



Evaluation of water resources of some satellite towns in the central part of Anambra State, SE, Nigeria

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Abstract

Water, an integral part of human life should regularly be assessed to ensure the desired quantity and quality. No aspect of the living organism and industrialisation can be sustained without water. The satellite towns of Ebenebe, Ugbene, Urum, Isuaniocha and Mgbakwu are located very close to Awka the capital of Anambra State, SE, Nigeria. This study is geared toward assessing the suitability of the water sources in these towns for domestic, agricultural and industrial uses. Fifteen water samples were collected from both surface water and groundwater sources. The samples were subjected to chemical and microbial analyses. The result of chemical analysis indicates that the water sources are slightly acidic. The major ions are within the WHO desirable limit. There is, however, enrichment of heavy metals such as mercury, chromium, cadmium, and iron. These heavy metals have serious negative health implications. The biological analysis result indicates the presence of the coliform group of bacteria and the presence of fecal coliform. These denote the presence of biological pollution. The WQI values depict water that ranged from unsuitable to excellent. Also, the Heavy Metal Pollution Index indicates water that range from very poor to very good. The results obtained show that some of the water sources are polluted. Also, the %Na status is from good to excellent and SAR suggests water that is excellent for agriculture. Calcium and sulphate are the dominant ions. The major water types are $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl}^{-}\text{-SO}_4^{2-}$ and $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^{-}$ suggesting water that has undergone mixing. In 93.3% of the samples, the alkaline earths exceed the alkalis while strong acids exceed weak acids in 73.3% of the samples. The chloro-alkaline indices were positive indicating reverse ion exchange. Hence, the dominant hydrochemical process is reverse ion exchange.

Keywords Surface water · Groundwater · Water quality · Pollution · Nigeria

Introduction

One of the problems facing new settlements is inadequate water supply to sustain both life and industrial developments in such areas. Anambra State, SE Nigeria has no presence of municipal public water system. Hence, domestic and industrial water supply depends on private boreholes and surface water. The study area was until recently rural and majorly surviving on agriculture and with the absence of industries. The congestion in Awka the capital of Anambra State resulted in a shift and expansion of the urban area into the satellite areas. Expansion usually results in migration which in turn leads to population growth, commercialisation,

industrialization and other infrastructural developments. All these affect the quantity and quality of water required for sustenance. In view of all these, there is need for evaluation of both surface water and groundwater sources in the study area, to assess the extent of degradation in quality, and its applicability for different uses, using Piper (1944), Durov (1948), Schoeller (1965) diagrams, Chloro-alkaline indices (Schoeller 1967), Water Quality Index (WQI) (Reza and Singh 2010), Heavy Metal Pollution Index (HMPI) Sodium Absorption Ratio (SAR) (Todd 1980) and Percentage Sodium (%Na) (Wilcox 1955) methods which is the focus of the present research.

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Location of the study area

The study area comprises towns such as Isu-Aniocha, Ebenebe, Urum, Ugbene, Mgbakwu, Enugu-Agidi and Okpuno. It is located within latitudes 6°14' and 6°24'N, and longitudes 7°0' and 7°8'E (Fig. 1). It is situated in the central part of Anambra State, very close to the state capital and can be regarded as the satellite towns. The major river that drains the area is River Mamu with its tributaries

and the local variations in the names they bear. The river passes through the industrial area of Awka before making its way through the study area.

Materials and methods

The study was achieved through fieldwork which involved the collection of a total of 15 water samples; comprising surface water (7) and groundwater (8) (Fig. 2). The samples

Fig. 1 Location map of the study area

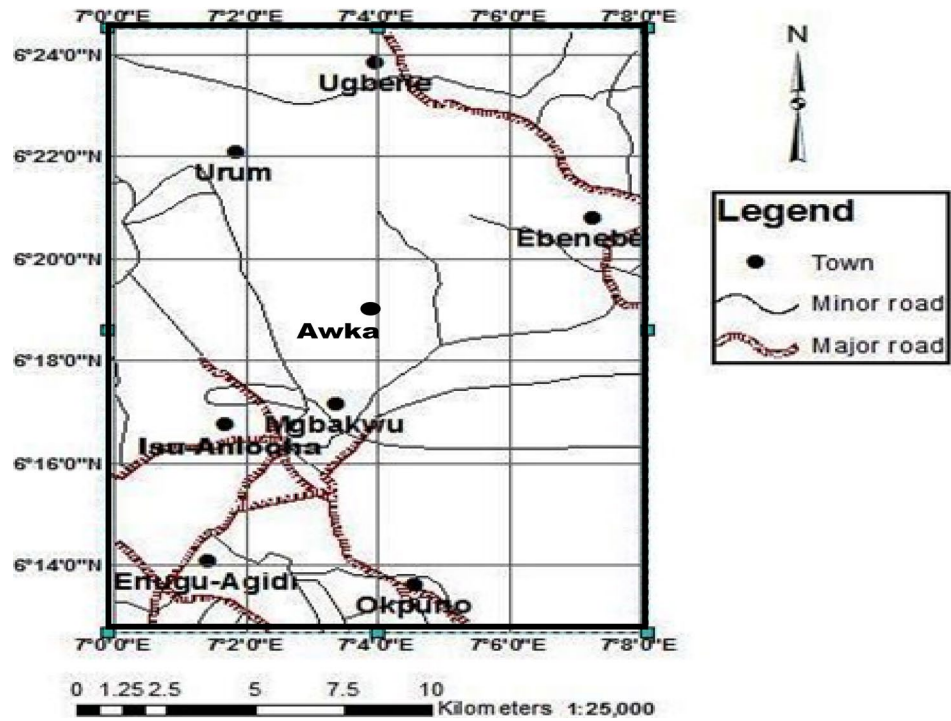
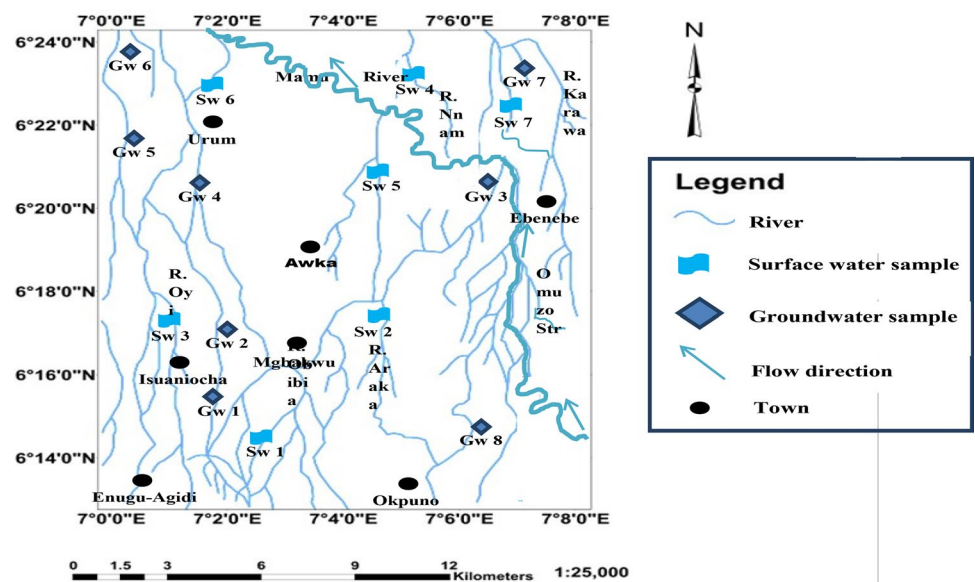


Fig. 2 Sample location map



were collected with a two litre polyethylene can which were thoroughly washed and at the sample collection points were rinsed with the samples to be collected before collecting. The groundwater samples were collected from the boreholes after allowing the water to flow for some time to enable the collection of representative sample and not water that has been standing in the pipe over a period of time. The samples for cation analysis were filtered using 0.45 µm Millipore filters to prevent adsorption of metals to colloidal materials present in the water. The samples collected were preserved using the APHA, 2005 method and taken to the laboratory and refrigerated until analysis.

The pH, electrical conductivity, and turbidity were measured in the field using Hannah pH meter and turbidity/EC meter to obtain results that have not been very much influenced by atmospheric changes. The cations were analysed with AAS and UV spectrophotometer (HACH DR) was used for the analysis of bicarbonate, chloride, nitrate and sulphate. Titrimetric methods were used to analyse total dissolved solids and total hardness, using procedures outlaid by the manual for examination of water quality (APHA, 2005).

Results

Hydrogeology

The aquiferous material in the study area is composed of medium-coarse grained sandstone. The sandstone occurs at variable depths (110–230 m). The sandstone is overlain by very thick shale (50–185 m). The aquifer has a thickness of about 30–50 m. The thickness of the shale has resulted in very high confining pressure in the aquifers, thus the aquifers exist mostly in artesian to flowing artesian condition. This has an added advantage of reducing the cost of bringing the water to the surface.

Water quality

The pH of the water samples range from 5.33 to 6.19 indicating slightly acidic water and none of the samples met the WHO guideline value for drinking water (Table 1). The concentration of iron ranges from 0 to 1.53 mg/L with the maximum value of 1.53 mg/L and average value of 0.44 mg/L. However, the individual concentration of the iron in water samples show that 47% of the samples have values exceeding the guideline values for drinking water. The concentration of iron in water sample may be indicative of water occurring in a reducing environment. The combination of iron and acidic pH is a favourable condition for corrosion and encrustation in the plumbing system. The major cations and anions, electrical conductivity and TDS are within

Table 1. Result of hydrochemical analysis of water samples from the study area

| Sam- ples | Cd ²⁺ mg/L | Hg ²⁺ mg/L | Cr ³⁺ mg/L | Fe mg/L | Mg ²⁺ mg/L | Na ⁺ mg/L | K ⁺ mg/L | Ca ²⁺ mg/L | As ³⁺ mg/L | pH | BOD mg/L | Cl ⁻ mg/L | Hard- ness mg/L | NO ₃ ⁻ mg/L | SO ₄ ²⁻ mg/L | HCO ₃ ⁻ mg/L | DO mg/L | Tur- bidity NTU | EC usm/ cm | TDS mg/L | TotalColi 100 ml/L | FecalColi 100 ml/L |
|--------------|--------------------------|--------------------------|--------------------------|------------|--------------------------|-------------------------|------------------------|--------------------------|--------------------------|------|-------------|-------------------------|-----------------------|--------------------------------------|---------------------------------------|---------------------------------------|------------|-----------------------|------------------|-------------|-----------------------|-----------------------|
| 1 | 0 | 0.13 | 0.15 | 0.85 | 5.85 | 5.37 | 4.11 | 5.47 | 0.01 | 6.22 | 322 | 2 | 36 | 5.37 | 6.39 | 30 | 27.2 | 22 | 30.7 | 16 | 15 | 0 |
| 2 | 1.75 | 0.67 | 0.29 | 0.13 | 6.64 | 8.98 | 5.11 | 3.83 | 0.03 | 6.02 | 443 | 8 | 20 | 5.42 | 9.59 | 18 | 33.6 | 30.5 | 36 | 22 | 8 | 0 |
| 3 | 0 | 0 | 0 | 0 | 10.94 | 5.37 | 8.24 | 5.47 | 0.01 | 6.19 | 256 | 4 | 18 | 7.04 | 5.7 | 28 | 26.8 | 76.2 | 38.4 | 21 | 8 | 0 |
| 4 | 0.68 | 0.11 | 0.06 | 1.53 | 6.64 | 7.31 | 3.06 | 2.94 | 0 | 5.98 | 244 | 2 | 24 | 6.07 | 12.6 | 18 | 42.6 | 43.9 | 24.7 | 11 | 20 | 5 |
| 5 | 0 | 0.21 | 0 | 0.13 | 12.39 | 9.26 | 11.71 | 7.98 | 0.01 | 5.33 | 465 | 91 | 50 | 5.79 | 6.81 | 30 | 24.4 | 37.6 | 95 | 116 | 12 | 0 |
| 6 | 0 | 0 | 0.16 | 0.76 | 2.98 | 0.78 | 1.84 | 3.17 | 0.03 | 5.91 | 314 | 59 | 22 | 8.51 | 95.43 | 25 | 29.7 | 43.6 | 57.8 | 80.28 | 16 | 0 |
| 7 | 0 | 1 | 0 | 0.63 | 2.78 | 0.83 | 2.01 | 6.46 | 0 | 6.17 | 262 | 49 | 48 | 8.09 | 91.4 | 20 | 28.6 | 40.6 | 27.5 | 30.18 | 52 | 24 |
| 8 | 0.03 | 0 | 0.09 | 0.96 | 1.92 | 0.95 | 2.25 | 8.53 | 0.01 | 6.03 | 294 | 47 | 58 | 6.64 | 93.49 | 35 | 30.3 | 97.9 | 44.5 | 30.12 | 22 | 0 |
| 9 | 0.03 | 0 | 0.07 | 0.01 | 2.16 | 0.52 | 2.89 | 8.83 | 0 | 5.41 | 440 | 40 | 28 | 2.48 | 132.4 | 5 | 36.7 | 83.2 | 11.7 | 10.54 | 4 | 0 |
| 10 | 0 | 0 | 0.05 | 0 | 2.45 | 0.53 | 3.29 | 6.64 | 0.02 | 5.8 | 454 | 50 | 28 | 6.97 | 97.36 | 20 | 46.1 | 80.3 | 56.9 | 40.28 | 6 | 8 |
| 11 | 0 | 0 | 0.06 | 0.29 | 6.11 | 1.18 | 3.98 | 7.48 | 0 | 5.62 | 510 | 39 | 54 | 5.57 | 97.95 | 25 | 47.4 | 33.3 | 8.2 | 10.2 | 12 | 0 |
| 12 | 0 | 0.23 | 0.07 | 0 | 3.57 | 0.99 | 2.98 | 5.38 | 0.08 | 5.38 | 298 | 58 | 96 | 0.72 | 103.9 | 25 | 36.1 | 25.8 | 31.9 | 40.14 | 8 | 0 |
| 13 | 0 | 0.82 | 0 | 0.44 | 2.92 | 1.07 | 2.47 | 12.8 | 0.04 | 5.73 | 386 | 30 | 38 | 1.78 | 98.02 | 20 | 35.4 | 36.6 | 8.4 | 10.12 | 34 | 10 |
| 14 | 0 | 0.7 | 0 | 0 | 2.62 | 0.16 | 3.01 | 5.85 | 0.01 | 5.78 | 242 | 35 | 16 | 0.77 | 101.2 | 25 | 31.3 | 39.6 | 11.2 | 10.12 | 24 | 20 |
| 15 | 0.06 | 0 | 0.11 | 0.83 | 2.64 | 0.81 | 0.38 | 4.37 | 0 | 5.81 | 520 | 58 | 18 | 7.76 | 112.8 | 20 | 42.8 | 35.7 | 7.4 | 20.02 | 22 | 0 |

the permissible limit of the WHO (2006) guideline values for drinking water. However, the heavy metals analyzed (Hg^{2+} (0–1 mg/L), Cr^{2+} (0–0.29 mg/L), Cd^{2+} (0–1.75 mg/L)) exceed the guideline values (Table 1). Though these heavy metals have been variously attributed to anthropogenic activities, there is no visible presence of industrialization except the existence of cottage industries and the industrial estate upstream of the River Mamu. Therefore, anthropogenic factors may not be the only contributor of heavy metals but also agricultural activities in the study area. The presence of these metals may be equally attributed to the presence of thick shale units in the lithology and this has been previously noted (Wedepohi 1978). The relative enrichment of these metals in shale increases with the richness of organic matter in the shale. The presence of heavy metals in drinking water has been associated with various chronic and dangerous diseases since they accumulate in human organs (Okolo et al. 2018). In view of the presence of the heavy metals, the water sources can be said to be polluted.

The total coliform range from 4 to 52 in 100 ml/l, while the fecal coliform range from 0 to 24 in 100 ml/l. All the samples show the presence of the coliform group of bacteria which is an indication of biological pollution. The guideline value indicates a total absence of coliform group of bacteria in 100 ml/l of drinking water. Their presence may also be attributed to the manner in which the samples were collected and handled during analysis. The fecal group of bacteria indicate pollution of water by the faeces of living organisms. This was observed in 33% of the samples confirming biological pollution.

Water quality index

The water quality index (WQI) was calculated using weighted arithmetic (Reza and Singh 2010). The parameters considered include; pH ($w_i = 5$), total hardness ($w_i = 2$), total dissolved solids ($w_i = 4$), calcium ($w_i = 2$), magnesium ($w_i = 2$), sodium ($w_i = 2$), nitrate ($w_i = 5$), chloride ($w_i = 4$), bicarbonate ($w_i = 3$), sulphate ($w_i = 4$), and fecal coliform ($w_i = 5$). All the parameters were selected because of their implication on water quality. The parameters of greater importance to water quality are assigned higher weight. q_i is the quality rating and is given by

$$q_i = (C_i/S_i) \times 100, \tag{1}$$

where C_i is the concentration of the parameters in mg/L in water samples and S_i is the WHO (2011) guideline values for the parameters. SI is the sub-index of the parameters and it is given by

$$SI = W_i q_i, \tag{2}$$

where w_i is the weight of each parameter and W is the relative weight of each parameter and is obtained by $w_i/\sum w_i$. The Water Quality Index is obtained by summation as shown by

$$WQI = \sum SI. \tag{3}$$

The values obtained and the WQI for samples are displayed in Table 2.

The calculated WQI show that water samples range from unsuitable to excellent for drinking. The study area is being invaded by urbanisation and the consequent industrialisation may lead to water contamination/pollution in the future if no checks are put in place to stop it. The presence of water with rating of very poor and unsuitable for drinking is an indication that some water sources in the study area are polluted.

Heavy Metal Pollution Index (HMPI)

Heavy Metal Pollution Index is a weighted rating that shows the composite influence of individual heavy metals on the overall quality of water. The method used by Reza and Singh (2010) was adopted in calculating the HMPI. The q_i is the sub index of the i th parameter, was calculated using Eq. (1). The unit weightage (W_i) of the i th parameter was obtained by

$$W_i = K/S_i, \tag{4}$$

where S_i is the recommended standard for the i th parameter (1–5) and K is the constant of proportionality.

Table 2 The calculated WQI and the rating for the different samples

| WQI value | Water quality | Sample number and value | Percentage in each WQI value |
|-----------|-------------------------|-------------------------|------------------------------|
| <50 | Excellent | S1 = 17.3 | 66.7 |
| | | S2 = 17.2 | |
| | | S3 = 19.3 | |
| | | S5 = 24.6 | |
| | | S6 = 24.7 | |
| | | S8 = 23.2 | |
| | | S9 = 21.1 | |
| | | S11 = 20.9 | |
| | | S12 = 22.0 | |
| | | S15 = 23.6 | |
| | | 50–100 | |
| 100–200 | Poor water | Nil | |
| 200–300 | Very poor water | S4 = 102.3 | 20 |
| | | S10 = 140.5 | |
| | | S14 = 243.1 | |
| | | S13 = 415.0 | |
| 300 | Unsuitable for drinking | S7 = 376.3 | 13.3 |
| | | S13 = 415.0 | |

The heavy metal pollution index was then calculated as follows

$$\text{HMPI} = \frac{\sum_{i=1}^n (q_i W_i)}{\sum_{i=1}^n W_i}, \quad (5)$$

where q_i is the sub index of the i th parameter, W_i is the unit weightage for the i th parameter and n is the number of parameters considered. The result of the heavy metal pollution index is shown in Table 3.

The heavy metal pollution index show that water sources range from Very poor to Very good quality in the study area. The samples with rating of very poor are located in the northern part of the study area which is in the downstream of the major river in the area.

Hydrochemical species

The major ions chemistry of groundwater is a powerful tool for determining solute sources and for describing groundwater evolution. Also, it can reveal the origin of solutes and processes that generated an observed water composition. Water chemistry is guided by complex weathering processes, ion exchange and geochemical processes (Appelo and Postma 2005; Rina et al. 2011). Graphical methods by Piper (1944), Durov (1948) and Schoeller (1965) were employed to deduce the water type, the dominant ionic species, the dominant geochemical processes operating in the groundwater environment, the hydrochemical regime and facies classification of

groundwater. Sample points with similar hydrochemistry tend to cluster together in the diagrams (Fig. 3).

The classification of the Piper diagram using Langguth (1966) into four major divisions (Fig. 4) shows that most of the points plot in division (I) and (III) which represent $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl}^{-}\text{-SO}_4^{2-}$ water and $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^{-}$ water types, respectively. However, Back and Hanshaw (1965) subdivided the Piper diagram into nine divisions (Fig. 4) which are described in (Table 4).

The water types are dominated by alkaline earth (Ca + Mg) exceeding the alkalis and the strong acids exceed the weak acids (Table 3). Most of the plot points fall into zone 6 which represents non carbonate hardness (permanent hardness). The source of this kind of hardness was attributed to formation composed of limestone, or dolomite deposits or water in an active recharge zone with short residence time (Hounslow 1995). The remaining points are located in zone 5 indicating magnesium bicarbonate hardness (temporal hardness). The three graphical methods indicate SO_4^{2-} as the dominate anion and Ca^{2+} as the dominant cation. The classification of Durov diagram (Table 5) by (Lloyd and Heatcoat, 1985) show that most of the water samples are related to simple dissolution and mixing, and also water related to reverse ion exchange. Thus, suggesting the water chemistry is controlled by reverse ion exchange.

Schoeller (1967) suggested two Chloro-alkaline indices CAI-I and CAI-II to give insight into the base-exchange reaction between groundwater and its environment. The following equations (6 and 7) were employed in the calculation.

$$\text{CAI - I} = \frac{\text{Cl}^{-}(\text{Na}^{+} + \text{K}^{+})}{\text{Cl}^{-}} \quad (6)$$

$$\text{CAI - II} = \frac{\text{Cl}^{-}(\text{Na}^{+} + \text{K}^{+})}{\text{SO}_4^{2-} + \text{HCO}_3^{-} + \text{NO}_3^{-}} \quad (7)$$

The values of the two indices are positive. When these indices are positive in a geochemical system, it means that there is exchange of sodium or potassium from water with calcium or magnesium from rocks indicating reverse ion exchange. This may explain why calcium is the dominant cation.

Suitability for irrigation

The study area is an agricultural area, hence there is need to evaluate the suitability of the water sources for agricultural purposes. The sodium absorption ration (SAR) and percentage sodium (%Na) were applied. The equations below were employed.

$$\text{SAR} = \frac{[\text{Na}^{+}]}{\sqrt{[\text{Ca}^{2+} + \text{Mg}^{2+}]}}/2 \quad (8)$$

$$\% \text{Na} = \frac{[\text{Na}^{+} + \text{K}^{+}]}{[\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^{+} + \text{K}^{+}]} \times 100 \quad (9)$$

Table 3 Heavy metal pollution status of the water sources in the study area

| HMPI value | Water quality status | Sample number and value | Percentage in each HMPI value |
|------------|----------------------|-------------------------|-------------------------------|
| 0–25 | Very good | S1 = 20.2 | 60 |
| | | S3 = 0 | |
| | | S5 = 2.8 | |
| | | S6 = 5.6 | |
| | | S8 = 5.5 | |
| | | S9 = 2.7 | |
| | | S10 = 1.3 | |
| | | S11 = 2.0 | |
| | | S15 = 5.7 | |
| | | S4 = 32.7 | |
| 26–50 | Good | S12 = 26.9 | 13.3 |
| | | Nil | Nil |
| 51–75 | Poor | Nil | Nil |
| > 75 | Very poor | S2 = 122.8 | 26.7 |
| | | S7 = 114.8 | |
| | | S13 = 94.4 | |
| | | S14 = 80.4 | |

Fig. 3 Graphical methods showing the distribution of the chemical species in water samples

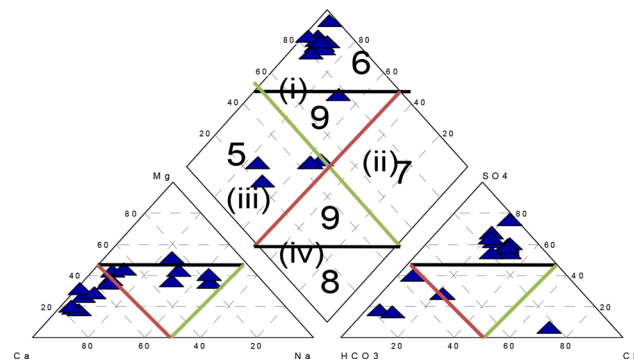
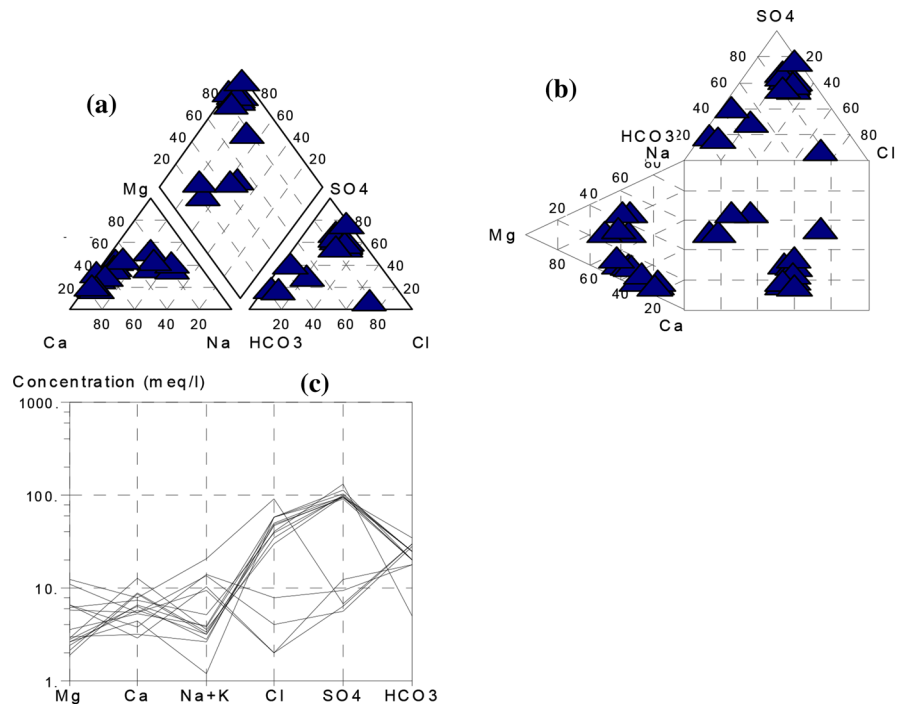


Fig. 4 Classification water samples using Back (1966) and Back and Hanshaw (1965)

The calculated SAR indicates that all the water samples are excellent while the %Na shows that water sources range from good (86.7%) to excellent (13.3%) for agricultural purposes. This is shown in Table 6 below.

Summary and conclusion

The geology of the study area is dominated by a succession of thick shale and sandstone which has resulted in aquifers existing under artesian to flowing artesian conditions. The water is slightly acidic and in the presence of high concentration of iron may encourage corrosion of and deposition

Table 4 Characterisation of groundwater of the study area on the basis of Piper trilinear diagram (Back (1966) and Back and Hanshaw (1965))

| Subdivisions | Characteristics of the subdivisions in the diamond | Percentage of samples in the category |
|--------------|---|---------------------------------------|
| 1 | Alkaline earth (Ca + Mg) exceed alkalis (Na + K) | 100 |
| 2 | Alkalis exceed alkaline earths | Nil |
| 3 | Weak acid (CO ₃ + HCO ₃) exceed strong acid (SO ₄ + Cl) | 20 |
| 4 | Strong acids exceed weak acids | 80 |
| 5 | Magnesium bicarbonate type | 20 |
| 6 | Calcium-chloride type | 73.3 |
| 7 | Sodium-chloride type | Nil |
| 8 | Sodium-bicarbonate type | Nil |
| 9 | Mixed type (no cation exceed 50%) | 6.7 |

Table 5 Classification of water samples based on Durov diagram (Lloyd and Heatcoat 1985)

| Subdivision | Water characteristics | Percentage |
|-------------|--|------------|
| 1 | HCO ₃ and Ca dominant, frequently indicates recharging water in limestone, sandstone and many other aquifers | Nil |
| 2 | This water type is dominated by Ca and HCO ₃ ions. Association with dolomite is presumed if Mg is significant. However, those samples in which Na is significant, an important ion exchange is presumed | Nil |
| 3 | HCO ₃ and Na are dominant, normally indicates ion exchanged water, although the generation of CO ₂ at depth can produce HCO ₃ where Na is dominant under certain circumstances | Nil |
| 4 | SO ₄ dominant or anion discriminate and Ca dominant, Ca and SO ₄ dominant frequently indicates recharge water in lava and gypsiferous deposits, otherwise, simple dissolution may be indicated | 20 |
| 5 | No dominant anion or cation indicate water exhibiting simple dissolution or mixing | 46.7 |
| 6 | SO ₄ dominant or anion discriminate and Na dominant, is a water type that is not frequently encountered and indicates probable mixing or uncommon dissolution influence | 6.7 |
| 7 | Cl and Na dominant is frequently encountered unless cement pollution is present otherwise, the water may result from reverse ion exchange of Na-Cl waters | Nil |
| 8 | Cl dominant anion and Na dominant cation indicate that groundwater related to reverse ion exchange of Na-Cl waters | 26.6 |
| 9 | Cl and Na dominant frequently indicate endpoint down gradient waters through dissolution | Nil |

Table 6 Classification of water using irrigation indices Na% (Wilcox 1955) and SAR values (Todd 1980)

| Water quality | Na% Values | Calculated Na% and sample no. | SAR values | Calculated SAR value and sample no. |
|---------------|------------|--|------------|-------------------------------------|
| Excellent | < 20 | S13 = 18.38 S15 = 14.51 | < 10 | S1 = 0.80 |
| | | | | S2 = 1.38 |
| | | | | S3 = 0.66 |
| | | | | S4 = 1.03 |
| | | | | S5 = 1.03 |
| | | | | S6 = 0.16 |
| | | | | S7 = 0.13 |
| | | | | S8 = 0.15 |
| | | | | S9 = 0.13 |
| | | | | S10 = 0.55 |
| | | | | S11 = 0.16 |
| | | | | S12 = 0.17 |
| | | | | S13 = 0.13 |
| | | | | S14 = 0.03 |
| | | | | S15 = 0.15 |
| Good | 21–40 | S6 = 29.87 S7 = 20.07 S8 = 23.44 S9 = 23.68 S10 = 32.07 S11 = 27.52 S12 = 30.73 S14 = 27.23 | 10–18 | Nil |
| | | | | Nil |
| | | | | Nil |
| | | | | Nil |
| | | | | Nil |
| | | | | Nil |
| Permissible | 41–60 | Nil | 18–26 | Nil |
| Doubtful | 61–80 | Nil | > 26 | Nil |
| Unsuitable | > 80 | Nil | | |

in plumbing system. The major cations and anions, TDS, and total hardness are within the permissible WHO guideline values. However, the concentration of the heavy metals and

biological parameters exceed the guideline values indicating pollution. The WQI and the HMPI were calculated. The WQI shows the ratings for water sources ranges from

unsuitable to excellent and the HMPI indicates rating of very poor to very good. The irrigation indices SAR depicts that all water sources are excellent and %Na shows that water sources range from good to excellent for agricultural activities. Two water types were observed with the alkaline earth metals exceeding the alkalis and the strong acid exceeding the weak acids. Most of the water sources exhibit permanent hardness. The geochemical process is dominated by rock dissolution and reverse ion exchange reactions.

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Compliance with ethical standards

Conflict of interest The authors hereby report that there are no conflict of interest arising from this research work and report.

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