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CALCIUM AND MAGNESIUM DISTRIBUTION IN GROUNDWATER AND FOOD SUBSTANCES IN PARTS OF CENTRAL PLATEAU STATE, NORTHCENTRAL NIGERIA.

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ABSTRACT

Adequate intakes of calcium and magnesium in water have been found to reduce the risk of some diseases (cardiovascular, diabetes, rectal cancer, neurological disturbances and pre-eclemsia in women) especially where adequate amount of these ions are not supplemented in foods. The dependence on waters abstracted directly from hand dug wells and other sources without any form of treatment and or regulation are of great concern to the health of humans and animals. Groundwater abstracted from hand dug wells and hand pumps without any form of treatment, are the main sources of water supply for rural inhabitants of central Plateau State, Nigeria. The aim of this study was to map out the distribution of calcium and magnesium using GIS in parts of central Plateau State. Multivariate analysis to explain the variation of these ions in aquifers of the area was also employed. Four rock types constitute the aquifers from which water is abstracted for drinking (migmatite, biotite granite, granite gneiss and basalts) exhibiting variations in their contents of calcium and magnesium. Averagely, content of calcium and magnesium are higher in the migmatite compared to the other rock types. Generally the total content of calcium in both foods and water do not meet the recommended daily intake of 1000 mg for an adult. Although, magnesium is quite low in 90% of water points, the daily recommended daily intake of 200 – 400 mg for adult is supplemented in (*Zea May*s, and *sorghum)* staple foods consumed daily by every household in the area. There is the need for calcium supplements in the area to meet the recommended daily intake.

INTRODUCTION

The links between the environment and health have been referenced by many ancient cultures (Sellinus et al, 2005). Occupational environments were often associated to health problems, but also close links to the natural environment were also noted. Chinese medical records dating back to the third century BC contain several references to relationships between environment and health. Both the Song Dynasty (1000 BC) and the Ming Dynasty (Fourteenth to Seventeenth century AD) noticed lung problems related to rock crushing and symptoms of occupational lead poisoning. Similarly, the Tang Dynasty alchemist Chen Shao-Wei stated that lead, silver, copper, antimony; gold and iron were poisonous (Nriagu, 1983).

Over the years, studies carried out in different parts of the world suggest the beneficial or protective role of calcium and magnesium on some diseases. These include studies on calcium in neurological disturbances (Jacqmin et al, 1994; Emsley et al, 2000) calcium and magnesium in amytrophic lateral sclerosis (Yasui et al, 1997), magnesium in preeclamsia in pregnant women (Melles and Kiss, 1992), calcium in high blood pressure (Rubenowitz, 1999), magnesium in high blood pressure and metabolic syndrome (Rasic Miutinovic, 2012).

Costi et al, 199 reported that a regular life-long daily intake of drinking water with highly bio- available calcium may be of importance for maintaining the calcium balances and improving the spinal bone mass.

Cepollaro et al, 1996 found out that calcium mineral water supplementation for one year showed an increase in the bone mass density in postmenopausal women. The link between low calcium content in drinking water and higher incidence of bone fracture in children was found in Spain (Verd Vallespir et al, 1992).

In the late 1990s, a number of epidemiological studies (mostly combined ecologic case control studies) carried out in Taiwan on relationship between drinking water hardness and mortality from various type of cancer, showed a significant geographical variation. Magnesium was found to have protective effect against cerebrovascular diseases (Yang, 1998) and hypertension (Yang and Chui, 199b). Kuo et al, 2010 reported the risk of rectal cancer increase from trihalomethanes (THM) when the magnesium level was low in drinking water and similarly the risk of kidney cancer from THM was higher in soft water areas (Liao et al, 2012). In areas where the magnesium content is higher than 17 mg/l, fewer deaths due to diabetes were recorded (Yang et al, 1998). The protective effect of magnesium in drinking water on decreased incidence of

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Type 2 diabetes among young adult was confirm in Finland (Kousa et al, 2012).

Kozisek, 2005 suggested what should be the optimum level in drinking water (from a health point of view) to range from 20 – 30 mg/l for magnesium and from 40 to 80 mg/l for calcium respectively and, for hardness as Σ Ca + Mg from about 2 – 4 mmol/l

Food is the principal dietary source of intake of both calcium and magnesium. Dairy products are the richest sources of dietary calcium, contributing over 50% of the total calcium in many diets. (Ong, Grandjean et al,. 2009). Some plant foods, including legumes, green leafy vegetables and broccoli, can also contribute to dietary calcium, but the content is lower than in dairy products, Dietary sources of magnesium are more varied; dairy products, vegetables, grains, fruits and nuts are important contributors.

Typical recommended dietary intakes are about 1000 mg of calcium per day and 200– 400 mg of magnesium per day(Ong, Grandjean et al,. 2009). Moves to reduce the intake of dairy products because of the fat content will lead to a lowering of calcium and magnesium intakes in some population groups. Populations that use only very small amount of dairy products would also have a lower intake of calcium.

Checklist administered on 500 respondents mostly in age range 40 years and above and data obtained from the Jos University Teaching Hospital Comprehensive Clinic Gindiri (Muthir, 2015) shows about 63% of the aged group 40 and above have cases of hypertension and or diabetes. Since calcium and magnesium elements have been implicated in reducing and or increasing the risk of hypertension and or diabetes in humans, the authors have been motivated to examine:

1. The distribution of calcium and magnesium in drinking water sources and in some foods commonly eaten in central Plateau State.
2. Determines if calcium and magnesium consumed in waters and food meets the daily recommended limit

DESCRIPTION OF THE STUDY AREA

Location, Extent and Accessibility of the Study Area

The area lies within the central parts of Plateau State (Pankshin, Pushit, Panyam, Kerang, Mangu and Gindiri (Fig 1). The study area falls within the Nigerian Basement Complex which was intruded by the Younger Granites. Geographically the area lies between (UTM) Latitudes 9.32091- 9.55765N and Longitudes 9.43526 - 9.18292E. Basically the main rock types in the study area are migmatite, granite gneiss, biotite granite and the volcanic rocks, mainly basalts

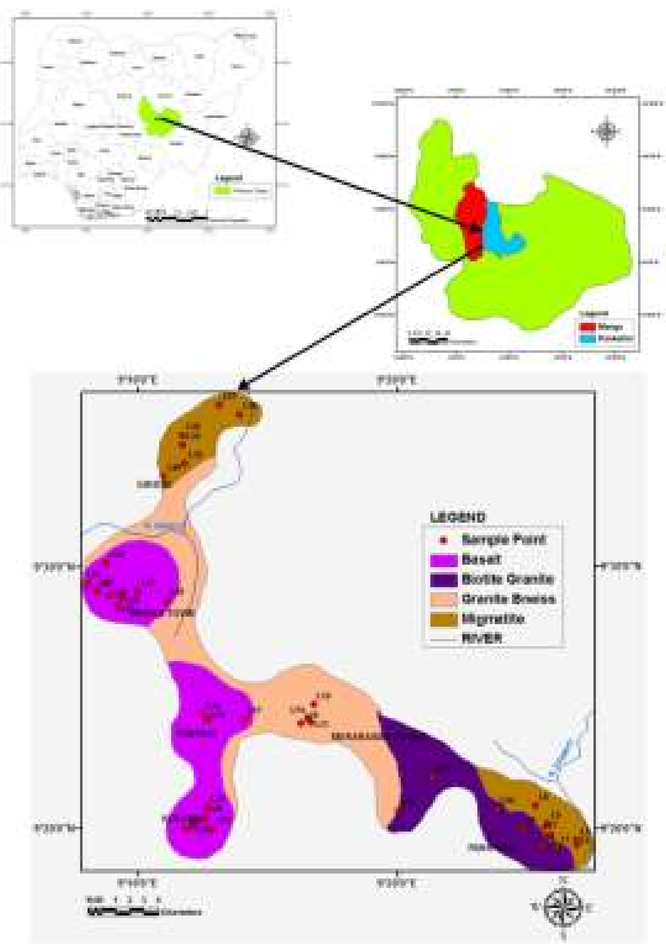

Fig 1: Geological map of the study area showing sample points.

Climate and Vegetation

The area of study is characterized by two seasons, wet and dry. The wet season is dominated by the South Tropical Maritime Air Mass which brings rain between the months of April and October. The dry season is affected by the North Eastern Tropical Continental Air Mass which occurs in the months of November to March and it is typically a period of dusty windy harmattan. Rainfall is high with the mean annual rainfall ranging from 131.75cm to 146cm with the highest rainfall usually recorded in the months of July and August. The area has a near temperate climate with approximate mean high temperature of 22^0C and low temperature of 18^0C. The area is characteristic of the Savannah type vegetation. The vegetation is dispersed with short trees and grasses. Land use is mostly farming, with cultivation of Irish potatoes and maize on a large scale.

Relief and Drainage

The topography of the area is made up of both high and lowlands, with the highest point reaching to 1318m at Fuvu Kerang volcanic hill. Both the highlands and lowlands have been extensively weathered and eroded with lateritic soils covering most parts of the lowlands. The drainage pattern in the study area is generally dendritic with streams and rivers that are mostly seasonal. The natural spring in Kerang flows all year round.

METHODOLOGY

Water samples were collected from different sources (hand dug wells - 33, hand pumps - 6 and springs - 1) in 40 locations. Before the water sampling exercise, 250ml plastic containers were rinsed severally with the sampled water before taking the water samples. Hand pumps were pumped for several minutes with the view that existing water should be pumped out so as to sample fresh water coming out from the aquifer. Two samples were collected from each location in a 250ml plastic container. One of the samples was acidified using two drops of concentrated nitric acid to a pH of < 2 to prevent possible adsorption and precipitation of ions thus preserving the cations. At each location, coordinates were taken using GPS. pH and electrical conductivity (EC) for all the samples were determined in the field with the conductivity/pH meter. Staple food substances (maize and sorghum) were bought from the inhabitants of the areas. Particular attention was taken to ensure the food materials were grown on the soils in the vicinities where the water samples were collected.

Laboratory Preparation and Analysis

The forty water samples collected were packaged in a 60 ml sterilized plastics bottles at the University of Jos, Department of Geology Laboratory and sent to ACME Laboratories in Canada for analysis of major and minor cations, trace and rare earth elements. The water samples were analysed using the Inductively Coupled Plasma Optical Emission Spectophometry at the ACME Laboratory in Canada. The anions, chloride (Cl^{-}) and bicarbonate (HCO_3^-) were analysed by titration, while sulphate ($SO4^{=}$) was analysed with the Multi Ion Parameter at the Department of Geology Laboratory University of Jos. The grains were grounded at the University of Jos, Department of Geology with pestle and mortar. Two grams of the powdered samples were weighed with an Ainsworth Electronic Balance Model U11417 – 73. Calcium and magnesium were analysed using the Atomic Absorption Spectrophotometer at the Nigerian Geological Survey Agency Laboratory at Kaduna.

Statistical Evaluation of Data

Field data was evaluated using the SPSS Version 16 software to determine the median, mean mode, maximum, minimum and standard deviation.

RESULTS AND DISCUSSION

RESULTS

Summary of chemical composition for water in the study area is presented in Table 1. The waters contain maximum concentration of Ca, 140.1; Mg, 45; Na, 94; K, 9; Cl, 85; SO4, 34; HCO_3, 276; TDS, 959; TH, 538 mg/l. pH, 9; and conductivity, 1199µs/cm. variations in Ca and Mg content for the entire area is presented as symbol map (Fig 1and 2). The mean value of calcium (22.92 mg/l) and the mean magnesium value (4.62 mg/l) in the groundwater of the study area is almost half the value of average calcium (50 mg/l) and magnesium 7 mg/l in world's groundwater average for these elements (Livingstone, 1987; Turekian, 1977).
Variations for the other ions in water are also presented according to the geological environment (Table 2,3,and 4)

Table 1: Summary of chemical composition (mg/l) of water in the study area. Conductivity is in µs/cm

Elements	Ca	Mg	Na	K	Cl	SO4	HCO3	pH	TDS	Cond	TH
Mean	22.92	4.68	18.88	4.22	27.92	14.18	74.76	5.70	193.45	248.27	77.84
Median	15.69	2.00	12.00	4.00	21.00	11.00	64.60	5.00	126.00	156.50	38.50
Std. Deviation	18.13	8.32	20.93	2.11	21.55	6.33	52.60	1.04	191.31	239.20	96.21
Skewness	2.09	3.42	1.95	0.24	1.07	1.78	2.33	1.65	2.42	2.41	3.26
Minimum	2.00	0.20	1.00	1.00	7.00	8.00	10.00	5.00	31.00	38.00	7.00
Maximum	140.10	45.00	94.00	9.00	85.00	34.00	276.00	9.00	959.00	1199.00	538.00

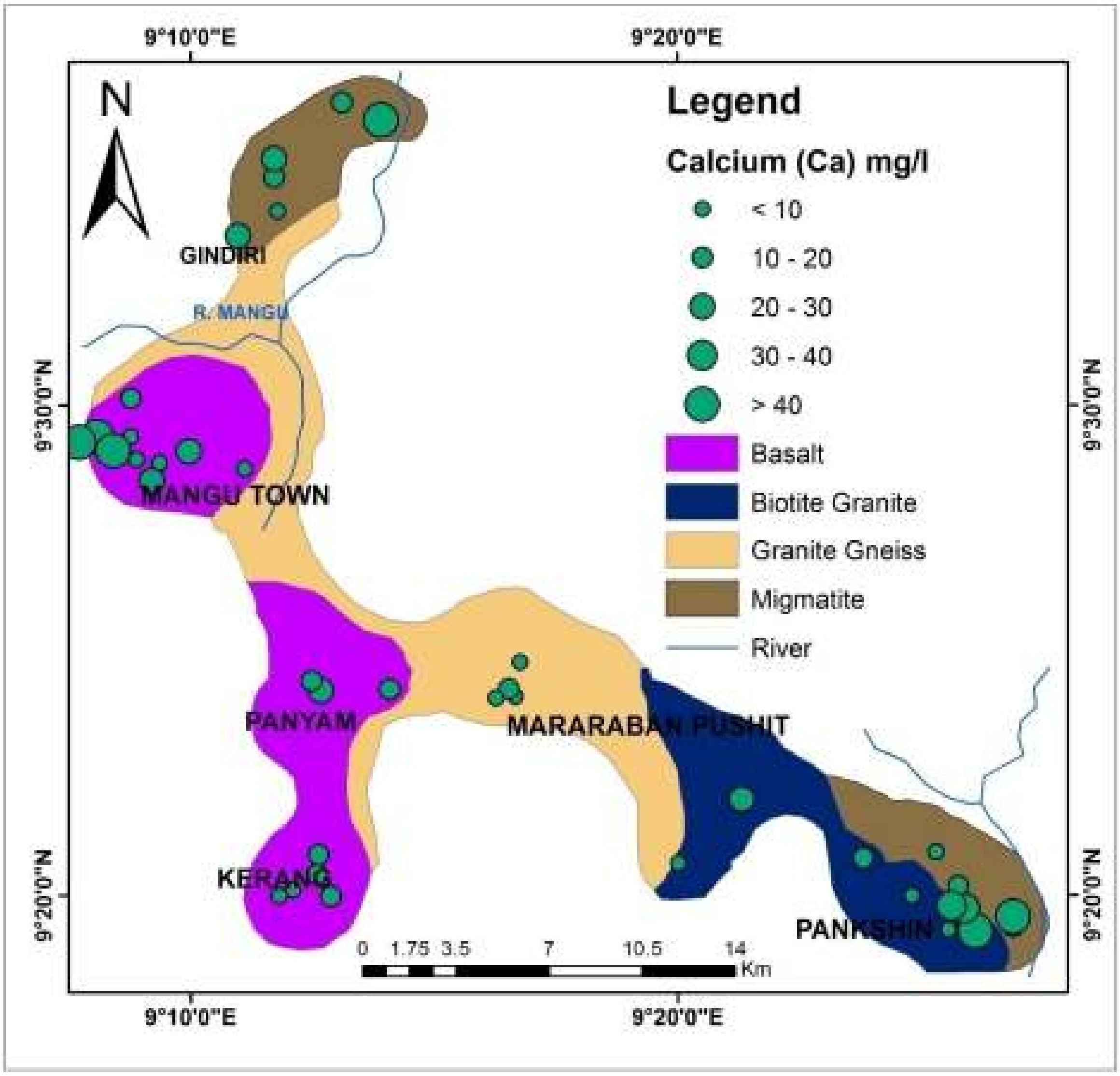

Figure 2: Distribution of calcium in the study.

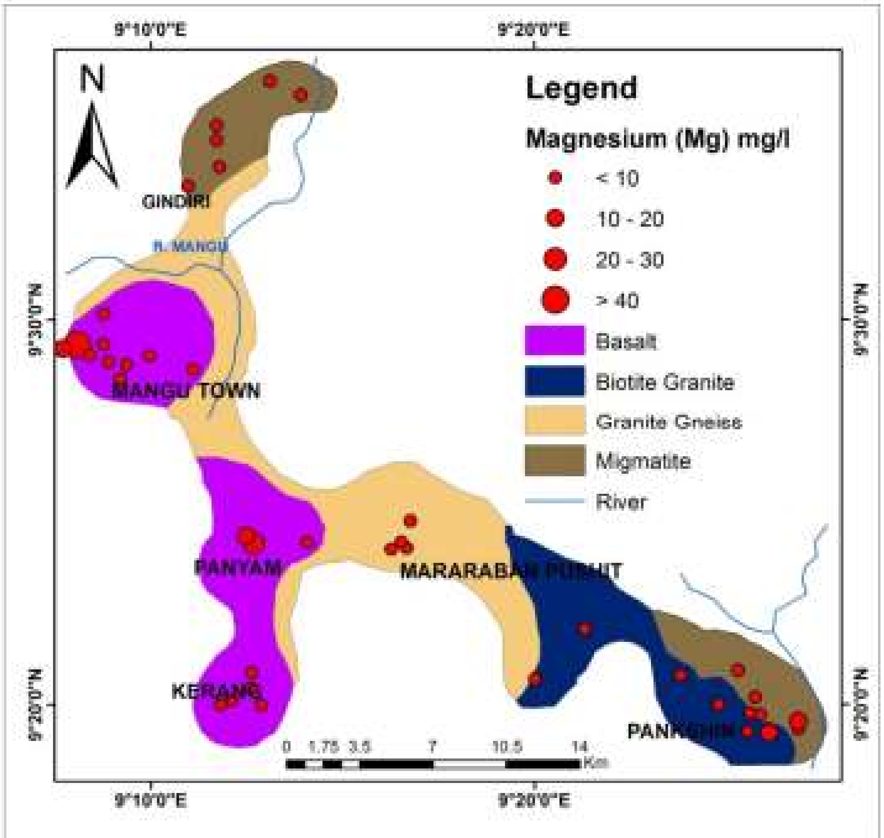

Figure 3: Distribution of magnesium in the study area.

The Basement Aquifer

Migmatite aquifer

The migmatite is located within parts of the northern region and the south western parts of the study area. Hydrochemical parameters for waters sampled in the migmatite aquifer are presented in Table 2.

Table 2: Hydrochemical parameters for waters sampled in the migmatite aquifer

Sample ID	Depth of Sampling	Ca	Mg	Na	K	Cl	SO4	HCO3	PH	TDS	Cond	T H
L 2	4.0m	15.86	2.60	15.73	2.07	7.18	8.5	58.58	6.1	136.94	168.74	50.16
L 3	6.4m	65.14	14.41	38.76	6.91	106.35	8	76.76	5.2	419.57	598.7	221.41
L 4	6.9m	37.43	1.01	7.38	7.29	14.18	9.5	74.74	9.3	186.79	238.5	97.35
L 5	3.1m	10.38	1.57	14.00	6.45	7.05	9	58.58	6.4	107.03	139.08	32.29
L 6	8.2m	9.61	0.83	8.62	4.23	14.18	11.7	48.48	6.3	84	105.58	27.33
L 7	3.5m	30.93	3.76	15.69	7.39	14.18	19.9	84.84	6.6	211.85	268.05	92.45
L 35	5.8m	12.49	1.89	16.86	2.01	7.09	11.7	131.3	5.9	149.34	166.85	38.85
L 36	5.8m	26.05	7.32	16.06	4.59	42.54	12.95	119.18	5.8	208.69	270.24	94.923
L 37	4.7m	18.91	5.04	12.07	3.59	35.45	16.6	105.04	6.1	152.66	201.9	67.77
L 38	5.7m	45.79	6.58	39.05	6.00	77.99	14.4	64.64	5.1	384.45	417.39	141.06
L 39	7.2m	4.96	0.73	3.38	4.70	28.36	32.6	44.44	5.4	40.17	64.35	15.34
L 40	7.5m	21.67	3.99	18.65	3.50	21.27	12.25	34.34	5.9	195.63	244.98	70.34

Obvious variations are seen for Ca, HCO_3 Cl, TDS, Conductivity and Total Hardness in this aquifer and no significant variations for the other ion (Table 2). Individual wells however, show variation in the content of the ions in different locations. Ca and Mg show no significant variations in the wells within the migmatite environment except for well L39 found within the premises of College of Education, Gindiri (Table 2) where lowest concentration for Ca (4.96 mg/l) and Mg (0.73 mg/l) are observed. Well L6 around Duk Pankshin also shows low Mg (0.83 mg/l) values. Na shows distinct variation in the wells in the migmatite. High Na (38.76) mg/l and (39.05) mg/l are recorded in well L3 and well L38 respectively in Pankshin and Mangu. However, the lowest Na (3.38 mg/l) value is in well L39 at Gindiri (Table.2). K and SO_4 show no significant variations in the wells within the migmatite environments.

Biotite Granite and Granite Gneiss Environment

Biotite granite covers the southern parts of Pushit and extends towards Pankshin area. Table 3 shows the chemical compositions of water in both the biotite granite and the granite gneiss environment. No significant variation in the concentration of Ca is observed in hand dug wells and hand pump boreholes within the biotite granite environment (Table 3). Ca concentrations falls within the range of 4.65-20.11 mg/l, however, well L1 in Pankshin area shows exceptionally high values of Ca (88.82 mg/l). Higher values are found towards the southeastern area around Pankshin(Fig 2). Other elements including Mg (14.07 mg/l), Na (94.56 mg/l), HCO_3 (185.04 mg/l), Cl (141.8 mg/l), and SO_4 (27.2 mg/l) are also high in this area (Table 3). Total Hardness is also higher in the Pankshin area as compared to the other areas. Soft water prevails in over 60% of areas in the biotite granite aquifer. Besides this extreme, no significant variation is observed in the elements in the hand pump boreholes and hand dug wells. Concentrations of Mg (0.2 mg/l), Na (3.5 mg/l) and Cl (7.09 mg/l) found in wells are the lowest in the area.

Table 3: Hydrochemical parameters for waters sampled in the Biotite granite and Granite gneiss aquifer

Sample ID	Depth of sampling	Ca	Mg	Na	K	Cl	SO4	HCO3	PH	TDS	Cond	T H
L 1	3.8m	88.82	14.07	94.56	28.05	141.8	27.2	105.04	5.80	744.5	938.39	279.05
L 8	4.2m	7.31	2.15	12.87	5.03	21.27	10.02	10.10	5.00	109.65	128.52	27.3
L 9	8.5	4.65	1.39	12.91	7.39	14.18	24.00	26.26	5.20	86.7	130.35	17.29
L 10	3.5m	14.99	0.20	3.51	4.14	7.09	11.70	50.50	5.90	92.13	120.64	38.14
L 11	8.0	7.30	2.39	6.35	5.49	21.27	9.40	64.64	5.40	100.37	118.45	27.99
L 12	7.5m	20.11	0.86	1.03	3.38	21.27	11.72	62.62	5.80	102.84	130.25	53.60
L 13	5.8m	2.23	0.28	2.09	2.67	7.09	10.4	20.20	6.30	31.62	37.56	6.70
L 14	4.1m	14.78	0.73	6.07	6.18	14.18	11.15	62.62	6.50	98.62	122.84	39.79
L 15	7.3m	4.73	0.33	1.15	2.34	7.09	11.72	22.22	7.60	34.24	43.01	13.13
L 16	6.3m	9.03	2.24	9.77	11.56	7.09	11.25	30.3	8.20	116.84	142.51	31.68

** Values for biotite granite in red

Granite gneiss covers northern part of Mangu town towards the western parts of Pushit. Ca (2.23 mg/l) and Mg (0.28 mg/l) found in well L13 around the Pushit area are the lowest within the granite gneiss environment (Table 3and Fig 1and 2). However, values of Ca in the range 12.5 – 16.5 mg/l dominate most of the granite aquifer, but no clear variation in the content of Mg (Fig.2). The southern eastern areas around Pushit have lower concentration compared to the areas around Mangu and Gindiri area. Areas characterized by hard water are less than 10% .Well L13 also has the lowest values of K (2.67 mg/l), HCO_3 (20.2 mg/l), Cl (7.09 mg/l), and SO_4 (10.4 mg/l) compared to other wells within the granite gneiss vicinity. Aside that, no significant variation occurs in the elements in wells in the granite gneiss environment (Table 4.6)

Volcanic Aquifer

The volcanic aquifer comprises of the central parts of the study area particularly Panyam and Kerang extending to some parts of Mangu. Hydrochemical parameters for waters sampled in the volcanic aquifer are presented in Table 4. Ca shows obvious variations in all the hand dug wells and hand pump boreholes sources. However, the well L31 at Mangu has the highest Ca value of 140.14 mg/l. In another point, Ca value in the borehole L29 in Mangu has the lowest value of 4.67 mg/l and also low values of Mg (0.96 mg/l), Na (8.26 mg/l), and K (4.58 mg/l).

The lowest Ca value of 3.52 mg/l is recorded in a hand dug well L23 at Fuvu Swan about 250m east of the Kerang Swan Water Factory. The water also shows low values of Mg (0.38 mg/l), Na (4.49 mg/l), and K (1.21 mg/l) (Table 4).

Table 4: Hydrochemical parameters for waters sampled in the volcanic aquifer

Sample ID	Depth of Samplin	Ca	Mg	Na	K	Cl	SO4	HCO3	PH	TDS	Cond	T H
L 17	1.5m	16.17	3.35	8.72	9.78	10.67	16.45	276.74	8.30	143.14	172.62	54.02
L 18	6.5m	28.83	22.56	53.26	6.24	14.18	18.50	242.40	7.70	409.57	471.74	164.45
L 19	6.5m	17.48	17.20	56.47	6.53	21.27	12.20	32.32	8.60	377.15	428.92	114.17
L 20	4.6m	19.80	4.75	26.15	5.98	49.63	10.40	36.36	5.10	184.71	282.11	68.81
L 21	3.4m	11.58	0.99	2.38	2.67	77.99	10.80	80.80	6.20	61.01	89.47	32.89
L 22	6.5m	7.51	3.17	7.87	6.56	35.45	10.45	44.44	5.40	85.09	114.78	31.71
L 23	8.6m	3.52	0.38	4.49	1.21	49.63	17.40	44.44	5.20	33.60	46.81	10.23
L 24	6.7m	11.71	2.02	11.47	7.36	49.63	14.65	78.78	5.20	104.84	147.12	37.45
L 25	6.1m	24.68	2.51	13.76	5.11	42.54	11.85	80.80	5.90	162.41	200.42	71.75
L 26	5.1m	9.62	0.80	33.68	8.20	49.63	10.60	76.76	5.60	169.29	230.16	27.24
L 27	4.6m	20.97	2.77	24.52	26.74	56.72	17.45	84.84	6.30	228.01	329.51	63.59
L 28	6.3m	6.31	3.36	15.45	4.56	14.18	11.00	72.72	5.90	97.58	141.45	29.50
L 29	8.0m	4.67	0.96	8.26	4.58	35.45	10.40	70.70	5.30	57.20	85.67	15.56
L 30	4.8m	9.12	0.26	1.21	4.97	7.09	17.70	46.46	5.70	47.42	70.10	23.77
L 31	3.2m	140.14	45.98	72.12	4.15	184.34	34.50	157.56	5.60	959.23	1199.4	538.06
L 32	1.6m	48.59	12.90	21.02	16.02	49.63	26.45	82.82	6.10	357.43	469.55	173.98
L 33	6.9m	50.70	6.35	52.21	23.25	85.08	16.00	58.58	5.20	412.19	562.26	152.34
L 34	4.8m	12.09	2.10	2.20	2.86	49.63	11.85	70.70	6.40	71.43	108.07	38.72

Mg and Na show distinct variations in the hand dug wells and hand pump boreholes in the volcanic environment but with no significant variations in K except in wells L27, L32 and L33 in Mangu area (Table 4). HCO_3 shows very little variations except were highest concentration of 276.74 mg/l is recorded in well L32 in Mangu town and also 157.56 mg/l in well L31. Well L31 also shows high concentration of Cl (184.34 mg/l) and SO_4 (34.5 mg/l). Apart from these wells (L31 and L32), Cl and SO_4 concentration show no significant variation. Mangu town has higher concentration of Ca with corresponding higher concentration of Mg (Fig 1 and 2). Higher Mg concentrations are however, restricted to the central areas between Kerang and Mangu town.

Calcium/Magnesium Molar ratio

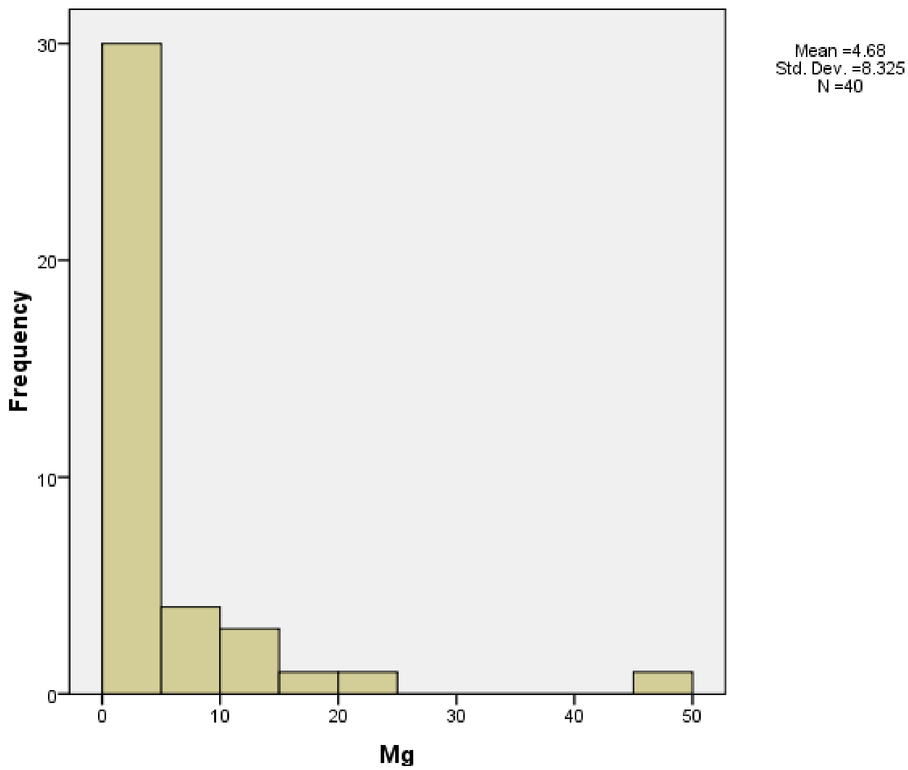

Fig 4: Histogram for Calcium in groundwater

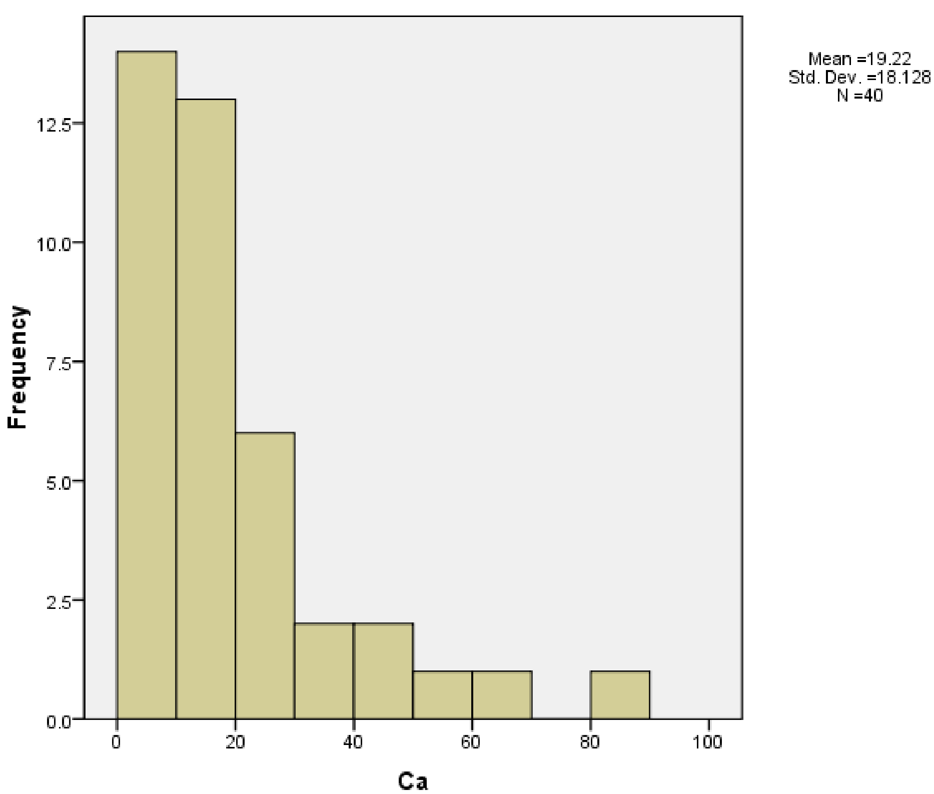

Fig. 5: Histogram for Mg in groundwater

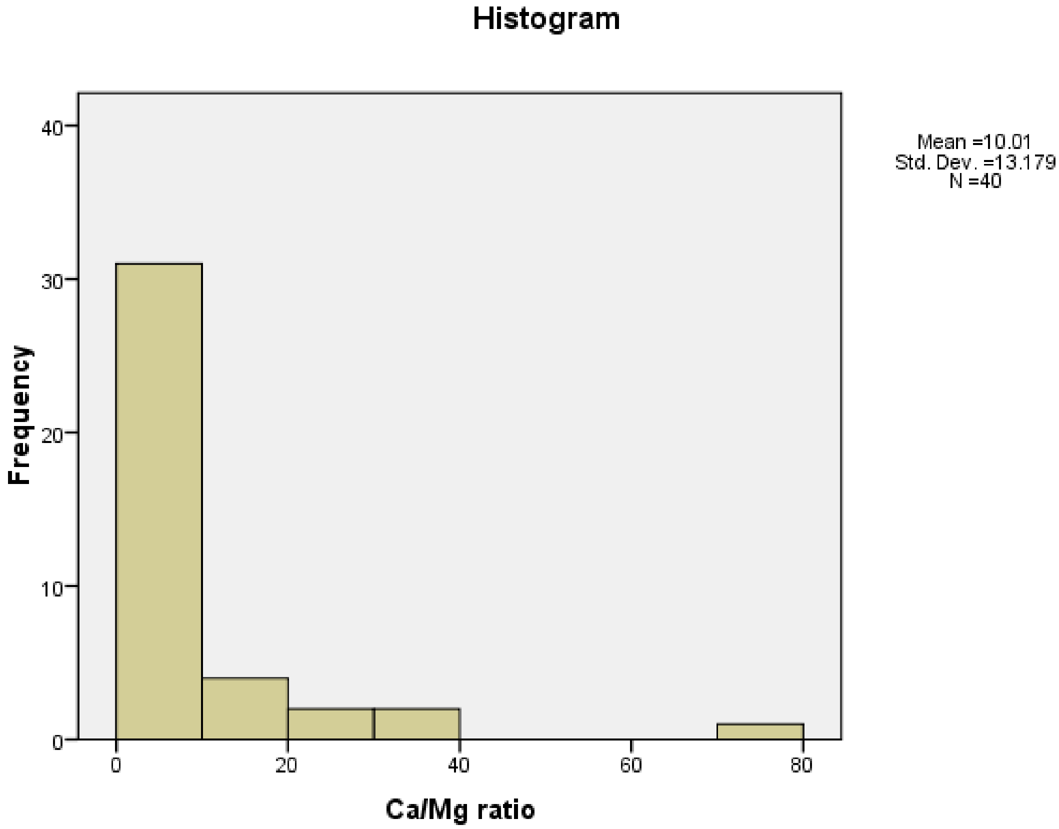

Fig 6: Histogram for Ca/Mg molar ratio

Groundwater Type

Groundwater types in the area (Fig 7) are dominantly of the Ca-Mg – HCO_3 and the Na-HCO_3-Cl. The Ca-Mg – HCO_3 water type constitute 77% in the basement aquifers (migmatite, biotite granite and granite gneiss and Na-HCO_3 and 14% and others 9%. In the volcanic environment, the Ca-Mg-HCO3 water type constitutes 56%, Na-HCO_3 water type 33% and others 11%.

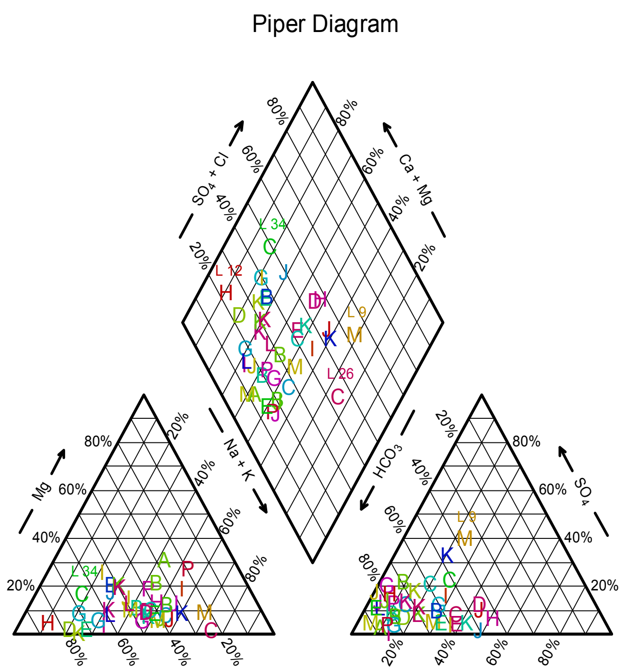

Figure 7: Piper trilinear diagram of the water types in the study area

Mineral Saturation Index

Modeling of mineral saturation index with the WATEQ4F (Ball and Nordstrom, 2004) (Fig 10) shows that 99% of the waters are both under-saturated with respect to both calcite and dolomite.

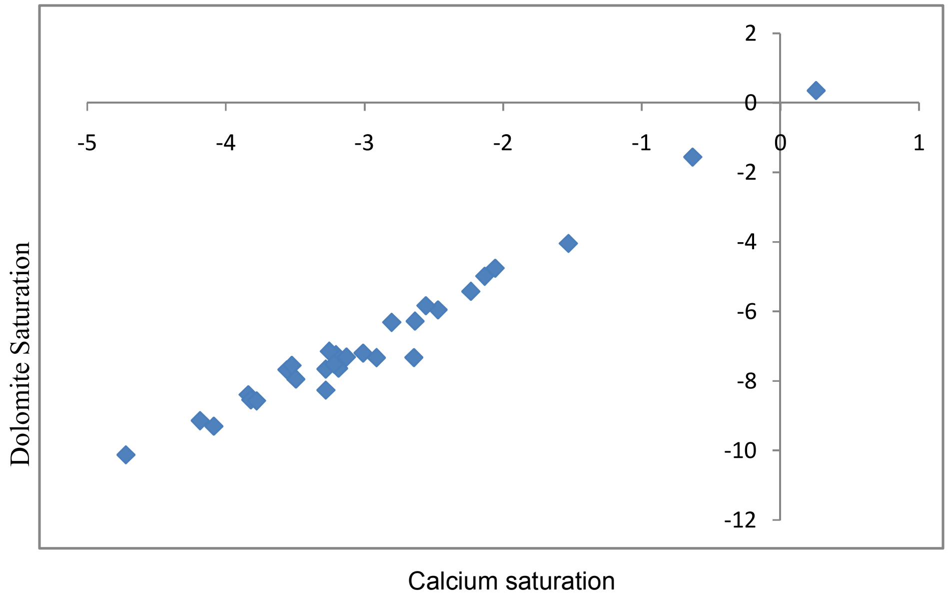

Fig 8: Calcium versus dolomite saturation index

Calcium and Magnesium in Foods

Calcium content of *zea may*s ranges from 299.43 to 340.06ppm and *sorghum* ranges from 291.18 to 323.16 with the highest value obtained at Pushit (Table 2).Contents of magnesium in *zea mays* and *sorghum* ranges from 1296.31 to 1482.40ppm and 1297.31 to 1500.06 ppm respectively (Table 2). Although, variation in the content of calcium and magnesium appear to be little in the villages, the Pushit grains show a marked difference.

Table 2: Concentration of Calcium and Magnesium in Grains consumed in the area.

S/No.	SAMPLE ID	Grain	Ca ppm	Mg ppm
1.	Panyam	*Zea mays*	334.39	1356.13
2.	Panyam	*Sorghum*	315.07	1381.99
3.	Pankshin	*Zea mays*	321.18	1341.01
4.	Pankshin	*Sorghum*	313.70	1313.26
5.	Mangu	*Zea mays*	299.43	1289.64
6.	Mangu	*Sorghum*	286.34	1297.31
7.	Pushit	*Zea mays*	340.06	1482.40
8.	Pushit	*Sorghum*	323.16	1500.06
9.	Gindiri	*Zea mays*	319.21	1310.39
10.	Gindiri	*Sorghum*	308.13	1348.16
11.	Kerang	*Zea mays*	302.28	1296.46
12.	Kerang	*Sorghum*	291.18	1318.07

DISCUSSION

Possible Sources of Calcium and Magnesium

No significant variations have been found in the distribution of both calcium and magnesium in water with respect to the rock types, except in some few isolated cases where elevated levels of calcium have been recorded. These isolated cases are located in densely populated areas which probably could be considered as input from anthropogenic sources. Since calcium and magnesium are lithophile elements that play an the environment (Jovic and Jovanovic, 2004), calcium may be leached into the groundwater of the area, from crystalline basement rocks. The minerals leaching these elements may be apatite, hornblende, epidote, biotite, tourmaline, magnesite and spinel (Clare and Rhodes, 1999). Magnesium may be leached into the groundwater from dark ferromagnesian minerals (olivine, pyroxenes and amphiboles). Lekmang in 2015 found out that, calcium rich minerals of the basement rocks (migmatite, granite gneiss and biotite granite) are the calcium – plagioclase feldspars and in the volcanic environment (calcium plagioclase feldspars, olivine and

rocks around Pankshin area are in contact with the anorogenic granites (syenite) rich in alkali feldspars (orthoclase) . The high calcium composition in southeastern part of Pankshin may be from the syenite.
In the study area, all the water points have been found to be under-saturated with respect to calcite and dolomite; hence removal of calcium from the water due to precipitation is not the reason for the low calcium in waters of the study area. The calcium species Ca^{2+} in the waters indicate near exact values of calcium in the waters since it constitutes 96% of calcium in the water.

Intake of Calcium and Magnesium in Drinking Water and Foods of the Study Area

In the study area with over 98% of water points having concentration of calcium in the range of 2.23 – 88.82 mg/l, calcium daily intake is grossly inadequate in both water and foods. However, taking into consideration what can be regarded as the optimal calcium level in drinking water (from health point of view) (Kozisek, 2005) which ranges from 40 to 80 mg/l, only well points L1, L3, L31, L32 and L33 constituting only 15% of the water points in the study area are within this range. The level of calcium in staple foods and in drinking water do not meet the recommended daily calcium requirements of 1000 mg/day (WHO, 2011) and thus inadequate.
Intake of magnesium in drinking water in the study area are also very low with only two water points (L18 and L31) within the range of 20 – 30 mg/l optimal level (Kozisek, 2005). The highest intake of 15 mg/l is around Mangu. Although magnesium levels in water is very low the staple foods compensate for the low values in water. Hence, daily intake of magnesium in the study area meets the requirement of 200-400mg/day. Foods consumed in the area may therefore serve as magnesium supplement for the low value in water of the study area .This suggests that magnesium is adequately consumed while calcium is not.

Possible Effects of Calcium and Magnesium on the Inhabitants of the Study Area.

Inadequate intake of calcium related diseases could probably be responsible for prevalence of the hypertension and diabetes earlier reported in the study area by Muthir in 2015, owing to the low intake of calcium in both food substances and in water. However, there may not be magnesium related diseases in the study area, with food substances having adequate daily recommended limit.

SUMMARY AND CONCLUSION

Four rock types, migmatite, biotite granite and granite gneiss and basalt make up the rock units of the area.
Sources of calcium and magnesium is from the calcium plagioclase feldspars (basement and volcanic rocks) and olivine and clinopyroxene (volcanic rocks)
Calcium and magnesium show no significant variations in the wells within the migmatite environment and granite gneiss environment,
Calcium daily intake is grossly inadequate in both water and foods but staple foods supplements the low values of magnesium in drinking water of the study area.
Although, direct correlation, could not be established between, the consumption of these minerals, in water and prevalence of diseases. Probably, inadequate consumption of the recommended levels of calcium in foods and water could contribute to prevalence of calcium diseases in the area in addition to other environmental or social factors.

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