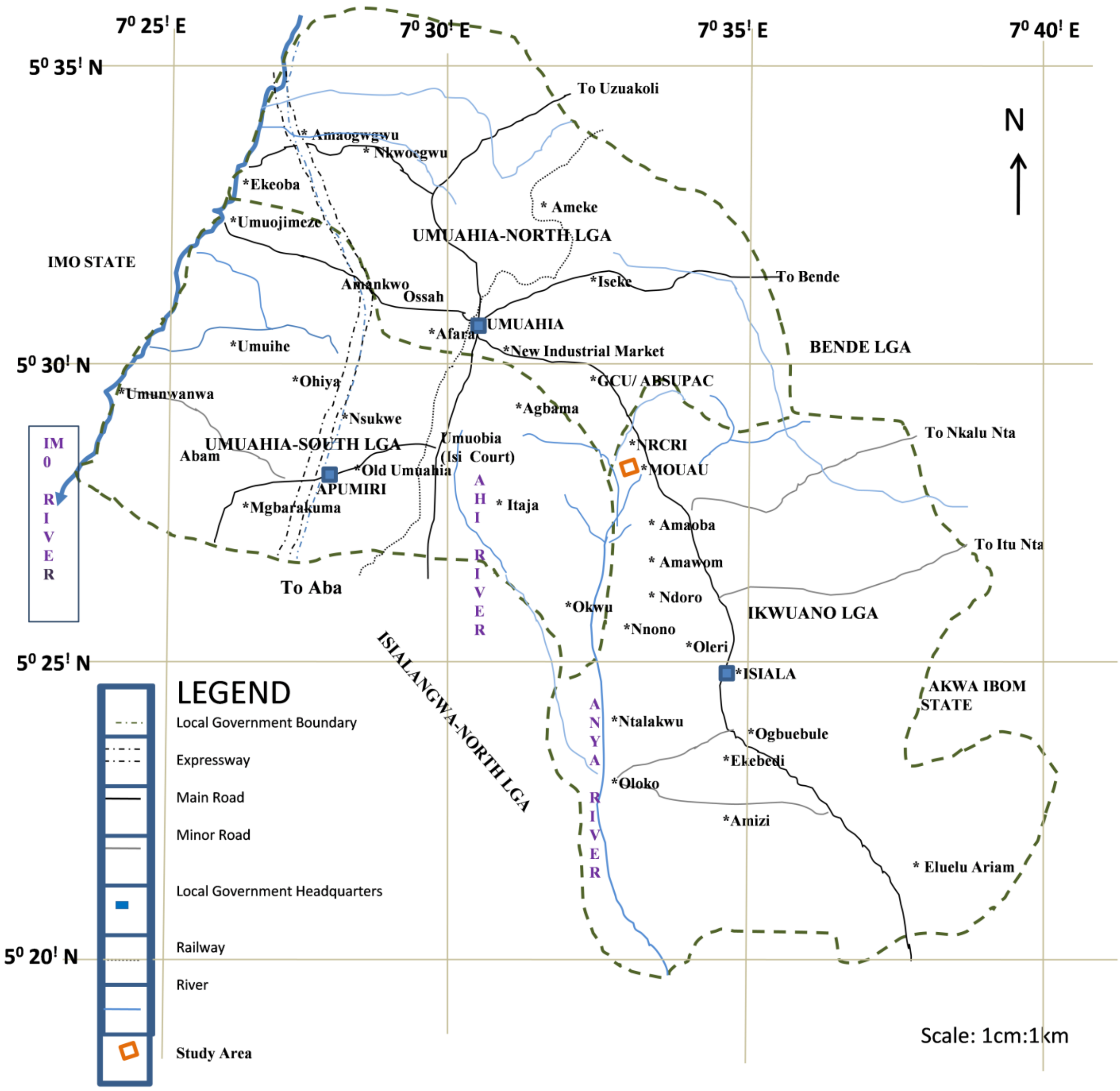

Figure 2: Physiographic map of Ikwuano-Umuahia area showing the study area

The Aim or Objective of the Study

The objective of the present work is to analyze the major ion constituents of the groundwater of Michael Okpara University of Agriculture, Umudike and classify the water in order to appraise its suitability for agricultural purposes.

Materials and Methods

In order not to lose the sight of the objective of this study which is to determine the suitability of the groundwater for agricultural purposes, the dry season which is when the groundwater will be mostly needed for agricultural purposes was chosen for the study.

Collection and analysis of water samples were done during the cold Harmattan period on eleven strategic boreholes spread across the university in the month of January which is the middle of the dry season in Nigeria.

Pre-washed and clean 500 ml screw cap plastic containers were used to collect water samples from the selected boreholes after pumping the wells for about five minutes to ensure stable laminar flow conditions.

A global positioning system (GPS), Garmin 72 model was used in recording the elevation of the sampling points (Table 1). Due to the sensitivity of groundwater to environmental changes, the following parameters were determined *in situ;* temperature, colour, pH and electrical conductivity. Thereafter, the samples were immediately taken to the laboratory for analysis.

Table 1: Groundwater (borehole) sample locations

S/No	Location	Elevation
GW 2	Chapel/ Bishop's house	123.7
GW 3	Engineering complex	91.2
GW 4	Demonstration School	131.6
GW 5	Male hostel	122.8
GW 6	Administrative block	125.4
GW 7	V.C's lodge	136.6
GW 8	Zenith bank (NRCRI)	125.6
GW 9	Opposite University gate (Gate 6)	127.4
GW 10	MPP6	166.4
GW 11	COLPAS	103.3

Results and Discussions

Physico-chemical Parameters

There is no more concern on the availability, productivity and quantity of groundwater in Michael Okpara University of Agriculture, Umudike as it used to be with the inception of the university [2-4]. Emphasis should now shift to the understanding of the groundwater quality because it is the main factor determining its suitability for intended use [5].

Table-2 below illustrates the various physico-chemical parameters of the groundwater samples from the selected boreholes within the university and its environs. The temperature ranged from 26.2°C to 26.9°C during the study period. Lowest water temperature was observed in GW 3, 6 and 10.

The pH values of the groundwater samples ranged from 4.67 to 6.92 with an average value of 5.65. This shows that the groundwater of the study area is slightly acidic in nature and all the samples did not meet the permissible limit prescribed by WHO (2004) except GW 3, GW 5 and GW 7. Acidic water corrodes pipe and plumbing materials of iron and steel thus clogging the distribution pipes which may stain clothes and rust cooking utensils, and also cause objectionable taste of drinks and food. Exposure to extreme pH values results in irritation to the eyes, skin, and mucous membranes. In sensitive individuals, gastrointestinal irritation may also occur.

The Total Dissolved Solids (TDS) value ranged from 69.0 to 96.0 with a mean of 81.8. TDS indicate the salinity behaviour of groundwater and since all the samples are below 100mg/l, thus indicating that the groundwater of the area is recharged mainly through rainfall. Water containing more than 500 mg/l of TDS is not considered desirable for drinking, and all samples fall within the standard permissible limit.

Electrical conductivity (EC) is a measure of the ability of water to conduct electricity. It signifies the amount of total dissolved salts in the water. The value of EC varied from 61.3 µs/cm to 307.6 µs/cm with an average value of 156.25µs/cm.

All samples are within the WHO permissible EC standard for drinking water though GW 11 recorded a relatively high value as against other samples.

The World Health Organization (WHO) International Standard for Drinking Water [6] classified water with a total hardness of $CaCO_3$ < 50mg/l as soft water, 50 to 150 mg/l as moderately hard water and above 150 mg/l as hard. Based on this classification, all the water samples are soft water except GW 6 which is moderately hard. Total Hardness (TH) values range from 11.30 mg/l to 52.65 mg/l.

Hardness of water mainly depends on the amount of calcium or magnesium salts and this property of water prevents the formation of lather with soap and increases the boiling points. GW 6 which has the highest value of Calcium, Magnesium and Chloride has also the highest value of hardness.

The dominant cation in the groundwater samples of the study area is the following order: Calcium> Sodium > Magnesium > Potassium > Iron; except in GW 9 where Sodium dominated Calcium. While the average concentration of major anions in the groundwater samples is as follows: - Sulphate > Bicarbonate> Nitrate > Chloride.

Table 2: Physico-Chemical Parameters of Groundwater samples in the study area

S/No	Temp °C)	Conductivity (µs/cm)	pH	Turbidity (NTU)	TDS	TSS	Fe^{2+}	Ca^{2+}	Mg^{2+}	Na^{2+}	K+	NO_3^-	Cl-	HCO_3^-	$SO_4$2-	PO_4^{3-}	Cu	Mn	Cr	Pb	Zn	Total Hardness
GW 1	26.7	79.0	4.67	90.4	71.0	3.50	0.22	2.47	1.25	2.25	0.62	1.44	0.10	3.80	2.30	ND	ND	ND	ND	0.002	0.005	11.30
GW 2	26.6	61.3	5.05	83.9	69.0	2.00	0.06	3.20	1.22	3.40	2.30	1.82	0.05	5.30	3.80	ND	ND	ND	ND	0.002	0.005	13.00
GW 3	26.2	93.3	6.88	85.2	78.0	2.50	0.16	3.20	1.12	2.21	1.45	0.74	0.20	8.80	6.42	NS	ND	ND	NS	0.002	0.005	12.60
GW 4	26.7	144.4	6.23	83.4	95.0	3.50	0.11	2.57	1.25	1.39	1.52	0.52	0.05	5.80	4.24	NS	ND	ND	ND	0.002	0.005	11.55
GW 5	26.5	155.6	6.77	85.4	81.0	2.00	0.15	4.06	1.16	1.36	0.95	0.44	0.50	2.39	1.80	ND	ND	ND	ND	0.002	0.005	14.86
GW 6	26.2	160.0	5.23	86.6	86.0	3.00	2.33	15.27	3.53	4.20	3.92	2.54	2.14	10.71	8.18	ND	ND	ND	ND	0.002	0.005	52.65
GW 7	26.5	215.1	6.92	83.9	86.0	1.00	0.01	2.68	1.64	2.70	0.45	0.32	0.05	6.35	5.06	ND	ND	ND	ND	0.002	0.005	13.42
GW 8	26.7	199.3	4.94	85.2	83.0	7.00	0.13	4.27	2.24	2.28	0.52	1.26	0.50	4.22	3.24	ND	ND	ND	ND	0.002	0.005	19.86
GW 9	26.9	171.5	4.94	85.6	79.0	4.00	0.12	2.17	1.48	2.26	0.22	1.16	0.05	5.18	4.08	ND	ND	ND	ND	0.002	0.005	11.49
GW 10	26.2	131.6	5.02	88.8	76.0	5.00	0.11	2.29	1.53	1.22	0.24	1.04	0.50	2.06	2.06	ND	ND	ND	ND	0.002	0.005	12.00
GW 11	26.4	307.6	5.45	83.4	96.0	12.00	0.12	2.99	1.31	1.98	0.79	0.83	0.22	5.20	4.68	ND	ND	ND	ND	0.002	0.005	12.85
WHO LIMITS	25	500	6.5-8.5	500	50-750	10-25	0.3	500	50	5	75	45	50		NS		0.05	0 .05	0.25	0.05	5.0	125
Methodology	Thermometer	Conductometry	pH meter/Buffer	Turbidometry	Gravimetry		Atomic Adsorption Spectrometry (AAS)						Argentometry		Turbidometry	Colourimetry		(AAS)	(AAS)	(AAS)	(AAS)	

*ND = Not Detected, NS = Not Stated, NTU = Nephelometric Turbidity Unit.

*All units of measurement are in "mg/l" except otherwise stated in the table.

Agricultural (Irrigation) Water Quality

Electrical Conductivity (EC)

EC is a good measure of salinity hazard to crops. Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil [7]. All the groundwater samples are of low-salinity characteristics; they are therefore suitable for irrigation purposes with minimal likelihood that soil salinity will develop except GW 11 which is of medium-salinity water and can be used for irrigation if a moderate amount of drainage occurs (Table 3).

Table 3: Quality of irrigation water based on Electrical Conductivity

Salinity hazard class	Specific Conductance (µS/cm)	Characteristics	Samples
Low	0-250	Low-salinity water can be used for irrigation on most soil with minimal likelihood that soil salinity will develop.	GW 1, GW 2, GW 3, GW 4, GW 5, GW 6, GW 7, GW 8, GW 9, GW 10
Medium	251-750	Medium-salinity water can be used for irrigation if a moderate amount of drainage occurs.	GW 11
High	751-2,250	High-salinity water is not suitable for use on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required.	Nil
Very high	More than 2,250	Very high-salinity water is not suitable for irrigation under normal conditions.	Nil

Sodium Absorption Ratio (SAR)

SAR is also an important parameter for determining the suitability of groundwater for irrigation because it is a measure of sodium hazard to crops. SAR can be estimated by the formula [8]:

$SAR = [Na^{+}] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$

Where, all ionic concentrations are expressed in meq/l.

SAR values ranges from 0.22 to 0.82 with an average value of 0.47. All the sampling stations fall in the excellent category because none of the samples exceeded the value of SAR = 10 (Table 4).

Table 4: SAR values can then be compared to characteristics of the four sodium-hazard classes as follows

SAR	Water-suitability for irrigation
0-10	Suitable for all types of soils except for those crops which are highly sensitive to Sodium
10-18	Suitable for coarse-textured or organic soil with good permeability. Relatively unsuitable in fine-textured soil.
18-26	Harmful for almost all types of soils. Requires good drainage, high leaching and gypsum addition.
>26	Unsuitable for irrigation

A further classification system to evaluate the suitability of water for agricultural purpose (irrigation) is graphically plotted using the values of EC and SAR on the US salinity diagram [9]. The analytical data plotted on the US Salinity diagram illustrates that the groundwater samples of GW4, GW5, GW6, GW7, GW8, GW9, and GW10 fall in the field of S1C1, thus indicating low (sodium) alkalinity hazard and low salinity hazard; while GW11 falls in the field of S1C2 indicating low alkalinity hazard and medium salinity hazard (Fig. 3). On the other hand, groundwater samples of GW1, GW2 and GW3 could not be plotted on the diagram because of their very low conductivity (< 100µS/cm^{-1}). The results therefore indicate that all the water samples can be used for irrigation on almost all types of soil with little danger of exchangeable sodium.

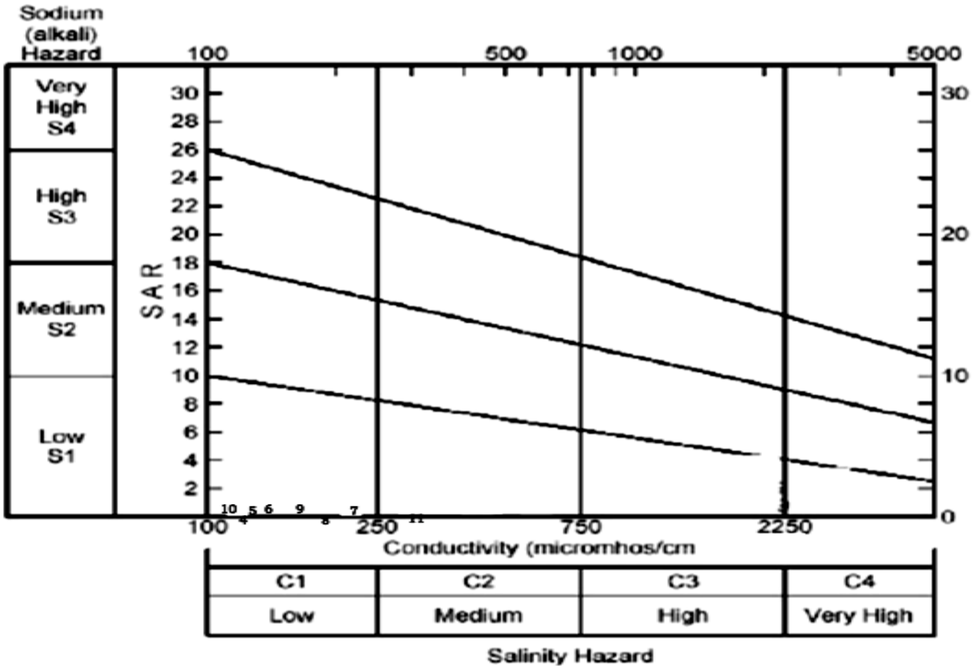

Figure 3: Classification of irrigation waters using U.S. Salinity diagram

Sodium Percentage % Na

The sodium in irrigation water is usually expressed in % Na. % Na can be determined by using the formula [10]. Na % =(Na^{+} + K^{+})100 divided by (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}) where all the ionic concentrations are expressed in meq/L. The value of % Na varies from 47.31 to 76.10 (Table 7). The quality of the groundwater samples of GW5, GW 6, GW 8 and GW 10 fall within the permissible limit for irrigation; while GW 1, GW 2, GW 3, GW 4, GW 7, GW 9 and GW 11 are considered doubtful for irrigation purposes.

Table 5: Quality of groundwater based on % Sodium

% Na	Quality of water	Samples
<20%	Excellent	Nil
20-40%	Good	Nil
40-60%	Permissible	GW 5, 6, 8 and 10
60-80%	Doubtful	GW 1, 2, 3, 4, 7, 9 and 11
>80%	Unsuitable	Nil

RSC

Residual Sodium Carbonate (RSC) has been calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose [12] and has been determined by the formula.

RSC = $[HCO_3^{2-} + CO_3^{-}] - [Ca^{2+} + Mg^{2+}]$

Where all the ionic concentrations were reported in meq/l. The classification of irrigation water according to the RSC values is presented in Table 6. According to the US Department of Agriculture, water having more than 2.5 epm of RSC is not suitable for irrigation purposes while those having 1.25-2.5 epm are marginally suitable and those with less than 1.25 epm are safe for irrigation (Table 6). The results show that all the samples are good for irrigation.

Table 6: Quality of groundwater based on Residual Sodium Carbonate

RSC	Remark the quality	Samples
< 1.25	Good	All
1.25-2.5	Doubtful	Nil
>2.5	Unsuitable	Nil

Table 7: The Value of SAR, Na % and RSC

Samples	SAR	%Na	RSC
GW1	0.58	66.67	-0.01
GW2	0.82	76.10	0
GW3	0.54	67.86	0.045
GW4	0.35	63.06	0.014
GW5	0.30	52.53	-0.065
GW6	0.36	51.73	-0.221
GW7	0.64	65.48	0.01
GW8	0.22	47.31	-0.047
GW9	0.58	64.20	0.005
GW10	0.30	49.20	-0.053
GW11	0.48	62.35	0.008

Conclusion

From the observation, it may be concluded that out of the eleven sampling stations considered, GW 5, 6, 8 and 10 are suitable for irrigation purposes according to EC, SAR, %Na and RSC values except GW 1, 2, 3, 4, 7, 9 and 11 with doubtful but not unsuitable %Na. The potable nature of the groundwater samples of the study area are not in doubt since none exceeded the WHO permissible limit; thus could be used for the domestication of animals.

Thus, it is recommended that the borehole locations of groundwater samples GW 5, 6, 8 and 10 be used for irrigation purposes; while all can be used for the domestication of animals.

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