



Groundwater quality and hydrogeochemistry of aquifers in the kwahu South District of Ghana

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ARTICLE INFO

Article history:

Received: 9 February 2012;

Received in revised form:

17 March 2012;

Accepted: 28 March 2012;

Keywords

Stiff diagrams,

Piper diagrams,

Schoeller diagram.

ABSTRACT

Chemical properties of groundwater resources were studied in the Kwahu South District of Ghana. The study used hydrochemical data employing a series of comprehensive data interpretation e.g. Bivariate plots, Schoeller and Piper diagram to obtain a better understanding of the system functioning. The physico-chemical parameters suggest that the groundwaters in the Kwahu South District are generally good for domestic use per World Health Organization (W.H.O) standards with the exception of boreholes from Nkyenenkyene (NKY and NKY 3) which have hydrogen sulphide problems. Stiff diagrams were superimposed on the map of the study area to display the area differences in water quality across the district. The following main hydrochemical processes were identified as factors controlling the chemistry of the groundwater system: dissolution, ion exchange, and reverse ion exchange. Three main hydrochemical facies were identified from the Piper diagram: Facies (I); Ca –HCO₃, Facies (II); Na –HCO₃ and Facies (III); Na–Cl. Three main hydrochemical groups were also identified by the Schoeller diagram: Group I, II, III. The groups identified by the Schoeller diagrams corresponded with the hydrochemical facies identified in the Piper Diagram respectively.

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Introduction

The overall accessibility to potable water supply in the Kwahu South District (including groundwater, rivers, streams etc) is estimated to be about 46.1%. Also, about 59% of the communities having access to potable water rely on groundwater (Ghana Statistical Service, 2000). The district has acute water problems. Although there is in existence a booster station at the district capital (Mpraeso), it has become obsolete and has very low capacity of water treatment and pumping equipment. This has resulted in inadequate supply of pipe borne water in both the urban and rural settlements; hence, they depend more on the groundwater located in their communities. Data on the chemical quality and sustainability of the waters in the Kwahu South District is limited.

The study of the geochemistry of groundwaters is an important aspect for drinking, irrigation, and industrial purposes. Each groundwater system in any area has a unique chemistry due to chemical alterations of meteoric water, recharging the aquifer system (Back 1966; Drever 1988; Hem 1991). The changes in the chemical quality of the meteoric water depends on many factors such as soil-water interaction, duration of solid water interaction, dissolution of mineral species and seawater and anthropogenic impacts (Stallard and Edmond 1983; Faure 1988; Karanth 1991; Subba Rao 2006; Subba Rao et al. 2006). Although studies by Ganyaglo et al, 2010 and Nkansah et al, 2011 in some parts of the eastern region of Ghana suggests majority of the boreholes are good for drinking and domestic purposes, the Kwahu South District was not covered extensively. Any useful hydrochemical study in the district must

therefore consider the ionic constituent of the groundwater and the sources of the ions in the groundwater. In a bid to determine these common sources of variation in the hydrochemistry, various graphical methods including Stiff diagrams, scatter diagrams, Piper diagram and Schoeller Diagrams Stiff diagrams (Hem, 1985) are the most familiar application of profile plots in water resources. In a Stiff diagram, the milliequivalents of major water-quality constituents are plotted for a single sample, with the cation profile plotted to the left of the center line, and anion profile to the right. A comparison between several samples based on multiple water-quality constituents is then easily done by comparing shapes of the Stiff diagrams. Figure 3 shows one such comparison for 14 groundwater samples from the Kwahu South District.

Piper diagrams are used to determine Hydrochemical facies. Major ions are plotted as cation and anion percentages in meq/l in two base triangles with total ions set to equal 100%. The Data points in the two triangles are then projected to central diamond which allows comparison of a large number of samples. The chemical data (in meq/L) is plotted on the Piper trilinear diagrams (Piper, 1944), with Cl⁻, HCO₃⁻ and SO₄²⁻ as the selected anions and Ca, Na⁺+ K⁺ and Mg²⁺ as the cations plotted. Grouping of waters on the Piper Diagram suggests a common composition and origin. The advantages of this plot are that; many samples can be plotted on the same diagram and can be used to classify the waters. It can also be used to identify mixing of waters too. However, with the piper plots, concentrations are renormalized thus cannot easily accommodate waters where

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other cations or anions may be significant and this may be a disadvantage.

Schoeller diagram are semi-logarithmic diagram that represents major ion analyses in meq/L. It demonstrates different hydrogeochemical patterns on the same diagram with common ions which can be used to characterize the water types and also infer the possible sources of ions based on trends of the graphs.

Study Area

The Kwahu South District is located in the north-western part of the Eastern Region of Ghana. It lies between latitudes 6° 30' N and 7° N and longitudes 0° 30' W and 1° W. It covers a total land area of about 1,462 km². It shares common boundaries with Sekyere East District to the north, Asante-Akim North and Asante Akim South Districts to the west, Afram Plains District to the east and Birim North, East Akim and Fanteakwa Districts to the south (Fig.1).

The district lies within the Wet Semi-Equatorial region and thus experiences the double maxima rainfall pattern namely the major and minor rainy seasons. The major rainy season starts from April and ends in July. On the other hand, the minor rainy season starts from September, ending in October [meteorological data, 1993–2003 from the Ghana Meteorological Agency (GMA)]. Annual average rainfall is between 1580 mm and 1780 mm. Rainfall intensity however, decreases towards the north. Mean monthly temperature ranges from 30°C in the dry season but declines to about 26°C in the wet season. It is worthy to note that the relatively higher altitude has moderating influence on the local temperature. Relative humidity in the district ranges between 75% and 80% [meteorological data, 1993–2003 from the Ghana Meteorological Agency (GMA)].

Again, the district lies within the Semi-Deciduous forest zone. The vegetation is dense in terms of tree coverage with most trees shedding off their leaves in the dry season. The forest is made of three layers namely the upper, middle and lower layers (Benneh and Dickson 1980). A greater part of the natural vegetation has been altered due to man's activities on the land. The forest, however, remains in their natural state in the five (5) reserve areas namely the Southern Scarp Forest, Oworobong South, Abisu, Northern Scarp West and Oworobong North Forest reserves. Together, the reserves cover a total of 37, 070 hectares of land.

Among the major rivers that drain the district are the Afram and Pra rivers. The River Afram is a major tributary of the Volta and flows through the northern border of the district with the Afram Plains. The Pra River takes its source from the Kwahu Scarp in Kwahu Twenedruase and flows through Akwasihu and Kwahu Praso where it leaves the district (<http://www.ghanadistricts.com>). The principal soil type in the study area is the forest ochrosols, which consist of fine sand loams, congregational loams, non-gravel sandy clay loams and iron pan soils. These soils possess a good chemical property of clay and some appreciable amount of humus, thus making them generally fertile (Dwomo and Asiamah, 1993; Asiamah et al., 2000). The forest ochrosols are generally slightly acidic in the topsoil with pH ranging from 6.5–5.1. Moderately to strongly acidic reactions have been encountered in cultivated sites in this zone in recent times (Agyili et al., 1993; Dwomo and Asiamah, 1993; Asiamah et al., 2000). Soils of the unsaturated zone (25–500 cm) in the study area have generally been observed to be of moderately acidic to alkaline nature with a pH range of 5.99–8.30 and exhibit anaerobic and strong reducing properties with Eh range of -107 to 50.2 mV. pH and Eh (pe) variations in the

profiles do not follow any general pattern and this has been attributed to the soil buffering mechanisms, which vary within the unsaturated zone (Bam, 2009).

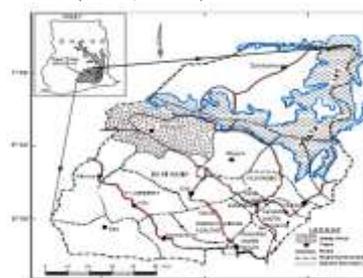


Fig. 1: Location Map of the Study Area (modified from Ganyaglo et al., 2010)

Geology and Hydrogeology

The geology of the study area is mainly the Mpraeso and the Abetifi sandstones formation of the Kwahu Group which forms part of the Volta basin in Ghana. The Voltaian Formation covers 45% area of Ghana, and is characterized by sedimentary rocks. About one third of the Voltaian Formation is covered by horizontal sandstone, shales, mudstones and conglomerates considered to be of the late Proterozoic to early Palaeozoic Era (Kesse, 1985; Anani, 1999). The Voltaian hydrogeologic formations form contact with the Birimian Formation and cover the central basin to the north east of the country (Acheampong and Hess, 1998). Within Ghana, the Voltaian is bounded in the south by the Birimian, and in the south east by the Akwapim-Atacora ranges. The Voltaian has an approximate thickness of 3000–4000 m and rests on the Lower Proterozoic Birimian system and related granitoids (Pelig-Ba, 2004).

From the basement of mountain Ejuenema, the contact between the Voltaian and the Birimian is clearly visible. Bedrocks of the Birimian granitoids are mantled by mudstones and siltstones, which form the local base of the Mpraeso sandstone. Some of the basal mudstones and siltstones beds show fluxering and load structures, which were possibly induced by compaction against an irregular Birimian surface. Beds of fine grained micaceous sandstone increase in proportion, and become progressively thicker, up the section. Higher up, the Kwahu escarpment is composed of a thick sequence of white, highly mature quartzitic sandstones forming the middle and top of the escarpment. The topography of the study area has great influence on the hydrology of the area. Owing to the relatively steep slopes, runoff erosion is high, and evidence of this process is the fast flow of surface water from the foot of the hills during periods of rainfall.

Primary porosity among all the rocks in the study area is reduced due to high levels of compaction and metamorphism of the sedimentary units. The mode of groundwater occurrence is therefore through the development of secondary permeabilities as a result of fracturing, jointing, shearing and deep weathering (Banoeng-Yakubo, 1989 et al; 2000), in the Voltaian formation (Pelig-Ba, 2009). The fractures developed from tectonic movement, pressure relief due to erosion of overburden rock, shrinking during cooling of the rock mass and the compression and tensional forces caused by regional tectonic stresses (Banoeng-Yakubo, 2000). The fracture zones are developed in the bedrock at depths of 20 m or more below ground surface (Buckley, 1986). Transmissivities vary between 1 and 72 m²/day (Buckley, 1986; Minor et al., 1995; Acheampong and Hess, 1998), with the average borehole yields in the quartzitic sandstone and quartzite being 5.5m³/d and 3.7m³/d respectively. The average aquifer transmissivities in the quartzitic sandstone

and the quartzitic aquifers are respectively $15.8\text{m}^3/\text{d}$ and $16.5\text{m}^3/\text{d}$ (Ref).

Methodology

The sampling and analytical procedures to obtain the data are described as follows. A total of 14 groundwater samples, comprising 10 samples from hand dug wells and 4 from boreholes were analyzed for the concentrations of the major hydrochemical parameters.

Strict standard sampling and analytical protocols were adhered to, in order to obtain representative data from each of the sampling points. Samples for both cations and anions were collected into 330mls polyethylene bottles with the samples for cations filtered on site through a $0.45\mu\text{m}$ filter of acetate cellulose and immediately acidified to a pH less than 2 by addition of MerckTH Ultra pure nitric acid.

On site analysis were necessary for electrical conductivity (EC), pH, Eh, temperature, and alkalinity. This is because these parameters are likely to change on transit to the laboratory. The TDS, salinity and electrical conductivity were measured using the Hach Sension5 whiles pH and temperature were measured using Hach Sension1.

Bicarbonate determination was also carried out in the field using double-indicator titration of 25ml sample against 0.01M HCl, with phenolphthalein and methyl orange as the indicator. (Eaton, et. al., 2005)

Laboratory analysis conducted includes; Sodium (Na) and potassium (K) which was analyzed using flame photometer (Sherwood Model 420 with detection limit of 0.001 (Eaton, et. al., 2005). Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Zinc (Zn), Cadmium (Cd), Chromium (Cr), and lead (Pb) were analyzed using digestion, followed by atomic spectrometry using the AA240FS Fast Sequential Atomic Absorption Spectrometer (Eaton et. al., 2005; Broekaert, 1998, Sperling and Welz, 1999, Sood et. al., 2004). Anions which includes, Fluoride (F^-), Chlorides (Cl^-), Nitrites (NO_2^-), Bromide (Br^-), Phosphate (PO_4^{3-}), Sulphates (SO_4^{2-}) Nitrates (NO_3^-) were all analyzed using ICS-90 ion chromatography.

Results and Discussion

Water chemistry

The statistical summaries of the hydrochemical data used for this study are presented in Table 1. The temperature of the groundwater sampled ranges from 19.2°C to 31.1°C . The pH of the water samples analyzed in the Study Area was mostly acidic with very few samples near neutral to basic.

The pH ranges were 3.43 to 8.02. It has been noted by Kersten and Forstner (1987) that pH increases with specific adsorption of heavy metals because of the stabilization of negative charges on the potential sorbent surfaces. This causes some heavy metals normally trapped in sediments to be released into acidified water.

The resultant effect may explain why some of the heavy metals such as arsenic, cadmium, chromium, cobalt and nickel were not measured in detectable concentrations in most of the water samples.

Samples examined as part of this study all have, with the exception of NKY and NKY3, low total dissolve solids (TDS). The TDS concentration ranges from 7.7mg/L to 281mg/L . The Electrical conductivity (EC) also followed a similar trend as the TDS stated above with ranges between $15.83\mu\text{S/cm}$ to $62\mu\text{S/cm}$. Since the EC and TDS are measurements of the total salt content, they must be directly proportional as shown in fig. 2

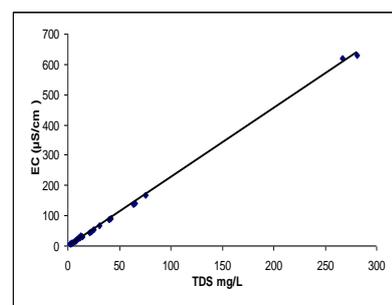


Fig. 2: A relation between the EC and the TDS

The concentrations of some heavy metals such as Cd, Ni, Pb and Cr were below instrumental detection limits except Fe which showed some elevated levels of concentrations (0.3mg/L ; WHO standard level for iron) across the district. The concentration of iron ranges from 0.133mg/L to 0.37mg/L for the samples with some areas showing elevated concentration of iron greater the 0.3mg/L , the WHO standard for iron in drinking water

The range of concentrations for Ca, Mg, K, and Na are 0.971mg/L to 39.58mg/L , 0.571mg/L to 7.505mg/L , 2.7mg/L to 46mg/L and 9mg/L to 101mg/L respectively. Na^+ concentrations for NKY and NKY3 were not included because they behaved like an outliers having concentrations of 809mg/L and 826mg/L respectively.

All the major ions at the various sampling points were below W.H.O (1996) limits with the exception NKY and NKY3 which had elevated Na concentrations well above the W.H.O (1996) standard limit

The chloride concentration was 7.041mg/L to 73.881mg/L excluding NKY and NKY3 which had concentrations of 529.52mg/L and 630.12mg/L respectively. The concentration of Cl at NKY and NKY3 exceeds the WHO (1996) standard limit for chloride. The Bicarbonates values ranges from 60mg/L to 350mg/L which are within the (WHO, 1996) standard limit. Sulphate values were generally low at almost all the sampling sites with the exception of the NKY and NKY2 which recorded relatively high concentrations. The sulphate values ranges from 0.024mg/L to 23.898mg/L (excluding NKY AND NKY3) which are far above WHO standard limit. Most of the phosphate and nitrate concentrations in the groundwater were below detection limit.



Figure 3: Stiff diagrams to display area differences in water quality in the Study Area

Major Ion Chemistry and Water Mineralization

Results from the water analysis were used as a tool to identify the processes and mechanisms affecting the chemistry of water in the study area. There is a strong correlation between Na^+ and Cl^- (Fig. 4) and can therefore be deduced that the sodium and the chloride originate from a common source. The possible sources are sea aerosol spray, halite dissolution, sea water intrusions and ion exchange.

Approximately, 90 percent of the samples have a ratio of Na^+ ($\text{Na}^+ + \text{Cl}^-$) greater than 0.5 which may give some indications of perhaps cation exchange or aluminosilicate incongruent dissolution rather than sea water intrusion or aerosol spray. If ion exchange is the controlling factor, the relation between $\text{Na}^+ - \text{Cl}^-$ and $\text{Ca}^{2+} + \text{Mg}^{2+} - \text{SO}_4^{2-} - \text{HCO}_3^-$ would show a negative linear trend with a slope of unity (Fisher and Mullican, 1997). From figure 6, the graph depicts a negative linear trend with a slope of 0.7873. This clearly shows that ion exchange could be the main factor controlling the composition of Na and Chloride ions. The graph of Na-Cl against $\text{Ca} + \text{Mg} + \text{HCO}_3^- - \text{SO}_4$ (figure ...) again, may suggest higher concentration of Na^+ . Also, the ionic ratio of $\text{Mg}^{2+} / \text{Mg}^{2+} + \text{Ca}$ is

The plot for $\text{Ca} + \text{Mg}$ versus $\text{SO}_4 + \text{HCO}_3$ (figure 7) is a major indicator to identify ion exchange or reverse ion exchange process activated in the study area. If ion exchange is the process, the points shift to the right side of the plot due to excess $\text{SO}_4 + \text{HCO}_3$. If reverse ions exchange is the process, the point's shifts left due to excess $\text{Ca} + \text{Mg}$. Figure 7, shows that most of the sample points are shifted to the left due to excess $\text{Ca} + \text{Mg}$, and this may be due to reverse ion exchange also taking place in the study area.

Bicarbonates in the waters may originate from natural conditions. In natural conditions, carbonic acid (H_2CO_3) formed from interaction of atmospheric CO_2 with water (H_2O) can react with CaCO_3 present in soil to form Ca^{2+} and HCO_3^- ions. A plot of $\text{HCO}_3^- / \text{Cl}^-$ versus Cl^- (figure 8) shows that, the HCO_3^- may be generated in the early evolution of the groundwaters.

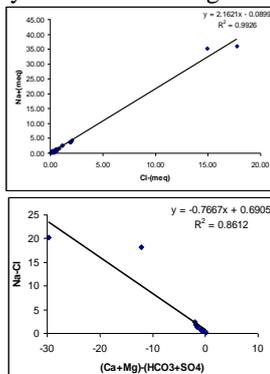


Fig. 4: Na^+ against Cl^-

Fig. 5: $\text{Na}^+ - \text{Cl}^-$ versus $\text{Ca}^{2+} + \text{Mg}^{2+} - \text{SO}_4^{2-} - \text{HCO}_3^-$

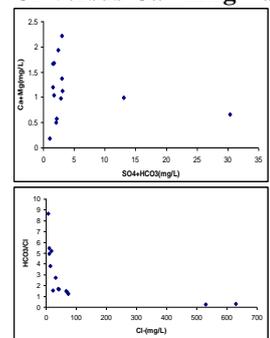


Fig. 6: A Plot of $\text{Ca} + \text{Mg}$ versus $\text{SO}_4 + \text{HCO}_3$

Fig. 7: A plot of $\text{HCO}_3^- / \text{Cl}^-$ versus Cl^-

Characterization of Water Types in the District

Various conventional graphical techniques have been used to adequately characterize hydrochemical systems in the past decades in Ghana (Ganyaglo et al, 2010; Adomako et al, 2009 and Yidana, 2008). Their uses have assisted in determining hydrogeochemical patterns. The hydrogeochemical patterns provide a basis for grouping samples with similar characteristics and in this instance, Piper and Schoeller diagrams have been

deployed to classify the water samples into homogeneous groups such that each graphical presentation complements the other for a better understanding of the hydrochemistry of the groundwater in the district

Three main hydrochemical facies were reported in the studied wells as detected from the Piper diagram (Fig. 8): Facies (I); $\text{Ca} - \text{HCO}_3$, Facies (II); $\text{Na} - \text{HCO}_3$ and Facies (III); $\text{Na} - \text{Cl}$.

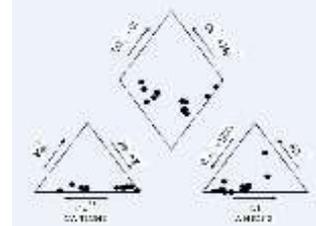


Fig. 8: Piper diagram and hydrogeochemical facies shown on Piper diagram

The hydrochemical patterns also from the Schoeller graphs identified three main hydrochemical groups showing distinct water patterns in each group. Each group identified by the Schoeller corresponded with a particular water type obtained from the piper diagram.

The following Groups were obtained:

Group I; this group consists of waters from TWE, BEP, BEP3, BEP4, KWT, MPR, and NTE. It is dominated by HCO_3^- followed by the Ca and $\text{Na} + \text{K}$. The SO_4 ion concentrations in this group are very low. The relative low ions and TDS in this group may suggest that these waters may either be originating directly from precipitation or the nearness of the recharge zone to the surface hence direct infiltration. They may not have travelled enough distances to dissolve enough ions hence their relative low ions and TDS. These low levels of ions and TDS lend credence to the fact that, these waters are relatively young. This group corresponds with the hydrochemical facie $\text{Ca} - \text{HCO}_3$.

Group II; this group consists of groundwaters from NKT2, NKT3, ABT, ATB, and MPR2. It is very similar to group 1 in terms of the concave pattern but unlike group 1, this group has higher $\text{Na} + \text{K}$ ions and lower Ca ions. From the graph, as $\text{Na} + \text{K}$ increases, Ca^{2+} decreases. The study area is predominantly rural and that anthropogenic activities may not be probable source in contributing to the high $\text{Na} + \text{K}$. The likely sources of relatively high $\text{Na} + \text{K}$ may be from the geology of the area. Owing to the Geology of the area, the pattern suggest that Ca ion is been replaced by $\text{Na} + \text{K}$ ion hence increasing the $\text{Na} + \text{K}$ ion concentration while Ca^{2+} ions decreases. This may indicate Ion Exchange reaction taking place in the study area. With $\text{Na} + \text{K}$ and HCO_3^- being the dominant cation and anion respectively, this group correspond to $\text{Na} - \text{HCO}_3$ type of water from the piper diagram.

Group III; this group consist of waters from NKT and NKT3. It is of much interest because it has certain characteristics that make it entirely different from Group I and II. The relatively high $\text{Na} + \text{K}$ value is accompanied by relatively high SO_4 , Cl and HCO_3^- . The relatively high TDS and salinity in this group suggest that the groundwater must have dissolved soluble salts along its flow lines during its trajectory and deposited the salts within the aquifers. Physical observation also made about these wells revealed that it was very salty relative to the other wells and also smells like a rotten egg. The smell of a rotten egg may signify the presence of hydrogen sulfide. This may suggest that, probably, there may be sulfate reduction taking place. The $\text{Na} + \text{K}$ value in this group was the highest in terms of anion dominance but the SO_4 value may also be considered to be very high if one considers the groundwater has

gone through a sulfate reduction zone. The relatively high SO₄ value of this group may indicate a possible existence of gypsum beds probably beneath the sandstones in that particular area.

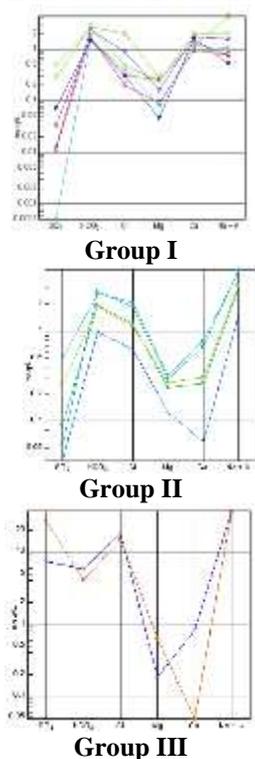


Fig. 9: Schoeller diagrams of the water types in the Study Area

Conclusions

The hydrochemical analysis of groundwater resources in the Kwahu South District revealed that the water is mildly acidic with very few samples near neutral to basic. The physico-chemical parameters suggest that the groundwaters in the Kwahu South District are generally good for domestic use with the exception of NKY and NKY 2, which have a smell of a rotten egg. Generally, all the chemical parameters are within internationally acceptable limits (WHO, Year) with the exception of waters from NKY and NKY3 which have elevated levels of Cl and SO₄. Dissolved concentration levels of some trace metals namely; Cd, Ni, Pb and Cr are below instrumental detection limits except Fe which shows some elevated levels of concentrations (0.3mg/l; WHO standard level for iron) across the various water systems in the district.

Two main hydrochemical facies were determined using the piper diagram and three groups of geochemical patterns were also determined using the Schoeller diagrams. The Chemical parameters (ions in the water) are influenced primarily by silicate weathering, ion exchange and reverse ion exchange processes in the study area.

Acknowledgement

The authors are thankful to those who contributed in diverse ways to make this work a reality, especially the staff of NAA laboratory and the Isotope hydrology laboratory.

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Table 1: Results showing concentrations of various elements

SAMPLE ID	ELEVATION/m	EH mV	PH	EC μ S/cm	TDS ‰	Ca	Mg	Na	K	Fe	Cl-	HCO ₃	SO ₄ ²⁻	F-
NKT 2	498	174	3.43	47.6	23.2	1.174	1.502	32.3	5.3	0.133	22.441	60	1.753	1.22
NKT 3	498	148	3.69	88.1	40.3	5.317	2.856	60.3	18.5	0.139	41.97	120	4.35	0
ABF	594	121	4.2	90.6	41.7	6.164	3.286	58.1	27.6	0.211	39.852	115	12.235	0.002
BEP	466	149	3.67	25.3	11.3	19.18	1.096	16.4	2.7	0.141	7.041	105	0.54	0.505
BEP 3	469	100	4.6	30.2	13.8	28.56	3.116	13.6	6.1	0.252	11.001	103	1.592	0.683
BEP 4	464	133	3.99	26.1	11.9	22.45	1.009	21.2	5.6	0.373	14.422	95	0.024	1.271
KWT	469	110	4.39	17.74	7.7	35.5	1.944	34.1	4.3	0.289	30.953	145	0.603	0.152
NTE	448	63	5.25	54.9	25.2	39.58	2.954	28	31.6	0.361	17.34	155	23.898	0
NKY	100	-80	7.92	629	281	0.971	7.505	809	37	0.146	529.524	250	1261.449	0
NKY 3	112	-0.86	8.02	621	267	16.25	2.239	826	46	0.169	630.123	350	353.829	0
TWE	558	113	4.36	15.83	8.1	32.43	0.571	9	5.1	0.203	10.531	90	3.497	0.002
ATB	473	143	3.81	140.7	65.5	13.7	3.592	85.9	44.8	0.221	66.516	170	2.625	2.383
MPR	469	67	5.2	138.7	63.5	21.89	3.454	85	24.7	0.137	69.982	165	13.486	0.506
MPR 2	469	125	4.14	166.4	75.3	16	3.963	101	12	0.349	73.881	160	23.83	0.372
Minimum	100	-80	3.43	15.83	7.7	0.971	0.571	9	2.7	0.133	7.041	60	0.024	0
Maximum	594	174	8.02	629	281	39.58	7.51	826	46	0.37	630.12	350	1261.45	2.38
Mean	434.79	97.51	4.76	149.44	66.82	18.51	2.79	155.71	19.38	0.22	111.83	148.79	121.69	0.51
Median	469	117	4.28	71.5	32.75	17.72	2.91	46.1	15.25	0.207	35.4	132.5	3.92	0.26
Std	139.63	65.14	1.41	199.89	87.36	12.02	1.66	271.65	15.21	0.08	193.24	71.63	328.48	0.67