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RESEARCH ARTICLE

Assessment of Seasonal Groundwater Quality for Domestic Use in Akure Metropolis, Ondo State, Nigeria

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ABSTRACT

Twenty groundwater samples from functional wells within Akure metropolis were collected and analysed for physiochemical parameters using standard field and laboratory procedures. The water samples were taken in February (Dry season) and in July (Rainy season) and analysed. The study area (Akure metropolis) was demarcated into ten zones; two (2) hand-dug wells were selected in each zone for physical measurement of well depth, water depth and diameter of the wells. The result obtained showed the following mean values during the dry season; PH of 6.59, TDS 210.9 mgL^{-1},TS 227.8 mgL^{-1}, Turbidity 5.16NTU, Chloride 69.3 mgL^{-1}, Sodium 23.77 mgL^{-1}, Electrical conductivity 564.55 us/cm, Temperature 28.67^{0}C, Total Hardness 219.5 mgL^{-1}, Total Alkalinity 104.9 mgL^{-1}, potassium 42.21mgL^{-1}, Iron 0.48mgL^{-1}, Sulphate 51 mgL^{-1}, Manganese 0.48 $mgL^{-1}$and Nitrate 0.38 mgL^{-1}.The mean values during the rainy season were PH 6.85, TDS 230.3 mgL^{-1},TS 281.65 mgL^{-1},Turbidity 4.46NTU, Chloride 67.7 mgL^{-1}, Sodium 22.21 mgL^{-1}, Electrical Conductivity 556.76 us/cm, Temperature 23.1^{0}C, Total Hardness 218.42 mgL^{-1}, Total Alkalinity 121.0 mgL^{-1}, potassium 42.91 mgL^{-1}, Iron 0.56 mgL^{-1}, Sulphate 51.6 mgL^{-1}, Manganese 0.12 $mgL^{-1}$and Nitrate 0.27 mgL^{-1}. When compared with the World health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) standards, the result showed that 85% of the well water samples were suitable for drinking and domestic uses, while the samples from Ijoka, Araromi and Obanla (Abattoir) areas were found to be polluted and unsuitable for drinking due to their physiochemical parameters. Such pollution posed a great threat to well water quality and could lead to an increase risk level of water borne diseases outbreak, therefore these wells require urgently certain levels of treatment before use**.** I will recommend that wells especially for groundwater portability should be situated far away from Abattoir dirty drainage channels, deep erosion channels, and septic tanks, since they can contaminate them.

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INTRODUCTION

Apart from air, water remains the second most important natural resources on which the survival of living things largely depends on. Human beings can live sixty (60) days without food, but can rarely survival for three (3) days without water (Wright *et al*., 2004). Groundwater is an important resource for livelihoods and food security of billions of people, especially in developing countries of Africa. The contribution from groundwater is important because about 2billion people depends directly on groundwater for drinking, and 40% of the world's food is produced by irrigated Agriculture that relies largely on groundwater(Morris *et al*., 2003).

The major source of groundwater is precipitation. Precipitation in form of rainfall contains very few impurities, it contains trace amount of mineral matter, gases and other substance as it forms and falls through the earth atmosphere (Oteze, 1982). Precipitation however, has virtually no bacterial content. Once precipitation reaches the earth's surface, many opportunities are presented for the introduction of mineral and organic substances, micro-organisms and other forms of pollution (contaminations). When water runs over or through the

ground surface, it may pick up particles of soil. This is noticeable in the water as cloudiness or turbidity. It also picks up particles of organic matter and bacteria. As surface water seeps downward in the soil and through the underlying materials to the water table, most of the suspended particles are filtered out. This natural filtration may be practically effective in throwing bacteria and other particulate materials in groundwater (Mathess, 1982). However, the chemical characteristics of water may change and vary widely when it comes in contact with mineral deposit.

Groundwater is an essential and vital resource in Akure metropolis as it constitutes the major source of water for drinking, industrial production, domestic and Agricultural uses (Ayodele, 1998). One of the important attributes of good quality water is that it should be free from disease-causing organisms such as pathogenic bacteria, viruses, protozoa or parasitic worms (Apkata & Ekundayo, 1978). More than half of the dwellers in Akure lack access to potable water, the few ones that have access are either linked to a piped source from the local water board or from few-well-treated boreholes. Most residents rely on water from shallow wells in most private homes. The water from these shallow well are not treated prior drinking, this may account for the prevalence of water borne diseases in Akure as shown in Table1.

Table 1: Clinical statistics of water borne disease in Akure from 1996-2000

Diseases	1996	1997	1998	1999	2000
Cholera	55	37	51	24	11
Diarrhea	3389	2254	4771	3918	1185
Dysentery	963	487	245	833	303
Guinea worm	3	11	19	2	-
Schistomomiasis	86	10	138	93	7
Typhoid	947	536	896	573	474
Total	5443	3335	5820	5443	1981

Source: Ondo State specialist hospital, Akure 2004 culled from Akinbile (2006)

Groundwater quality can be affected by both natural and anthropogenic activities ,In addition to natural contamination sources, groundwater can affected by Agricultural, municipal and industrial activities in the recharge zone of the aquifer, potential source of contaminants include recycle Irrigation water, waste water from human and animal waste and as by – product from industrial activities (Walton, 1991). Nitrate is an important constituent in fertilizer and is present in relatively high concentration in human and animal waste.

In recent years, a number of events affecting groundwater quality have contributed to a heightened public awareness and concern about the importance and vulnerability of this vital resource, media reports about contamination of wells from septic tanks, leaking petroleum product, pipe/gasoline underground storage tanks and dry cleaning solvents, chemical leakages from industries and livestock waste have raised public concern about groundwater quality.

Water quality is a guideline value that represents the level (concentration or a number) of constituents that ensures an aesthetically pleasing water and do not result in any significant risk to the health of the consumer (Frederick, 1990). Potable water is the one that is safe to drink, pleasant to taste and usable for domestic purposes. It must be free from objectionable odour, colour, taste, hardness and contaminations (Wilcock, 1983).

MATERIALS AND METHODS

Study Area

This research was carried out in Akure Metropolis, capital city of Ondo State, which is located between latitude 7˚13' and 7˚18' north of the Equator and longitude 5˚9 and 5˚14 east of the Greenwich meridian. Akure has a tropical climate with two distinct seasons; a relatively dry season from November to March and a rainy season from April to October. The average rainfall is within the range of 140mm-2400mm, the mean monthly temperature of about 28^0C, relative humidity of about 75%. Akure stands on an attitude of 370m above sea level and topography of are composed of highlands and lowlands. In general, the land rises from the coastal part of Akure north to Akure south (Nwankwoala & Nwagbowa, 2012).

Areas Covered in the Project

Upon the study of the population distribution of Akure, the following densely populated areas of Akure were selected for the field study.

(1) FUTA Area
(2) Osokoti/Osolo Layout
(3) Fanibi Layout
(4) Obanla/Abbatior
(5) Araromi/Abbatior
(6) Leo Area
(7) Oke-Aro Area
(8) Oke Ogba Area
(9) Ijoka Area
(10) Sijuade Area

Sample Collection and treatments

Sampling containers were pre-sterilized with hot water. At each location, samples for physiochemical parameters were collected in a two (2) litres plastic container which was covered and labeled appropriately to reflect the locations. Before the sample collection, the container was thoroughly rinsed with the water to be sampled. The water quality analysis was carried out at the water laboratories of the Ondo state water corporation and the Federal University of Technology, Akure chemistry department.

Methods

A measuring tape was used to take the diameter of the wells, depth of the wells and the height of the well ring. The water level indicator was used to measure the water level in the wells. Information was gathered on the nature of the wells selected. Oral interview was conducted with people in the neighborhood to determine the use(s) and availability of water in the wells. During the measurement, it was observed that the diurnal fluctuation and differential local discharge effect are negligible within the range.

Analysis

The in situ and laboratories test were carried out in accordance with standard American Public Health Association (APHA, 1998) standards.

Table 2: Locations and features of the wells

Sample location	Well	Water depth dry depth (M)	Water depth rainy season (M)	Seasonal draw season (M)	Well diameter down (M)	Lining casing (M)	Type of cover	Use of well	Remarks
1. FUTA AREA									
WS1 FUTA 1	10.97	1.52	2.50	0.98	0.85	Ringed concrete	Iron	Domestic	Clean Surroundings
WS2 FUTA 2	8.29	1.13	2.01	0.88	0.82	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
2. LEO AREA									
WS3 LEO 1	6.70	0.88	1.55	0.67	0.85	Ringed concrete	Iron	Domestic &Drinking	Dirty Surroundings
WS4 LEO 2	5.21	0.64	1.09	0.45	0.91	Ringed concrete	Iron	Domestic	Clean Surroundings
3. IJOKA AREA									
WS5 IJOKA 1	5.57	0.41	0.91	0.52	0.82	Not Ringed	Iron	Domestic &Drinking	Dirty Surroundings
WS6 IJOKA 2	6.14	0.51	1.07	0.56	0.91	Ringed concrete	Wood	Domestic &Drinking	Clean Surroundings
4. SIJUADE AREA									
WS7 SIJUADE 1	8.82	0.43	2.24	1.81	1.04	Ringed concrete	Iron	Domestic &Drinking	Dirty Surroundings
WS8 SIJUADE 2	5.67	2.27	1.13	0.86	0.73	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
5. FANIBA									
WS9 FANIBA 1	3.91	0.67	2.19	1.52	0.91	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
WS10 FANIBA 2	4.88	0.43	1.04	1.61	1.04	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
6. OKE OGBA AREA									
WS11 OKE OGBA 1	9.02	9.76	2.45	1.69	0.85	Not Ringed	Iron	Domestic &Drinking	Clean Surroundings
WS12 OKE OGBA 2	7.28	0.60	1.92	1.32	0.85	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
7. OBANLA AREA									
WS13 OBANLA 1	3.62	0.92	1.83	0.91	0.91	Ringed concrete	Iron	Domestic	Clean Surroundings
WS14 OBANLA 2	5.03	0.71	1.69	0.98	0.91	Ringed concrete	Iron	Domestic &Drinking	Dirty Surroundings
8. ISOKOTI AREA									
WS15 ISOKOTI 1	5.79	0.46	1.98	1.52	0.91	Ringed concrete	Wood	Domestic &Drinking	Clean Surroundings
WS16 ISOKOTI 2	4.22	0.60	2.10	1.52	0.73	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
9. ARAROMI AREA									
WS17 ARAROMI 1	4.30	0.55	0.80	0.25	1.04	Not Ringed	No cover	Domestic &Drinking	Dirty Surroundings
WS18 ARAROMI 2	3.59	0.18	0.50	0.32	0.73	Not Ringed	Iron	Domestic	Erosion Around
10. OKE ARO AREA									
WS19 OKE ARO 1	5.91	0.90	2.19	2.10	0.91	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings
WS20 OKE ARO 2	3.47	1.12	2.90	1.78	0.85	Ringed concrete	Iron	Domestic &Drinking	Clean Surroundings

The in situ measurements were carried out using Potable digital meter, EXECH PH-100, digital EC/TDS/ Temperature COM-100 and Turbidimeter to measure the parameters; PH, EC, TDS, Temperature and Turbidity. The chemical analysis of TA, TH, Acidity and Chloride concentration were determined using titrimetrical techniques. The concentration of metals (Iron, Lead, Manganese, Zinc and Calcium) was determined by Atomic Absorption Spectrophotometer (AAS). While TSS, sulphate and Nitrate were determined using HACH DR/2000 direct reading spectrophotometer.

RESULTS AND DISCUSSION

Observation from Field Survey

During the field survey conducted, the following observation were noted

1. Forty percent (40%) of areas where the water samples were taken had poor drainage system.
2. Sixty percent (80%) of the wells where water samples were collection are consumed by the people living in the vicinity of the well.
3. Seventy five percent (75%) of the wells were covered with Iron covers, while fifteen percent (15%) of the wells were covered with wooden cover while ten percent (10%) of the well had no cover at all. The well locations and features are presented in Table 2 below;

Analysis of Result from Field Survey

The results obtained from the analysis of the water samples collected from twenty different wells in Akure are found in Tables 3, 4, 5 and Table 6.

Temperature

The mean temperature value for all locations is 28.76˚C during the dry season, with the highest temperature recorded been 30˚c by samples WS1, WS4, WS9 and WS10 (Table 4). The mean temperature for all location during the rainy season is 23.1˚C, while the highest value was recorded in sample WS11 (Table 5). The mean temperature during the dry season is higher this is due to the prevalent atmospheric conditions. Temperature is very important because it determines the level of dissolved oxygen, substance solubility and bacterial activities in water.

Total Dissolved Solids

The TDS concentration in the study area from analytical results range between 77 mg/L in WS5 to 370 mg/L in WS20 with an average of 210.9 mg/L during the dry season as shown in (Table 5).The minimum, maximum and average value of TDS during the rainy season are 79 mg/L (WS12), 434 mg/L (WS9) and 230.3 mg/L as shown in Table 3. All the well samples met the WHO and NSDWQ standards for drinking water quality. TDS greater than 600 mg/L will make water unpalatable and might cause excessive scaling in water pipes, heaters and boilers (WHO, 2011). TDS in groundwater are generally not harmful to human being but high concentration may affect persons, who are suffering from kidney and heart diseases (Gupta, 2004).

Total Solids

The total solids ranges in value from 90mg/L recorded in sample WS5 collected from Ijoka area to 920 mg/L in sample WS16 collected from Isokoti area.

Table 3: Physical Parameters of Well Water Samples During the Rainy Season

Sample	Appearc.	Colour H^+	Temp. ^0C	Odour	Taste	Turb. NTU	EC	PH
WS1	Clear	13	24.7	Mild	Tasty	1.5	450	6.9
WS2	Cloudy	9	26	Mild	Insipid	1.2	338	6.5
WS3	Clear	12	22	Mild	Insipid	1.5	620	6.9
WS4	Clear	7	23.1	Mild	Insipid	2.3	780	7.2
WS5	Clear	4	22.2	Mild	Insipid	3.8	200	6.7
WS6	Cloudy	8	20.1	Mild	Insipid	3.6	420	7.6
WS7	Clear	6	25	Odour	Insipid	7	290	6.8
WS8	Cloudy	13	21	Mild	Tasty	1.5	340	6.9
WS9	Clear	2	23	Mild	Insipid	3	620	7.3
WS10	Clear	6	23.7	Mild	Insipid	4	600	6.7
WS11	Cloudy	3	24.1	Odour	Tasty	2.6	250	6.8
WS12	Clear	11	25	Mild	Insipid	12	270	6.5
WS13	Cloudy	15	21.3	Tasty	Odour	17	360	6.8
WS14	Cloudy	7	24	Mild	Odour	12	1800	6.9
WS15	Clear	6	22.1	Mild	Insipid	1.5	290	7.2
WS16	Clear	2	23	Mild	Insipid	3	480	6.7
WS17	Clear	11	24.3	Odour	Tasty	4.1	700	6.4
WS18	Cloudy	6	21.6	Mild	Insipid	3.7	1120	7.1
WS19	Clear	6	24.8	Mild	Tasty	1.8	400	6.5
WS20	Clear	5	21	Mild	Insipid	2.1	810	6.6

Table 4: Physical Parameters of Well Water Samples During the Dry Season

Sample	Appearc.	Colour H^+	Temp. ^0C	Odour	Taste	Turb NTU	EC	PH
WS1	Clear	3	30	Mild	Tasty	1.5	400	6.8
WS2	Cloudy	5	28.1	Mild	Insipid	1.1	340	6.5
WS3	Clear	2	26.7	Mild	Insipid	4.3	410	6.6
WS4	Clear	7	30	Mild	Insipid	2.2	550	6.4
WS5	Clear	4	27	Mild	Tasty	4.5	180	6.4
WS6	Cloudy	8	30	Mild	Insipid	3.8	450	6.7
WS7	Clear	3	27.2	Odour	Insipid	5	290	6.6
WS8	Cloudy	6	27.7	Mild	Tasty	10	520	6.1
WS9	Clear	2	30	Mild	Insipid	2.5	420	6.2
WS10	Clear	4	30	Mild	Insipid	2.7	620	6.8
WS11	Cloudy	3	29.1	Mild	Tasty	13	290	6.4
WS12	Clear	12	29.4	Mild	Insipid	11	220	6.5
WS13	Cloudy	8	29.2	Odour	Tasty	18	1300	6.8
WS14	Cloudy	11	29.7	Mild	Tasty	10	1467	6.4
WS15	Clear	6	27.8	Mild	Odour	1.5	270	6.8
WS16	Clear	2	28.3	Mild	Insipid	1.6	520	6.7
WS17	Clear	11	29	Odour	Tasty	3.8	669	6.4
WS18	Cloudy	7	29.1	Mild	Insipid	2.9	1213	6.9
WS19	Clear	6	28.5	Mild	Tasty	1.8	380	7.2
WS20	Clear	5	28.4	Mild	Insipid	2.1	790	6.6

The TS has an average value of 281.65 mg/L (Table 5) during the rainy season and average of 227.32 mg/L during the dry season (Table 6). When compared to the WHO and NSDWQ standards for drinking water quality, all other sample were found suitable for human consumption and domestic use.

Total Hardness

The total hardness ranges from 76 mg/L in sample WS4 collected from LEO Area during the dry season (Table 6) to 740 mg/L in sample WS11 collected from OKE OGBA. With an average of 218.4 mg/L during the rainy season (Table 5) and 219.4 mg/L during the dry season (Table 6). When compared to the standard for potable water, The total hardness for samples WS11, WS13, WS14, WS16 and WS17 exceeded the WHO and NSDWQ standards hence the samples are adjudged as hard (Tables 5 and 6). Total hardness (TH) does not have any associated adverse health related effects on humans but is an indication of deposits of Ca and/or Mg ions. Their presence will disallow water from forming lathe with soap thereby preventing economic management of water resource (Akinbile, 2006).

Electrical Conductivity (EC)

The electrical conductivity values of well water samples range from 200 µs/cm in WS5 to 1800 µs/cm in WS14 with an average of 556.69 µs/cm during the rainy season (Table 3). The minimum, maximum and average values of EC during the dry season were 220µs/cm, 1467.65 µs/cm and 564.95 µs/cm in samples WS12 and WS14 respectively (Table 4).

Turbidity

The turbidity ranges in value from 1.1NTU to 18NTU in samples WS2 in FUTA 2 (Aba area) and WS13 in Obanla1 (Abattoir) respectively. The mean turbidity during the dry season is 5.56NTU and the mean turbidity during the rainy season is 4.46NTU. Samples WS7, WS8, WS11, WS12, WS13 and WS14 with value 7NTU, 10NTU, 13NTU, 12NTU, 18NTU, and 12NTU (Tables 5 and 6) respectively are turbid as their values exceeds the

Table 5: Chemical Parameters of Well Water Samples Collected During the Rainy Season

Sample	TDS mg/L	TSS mg/L	TS mg/L	TA mg/L	ACDT mg/L	TH mg/L	CA H mg/L	Mg H mg/L	CL^- mg/L	S04 mg/L	Nitrate mg/L	Fe mg/L	K mg/L	Na mg/L	Mn mg/L	Pb mg/L	Free carbon
WS1	280	N.D	280	140	340	138	76	62	58	6	0.5	2.5	10	20	0.1	N.D	70
WS2	239	7	246	120	300	84	46	38	20	N.D	0.4	0.2	30	12	N.D	N.D	50
WS3	324	N.D	324	48	600	137	96	41	90	0.6	N.D	0.3	1	30	N.D	0.07	45
WS4	200	N.D	200	50	420	100	54	46	62	0.1	0.2	0.1	N.D	15	0.1	N.D	80
WS5	50	N.D	94	13	758	89	25	64	42	0.3	N.D	N.D	10	0.1	0.2	N.D	60
WS6	210	N.D	210	50	502	80	41	39	74	11.9	0.1	0.1	90	30	0.1	N.D	80
WS7	400	13	413	12	233	100	29	71	40	2.1	0.1	N.D	1.6	10	N.D	0.03	87
WS8	194	44	238	100	328	122	84	38	27	173	0.4	0.4	20	60	N.D	N.D	34
WS9	434	N.D	434	122	493	176	128	48	122	1.7	0.1	0.1	32.4	1.5	N.D	0.1	25
WS10	211	11	222	176	120	140	83	57	30	N.D	N.D	N.D	45	30	0.5	N.D	95
WS11	280	133	413	51	361	740	581	159	30	16.1	N.D	0.1	4.2	18	N.D	N.D	80
WS12	79	19	98	152	643	97	51	48	21	10.5	0.2	N.D	N.D	11	0.07	N.D	95
WS13	232	22	234	291	170	291	192	99	38	3	N.D	0.4	10	20	N.D	N.D	20
WS14	314	11	325	200	194	420	247	81	35	N.D	N.D	0.7	203	0.1	N.D	N.D	75
WS15	130	N.D	130	120	547	221	184	37	123	300	N.D	N.D	20	10	0.1	0.01	40
WS16	256	64	920	111	295	420	285	135	120	5.5	N.D	N.D	0.4	26	0.01	N.D	60
WS17	172	41	213	80	411	410	287	123	40	135	0.5	1.3	47.1	0.2	N.D	N.D	30
WS18	346	21	161	326	269	81	54	27	167	0.3	N.D	N.D	70	20	0.06	N.D	85
WS19	291	17	308	130	391	321	181	140	118	113	N.D	N.D	167	130	0.03	0.02	45
WS20	170	N.D	170	128	193	293	191	102	98	98	N.D	N.D	10.8	0.4	N.D	N.D	60
NSDWQ	500	250	1000	200		400	75	30	250	200	10	0.3	200	200	0.1	0.1	100
WHO	1000	250	1000	200		400	75	30	200	200	10	0.3	200	200	0.2	0.1	100

TA=Total Alkanity, TH=Total Hardness, ACDT= Acidity, TSS=Total Suspended solid, Ca H=Calcuim Hardness, TDS=Total dissolved Solid, N.D= Not detected

Table 6: Chemical Parameters of Well Water Samples Collected During the Dry Season

Sample	TDS mg/L	TSS mg/L	TS mg/L	TA mg/L	ACDT mg/L	TH mg/L	CA mg/L	HMg mg/L	HCL^- mg/L	S04 mg/L	Nitrate mg/L	Fe mg/L	K mg/L	Na mg/L	Mn mg/L	Pb mg/L	Free carbon
WS1	280	N.D	280	122	340	112	74	38	27	7	0.5	2.4	14	20	1	N.D	50
WS2	231	N.D	231	110	300	116	84	32	29	N.D	0.41	0.2	20	10	N.D	N.D	30
WS3	245	22	277	46	600	88	64	39	89	0.6	N.D	0.3	5	32	N.D	0.09	45
WS4	232	N.D	232	35	420	76	50	26	41	N.D	0.2	N.D	3	9	0.1	N.D	30
WS5	77	13	90	58	758	116	70	46	42	3	N.D	N.D	10	0.2	0.2	N.D	60
WS6	203	N.D	203	40	502	80	45	35	71	13	0.2	0.1	91	29	0.1	N.D	80
WS7	280	10	290	12	233	88	62	26	39	2.1	0.1	0.2	2	18	N.D	0.03	84
WS8	210	49	259	16	328	80	30	50	20	170	0.7	0.3	13	77	N.D	N.D	63
WS9	140	44	184	58	493	92	70	22	128	2.9	0.3	0.1	31	13	N.D	0.1	80
WS10	194	N.D	194	45	120	150	80	70	30	0.05	N.D	N.D	49	12	3	N.D	95
WS11	208	79	287	49	361	730	50	23	33	12.8	0.01	0.2	4.2	14	N.D	N.D	80
WS12	134	N.D	134	17	643	106	63	53	29	8.7	0.9	N.D	N.D	9	0.6	N.D	60
WS13	196	30	226	284	170	425	292	133	47	2.88	N.D	0.4	11	0.9	N.D	N.D	70
WS14	280	19	299	200	194	423	150	100	25	N.D	N.D	0.6	202	10	0.01	N.D	50
WS15	120	10	130	154	547	356	288	66	125	300	0.1	N.D	29	26	0.1	0.2	60
WS16	234	6	240	120	295	310	176	134	150	5.7	N.D	0.1	5	22	0.1	N.D	30
WS17	154	27	181	84	411	420	296	124	60	129	0.5	1.1	41.8	3	N.D	N.D	85
WS18	150	2	163	326	269	77	58	18	188	0.3	N.D	N.D	54	39	0.06	N.D	78
WS19	280	7	287	142	391	318	174	144	119	111	0.6	0.2	198	131	0.03	0.02	30
WS20	370	N.D	370	180	193	300	180	120	94	97.3	N.D	N.D	19.1	0.4	N.D	N.D	60
NSDWQ	500	250	1000	200		400	75	30	200	250	10	0.3	200	200	0.1	0.1	100
WHO	1000	250	1000	200		400	75	30	200	200	10	0.3	200	200	0.1	0.1	100

TA=Total Alkanity, TH=Total Hardness, ACDT= Acidity, TSS=Total Suspended Solid, Ca H=Calcuim Hardness, TDS=Total dissolved Solid, N.D= Not detected

WHO and NSDWQ standard turbidity guideline value. Samples WS13 and WS12 are not used as drinking water by the people living in the various areas while sample WS7 and WS8 are used for drinking water (Table 2).

Sulphate

Sulphur ranges in value from 0.05 mg/L in sample WS10 collected from Leo2 area to 300 mg/L in sample WS15 collected from Isototi area. All the samples fall below the guideline values for potable water in WHO and NSDWQ standard with exception of sample WS15 (Table 5 and 6). The highest value was recorded in Isokoti area. Hence the well is high in sulphate.

Sodium

Sodium ranges in value from 0.1 mg/L in samples WS5 and WS14 collected during the rainy season to 131 mg/L in sample WS19 collected from Oke Aro area. All the samples fall within the recommended guideline value potable for water in WHO and NSDWQ standards.

Potassium

Potassium ranges in value from 0.4 mg/L in sample WS16 collected from Isokoti area to 203 mg/L in sample WS14 collected from Obanla2 area. The average of samples during the rainy season is 42.21 mg/L and 42.91 mg/L during the dry season (Table 5 and 6). When compared with WHO and NSDWQ standard permissible limit, all samples fall within required standard for drinking and domestic uses. With exception of sample WS14 which is too high.

Chloride

The maximum, minimum and average levels of chloride in the water samples investigated were 20 mg/L, 167 mg/L and 67.75 mg/L respectively during the rainy

Table 7: Statistical Description of Well Water Physiochemical Parameters

Parameter	Unit	Mean for Rainy season	Mean for dry season	Average value for both seasons	WHO/ NSDWQ STD
Colour	H^o	7.6	5.57	6.58	15
Turb.	NTU	4.46	5.16	4.81	5
EC	µs/cm	556.76	564.55	560.65	1000
PH		6.85	6.59	6.72	6.5-8.5
Temp	^0C	23.1	28.76	25.93	25-28
TDS	mg/L	230.3	210.9	220.6	1000
TSS	mg/L	33.58	24.46	29.02	250
TS	mg/L	281.65	227.8	254.7	1000
TA	mg/L	121	104.9	112.95	100-200
ACDT	mg/L	378.4	378.4	374.4	400
TH	mg/L	218.4	219.5	218.95	400
CA H	mg/L	145.75	117.8	131.77	75
Mg H	mg/L	72.75	64.95	68.85	30
CL^-	mg/L	67.7	69.3	68.5	200
S04	mg/L	51.6	51	51.3	200
Nitrate	mg/L	0.277	0.38	0.328	10
Fe	mg/L	0.56	0.48	0.52	0.3
K	mg/L	42.91	42.21	42.56	200
Na	mg/L	22.21	23.77	22.99	200
Mn	mg/L	0.12	0.48	0.3	0.1
Pb	mg/L	0.046	0.088	0.067	0.1
Free carbon		60.8	61	60.9	100

season (Table 5). The dry season concentrations are 20 mg/L, 188 mg/L with an average of 69.3 mg/L (Table 6).When compared to the NSDWQ and WHO limits, all samples were lower than the stipulated 200mg/L value.

Iron

The Fe ion contents in the well water samples in the area during both seasons are characterized by low concentrations. But samples WS1, WS8, WS14, WS15 and WS17 concentrations exceed the WHO and NSDWQ acceptable limit of 0.3 mg/L. The effects of excess Fe^{2+} ions in water could cause taste, coloration and odour problems as seen in Table 3 and 4.

Nitrate

Nitrate concentration ranges from 0.01mg/L in sample WS11 to 0.9 mg/L in WS12 with an average of 0.377 mg/L during the dry season (Table 6) and varies from 0.1-0.5 mg/L with an average of 0.27 mg/L for the rainy season (Table 5). Nitrate in groundwater is derived mainly from Agricultural chemicals used in the area. However, the nitrate concentration for all samples falls within the WHO and NSDWQ standard for drinking water quality.

Conclusion

This study assessed the physiochemical characteristics of hand dug wells in Akure metropolis during the rainy and dry seasons. The WHO and NSDWQ drinking water quality standards adopted shows that most of the well samples are suitable for drinking and domestic uses except well WS14, WS15 and WS18 (Tables 3,4,5 and 6). The well water samples WS14 and WS18 contamination could be attributed to their location, very close to Abattoirs, although WS18 is not used as drinking water.

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