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Hydrochemical Studies of the Groundwater Resources of the Middle Zone Aquifer in the Southwestern Chad Basin.

A.K. Yusuf [1], I.B.Goni [2] M. Hassan [3]
[1]*Centre for Arid Zone Studies, University of Maiduguri.*
[2]*Department of Geology, University of Maiduguri.*
[3]*Department of Physics, University of Maiduguri.*

Abstract: *The groundwater of the Middle aquifer was collected to examine its characteristics. The chemistry of the water showed that it has SAR value of about 4.6 and EC is 667 Scm^{-1}.*
This makes the water suitable as fresh water and can be used for irrigation. The results were presented in Richards and Piper's diagrams for easy visualization. The water samples plots in good and permissible water class with salinity hazards of medium – high salinity groups. While the water samples plots in the same region in the piper's diagram indicating that they are hydrogeologically connected and continuous. The chemical data recognized a water type classified as sodium bicarbonate type (Na + HCO_3) facies where sodium is significant in its concentration; with cation and ions in the order of Na > Ca > K > Mg and HCO_3 > CO_3 > Cl > SO_4 for drinking water quality.
Keywords: *Groundwater, Salinity hazard, Hydrogeologically, Sodium bicarbonate, Facies.*

I. Introduction

The Chad Formation is the youngest and most prolific formation in the basin. Groundwater resources of the Nigerian sector of the Chad Basin occur in that formation. Groundwater in this deposit occurs under both confined and unconfined conditions. Three well known aquifers are demarcated in the zone by Barber and Jones (1960), as Upper, Middle and Lower aquifers. The Upper aquifer is semi-confined to confine while the Middle and Lower is in a confined condition. The Middle aquifer is the most extensive and most exploited of all the three aquifers. Because of the thick clay (in some places up to 100 m), boreholes drilled to this zone yield piezometric head as high as 20 m above ground level (agl) in the 1960's. Due to the depth of occurrence and the overlying clay thickness the water in that aquifer becomes under high pressure yielding artesian wells. The lack of usage of the water for irrigation might not be unconnected with the chemistry of the water. A similar assumption was earlier made by Barber (1965) that lack of irrigation activities in the area might not be unconnected with the chemistry and temperature of the water. This lack of irrigation activities using the artesian wells water necessitated the qualitative study of the Middle zone aquifer water for both agriculture and human use.

II. Scope Of Study

The study area is the Middle zone aquifer of the Nigerian sector of the Chad Basin. The area falls within latitude 11°30'N and 13°30'N and longitude 12°00'E and 14°30'E.

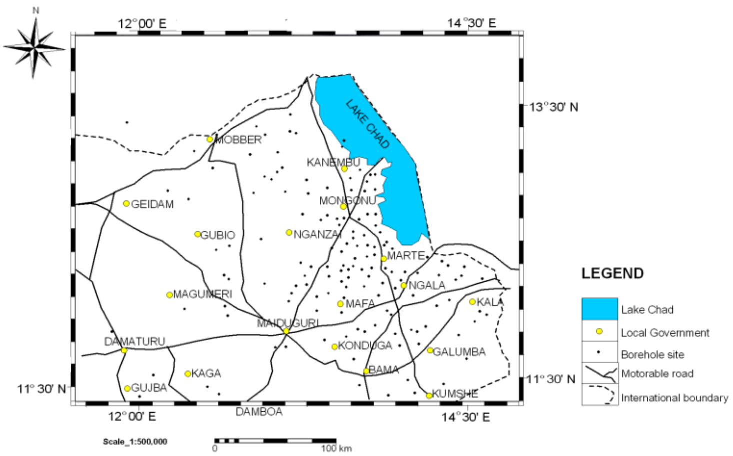

Fig.1. Map of the study area and sample locations.

Climate

The area is a semi-arid region characterized by tropical climate with both seasonal and diurnal weather variations. The rainfall occurs mainly in the months of June- September. The temperature in the area ranges between 35^o C to 44^oC in March and May while in December and January the temperature range from 12^oC to 18^oC.

Soil Types

Lake Chad Basin is a fertile area with a great agricultural potential. This potential is however limited by scarcity of water. Surface water, in streams appears seasonally for a couple of months, usually from August to November. For the rest of the year streams are dry and the only source of water is groundwater. Major crops grown in the area are cereals and legumes.

Geology

The stratigraphy and geology of the Chad Basin are well documented (Barber and Jones, 1960; Carter, Barber, Jones and Tait, 1963; Barber, 1965; Miller et al., 1968; Burke, 1976; Offodile, 1972; Adefila, 1975; Oteze and Fayose, 1988; Ndubisi, 1990; Olugboye, 1995). The Chad Formation is the youngest and last phase of deposition sequence in the stratigraphy succession of the basin. It is basically an argillaceous sequence with three well defined arenaceous horizons (Barber and Jones, 1960).

The Middle zone arenaceous horizon is the most extensive of the zones, extending to republics of Niger, Cameroun and Chad. It is overlain by variable thickness (up to 150 m) of clay layer. This zone consists of sand, sandy clay and clay, with extremely variable proportion in different sections. The sand varies from fine grained to very coarse grained, with little gravel. Feldspar grains, iron ore and mica are present along with fragments of granites, but quartz grains form the bulk of the arenaceous material. The sand particles are poorly graded and usually angular to sub angular.

In few areas silica and ferruginous material, but not enough to drastically reduce the porosity and permeability of the sands cement the grains. The clays and sandy clays of the zone are usually brightly coloured. This zone is probably composed of Lake Margin deposits laid down at the mouth of the rivers which flowed into the Lake (Dar Al-Handasah, 1981). This accounts for the low degree of grading, and the vertical and lateral variability of the sediments. The sand beds are thought to occur as lenses of varying thickness and extent.

Hydrogeology

The Middle zone arenaceous horizon stores water and termed Middle zone aquifer (Barber and Jones, 1960). This aquifer is confined by a clay layer up to 100m thick in some places, with pressure sufficient to cause artesian flow. Because of the heterogeneity of the aquifer materials, there is variability in hydraulic properties. Miller et al. (1968) subdivides the aquifer into six based on water yielding capability. They also give the following hydraulic parameters: Hydraulic conductivity range from 0.0000428 – 0.000179 m/sec (90 – 380 gpd per square foot); transmissivity 0.000818 – $0.1141m^2/sec$ (520 – 72,500 gpd per foot; storage coefficient 0.000014 – 0.00018. However it was observed that most of the boreholes tapping this aquifer are of very small diameter 63.5 mm (2.5 in) in relation to their depth 182 – 365 m (600 – 1200 ft), resulting in considerable head lost due to friction.

III. Methodology

Ninety six water samples were collected for geochemical analysis for major and minor elements in the study area. The temperature; electrical conductivity and the p^H were measured by the use of water testing kit on the field. The water samples were collected from the main borehole outlet after rinsing the one litre plastic can. The samples were later taken to the Department of Geology, University of Maiduguri laboratory for the analysis. The Na and K cations were analysed using the Flame Photometer while Atomic Absorption Spectrophotometer (AAS) was used to determined Mg and Ca. The titration determination was used for CO_3, HCO_3 and Cl anions while Ultra Violet Spectrophotometer was used to analyse SO_4 anion.

IV. Discussions

Despite that there is large pool of water formed by the free-flowing wells. There is no much agricultural/irrigation activities during the dry season in study area. The people in the area mostly depend on rain fed agriculture. These people are also fishermen and tend to move towards the Lake for fishing mostly during the dry season.

Lack of usage of the water for irrigation might not be unconnected with the chemistry and temperature of the water (Barber, 1965). The artesian water temperature in the area is about 40^oC which is far above the recommended temperature for irrigation water of 14^oC (Todd, 1980).

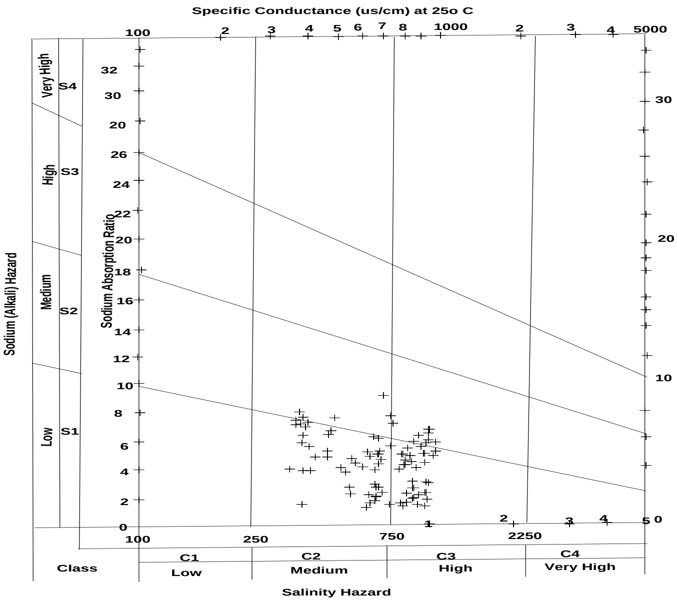

Fig.2: Graphical Classification of Irrigation water (after Richards, 1954).

The groundwater quality for irrigation from boreholes tapping the Middle Zone Aquifer was analysed for its suitability for irrigation and presented for easy understanding in a graphical Charts by Richards (1954).This Chart is based on SAR and Electrical Conductivity. The water samples from the study area fall in two dominant groups of medium and high salinity hazards of classes 2 and 3 (fig.2) which is interpreted by Wilcox (table 1) as "good and permissible grades".

The suitability of groundwater for irrigation depends on several factors, which have direct relationship with plant and soil. These include the percent sodium (percent Na) and the sodium adsorption ratio (SAR), (table 1).The percent Na is determined as:

% Na = ((Na + K) / (Ca + Mg + Na + K)) 100 ------------------------------- 1

Wilcox (1948) and Todd (1980).

Where ionic concentration are expressed in milli equivalents per litre (meq/l)

In the study area, the groundwater samples have the percent sodium values ranging from 52-90 with a mean of 66.5 .The major ions of Na, K, Ca and Mg have average values of 3, 0.46, 1.3 and 0.77 mg/L while the minor elements of Cl, SO_4 and HCO_3 have mode values of 1.3, 1.16 and 2.42 mg/L. The physical parameters of temperature and P^H have 37.3^{o}C and 7.14.

Table1:Modified Wilcox quality Classification of irrigation waters (Adopted Todd 1980)

S/No	Water Class	Grades	% Na	Electrical Us/cm	SAR	Salinity Hazard
1	Class 1	Excellent	< 20	250	1-10	Low
2	Class 2	Good	20 – 40	250 – 750	10-18	Medium
3	Class 3	Permissible	40 – 60	750 – 2000	18-26	High
4	Class 4	Doubtful	60 – 80	2000 – 3000	> 26	Very High
5	Class 5	Unsuitable	> 80	> 3000	>26	Very High

The risk of sodium alkalinisation is measured as a ratio, which shows the extent of the replacement of calcium and magnesium ions by sodium ions at the soil exchange sites. Richards (1954) defined this ratio, the sodium adsorption ratio (SAR) as:

SAR= Na^+ / √ (Ca^{2+} + Mg^{2+}) / 2-- 2 SAR=

Where ionic concentrations are expressed in mill equivalents per litre (meq)

A graphical classification of irrigation water based on SAR and electrical conductivity (EC) according to Richards (1954) has been prepared for the study area Fig.2.

Good irrigation water should have SAR value of less than 15 and an EC value below 750 uʃ cm^{-1}. The average value of SAR in the study area is about 4.6 which are considered as "excellent" water class, while the average EC is about 667 uʃ cm^{-1} which makes the water suitable as fresh water and can be used for irrigation (Wilcox, 1948). Fig.2 shows that the 96 groundwater samples) plot in two major classes on this irrigation water classification diagram. Majority of the groundwater samples about 60% (58 samples) from this zone fall within the "good" water class with medium salinity hazards, while 38 samples (40%) fall within the "permissible" class with high salinity group (salty) and none of the samples falls in the fresh water zone of the "excellent class". The quality of groundwater for drinking has been pointed out by numerous writers that it is largely a matter of opinion whether water is good to drink. The population of areas where low salinity waters are plentiful would probably fine quite small amounts of salts distasteful whereas dwellers in more arid countries have much more tolerant limits. Thus, rigid standards of chemical quality cannot be established except for definitely toxic substances. Dixey (1931,) remarks that in England and the Eastern united State, 570 ppm was regarded as the extreme limit of salinity. Later workers, influenced by data from dessert regions, regard concentrations as high as 2,500 ppm of soluble salts as permissible. In parts New Mexico and California water with 4,000 ppm is used for drinking and water with 2000 ppm is regarded as good. Bearing in mind the quality of the water available to the people of north – eastern Borno and Dikwa prior to the tapping to the artesian supplies, it is not surprising that there been relatively few complaints about the portability of the pressure water.

The average results of the major and minor elements concentration are presented in (Appendix 1).All the groundwater samples of the Middle aquifer tend to plot in the same region, this indicate that they are hydrogeologically connected and continuous .Detailed analysis of the major ions indicates that alkali metal (Na + K) and bicarbonate are dominant in majority of the groundwater only differing in relative percentage. The major cations Ca, Mg, and the alkali metal (Na + K) constitute only about 5%, 2% and 19% respectively. While the anions of CO_3 + HCO_3, SO_4 and Cl constitute 51%, 11% and 12% respectively. The major cations of Na, K, Ca and Mg have a mean value of 98 mg/L, 20 mg/L, 31 mg/L and 12 mg/L respectively. The above concentrations are within WHO (1984) standards for drinking water. Furthermore, major anions of CO_3, HCO_3, SO_4 and Cl have an average value of 87 mg/L, 224 mg/L, 64 mg/L and 71 mg/L respectively. These concentrations are all within the WHO (1984) requirement for portable water. It revealed that the cations plot in the region of dominant Na cations; while the anions plots towards where the bicarbonate is dominant hence the water from Middle zone aquifer of the Nigerian sector of the Chad Basin is classified as sodium bicarbonate type (Na + HCO_3).

The results of the chemical analysis are presented in a piper diagram (Fig.3) in order to facilitate interpretation by visual inspection. The cation and anion in the groundwater of the Middle zone aquifer of the Chad Formation in the Nigerian sector of the Chad Basin are in the order: Na > Ca > K > Mg and HCO_3 > CO_3 > Cl > SO_4 respectively.

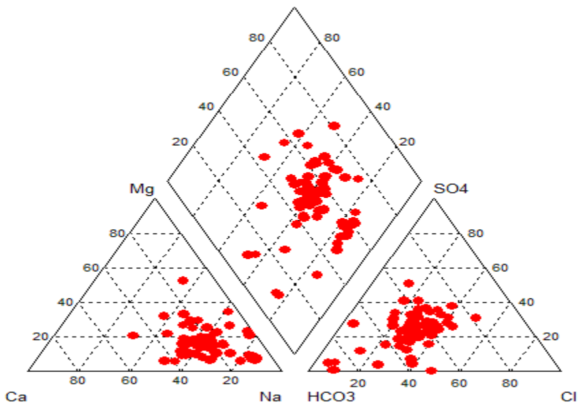

Fig.3: Piper's Diagram for the water analysis of the Middle zone aquifer of the Nigerian sector of the Chad Basin.

V. Conclusion

The groundwater of the Middle aquifer has SAR value of about 4.6 and EC is 667 Scm^{-1}
This makes the water suitable as fresh water and can be used for irrigation. The water samples plots in good and permissible water class with salinity hazards of medium – high salinity groups. These two classes of water can be used for irrigation. While the water quality is classified as Sodium Bicarbonate type (Na+ HCO_3) facies and is within the WHO requirement for drinking water.

Acknowledgement

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References

[1]. Adefila, S.F. (1975): Decline in the Pressure of the Middle Aquifer of the Chad Formation in Parts of the South Eastern Niger and North Eastern Nigeria. J. Mining and Geology, 12: 23-26.

[2]. Barbers, W. (1965): Pressure Water in the Chad Formation of Bornu and Dikwa Emirate, Northeastern Nigeria. Geological Survey of Nigeria Bulletin No. 35,138p.

[3]. Barber, (1965) W. and Jones, D.G. (1960):The Geology and Hydrology of Maiduguri, Bornu Province (Unpublished Records) Geological Survey of Nigeria.1958,P1-20

[4]. Burke,K.C.,(1976): The Chad Basin; an active intra- continental basin. Tectonophysics, 36. Pp 197 -206.

[5]. Carter , J.D., Barber, W., Tait, E.A., Jones , D. G. (1963) : The Geology of Parts of damawa, Bauchi and Borno Provinces, Northeastern Nigeria: Bulletin of Geological Survey of Nigeria, No.30.

[6]. Dar Al-Handasah. (1983): Maidugrui Water Supply; Feasibility Study Final Report. Dar Al-Handasah (Shair and Partners): Maiduguri.

[7]. Miller, R.E., Johnson, R.H., Olowu J.A.I. and Uzeoma J.U., (1968): Groundwater Hydrology of the Chad Basin in Borno and Dikwa Emirates; North-Eastern Nigeria with Special Emphases on the Flows Life of the Artesian System. Hydrology of Africa and the Mediterranean Regions.USGS Water Supply Report, 1757 – 1, 48p.

[8]. Ndubisi, O.L., (1990): Managing GroundwaterbResources of the Lake Chad Basin in Nigeria. Proc.Nat.Hydrol.Symp.Maiduguri.Pp 429 – 436.

[9]. Offodile, M.E. (1972): Groundwater Level Fluctuation in the East Chad Basin of Nigeria.

[10]. Min. Geol. Vol. 7. No. 1&2: 19-34.

[11]. Olugboye, M.O., (1995): Groundwater Monitoring Network as an aid to averting some Ecological Disaster, the Case for Chad Basin Area. Water Resources, Vol. 6 No.1&2: 57-60.

[12]. Oteze, G.E. and Fayose, S.A. (1988): Regional Development in the Hydrogeology of Chad Basin. Water Resources Vol. 1 No. 9-29.

[13]. Piper, A.M. (1944).A graphic procedure in geochemical interpretation of water analysis: Trans, Amer. Geophysical Union, Union, Vol. 25, pp. 914 – 928.

[14]. Richards, L. A. (1954). Diagnosis and improvement of saline and alkali soils. U.S. Dept. of Agric. Handbook No.50. U.S. Govt. Printing Office, Washington D. C., 160p.

[15]. Todd, D.K.(1980):Groundwater Hydrology, 2nd ed. John Wiley and Son Inc.535p.

[16]. Wilcox, L.V. (1948): The quality of water for irrigation use. U. S. Dept. of Agricture Tech. Bull. 962, pp 1 – 40.

[17]. World Health Organisation (1984): Guidelines for Drinking Water Quality Vol.1.

[18]. Recommendations, WHO, Geneva, Switzerland. Pp139.

Appendix 1: Middle Zone Aquifer Water Analysis in the Nigerian Sector of the Chad Basin (in mg/L)

S/No	Location	L.G.A.	PH	ToC	EC	Na	Ca	K	Mg	Cl	SO4	CO3	HCO3
1	Damboa	Damboa	6.84	31.6	670	52.6	1.32	2.2	8.6	10	1.2	22	161.4
2	Dalwa	Konduga	6.82	32	664	70.61	1.9	3.4	10.3	12	1.33	33	183.1
3	Airport	Maiduguri	7.21	34.4	552	49.36	14.88	8.55	5.61	46	7.39	95.3	115.9
4	Chobbal	Konduga	7.22	34.5	585	48.4	16.71	9.6	7.4	48.4	12.8	92.6	125
5	Tungushe	Nganzai	6.95	35	647	35.6	48.49	27.7	12.62	58	30.18	88.6	167.3
6	Kurnowa	Nganzai	6.42	36	612	73.51	19.99	14.8	11	72	38.7	138.1	138.1
7	Gajiganna	Nganzai	7.2	38.2	680	106	78.54	7.92	6.88	82	76	122	245.3
8	Gajiram	Nganzai	6.88	37.4	720	103	14.4	13	5.88	84.6	75	122	248
9	Badu	Nganzai	6.5	38.8	740	116.4	35.6	21.4	7.3	98.2	94.4	137.8	258
10	Gudumbali	Guzamala	7.2	37.6	746	122.3	39.6	28.2	6.4	87.8	90	141.6	255.3
11	Garere	Mobbar	6.54	38.6	812	235.5	36.4	32.6	11.7	96.3	101.2	156.4	276.6
12	Arege	Mobbar	6.8	38.4	952	268	43.2	14.5	13.4	105.8	106.2	154.3	282.2
13	Maiduguri	Maiduguri	6.9	35.6	414	52.71	13.25	15	6.44	18	19.9	77.2	156.3
14	Mbutta	Mafa	6.9	39.1	820	65.9	45.06	25.5	17.51	60	12.39	130.7	280.7
15	Kesa Nga	Mafa	6.8	38.6	846	69.55	23.43	26.3	9.64	62	51.4	90.5	100.2
16	Masu	Mafa	6.8	39.2	856	71.3	32.52	28.3	11.24	66	55.6	96.4	105.4
17	Ngurno	Monguno	7.3	39.4	415	74.2	34.6	27.55	12.6	68	59.7	103.6	122.6
18	Kauwa Ob	Kukawa	7.3	30.1	352	83.14	39.6	25.25	13.99	69	82.59	228	170.86
19	Baga	Kukawa	7.28	38.2	386	91.96	39.8	0.65	16.29	73	106.46	284	317.3
20	Auno	Konduga	7.2	34.2	682	75.6	15.67	10.6	12.26	66.8	68.2	52.4	192.8
21	Gabchari	Kaga	7.1	33.8	680	76.3	28.38	11.25	5.32	72	71.4	78.5	193.4
22	Kingowa	Magumeri	7	34.1	688	88.4	48.49	11.7	7.62	78	76.18	88.6	197.3
23	G.Bukarti	Magumeri	7.2	35.5	692	92.1	46.8	12.6	10.4	83.4	79.6	97.4	208.6
24	Magumeri	Magumeri	6.92	35.8	682	94.8	51.2	12	9.8	81.6	76.2	95.3	206.8
25	Kabulele	Gubio	7.2	36.2	890	102.2	51.8	11.8	8.8	76.9	77.2	102.4	216.6
26	Kwa	Gubio	7.2	39.2	892	114.6	53.1	12.2	10.6	80.1	79.4	98.6	210
27	Chingowa	Gubio	7.3	37.2	840	106.4	53	12.8	10.9	81.2	81.6	99.3	224.3
28	Gazabure	Gubio	6.9	39	827	125.6	51.9	13.4	10.9	80.3	84.9	97.7	231.4
29	Majiri	Gubio	6.8	38.8	842	150.3	52.3	12.6	11	79.3	85.2	102.3	232.2
30	Tamsuguwa	Mobbar	6.46	39.8	862	162.4	52.8	13.5	11.1	79.6	86.6	99.8	233.4
31	Gashagar	Mobbar	6.33	40	844	168.6	52.7	13.4	10.9	80.6	85.4	104.2	233.6
32	Damaturu	Damaturu	6.7	31.4	506	21.9	12.84	18.7	3.86	5.6	4.9	98.4	102.6
33	Kukaretta	Damaturu	6.8	31.6	508	27.2	14	39.62	4.37	6	7.27	117.2	188.7
34	Ngamdu	Kaga	6.84	32	546	70.5	27.17	12.6	9.5	46	57.89	69.6	164.8
35	Benisheik	Kaga	7.2	34.8	592	71.8	29.4	10.34	10.61	48.2	46.24	57.2	171.4
36	Mainok	Kaga	6.74	33	688	72.44	23.8	12.8	11.7	62	44.75	55.8	174.5
37	Kesawa	Magumeri	6.8	33.8	692	73.2	22.6	11.4	10.8	64.7	66.4	50	183.2
38	Muna	Maiduguri	7.1	36.2	826	74.8	18.92	13.62	17.4	56.4	48.2	83.6	189.4
39	Shuari	Mafa	6.77	35	954	112.5	22.33	14.31	21.45	63	57.37	75.4	292.9
40	Mafa	Mafa	6.93	36.5	966	106.8	31.89	29.7	14.6	128	71.28	106.8	231.9

41	Majigetti	Dikwa	6.96	38.2	974	126.4	36.7	32.7	15.8	124.8	93.6	62.8	348
42	M. Majia	Dikwa Kala	6.6	38.8	980	124.8	32.64	38.42	18.4	129.9	104.8	37.6	352.8
43	Koma	Balge	7	39	980	188.3	36.8	41.3	21.8	153.8	120	18.7	362.8
44	Konduga	Konduga	7.17	32.8	678	86.4	18.9	33.8	16.4	68.3	71.8	34	224.8
45	Kadari	Konduga	7.26	32.9	688	94.2	31.4	34.6	17.2	112.8	106.3	36.1	268.8
46	Kaza	Dikwa	7.1	38.2	962	127.3	36.4	42.6	21.3	127.6	116.4	41.2	371.4
47	Muktu	Dikwa	7	38.6	966	134.1	40.8	46.5	19.4	126.4	121.3	42.3	386.5
48	Dogamashe	Dikwa Kala	7.3	38	938	132.8	44.3	47.2	19.2	131.8	143.6	42.1	388.2
49	Ran	Balge	7.3	39	975	154.7	56.3	48.3	18.8	152.4	144.4	44.3	391.6
50	Lawanti	Kukawa	7.35	40.3	382	5143	3.85	15.34	2.897	28	36.79	132	207.97
51	B. Lawanti	Kukawa	7.27	39.1	369	50.37	4.62	17.66	3.046	30	43.12	36	244.1
52	Sidjin	Kukawa	8.46	43	398	22.73	7.352	27.99	18.28	30	78.22	60	54.22
53	Gwange	Kukawa	8.72	42.1	576	51.54	10.2	18.84	6.377	50	73.2	151.2	292.89
54	Mile 1	Kukawa	8.49	43.7	360	49.76	3.78	14.4	2.083	32	37.93	84	219.7
55	C. Kauwa	Kukawa	8.75	42.9	700	52.47	11.289	18.38	6.674	38	72.25	132	175.54
56	Budumari	Kukawa	8.7	42.5	1040	51.96	19.83	25.25	16.29	30	106.46	84	317.3
57	Kauwa L	Kukawa	8.61	38.8	477	53.14	9.6	17.55	3.998	46	82.59	228	170.86
58	Bundur	Kukawa	7.3	41.1	477	51.75	4.57	25.45	2.999	32	56.32	132	268.5
59	Madari	Kukawa	7.3	40.9	436	50.58	3.75	11.84	2.623	26	49.38	156	244.1
60	Kekeno	Kukawa	7.34	39.1	420	50.82	4.33	9.59	2.612	26	44.52	156	268.5
61	Yoyo	Kukawa	7.38	39.2	378	50.54	3.87	9.489	2.386	22	38.56	119.99	219.7
62	MN- 1	Monguno	7.31	39.1	427	51.22	7.4	9.43	2.067	24	38.28	84	268.5
63	MN- 2	Monguno	7.26	38.8	408	50.09	4.2	9.43	2.255	18	39.59	119.99	195.26
64	MN – 4	Monguno	8.62	38.4	415	50.76	3.75	9.362	2.139	26	38.04	108	317.3
65	MN – 6	Monguno	7.28	38.2	386	51.51	3.78	10.12	2.259	28	34.3	228	170.86
66	MN – 5	Monguno	7.35	40.5	401	51.26	3.92	9.72	2.459	28	43.34	228	170.86
67	MN – 3	Kukawa	7.29	42.6	422	51.64	3.42	10.21	2.413	4	37.37	84	317.3
68	Veternary	Kukawa	7.32	38.3	486	51.15	3.31	11.14	2.232	20	35.24	108	219.7
69	Ali Banya	Marte	6.73	40.1	979	14.3	10.18	15.66	6.523	10	73.22	204	341.7
70	Ala 1	Marte	6.66	38	954	18.75	8.098	15.05	7.42	24	42	168	366.12
71	Ala 2	Marte	6.87	35.7	950	18.84	5.816	17.13	5.676	66	78.27	156	414.9
72	Kaje	Marte	6.67	39.8	900	19.06	10.78	16.43	5.697	32	62	228	366.12
73	Garadai	Marte	6.9	34.4	877	19.32	7.324	14.79	4.952	62	62.24	204	317.3
74	N. Marte	Marte	7.82	41.6	674	18.75	8.612	15.765	6.025	28	59.4	119.99	305.1
75	Bul. Biafra	Dikwa	6.63	35.6	851	19.08	6.959	14.77	8.265	28	25.97	156	341.7
76	Gajibo	Dikwa	6.68	36.2	965	18.78	10.95	16.72	8.015	38	32.24	108	414.9
77	Logomani 1	Ngala	6.91	36.6	848	19.05	8.51	15.53	5.546	42	28.44	228	366.12
78	Logomani 2	Ngala	6.78	37.7	873	19.1	8.454	15.57	5.854	44.02	46.22	204	183.1
79	Ngala	Ngala	7.95	37.5	698	19.16	10.923	14.86	6.748	42	10.762	136.8	266
80	Kiyuba	Ngala	6.99	40.7	715	18.65	4.88	10.89	3.968	26	30	156	414.9
81	S. Dikwa	Dikwa	6.95	35.9	810	18.21	10.73	11.59	6.333	42.55	27.7	108	366.16
82	Ad. Dikwa	Dikwa	6.78	34.1	810	18.51	5.262	12.36	6.688	46.22	6.59	168	317.3
83	Rabiri	Dikwa	6.54	39.5	752	18.84	7.286	17.19	6.617	48.42	14.51	84	366.16
84	Bama	Bama	7.1	31.6	246	62.8	16.3	6.2	8.9	12.4	46.3	38.4	170.6
85	Bulonguwa	Dikwa	6.8	37.5	292	84.6	17.6	10.4	12.6	18.2	53.4	62.4	185.6
86	Yedi	Marte	7.9	38.1	589	47.4	17.8	13.9	11.2	39	61.3	118.6	110.8
87	Waramari	Bama	7.2	30.8	248	63.2	5.9	6.2	6	11	45.9	39.8	148
88	Jurom	Mafa	7.1	35.6	321	73.4	6.4	10.4	8	23	72.8	110.8	136
89	Kinjimeram Karaga	Mafa	7.6	37.2	564	98.3	13.1	12.2	8.7	48.4	76.3	128.4	178
90	Waru	Kaga	6.72	34	588	41.6	17.5	11.8	9.2	23.8	61.3	89.4	168.6
91	Wamiri	Kukawa	7.1	38.6	388	64.3	18.4	16.6	12.8	44.2	78.3	125	170.9
92	Goniri	Gujba	6.4	31	212	28.4	8.9	7.3	5.8	3.7	42.3	56.2	122.6
93	Chira Chira	Magumeri	7	38.4	346	43.6	16.9	13.8	12.4	41.8	66.6	122	172.3
94	Bindundul	Gubio	7.2	36.5	324	41.2	2.4	6.8	1.4	15.2	22.4	58.9	224.6
95	Chawa	Gubio	7.3	38.7	851	84.8	48.2	31.6	18.9	68.6	82	96.4	343.5
96	Damasak	Mobbar	7.5	39.6	1256	132.4	74.2	38.9	22.2	98.4	92.6	161.3	384.2
	Average		7.14	37.3	667	126.335	22.71	17.7123	9.4	55.52	60.29	110.117	240.528