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Assessment of Water Quality Index for the Groundwater in Gombe and Environs, North-east Nigeria.

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Abstract: *The study is aimed at assessing the water quality index (WQI) for groundwater in Gombe and Environs. WQI, a technique of ratingwater quality, is an effective tool to assess spatial and temporal changes in groundwater quality. This has been determined by collecting 50 groundwater samples from bore holes and hand dug wells and subjecting the samples to comprehensive physicochemical analysis. The following 15 parameters were considered for calculating WQI: Sodium, potassium, calcium, magnesium, chloride, bicarbonate, Sulphate, nitrate, iron, pH, Total Hardness, Conductivity, fluoride, and phosphate. The values of WQI of the samples were found in the range of 38.5 to 67.52. The majority of groundwater samples fall in good category (66%) others fall in excellent category (44%) indicating groundwater is fit for drinking purposes.*

Key Words:*water quality index, groundwater, physicochemical analysis and parameters.*

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I. Introduction

Water is the primary need of every living thing on this planet earth which is essential for sustaining life. Groundwater is that water found within the saturated voids beneath the ground (Abdulrahman*et al*., 2017). The source of groundwater is chiefly from precipitating atmospheric moisture which has percolated down into the soil and subsoil layers. Groundwater is used for domestic and industrial water supply and irrigation all over theWorld. The assessment and determination of groundwater quality for human consumption is important forthe wellbeing of the ever increasing population (Ishaku, 2011). Good quality water will enhance the sustainability of socio-economic development,bysignificantly bringing down government’s expenditure towards combating outbreaks of water borne diseases due to consumption of contaminated groundwater. Groundwater quality is mainly controlled by the range and type of human influence as well as geochemical, physical and biological processes occurring in the ground (Zaporozec, 1981; Carter et al., 1987). Groundwater quality depends, to some extent, on its chemical composition (Wadie and Abduljalil, 2010) which may be modified by natural and anthropogenic sources. Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater due to waste disposal practice, especially in urban areas.According to WHO, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it.

Water quality index (WQI) is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of groundwater. WQI is defined as a rating reflecting the composite influence of different water quality parameters.The concept of WQI to represent gradation in water quality was first proposed by Horten, 1965. It is calculated from the point of view of the suitability of groundwater for human consumption.

The objective of the present work is to discuss the suitability of groundwater for human consumption based on computed water quality index values.

II. Study Area

Gombe and environs is the study area. It is located in the northeastern part of Nigeria and it lies between longitudes $11^0$7'0''E to $11^0$14'0''E and latitudes $10^0$15'0''N to $10^0$21'0''N (Fig 1), and covers an area of about 136.08km^2. The study area falls within the tropical continental climate zone. It is characterized by two seasons; a rainy season, which starts in May and ends in October and the dry season, which normally spans between October and April. The rainy season is the period when tropical maritime air mass travels northwards over the study area from the Gulf of Guinea.

The mean annual rainfall is 1015mm for Gombe where the study area is situated while the dry season is characterized by an arid wind or tropical continental air mass originating from the Sahara Desert. During the period, there is little cloud cover and the temperature ranges from 14^0C – 32^0C. The study area is mainly classified as a Sudan savannah region, which is characterized by grasses, shrubs and trees with large trunks. The grasses dry and trees shade off their leaves during dry season and flourish again when wet season returns.

The topography of the area is generally hilly with some parts having elevations more than the other surroundings. The elevation ranges from about 400m to 600m (Fig 1). The outcrops generally consist of rocks which are made up of sandstones. Surface drainage systems in the study area comprise numerous streams formedinthedirection of the river basin towards the southeast.Most ofthestreamsareseasonaloverflowingtheirbanksduring rainy season.

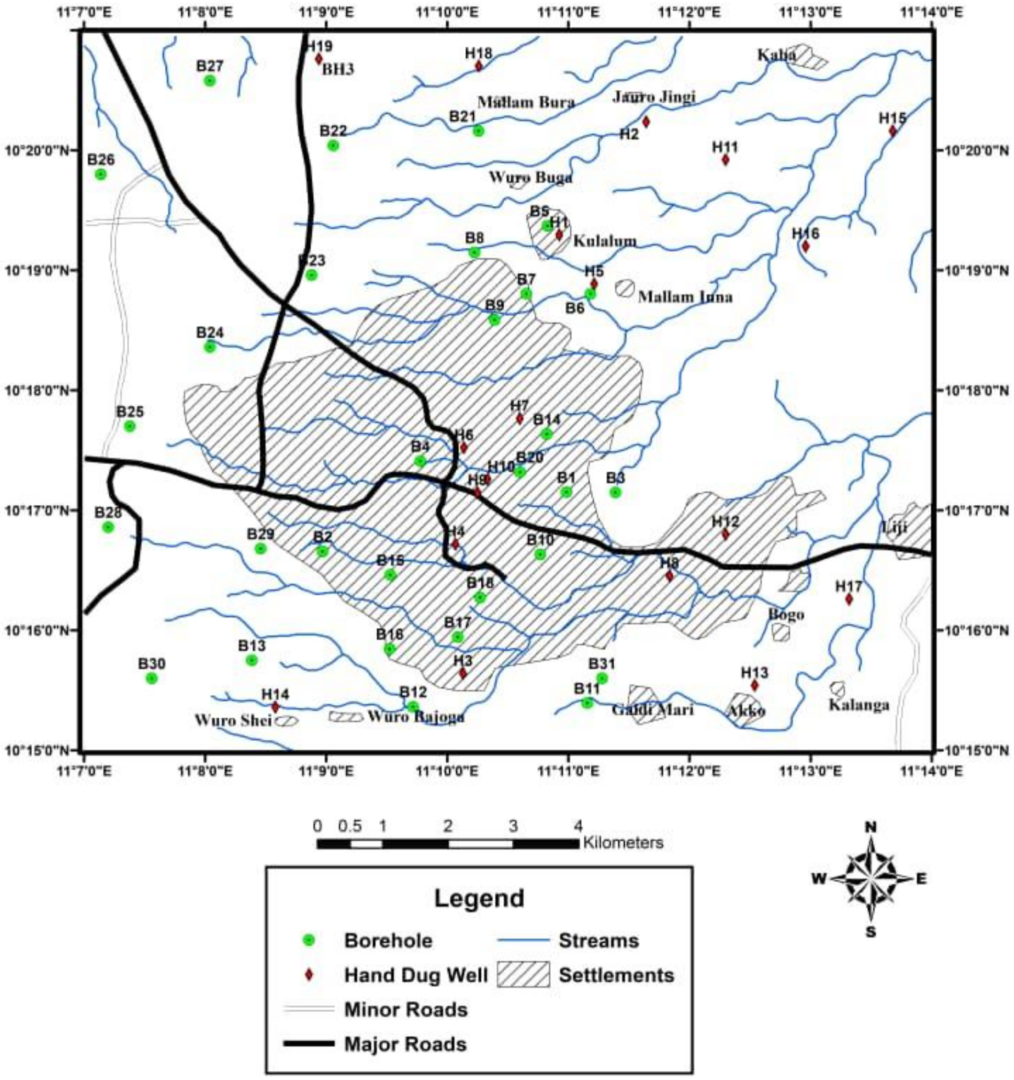

Fig: 1 Topographic map of the study area showing groundwater sampling points.

2.1 Geology of the study area.

The study area is underlain by Pre Cambrian Basement Complex rocks and Cretaceous sediments. The basement Complex rocks are represented by Diorite and Granites while the Cretaceous sediments are represented by Bima, Yolde, Fika and Gombe Formations (Fig. 2). Field studies indicate that the rocks in the area were subjected to a wide range of tectonic disturbances involving Faulting. The orientation of the fault is mainly trending NW-SE.

The cross section A-B (Fig. 2) indicates that from the oldest to recent, the area constituted Basement rocks, Bima Formations, Yolde Formation, Fika Shales and then Gombe Formation.

The Bima Sandstone, a continental formation, is the basal part of the sedimentary successions in the study area. It lies unconformably on the Precambrian Basement Complex. It ranges in age from Upper Aptian to Lower Albian (Allix*et al*., 1981). The sediments consist of poorly sorted, angular, highly arkosic pebbly sandstones, granulestones and pebble conglomerates (Zarborski*et al.*, 1997).The Yolde Formation is indeed a transitional sequence between continental Bima Formation and the marine deposits of the lower part of Pindiga Formation (Fika Shales). The lower portion of Yolde Formation consists of sandstone-mudstone whereas the upper portion represents thinly and regularly bedded bioturbated sandstones. The exposure of Fika shales mostly revealed shaly mudstones. Dark grey when fresh but weathered to lighter blue-green to grey colour. Gombe Formation consist of pebbly coarse grained sandstone with indistinct cross bedding. In the lower part the sandstones are fine to medium grained and generally show tabular cross bedding which is highlighted by layers and streaks of white sandstone.

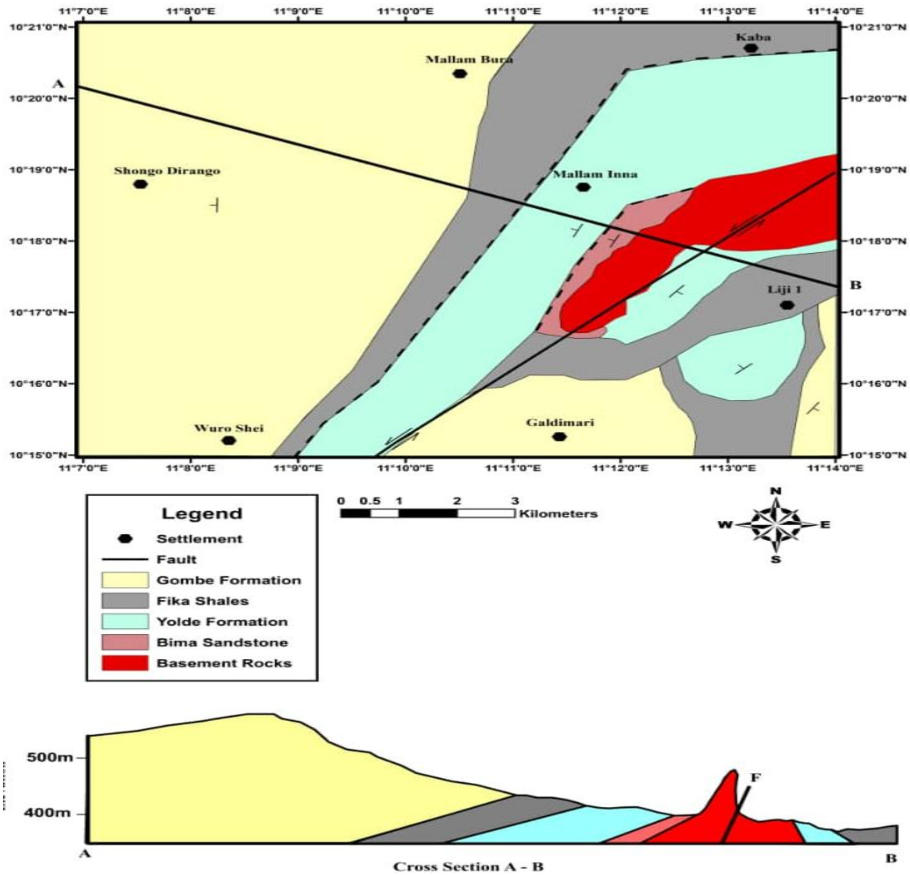

Fig 2 Geologic Map of the study area

III. Materials And Method

A total of 50 groundwater samples from hand dug wells and boreholes were collected (Fig. 7) in a container that was rinsed two to three times according to Barcelona *et al.* (1985) method using the representative ground water samples.The position of boreholes and hand-dug wells were determined using GPS (Model Garmin eTrex HC Series), and later transferred to the base map of the study area (Fig 1). Immediately after sampling, field parameters such as: pH and Temperature were measured using Pen PH and Temperature meter (Model CT6021A), Turbidity was measured using Hand held turbidity meter (Model HAUX 2100Q), Conductivity was measured using Pen Conductivity meter (Model CT 3030), and Total Dissolved Solids (TDS) was measured using Pen TDS Meters (Model 21000).

Water Samples collected were sent to Adamawa State Water Board for analysis to measure the chemical/inorganic and microbiological constituents of the water. Carbonate and bicarbonate were determined in the field using titrimetric method using HACH Digital Titrator (Model 16900). All other parameters such as Potassium (K^+), Calcium (Ca^{2+}), Copper (Cu^{2+}), Sodium (Na^+), Magnesium (Mg^{2+}), Iron (Fe^{2+}), Manganese

(Mn^-), Chloride (Cl^-), Nitrate (NO_3^-), Fluoride (F^-), Zinc (Zn^-), Sulphate (SO_4^{2-}), Lead (Pb^-)and Chromium (Cr^{6+}) were determined in the laboratory by spectrophotometry using HACH digital Spectrophotometer (Model DR2400, USA).

Water Quality Index (WQI)

Water quality index is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water (Tiwari and Manzoor, 1988). The WQI was calculated to evaluate the suitability of groundwater quality for drinking purposes. Water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public.

In this study, for the calculation of WQI, 15 important parameters were chosen. The WQI was computed in four steps as follows:

In the first step, each parameter has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 is assigned to parameters like total dissolved solids, chloride, sulphate and nitrate due to their major importance in water quality assessment (Srinivasamoorthy*et al*., 2008). Bicarbonate is given the minimum weight of 1 as it plays an insignificant role in the water quality assessment. Other parameters like calcium, magnesium, sodium and potassium are assigned a weight between 1 and 5 depending on their importance in the overall quality of water for drinking purposes.

In the second step, the relative weight (Wi) is computed using a weighted arithmetic index method given below (Tiwari and Manzoor, 1988) in the following steps:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. In the third step, a quality rating scale (Qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines of WHO (2004) and then multiplied by 100:

$$Qi = (Ci / Si) \times 100 \qquad (2)$$

Where Qi is the quality rating, Ci is the concentration of each chemical parameter in each water sample in mg/l, and Si is the WHO drinking water standard for each chemical parameter in mg/l according to the guidelines of WHO (2004).

In the fourth step, the SI is determined first for each chemical parameter, which will then be used to determine the WQI as per the following equation:

$$SIi = Wi \times Qi \qquad (3)$$

SIi is the sub index of ith parameter and Qi is the rating based on concentration of ith parameter. The overall water quality index (WQI) is calculated by adding together each sub index values of each groundwater samples as follows:

$$WQI = \Sigma SIi \qquad (4)$$

Computed WQI values are usually classified into five categories: excellent, good, poor, very poor and unfit water for drinking purposes (Ramakrishnaiah, *et al*., 2009). This classification is presented in Table 1. Spatial distribution map of the water quality index was plotted using surfer 13.

Table 1Water quality classification based on WQI value (Ramakrishnaiah*et al*., 2009).

WQI Values	Rating
< 50	Excellent Water
50.1-100	Good Quality Water
100.1-200	Poor Quality Water
,h200.1-300	Very Poor Quality Water
>300	Water Unfit for drinking

IV. Results And Discussion

Fig 3 indicate that the ground water flow is from the central part of the map, north of Arawa (Recharge area) towards North eastern part around Kaba and then Down towards Arawa (Discharge area). Another recharge area is from the north-western part near ShongoDirangoand flows down south. Also another Recharge area is near Kundulum due north towards main market (Discharge area) and then down south towards

Kundulumand also out wards to Wuro Shie.The flow of groundwater is highly influenced by the hydraulic heads of the recharge area.

The groundwater quality results for the physical, chemical and micro-biological analysis of the fifty (50) groundwater samples from the research area is presented in Table 2.The results indicate that Temperature range from 20.4^o to 27.2°C with average of 25.85^o and standard deviation of 1.48^0. pH in the area range from 5.81 to 8.1mg/l with average value of 6.53mg/l which indicate moderately acidic to neutral water (Ogunribido, 2018). Electrical Conductivity (EC) in the study area range from 189 to 369 with a mean of 286.92μS/cm and thus indicates less mineralized water (Ogunribido, 2018). Total Hardness (TH) 46.62 – 73.12mg/l, with average of 59.93mg/l, thus indicate soft to moderately hard water. Total Dissolved Solids (TDS) in the area range from 110 to 251mg/l with average of 188.40mg/l and be regarded as fresh water (Feter 1990).

Table 2 Physico-chemical parameters of groundwater from the study area

Sample Locations	Water source	Temp (°C)	pH	EC (μs/cm)	TDS (mg/l)	Turbidity (NTU)	TH mg/l	CO_3^{2-}	HCO_3^-	Ca^{2+}	K^+	Cu^{2+}	Na^{2+}	Mg^{2+}	Fe^{2+}	SO_4^{2-}	F^-	Cl^-	NO_3^-	PO_4^{3+}
								mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ARAWA	BH1	26.83	5.92	309	205	0.11	47.54	0	118.7	36.84	5.33	1.09	0.96	10.11	0.83	28.01	0.61	20.42	10.43	1.02
WURO BIRIJI	BH2	26.73	6.44	341	226	1.053	46.62	1.1	220	34.42	5.6	0.8	1	11.01	0.49	28.08	0.5	16.88	13.2	0.94
RAILWAY	BH3	26	6.41	289	190	0.25	59.84	0	200	46	5.53	0.99	1	14.01	0.83	27	0.47	23.07	9.66	0.86
BYE PASS	BH4	26.97	6.25	268	177	0.075	54.05	0	191.11	41.67	5.3	1.1	0.94	12.61	0.77	26.57	0.67	17.63	12.08	1.04
PANTAMI	BH5	26.12	6.22	297	196	0.105	64.97	0	196.1	43.23	4.77	1	1.14	18.11	0.63	29.66	0.56	18.53	9.88	1.01
JEKA DA FARI	BH6	25.92	6.37	298	200	0.005	54.66	0	192.5	41.08	5.1	1.09	0.9	12.82	1.02	26.99	0.68	20.18	10.42	0.97
BOLARI	BH7	26	6.44	340	227	0.066	51.27	0	90	43.37	7	0.97	0.9	7.49	0.8	27.55	0.44	16.83	8.62	1
JAURO KUNA	BH8	27.01	6.23	287	190	0.108	53	0	174	43.13	4.83	0.9	0.89	8.97	0.7	26.77	0.82	21	9.18	0.83
MAIN MARKET	BH9	27.05	5.97	255	169	0.027	47.48	0	102	38.11	6.9	1.04	0.78	8.55	0.6	26.84	0.83	19.4	7.58	0.71
IDI QUARTERS	BH10	26	6.65	297	199	0.042	52.89	0	188	37.01	5.38	1.2	0.86	16.42	0.59	27.9	0.92	16.57	8.63	0.85
KUNDULUM	BH11	26.81	6.31	348	231	0.029	55.98	0	201.4	40	4.88	0.8	0.88	16.73	1	28.01	0.6	18.93	9.77	1
TAURA	BH12	26.91	6.21	311	210	0.125	52.09	0	186.4	38.87	4.2	0.73	0.98	12.44	0.67	28.11	0.33	17.67	8.73	1.1
WURO KESA	BH13	27.11	6	353	237	0.95	47.67	1	190.8	37.73	5.4	0.69	1	9.08	0.55	28.73	0.73	17.88	12	1.06
WURO JULI	BH14	26.64	6.6	314	209	0.028	59.12	0	205	39	6.1	0.78	1	19.83	0.5	27.01	0.49	16	9.07	0.88
NEW GRA	BH15	25.7	6.48	274	184	0.035	52.6	0	133	38.93	6.6	1.11	0.8	14.4	0.78	26.81	0.44	23.11	11.52	1
GABUKKA	BH16	27.03	6.18	269	179	0.091	50.24	0	109	40.83	4.9	1.1	0.84	8.87	0.43	26.11	0.5	21.43	10.55	0.9
STATE LOWCOST	BH17	27.2	6.2	317	210	0.15	53.94	0	166.73	42.84	4.8	0.67	0.8	11.47	0.92	27.11	0.61	15.93	9.4	1
T/WADA PANTAMI	BH18	26.9	6.2	273	181	0.511	49.05	0	124	39.66	6.6	0.91	0.91	9.16	0.39	27.41	0.37	19.53	7.93	0.78
WURO BOGGA	BH19	26.87	6.1	284	188	0.907	50.97	1	108.6	38.55	6	1.02	0/91	12.83	0.6	29	0.77	22	11	0.95
MKTTAKO	BH20	25.99	6.09	285	191	0.315	55.95	0	211.4	44.42	6.42	1.03	0.92	11.73	1	25.93	0.48	16.87	9.91	0.96
MALAM BURRA 1	BH21	27.1	6	217	134	1.02	59.11	2.1	193	37.81	6.61	0.73	2.44	21.07	0.27	23.42	0.39	24	23.66	0.43
MALM BURRA 2	BH22	27	6.12	212	129	0.65	62.28	2.4	187	40.66	6.42	1.01	2.81	21.44	0.52	24.81	0.48	21.1	19.48	0.59
CBN	BH23	26.81	6.33	284	251	0.55	70.17	1.4	198	41.92	4.93	1	2.73	27.12	0.49	24.66	0.64	16.5	20.48	0.81
LEGISLATIVE QUARTERS	BH24	26.12	6.17	271	241	0.41	68.84	0	191	39.73	5.1	0.67	1.66	27.91	0.44	25.92	0.44	20.1	19.68	0.75
JIYAMERE	BH25	24.93	6.16	255	149	0.112	62.91	0	207	41.1	5	0.7	1.47	23.42	0.4	26.6	0.59	16.5	19	1

SHONGO DIRANGO	BH26	26	6.53	189	118	1	73.12	0	200	44.87	4.99	0.4	1.88	31.27	0.37	26.1	0.6	20	18.97	0.63
DORAWA 2	BH27	26.53	6	200	110	0.215	53.92	0	178	37.08	6	0.51	2.93	19.79	0.22	27	0.34	17.5	20.55	1.04
NEW MILE 3	BH28	27.1	5.81	298	181	0.405	51.73	1.1	153	32.91	7.01	0.88	2.91	19.88	0.377	27.12	0.72	18.8	12.54	0.44
NEAR HOUSE OF ASSEMBLY	BH29	26.81	5.93	300	186	0.095	50.93	0	149	33.03	6.98	0.47	1.88	18.78	0.4	27.11	0.67	16.9	11.73	0.57
WURO SHIE 3	BH30	26.44	6.18	283	172	0.073	68.22	0	188	40.43	5.23	0.59	1.9	27.19	0.501	26.93	0.41	14.5	10.46	1.1
GALDIMARI	BH31	27.2	6.27	219	137	1.05	64.79	0	158	46.27	5.93	0.8	2.48	19.39	0.45	26.14	0.8	23.7	21.18	1.21
RIYAL QUARTERS	HDW1	23.67	8.1	321	210.5	0.063	64.11	1.1	107	39.73	8.6	0.37	1.14	23.59	0.56	28.72	0.9	22.97	16.73	0.43
YALANGURUZA	HDW2	24.28	7.6	331	216.5	0.095	67.51	0	121	48.91	13	0.72	1.01	17.55	0.601	26.15	0.82	30	20	1
WURO KESA 2	HDW3	24.08	7.81	301	196.7	0.205	71.08	3.2	101	47.88	10.4	0.39	1.34	22.88	0.4	28.09	0.79	29.72	38.42	0.56
ANGUWAN GANDU	HDW4	23.67	7.4	334	221	0.1	71	0	178.63	49	12.8	0.81	1.06	21.67	0.453	27.08	0.75	24.88	8.4	0.68
JAURO JINGI	HDW5	24	7.44	303	201.1	0.101	71.22	0	123.3	49.6	13.1	0.2	1.08	20.15	0.443	28.01	0.83	18.77	19.72	0.84
KUMBIYA KUMBIYA	HDW6	22.83	7.63	348	221	0.201	69.89	1.2	110.1	51.66	9.9	0.44	1.04	19.67	0.617	27.15	0.75	21.76	16.92	1.05
ANGUWAN FADA	HDW7	23.11	7.55	367.1	240	0.411	73.05	2.6	100	53	11.6	0.63	1.24	19	0.37	28.1	0.81	26.52	9.43	0.87
KUNDULUM	HDW8	23.42	7.9	309	214	0.152	66.93	0	188	44.11	10	0.6	1.31	23.42	0.411	26.15	0.51	21.67	15.62	0.77
BAYAN STADIUM	HDW9	23.92	7.48	369	244.5	0.927	57.85	1.4	120	37.28	9.1	0.52	1	20.85	0.49	28.1	0.64	19.4	14.93	0.72
HERWAGANA	HDW10	23.91	8	322	212.9	0.104	72	1	96.6	46.77	12.6	0.56	1.21	24.22	0.318	27.62	0.54	26.15	16	1.19
JAURO JINGI 2	HDW11	26.66	6.14	269	159	0.511	71.43	0	181	40.72	6.1	0.47	1.97	28.93	0.321	26.88	0.41	20.4	18.92	0.72
NASARAWO	HDW12	20.4	6.23	274	248	0.501	64.8	0	174	37.12	4.88	0.51	2.04	20.61	0.34	24.92	0.4	25	22.47	0.71
AKKO	HDW13	26	6.44	300	167	1.02	60.11	0	212	39.61	6.27	0.92	1.86	21.43	0.41	25.9	0.53	23.1	19.67	0.64
WURO SHIE 2	HDW14	25.93	6.51	260	149	0.45	59.82	2	199	30.1	5.91	1	1.09	27.11	0.48	26	0.47	19.6	11.1	1.02
KABA	HDW15	26.17	6.28	254	144	0.09	66.81	1.1	179	36.33	4.99	0.87	1.43	28	0.33	27.11	0.51	25.9	21.68	0.8
LIJI	HDW16	26.11	6.51	209	129	1.02	61.91	0	241	34.17	6.01	0.43	1.67	29.01	0.29	27.01	0.62	24.9	19.77	0.54
LIJI 2	HDW17	27	6.42	227	131	0.25	60	0	210	36.72	6.3	0.55	2.42	21.63	0.48	26.9	0.51	24.9	18	1.03
MALAM BURRA 3	HDW18	26.91	6.4	241	141	0.05	64	0	221	31.98	5.88	0.48	2.81	30.99	0.41	27.8	0.63	23.8	20.12	1
DORAWA 1	HDW19	26.84	5.98	270	167	1.005	57.21	1.2	168	36	7.1	0.61	1.09	19.53	0.33	27	0.67	21.4	24.11	0.69

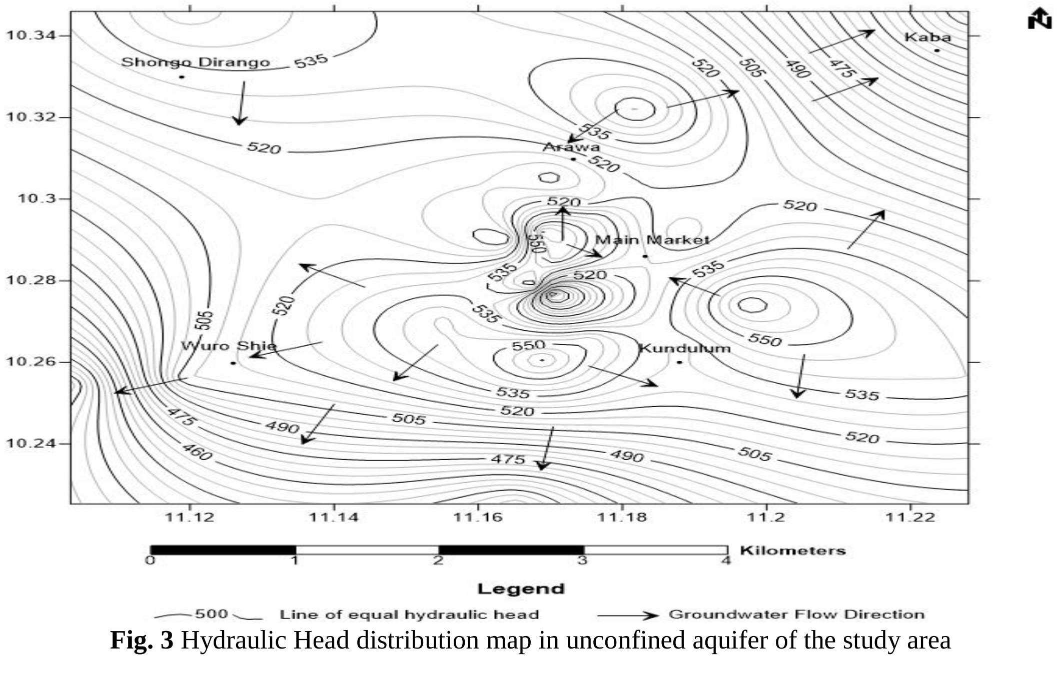

Fig. 3 Hydraulic Head distribution map in unconfined aquifer of the study area

4.1 Water Quality Index

The WQI was calculated to evaluate the suitability of groundwater quality for drinking purposes. The values of WQI ranges from 38.5 to 67.52 with an average of 52.99. It is used to access the influence of natural and anthropogenic activities on groundwater quality. From the analysis, BH9, BH16, BH18, BH21, BH24, BH26, BH27, BH28, BH29, HDW10, HDW11, HDW12, HDW15, HDW16, HDW17, HDW18, and HDW19 have excellent quality water rating whereas all other water sources in the study area have good quality water rating (Table 3). The map of the study area showing spatial distribution of Water quality index (Fig 4) depicts that Excellent quality water are found around the out sketch of Gombe town, mostly towards the Eastern and north-western part of the study area, where as good quality waters are concentrated around the central portion of the area. Another Excellent quality water also are found around north and Eastern of Wuro Shie. Thirty four percent (34%) of the samples collected were excellent quality water while sixty six percent (66%) are good quality water, this shows that groundwater in the study area is fit for drinking purpose.

Table 3 Water Quality Index Rating of water from the Study Area

S/No	Sample Locations	Water source	WQI	Rating
1	ARAWA	BH1	57.39	Good
2	WURO BIRIJI	BH2	54.47	Good
3	RAILWAY	BH3	61.29	Good
4	BYE PASS	BH4	59.71	Good
5	PANTAMI	BH5	56.13	Good
6	JEKA DA FARI	BH6	67.52	Good
7	BOLARI	BH7	55.83	Good
8	JAURO KUNA	BH8	57.68	Good
9	MAIN MARKET	BH9	49.97	Excellent
10	IDI QUARTERS	BH10	56.79	Good
11	KUNDULUM	BH11	59.81	Good
12	TAURA	BH12	54.49	Good
13	WURO KESA	BH13	56.13	Good
14	WURO JULI	BH14	53.27	Good
15	NEW GRA	BH15	56.21	Good
16	GABUKKA	BH16	44.14	Excellent
17	STATE LOWCOST	BH17	62.89	Good
18	T/WADA PANTAMI	BH18	42.98	Excellent
19	WURO BOGGA	BH19	53.43	Good
20	MKTTAKO	BH20	66.28	Good
21	MALAM BURRA 1	BH21	45	Excellent
22	MALM BURRA 2	BH22	51.49	Good
23	CBN	BH23	56.31	Good
24	LEGISLATIVE QUARTERS	BH24	44.59	Excellent
25	JIYAMERE	BH25	51.1	Good
26	SHONGO DIRANGO	BH26	48.78	Excellent
27	DORAWA 2	BH27	38.5	Excellent
28	NEW MILE 3	BH28	47.75	Excellent
29	NEAR HOUSE OF ASSEMBLY	BH29	47.81	Excellent
30	WURO SHIE 3	BH30	50.06	Good

31	GALDIMARI	BH31	56.55	Good
32	RIYAL QUARTERS	HDW1	57.16	Good
33	YALANGURUZA	HDW2	60.99	Good
34	WURO KESA 2	HDW3	56.56	Good
35	ANGUWAN GANDU	HDW4	56.91	Good
36	JAURO JINGI	HDW5	55.76	Good
37	KUMBIYA KUMBIYA	HDW6	58.86	Good
38	ANGUWAN FADA	HDW7	52.07	Good
39	KUNDULUM	HDW8	56.69	Good
40	BAYAN STADIUM	HDW9	54.4	Good
41	HERWAGANA	HDW10	49.3	Excellent
42	JAURO JINGI 2	HDW11	47.03	Excellent
43	NASARAWO	HDW12	48.87	Excellent
44	AKKO	HDW13	52.63	Good
45	WURO SHIE 2	HDW14	50.28	Good
46	KABA	HDW15	47.43	Excellent
47	LIJI	HDW16	49.22	Excellent
48	LIJI 2	HDW17	39.32	Excellent
49	MALAM BURRA 3	HDW18	42.54	Excellent
50	DORAWA 1	HDW19	49.03	Excellent

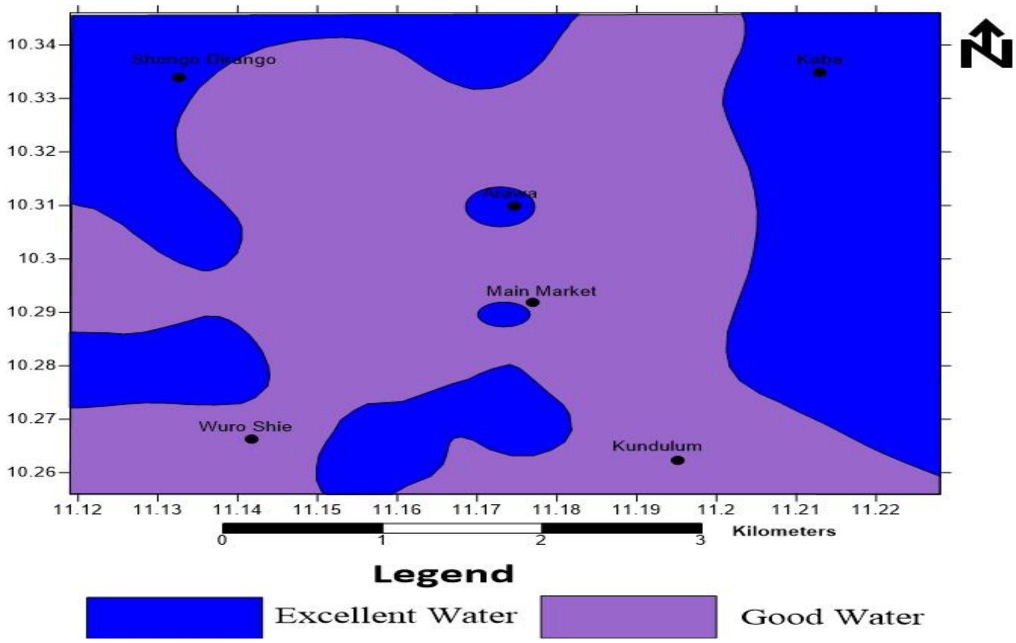

Fig. 4: Spatial Distribution of Water Quality Index in the Study Area

V. Conclusion

The results of water quality index for drinking purposes revealed values ranging from 38.5 to 67.52 indicating excellent to good quality water. Thirty four percent (34%) of the samples collected were excellent quality water while sixty six percent (66%) are good quality water, this shows that groundwater in the study area is fit for drinking purpose.But, the groundwater quality needs further investigations to see if there exists violence in its quality as far as irrigation practice is undertaking. Thus, enables to conduct water quality management as the water quality indices are among the most effective ways to communicate the information on water quality trends to the general public or to the policy makers.

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