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The Physicochemical Quality of Groundwater in Relation to Surface Water Pollution in Majidun Area of Ikorodu, Lagos State, Nigeria

Olushola M. Awoyemi[1,*], Albert C. Achudume[2], Aderonke A. Okoya[3]

[1]Department of Zoology, Faculty of Science, University of Lagos, Akoka-Lagos, Nigeria
[2]Department of Biochemistry, Oduduwa University, Ile-Ife, Nigeria
[3]Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria
*Corresponding author: doctoroma@yahoo.com

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Abstract The piece of investigation was carried out to study the ground water as well as surface water quality, nutrient status and physico-chemical characteristic of Majidun-Ilaje Area of Ikorodu, Nigeria. The study area is situated between 3°27'E - 3°28'E longitude and 6°37'E latitude and covers about 1.71km^2 area of land. The present work has been conducted by monitoring two types of groundwater i.e. hand dug well water and borehole water of the community as well as the surface water i.e. river of the community. Attempts were made to study and analyze the physico-chemical characteristics of the water. Various parameters like Temperature, pH, Total Dissolved Solids, Total Hardness, Alkalinity, True and Apparent Color, Turbidity, Electrical Conductivity, Chemical Oxygen Demand, Total Organic Carbon, Total Organic Matter, Nitrate, Chloride, Phosphate, Sulphate, Sodium, Potassium, Calcium and Magnesium give a picture of quality parameter in both hand dug well and borehole water as well as river water of the community. By observing the result it can be concluded that the parameters which were taken for study of the water quality are below the pollution level for only borehole type of ground water which satisfy the requirement for the use of various purposes like domestic, agricultural, industrial etc. The quality of the hand dug wells and a closer borehole to the river is relatively above the permissible limit varying with depth and distance from the river. But in case of surface water, the water quality of the river is above the WHO and Federal EPA permissible limits.

Keywords: *groundwater, surface water, physicochemical characteristics, water quality, permissible limit, pollution*

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1. Introduction

Much of the current concern with regards to environmental quality is focused on water because of its importance in maintaining the human health and health of the ecosystem. Fresh water is finite resource, essential for agriculture, industry and even human existence, without fresh water of adequate quantity and quality, sustainable development will not be possible [1]. Fresh water resource deterioration is now a global problem and is increasing at a faster rate [2]. Discharge of toxic chemicals, over pumping of aquifer and contamination of water bodies with substances that promote algae growth are some of the major causes of water quality deterioration. Direct contamination of surface water with metals in discharges from mining, smelting and industrial manufacturing, is a long-standing phenomenon. Today there is trace contamination not only of surface water but also of groundwater bodies, which are susceptible to leaching from waste dumps, mine tailings and industrial production sites [2]. Water quality reflects the composition of water as affected by natural cause and man's cultural activities expressed in terms of measurable quantities and related to intended water use [1]. The composition of surface and groundwater is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal difference in runoff volumes, weather conditions and water levels [3]. Groundwater is an increasingly important resource all over the world. The term groundwater is usually reserved for the subsurface water that occurs beneath the water table in soils and geologic formation that are fully saturated [4]. Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies [5]. Importantly, groundwater can also be contaminated by naturally occurring sources. Soil and geologic formation containing high levels of heavy metals can leach those metals into groundwater. Pollution of groundwater due to industrial effluents and municipal waste in water bodies is another major concern in many cities and industrial clusters in Nigeria. Groundwater is very difficult to remediate, except in small defined areas and therefore the emphasis has to be on prevention. Surface water and groundwater, have provided livelihood to people over the century. Majidun Community has about 1.71 km^2 area of dry and wet lands comprising ponds, swamps and a major river.

The annual and seasonal distributions of pH, temperature etc. parameters are studied so as to understand quality of water dependent season [6]. Quality of surface and groundwater is inadequate even for costummering living and is getting deteriorated due to unwise utilization of water resources, dehumanizing manner of organization, Industrilization and other developed activities [7]. Today many rivers receive million liters of industrial effluents, sewage domestic waste, agricultural and land drainage etc. This effluents cause deterioration of water quality; the accelerated pace of development and population growth have led to the scarcity of potable water. So, the knowledge of extent of pollution and the status of water become essential in order to preserve the valuable sources of water for future generation.

Majidun River is an extention of Oba River which channels into the Lagos lagoon. The river is about 15 meters wide. The river provides means of livelihood and transport, sand dredging and dumpsite for residential discharges. There is differential salinity in the Majidun River water due to the influx of Lagoon water and fluctuates both seasonally and semi-diurnally. Seasonal and diurnal salinity fluctuations are greatest in dry season due to influx of water from the Lagoon at different time of the day and year. This salinity decreases as distance increases from the Lagoon [8]. The seasonal and diurnal influx of the Lagoon water into Majidun River introduces pollutants from industrial effluents into the river and this along with other anthropogenic activities in Majidun-Ilaje community such as dredging of sand, sewage and refuse disposal may have influence on the quality of the groundwater in the area.

Surface water in the area of study is being polluted and this can cause variation in the groundwater quality in the area. However, there is limited documentation of the changes that take place on the physico-chemical quality of surface and groundwater of the study area. This study aims to determine the physico-chemical water quality of groundwater resource in Majidun area of Ikorodu, Lagos State; determine the seasonal variation pattern in groundwater quality in the area; and assess the effect of surface water pollution on the physico-chemical quality of the groundwater resource.

1.1. Geographical Location of the Study Area

The study area Majidun-ilaje community is located in Ikorodu west area of Lagos State between longitudes 3°27' E and 3°28' E and latitude 6°37' N. It is situated along the Coast of Majidun River, an extension of Oba River which channels into Lagos lagoon. The area is populated and covers 1.71 km^2 area of land. The maps of the sample location (majidun area) and sampling points are shown in Figure 1.

Majidun River which is about 15 meters wide provides means of livelihood and transport, sand dredging and dumpsite for residential discharges. There is differential salinity in the Majidun River water due to the influx of Lagoon water and this fluctuates both seasonally and semi-diurnally. Seasonal and diurnal salinity fluctuations are greatest in dry season due to influx of water from the Lagoon at different time of the day and year. This salinity decreases as distance increases from the Lagoon [8].

Lagos state covers an area of about 3,577 Km^2 with its headquarters at Ikeja. It is located between longitudes 2°42' E and 3°42' E and latitudes 6°22' N and 6°52' N [9]. It is bounded in the South by the Guinea Coast, in the West by the Republic of Benin and in the North and East by Ogun State [9]. The state falls within tropical climate. Annual average rainfall is 1532 mm [9]. It experiences an annual mean temperature of 27°C. The vegetation cover is dominated by swamp forest, wetlands and tropical swamp forest comprising of freshwaters and mangrove [9]. Surface water and Groundwater quality and salinity in the aquifers change from north to south with salt water intrusion which may be tidal, seasonal and/or diurnal. In the northern and central parts of the state is fresh water-bearing aquifer while, in the southern coastal belt is the salt water-bearing aquifer. The occurrence of salt water zone varies from West to East. Rainy season in the South Western part of Nigeria begins from April and ends in October while the dry season runs from November to March [9].

2. Materials and Methods

Water samples were collected from two boreholes (BH-1 and BH-2), four hand-dug wells (HDW-1, HDW-2, HDW-3, and HDW-4) and Majidun River (two samples along the river course at 70.4 metres interval) (RW-1 and RW-2) in the area. Altogether, eight water samples were collected five times every other month from January to September to cover the dry and wet seasons. A total of fourty water samples were collected from eight sampling points in Majidun community of Ikorodu, Lagos. Collection was carried out at each season [i.e. January and March, 2011 (Dry season), April, July and September, 2011 (Rainy season)] using standard procedure [10,11] to give a total of fourty samples. A clean rubber container made locally from old tyre inner tube used by the local people to fetch water was used in drawing samples from the hand dug wells and through tap for the boreholes. 10 L polythene bucket was used to collect river water samples; 10 cm below the surface. All samples were stored in clean polythene bottles (2.5 L capacity), properly labelled and then taken to the laboratory for physico-chemical analysis. Water samples from boreholes were labelled BH-1 and BH-2, RW-1 and RW-2 for river water samples and HDWs 1, 2, 3 and 4 for the hand dug wells.

In-situ physical parameters determined includes: temperature (using mercury in glass-bulb thermometer), pH (using pH meter, Hanna Instruments 5358236), depth of the water level and total depth (using graduated line with weight attached) basically for the hand dug wells. The distance of each sample points from the river were also measured using the GPS. Samples were preserved with 10ml 6N HNO_3 and taken to the laboratory for further analysis. Water colour and turbidity were determined in the laboratory by colorimetric method, conductivity (using conductivity meter) and Total dissolved solids (TDS) using gravimetric method. The chemical parameters analysed include: Ca^{2+}, Mg^{2+}, Total hardness (TH) and Alkalinity using volumetric methods and Na^{+}, K^{+} using flame analyzer. Colorimetric analyzes was employed for Cl^{-}, PO_4^{3-}, SO_4^{2-}, and NO_3^{-}. The Organic carbon (TOC), Total organic matter (TOM) and Chemical oxygen demand (COD) were analyzed by chromic acid wet digestion titrimetric method. Data obtained were subjected to mean and standard error of mean (SEM), Pearson correlation, analysis of variance (ANOVA) and Sheffe multivariate analysis.

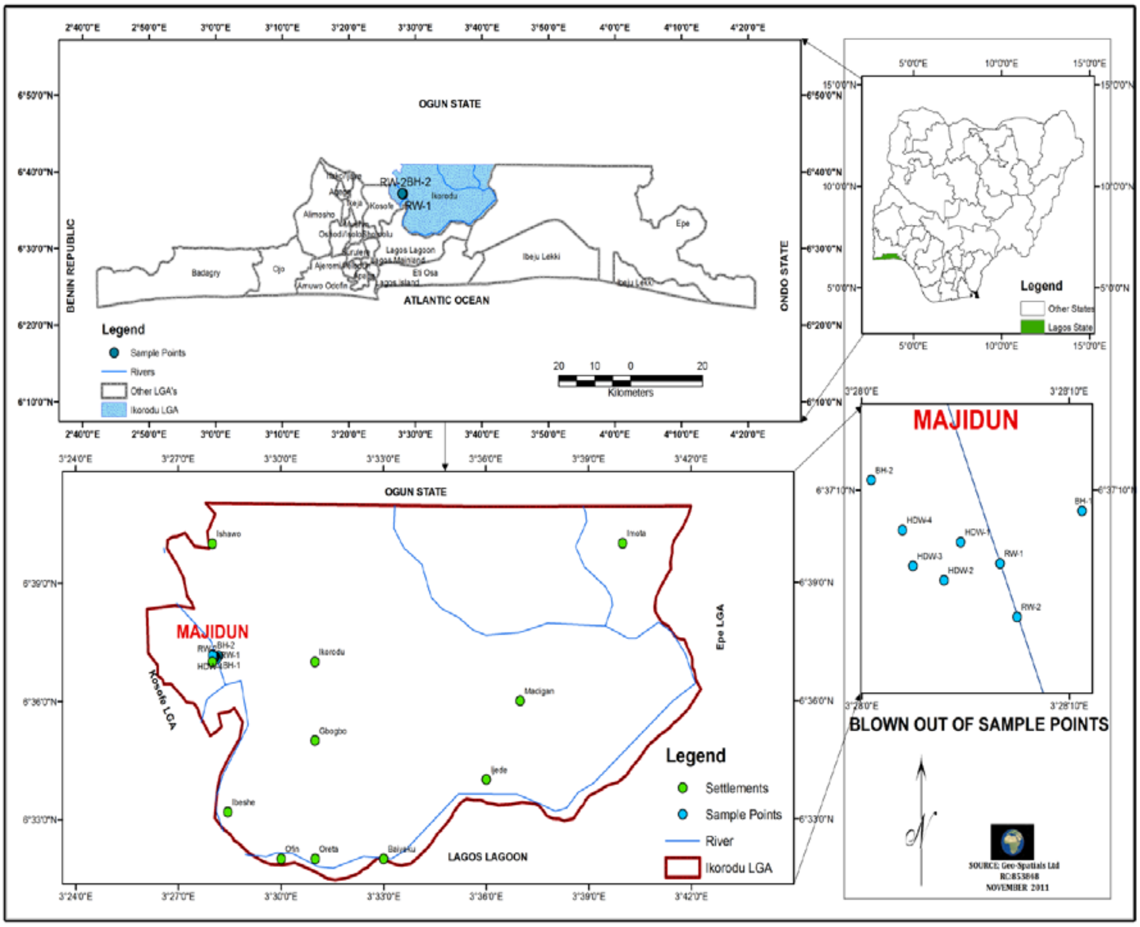

Figure 1. Map of the Study Area (Majidun area, Ikorodu) and the Sampling points

3. Results

The physico-chemical parameters in water bodies vary in composition and concentration on a seasonal, diurnal or even hourly basis. The patterns of spatial distribution of physico-chemical parameters measured for river Majidun and the wells selected in the community for this study were generally similar. The mean seasonal variation and overall average of physico-Chemical parameters of river, hand dug wells and boreholes are presented in the Table 1 while Table 2 shows the concentrations of the mineral ions.

Analysis of variance (ANOVA) showed that there is significant difference in values of the physico-chemical parameters as per season. The significant seasonal variation at $p < 0.05$ was found in temperature, TOC, TOM, COD, Mg^{2+}, alkalinity and total hardness (for river water) (Table 3), temperature, pH, TOC, TOM, COD, K^{+}, Ca^{2+}, SO_4^{2-}, $NO_3^{-}$and alkalinity (for hand dug well water) (Table 4), temperature, TOC, TOM, COD, $NO3^{-}$ and alkalinity (for borehole water) (Table 5).

Post hoc multivariate comparison (Table 6) showed that there is significant influence of the surface water on the groundwater at $p < 0.05$ level of significance. This significant effect was more on the hand dug well than the borehole.

4. Discussion

The pH of the samples ranged between 6.10 during the rainy season and 7.45 during dry season. There is no remarkable variation of pH found with reference to season except in HDW-4. The pH value of the samples was found to be within the WHO permissible limit. The WHO standard prescribed the range of pH to be between 6.5 to 8.5. If pH value is higher than the permissible limit, this will affect adversely alkalinity of soils, microbial life and corrosion rate [12].

Temperature ranged between 26.10°C to 26.55°C in rainy season and it increased to 28.10°C in dry season. This range was in line with a similar work by Mahananda *et al.*, [13]. The temperature of Borehole water was lower than those of river and Hand dug well water [12].

Electrical conductivity (EC) is a measure of water capability to transmit electric current. Electrical conductivity was within range 60 to 13880 µS/cm.

Table 1. Mean and standard error of mean of physical and chemical variables investigated in dry and wet seasons for river water, hand-dug wells and boreholes in Majidun area of Ikorodu, Lagos

Parameters	Season	Permissible Limit (WHO)	RW-1	RW-2	HDW-1	HDW-2	HDW-3	HDW-4	BH-1	BH-2
Temp (°C)	Dry	Ambient	28.05±0.05	28.10±0.10	27.80±0.10	28.00±0.10	27.65±0.15	27.70±0.10	28.10±0.10	27.65±0.05
	Wet		26.55±0.35	26.35±0.35	26.15±0.05	26.10±0.20	26.20±0.00	26.20±0.10	26.30±0.20	26.30±0.10
Ph	Dry	6.5-8.5	6.90±0.10	6.85±0.25	7.15±0.15	6.80±0.00	7.45±0.05	7.35±0.05	6.85±0.25	6.90±0.40
	Wet		6.65±0.55	6.45±0.45	6.40±0.40	6.70±0.00	7.10±0.20	6.60±0.00	6.80±0.30	6.10±0.20
App.C (Pt.Co)	Dry	≤15	139.96±32.01	171.58±32.33	171.58±32.33	27.98±15.99	27.98±15.99	43.97±0.00	43.97±0.00	0.00±0.00
	Wet		219.90±16.00	251.87±15.99	59.97±16.00	11.99±0.00	6.00±6.00	27.98±15.99	91.96±16.00	6.00±6.00
Tr.C (Pt.Co)	Dry	≤15	27.98±15.99	43.97±0.00	27.98±15.99	11.99±0.00	6.00±6.00	11.99±0.00	11.99±0.00	0.00±0.00
	Wet		75.96±31.99	107.95±31.99	11.99±0.00	11.99±0.00	0.00±0.00	11.99±0.00	11.99±0.00	0.00±0.00
Turb (NTU)	Dry	≤5	8.53±4.90	11.80±4.90	21.60±1.63	3.64±3.26	11.80±1.63	3.64±3.26	6.90±0.00	0.37±0.00
	Wet		18.34±1.64	18.33±4.90	13.44±3.26	2.00±1.63	3.64±3.26	5.26±1.64	8.94±2.04	2.00±1.63
EC (µS/cm)	Dry	≤1000	13880.0±5350.00	13730.0±5090.00	4290.00±150.00	2040.00±30.00	1880.00±10.00	1900.00±80.00	1620.00±0.00	60.00±0.00
	Wet		3050.00±2690.00	2925.00±2525.00	3350.00±510.00	1860.00±330.00	2340.00±410.00	1620.00±320.00	1540.00±140.00	165.00±95.00
TDS (mg/L)	Dry	≤500	8883.20±4324.00	8787.00±3257.60	2745.6±96.00	1305.60±19.20	1203.20±6.40	1216.00±51.20	1036.80±0.00	38.40±0.00
	Wet		1830.00±1614.00	1755.00±1515.00	2010.00±306.00	1116.00±198.00	1404.00±246.00	972.00±192.00	924.00±84.00	99.00±57.00
Alk (mg/L)	Dry	50-200	48.00±8.00	44.00±8.00	33.00±1.00	27.00±1.00	29.00±1.00	24.00±2.00	25.00±1.00	23.00±1.00
	Wet		13.00±1.00	16.50±5.50	73.00±17.00	80.00±7.00	92.00±12.00	93.00±20.00	74.00±10.00	13.00±2.00
TH (mg/L)	Dry	≤500	1470.23±238.62	1494.43±54.32	1366.30±276.85	1039.85±227.65	1393.63±218.28	1276.48±218.28	981.28±267.48	842.65±49.20
	Wet		258.14±172.10	241.32±126.58	358.07±147.03	402.92±170.78	534.56±120.24	452.78±208.14	229.40±44.88	365.20±239.32
TOC (mg/L)	Dry	≤1.0	0.13±0.00	0.24±0.02	0.18±0.02	0.66±0.12	0.11±0.01	0.12±0.00	0.13±0.01	0.07±0.00
	Wet		4.57±0.22	4.18±0.33	4.34±0.06	4.82±0.12	4.26±0.21	4.16±0.20	4.34±0.02	3.64±0.84
TOM(mg/L)	Dry	≤3.0	0.28±0.04	0.42±0.04	0.32±0.02	1.13±0.21	0.19±0.02	0.20±0.01	0.22±0.02	0.13±0.01
	Wet		7.88±0.37	7.21±0.57	7.48±0.10	8.32±0.20	7.34±0.36	7.18±0.34	7.48±0.03	6.27±1.44
COD(mg/L)	Dry	≤5.0	0.36±0.02	0.65±0.06	0.49±0.04	1.75±0.32	0.29±0.03	0.31±0.02	0.34±0.03	0.20±0.02
	Wet		12.20±0.58	11.16±0.88	11.57±0.16	12.88±0.31	11.36±0.56	11.10±0.52	11.58±0.04	9.70±2.23

Table 2. Mean and standard error of mean of ionic variables investigated in dry and wet seasons for river water, hand-dug wellsand boreholes in Majidun area of Ikorodu, Lagos

Parameters	Season	Permissible Limit (WHO)	RW-1	RW-2	HDW-1	HDW-2	HDW-3	HDW-4	BH-1	BH-2
K^+ (mg/L)	Dry	≤50	45.50±15.50	45.50±15.25	26.00±0.00	27.75±1.25	17.63±0.88	30.38±1.12	14.25±0.25	1.38±0.12
	Wet		13.75±10.00	13.00±9.25	34.13±1.62	26.12±3.88	24.00±3.50	30.25±2.25	15.00±0.00	3.38±2.12
Na^+ (mg/L)	Dry	≤200	926.00±238.00	1009.00±274.00	434.50±35.50	151.00±11.00	145.50±5.50	150.00±5.00	162.00±6.00	11.00±0.00
	Wet		265.50±234.50	259.00±231.00	219.00±121.00	112.00±43.00	140.50±30.50	105.50±24.50	139.50±13.50	9.75±1.25
Mg^{2+} (mg/L)	Dry	≤250	306.00±30.00	318.00±18.00	318.00±66.00	246.00±54.00	330.00±54.00	306.00±54.00	234.00±66.00	204.00±12.00
	Wet		52.29±32.83	49.71±23.25	58.37±38.91	69.31±40.13	89.98±31.62	81.47±52.29	49.86±10.94	87.55±58.37
Ca^{2+} (mg/L)	Dry	≤200	86.25±46.25	76.25±51.25	25.00±2.50	12.50±2.50	16.25±1.25	8.75±1.25	8.75±1.25	2.50±0.00
	Wet		52.29±32.83	49.71±23.25	58.37±38.91	69.31±40.13	89.98±31.62	81.47±52.29	49.86±10.94	87.55±58.37
Cl^- (mg/L)	Dry	≤250	32684.9±10138.70	37438.30±7937.70	4573.06±63.81	1396.73±35.45	1318.74±155.98	1191.12±85.08	1474.72±28.36	247.33±34.63
	Wet		2906.90±2495.68	3417.38±2991.98	2396.42±1020.96	1120.22±70.90	1155.67±475.03	744.45±177.25	1269.06±347.44	233.97±21.27
SO_4^{2-} (mg/L)	Dry	≤100	6.14±1.35	8.52±5.10	1.27±0.03	1.60±0.76	3.82±0.06	4.08±0.87	1.10±0.08	1.02±0.28
	Wet		24.96±8.11	19.66±7.80	22.46±7.48	16.22±0.00	53.20±0.80	21.72±0.74	6.24±2.50	7.18±2.80
PO_4^{3-} (mg/L)	Dry	≤100	1.57±1.14	1.10±1.07	0.72±0.10	0.86±0.16	1.48±0.55	1.20±0.46	0.58±0.18	1.26±0.55
	Wet		1.42±0.42	1.68±0.56	2.94±2.16	1.20±0.84	2.21±1.46	1.64±1.22	1.68±0.36	1.64±0.81
NO_3^- (mg/L)	Dry	≤45	0.96±0.00	0.33±0.12	0.96±0.25	0.58±0.12	0.46±0.00	0.23±0.23	0.23±0.23	0.10±0.10
	Wet		1.08±0.12	1.08±0.37	1.58±0.87	1.45±0.99	1.33±0.87	1.70±0.25	0.83±0.12	0.83±0.12

KEY: HDW- Hand dug well; BW- Borehole; RW- River water.

Table 3. ANOVA of the physico-chemical parameters between season (dry and wet) for River water

Samples Parameters	River water (RW-1) F Sig.		River water (RW-2) F Sig.	
Temperature (°C)	18.000	0.051	23.113	0.041*
pH	0.200	0.698	0.604	0.518
Conductivity (µS/cm)	3.271	0.212	3.616	0.198
TOC (mg/l)	426.380	0.002**	139.449	0.007**
TOM (mg/l)	417.040	0.002**	141.207	0.007**
COD (mg/l)	423.713	0.002**	141.980	0.007**
Chloride ion (mg/l)	8.134	0.104	16.084	0.057
Sulphate ion (mg/l)	5.240	0.149	1.428	0.355
Phosphate ion (mg/l)	0.015	0.913	0.231	0.678
Nitrate ion (mg/l)	1.000	0.423	3.606	0.198
Potassium ion (mg/l)	2.963	0.227	3.320	0.210
Sodium ion (mg/l)	3.908	0.187	4.380	0.171
Magnessium ion (mg/l)	32.545	0.029*	83.255	0.012*
Calcium ion (mg/l)	1.999	0.293	1.348	0.365
Total dissolved solid (mg/l)	3.472	0.203	3.381	0.189
Turbidity (NTU)	3.306	0.198	0.888	0.445
Alkalinity (mg/l)	18.846	0.049*	8.024	0.105
Total hardness (mg/l)	16.973	0.054	82.767	0.012*
Apparent color (Pt.Co)	4.991	0.115	4.958	0.156
True color (Pt.Co)	1.800	0.312	4.000	0.184

*. The mean difference is significant at the 0.05 level (2-tailed)
**. The mean difference is significant at the 0.01 level (2-tailed)

Table 4. ANOVA of the physico-chemical parameters between season (dry and wet) for Hand dug wells

Samples Parameters	HDW-1 F Sig.		HDW-2 F Sig.		HDW-3 F Sig.		HDW-4 F Sig.	
Temp (°C)	217.800	0.005**	72.200	0.014*	93.444	0.011*	112.500	0.009**
pH	3.082	0.221	-	-	2.882	0.232	169.000	0.006**
E. C(µS/cm)	3.127	0.219	0.295	0.641	1.258	0.379	0.721	0.485
TOC (mg/l)	4584.000	0.000**	602.735	0.002**	381.014	0.003**	431.078	0.002**
TOM (mg/l)	4400.000	0.000**	614.698	0.002**	383.117	0.003**	433.124	0.002**
COD (mg/l)	4315.000	0.000**	615.817	0.002**	383.149	0.003**	430.603	0.002**
Cl^-(mg/l)	4.528	0.167	12.168	0.073	0.106	0.775	5.161	0.151
SO_4^{2-}(mg/l)	8.018	0.105	370.056	0.003**	3840.000	0.000**	238.536	0.004**
PO_4^{3-}(mg/l)	1.040	0.415	0.157	0.731	0.219	0.686	0.111	0.771
NO_3^- (mg/l)	0.472	0.563	0.753	0.477	1.000	0.423	18.962	0.049*
K^+(mg/l)	25.000	0.038*	0.159	0.728	3.122	0.219	0.002	0.965
Na^+ (mg/l)	2.921	0.230	0.772	0.472	0.026	0.887	3.167	0.217
Mg^{2+} (mg/l)	11.483	0.077	6.897	0.120	14.713	0.062	8.922	0.096
Ca^{2+} (mg/l)	16.200	0.057	98.000	0.010*	160.000	0.006**	192.200	0.005**
TDS (mg/l)	5.261	0.149	0.908	0.441	0.666	0.500	1.508	0.344
Turb (NTU)	5.006	0.155	0.201	0.698	5.006	0.155	0.199	0.699
Alk (mg/l)	5.517	0.143	56.180	0.017*	27.372	0.035*	11.785	0.075
TH (mg/l)	10.345	0.085	5.009	0.155	11.883	0.075	7.459	0.112
AC (Pt.Co)	9.575	0.090	1.000	0.423	1.657	0.327	1.000	0.423
TC (Pt.Co)	1.000	0.423	-	-	1.000	0.423	-	-

*. The mean difference is significant at the 0.05 level (2-tailed)
**. The mean difference is significant at the 0.01 level (2-tailed)

Table 5. ANOVA of the physico-chemical parameters between season (dry and wet) for Boreholes

Samples Parameters	BH-1 F Sig.		BH-2 F Sig.	
Temperature (°C)	64.800	0.015*	145.800	0.007**
pH	0.016	0.910	3.200	0.216
Conductivity (µS/cm)	0.327	0.625	1.222	0.384
TOC (mg/l)	36900	0.000**	18.174	0.051
TOM (mg/l)	40540	0.000**	18.180	0.051
COD (mg/l)	43150	0.000**	18.190	0.051
Chloride ion (mg/l)	0.348	0.615	0.108	0.774
Sulphate ion (mg/l)	4.230	0.176	4.773	0.161
Phosphate ion (mg/l)	7.226	0.115	0.151	0.735
Nitrate (mg/l)	5.344	0.147	20.332	0.046*
Potassium ion (mg/l)	9.000	0.095	0.883	0.447
Sodium ion (mg/l)	2.320	0.267	1.000	0.423
Magnessium ion (mg/l)	7.576	0.111	3.819	0.190
Calcium ion (mg/l)	1.000	0.423	-	-
Total dissolved solid (mg/l)	1.803	0.311	1.130	0.399
Turbidity (NTU)	1.000	0.423	1.000	0.423
Alkalinity (mg/l)	23.772	0.040*	20.000	0.047*
Total hardness (mg/l)	7.685	0.109	3.819	0.190
Apparent color (Pt.Co)	9.000	0.095	1.000	0.423
True color (Pt.Co)	-	-	-	-

*. The mean difference is significant at the 0.05 level (2-tailed)
**. The mean difference is significant at the 0.01 level (2-tailed)

Table 6. Post-Hoc multivariate comparism (Sheffe) to compare between physico-chemical parameters of water sources

Samples Parameters	River and HDW Sig.	River and BH Sig.	BH and HDW Sig.
Temperature (°C)	0.751	0.923	0.957
Ph	0.429	0.973	0.297
Conductivity (µS/cm)	0.003**	0.001**	0.619
TOC (mg/l)	0.999	0.976	0.955
TOM (mg/l)	0.999	0.975	0.955
COD (mg/l)	0.999	0.976	0.955
Chloride ion (mg/l)	0.001**	0.002**	0.973
Sulphate ion (mg/l)	0.992	0.288	0.158
Phosphate ion (mg/l)	0.984	0.963	0.885
Nitrate (mg/l)	0.825	0.536	0.174
Potassium ion (mg/l)	0.897	0.006**	0.005**
Sodium ion (mg/l)	0.001**	0.001**	0.633
Magnessium ion (mg/l)	0.994	0.837	0.729
Calcium ion (mg/l)	0.517	0.025*	0.109
TDS (mg/l)	0.003**	0.001**	0.639
Turbidity (NTU)	0.101	0.018*	0.440
Alkalinity (mg/l)	0.112	0.971	0.184
Total hardness (mg/l)	0.998	0.612	0.555
Apparent color (Pt.Co)	0.000**	0.000**	0.869
True color (Pt.Co)	0.000**	0.000**	0.833

*. The mean difference is significant at the 0.05 level (2-tailed)

**. The mean difference is significant at the 0.01 level (2-tailed)

EC was found to be maximum in dry season compared to rainy season. This is in contrast to the result of Shaikh and Mandre [12] except for HDW-3 and BH-2. Water with high electrical conductivity values are predominant in sodium and chloride ions and further it is noted that the electrical conductivity is higher during post rainy season. Conductivity values were greater than the WHO [14] permissible limit for all the water samples except for the farthest borehole water sample. EC was found to be maximal in river water and mnimum in borehole water [15].

The total dissolved solid (TDS) of water is probably the most used criterion of its quality. The TDS consists mainly of bicarbonate, carbonate, sulphate, chloride, nitrates and other substance. The TDS found in studied water samples found in the range 38.40 to 8883.20 mg/L. Quite maximum ranges are found in rainy season much higher than the value of TDS of a similar work by Shaikh and Mandre [12]. River water, Hand dug well water and the closest borehole water to the river were found to have maximum range than permissible limit (by WHO) while the farthest borehole water (BW-2) to the river showed satisfactory range of TDS [14,16]. The huge amount of dissolved solids present in the water is an indication of its suitability for domestic use only and not for drinking purpose.

In the water samples alkalinity ranged from 13.00 to 93.00 mg/L and a high value was recorded in rainy season [12]. All samples showed concentration within permissible limit by WHO which showed satisfactory range of alkalinity. Alkalinity is itself not harmful to human beings [17].

Total organic carbon (TOC) of the water samples was in the range 0.07 to 4.82 mg/L. Remarkable seasonal variation was found in all samples except for BH-2. The concentration of TOC in all the samples was lower in the dry but higher in the rainy season than the WHO permissible limit. This may be due to introduction of domestic waste and sewage in surface water and infiltration into the groundwater during rainfall. Borehole (BH-2) showed minimal TOC concentration while the concentration was much remarkable in Hand dug well water samples and river water in line with the result by Shaikh and Mandre [12].

Total organic matter (TOM) is one of the most important factors for existence of an aquatic organism in water body. It is of an importance factor in natural water both as regulator of metabolic process of biotic community and an indicator of aquatic health. TOM of the water samples was in the range 0.13 to 8.32 mg/L. Remarkable seasonal variation was found in all samples except for BH-2 in contrast to the result by Shaikh and Mandre [12]. The concentration of TOM in all the samples was lower in the dry but higher in the rainy season than the WHO permissible limit. This may be due to introduction of domestic waste and sewage in surface water and infiltration into the groundwater during rainfall. Borehole water (BH-2) showed minimal TOM concentration while maximum concentration was much remarkable in Hand dug well water samples and river water in line with the result by Shaikh and Mandre [12].

Chemical oxygen demand (COD) is the amount of oxygen required to carry out oxidation of organic waste by using strong oxidizing agent. COD of the water samples was in the range 0.20 to 12.88 mg/L. Remarkable seasonal variation was found in all samples except for BW-2 in contrast to the result by Shaikh and Mandre [12]. The concentration of COD in all the samples was lower in the dry but higher in the rainy season than the WHO permissible limit. This may be due to introduction of chemical waste materials in surface water and infiltration into the groundwater during rainfall. Borewell (BW-2) showed minimal COD concentration while maximum concentration was much remarkable in Hand dug well water samples and river water in line with the result by Shaikh and Mandre [12].

Hardness in water is due to natural accumulation of salts from contact with soil and geological formation or it may enter from direct pollution by human activities. Most people like water with little hardness. It usually tastes better and it washes the soap off when you bathe. Sulphates, chlorides, silicates etc. of calcium, magnesium, sodium, potassium, aluminum etc. present as impurities in the limestone, become exposed to the solvent action of water and pass into solution, thereby adding to the hardness [18]. Hardness of the water samples was in the range 229 to 1494 mg/L. Hardness was higher in dry season compared to rainy season. This was found to be higher than the result of a similar work by Shaikh and Mandre [12]. In all water samples, hardness was found within permissible limit in the rainy season but above the permissible limit in the dry season [19].

The result of mineral nutrients in water samples showed the range of K^+ (1.38-45.50 mg/L), Ca^{2+} (2.50 - 86.25 mg/L), Mg^{2+} (49.71 -330.00mg/L) and Na^+ (9.75 - 1009 mg/L) (Table 2). The value of sodium concentration in the river and the closest hand dug well (HDW-1) water sample was beyond the permissible limit in both seasons. The magnesium concentration of the river water and hand dug wells was beyond the permissible limit in the dry season. In general, the mineral nutrient level in the water samples was higher in dry season than the result of Mahananda *et al*., [13].

Chloride usually occurs as NaCl, $CaCl_2$ and $MgCl_2$ in widely varying concentrations, in all natural waters. They enter water by solvent action of water on salts present in the soil, from polluting material like sewage, trade wastes [12] and seawater intrusion in coastal areas [20]. Chloride when reaches concentration above 250mg/L; imparts an unacceptable taste to water. Chloride concentration of the water samples was in the range 233 to 37,438 mg/L. Only one water sample (BH-2) showed satisfactory level within WHO guideline limit [14]. Chloride level was found to be higher in dry season than in rainy season. This corresponds to the seasonal trend according to Shaikh and Mandre [12].

Sulphate in the water samples was in the range 1.02 - 53.20 mg/L, Phosphate was in the range 0.58 - 2.94 mg/L and Nitrate was in the range 0.10 - 1.70 mg/L. Sulphate, Phosphate and Nitrate concentrations the water samples were in a range within the WHO permissible limit [14]. This corresponds to the result of a similar work by Mahananda *et al*., [13]. Sulphate, Phosphate and Nitrate occur naturally in low concentrations in natural water and higher concentrations may be due to pollution by man.

The appearance of colour in drinking water is caused by the absorption of certain wavelengths of normal white light by dissolved or colloidally dispersed substances, by fluorescence in the visible wavelength region from substances that absorb white or ultraviolet light [21], by the presence of coloured suspended solids, and by the preferential scattering of short wavelengths of light by the smallest suspended particles [21]. Colour measured in water that contains suspended matter is defined as apparent colour while true colour is measured in water samples from which particulate matter has been removed by centrifugation [22]. True colour of the water samples was in the range 0.00 - 75.96 Pt.Co and Apparent colour of the water samples was in the range 3.00 - 211.73 Pt.Co. Apparent color and True color were higher in the river water samples and minimal in the borehole water. Colour was higher in rainy season than in dry season. This may be due to introduction of more particulates into the surface water through runoffs during rainfall. The apparent and true colour was beyond the permissible limit given by WHO [14] in all the water samples except for BH-2. In general, the true colour of the water samples is substantially lesser than its apparent colour [22].

Turbidity is a "measure of the relative clarity of water" [23]. Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. Turbidity in the water samples was in the range 0.37-21.60 NTU. Turbidity was higher in rainy season than dry season for river and borehole water samples while it was higher in dry season than rainy season for the hand dug well water samples. The reason for this may be as a result of increased particulates introduced into the surface water through runoffs during rainfall. The turbidity of the water samples was beyond the WHO permissible limit except for HDW-2 and BH-2 (WHO, 1998).

5. Conclusion

The study has provided information on the quality of surface and groundwater and the impact of anthropogenic activities on the groundwater quality in relation to surface water pollution in Majidun community, Ikorodu, Lagos. The ground water (hand dug well and borehole) as well as the river water analyses indicated that parameters like electrical conductivity, total dissolved solid, turbidity, colour, chloride, sodium, magnesium, TOC, TOM, COD and total hardness are above WHO acceptable limit for the water samples to be used for various purposes except for the farthest borehole water (BH-2) to the river. The study of river water indicated that it is highly polluted (above WHO & FEPA guideline limits) and unsafe for human drinking and domestic purposes. The hand dug wells and the closest borehole to the river is relatively polluted and unsafe for drinking purpose.

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