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Quality Assessment Of Groundwater System In Itori Community Of Ewekoro Local Government Area, South-West Nigeria

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***Abstract*—The availability of quality water resources has always been the primary concern of societies in urban and rural areas even in the areas of abundant rainfall. The overall significance of quality water consumption for overall health and wellness of any population cannot be overemphasized. The water quality status of boreholes and hand-dug wells in Itori community of Ewekoro Local Government Area, South-West Nigeria was investigated in this study. Inhabitants of this region depend on these water resources for drinking and other purposes. Water samples were collected from 25 boreholes and 25 hand-dug wells at various sampled points across the study area. Standard Analytical Methods were employed for all analyses and the results were compared with both National and International water quality standards of WHO, NESREA, NSDWQ and NAFDAC. Most quality determinants in the sampled water are within WHO guidelines except BOD, ALK, Cl^-, NH_4^+, HCO_3^{2-}, $MgCO_3^-$, Zn^{2+} and Fe^{3+}. The overall ionic dominance pattern for the borehole and well follow the same trend $K^+ > Na^{2+} > Fe^{3+} > Mn^{2+}$ and $Cl^- > NO_3^- > NO_2^-$. The hygienic condition of the water bodies is found to be poor. High BOD_5, Coliform Count and BOD_5:NO_3^- ratios of groundwater samples are indicative of organic pollution due to faecal contamination. Multivariate statistical approach [Correlation, Principal Component Analysis (PCA), Cluster Analysis (CA) and Bubble Plot] was used to identify interrelationships among the analyzed physicochemical parameters and the pollution sources. The results imply that water bodies in Itori are polluted and pose potential risk to humans.**

Keywords—Hand-dug wells; Water quality; Organic pollution index; Multivariate analysis

1 Introduction

Water has been the most important and unavoidable natural resource on earth. It is essential for all known forms of life, and is approximated to cover 70.9% of the earth surface (Foster, 2001; Pasquini and Alexander, 2004; Verplanck *et al.*, 2006). Despite its abundance, the quality and accessibility of potable water remains a global challenge; moreso, in rural and semi-rural communities in the developing countries (Faremi and Oloyede, 2010; Foster, 2001; Lashkaripour, 2003). Poor water quality continues to pose major threats to human health. Today, contaminated water has been reported to kill more people than cancer, AIDS, war or even accident (WHO, 2011a). Diarrhoeal diseases alone account for an estimated 4.1% of total daily global burden of disease and are responsible for the deaths of 1.8 million people every year; 88% of this burden is attributable to unsafe water supply, poor sanitation and hygiene (WHO, 2004). Microbial contamination of drinking water supplies especially from human faeces is a major contributor to diarrhoeal diseases that kill millions of children every year (Foppen, 2002; Horward *et al.*, 2006; Verplanck *et al.*, 2006; UNEP *et al.*, 2008). It is therefore important that drinking water is free from disease causing germs and toxic chemicals that endanger public health. Hence, this study is to assess the quality of surface and ground water sources in some autonomous villages in Itori communities of Ewekoro Local Government Area of Ogun State.

2 Material and methods

2.1 Study Area

Itori is located on latitude of 6°56'22.44"N and a longitude of 3°13'14.38"E with elevation of 27.25 Meters (89.42 Feet) as displayed on the inset map showing the study areas in ogun state within Nigeria continental domain. Ewekoro formation is the local geology in the study area which is generally consistent with the regional geology of eastern part of the Dahomey Basin; predominantly comprises of the non-crystalline and highly non-fossiliferous and fossiliferous limestone and thinly laminated fissile and probably non-fossiliferous shale (Ushie *et al.*, 2014). It is the sedimentary terrain of southwestern Nigeria. Figure 1 is an inset map showing the study areas in ogun state within nigeria continental domain while figure 2 is the data acquisition map showing the investigated locations inthe study area **(**Ishola, 2019**).**

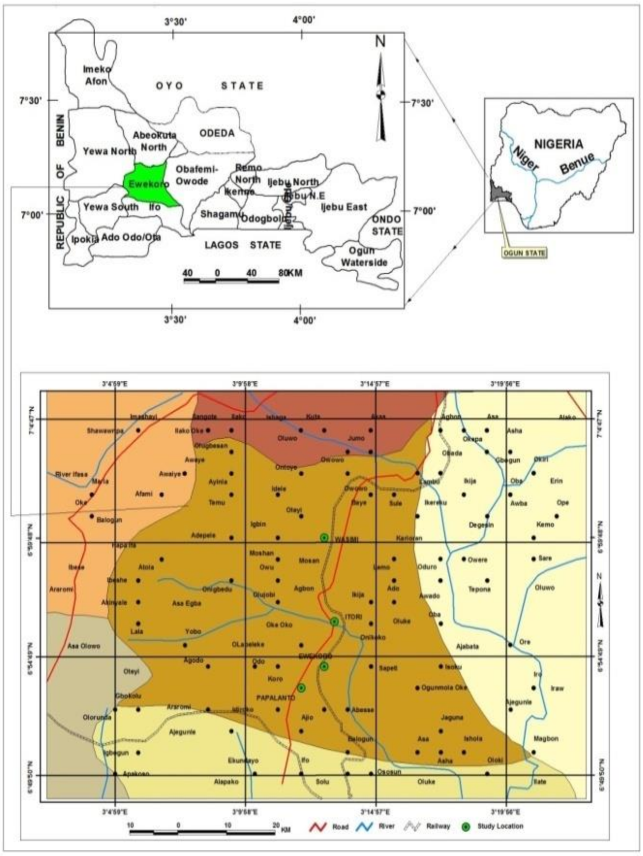

Fig. 1. Inset Map showing the Study Areas in Ogun State within Nigeria Continental Domain (Arcview GIS 3.2A Environment, Ishola, 2019)

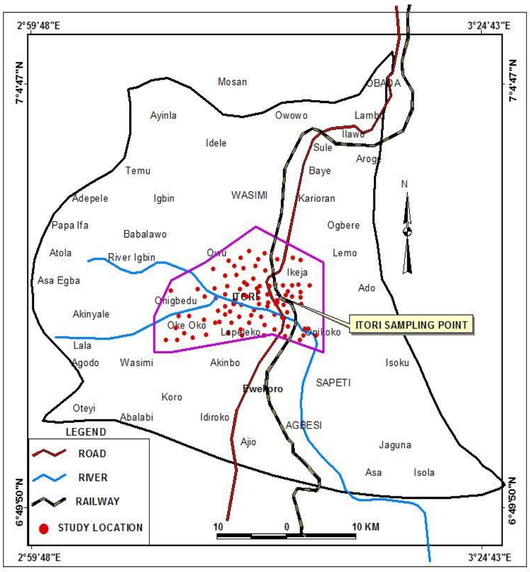

Fig. 2: Data Acquisition Map showing the Investigated Locations inthe Study area (Ishola, 2019**).**

2.2 Data source

Water samples were strategically collected from existing and functional 25 boreholes and 25 hand-dug wells at different sampling points within Itori communities. Physico-chemical analyses of the water samples were carried out to identify and quantify the physical properties and chemical components of water. This includes pH, cations, anions, trace elements. For DO, BOD5 and bacteriological determinations, the mouth of the tap was heated for five minutes with a spirit lighter to destroy microorganisms, and the tap water allowed to run freely for 5 minutes prior to sample collection. Samples collected were immediately stored in clean air tight, leak proof plastic bottles and labeled appropriately while Samples for metals were preserved using 1 ml concentrated HNO_3 per litre of sample. All water samples were stored in an insulated cooler containing ice (maintained at 4 °C) and delivered to the laboratory. Physicochemical parameters, Heavy metal concentrations and bacteriological examination were measured in the laboratory using standard procedures of inductively coupled optical emission spectrophotometry and pour plate techniques (APHA, 1992). Physico-chemical properties (Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature, Dissolved Oxygen (DO) and pH were determined insitu using Hannah Combo TDS/pH/EC/Temperature meter series multi-parameters (model HI991300), whereas Hannah (model HI9147)

equipment was used for DO in order to ensure that they are not subjected to alteration such as temperature while BOD5 was measured with JYD-IA DO meter after five days incubation. Other physicochemical parameters, bacteriological evaluation and metals levels were measured in the laboratory using standard procedures (APHA, 1992).
Descriptive and Multivariate analyses were performed on a set of water quality data.

3.0 Results and Discussion

The pH levels of the water sources range from 6.40 to 6.86 for borehole and 6.50 to 7.80
for hand-dug wells. The temperatures of the water bodies range from 25°C to 30°C for borehole and 26°C to 28°C for well water. Electrical conductivity is a good measure of dissolved solids; it is an important criterion in determining the suitability of a body of water for irrigation (Kumar and Pal, 2012). The values for Electrical Conductivity of the water sources range from 550 µs/cm to 710 µs/cm for borehole while that of the wells range from 510µs/cm to 880 µs/cm across the study area. The alkalinity levels of the water bodies in the study area is very high and range from 141.40 to 1446.10 mg/L in boreholes and 144.70 mg/L to 2881.40 mg/L for wells while the levels of COD obtained from borehole water sources range from 24.10 mg/L to 36.20 mg/L and 23.81 mg/L to 36.82 mg/L from well sources. Ammonium levels in samples from the study area range from 0.44 mg/L to 1.74 mg/L for boreholes and 0.12 mg/L to 1.46 mg/L for hand-dug wells. The levels of anions in the different water sources are as follows: Chloride ranges from 34.91 mg/L to 360.50 mg/L in boreholes and 34.92 mg/L to 380.11 mg/L in wells; The water sources in all the zones have considerable high levels of coliform count (Table 2). In borehole water, the Total Hetetrophic Bacteria Count (THBC) ranges from 0 to 2.83×10^2 cfu/ml and 0.2×10^2 cfu/ml to 21×10^2 cfu/ml in hand-dug wells; the Total Coliform Count (TCC) ranges from 0 to 18 MPN/100mL in boreholes and 3 MPN/100mL to 241 MPN/100mL in wells while the Faecal Coliform Count (FCC) ranges from 0 to 1.3×10^2 cfu/ml in boreholes and and 0 to 6.5×10^2 cfu/ml for wells. Well water from the study area has the higher total bacteria counts (Table 1 and Table 2).
$BOD:NO_3$- ratio is used as an index to measure organic pollution of water bodies from Itori. $BOD_5:NO_3$- ratio ranges from 162.55 in borehole and 148.33 in well water.

Table 1: Physico-Chemical Parameters of Itori Boreholes (N=25)

Parameters	Min	Max	Mean±SD	WHO (mg/L)	NESREA (mg/L)	NSDWQ (mg/L)	USEPA (mg/L)
PH	6.40	6.86	6.66±0.16	6.5 – 9.5	7.00-8.50	6.50-8.50	6.50-8.50
TEMP (^0C)	26.00	28.00	26.52±0.77	27	NA	NA	27
EC(μScm^{-1})	550.00	710.00	614.32±56.93	1200	NA	900	1200
DO (mg/L)	6.82	7.84	3.56±155.30	7.5	NA	7.5	NA
BOD (mg/L)	16.70	20.96	17.88±1.13	10	NA	10	NA
COD (mg/L)	24.10	36.20	28.75±3.17	NA	NA	NA	NA
TDS (mg/L)	0.48	10.90	7.59±2.28	100	1500	500	500
TSS (mg/L)	0.15	0.61	0.34±0.10	< 10	<10	NA	NA
TS (mg/L)	0.28	1.21	0.60±0.29	1500	NA	NA	NA
TURB (NTU)	0.10	1.11	0.28±0.28	< 4	5.0	5.0	5.0
ALK (mg/L)	141.40	1446.10	489.02±507.57	200	500	100	100
TH (mg/L)	12.50	25.94	17.46±3.77	< 200	100-300	500	NA
THC(mg/L)	0.00	0.41	0.07±0.12	NA	NA	NA	NA
Na^{2+} (mg/L)	24.10	42.10	30.48±5.10	< 200	NA	200	NA
K^+ (mg/L)	31.80	56.91	38.69±8.72	250	200	NA	200
Ca^{2+} (mg/L)	9.40	22.90	12.96±3.84	100	75	NA	75
Mg^{3+} (mg/L)	1.70	5.83	4.20±1.08	20	15	NA	20
Cl^- (mg/L)	34.91	360.50	122.04±118.17	250	200	250	100
NO_3^- (mg/L)	0.04	0.13	0.11±0.02	50	45	NA	10
NO_2^- (mg/L)	0.01	0.03	0.02±0.008	< 3.0	NA	NA	NA
SO_4^{2-} (mg/L)	5.11	12.74	7.80±2.72	400	500	200	250
NH_4^+ (mg/L)	0.44	1.74	0.95±0.36	1.50	NA	NA	NA
PO_4^{3-} (mg/L)	7.20	10.72	8.35±1.08	NA	NA	NA	NA
HCO_3^- (mg/L)	72.35	743.50	334.65±289.19	100	NA	NA	NA
Cu^{2+} (mg/L)	0.00	0.05	0.02±0.01	2.0	NA	1.0	1.3
Pb^{2+} (mg/L)	0.00	0.0004	0.0004±0.0005	0.01	0.01	0.01	0.01
Cd^{2+} (mg/L)	0.00	0.0002	0.0002±0.0004	0.003	0.003	0.001	0.005
Mn^{2+} (mg/L)	0.00	0.03	0.01±0.009	0.1	0.2	0.5	0.4
Zn^{2+} (mg/L)	0.40	1.74	1.008±0.37	0.01	NA	NA	NA
Fe^{3+} (mg/L)	0.04	1.20	0.44±0.34	0.3	0.3	0.3	0.3
Cr (mg/L)	0.00	0.0001	0.0001±0.0003	0.05	0.05	0.05	0.05
Co (mg/L)	0.00	0.0001	0.0001±0.0003	0.05	0.05	0.05	0.05
Ni (mg/L)	0.00	0.0003	0.0003±0.0005	0.02	0.05	NA	NA
S (mg/L)	0.15	2.81	1.08±0.67	250	NA	NA	NA
Al^{3+} (mg/L)	0.00	0.00	0.0004±0.0005	0.2	NA	NA	0.2
I (mg/L)	0.02	0.07	0.03±0.01	NA	NA	NA	NA
Si (mg/L)	0.00	0.02	0.002±0.006	NA	NA	NA	NA

The multivariate Analysis shows significant correlation for each elemental and Physico-chemical variable with 95% confidence interval for mean using Pearson correlation coefficient (2-tailed) which was computed to deduce common source of water quality parameters in the boreholes and wells with significant high positive correlations. It must be pointed out that some correlation seems to be significant due to the rounding of the values when in actual fact, they are not significant. Maximum benefit is derived from water usage when it is within the accepted quality standards; however, where there are alterations in the physiochemical parameters, it is imperative that it goes through processes to improve quality prior to such usage, especially for drinking. The overall ionic dominance pattern for Itori borehole and well water samples follow the same trend Cl^- >K^+ >Na^{2+} > Fe^{3+} > NO_3^- >NO_2^- >Mn^{2+}. The borehole and well water samples contain more Fe^{3+} than Mn^{2+} **(**Table 1 and Table 2) which is in agreement with (USEPA, 2002 USEPA, 2010) report while the elevated values of HCO_3^{2-} and $MgCO_3^-$ is suggestive of possible subsurface dilution of the weathering of the carbonate rocks of the study area being a typical limestone

Table 2: Physico-Chemical and Elemental Parameters of Itori Hand-Dug Wells (N=25)

Parameters	Min	Max	Mean±SD	WHO (mg/L)	NESREA (mg/L)	NSDWQ (mg/L)	USEPA (mg/L)
PH	6.50	7.80	7.14±0.41	6.5 – 9.5	7.00-8.50	6.50-8.50	6.50-8.50
TEMP (^{0}C)	22.00	28.00	26.24±1.71	27	NA	NA	27
EC (μScm^{-1})	510.0	880.00	671.44±94.6	1200	NA	900	1200
DO (mg/L)	6.70	8.16	7.58±0.44	7.5	NA	7.5	NA
BOD (mg/L)	15.75	21.91	17.80±1.79	10	NA	10	NA
COD (mg/L)	23.81	36.82	29.88±3.57	NA	NA	NA	NA
TDS (mg/L)	0.68	10.44	6.29±2.94	100	1500	500	500
TSS (mg/L)	0.22	0.67	0.33±0.15	<10	<10	NA	NA
TS (mg/L)	0.33	1.16	0.92±0.32	1500	NA	NA	NA
TURB (NTU)	0.10	1.09	0.26±0.25	< 4	5.0	5.0	5.0
ALK (mg/L)	144.7	2881.40	566.71±658.	200	500	100	100
TH (mg/L)	14.44	27.92	20.52±3.14	< 200	100 -300	500	NA
THC (mg/L)	0.00	0.22	0.09±0.07	NA	NA	NA	NA
Na^{2+} (mg/L)	24.61	51.82	37.33±7.42	< 200	NA	200	NA
K^+ (mg/L)	30.12	65.81	46.14±9.26	250	200	NA	200
Ca^{2+} (mg/L)	9.74	23.74	14.60±3.66	75	NA	NA	75
Mg^{3+} (mg/L)	2.84	10.86	4.73±2.27	20	15	NA	20
Cl^- (mg/L)	34.92	380.11	252.12±126	250	200	250	100
NO_3^- (mg/L)	0.11	0.13	0.12±0.007	50	45	NA	10
NO_2^- (mg/L)	0.01	0.04	0.02±0.007	< 3.0	NA	NA	NA
SO_4^{2-} (mg/L)	5.11	18.68	9.51±3.12	400	500	200	250
NH_4^+ (mg/L)	0.12	1.46	0.87±0.34	1.50	NA	NA	NA
PO_4^{3-} (mg/L)	7.88	12.71	9.38±1.23	NA	NA	NA	NA
HCO_3^- (mg/L)	72.35	1440.71	236.28±300	100	NA	NA	NA
Cu^{2+} (mg/L)	0.01	0.06	0.04±0.02	2.0	NA	1.0	1.3
Pb^{2+} (mg/L)	0.00	0.0008	0.0008±0.00	0.01	0.01	0.01	0.01
Cd^{2+} (mg/L)	0.00	0.0007	0.0007±0.00	0.003	0.003	0.001	0.005
Mn^{2+} (mg/L)	0.01	0.06	0.04±0.01	0.1	0.2	0.5	0.4
Zn^{2+} (mg/L)	0.46	4.30	1.60±0.89	0.01	NA	NA	NA
Fe^{3+} (mg/L)	0.02	1.40	0.54±0.32	0.3	0.3	0.3	0.3
Ni (mg/L)	0.00	0.03	0.007±0.01	0.02	0.05	NA	NA
S (mg/L)	1.00	7.40	3.36±1.71	250	NA	NA	NA
Al^{3+} (mg/L)	0.00	0.01	0.001±0.002	0.2	NA	NA	0.2
I (mg/L)	0.02	0.08	0.04±0.01	NA	NA	NA	NA
Si (mg/L)	0.00	0.02	0.002±0.005	NA	NA	NA	NA

KEY

NA− NOT AVAILABLE IN THE NATIONAL GUIDELINES AND STANDARDS DRINKING WATER QUALITY
WHO − WORLD HEALTH ORGANISATION
NESREA −NATIONAL ENVIRONMENTAL STANDARD REGULATION AGENCY
USEPA − UNITED STATE ENVIRONMENTAL PROTECTION AGENCY
NSDWQ− NATIONAL STANDARDS FOR DRINKING WATER QUALITY

formation; this is supported by the predominance of HCO_3^{2-} among the anionic water quality determinants displayed in the bubble plot (Fig. 3)**.** The results obtained for microbial analyses are shown in Table 3 and Table 4. The highest Total Coliform Count of 241 x 10^2 MPN/100 ml is found in well water while the highest Total Heterotrophic Bacteria Count (THBC) and Faecal Coliform Count (FCC) are also found in well water samples; 5.2x10^2 cfu/ml and 6.5 x 10^2 cfu/ml respectively (Table 3 and Table 4). The high coliform count obtained from the analyzed groundwater samples of the investigated study area implies poor sanitary conditions of the water bodies, and is also an indication of pollution by organic materials (APHA, 1992; WHO, 2011a). Proximity of hand-dug wells to latrines and suck away pits could make the well to be highly vulnerable to coliform infestation.

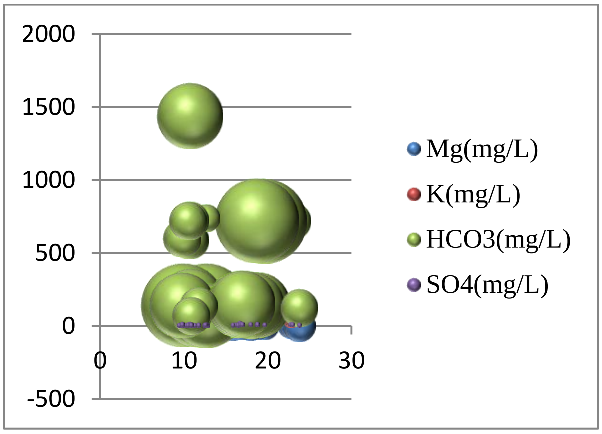

Fig. 3: Bubble Plot of Itori quality determinants showing the predominance of HCO_3^{2-}

Table 3: Bacteriological Counts of borehole Water Sample in Itori

SAMPLE CODE	DO (mg/L)	BOD (mg/L)	COLOUR (TCU)	THBC ($\times10^2$cfu/ml)	TCC (MPN/100ml)	FCC ($\times10^2$ cfu/ml)
ITOBH1	7.50	18.00	5	2.6	18	0
ITOBH2	7.46	18.40	5	2.02	17	0
ITOBH3	8.00	18.80	10	2.8	18	0
ITOBH4	8.04	18.60	5	1.6	17	0
ITOBH5	7.84	18.60	10	2.8	18	0
ITOBH6	7.70	18.10	5	2.8	18	0
ITOBH7	7.40	16.75	5	2.6	5	0
ITOBH8	7.35	16.84	5	0	0	0
ITOBH9	7.40	18.90	5	1.7	16	0
ITOBH10	7.30	18.20	6	1.9	16	0
ITOBH11	6.92	20.96	5	2.7	18	0
ITOBH12	6.89	20.16	5	1.8	15	0
ITOBH13	7.84	18.60	6	2.5	18	0
ITOBH14	7.82	18.60	6	1.8	16	1.2
ITOBH15	7.60	16.70	4	0	0	0
ITOBH16	7.62	16.70	5	1.6	18	0
ITOBH17	7.60	16.92	5	2.8	18	0
ITOBH18	7.60	16.90	5	1.6	18	0
ITOBH19	7.64	16.90	5	2.8	15	0
ITOBH20	7.62	16.90	5	1.6	18	1.3
ITOBH21	7.40	16.96	5	1.6	18	0
ITOBH22	7.62	16.94	4	0.9	7	0
ITOBH23	7.64	16.92	3	0	0	0
ITOBH24	7.20	18.10	5	2.6	18	0
ITOBH25	6.82	17.60	5	1.43	17	0
			WHO (1996) USEPA (2002) Guidelines	**1.0 $\times10^2$cfu/ml**	**0.00 MPN/100 ml**	**0 $\times10^2$ cfu/ml**

Key:
ITOBH = Itori Borehole Water
DO = Dissolved Oxygen
BOD= Biological Oxygen Demand
THBC = Total Heterotrophic Bacteria Counts
TCC = Total Coliform Counts
FCC = Total Faecal Coliform Counts

Table 3: Bacteriological Counts of Well Water Sample in Itori

SAMPLE CODE	DO (mg/L)	BOD (mg/L)	COLOUR (TCU)	THBC ($\times10^2$cfu/ml)	TCC (MPN/100ml)	FCC ($\times10^2$ cfu/ml)
ITOWW1	6.70	15.80	10	5.2	111	3.2
ITOWW2	6.84	15.82	6	3.8	16	1.6
ITOWW3	7.90	16.88	5	3.2	110	3.2
ITOWW4	7.90	16.70	5	2.0	10	2.8
ITOWW5	6.90	15.75	5	5.2	241	2.0
ITOWW6	6.92	16.10	5	1.4	52	3.7
ITOWW7	8.10	21.70	5	0.17	11	1.5
ITOWW8	8.16	21.90	6	0.2	11	1.7
ITOWW9	7.40	16.75	5	21	73	4.8
ITOWW10	7.35	16.84	5	1.01	13	5.3
ITOWW11	7.00	20.50	5	0.2	4	6.5
ITOWW12	7.10	21.10	5	3.17	30	1.5
ITOWW13	7.90	17.26	6	1.1	60	6.2
ITOWW14	7.92	17.22	5	3.2	10	4.5
ITOWW15	7.80	17.20	4	5.6	11	0
ITOWW16	7.82	17.20	5	2.6	50	0
ITOWW17	7.98	16.94	5	2.8	30	0
ITOWW18	7.77	18.64	5	0.5	3	0
ITOWW19	7.96	16.91	5	8.8	62	0
ITOWW20	7.94	16.89	5	8.5	53	0
ITOWW21	7.80	18.72	4	4.7	7	0
ITOWW22	7.46	18.40	3	0.13	79	0
ITOWW23	7.70	18.42	5	0.3	14	0
ITOWW24	7.85	16.94	5	0.25	17	4.8
ITOWW25	7.40	18.40	5	2.9	10	4.4
			WHO (1996) USEPA (2002)	**1.0 x 10^2 cfu/ml**	**0.00 MPN/100 ml**	**0 $\times10^2$ cfu/ml**

Guidelines

Key:
ITOWW = Itori Well Water
DO = Dissolved Oxygen
BOD= Biological Oxygen Demand
THBC = Total Heterotrophic Bacteria Counts
TCC = Total Coliform Counts
FCC = Total Faecal Coliform Counts

Maximum benefit is derived from water usage when it is within the accepted quality standards; however, where there are alterations in the physiochemical parameters, it is imperative that it goes through processes to improve quality prior to such usage, especially for drinking. Therefore, it is well recommendable for setting up of domestic and commercial pond for fish farming. The mean value of the pH of Itori boreholes is 6.66±0.16. The acidic nature of these water sources can be attributed to a number of factors. In shallow wells, the acidity might be due to the drainage of metal-rich rocks (Essumang *et al.*, 2011). In boreholes, the presence of organic acids from decaying vegetation (Verplanck *et al.*, 2006), as well as dissolved carbon dioxide and the dissolution of sulphide minerals may play a significant role in the low levels of water pH (Todd, 1980). Furthermore, acid rain caused by industrial discharges as is the case in the environs of Itori and the nearby Lafarge Cement Company, could contribute to the acidic pH of ground waters (Ishola, 2019). From the study, the Colour of all water samples does not exceed the limit prescribed by WHO (15 Hazen Unit) **(**Table 3 and Table 4). The colour of the groundwater samples are somewhat similar to that obtained for water in Abeokuta, Nigeria (Shittu *et al.*, 2008). Electrical Conductivity (EC) is a measure of the capacity of a water sample to conduct electric current as well as the relative level of dissolved salts in the water (Gopalkrushna, 2011b). In the present study, EC of borehole and well in study are below the WHO, USEPA, NSDWQ and NAFDAC recommended limit. However, levels of EC higher in wells than in boreholes of the study area with the highest recorded value (880µs/cm) as supported by very low TDS value (Table 1 and Table 2). This signifies low levels of contamination due to dissolved ions (Essumang *et al.*, 2011; Gopalkrushna, 2011a,b), thus rendering them fit for human consumption. EC does not correlate positively and significantly with TDS in the groundwater, and is in disagreement with those reported by Sha'Ato et al. (2010) for water in

Benue State, Nigeria. Total Dissolved Solids (TDS) is a measure of both anions and cations concentration in a water body. The major anions and cations of TDS include Bicarbonates, Sulphates, Hydrogen, Silicate, Chloride, Calcium, Magnesium, Manganese, Sodium, Potassium, Nitrates, and Phosphates (Mahananda *et al.*, 2010). High levels of DO in both borehole and well water could probably result from presence of materials of low organic content leading to oxygen replenishment (Gasim *et al*, 2007). Lack of oxygen indicates a higher rate of deoxygenation due to biological decomposition of organic matter compared to adequate supply of oxygen that eventually leads to reoxygenation from atmosphere or probably due to the presence of oxidizable minerals in the aquifer (Mahananda *et al.*, 2010).This finding implies a low degree of organic pollution in Itori water. BOD_5 indicates the amount of organic waste present in water. BOD_5 value of 3 mg/L in surface water has been reported to show sewage contamination through runoff (Pradhan *et al.*, 1998). It can be inferred from this that contamination of boreholes and well water from all the sampling points in the study area is through runoff containing organic pollutants; the wells being more impacted than the boreholes. The range of the BOD_5 in borehole is 16.70 mg/L to 20.96 mg/L while that of the well is 15.75 mg/L to 21.96 mg/L; these range of values are far higher than the allowable National and International water quality standards. The low DO and high BOD_5 indicate influx of percolating organic pollutants into the groundwater bodies in Itori. The Alkalinity (ALK) of the sampled water indicates the buffering capacity of water against extreme pH changes. Alkalinity in water is primarily a function of carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and hydroxide (OH^-) ions and other basic compounds like Borates, Phosphates and if present (Gopalkrushna, 2011a,b; Mahananda *et al.*, 2010). Alkalinity level in Itori boreholes and wells far exceeded the recommended limit of water standards (Table 1 and Table 2). The well water samples have higher values which ranges from 144.70 mg/L to 2881.40 mg/L with a mean value 566.71$\pm$658.40 than borehole samples whose values ranges from 141.40 mg/L to 1446.10 mg/L with a mean value 489.02$\pm$507.57 (Table 1 and Table 2). Alkalinity in borehole and well in the present study is far higher than that reported for borehole (11.55-14.65 mg/L) and well (11.75-13.17 mg/L) water in Orissa, India (Mahananda *et al.*, 2010); well water (15.0-180 mg/L) in Ghana (Essumang *et al.,* 2011) and in Ken river water (182-192 mg/L) in India (Kumar and Pal, 2012). Hardness of water is the property that decreases the lather formation of soap, and increases scale formation in hot-water heaters and low-pressure boiler at high levels. Total hardness (TH) is mainly due to Calcium and Magnesium salts (Gopalkrushna, 2011a,b; Kumar and Pal, 2012; Mulla *et al.*, 2012) and is derived from dissolved limestone or industrial effluents. Chloride level higher than 10 mg/L is a result of anthropogenic source of pollution by sewage, septic systems, landfill, or fertilizers (Essumang, 2011; Gopalkrushna 2011a,b; Mahananda *et al.*, 2010). Higher chloride concentration in water causes laxative effects. The range of Cl^- in boreholes and wells are 34.91 to 360.50 mg/L with a mean value of 122.64$\pm$118.17 and 34.92 to 380.11 mg/L with a mean value of 252.12$\pm$125.69 respectively **(**Table 1 and Table 2). Mean Concentration of Cl^- content in well water from all the sampling stations is higher than the limit (250 mg/L) set by all the aforementioned water standards for drinking water while that of the borehole is well within these limits including WHO and NESREA except the USEPA and NAFDAC recommended limits. The Cl^- content of boreholes in the present study is comparably far higher than that of water from Lagos State, Nigeria (2.84-13.47 mg/L) but lower than the basal value for water from Akot, India (290-308 mg/L) whose upper value of 308 mg/L is in turn lower than the upper value of Itori boreholes and wells of recorded values of 360.50 mg/L and 380.11 mg/L respectively (Gopalkrushna, 2011a; Longe and Balogun, 2010). Low to high mean concentration levels of Na^+ and Cl^- in Itori water sources are indications of possible invasions of sea water intrusion (Essumang, 2011); these elevated values may increase the salinity of the study area in the nearest future. Nitrate, Nitrite and Ammonium levels in borehole and well water in all the sampling points are also presented in **(**Table 1 and Table 2). Nitrates are the final product of the biochemical oxidation of ammonia (Mahananda *et al.*, 2010). The determination of level of nitrates in water is necessary because of its implication for human health. It serves as an indicator of the degree of organic pollution of the water source (Gopalkrushna, 2011a,b; Mahananda *et al.*, 2010). High Nitrate concentration in drinking water has detrimental effects on pregnant women and babies less than six months old. The Nitrate concentrations in both water sources are very low in comparable with the approved water standards. Nitrites occur as an intermediate product of conversion of Ammonium ion to Nitrate as well as in the nitrification process of Ammonia. Nitrites can be more harmful than Nitrates in drinking water supply as Nitrites can oxidize haemoglobin to methaemoglobin in the body and hinder the transportation of oxygen around the body (WHO, 2011a). The mean values for all the water sources are 0.02 ± 0.008 mg/L (borehole) and 0.02 ± 0.007 mg/L (well). These values are lower than the WHO prescribed limit of less than 3.0 mg/L. Like NO_3^- **(**Table 1 and Table 2). The mean levels of ammonium in borehole and well water samples are 9 and 7 times greater than the levels of NO_3^- and 48 and 44 times greater than NO_2^- respectively. The borehole water samples are observed to have the higher level of Ammonium. Na^{2+} and K^+ levels are below the WHO recommended limit of 250 mg/L **(**Table 1 and Table 2). The higher level of Na^{2+} is observed for well water. K^+ on the other hand is higher in well water samples but relatively lower in borehole water sample **(**Table 1 and Table 2). The WHO recommended limit for drinking water supplies is 0.3 mg/L. mean concentration level of Fe^{3+} in both water sources are higher than the WHO limit. A notable tipper garage where both movable and damaged trucks that constitently load and convey cement bags from the nearby Lafarge Cement Company in Ewekoro are parked and the damaged ones repaired is located in Itori, hence these environments are littered with broken down trucks undergoing repairs with worn out parts, rusted metal rods and pipes. This may have possibly contributed to the high level of Fe^{3+} contents that could have possibly seeped down to the subsurface and migrated its way with unprecedented impacts on the groundwater system of the study area. It is worthy of note that if the water sources had been acidic in nature it could have further increase in the level of Fe^{3+} in both ground water sources (Verplanck *et al.*, 2006; WHO, 2004). The results obtained for microbial analyses are shown in Table 3 and Table 4. The highest Total Coliform Count of 241 x 10^2 MPN/100 ml is found in well water while the highest Total Heterotrophic Bacteria Count (THBC) and Faecal Coliform Count (FCC) are also found in well water samples; 5.2x10^2 cfu/ml and 6.5 x 10^2 cfu/ml respectively. The high coliform count obtained from the analyzed groundwater samples of the investigated study area implies poor sanitary conditions of the water bodies, and is also an indication of pollution by organic materials (APHA, 1992; Mahananda *et al.*, 2010; Sha'Ato *et al.*, 2010; WHO, 2011). Proximity of hand-dug wells to latrines and suck away pits could make the well to be highly vulnerable to coliform infestation. It is also a common practice for those living along the river catchment to discharge domestic waste, agricultural waste as well as human faeces into rivers and streams which may get to the underground aquiferous zone through the drainable porous strata. Total coliform count exceeds the WHO limit of 0.00 MPN/100 ml for underground sources of drinking water. $BOD_5:NO_3^-$ ratio is a measure of organic pollution for water sources. Water with BOD_5: NO_3^- ratio <4 is considered potable while >4 is polluted. This ratio is used to classify borehole and well water in the present study. It is found that the two underground water bodies are polluted, having $BOD_5:NO_3^-$ ratio > 4 with mean values of 163 and 148 for borehole and well water respectively. The study therefore reveals heavy organic pollution of both water bodies though the revealed Organic load is less in boreholes than than the Hand-dug wells.

4.0 Conclusions

The Physicochemical and Microbial analyses of potable water sources in Itori communities of Ewekoro Local Government of Ogun State, South-West Nigeria reveals that borehole and well water are Alkaline. The BOD, ALK, Cl^-, NH_4^+, HCO_3^{2-}, Zn^{2+} and Fe^{3+} and Total Coliform levels are higher than the recommended limits of the set standards including WHO and NESREA with the quality determinants revealing the predominance of HCO_3^{2-}. The BOD5:NO_3^- ratio-an index of organic pollution implies that these underground water bodies are heavily polluted with materials of organic origin. Sources of the pollution may include among others, wastes from domestic and agricultural activities, leachates from waste dumps and sewer tanks. These groundwater bodies invariably, are unfit for human consumption. There is therefore need for the existence of a statutory unit charged with responsibility for continuous monitoring of water bodies, sensitization and education of the rural populace in Itori on the adverse health implications of the presence of toxic materials in their water supply sources.

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