HYDRO-CHEMICAL ASSESSMENT OF GROUNDWATER QUALITY WITHIN ILORIN NW SHEET 223, SOUTH-WESTERN NIGERIA

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ABSTRACT

The assessment of groundwater quality within Ilorin NW, Sheet 223 using physico–chemical indices has been carried out. The study assesses quality of groundwater in the area for domestic and agricultural purposes by insitu measurement of its physical parameters; laboratory analysis of its chemical parameters and assessment of levels of some hazard parameters for irrigation quality. The physical parameters which include colour, turbidity, pH, temperature and electrical conductivity were measured by insitu method using HANA Model HI83200 Multimeter while the chemical parameters which are (Ca^{2+}), (Na^{+}), (K^{+}), (Mg^{2+}) ,(Cu^{2+}), (Fe^{2+}), (Mn^{+}), (Zn^{+}),(Pb^{2+}),(Cd^{+}),(SO_4^{-}),(PO_4^{-}) (Cl^{-}) , (HCO_3^{-}) , (CO_3^{-}) , and (NO_3^{-}) were analysed by rock chemical composition determination methods at the University of Ilorin Central Research Laboratory. The parameters assessed for irrigation purpose include Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Salinity Hazard, Toxic Elements Hazard and Kelley's Index (K.I) using specified chemical equations. The result of the physical parameters measured shows average concentrations of 5 (TCU), 182.3 (NTU), 5.8, 31.29^{0}C and 359.14 (µS/cm) respectively, the laboratory analysis of chemical parameters indicates average concentrations of 0.85, 1.23, 0.35, 0.56, 0.03, 0.1, 0.02, 0.03, 0.05, 0.02, 0.11, 1.43, 65, 157, 123 and 0.47 (all in mg/l) respectively and the parameters calculated for irrigation quality revealed unsuitable (RSC), Excellent (SAR), medium salinity hazard, low toxic elements and suitable K.I. The major water types based on piper trilinear plot are Sodium–potassium bicarbonate and Calcium bicarbonate. Conclusively, the result of the physico–chemical assessment of groundwater samples in the area shows values that fall below the maximum desirable and permissible limits of World Health Organization (WHO) standard; suggesting that the groundwater is good for human consumption. It was also observed that the suitability of groundwater in the area for irrigation purpose is of excellent to good quality based on irrigation quality assessed parameters.

Key words: Groundwater, Hydro-chemical, Parameters, Quality assessment

INTRODUCTION

Groundwater is reported to have been a more reliable source of water for over half of the world population (Alabi *et al.,* 2010, Anomoharan, 2013). Groundwater is known to be fairly free most times from pollutants and hence requires little susceptibility to contamination. The limit of group of rocks in a region determines the extent of groundwater resources in the region. Lawrence and Ojo (2012) noted that groundwater that is most generally free from odour and colour has very low dissolved solid. It is also not usually affected by natural factors such as drought.

Most of the rural areas in Nigeria have their water supply from rivers, streams and hand-dug wells while the urban settlements depend on treated pipe-borne water and boreholes for their water supply. Olatunji *et al.* (2021) reported that population explosion and technological development

result in sporadic development of dumpsites where rubbish is kept; this causes pollutant. The authors added that the natural contaminants in the subsurface rocks add up to the artificial/manmade contaminant. These pose serious danger to the consumption of exploited groundwater. Thus, a thorough chemical analysis is imperative to ascertain the quality of the exploited groundwater.

The study area is a sub-urban settlement within the Basement Complex of southwestern Nigeria. The area is bounded between latitude 8^0 15' and 8^0 25'N and between longitude 4^0 30' and $4^0$37.5' E covering an area of 72 km^2 (Figure 1). The study area is underlain by crystalline rocks and generally, crystalline rocks have porosities of less than 3% (Bouwer, 1978). As such rocks of the Basement Complex, when not weathered are practically impermeable and have no storage capacity. However, appreciable porosity and permeability might have been developed in the rocks through fracturing and weathering processes (Davis and De Wiest, 1966), depending on the lithology and texture of the original rock. The local geology of the area consists of gneissic rocks of different varieties (migmatite gneiss, banded gneiss, augen gneiss, and granite gneiss), quartz mica schist, and fine-grained granite. The area which is of a dissected topography lies within the humid tropical climate with a total annual rainfall of about 1200 mm. It has a dendritic drainage pattern (Figure 1).

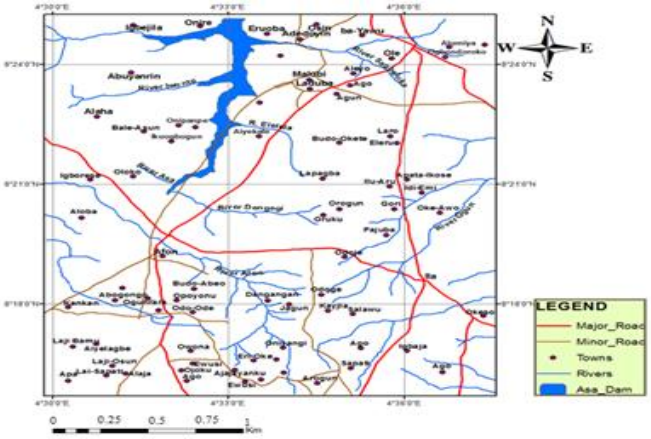


Figure 1: Topographical map of the study area

MATERIALS AND METHODS

The physical parameters measured are colour, turbidity, temperature, electrical conductivity and pH. The Parameters were assessed by visual inspection, turbidity metre, thermometer, electrical conductivity metre and pH metre in a four in one instrument known as HANA Model HI83200 Multimeter. The instrument was dipped in the groundwater samples carefully by making sure that it doesn't touch the container at the points of sampling while readings were taken. The major cations including heavy metals analysed are (Ca^+), (Na^+), (K^+), (Mg^+), (Cu), (Fe), (Mn), (Zn), (Pb), (Cd), by Atomic Absorption Spectrophotometer (AAS). Major anions such as Cl^- was analysed by the Argentimetric method, (SO_4^-), (PO_4^-) and (NO_3^-) by UV-spectrophotometric method, (HCO_3^-) by methyl orange alkalinity method and (CO_3^-) by Phenolphtaline alkalinity method. Total Dissolved Solid (TDS) was determined by multiplying electrical conductivity value of groundwater with 0.7 factors. Total Hardness (TH) was determined using hardness formula which is

Hardness (H) = 2.497 (Ca) + 4.118 (Mg)----------1

The quality of the groundwater for irrigation was assessed by evaluating the concentrations of Bicarbonate hazard or Residual Sodium carbonate (RSC), Sodium hazard or Sodium adsorption Ratio (SAR), Salinity hazard, Toxic elements hazard and Kelley's Index (K.I)). The parameters were calculated using the formulae and methods 2, 3, 4, 5, and 6 respectively.

$RSC= (HCO_3^- + CO_3^{2-}) – (Ca^{2+} + Mg^{2+})$ -2

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$ ----------3

Electro-conductivity of water =----------4

Atomic Absorption Spectrophotometer (AAS) ----------5

$$KI = \frac{Na}{Ca+Mg}$$ ----------6

RESULTS AND DISCUSSION

Results

Table 1: Laboratory values of physico-chemical parameters of groundwater in the area

Lat.(deg.)	Long.(deg.)	Locations	Villages	pH	Temp.(oC)	Elect.Cond.	Turbidity	TH (mg/l)	TDS (mg/l)	Ca^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	Mg^{2+} (mg/l)	Cu^{2+} (mg/l)	Fe^{2+} (mg/l)	Mn^{+} (mg/l)	Zn^{+} (mg/l)	Pb^{2+} (mg/l)	Cd^{+} (mg/l)	SO_4^{2-}(mg/l)	PO_4^{-}(mg/l)	Cl(mg/l)	HCO_3^{-}(mg/l)	CO_3^{-}(mg/l)	NO_3^{-}(mg/l)
8.43	4.57	L1	Osin Aremu	4.6	29	160	80	2.2815	112	0.765	0.66	0.17	0.09	0.015	0.06	0.045	ND	ND	0.015	0.1064	1.4299	40	125	0	0.6977
8.42	4.57	L2	Osin Idiem	5.2	32	330	160	4.447	231	0.475	1.405	0.72	0.795	0.015	0.2	0.01	ND	ND	ND	0.1065	1.4269	75	90	0	0.7365
8.43	4.55	L3	Apata out	4.8	34	400	200	4.3755	280	0.635	1.75	0.52	0.68	0.045	0.305	0.02	ND	ND	ND	0.1065	1.4289	35	130	230	0.6202
8.42	4.6	L4	Ganmo	5.6	30	530	260	3.525	371	0.795	1.36	0.4	0.375	0.02	0.05	0.01	ND	ND	ND	0.1064	1.43	230	100	0	0.6202
8.39	4.6	L5	Ogbondokc	5.3	31	460	230	3.4325	322	0.635	0.95	0.95	0.45	0.01	0.06	0.01	ND	ND	ND	0.1065	1.4302	115	155	220	0.6978
8.39	4.6	L6	Ogbondokc	4.1	30	270	130	2.95	189	0.77	0.73	0.2	0.25	0.055	0.085	0.025	ND	ND	0.02	0.1065	1.4272	40	135	125	0.3101
8.39	4.58	L7	Ago-Oja	3.7	31	390	190	5.96	273	0.58	2.01	0.475	1.1	0.03	0.425	0.055	0.015	ND	ND	0.1065	1.4268	40	160	220	0.8528
8.38	4.57	L8	Laduba	4.9	32	470	230	6.6725	329	0.865	1.06	0.3	1.1	0.025	0.035	0.01	ND	ND	ND	0.1065	1.4277	80	160	0	0.7365
8.38	4.56	L9	Malubi	4.6	30	420	210	8.889	294	1.44	1.465	0.515	1.29	0.035	0.08	0.01	0.01	ND	0.02	0.1065	1.4288	60	140	215	0.5815
8.35	4.52	L10	Olooko	4.7	35	610	300	6.648	427	0.97	1.515	0.21	1.03	0.045	0.065	0.01	ND	ND	ND	0.1065	1.4284	60	245	0	0.3876
8.36	4.5	L11	Arowosaye	4.3	30	120	250	3.88	84	0.855	0.935	0.235	0.425	0.03	0.03	0.01	0.025	ND	0.02	0.1065	1.4305	50	90	200	0.4652
8.37	4.51	L12	Alaha	4.1	29	280	140	2.7225	196	0.72	2.725	0.145	0.225	0.015	0.445	0.05	ND	ND	0.015	0.1065	1.4309	55	125	140	0.4264
8.42	4.52	L13	Ilu-Oba	4.5	29	460	230	6.365	322	1.07	1.705	0.25	0.9	0.01	0.08	0.025	ND	ND	0.03	0.1065	1.4304	40	175	455	0.3489
8.43	4.52	L14	Aloba	5.5	31	250	120	4.8185	175	0.845	1.27	0.135	0.66	0.03	0.045	0.01	ND	ND	0.02	0.1065	1.4317	70	195	130	0.1551
8.42	4.53	L15	Onire	4.8	32	430	210	4.2985	301	1.17	1.095	0.355	0.335	0.04	0.065	0.025	0.04	ND	ND	0.1064	1.4289	70	50	225	0.6202
8.42	4.52	L16	Obate	6.2	32	110	50	3.814	77	1.05	1.36	0.21	0.29	0.02	0.045	0.015	ND	ND	ND	0.1065	1.4288	70	100	205	0.6202
8.42	4.53	L17	Abeokuta	6.8	32	410	200	5.5135	287	1.41	1.18	0.33	0.485	0.01	0.03	0.015	ND	ND	ND	0.1064	1.4278	40	30	100	0.6589
8.42	4.52	L18	Ilu-Oba2	6.2	31	100	50	2.965	70	1.145	0.895	0.155	0.025	0.03	0.04	0.015	ND	ND	0.035	0.1076	1.4318	45	245	0	0.6202
8.41	4.52	L19	Egbejila	7.1	29	240	120	6.2585	168	1.995	0.7	0.115	0.31	0.045	0.05	0.01	0.01	ND	ND	0.1065	1.4281	35	200	135	0.3101
8.32	4.53	L20	Afon Elera	5.7	29	940	470	9.538	658	1.675	1.06	0.265	1.305	0.01	0.265	0.12	ND	ND	ND	0.1065	1.4296	160	165	0	0.3489
8.31	4.53	L21	Afon2	6.5	30	150	70	1.5615	105	0.395	0.84	0.14	0.14	0.01	0.015	0.015	0.01	ND	0.01	0.1064	1.4299	50	115	600	0.3877
8.3	4.51	L22	Alapako	6.8	30	410	200	5.573	287	0.54	1.475	0.345	1.03	0.02	0.075	0.03	ND	ND	ND	0.1064	1.4277	65	115	205	0.3101
8.28	4.49	L23	Kankan	6.5	30	240	120	4.198	168	0.81	2.075	0.435	0.53	0.03	0.18	0.025	ND	ND	ND	0.1065	1.425	40	90	155	0.3101
8.29	4.51	L24	Ajibaba	7.3	30	770	380	9.65	539	1.81	1.62	1.62	1.25	0.02	0.065	0.085	ND	ND	0.025	0.1065	1.4279	60	370	210	0.3877
8.28	4.53	L25	Sakamo	7.9	31	390	190	1.657	273	0.425	0.18	0.18	0.145	0.03	0.03	0.015	ND	ND	ND	0.1065	1.4292	35	125	210	0.3489
8.28	4.53	L26	Odo-Ode	6.2	31	180	90	1.591	126	0.415	0.885	0.205	0.135	0.015	0.065	0.015	0.11	ND	ND	0.1065	1.4299	75	115	0	0.3489
8.28	4.54	L27	Gbogbin	6.4	32	680	340	4.268	476	0.92	0.815	0.515	0.48	0.01	0.065	0.055	ND	ND	ND	0.1065	1.4262	45	300	0	0.6977
8.25	4.53	L28	Budo-Ojok	6.9	31	280	140	3.9495	196	0.645	1.17	0.235	0.57	0.03	0.035	0.015	ND	0.165	0.02	0.1064	1.4297	35	210	0	0.2714
8.23	4.51	L29	Ajila	6.3	33	380	190	4.931	266	0.685	1.11	0.17	0.785	0.02	0.035	0.015	ND	ND	0.015	0.1064	1.43	60	285	310	0.7365
8.26	4.51	L30	Lajisapati	6.5	33	210	100	2.814	147	0.65	1.295	0.25	0.29	0.035	0.045	0.01	ND	0.025	ND	0.1065	1.4293	55	70	0	0.1939
8.26	4.53	L31	Ewusi	6.3	35	150	70	1.768	105	0.535	0.955	0.21	0.105	0.02	0.095	0.02	ND	0.015	ND	0.1064	1.4272	65	140	0	0.3101
8.28	4.55	L32	Sholu	6.8	36	830	410	6.783	581	0.245	1.91	0.52	1.505	0.05	0.03	0.01	ND	0.01	ND	0.1065	1.4308	80	245	0	0.6978
8.26	4.58	L33	SapatiOko	5.7	31	50	20	2.0665	35	0.72	0.92	0.32	0.065	0.02	0.16	0.01	ND	0.015	ND	0.1065	1.4276	80	165	0	0.1551
8.28	4.58	L34	Idi-Ayan	6.3	31	120	60	1.5445	84	0.585	0.81	0.185	0.02	0.06	0.065	0.01	ND	ND	ND	0.1064	1.4291	70	170	0	0.1551
8.32	4.58	L35	Odoje	6.7	33	350	170	2.8215	245	0.53	1.145	0.29	0.365	0.01	0.09	0.02	ND	ND	ND	0.1064	1.4299	40	155	0	0.1551
		SUM		**201.8**	**1095**	**12570**	**6380**	**154.531**	**8799**	**29.78**	**43.04**	**12.28**	**19.54**	**0.92**	**3.51**	**0.85**	**0.22**	**0.23**	**0.25**	**3.73**	**50.01**	**2265**	**5485**	**4290**	**16.28**
		AVERAGES		**5.77**	**31.29**	**359.14**	**182.29**	**4.415**	**251.4**	**0.85**	**1.23**	**0.35**	**0.56**	**0.03**	**0.1**	**0.02**	**0.03**	**0.05**	**0.02**	**0.11**	**1.43**	**64.71**	**156.71**	**122.57**	**0.47**

Quality of Groundwater in the area for human consumption purpose

The result of the physical parameters (table 1) (colour, turbidity, pH, temperature and electrical conductivity) shows average concentrations of 5 TCU, 182.3 NTU, 5.8, 31.29 ^{0}C and 359.14 µs/cm respectively. The chemical parameters on the other hand which are (Ca^{2+}), (Na^{+}), (K^{+}), (Mg^{2+}),(Cu^{2+}), (Fe^{2+}), (Mn^{+}),(Zn^{+}),(Pb^{2+}), (Cd^{+}), (SO_4^{-}),(PO_4^{-}), (Cl^{-}) (HCO_3^{-}) , (CO_3^{-}) , and (NO_3^{-}) (table 1) have average concentrations of 0.85, 1.23, 0.35, 0.56, 0.03, 0.1, 0.02, 0.03, 0.05, 0.02, 0.11, 1.43, 65, 157, 123 and 0.47 (all in mg/l) respectively.

The values of water quality index of the 35 groundwater samples in the area are presented in Table 2

Table 2: Calculated values of groundwater quality index for the groundwater samples in the area

Location ID	Location Names	Groundwater Source	WQI
L1	OsinAremu	Hand-dug well	15.38
L2	OsinIdiemi	Borehole	18.12
L3	Apata out	Borehole	24.80
L4	Ganmo	Hand-dug well	29.12
L5	Ogbondoroko	Hand-dug well	30.88
L6	Ogbondoroko	Hand-dug well	33.78
L7	Ago-Oja	Borehole	33.47
L8	Laduba	Borehole	39.99
L9	Malubi	Hand-dug well	35.04
L10	Olooko	Borehole	28.63
L11	Arowosaye	Hand-dug well	34.99

L12	Alaha	Hand-dug well	29.02
L13	Ilu-Oba	Hand-dug well	31.02
L14	Aloba	Hand-dug well	21.80
L15	Onire	Hand-dug well	22.19
L16	Obate	Borehole	16.24
L17	Abeokuta	Borehole	18.32
L18	Ilu-Oba2	Borehole	28.81
L19	Egbejila	Hand-dug well	34.21
L20	AfonEleran	Borehole	32.07
L21	Afon2	Hand-dug well	35.04
L22	Alapako	Borehole	28.63
L23	Kankan	Borehole	34.99
L24	Ajibaba	Hand-dug well	35.04
L25	Sakamo	Borehole	28.63
L26	Odo-Ode	Borehole	14.63
L27	Gbogbin	Hand-dug well	17.202
L28	Budo-Ojoku	Borehole	19.43
L29	Ajila	Borehole	14.63
L30	Lajisapati	Borehole	17.20
L31	Ewusi	Borehole	19.43
L32	Sholu	Borehole	21.28
L33	SapatiOko	Borehole	21.77
L34	Idi-Ayan	Hand-dug well	24.66
L35	Odoje	Borehole	24.02

Quality of the groundwater for irrigation purpose

The results of quality of groundwater in the area for irrigation purpose are presented in tables 4 to 8.

Table 4: Calculated values of Residual Sodium Carbonate of groundwater samples in the area

LOCATION I.D	Groundwater Source	$HCO_3 + CO_3$	Ca + Mg	RSC	Remarks (RSC < 1.25 = Low, RSC between. 1.25 and 2.5 = Marginal, RSC > 2.5 = high (Richards, 1954).
L1	Hand-dug well	2.049	0.045	2.0033	M. Suitable
L2	Borehole	1.475	0.090	1.3850	M. Suitable
L3	Borehole	5.964	0.088	5.8756	Unsuitable
L4	Hand-dug well	1.639	0.071	1.568	M. Suitable
L5	Hand-dug well	5.552	0.069	5.4828	Unsuitable
L6	Hand-dug well	4.296	0.059	4.2367	Unsuitable
L7	Borehole	6.290	0.121	6.1693	Unsuitable
L8	Borehole	2.623	0.135	2.4881	M. Suitable
L9	Hand-dug well	5.878	0.179	5.6985	Unsuitable
L10	Borehole	4.016	0.134	3.8817	Unsuitable
L11	Hand-dug well	4.808	0.078	4.7298	Unsuitable

L12	Hand-dug well	4.382	0.055	4.3273	Unsuitable
L13	Hand-dug well	10.452	0.129	10.3235	Unsuitable
L14	Hand-dug well	5.364	0.0973	5.2668	Unsuitable
L15	Hand-dug well	4.569	0.086	4.4826	Unsuitable
L16	Borehole	5.056	0.077	4.9793	Unsuitable
L17	Borehole	2.159	0.110	2.0481	M. Suitable
L18	Borehole	4.016	0.059	3.9567	Unsuitable
L19	Hand-dug well	5.529	0.126	5.4034	Unsuitable
L20	Borehole	2.705	0.192	2.5125	M. Suitable
L21	Hand-dug well	11.885	0.031	11.8536	Unsuitable
L22	Borehole	5.302	0.113	5.1892	Unsuitable
L23	Borehole	4.058	0.0845	3.9733	Unsuitable
L24	Hand-dug well	9.566	0.195	9.3713	Unsuitable
L25	Borehole	5.549	0.033	5.5157	Unsuitable
L26	Borehole	1.885	0.032	1.853	M. Suitable
L27	Hand-dug well	4.918	0.086	4.832	Unsuitable
L28	Borehole	3.442	0.079	3.3623	Unsuitable
L29	Borehole	9.839	0.099	9.7393	Unsuitable
L30	Borehole	1.148	0.057	1.0913	Suitable
L31	Borehole	2.295	0.035	2.2595	M. Suitable
L32	Borehole	4.016	0.137	4.0022	Unsuitable
L33	Borehole	2.705	0.041	2.6636	Un Suitable
L34	Hand-dug well	2.787	0.030	2.7561	Un Suitable
L35	Borehole	2.541	0.056	2.4841	M. Suitable

M. suitable = marginally suitable

Table 4: Calculated values of Sodium Adsorption ratio for groundwater in the area

LOCATION I.D	Na	(Ca+Mg)	√(Ca+Mg)	√(Ca+Mg)/2	SAR = (Na/√(Ca+Mg)/2	Remark
L1	0.02900	0.04575	0.213892	0.106946	0.27116	Excellent
L2	0.06100	0.09	0.3	0.15	0.40666	Excellent
L3	0.07600	0.088417	0.297349	0.148675	0.51118	Excellent
L4	0.05900	0.071	0.266458	0.133229	0.44284	Excellent
L5	0.04100	0.06925	0.263154	0.131577	0.31160	Excellent
L6	0.03200	0.059333	0.243584	0.121792	0.26274	Excellent
L7	0.08700	0.120667	0.347371	0.173686	0.50090	Excellent
L8	0.04600	0.134917	0.36731	0.183655	0.25047	Excellent
L9	0.06400	0.1795	0.423674	0.211837	0.302119	Excellent
L10	0.06600	0.134333	0.366515	0.183258	0.36015	Excellent
L11	0.04100	0.078167	0.279583	0.139792	0.29329	Excellent
L12	0.11800	0.05475	0.233987	0.116994	1.008559	Excellent
L13	0.07400	0.1285	0.358469	0.179234	0.41287	Excellent
L14	0.05500	0.09725	0.311849	0.155925	0.35273	Excellent
L15	0.04800	0.086417	0.293967	0.146984	0.32657	Excellent
L16	0.05901	0.076667	0.276887	0.138444	0.42617	Excellent
L17	0.05100	0.110917	0.333042	0.166521	0.30627	Excellent
L18	0.03911	0.059333	0.243584	0.121792	0.32021	Excellent
L19	0.03000	0.125583	0.354377	0.177189	0.16931	Excellent
L20	0.04611	0.1925	0.438748	0.219374	0.20969	Excellent
L21	0.03712	0.031417	0.177247	0.088624	0.41749	Excellent
L22	0.06411	0.112833	0.335907	0.167953	0.38106	Excellent
L23	0.09000	0.084667	0.290975	0.145488	0.63661	Excellent
L24	0.07000	0.194667	0.44121	0.220605	0.31731	Excellent
L25	0.00811	0.033333	0.182574	0.091287	0.08764	Excellent
L26	0.03811	0.032	0.178885	0.089443	0.42485	Excellent
L27	0.03512	0.086	0.293258	0.146629	0.23669	Excellent
L28	0.05111	0.07975	0.2824	0.1412	0.36119	Excellent
L29	0.04810	0.099667	0.3157	0.15785	0.30409	Excellent
L30	0.05611	0.056667	0.238048	0.119024	0.47049	Excellent
L31	0.04211	0.0355	0.188414	0.094207	0.44583	Excellent
L32	0.08301	0.137667	0.371035	0.185517	0.44739	Excellent
L33	0.04000	0.041417	0.203511	0.101755	0.39310	Excellent
L34	0.03512	0.030917	0.175831	0.087916	0.39811	Excellent
L35	0.04911	0.056917	0.238572	0.119286	0.41078	Excellent

Table 5: Calculated values of salinity Hazard for groundwater of the study area

LOCATION I.D	ELECTROCONDUCTIVITY (µs/cm)	SALINITY HAZARD
L1	160	LOW
L2	330	MEDIUM
L3	400	MEDIUM
L4	530	MEDIUM
L5	460	MEDIUM
L6	270	MEDIUM
L7	390	MEDIUM
L8	470	MEDIUM
L9	420	MEDIUM
L10	610	MEDIUM
L11	120	LOW
L12	280	MEDIUM
L13	460	MEDIUM
L14	250	LOW
L15	430	MEDIUM
L16	110	LOW
L17	410	MEDIUM
L18	100	LOW
L19	240	LOW
L20	940	HIGH
L21	150	LOW
L22	410	MEDIUM
L23	240	LOW
L24	770	HIGH
L25	390	MEDIUM
L26	180	LOW
L27	680	MEDIUM
L28	280	MEDIUM
L29	380	MEDIUM
L30	210	LOW
L31	150	LOW
L32	830	HIGH
L33	50	LOW
L34	120	LOW
L35	350	MEDIUM

Table 6: Obtained values of Toxic elements compared with FAO (1985) and WHO(1993) Guidelines

parameters	FAO (1985) Values (mg/l)	WHO (1993)Guideline Values (mg/l)	Obtained values in the area (mg/l)
Zn	<2	3.000	0.03
Mn	<0.2	0.500	0.02
Pb	<5	0.010	0.05
Cd	<0.01	0.003	0.02
Cu		2.000	0.03

Table 7: Kelley Index for suitability of groundwater for irrigation purpose in the study area

LOCATION I.D	Na	Mg + Ca	K.I = Na/(Mg+Ca)	Remarks
L1	0.02869	0.0458	0.6272	Suitable
L2	0.06108	0.09	0.6787	Suitable
L3	0.07608	0.0884	0.8605	Suitable
L4	0.0591	0.071	0.8328	Suitable
L5	0.0413	0.0693	0.5965	Suitable
L6	0.0317	0.0593	0.5349	Suitable
L7	0.0874	0.1207	0.7242	Suitable
L8	0.0460	0.1349	0.3416	Suitable
L9	0.06369	0.1795	0.3549	Suitable
L10	0.0658	0.1343	0.4903	Suitable
L11	0.04065	0.0782	0.5200	Suitable
L12	0.11847	0.0548	2.1639	Unsuitable
L13	0.0741	0.1285	0.5769	Suitable
L14	0.05521	0.0973	0.5678	Suitable
L15	0.04760	0.0864	0.5509	Suitable
L16	0.0591	0.0767	0.7713	Suitable
L17	0.0513	0.1109	0.4625	Suitable
L18	0.0389	0.0593	0.6558	Suitable
L19	0.0304	0.1256	0.2423	Suitable
L20	0.0460	0.1925	0.2394	Suitable
L21	0.0365	0.0314	1.1625	Unsuitable
L22	0.06413	0.1128	0.5684	Suitable
L23	0.0902	0.0847	1.0656	Unsuitable
L24	0.0704	0.1947	0.3618	Suitable
L25	0.0078	0.0333	0.2348	Suitable
L26	0.0384	0.032	1.2024	Unsuitable
L27	0.0354	0.086	0.4120	Suitable
L28	0.0508	0.0797	0.6379	Suitable
L29	0.0482	0.0997	0.4842	Suitable
L30	0.0563	0.0567	0.994	Suitable
L31	0.0415	0.0355	1.1696	Unsuitable
L32	0.0830	0.1377	0.6032	Suitable
L33	0.0400	0.0414	0.9658	Suitable
L34	0.0352	0.0309	1.1391	Unsuitable
L35	0.0497	0.0569	0.8747	Suitable

DISCUSSION

The physico–chemical analysis of 35 groundwater samples in the study area was carried out to assess the quality of the groundwater for domestic and agricultural uses. The physical and chemical parameters analysed showed that the groundwater in the study area is potable for human consumption, in line with the reports by Adekeye, 2001; Tijani and Ayodeji, 2001; Adeyemi *et al.,* 2003 and Adekunle *et al.,* 2007. Figures 2 and 3 show comparisons between the average concentrations obtained from the water samples and the WHO acceptable and permissible limits for the physical and chemical parameters. The figures indicated that the concentrations of physical and chemical parameters of groundwater in the area are mostly below the WHO desirable and permissible limits; signifying the potability of the ground water. Also, Based on Residual Sodium Carbonate (RSC), most of groundwater samples in the study area are unsuitable for irrigation purposes (Richards, 1954). Sodium adsorption Ratio (SAR) revealed that groundwater in the area is of low sodium which indicates that they are excellent for irrigation purpose. The Salinity hazard of groundwater in the area is of medium range and toxic elements hazard are absent indicating that the groundwater is good for irrigation. Kelley Index values of groundwater in the area are all lesser than one, indicating the suitability and excellence use of groundwater in the area for irrigation purpose according to Kelley's index ratio (1951)

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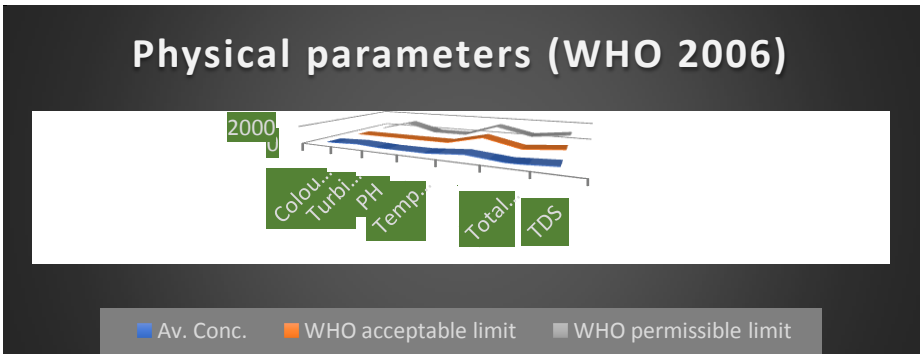


Figure 2: Graph comparing the average concentrations obtained for the physical parameters with the WHO acceptable and permissible limits

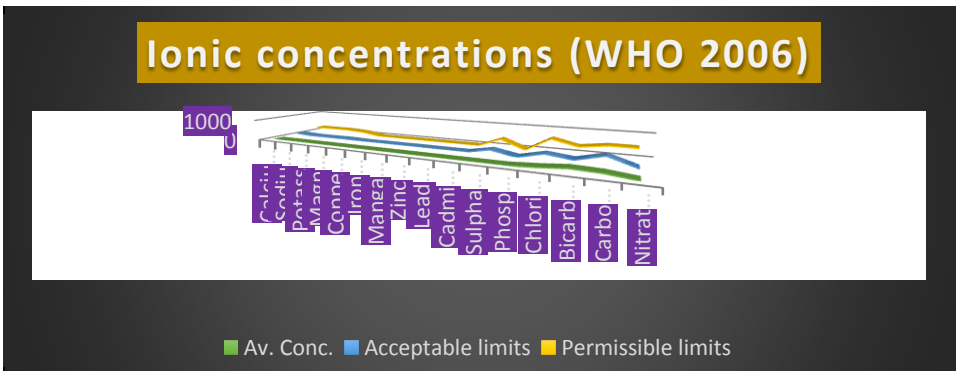


Figure 3: Graph comparing the average concentrations obtained for the ionic concentrations with the WHO acceptable and permissible limits.

CONCLUSION

The result of physico–chemical assessment of groundwater samples in the study area shows that the concentrations of ions in the groundwater fall within the desirable and permissible limits of World Health Organization (WHO) standard. This confirms that the groundwater in the area is potable for domestic purposes.

The groundwater quality index values calculated for the groundwater samples of the area indicated good to excellent quality rating; suggesting good potability of the groundwater.

Based on major hazard parameters analysed to reveal the suitability of groundwater in the area for irrigation purpose, the groundwater is of excellent to good for irrigation purpose

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