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GROUNDWATER STUDY OF SOUTHWEST GWOZA (SHEET 114) BORNO STATE, NIGERIA

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Abstract
Hydrogeological mapping and water chemistry of Gwoza South-West (topographical sheet 114) of the crystalline basement complex at the foot of Mandara Hills in North-Eastern Nigeria was carried out. Rainfall data was collected from the area for a period of 16 years. Water table configuration map and direction of groundwater flow was produced. Chemical analyses and physical parameters of the water was determined using spectrophotometer, flame photometer, ph meter, and electrical conductivity meter. Semi urban water consumption per family per capita per day was determined using 20 households. A total of nine major ions (Ca^{2+}, Na^{+}, K^{+}, Mg_2^{+}, Cl^{-}, $S0_4^{2-}$, $N0_2^{-}$ and $HC0_3^{-}$) were analyzed. Results of the study indicate that the area experiences a moderately average rainfall of about 743mm per annum, depth to water table ranged between 2.6 – 18.8m and 0.1 – 18.2m at the peak of dry season and rainy season respectively and per capital daily water consumption per family, ranged from 9 litres to 76 litres. The values of major ions present in water indicate that it is fit for both human and animal consumption as they fall within WHO (1996) standard. Demand for water is highest in the dry season, when recharge is poorest.

Keywords: Hydrogeological mapping, water chemistry, groundwater flow, Gwoza, North-Eastern Nigeria

1. Introduction

Gwoza South-West (topographical sheet 114) forms part of the basement complex of North Eastern, Nigeria. It is bound by latitude 11.00° to 11.15° N and longitudes 13.03° to 13.8° E (Figure 1), covering an area of approximately 749 km^2.

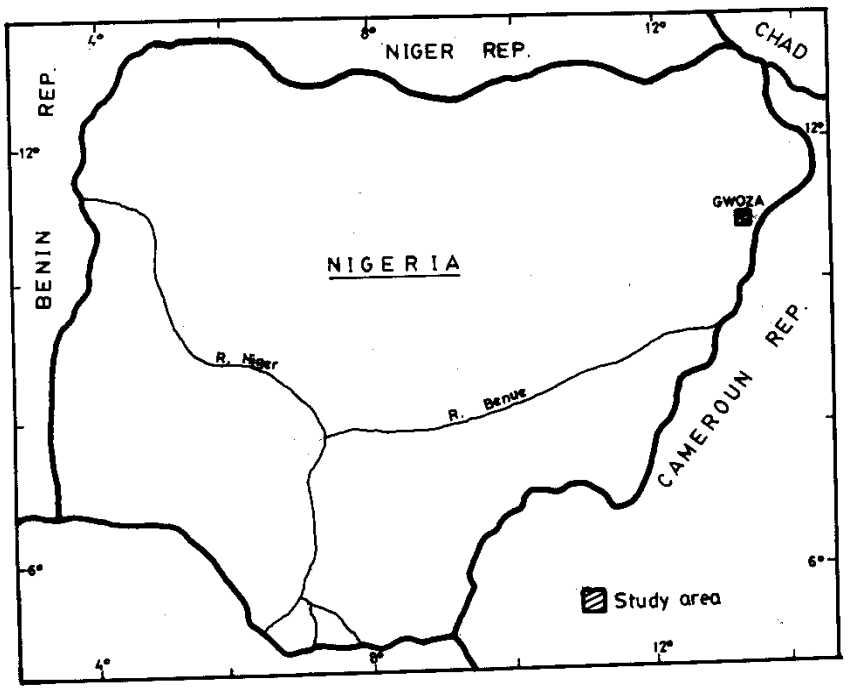

Figure 1: Map of Nigeria showing the study area

The study area is of the Sudan Savannah vegetation type with a typical wet season and dry season and moderate rainfall. The rainy season usually starts in March and terminates in October, while the dry season begins in October and ends in February. An average annual rainfall of 743mm is experienced in Gwoza area (Table 1).

Over the years successive Nigerian Governments have taken steps aimed at providing potable water and meeting one of the cardinal objectives of the millennium development goals. Despite such efforts, a large proportion of the population do not have access to water. Gowza is noted for scarcity of water especially during the dry seasons and so most researchers in the area tend to dwell more on aspects of hydrogeology with a view to contributing towards solving the problem.

The aim of this work was to assess the ground water resources of the study area with a view to determining the water level fluctuation between dry and wet season, water consumption rate and also to know the quality of the groundwater in the area.

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Table 1: Mean monthly rainfall, mm (1974 – 1989)

Month / Year	Jan	Feb	Mar	April	May	June	July	August	Sept.	Oct	Nov.	Dec.	*Annual Total*
1974	0.00	0.00	0.50	19.00	31.00	112.30	192.30	348.00	152.50	14.50	0.00	0.00	***870.10***
1975	0.00	0.00	0.00	26.90	50.80	137.90	275.80	359.90	183.10	59.20	0.00	0.00	***1093.60***
1976	0.00	0.00	0.00	26.40	55.40	304.00	187.20	126.50	191.30	0.00	0.00	0.00	***890.80***
1977	0.00	0.00	0.00	32.00	90.20	69.30	71.40	335.00	0.00	0.00	0.00	0.00	***597.90***
1978	0.00	0.00	0.00	19.30	55.90	115.10	399.80	245.60	47.00	17.30	0.00	0.00	***900.00***
1979	0.00	0.00	41.30	25.40	102.50	127.70	108.00	220.90	178.50	45.90	0.00	0.00	***850.20***
1980	0.00	0.00	0.00	0.00	106.40	74.60	276.90	183.40	70.40	10.81	0.00	0.00	***722.51***
1981	0.00	0.00	0.00	14.00	25.40	152.40	60.70	151.40	0.00	0.00	0.00	0.00	***403.90***
1982	0.00	0.00	0.00	33.50	45.50	69.25	177.75	189.25	69.50	0.00	0.00	0.00	***584.75***
1983	0.00	0.00	0.00	0.00	1.00	100.00	195.00	114.00	115.25	0.63	0.00	0.00	***525.88***
1984	0.00	0.00	0.00	0.30	41.29	62.09	284.57	146.27	202.56	0.00	0.00	0.00	***737.08***
1985	0.00	0.00	7.70	6.00	87.40	151.30	208.20	197.05	136.20	0.00	0.00	0.00	***793.85***
1986	0.00	0.00	7.00	0.40	0.00	109.20	283.60	284.60	127.10	2.00	0.00	0.00	***813.90***
1987	0.00	0.00	0.00	0.00	0.00	21.60	113.50	341.20	60.30	13.00	0.00	0.00	***549.60***
1988	0.00	0.00	0.00	12.10	30.41	110.60	190.50	416.85	92.72	0.00	0.00	0.00	***853.18***
1989	0.00	0.00	0.00	0.00	36.20	83.90	109.35	232.45	147.40	91.80	0.00	0.00	***701.10***
Mean	***0.00***	***0.00***	***3.53***	***13.46***	***47.46***	***112.58***	***195.91***	***243.27***	***110.86***	***15.95***	***0.00***	***0.00***	***743.02***
Minimum	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***21.60***	***60.70***	***114.00***	***0.00***	***0.00***	***0.00***	***0.00***	***403.90***
Maximum	***0.00***	***0.00***	***41.30***	***33.50***	***106.40***	***304.00***	***399.80***	***416.85***	***202.56***	***91.80***	***0.00***	***0.00***	***1093.60***

Source: Ministry of Agriculture, Borno State

2. The study area

2.1 General geology of Mandara hills

The geology of Gwoza South-West (topographical sheet 114) belongs to the precambrian basement complex of Nigeria located between the Congo craton and the West African craton. The area is essentially composed of granitic rocks, meta-igneous and meta-volcanics (Islam and Baba, 1990). The undifferentiated basement rocks form the oldest rock units and are also precambrian in age (Grant, 1971). The older granites which are the most widespread rock units in the area occur as basic, intermediate or acid intrusive (Turner, 1964), with varying textures from medium-coarse-grained and sometimes porphyritic (Figure 2). Minor rocks in the area include dolerites, pegmatites, rhyolites and mylonites (McCurry, 1976). Sani (2005) classified the rocks around Amdaga as coarse-grained granites contrary to the earlier migmatite-gneiss and quartzites mentioned by Islam and Baba (1990).

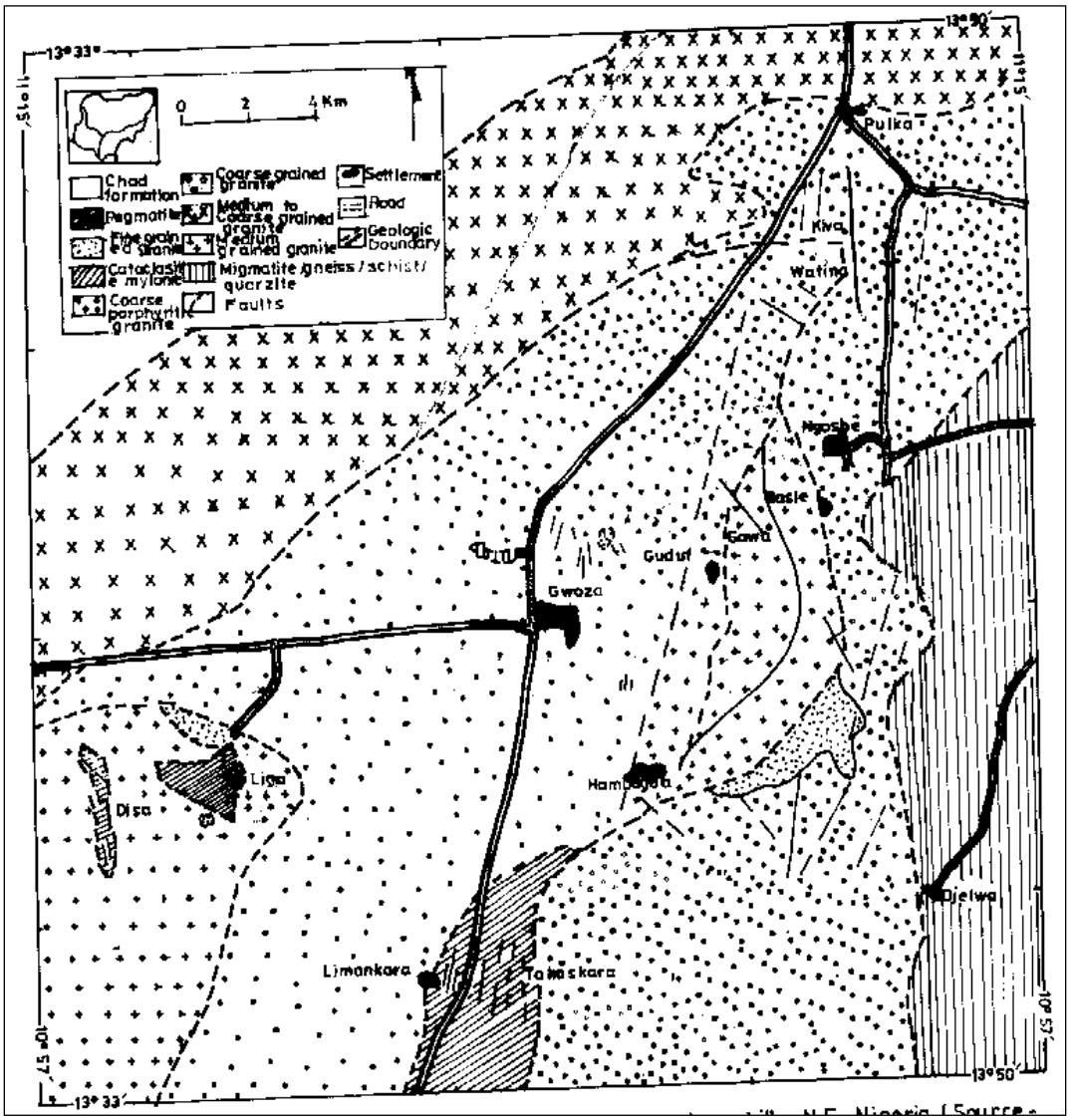

Figure 2: Geological map of Gwoza South-West (modified from Islam and Baba, 1990)

2.2 Hydrology and hydrogeology

Three surface water types occur in Gwoza, namely perennial, seasonal and ephemeral streams (Figure 3).

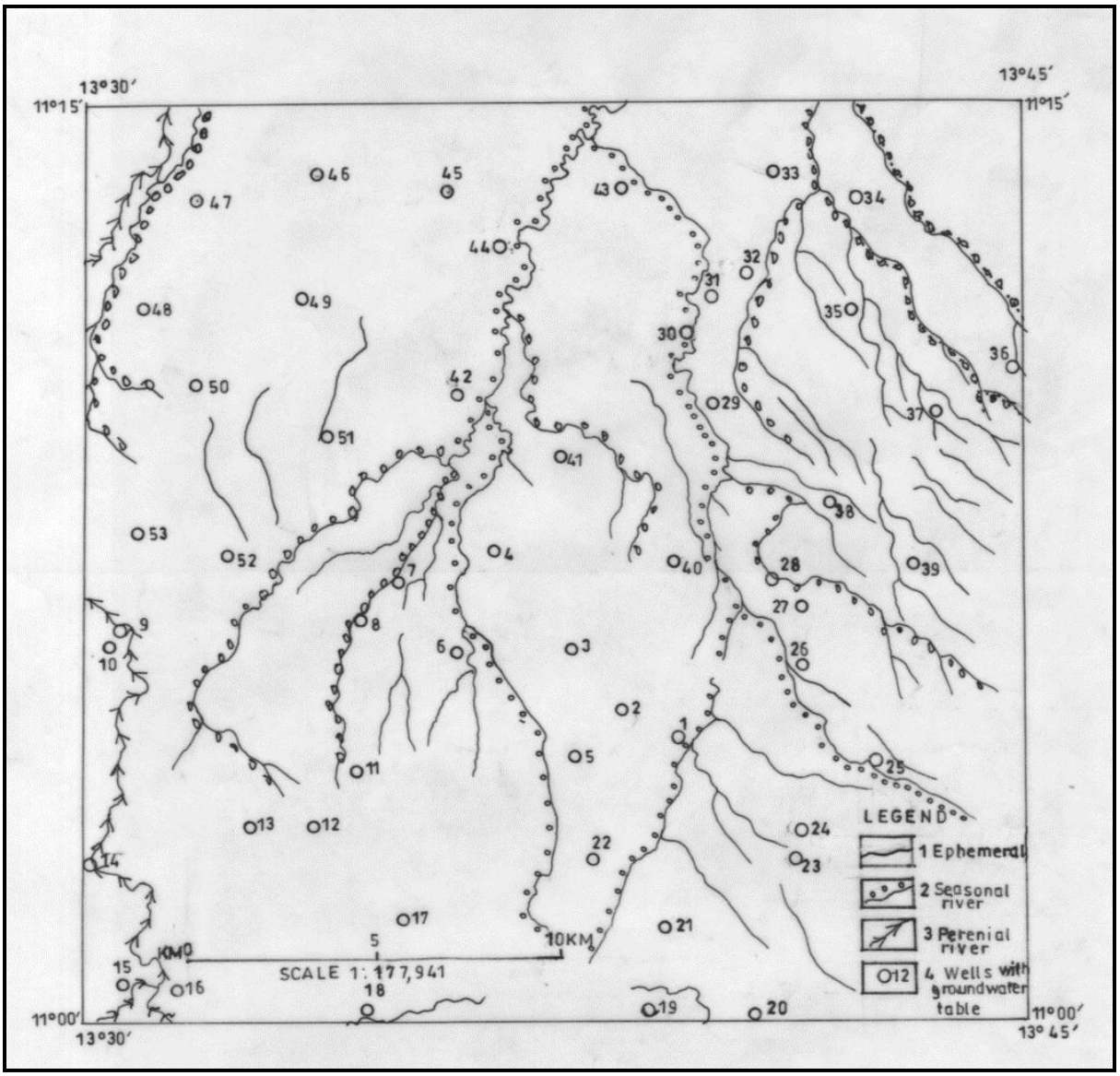

Figure 3: Distribution of principal streams in the study area and sample location

Two perennial rivers, which flow all year round, have been noted to be those of Yamtake and Dangalang. Though flowing all year round, the volume of such streams tends to decrease profoundly in the dry season. The seasonal streams include Baladagwa, Ganiyo, Luhva, Zambala and Lokodisa which flow only for a short period especially at the peak of rainy season (July-September) and cease thereafter. The Wala and Limankara streams are ephemeral in nature as they flow for few hours after a heavy down pour and cease immediately the rains stop.

Hydrogeologically, two distinct aquifer types have been noted in Gwoza area. These are the soft over burden (regolith) and the fractured basement aquifers. Only few wells exploit the fractured

basement aquifers. Water is exploited mostly from the soft overburden aquifers through hand-dug wells and wash bores. The soft over burden aquifers vary in thickness from 1m to a maximum of 40m in places (Figure 4), depending on local geology, topography and climatic condition.

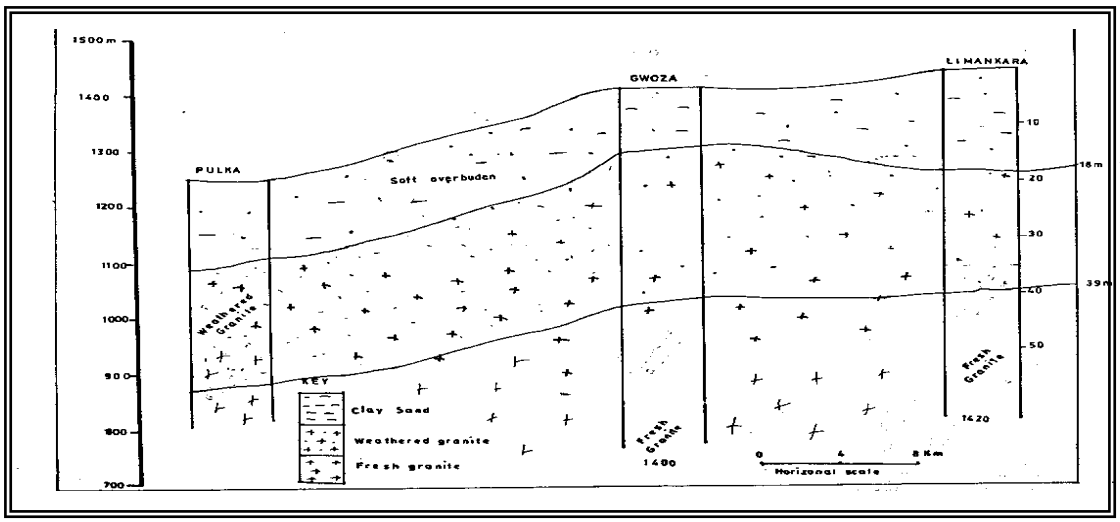

Figure 4: Borehole correlation in the study area

Typically, the water table occurs at a depth ranging between 3 – 18m (Table 2). Boreholes are few in the study area, with only 3 functional at the time of this investigation, and yields ranging between 0.11 l/s to 5.0l/s. Groundwater recharge is mostly through rainfall passing through the unsaturated zones. Recharge during the dry season is minimal coming mostly through the perennial streams of Yamtake and Dangalang.

3. Methodology

The hydrogeology mapping involves repeated water level measurements from 53 hand-dug wells and 5 bore holes using water level indicator. These measurements were undertaken at the peak of dry season and wet seasons. Data obtained from such measurement is used in the construction of water table configuration map.

Twenty households were randomly selected covering high and low income earners and semi-urban water consumption per family per capita was calculated. A total of 20 representative water samples were collected from 15 hand-dug wells and 5 boreholes in airtight plastic containers, sealed and taken to the water laboratory of the Borno State Water treatment plant for Chemical (major ion) analysis. The chemical analysis involved the use of spectrophotometer; flame photometer and titration analytic techniques while physical parameters such as pH, total dissolved solids (TDS), and electrical conductivity (EC) were measured on the spot in the field.

Rainfall data over a period of 16 years were collected from the Borno State Ministry of Agriculture. These data were used to calculate the mean annual rainfall for the period in question.

4. Results and discussion

Since groundwater is not chemically pure, its chemical analysis is of paramount importance to determine its usefulness for domestic, industrial and agricultural purposes. Results of major ions from 15 hand-dug wells and 5 boreholes as presented in Table 2 (a, b and c) show that the concentration of Ca^{2+} and K^{+} ranges between 7- 31.0 mg/l and 3.42 – 1 mg/l respectively. The concentration of Fe^{2+} ranges between 18 – 67 mg/l SO_4^{2-} and Cl^{-} concentration ranged between 0.1 – 9.2 mg/l and 3.7 – 11.3 mg/l/ NO_{3-} concentration ranged between 5.0 – 19.2 mg/l. From the above result, it is observed that the cation concentration values are generally low compared to the WHO (1996) standards. The anions on the other hand have a variable concentration values with some falling below and only HCO_3^{-} being above the WHO (1996) standards. Typical amongst such anions are Cl^{-}, NO_3^{-} and SO_4^{2-} whose values in wells 6, 10, and 26 falls below the WHO (1996) standards while HCO_3^{-} values in same wells were above the WHO (1996) standards possibly due to CO_2 charged recharge.

Table 2a: Results of water quality analysis for well numbers 38, 36, 39, 50, 25 and 28

Physical parameter	Well 38	Well 36	Well 21	Well 39	Well 50	Well 25	Well 28
Sampling date	12/11/03	12/11/03	12/11/03	12/11/03	15/11/03	15/11/03	15/11/03
Locations	Luhva	Warabe	Uvaha	Fatchekwe	Sasawa	Graveyard	G.S.S
Type of well	Cement	Cement	Hand pump	Cement	Cement	Cement	Cement
Depth (m)	15	16.9	39.3	15.2	14.8	16.2	16.4
Tempt (^oC)	31	29	29	30	31	30	29
pH	6.9	7.2	6.6	7.3	6.3	6.9	6.9
E.C µs/cm	272	278	369	461	713	314	326
T.D.S	148	150	210.5	268	397	181	186
Chemical parameter (mg/l)							
Ca^{+}	28.0	31.0	19.0	23.0	21.0	25.0	23.3
Mg^{+}	14.0	12.0	7.9	19.0	13.5	15.0	11.2
K^{+}	8.0	6.0	4.40	9.40	11.0	8.6	3.42
Na^{+}	0.02	0.55	0.12	0.48	0.82	0.03	0.45
HCO_3^{-}	39	25	28	32	40	23	45
Cl^{-}	4.2	4.0	3.70	11.0	5.0	9.20	6.6
NO_3^{-}	11	19.2	13	16.2	15.4	11.0	15
SO_4^{2-}	9.20	0.2	3.4	0.1	2.0	4.0	0.6
Fe^{2+}	0.12	0.30	0.06	0.8	0.26	0.18	0.07

Table 2b: Results of water quality analysis for well numbers 10, 7, 29, 32, 26, 37 and 15

Physical parameter	Well 10	Well 7	Well 29	Well 32	Well 26	Well 37	Well 15
Sampling date	15/11/03	15/11/03	18/11/03	18/11/03	18/11/03	18/11/03	23/11/03
Locations	Yamtake	Lokodisa	Amdaga	Balazala	Gz Wakane	Wala "B"	Gatha
Type of well	Cement	Cement	Cement	Cement	Hand pump	Cement	Cement
Depth (m)	4.6	12.1	6.4	17.2	33	15.1	4.4
pH	6.9	6.8	6.7	6.8	7.0	7.1	7.7
Tempt (^oC)	29	29	29	30	30	29	30
E.C µs/cm	326	186	161	326	188	211	571
T.D.S	105	81	184	108.6	141	125	319
Chemical parameter (mg/l)							
Ca^+	30	24	17	7	19.0	19.0	24
Mg^+	17	15.7	19.4	9.90	1.3	11	9
K^+	8	11	7	4	6.4	8.2	11
Na^+	0.05	0.28	0.58	0.32	0.29	0.98	0.10
HCO_3^-	54	28	33	42	55	23	18
Cl^-	7	5	4.4	3.9	4.7	5	8.50
NO_3^-	10	14	9	14	8	13	11.7
SO_4^{2-}	0.7	4.9	3.4	1.4	0.9	6.2	4.1
Fe^{2+}	0.13	0.02	0.24	0.10	0.08	0.19	0.32

Table 2c: Results of water quality analysis for well numbers 24, 23, 19, 6 and 18

Physical parameter	Well 24	Well 23	Well 19	Well 6	Well 18
Sampling date	23/11/03	23/11/03	23/11/03	23/11/03	23/11/03
Locations	Hambagda	Hudugum	Limankara	Fadagwe	Disa
Type of well	Cement	Hand pump	Hand pump	Cement	Hand pump
Depth (m)	16.8	32.4	36.1	8.2	4.4
PH	6.7	6.9	6.6	7.1	6.7
Tempt (^oC)	30	30	30	29	30
E.C µs/cm	214	470	445	240	190
T.D.S	240	190	445	382	421
Chemical parameter (mg/l)					
Ca^+	26	21	21	13.9	12
Mg^+	8.2	6	19.10	8.4	11
K^+	5	7.4	14	11	3.5
Na^+	0.04	0.12	0.82	0.30	0.53
HCO_3^-	27	40	38	67	52
Cl^-	9	5.30	9	11.3	6.5
NO_3^-	7.7	5.0	13.6	16	14
SO_4^{2-}	7.7	5.0	6.4	3.1	2.4
Fe^{2+}	0.09	0.04	0.10	0.14	0.25

The concentration of Fe^{2+} in wells 15 and 36 with values of 0.3mg/l and 0.32mg/l respectively, thereby falls within the WHO (1996) standard value for Fe^{2+} which is 0.3mg/l. Physical parameters (Table 2) gave a temperature of between 290 – 310^{o}C, a pH of between 6.3 – 7.7, an E.C of between 161 – 713 and a TDS of 81 – 445. Most of these physical parameters fall within WHO standards of (1996) permissible limit. Semi urban water demand calculated from 20 households (Table 3) indicates that the daily water consumption per family ranged between 9 – 76 liters per capital daily consumption with an average of 28 liters per family per capital daily water consumption, for family sizes varying from 4 – 32 people. From this data, it can be deduced that the demand for water is highest in the dry season and that high income households consume more water than their low income counterparts. This may be attributed to the availability and affordability of domestic livestock such as cows, goats and horses.

Groundwater recharge in the area was mainly through precipitation with contribution from ephemeral and seasonal streams identified in the study area. During the dry season, the only source of recharge which is minimal comes from the perennial streams of Yamtake and Dangalang (Fig. 3). Water table measurements show that the depth to the water table at peak of wet season ranged between 0.1 – 18.2m, but during the dry (peak) season, the depth ranged between 2.6 – 18.8m which was not quite different from the rainy season values. The dry season months are a period of low water table as a result of cessation of rainfall and lack of recharge to the groundwater (Table 4). Though two distinct aquifer types (soft overburden and fractured basement) exist in the area, most households depend largely on wells and wash bores sunk within the regolith (soft overburden) aquifer, providing more than 95% of water use in the year.

The rock-water interaction and human activities in the area pose no threat of polluting the aquifers as most of major ions analyzed does not show evidence of a major deviation from the WHO standard but this is subject to further research and confirmation.

Table 3: Family size, source of water and daily consumption

S/No	Name of household head	Family size	Water source	Consumption (l/day)	Per capita consumption (l/day)
1	Alh. Adamu Ndawoyo	21	Open well	929.1	44.2
2	Abdullahi Kanti	5	Open well	79.6	16
3	Abubakar Ahmadu	5	Open well	79	15.2
4	Adamu Ngoshe	32	Water tanker	1080.5	33.8
5	Dr. Dahiru	5	Water tanker	272.5	48.5
6	Ali Abba	6	Pipe water	122.4	20.4
7	Buba Wahe	17	Water tanker	908	53.4
8	Sani Lumbuda	9	Water tanker	464	51.6
9	Alh. Gana Dahiru	5	Pipe water	146.1	29.2
10	Umaru Usman Lumbuda	10	Open well	462	46.2
11	Umaru Mbada	12	Open well	127.2	10.6
12	Musa Idrisa Gupa	11	Water tanker	317	28.8
13	Mohd Lamido Chudel	4	Open well	129.5	32.4
14	Alh. Hammajulde	16	Open well	372	23.3
15	Musa Usman	9	Water tanker	177.6	19.7
16	Alh. Bello Tada	17	Open well	262.8	15.5
17	Ishaku Audu	9	Open well	252	28
18	Aishatu Hamba	8	Open well	72	9
19	Buba Ahmadu Jama	10	Open well	153	15.3
20	Idrisa Ahmed	9	Water tanker	681	75.7
	Total	**220**		**7087.3**	**32.2**

Table 4: Depth to water table at the peak of dry and wet season for study area

Well identification number	Location of the wells	Co-ordinates of the wells and date of construct	Depth of water table below ground surface (m)		Time of measurement for Dry and wet season	Date of measurement for dry and wet season	Source description	Well elevation(Ft)	Elevation of water Above sea level (Ft)	
			Dry season	Wet season					Dry season	Wet season
1.	Farm center	$11^0$04.698'N $13^0$39.400'E (1972)	5.0	1.0	6.35am 7.15am	3-4-2002 4-8-2002	Concrete lined with Diameter 2.1m	1285	12825	1281.7
2.	Fadagwe Fulani	$11^0$05.003'N $13^0$38.437'E (1982)	10.2	1.5	6.45am 8.20am	"	Concrete lined with diameter 2.4m	1265	1231.5	1260.1
3.	Fadgwe Bulama Shatu (1)	$11^0$06.154'N $13^0$37.643'E (1984)	8.1	0.9	6.5am 8.40am	"	Concrete with diameter 2.2m	1245	1218.4	1242.1
4.	Fadagwe Bulama Shatu (2)	$11^0$07.843'N $13^0$36.447'E (1992)	8.4	0.6	7.05am 9.00am	"	Concrete lined with diameter 2.2m	1205	1177.4	1202
5.	Fadagwe Sterling	$11^0$04.308'N $13^0$37.526'E	7.2	1.3	7.15am 9.34am	"	Concrete lined with diameter 2.3m	1296	1272.4	1291.7
6.	Fadagwe Mumi	$11^0$06.117'N $13^0$35.928'E (2000)	2.6	0.9	7.30am 10.05am	"	Concrete lined with diameter 2.2m	1238	1213.1	1235
7.	Lokodisa Gwaigwai	$11^0$06.442'N $13^0$34.167'E	5.9	4.7	7.45am 10.28am	"	Concrete lined with diameter 2.3m	1224	1204.6	1209.6
8.	Lokodisa Nahe Suno	$11^0$07.204'N $13^0$34.974'E (1998)	6.4	3.1	7.55am 10.54am	"	Concrete lined with diameter of 2.1m	1242	1221	1231.8
9.	Yamtake Ajiya	$11^0$06.444'N $13^0$30.513'E (2002)	4.6	0.4	8.5am 11.08am	"	Concrete lined with diameter of 2.1m	1247	1231.9	1245.7
10.	Yamtake Wasani	$11^0$06.333'N $13^0$30.476'E	8.5	2.9	8.05am 11.20am	"	Concrete lined with diameter 2.1m	1245	1217.1	1235.5
11.	Sabongari Zalidva	$11^0$04.144'N $13^0$34.306'E (1979)	8.8	4.2	8.20am 11.50am	"	Concrete lined with diameter 2.3m	1326	1297.1	1312.2
12.	Gavva West	$11^0$03.163'N $13^0$33.578'E	9.8	4.7	8.35am 1.05pm	"	Concrete lined with diameter	1360	1327.8	1344.6

5. Conclusions

This study has confirmed the existence of 2 aquifer types namely; the soft overburden and the fractured basement, with the former providing most of the water requirement in the area. Physical parameters and chemical analysis of water in Gwoza area shows that it is fit for human and animal consumption as it falls within the WHO (1996) standard for drinking water.

Semi-urban water consumption show a high demand in the dry season, and that high income household consume more water than low income households. The dry season months are a

period of poor recharge. In addition, a more collaborative approach by way of detail geologic, hydrogeologic, hydrologic and hydrogeochemical study be carried out in the area.

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