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Application of Correlation and Regression Models in Predicting the Physico-chemical Quality of Groundwater from Insitu Measured Parameters

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Abstract — **Groundwater is the major source of municipal and private potable water supply for meeting the drinking, domestic, agricultural and industrial requirements on man around the world. The cost of analyzing water quality in the laboratory to ascertain its potability is usually high and sometimes not available. Groundwater samples were collected from fifty (50) spatially referenced bore well locations in Warri and its environs in the dry and wet seasons (November 2019 to January 2020) in the study area. The water samples were analyzed for twenty-six (26) physical, chemical and bacteriological parameters both in the field and laboratory in line with APHA standard procedures for testing water and waste water inorder to evaluate the status of potability of groundwater across Warri, Delta State Nigeria. The data analysis tool in Microsoft Excel was used to explore and study the interrelationship between some conservative parameters measured in the field (pH, EC, TDS, and DO) as independent variables and some cations, anions and heavy metals (Na, Mg, Ca, HCO3, SO4 Cl, Fe, Cd, Cr, Cu and Pb) analysed in the laboratory as dependent variables. The results obtained from the parameters analysed insitu in the field which are cheap to perform and easily affordable were used to check and evaluate and the inter-relationships with some cations, anions and heavy metals. Highly correlated water quality parameters were determined by correlation coefficient (R) values obtained from correlation matrix and related by Regression equations (models). The regression models can be adopted to predict the concentration of these cations, anions and heavy metals before the rigorous laboratory analysis, to serve as a quick check for concentration of most disease-causing pollutants and to save time, money and resources, especially the near absence of AAS for analysing heavy metals in a good number of laboratories. The regression models developed in the study can be used for monitoring the water quality parameters by knowing the concentration of independent parameters obtained in the field alone. There is a relationship between variables which show that one variable actually causes changes in another variable. It was observed that multiple regression models can predict most parameters at 5% level of significance. Significantly positive correlation at 1 and 5% was found between many parameters. This technique studied and calculated the correlation coefficients between various physico-chemical parameters of drinking water and provided an excellent device for the calculation of parameter values within realistic degree of accuracy. The results proved to be easiest, useful, and rapid means for monitoring of water quality with the help of systematic calculations of correlation coefficient. It is recommended to treat groundwater prior to domestic use.**

Keywords — **Correlation and Regression Analysis. Groundwater Physico-chemical, Water Supply, Water Quality.**

I. INTRODUCTION

Groundwater is the most realistic and the major potable water supply option in Warri. Rapid population growth, urbanization, accelerated pace of industrialization, agricultural activities, crude oil exploration and hydrocarbon related activities which are the dominant activities in Warri have led to increased dependence on groundwater for meeting man's water demand for domestic, drinking, agricultural and industrial needs because of its seemingly potable status [1]. These activities have caused surface water resources to either be fully utilized or now of poor quality. The diminishing surface water resources for exploitation has caused governmental agencies, industrial and private users to resort to groundwater resources for their water supply needs with little or no form of treatment. The quality of groundwater has deteriorated over time as a result of natural and anthropogenic activities. The quality of water depends to some extent, on its physico-chemical composition [2], [3]. Increasing demand and groundwater withdrawal, changes in land use pattern, vast industrial and agricultural effluents entering the hydrological cycle, groundwater recharge due to seasonal variation all affect the quality and quantity of groundwater [4]-[6].

The need for water quality assessment in growing urban cities like the Warri metropolis thus cannot be emphasized enough. During the past few decades, the groundwater is being contaminated and it is deteriorating daily thus causing numerous water quality problems in both groundwater and surface water systems that is affecting large numbers of people. Contaminated water has resulted in epidemics, detrimental health problems and environmental issues [7]. Low-quality drinking water results in 80% of the incidence of many acute and chronic diseases that cause mortality in many communities [8], [9].

Considering the huge groundwater consumption in Warri and its environs and lack of water quality monitoring, the present study is undertaken to assess the physicochemical and

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bacteriological characteristics of groundwater in and around Warri town in dry and wet seasons using a large number of spatially referenced sampling wells located across various locations of the city. Statistical analysis and characterization of hydro geochemistry of the groundwater and correlation and regression models are explored in obtaining the concentration of some water quality parameters.

II. Study Area

Warri (Fig. 1) is a major commercial city in the Niger Delta region of Nigeria. It has a sea port, a refinery and several oil fields and flow stations. It is located in the western end and coastal region of the Nigerian Niger Delta and it is about some 40 kilometres away from the shores of the Atlantic Ocean in Delta State, in Southern Nigeria. It is situated at latitude 5º54´00″N and 5º35´00″N of the Equator and longitude 5º42´00″E and 5º54´00″E of the Greenwich Meridian.

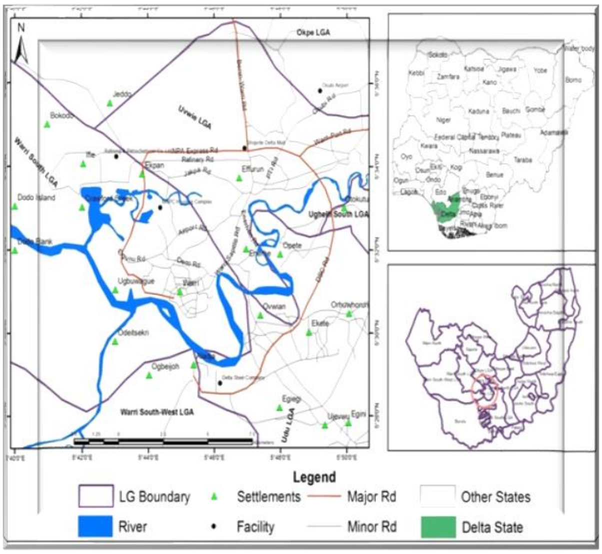

Fig. 1. Map of Warri and its environs. Source: [4] and [10].

Warri and its environs are situated on a low-lying plain in the continental shelf of West Africa on the Gulf of Guinea and it is comprised of three major litho-stratigraphic units namely: Akata, Agbada and Benin formations. These formations are generally inherently susceptible and vulnerable to a high risk of contamination because of the shallow, unconfined, and unprotected aquifer consisting mainly of unconsolidated sediments [11]. The geological formation consists of more than 90% sands and about 10% shale/clays. The sands range in size from fine-to-medium and coarse-grained unconsolidated sands, with occasional intercalations of gravelly beds that are also poorly-sorted, sub-angular to well-rounded, and bear lignite streaks and wood fragments peat or lenses of plastic clay [12]-[14] with a water table of about 10 metres below ground surface, which however, depends on the season [15]-[19]. This formation contains the most productive and hence most tapped aquifer in the Niger Delta region due to the fact that it is shallow [20]. The average annual rainfall is about 3000mm and occurs mostly due to the south-west monsoon wind [21]. Groundwater and surface water in the study area is under threat of contamination from crude oil exploration and exploitation activities. Being an ancient city, solid waste and effluent disposal systems are not engineered. This has further threatened the quality of groundwater. The near absence of government water schemes has compelled individuals to extract groundwater from large number of boreholes. Though there are no records of the number of boreholes in the city, from physical observations, it could be safely said that almost each building has a borehole and the water extracted are consumed without any form of analysis and treatment.

III. Materials and Methods

A. *Establishment of Sampling Locations and Water Samples Collection*

Groundwater samples were collected from fifty (50) identified boreholes with their UTM coordinates read with a hand-held GPS (GARMIN GPSMAP 76CSx model). The boreholes were all tapping the Somebreiro-Warri Deltaic Plain Sands aquifer to an average depth of 17m. The water samples were collected in new 1.5L capacity high-density PET screw-capped containers during the dry season (November to December, 2019) and wet season (May and July, 2020) and recorded in Table I with their sampling codes for the purpose of geo-referencing. The criteria of selecting sampling points were based on the population density, areas of industrial or anthropogenic activities such as crude oil refining activities, open solid waste dump sites, high- and low-density areas and the river catchment areas.

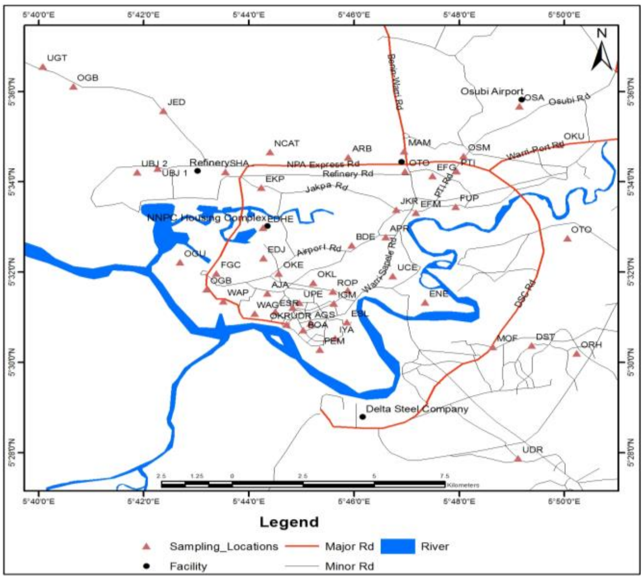

Fig. 2. Digitized map of Warri and its environs (Study Area) showing sampling locations.

All the drinking water samples were taken from running tap water of residential and commercial areas. Water from the taps were allowed to run for 2 to 3 minutes and the PET containers and stoppers were thoroughly washed with distilled water for three times and once with the water to be sampled before collecting the actual sample. The bottles were filled, allowed to overflow and immediately corked, properly labelled to avoid mix up, placed in an ice block chest and transported to a laboratory within a prescribed period of not more than three hours after collection. Collection, preservation and transportation of the water samples to the laboratory and field and laboratory analysis followed the standard guidelines recommended by [23] for testing water and waste water. The water samples were preserved in refrigerators at 4 ºC to keep them intact until analysis was carried out.

TABLE I: SAMPLING LOCATIONS AND THEIR GPS IN UTM COORDINATES

S/N	Sample Locations	Sample Location Code	UTM Coordinates	
			Longitudes (E)	Latitudes (N)
1	Okuokoko	OKU	873764.26	617561.74
2	Effurun GRA	EFG	809311.71	616265.61
3	Army Barracks	ARB	806343.49	617014.43
4	Niger CAT	NCAT	803585.72	617216.33
5	Airport Road	APR	807682.28	613754.57
6	Jakpa Road	JKR	808039.86	614880.60
7	Shagholoh	SHA	802034.58	616405.78
8	Ekpan	EKP	803288.04	615763.82
9	Urhobo College Effurun	UCE	807932.75	612162,37
10	Effurun Market	EFM	808734.27	614759.96
11	Ogborode	OGD	796661.77	619874.80
12	Ughoton	UGT	795589.43	620671.69
13	Jeddo	JED	799838.04	618888.51
14	Ubeji 1	UBJ 1	799644.98	616528.51
15	Ubeji 2	UBJ 2	798928.54	616368.90
16	Osubi Market	OSM	810399.60	617088.74
17	Osubi Airport	OSA	812355.65	619128.23
18	Ogbuwangue	OGB	801383.19	611606.79
19	Warri Port	WAP	801978.92	611118.32
20	Ogunu	OGU	800441.59	612708.26
21	Edjebah	EDJ	803381.05	612880.96
22	Edjeba Housing Estate	EDHE	803354.16	614121.37
23	Federal Government College	FGC	801725.36	612241.99
24	Ajamimogha	AJA	803523.10	611447.95
25	Warri GRA	WAG	803089.34	610613.97
26	Okumagba Layout	OKL	805132.67	611876.84
27	Okere Road	OKR	804414.63	610867.87
28	Marine Quarters	MRQ	806349.18	611574.71
29	Essi Layout	ESL	806328.36	610275.72
30	Igbudu Market	IGM	805866.77	611039.40
31	Agbassa	AGS	805043.38	610226.30
32	Bowen Avenue	BOA	804792.89	609943.85
33	Iyara	IYA	805907.77	609616.93
34	Pessu Market	PEM	805373.32	609158.42
35	Orhunworun	ORH	814412.45	609039.09
36	Enerhen	ENE	809072.91	611100.90
37	Udu Road	UDR	812370.15	604744.47
38	Otokutu	OTO	814056.74	613752.53
39	Bendel Estate	BDE	806477.20	613425.55
40	Upper Erejuwah	UPE	804644.73	611059.84
41	Mammy Market	MAM	808310.16	617280.79
42	DSC Township	DST	812824.27	609360.84
43	Okumagba Estate	OKE	803923.81	612262.10
44	Mofor	MOF	811465.26	609295.86
45	FUPRE	FUP	810120.84	615008.04
46	Shoprite	SHP	808339.43	616442.94
47	Robbinson Plaza	ROP	805827.10	611528.83
48	Esisi Road	ESR	803801.62	610690.62
49	Robert Road	ROR	804203.17	610182.10
50	PTI Road	PTR	810142.35	616473.42

As prescribed by [22], at the sampling locations, samples were collected in triplicates. One bottle was filled with water having no acid while a second bottle was filled and acidified by adding few drops of 5% nitric acid (HNO_3) to stop the activities of microorganisms and samples for bacteriological quality analysis were collected using autoclave-sterilized sampling bottles to avoid unpredictable changes in characteristics. Thus, the black bottles were air tightened for the analysis of BOD after five days, to prevent photosynthetic oxygen generation. The second white bottles were for microbial analysis and the remaining samples were for the physico-chemical analysis which were stored in ice chest boxes (coolers).

B. Field and Laboratory Analysis of Water Samples

The American Public Health Association [22] recommended standard methods of testing water quality were employed in this research to obtain the concentration of some physico-chemical and bacteriological parameters. This was inclusive of the determination of hydrocarbon constituents in the water samples.

C. Field Analysis

Non conservative sensitive parameters such as temperature, pH, electrical conductivity (EC), pH and dissolved oxygen (DO) which change with storage time [24], were measured in-situ and recorded before samples were transported to laboratory for further physical and chemical analyses. Temperature was measured using a mercury-filled Celsius thermometer, Total Dissolved Solids (TDS) and Electrical Conductivity were estimated with Oakton TDS/Conductivity meter electrical conductivity meter (HI 2315, Hanna Instrument). pH was estimated using a portable pH meter (PHS-25) and the DO with portable DO meter (DO analyser JPG 607) respectively. The procedure was repeated three (3) times and the mean value calculated for each parameter. DO meter was also inserted into the water sample at about 10cm using the oxygen probe handle.

D. Laboratory Analysis

The following standard methods of [22] were adopted in the laboratory for each parametric analysis of the groundwater samples. Chemical Oxygen Demand (COD), nitrate and ammonia have permissible storage time of 24 hours and were therefore analysed immediately as recommended by [25]. Samples were stored in a refrigerator at about 4 ºC [25] for examination of other water quality parameters that experience no change with storage time. However, analyses of those parameters were conducted within a period not more than two (2) weeks. SP2900 Pye-Unicam Atomic Spectrometer (AAS) was used to determine Fe, Cu, Cr, Cd and Pb while UV visible spectrophotometer (Thermo Scientific Spectronic 20D$^+$) was used to analyse PO_4, NO_3, SO_4 and NH_4. The concentration of Na^+ and K^+ were determined with a Flame emission analyser. Ca^{2+} and Mg^{2+} were determined by EDTA Titrimetry. Cl^- and HCO_{3-} were also measured by appropriate titrimetric methods. NO3- was measured by Colorimetry while SO_{42-} was determined by precipitation using $BaCl_2$ and measurement of absorbency with a spectrophotometer. Iron concentrations were estimated using model Atomic Absorption spectrophotometer. Biochemical Oxygen Demand (BOD) and Chemical Oxygen

Demand (COD) were determined using the modified Winkler and $KMnO_4$ methods, respectively.

IV. Results of Analysis

Results of the field and laboratory analysis of various physico-chemical and bacteriological parameters of the groundwater samples are given in Table III and Table IV. Mean values were taken into consideration as characteristic values to see the differences during the two (2) seasons and the obtained results were compared with WHO standard of water quality parameters (Table II) [26]. The mean and standard deviation in the parameters in both seasons were computed and the seasonal variations for each parameter was obtained.

TABLE II: Comparison of Water Quality Parameters with WHO standards

Parameter (mg/l)	Dry season (n = 50)				Wet season (n = 50)			
	Range		Mean	SD	Range		Mean	SD
	min	max			min	max		
Temperature (°C)	23.2	32.2	27.3	2.4	22.2	32.2	27.5	2.5
pH	4.2	6.7	5.4	0.6	3.4	5.9	4.5	0.5
EC ($\mu S/cm$)	40.0	532.0	162.7	127.4	46.0	678.0	186.7	150.0
Turbidity (NTU)	0.0	37.5	5.7	7.8	0.0	35.8	6.3	7.5
TH (mg/l)	3.7	336.3	51.0	91.9	3.7	336.3	55.5	90.4
TSS (mg/l)	0.0	42.5	6.9	9.2	0.0	46.9	11.2	10.4
T.D.S (mg/l)	22.0	298.0	91.2	71.4	26.0	380.0	104.5	84.0
DO (mg/l)	1.0	7.7	3.2	1.7	1.9	9.6	4.3	2.4
BOD (mg/l)	0.3	1.4	0.1	0.4	0.7	2.5	0.7	0.5
COD (mg/l)	1.1	8.9	4.4	1.9	0.3	9.2	3.9	2.5
Total Coli (CFU's/100ml)	0.0	35.0	11.1	11.6	0.0	36.5	11.6	11.2
Na (mg/l)	0.0	35.0	11.1	6.98	0.0	36.5	10.34	11.2
K (mg/l)	1.5	27.3	9.3	7.0	1.5	30.5	10.3	7.6
Ca (mg/l)	0.1	3.9	1.3	0.9	0.1	4.2	1.7	1.2
Mg (mg/l)	4.0	69.0	18.5	16.2	4.1	90.2	21.4	19.7
SO_4 (mg/l)	0.1	1.9	0.5	0.4	0.1	2.4	0.6	0.5
NO_3 (mg/l)	0.1	5.9	1.0	1.1	0.1	8.1	1.2	1.5
Cl (mg/l)	0.0	3.3	0.8	0.8	0.0	4.1	1.1	1.1
HCO_3 (mg/l)	10.3	117.0	34.9	26.7	12.3	147.1	39.4	30.4
NH_4 (mg/l)	3.1	79.5	19.6	16.7	3.1	82.3	21.9	19.1
PO_4 (mg/l)	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Fe (mg/l)	0.0	0.8	0.2	0.2	0.0	0.9	0.3	0.2
Cd (mg/l)	0.2	0.2	0.2	0.0	0.2	0.3	0.2	0.0
Cr (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cu (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pb (mg/l)	0.0	0.2	0.2	0.2	0.0	0.2	0.2	0.2

KEY: AL – Above Limit, WL – Within Limit, NL – No Limit, Perm. –Permissible.

A. Statistical Analysis

Results of the statistical analysis of water quality parameters of the water samples showing the minimum, maximum, mean and standard deviation for both dry and wet seasons are presented in Table V. The range, mean and standard deviation values revealed considerable variations in most water samples with respect to their chemical composition.

B. Correlation and Multiple Regression Modelling for Domestic Borehole Water Quality

Correlation and multiple regression analysis are useful for interpreting groundwater quality data and relating them to specific hydrogeological processes. These tools are quite useful in characterizing and obtaining firsthand information of the groundwater system than actually going through complex procedures and methods.

C. Correlation Analysis of Water Quality Parameters

The degree of linear association between any two of the water quality parameters (dependent and independent variables) is measured by the simple correlation coefficient (R). Results showing the interrelationship between some measured insitu water quality parameters of sampled domestic boreholes in the dry and wet seasons as independent variables and laboratory measured concentration of ions of sampled boreholes as dependent variables using the data analysis package in Microsoft office excel. The results of the multiple correlation matrix using the cations, anions and heavy metals (Na, K, Ca, Mg, SO_4, NO_3, Cl, PO_4, HCO_3, NH_4, Fe, Cd, Cr, Cu, and Pb) interchangeably as dependent variables and pH, EC, TDS and DO as independent variables are presented in Table VI (a-o) for both dry and wet seasons.

D. Regression Analysis of Water quality parameters

The result of multiple regression for Na, K, Ca, Mg, SO_4, NO_3, Cl, PO_4, HCO_3 and NH_4 using correlated significant predictors that were found to have better and higher level of significance in their correlation coefficient are presented in the regression statistics on Tables VII (a and b) for both the dry and wet seasons.

The greater the value of regression coefficient, the better is the fit and more useful the regression variables [27]. The multiple regression equations for prediction of ion concentrations using insitu parameters concentrations as independent variables are given in Table VIII for both seasons.

TABLE III: RESULTS OF GROUNDWATER QUALITY PARAMETERS ANALYSIS FOR THE DRY SEASON

SL Code	Temp. (°C)	pH	EC (μS/cm)	Turbidity	TH	TSS	TDS	DO	BOD	COD	Total Coli.	CATIONS				ANIONS							HEAVY METALS			
												Na (Mg/l)	K (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	SO_4^{2+} (Mg/l)	NO_3 (Mg/l)	Cl (Mg/l)	HCO_3 (Mg/l)	NH_4 (Mg/l)	PO_4 (Mg/l)	Fe (Mg/l)	Cd (Mg/l)	Cr (Mg/l)	Cu (Mg/l)	Pb (Mg/l)
OKU	28.85	6.92	492.00	0.35	194.00	0.00	112.00	2.06	1.40	2.90	32.12	1.74	0.79	3.21	0.67	0.13	0.32	2.67	2.92	5.87	0.07	0.25	0.001	0.001	0.00	0.01
EFG	26.70	3.89	210.00	0.62	5.80	5.00	150.00	4.15	1.30	2.60	0.00	1.77	0.06	6.75	3.14	1.12	0.72	25.58	0.01	4.38	0.08	0.10	0.002	0.002	0.00	0.03
ARB	26.95	6.84	380.00	6.31	17.32	15.67	10.11	0.78	1.30	2.70	11.00	4.36	6.84	13.94	14.33	8.36	10.34	18.78	3.12	1.24	4.17	0.40	0.002	0.001	ND	0.04
NCAT	25.50	5.74	415.00	2.11	4.79	16.01	10.07	5.21	1.70	2.30	30.19	4.73	5.62	13.16	8.42	7.89	10.16	8.17	1.94	3.61	2.66	ND	0.002	0.001	ND	0.02
APR	28.80	7.05	63.00	0.31	28.71	0.00	32.00	3.20	1.60	2.70	0.00	0.45	0.26	4.99	1.32	31.57	2.13	26.41	3.16	3.50	1.72	0.36	0.001	0.000	0.20	0.01
JKR	30.60	6.00	554.00	16.10	4.28	10.00	227.00	3.10	1.50	2.40	Nil	0.08	0.71	1.18	0.09	8.44	2.38	12.01	35.00	1.35	0.30	0.32	0.001	0.001	0.02	<0.001
SHA	25.70	5.90	304.00	2.60	25.02	0.00	152.00	0.67	1.20	2.70	Nil	14.56	0.53	3.50	1.92	0.13	0.00	7.90	0.18	3.72	0.04	<0.001	0.003	0.004	0.30	<0.001
EKP	29.20	4.48	110.00	0.91	5.13	0.00	52.00	2.74	1.40	2.50	13.00	4.92	0.24	2.23	0.97	0.18	0.07	20.02	0.10	1.35	0.02	0.22	0.015	0.002	0.01	0.00
UCE	29.20	5.72	46.55	0.00	14.57	23.00	84.75	3.10	1.54	2.40	0.00	1.99	1.62	1.04	1.24	0.14	0.48	6.06	3.55	4.27	0.59	0.34	0.002	0.001	0.40	0.02
EFM	30.70	6.40	612.00	16.70	4.60	10.00	306.00	3.20	8.52	2.70	5.02	0.09	1.18	1.61	0.12	14.94	1.98	25.03	32.00	5.76	0.28	0.39	0.001	0.002	0.31	0.03
OGB	23.40	6.20	508.00	0.00	30.68	0.00	254.00	2.50	1.50	2.30	Nil	1.24	3.60	2.04	4.20	0.01	0.01	14.80	19.85	0.68	0.86	0.20	0.002	0.002	ND	<0.001
UGT	25.60	6.10	38.00	0.25	302.00	1.00	17.00	0.80	1.10	2.70	0.00	2.79	1.20	4.85	3.31	1.65	0.75	6.50	7.32	4.27	0.82	0.44	0.000	0.001	0.00	0.00
JED	28.60	6.40	159.40	12.60	5.84	12.00	79.60	4.60	1.10	2.20	25.98	0.05	1.04	2.13	0.14	2.52	12.46	4.50	3.00	1.13	0.46	3.00	0.005	0.004	1.45	0.03
UBJ 1	25.84	6.40	159.40	0.60	4.36	N/A	76.60	4.60	1.10	2.70	4.80	3.52	0.70	2.33	1.25	4.00	0.00	51.97	42.79	3.50	5.38	0.03	0.006	0.005	0.05	0.00
UBJ 2	24.95	4.10	57.37	14.20	3.75	N/A	63.78	3.92	5.03	2.60	5.91	0.05	11.04	2.13	0.14	2.52	12.49	4.50	18.00	3.40	0.46	3.00	0.007	0.002	0.01	<0.001
OSM	28.07	7.44	426.74	37.53	16.32	32.67	228.54	0.90	7.70	2.70	33.33	19.98	2.27	0.89	1.70	15.86	1.32	127.91	0.31	1.24	0.36	1.41	0.001	0.001	0.00	0.00
OSA	28.28	6.72	67.37	2.07	4.54	1.20	36.99	5.08	1.63	2.90	10.67	2.56	0.44	0.24	0.32	0.91	0.30	14.81	0.31	2.61	0.03	0.26	0.001	0.012	0.00	0.00
OGW	23.21	7.00	29.90	3.40	22.87	0.00	14.90	2.63	6.05	2.10	30.53	1.63	0.62	1.42	0.12	0.00	0.02	1.70	4.56	1.24	0.50	0.02	0.002	0.002	0.02	<0.001
WAP	24.00	7.20	52.00	13.40	4.21	11.00	25.90	3.45	1.60	2.90	0.00	1.66	0.17	2.64	15.00	0.01	0.02	2.10	23.48	4.16	0.39	0.04	0.001	0.001	0.07	<0.001
OGU	23.70	5.90	342.00	0.00	5.75	0.00	171.10	3.00	1.47	2.70	12.05	13.76	0.85	3.20	2.13	0.06	0.01	16.10	0.08	5.98	0.07	0.00	0.003	0.001	1.56	<0.001
EDJ	25.20	7.00	30.00	0.70	281.00	0.00	15.00	0.70	1.30	2.20	6.97	0.34	6.73	2.11	0.56	0.01	0.00	1.40	20.02	0.57	0.97	<0.001	0.002	0.000	0.00	<0.001
EDHE	29.00	7.60	244.00	13.90	4.82	10.00	122.00	2.10	1.30	2.30	0.00	0.06	1.19	2.40	0.43	2.66	10.72	6.51	18.00	4.05	0.93	12.00	0.001	0.001	ND	0.03
FGC	23.50	6.20	44.40	0.00	28.04	0.00	22.20	2.60	1.30	2.70	28.50	1.19	5.12	0.84	3.03	0.00	0.01	2.60	8.21	1.02	0.28	0.07	0.002	0.003	0.42	<0.001
AJA	25.40	6.00	174.00	1.80	4.42	3.00	87.00	5.70	1.70	2.40	15.11	1.20	0.12	1.58	9.31	0.09	0.00	4.60	5.00	3.40	5.22	0.07	0.003	0.001	0.60	<0.001
WAG	25.00	6.50	29.80	1.20	26.25	6.00	14.90	4.12	1.40	2.50	5.90	2.96	0.14	1.83	4.73	0.00	0.01	1.70	0.04	0.79	0.01	<0.001	0.001	0.000	0.02	<0.001
OKL	26.00	5.40	292.00	0.00	12.97	0.00	146.00	0.90	1.20	2.70	Nil	4.67	0.35	2.00	1.21	0.25	0.02	10.90	24.53	4.38	0.08	0.07	0.001	0.000	0.40	<0.001
OKR	25.20	5.00	224.00	0.40	30.28	1.00	112.00	5.17	1.50	2.40	35.00	4.23	1.32	0.97	0.44	0.00	0.00	10.80	0.09	1.27	0.86	<0.001	0.000	0.000	0.09	<0.001
MRQ	25.90	5.30	158.00	0.00	4.31	0.00	79.00	4.50	1.60	2.70	11.00	0.37	1.28	1.92	1.62	0.00	1.00	6.40	19.01	2.72	0.82	0.00	0.000	0.000	0.02	<0.001
ESL	30.00	4.47	89.95	0.88	12.00	1.00	239.45	2.85	1.65	2.30	5.40	0.23	3.48	8.00	4.00	1.75	30.00	15.18	<0.010	1.35	0.17	0.76	0.001	0.011	0.50	Nil
IGM	27.65	7.40	483.10	13.20	19.96	13.03	294.70	3.34	7.30	2.70	0.00	10.95	9.87	14.90	9.89	45.78	31.24	104.00	7.70	6.96	2.25	0.87	0.001	0.000	ND	0.00
AGS	25.40	6.70	500.00	0.60	4.73	0.00	250.00	3.56	1.72	2.60	30.70	1.57	2.53	2.11	0.15	0.32	0.01	11.50	6.54	5.22	0.60	<0.001	0.002	0.000	ND	<0.001
BOA	27.84	6.60	602.00	0.77	205.00	10.00	598.00	0.60	1.10	2.90	11.50	1.68	1.76	2.25	1.86	0.14	0.47	4.21	3.84	2.64	0.64	0.38	0.002	0.000	0.70	0.02
IYA	25.70	5.40	384.00	0.00	11.67	0.00	192.00	2.20	8.01	2.90	4.80	11.25	0.87	1.07	2.22	0.25	0.00	9.20	0.18	5.11	0.06	0.05	<0.001	0.000	0.05	<0.001
PEM	25.80	6.20	116.00	0.40	5.86	0.00	58.00	2.80	1.40	2.60	31.22	4.32	0.11	1.34	2.31	0.01	0.00	5.50	2.90	0.02	0.18	0.01	0.002	0.003	0.0020	<0.001
ORH	26.76	7.20	342.00	0.58	253.00	7.00	328.00	5.51	1.20	2.70	0.00	0.83	0.26	4.23	0.83	0.12	0.24	1.71	1.69	0.01	2.05	0.26	0.002	0.001	0.0000	0.27
ENE	29.00	4.38	216.65	0.40	12.00	<1.00	36.57	4.81	1.20	2.30	12.23	1.82	1.24	8.00	4.00	2.98	0.33	2.83	<0.010	0.01	0.71	0.00	0.001	0.002	0.0000	Nil
UDR	25.40	6.30	309.00	5.20	5.29	8.00	154.50	2.94	1.50	2.10	6.12	2.45	0.18	2.06	0.94	0.20	0.00	9.60	0.15	0.03	0.75	<0.001	0.001	0.001	0.0000	<0.001
OTO	23.60	6.10	31.20	0.00	4.96	0.00	15.10	2.76	1.60	2.40	0.00	20.70	0.70	2.56	5.12	0.01	0.00	1.40	2.81	6.02	0.06	0.01	0.001	0.001	0.00	<0.001
BDE	29.50	4.42	97.20	0.26	5.33	<1.00	87.63	3.12	1.60	2.50	Nil	1.50	0.65	8.00	4.00	2.13	0.07	67.50	<0.010	5.40	0.02	0.03	0.011	0.002	0.02	Nil
UPE	30.00	4.48	385.20	0.37	12.00	<1.00	179.00	2.87	1.40	2.40	Nil	5.27	0.20	8.00	4.00	3.18	0.21	11.20	<0.010	1.57	4.76	0.03	0.002	0.001	1.80	0.16
MAM	27.76	6.80	482.00	4.13	184.00	4.00	510.00	0.40	1.70	2.30	30.45	1.96	0.90	3.00	0.69	0.13	0.24	2.54	2.96	6.87	3.68	0.30	0.002	0.002	0.03	0.01
DST	26.90	7.50	410.00	14.50	328.00	25.07	25.06	2.10	1.20	2.20	0.00	0.28	0.16	5.89	0.65	0.12	0.17	2.38	2.52	5.26	0.10	0.16	0.001	0.003	0.00	0.01
OKE	25.60	5.50	565.00	5.20	5.44	0.00	282.50	2.90	1.40	2.90	11.15	6.19	1.13	1.77	3.87	0.39	0.00	9.40	0.11	2.75	0.03	0.01	0.001	0.001	ND	<0.001
MOF	30.00	7.44	423.00	5.00	275.00	3.00	440.00	0.68	8.67	2.60	12.46	1.22	0.21	4.29	1.22	3.00	0.00	0.50	3.61	0.01	B/D	0.38	0.002	0.000	0.02	0.01
FUP	29.22	5.40	105.60	0.72	5.59	10.00	58.95	2.60	1.48	2.70	5.13	1.80	2.64	3.01	2.40	2.24	0.04	8.50	0.30	0.02	0.21	0.02	0.002	0.000	0.04	<0.001
SHP	29.93	5.60	255.65	0.66	4.91	0.00	184.00	5.38	6.83	2.30	4.42	2.33	1.55	0.54	0.85	0.94	0.36	3.12	2.16	0.06	1.41	0.00	0.001	0.000	1.61	1.83
ROP	31.00	6.70	384.00	16.80	5.62	10.00	192.00	3.00	1.40	2.70	0.00	0.04	0.51	0.65	0.04	20.74	2.40	31.53	20.00	5.08	0.32	0.11	0.001	0.000	0.03	Nil
ESR	28.40	6.61	244.00	20.90	11.00	12.00	172.00	4.90	1.40	2.70	30.20	0.03	1.16	3.06	0.28	2.11	0.13	12.90	15.00	4.77	4.69	0.29	<0.001	0.000	0.01	<0.001
ROR	30.50	5.60	422.00	16.00	5.14	10.00	211.00	3.80	1.30	2.90	11.50	0.06	0.54	0.80	0.06	22.04	2.70	14.51	5.00	1.38	0.26	0.23	0.002	0.000	0.05	1.72
PTR	29.11	4.12	115.05	0.00	12.00	21.22	285.20	0.47	1.20	2.10	6.11	14.29	0.73	2.04	12.87	0.01	0.01	14.80	<0.010	2.14	2.34	0.02	0.001	0.000	0.02	<0.001

TABLE IV: RESULTS OF GROUNDWATER QUALITY PARAMETERS ANALYSIS FOR THE WET SEASON

SL Code	Temp. (°C)	pH	EC (µS/cm)	Turbidity	TH	TSS	TDS	DO	BOD	COD	Total Coli.	CATIONS				ANIONS						HEAVY METALS				
												Na (Mg/l)	K (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	SO_4^{2+} (Mg/l)	NO_3 (Mg/l)	Cl (Mg/l)	HCO_3 (Mg/l)	NH_4 (Mg/l)	PO_4 (Mg/l)	Fe (Mg/l)	Cd (Mg/l)	Cr (Mg/l)	Cu (Mg/l)	Pb (Mg/l)
OKU	29.03	7.02	538.70	0.53	202.24	10.75	130.00	2.46	1.00	4.45	27.35	0.54	0.19	1.52	1.09	0.26	0.24	4.76	7.72	5.88	0.26	0.19	0.00	0.08	0.00	0.51
EFG	26.86	4.49	242.80	1.73	14.19	22.38	160.22	6.75	0.60	3.80	0.09	0.51	0.54	5.06	1.38	0.73	0.64	29.85	0.41	4.41	0.29	0.04	0.00	0.01	0.00	0.66
ARB	27.12	7.34	377.70	7.42	25.57	25.05	21.33	2.88	1.70	3.90	15.77	2.08	2.19	6.97	6.83	5.91	9.85	20.78	7.92	1.25	4.36	0.34	0.09	0.00	1.18	0.54
NCAT	25.32	6.34	427.90	3.23	13.05	27.84	28.07	6.11	3.60	3.50	32.69	2.45	5.02	6.19	6.66	5.44	9.67	19.92	2.34	3.62	2.47	0.00	0.00	0.01	0.01	0.65
APR	29.10	6.95	116.00	1.34	36.97	14.78	42.50	3.35	0.70	4.25	9.85	1.83	0.34	3.30	0.44	29.21	2.05	38.16	3.56	3.53	1.91	0.30	0.00	0.01	0.12	0.51
JKR	31.80	6.06	614.90	15.00	12.55	9.90	239.56	5.70	0.50	3.95	4.13	2.20	0.11	0.51	0.09	5.99	2.30	10.10	39.80	1.38	0.51	0.26	0.07	0.09	0.01	0.01
SHA	26.70	6.00	330.50	5.67	33.30	0.00	167.45	1.12	0.00	4.25	4.13	9.52	0.07	1.81	0.56	0.62	0.00	5.09	0.58	3.73	0.23	0.04	11.59	0.00	0.20	0.01
EKP	28.70	4.78	156.70	9.10	13.42	17.38	70.00	3.38	0.60	3.70	6.24	2.64	0.36	0.54	0.79	0.12	0.05	31.77	0.50	1.41	0.23	0.06	0.06	0.01	0.00	0.50
UCE	28.30	5.92	71.55	1.23	22.86	6.98	74.57	5.20	0.89	3.60	0.06	1.22	1.02	0.65	0.52	0.12	0.40	8.55	8.35	4.28	0.80	0.28	6.05	0.00	0.20	0.52
EFM	31.90	6.70	562.00	16.00	12.90	8.88	306.56	5.50	6.62	3.90	0.08	2.19	0.58	0.08	1.88	12.49	1.90	23.30	36.80	5.75	0.47	0.33	0.01	0.00	0.30	0.03
OGB	22.20	5.70	570.40	0.34	22.38	0.00	236.00	5.00	1.90	3.50	0.02	1.04	3.00	0.35	2.44	0.01	0.01	16.08	24.65	0.74	1.05	0.14	0.11	1.62	1.11	0.01
UGT	24.90	6.20	93.80	0.52	310.31	14.38	29.60	1.60	0.60	4.25	3.11	0.51	0.60	3.16	1.55	1.26	0.67	8.05	7.72	4.31	0.82	0.38	1.10	0.00	0.04	0.00
JED	29.80	7.00	204.70	12.55	14.16	12.01	81.10	6.30	0.20	3.75	24.67	2.23	0.44	0.44	1.32	0.07	11.97	6.09	3.40	1.16	0.64	2.94	7.95	0.05	0.02	0.03
UBJ 1	26.84	6.90	193.90	6.06	12.93	46.92	92.09	6.70	0.20	4.25	7.60	1.24	0.10	0.64	0.51	3.61	0.01	63.72	47.59	3.51	5.17	0.03	0.06	0.01	0.01	0.63
UBJ 2	25.85	4.70	82.57	14.52	12.09	11.74	73.87	6.85	4.43	3.80	4.80	2.23	6.39	4.84	1.62	0.07	12.00	6.50	22.80	3.41	0.65	2.72	7.37	0.01	0.01	0.01
OSM	28.67	4.20	449.84	35.77	24.67	0.02	241.06	1.85	5.00	3.90	36.54	14.94	1.67	0.80	0.06	13.41	1.24	125.19	0.71	1.25	0.55	1.13	0.00	0.06	0.01	0.56
OSA	28.28	7.12	44.17	3.09	12.90	0.01	48.54	7.08	1.57	4.45	14.52	0.28	0.16	6.73	0.44	0.52	0.03	16.17	0.71	2.61	0.22	0.02	0.03	0.00	0.07	0.53
OGB	24.41	7.10	79.90	3.88	31.24	11.00	27.54	4.99	4.55	3.30	26.52	0.65	0.02	0.27	0.64	0.00	0.01	0.32	9.36	1.42	0.71	0.02	0.09	0.00	0.01	0.01
WAP	24.50	7.20	102.40	15.00	4.16	0.00	25.00	5.15	0.23	4.45	1.19	0.62	0.43	0.95	7.50	0.01	0.02	0.03	28.28	4.61	0.58	0.01	0.02	0.04	0.35	0.01
OGU	23.10	6.30	405.00	0.02	14.13	10.84	153.50	2.60	0.78	4.25	16.05	8.72	0.85	1.51	0.37	0.33	0.02	18.01	4.88	5.99	0.14	0.00	0.08	0.00	0.45	0.06
EDJ	26.10	7.30	70.50	0.89	272.61	13.40	33.00	2.40	0.73	3.75	10.36	1.94	2.08	0.42	0.20	0.01	0.01	3.04	24.82	0.54	0.78	0.02	0.02	0.09	0.02	0.05
EDHE	30.20	7.80	254.40	14.00	13.20	11.75	136.60	1.30	0.30	3.85	0.07	2.22	3.46	0.71	0.27	2.27	10.27	8.15	22.80	4.08	0.72	11.72	7.26	0.01	0.09	0.53
FGC	23.00	5.90	69.40	0.03	36.41	0.11	37.00	5.20	1.80	4.25	31.94	1.09	4.52	0.85	1.36	0.39	0.01	4.06	13.01	1.05	0.47	0.04	4.15	0.00	0.01	0.01
AJA	25.40	5.60	236.10	2.65	12.79	3.50	100.50	6.68	0.30	3.95	16.88	1.08	0.48	5.39	7.55	0.09	0.01	6.40	5.40	3.43	5.03	0.05	0.04	0.04	0.03	0.02
WAG	26.60	7.10	80.00	2.45	34.61	23.38	29.80	6.26	0.00	4.05	18.00	0.68	0.46	0.14	2.97	0.00	0.04	3.07	5.44	0.82	0.10	0.01	0.06	0.00	0.06	0.06
OKL	24.80	5.90	333.90	0.03	21.32	1.23	128.00	2.30	1.88	4.25	0.01	2.39	0.25	0.31	0.55	0.14	0.02	14.09	29.33	4.39	0.08	0.03	6.63	0.02	0.06	0.08
OKR	26.10	5.40	236.30	0.78	38.62	8.05	129.50	6.74	1.10	3.60	25.54	1.95	0.72	0.72	1.32	0.00	0.00	12.08	4.89	1.30	0.69	0.02	6.15	0.00	0.08	0.09
MRQ	26.90	5.40	214.40	0.09	12.65	15.90	88.00	6.70	1.00	2.70	13.55	1.91	0.68	1.23	0.56	0.00	0.51	8.04	23.81	2.73	0.61	0.01	0.02	0.06	0.02	0.07
ESL	29.20	4.77	125.55	0.99	20.33	16.82	257.35	4.33	0.35	3.55	9.65	2.05	2.88	1.03	2.24	1.61	29.51	17.18	0.01	1.36	0.36	0.07	0.04	0.01	0.31	0.65
IGM	28.05	6.90	546.10	15.00	11.62	0.00	304.70	4.14	5.40	2.70	4.00	5.91	5.22	13.21	8.13	43.33	29.28	106.11	12.50	6.93	2.44	0.08	0.08	0.08	0.03	0.05
AGS	26.60	6.30	438.00	2.01	4.73	7.00	232.41	6.12	0.73	6.02	33.97	0.71	2.53	0.42	0.14	0.07	0.01	13.05	11.34	5.23	0.79	0.00	0.03	0.09	0.02	0.21
BOA	27.54	6.60	559.41	0.77	213.32	13.03	581.60	1.80	0.64	4.42	11.55	1.53	2.89	0.35	0.10	0.13	0.23	6.12	8.64	2.65	0.85	0.32	0.02	1.00	0.01	0.01
IYA	25.70	6.00	347.70	0.00	19.98	0.00	185.50	4.70	6.11	4.45	3.90	6.21	0.27	0.62	0.46	0.14	0.00	11.02	0.58	5.12	0.25	0.01	0.01	0.04	0.07	0.01
PEM	25.80	6.80	139.10	0.32	14.16	10.00	76.00	6.00	0.69	3.80	26.45	2.04	0.49	0.35	0.55	0.01	0.00	7.05	3.30	0.03	0.36	0.04	0.09	0.04	0.02	0.35
ORH	26.76	7.70	389.00	0.85	245.00	9.87	335.40	7.05	1.60	3.95	0.02	1.48	0.34	2.54	0.39	0.27	0.16	2.17	2.09	0.04	1.84	0.02	0.06	0.05	0.25	0.06
ENE	30.20	4.88	243.45	0.04	20.24	1.00	37.07	6.31	1.20	3.52	0.09	0.46	0.64	1.03	2.24	2.59	0.23	4.38	0.01	0.04	0.52	0.00	7.04	0.05	0.02	0.11
UDR	24.20	6.90	243.45	5.00	13.54	26.00	137.50	5.88	0.10	3.65	0.02	0.17	0.42	0.37	0.82	0.19	0.02	11.90	0.55	0.04	0.94	0.01	11.26	0.05	0.27	2.17
OTO	24.80	6.50	80.90	0.77	13.22	0.96	30.20	3.36	1.50	4.02	0.57	15.66	0.10	0.87	3.36	0.01	0.00	3.04	7.61	5.99	0.27	0.03	0.01	0.00	0.01	0.01
BDE	30.70	5.02	128.70	2.16	13.60	1.00	93.23	5.99	0.70	2.50	15.67	0.78	0.05	1.03	3.50	1.74	0.03	69.05	0.01	5.39	0.21	0.04	0.05	0.03	0.01	0.09
UPE	31.20	4.78	442.50	3.27	3.72	0.50	183.30	2.87	1.80	3.60	8.23	2.99	0.40	0.03	2.42	2.79	0.12	13.02	0.01	1.58	4.55	0.02	0.04	0.00	0.70	0.03
MAM	27.26	6.30	524.30	5.11	192.28	3.50	513.50	0.96	1.02	3.85	25.90	1.25	0.30	1.31	0.58	0.13	0.16	4.44	3.36	6.84	3.48	0.10	0.09	0.05	0.02	0.06
DST	27.30	8.10	435.36	15.34	336.29	42.47	38.79	3.09	0.59	3.40	0.00	2.00	0.44	1.08	0.56	0.12	0.09	4.92	7.32	5.27	0.01	0.33	0.06	0.00	0.01	0.61
OKE	24.70	6.00	596.64	6.13	13.74	10.00	294.80	4.40	1.00	4.15	12.92	3.91	1.73	0.08	3.78	0.00	0.04	11.05	0.51	2.76	0.22	0.02	0.01	0.01	0.09	0.03
MOF	29.50	7.04	479.40	9.00	266.69	17.52	450.00	2.18	6.77	3.85	11.13	1.06	0.81	2.68	0.22	2.61	0.08	2.25	8.41	0.02	0.23	0.10	0.00	0.08	0.01	0.01
FUP	29.22	6.00	145.70	7.81	13.91	11.00	75.95	4.07	1.88	4.25	6.37	1.41	2.04	1.32	2.04	1.85	0.04	10.05	5.10	0.21	0.12	0.04	2.82	0.00	0.03	0.001
SHP	31.13	5.30	196.75	5.13	4.91	5.29	170.00	4.98	5.38	3.85	7.41	0.05	0.95	1.15	0.58	0.55	0.13	5.21	6.96	0.05	1.61	0.01	0.02	0.05	0.16	0.01
ROP	32.20	7.30	321.00	20.06	13.95	12.22	202.02	4.50	1.00	3.90	0.07	2.24	0.09	0.04	0.04	18.29	1.91	33.36	24.80	5.05	0.52	0.05	0.02	0.00	0.02	3.81
ESR	27.40	6.91	301.45	19.65	19.34	6.10	155.60	2.30	0.41	3.90	34.20	1.25	0.56	3.06	0.48	1.72	0.05	14.09	19.80	4.69	4.89	0.23	0.05	0.07	0.00	0.05
ROR	31.50	5.60	365.02	20.01	13.49	13.00	214.47	5.21	0.26	2.90	12.80	1.22	0.06	0.89	0.06	19.59	2.62	16.15	5.40	1.41	0.47	0.17	0.11	0.09	0.23	0.04
PTR	29.91	4.72	80.49	0.05	20.39	23.09	299.30	0.87	2.40	1.01	2.11	9.25	0.13	0.35	5.37	0.01	0.01	16.20	4.81	3.01	2.15	0.02	6.04	0.00	0.01	0.33

TABLE V: GROUNDWATER QUALITY STATISTICS OF DOMESTIC BOREHOLES SAMPLES ANALYSED DURING THE DRY AND WET SEASONS (WHERE, N = NUMBER OF SAMPLES COLLECTED = 50)

Parameter (mg/l)	Dry Season		Wet Season		WHO Permissible Standards [27]	Remark
	Mean Values	Std. deviation	Mean Values	Std. deviation		
Temp. (ºC)	27.27±0.340	2.40	27.47 ± 0.356	0.622	25	AL
pH	5.41±0.088	0.62	4.49 ± 0.077	1.061	6.5 – 8.5	Perm.
EC (μS/cm)	162.74±18.013	127.37	186.68 ± 21.207	20.506	400	WL
Turbidity (NTU)	5.69±1.108	7.84	6.27 ± 1.065	0.339	5	WL
TH (mg/l)	51.03±13.003	91.94	55.53 ± 12.781	16.327	500	WL
TSS (mg/l)	6.88± 1.280	9.18	11.17 ± 1.469	8.726	No guideline	NL
TDS (mg/l)	91.16±10.092	71.36	104.52 ± 11.874	11.314	500	WL
DO (mg/l)	3.22±0.234	1.66	4.29 ± 0.342	1.556	6	AL
BOD_5 (mg/l)	0.07±0.030	0.36	0.70 ± 0.121	1.061	10	WL
COD (mg/l)	4.36±0.267	1.89	3.92 ± 0.353	2.263	10-20	WL
Total Coli. (MPN/100l)	11.13 ± 1.637	11.58	11.58±1.582	17.847	10	AL
Na (mg/l)	9.30±0.987	6.98	10.34 ± 1.077	0.212	40	WL
K (mg/l)	1.30± 0.129	0.91	1.74 ± 0.173	0.000	20	WL
Ca (mg/l)	18.54±2.285	16.15	21.42 ± 2.783	3.465	75-200	WL
Mg (mg/l)	0.47±0.054	0.38	0.59 ± 0.064	0.014	30	AL
SO_4 (mg/l)	1.00±0.161	1.14	1.20 ± 0.213	0.099	250	WL
NO_3 (mg/l)	0.83±0.114	0.81	1.06 ± 0.152	0.106	50	WL
Cl (mg/l)	34.89±3.774	26.69	39.41 ± 4.299	4.172	5	AL
HCO_3 (mg/l)	19.62±2.360	16.69	21.92 ± 2.694	2.758	125–350	WL
NH_4 (mg/l)	0.01±0.002	0.02	0.02±0.002	0.006	< 1.5	WL
PO_4 (mg/l)	0.19±0.024	0.17	0.28 ± 0.034	0.106	0.3	WL
Fe (mg/l)	0.21±0.001	0.01	0.22±0.002	0.01	0.3	WL
Cd (mg/l)	0.00±0.000	0.002	0.00±0.003	0.002	0.003	WL
Cr (mg/l)	0.00±0.000	0.001	0.00±0.000	0.001	0.05	WL
Cu (mg/l)	0.20±0.047	0.246	0.20±0.035	0.246	2	WL
Pb (mg/l)	0.02±0.077	0.023	0.02±0.088	0.023	0.01	AL

TABLE VI (A): SODIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Na		pH	EC	TDS	DO	Na
pH	1					pH	1				
EC	-0.074	1				EC	-0.285	1			
TDS	-0.073	1	1			TDS	-0.286	1	1		
DO	0.3107	-0.036	-0.037	1		DO	-0.008	-0.06	-0.06	1	
Na	-0.104	0.8876	0.888	-0.026	1	Na	-0.331	0.8801	0.8805	-0.056	1

TABLE VI (B): POTASSIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	K		pH	EC	TDS	DO	K
pH	1					pH	1				
EC	-0.074	1				EC	-0.285	1			
TDS	-0.073	1	1			TDS	-0.286	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.008	-0.06	-0.06	1	
K	-0.194	0.722	0.7228	-0.1045	1	K	-0.295	0.7462	0.746	-0.096	1

TABLE VI (C): CALCIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Ca		pH	EC	TDS	DO	Ca
pH	1					pH	1				
EC	-0.074	1				EC	-0.285	1			
TDS	-0.073	1	1			TDS	-0.286	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.008	-0.06	-0.06	1	
Ca	-0.044	0.982	0.9821	-0.0333	1	Ca	-0.262	0.9815	0.9815	-0.063	1

TABLE VI (D): MAGNESIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	SO_4		pH	EC	TDS	DO	SO_4
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
SO_4	-0.053	0.936	0.9359	0.0099	1	SO_4	-0.149	0.9456	0.9458	0.0093	1

TABLE VI (E): SULPHATE CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	SO_4		pH	EC	TDS	DO	SO_4
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
SO_4	-0.053	0.936	0.9359	0.0099	1	SO_4	-0.149	0.9456	0.9458	0.0093	1

TABLE VI (F): NITRATE CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	NO_3		pH	EC	TDS	DO	NO_3
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
NO_3	-0.141	0.898	0.8993	-0.0914	1	NO_3	-0.278	0.9292	0.929	-0.1	1

TABLE VI (G): CHLORIDE CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Cl		pH	EC	TDS	DO	Cl
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
Cl	-0.073	0.991	0.9906	-0.0207	1	Cl	-0.238	0.9922	0.9922	-0.024	1

TABLE VI (H): PHOSPHATE CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	PO_4		pH	EC	TDS	DO	PO_4
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
PO_4	0.0514	0.807	0.8075	0.0627	1	PO_4	-0.235	0.8753	0.8749	-0.032	1

TABLE VI (I): BICARBONATE CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	HCO_3		pH	EC	TDS	DO	HCO_3
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
HCO_3	-0.073	0.962	0.9622	-0.0678	1	HCO_3	-0.284	0.9722	0.9721	-0.066	1

TABLE VI (J): AMMONIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	NH_4		pH	EC	TDS	DO	NH_4
pH	1					pH	1				
EC	-0.074	1				EC	-0.263	1			
TDS	-0.073	1	1			TDS	-0.264	1	1		
DO	0.3107	-0.04	-0.037	1		DO	-0.041	-0.043	-0.043	1	
NH_4	-0.035	0.353	0.353	-0.0312	1	NH_4	-0.075	0.573	0.574	-0.175	1

TABLE VI (K): IRON CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Fe		pH	EC	TDS	DO	Fe
pH	1					pH	1				
EC	-0.074	1				EC	-0.074	1			
TDS	-0.073	1	1			TDS	-0.073	1	1		
DO	0.3107	-0.04	-0.037	1		DO	0.3107	-0.036	-0.037	1	
Fe	0.05	0.954	0.9542	0.0128	1	Fe	0.0595	0.7248	0.7276	-0.017	1

TABLE VI (L): CADMIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Cd		pH	EC	TDS	DO	Cd
pH	1					pH	1				
EC	-0.074	1				EC	-0.074	1			
TDS	-0.073	1	1			TDS	-0.073	1	1		
DO	0.3107	-0.04	-0.037	1		DO	0.3107	-0.036	-0.037	1	
Cd	-0.914	0.062	0.0608	-0.2939	1	Cd	-0.914	0.0617	0.0608	-0.294	1

TABLE VI (M): CHROMIUM CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Cr		pH	EC	TDS	DO	Cr
pH	1					pH	1				
EC	-0.074	1				EC	-0.074	1			
TDS	-0.073	1	1			TDS	-0.073	1	1		
DO	0.3107	-0.04	-0.037	1		DO	0.3107	-0.036	-0.037	1	
Cr	-0.928	0.171	0.1692	-0.306	1	Cr	-0.928	0.171	0.1692	-0.306	1

TABLE VI (N): COPPER CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Cu		pH	EC	TDS	DO	Cu
pH	1					pH	1				
EC	-0.074	1				EC	-0.074	1			
TDS	-0.073	1	1			TDS	-0.073	1	1		
DO	0.3107	-0.04	-0.037	1		DO	0.3107	-0.036	-0.037	1	

TABLE VI (O): LEAD CORRELATION MATRIX

	DS (Dry Season)						WS (Wet Season)				
	pH	EC	TDS	DO	Pb		pH	EC	TDS	DO	Pb
pH	1					pH	1				
EC	-0.074	1				EC	-0.074	1			
TDS	-0.073	1	1			TDS	-0.073	1	1		
DO	0.3107	-0.04	-0.037	1		DO	0.3107	-0.036	-0.037	1	
Pb	-0.848	0.123	0.1226	-0.2835	1	Pb	-0.848	0.1234	0.1226	-0.283	1

TABLE VII (A): REGRESSION STATISTICS FOR CORRELATED WATER QUALITY PARAMETERS FOR DRY SEASON

Regression Statistics of Calcium (Ca^{2+}) for Dry Season

Multiple R	0.9824
R Square	0.9652
Adjusted R Square	0.9637
Standard Error	3.0788
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	12342.4650	6171.2325	651.0467	0.0000
Residual	47.0000	445.5102	9.4789		
Total	49.0000	12787.9752			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**-1.7477**	0.7110	-2.4580	0.0177	-3.1781	-0.3173	-3.1781	-0.3173
EC	**0.4032**	0.4237	0.9518	0.3461	-0.4491	1.2556	-0.4491	1.2556
TDS	**-0.4974**	0.7562	-0.6577	0.5139	-2.0187	1.0239	-2.0187	1.0239

Regression Statistics of Sodium (Na^{+}) for Dry Season

Multiple R	0.8887
R Square	0.7898
Adjusted R Square	0.7809
Standard Error	3.2655
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	1883.1922	941.5961	88.2985	0.0000
Residual	47.0000	501.1976	10.6638		
Total	49.0000	2384.3898			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	**1.3990**	0.7542	1.8551	0.0699	-0.1182	2.9162
EC	**-0.2430**	0.4494	-0.5407	0.5913	-1.1470	0.6611
TDS	**0.5204**	0.8021	0.6489	0.5196	-1.0931	2.1340

Regression Statistics of Potassium (K^{+}) for Dry Season

Multiple R	0.7318
R Square	0.5356
Adjusted R Square	0.5158
Standard Error	0.6363
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	21.9475	10.9737	27.1003	0.0000
Residual	47.0000	19.0317	0.4049		
Total	49.0000	40.9792			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	**0.4638**	0.1470	3.1558	0.0028
EC	**-0.1012**	0.0876	-1.1558	0.2536
TDS	**0.1899**	0.1563	1.2150	0.2304

Regression Statistics of Magnesium (Mg^{2+}) for Dry Season

Multiple R	0.8574
R Square	0.7351
Adjusted R Square	0.7238
Standard Error	0.1992
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	5.1758	2.5879
Residual	47.0000	1.8650	0.0397
Total	49.0000	7.0408	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.0568**	0.0460	1.2339
EC	**0.0016**	0.0274	0.0579
TDS	**0.0017**	0.0489	0.0352

Regression Statistics of Sulphate (SO_4) for Dry Season

Multiple R	0.9362
R Square	0.8765
Adjusted R Square	0.8712
Standard Error	0.4081
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	55.5258	27.7629
Residual	47.0000	7.8271	0.1665
Total	49.0000	63.3528	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**-0.3626**	0.0942	-3.8479
EC	**-0.0276**	0.0562	-0.4911
TDS	**0.0641**	0.1002	0.6399

Regression Statistics of Nitrate (NO_3) for Dry Season

Multiple R	0.9040
R Square	0.8172
Adjusted R Square	0.8094
Standard Error	0.3531
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	26.1895	13.0948
Residual	47.0000	5.8596	0.1247
Total	49.0000	32.0491	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**-0.0938**	0.0815	-1.1497
EC	**-0.0717**	0.0486	-1.4755
TDS	**0.1381**	0.0867	1.5929

Regression Statistics of Chloride (Cl^-) for Dry Season

Multiple R	0.9906
R Square	0.9814
Adjusted R Square	0.9806
Standard Error	3.7182
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	34244.8480	#########
Residual	47.0000	649.7888	13.8253
Total	49.0000	34894.6368	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**1.1129**	0.8587	1.2960
EC	**0.2378**	0.5117	0.4647
TDS	**-0.0540**	0.9133	-0.0591

Regression Statistics of Phosphate (PO_4) for Dry Season

Multiple R	0.8083
R Square	0.6533
Adjusted R Square	0.6386
Standard Error	0.1011
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	0.9058	0.4529
Residual	47.0000	0.4807	0.0102
Total	49.0000	1.3865	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.0135**	0.0234	0.5787
EC	**-0.0058**	0.0139	-0.4145
TDS	**0.0122**	0.0248	0.4911

Regression Statistics of HCO_3 for Dry Season

Multiple R	0.9622
R Square	0.9259
Adjusted R Square	0.9227
Standard Error	4.6392
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	12631.9748	6315.9874
Residual	47.0000	1011.5324	21.5220
Total	49.0000	13643.5072	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**-0.8940**	1.0714	-0.8344
EC	**-0.0183**	0.6384	-0.0286
TDS	**0.2576**	1.1395	0.2261

Regression Statistics of NH_4 for Dry Season

Multiple R	0.3568
R Square	0.1273
Adjusted R Square	0.0902
Standard Error	0.0147
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	0.0015	0.0007
Residual	47.0000	0.0101	0.0002
Total	49.0000	0.0116	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.0029**	0.0034	0.8629
EC	**0.0008**	0.0020	0.3794
TDS	**-0.0013**	0.0036	-0.3583

Multiple R	0.9542
R Square	0.9105
Adjusted R Square	0.9067
Standard Error	0.0028
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	2.0000	0.0037	0.0018
Residual	47.0000	0.0004	0.0000
Total	49.0000	0.0040	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.1945**	0.0006	304.0051
EC	**-0.0001**	0.0004	-0.1755
TDS	**0.0002**	0.0007	0.3537

Regression Statistics of Cd for Dry Season	
Multiple R	0.9138
R Square	0.8350
Adjusted R Square	0.8316
Standard Error	0.0009
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	1.0000	0.0002	0.0002
Residual	48.0000	0.0000	0.0000
Total	49.0000	0.0002	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.0201**	0.0011	17.7317
pH	**-0.0032**	0.0002	-15.5864

Regression Statistics of Cr for Dry Season	
Multiple R	0.9280
R Square	0.8612
Adjusted R Square	0.8584
Standard Error	0.0006
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	1.0000	0.0001	0.0001
Residual	48.0000	0.0000	0.0000
Total	49.0000	0.0001	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.0146**	0.0007	19.5982
pH	**-0.0024**	0.0001	-17.2605

Regression Statistics of Cu for Dry Season	
Multiple R	0.8525
R Square	0.7268
Adjusted R Square	0.7211
Standard Error	0.1302
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	1.0000	2.1636	2.1636
Residual	48.0000	0.8135	0.0169
Total	49.0000	2.9771	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**2.0357**	0.1634	12.4564
pH	**-0.3393**	0.0300	-11.2989

Regression Statistics of Pb for Dry Season	
Multiple R	0.8477
R Square	0.7186
Adjusted R Square	0.7127
Standard Error	0.0121
Observations	50.0000

ANOVA

	df	*SS*	*MS*
Regression	1.0000	0.0181	0.0181
Residual	48.0000	0.0071	0.0001
Total	49.0000	0.0252	

	Coefficients	*Standard Error*	*t Stat*
Intercept	**0.1859**	0.0152	12.1918
pH	**-0.0310**	0.0028	-11.0714

TABLE VII (B): REGRESSION STATISTICS FOR CORRELATED WATER QUALITY PARAMETERS FOR WET SEASON

Regression Statistics of Calcium (Ca^{2+}) for Wet Season

Multiple R	0.9817
R Square	0.9638
Adjusted R Square	0.9623
Standard Error	3.8220
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	18288.6529	9144.3264	625.9835	0.0000
Residual	47.0000	686.5729	14.6079		
Total	49.0000	18975.2258			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**-2.6207**	0.8684	-3.0178	0.0041	-4.3678	-0.8737	-4.3678	-0.8737
EC	**0.7937**	0.9207	0.8620	0.3931	-1.0586	2.6459	-1.0586	2.6459
TDS	**-1.1875**	1.6445	-0.7221	0.4738	-4.4958	2.1208	-4.4958	2.1208

Regression Statistics of Sodium (Na^{+}) for Wet Season

Multiple R	0.8856
R Square	0.7842
Adjusted R Square	0.7751
Standard Error	3.6129
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	2229.9486	1114.9743	85.4185	0.0000
Residual	47.0000	613.4946	13.0531		
Total	49.0000	2843.4432			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**1.9928**	0.8209	2.4276	0.0191	0.3414	3.6443	0.3414	3.6443
EC	**-1.2177**	0.8703	-1.3991	0.1683	-2.9686	0.5332	-2.9686	0.5332
TDS	**2.2548**	1.5545	1.4505	0.1536	-0.8725	5.3821	-0.8725	5.3821

Regression Statistics of Potassium (K^{+}) for Wet Season

Multiple R	0.7471
R Square	0.5582
Adjusted R Square	0.5394
Standard Error	0.8292
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	40.8286	20.4143	29.6917	0.0000
Residual	47.0000	32.3146	0.6875		
Total	49.0000	73.1432			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**0.6094**	0.1884	3.2345	0.0022	0.2304	0.9884	0.2304	0.9884
EC	**0.0836**	0.1997	0.4187	0.6773	-0.3182	0.4855	-0.3182	0.4855
TDS	**-0.1385**	0.3568	-0.3883	0.6995	-0.8563	0.5792	-0.8563	0.5792

Regression Statistics of Magnesium (Mg^{2+}) for Wet Season

Multiple R	0.9106
R Square	0.8292
Adjusted R Square	0.8219
Standard Error	0.1902
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2.0000	8.2561	4.1281	114.0729	0.0000
Residual	47.0000	1.7008	0.0362		
Total	49.0000	9.9570			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.0796**	0.0432	1.8405	0.0720	-0.0074	0.1665	-0.0074	0.1665
EC	**-0.0514**	0.0458	-1.1218	0.2677	-0.1436	0.0408	-0.1436	0.0408
TDS	**0.0967**	0.0819	1.1813	0.2434	-0.0680	0.2614	-0.0680	0.2614

Regression Statistics of Sulphate (SO_4) for Wet Season

Multiple R	0.9473
R Square	0.8973
Adjusted R Square	0.8929
Standard Error	0.4939
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	100.1460	50.0730	205.2985	0.0000
Residual	47.0000	11.4635	0.2439		
Total	49.0000	111.6095			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**-0.5743**	0.1122	-5.1179	0.0000	-0.8001	-0.3486	-0.8001	-0.3486
EC	**-0.1237**	0.1190	-1.0398	0.3038	-0.3630	0.1156	-0.3630	0.1156
TDS	**0.2379**	0.2125	1.1198	0.2685	-0.1895	0.6654	-0.1895	0.6654

Regression Statistics of Nitrate (NO_3) for Wet Season

Multiple R	0.9315
R Square	0.8676
Adjusted R Square	0.8620
Standard Error	0.4001
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	49.2997	24.6498	154.0174	0.0000
Residual	47.0000	7.5221	0.1600		
Total	49.0000	56.8218			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**-0.1840**	0.0909	-2.0239	0.0487	-0.3668	-0.0011	-0.3668	-0.0011
EC	**0.0917**	0.0964	0.9516	0.3462	-0.1022	0.2856	-0.1022	0.2856
TDS	**-0.1519**	0.1721	-0.8823	0.3821	-0.4982	0.1944	-0.4982	0.1944

Regression Statistics of Chloride (Cl^-) for Wet Season

Multiple R	0.9923
R Square	0.9847
Adjusted R Square	0.9840
Standard Error	3.8422
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	44581.3264	22290.6632	1509.9423	0.0000
Residual	47.0000	693.8418	14.7626		
Total	49.0000	45275.1682			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**1.8571**	0.8730	2.1272	0.0387	0.1008	3.6134	0.1008	3.6134
EC	**0.3682**	0.9256	0.3978	0.6926	-1.4938	2.2302	-1.4938	2.2302
TDS	**-0.2984**	1.6532	-0.1805	0.8575	-3.6242	3.0274	-3.6242	3.0274

Regression Statistics of Phosphate (PO_4) for Wet Season

Multiple R	0.8854
R Square	0.7839
Adjusted R Square	0.7747
Standard Error	0.1156
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	2.2772	1.1386	85.2607	0.0000
Residual	47.0000	0.6277	0.0134		
Total	49.0000	2.9049			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.0140**	0.0263	0.5318	0.5974	-0.0389	0.0668	-0.0389	0.0668
EC	**0.0494**	0.0278	1.7736	0.0826	-0.0066	0.1054	-0.0066	0.1054
TDS	**-0.0856**	0.0497	-1.7224	0.0916	-0.1857	0.0144	-0.1857	0.0144

Regression Statistics of HCO_3 for Wet Season

Multiple R	0.9727
R Square	0.9462
Adjusted R Square	0.9439
Standard Error	4.5138
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	16826.2526	8413.1263	412.9342	0.0000
Residual	47.0000	957.5786	20.3740		
Total	49.0000	17783.8312			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**-1.1427**	1.0256	-1.1142	0.2709	-3.2060	0.9205	-3.2060	0.9205
EC	**0.4042**	1.0874	0.3718	0.7117	-1.7832	2.5917	-1.7832	2.5917
TDS	**-0.5013**	1.9421	-0.2581	0.7974	-4.4083	3.4057	-4.4083	3.4057

Regression Statistics of NH_4 for Wet Season

Multiple R	0.6223
R Square	0.3873
Adjusted R Square	0.3612
Standard Error	0.0125

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	0.0046	0.0023	14.8541	0.0000
Residual	47.0000	0.0073	0.0002		
Total	49.0000	0.0120			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.0048**	0.0028	1.6762	0.1003	-0.0010	0.0105	-0.0010	0.0105
EC	**-0.0064**	0.0030	-2.1180	0.0395	-0.0124	-0.0003	-0.0124	-0.0003
TDS	**0.0115**	0.0054	2.1379	0.0378	0.0007	0.0223	0.0007	0.0223

Regression Statistics of Fe for Wet Season

Multiple R	0.8016
R Square	0.6425
Adjusted R Square	0.6273
Standard Error	0.0080
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	2.0000	0.0054	0.0027	42.2405	0.0000
Residual	47.0000	0.0030	0.0001		
Total	49.0000	0.0084			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.2117**	0.0019	114.3950	0.0000	0.2080	0.2154	0.2080	0.2154
EC	**-0.0043**	0.0011	-3.8570	0.0003	-0.0065	-0.0020	-0.0065	-0.0020
TDS	**0.0077**	0.0020	3.9248	0.0003	0.0038	0.0117	0.0038	0.0117

Regression Statistics of Cd for Wet Season

Multiple R	0.9138
R Square	0.8350
Adjusted R Square	0.8316
Standard Error	0.0009
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.0000	0.0002	0.0002	242.9367	0.0000
Residual	48.0000	0.0000	0.0000		
Total	49.0000	0.0002			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.0201**	0.0011	17.7317	0.0000	0.0178	0.0223	0.0178	0.0223
pH	**-0.0032**	0.0002	-15.5864	0.0000	-0.0037	-0.0028	-0.0037	-0.0028

Regression Statistics of Cr for Wet Season	
Multiple R	0.9280
R Square	0.8612
Adjusted R Square	0.8584
Standard Error	0.0006
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.0000	0.0001	0.0001	297.9261	0.0000
Residual	48.0000	0.0000	0.0000		
Total	49.0000	0.0001			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.0146**	0.0007	19.5982	0.0000	0.0131	0.0161	0.0131	0.0161
pH	**-0.0024**	0.0001	-17.2605	0.0000	-0.0026	-0.0021	-0.0026	-0.0021

Regression Statistics of Cu for Wet Season	
Multiple R	0.8525
R Square	0.7268
Adjusted R Square	0.7211
Standard Error	0.1302
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.0000	2.1636	2.1636	127.6661	0.0000
Residual	48.0000	0.8135	0.0169		
Total	49.0000	2.9771			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**2.0357**	0.1634	12.4564	0.0000	1.7071	2.3643	1.7071	2.3643
pH	**-0.3393**	0.0300	-11.2989	0.0000	-0.3996	-0.2789	-0.3996	-0.2789

Regression Statistics of Pb for Wet Season	
Multiple R	0.8477
R Square	0.7186
Adjusted R Square	0.7127
Standard Error	0.0121
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.0000	0.0181	0.0181	122.5759	0.0000
Residual	48.0000	0.0071	0.0001		
Total	49.0000	0.0252			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	**0.1859**	0.0152	12.1918	0.0000	0.1553	0.2166	0.1553	0.2166
pH	**-0.0310**	0.0028	-11.0714	0.0000	-0.0367	-0.0254	-0.0367	-0.0254

Regression Statistics of Cr for Wet Season	
Multiple R	0.9280
R Square	0.8612
Adjusted R Square	0.8584
Standard Error	0.0006
Observations	50.0000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.0000	0.0001	0.0001	297.9261	0.0000
Residual	48.0000	0.0000	0.0000		
Total	49.0000	0.0001			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**0.0146**	0.0007	19.5982	0.0000	0.0131	0.0161	0.0131	0.0161
pH	**-0.0024**	0.0001	-17.2605	0.0000	-0.0026	-0.0021	-0.0026	-0.0021

Regression Statistics of Cu for Wet Season	
Multiple R	0.8525
R Square	0.7268
Adjusted R Square	0.7211
Standard Error	0.1302
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.0000	2.1636	2.1636	127.6661	0.0000
Residual	48.0000	0.8135	0.0169		
Total	49.0000	2.9771			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**2.0357**	0.1634	12.4564	0.0000	1.7071	2.3643	1.7071	2.3643
pH	**-0.3393**	0.0300	-11.2989	0.0000	-0.3996	-0.2789	-0.3996	-0.2789

Regression Statistics of Pb for Wet Season	
Multiple R	0.8477
R Square	0.7186
Adjusted R Square	0.7127
Standard Error	0.0121
Observations	50.0000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.0000	0.0181	0.0181	122.5759	0.0000
Residual	48.0000	0.0071	0.0001		
Total	49.0000	0.0252			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	**0.1859**	0.0152	12.1918	0.0000	0.1553	0.2166	0.1553	0.2166
pH	**-0.0310**	0.0028	-11.0714	0.0000	-0.0367	-0.0254	-0.0367	-0.0254

V. Discussion of Results

A. Comparison of Physico-Chemical Parameter Results with WHO Standard for Drinking Water

The obtained results of measured concentrations of each water quality parameter in both dry and wet seasons were compared with the WHO standard values given in Table IV. Also, the numbers of boreholes within and above the recommended values are as presented.

The average values of BOD, ammonia and iron recorded highest in wet compared to the dry season, which could be due to acidification of water by elevated microbial degradation of organic debris and concentrated dissolved solids wet season. As a momentous role of DO amount in water quality of the groundwater, the average concentration of DO was lowest in dry season (directly proportional to temperature) and highest in the wet season (increase in phytoplankton and microbial activity) consequently increase in BOD and COD. DO values vary slightly less at the dry season. It might be due to copious growth of phytoplankton with less water flow, disturbance and uprooting leading to increased generation of oxygen by photosynthetic activities. Total hardness (TH) was recorded comparatively highest in the wet season and lowest in dry season. pH exhibited higher values in dry and lowest in wet season. Application of chemical fertilizers, run off from agricultural field, leaching of industrial/domestic waste and sewage inflow and other anthropogenic sources are the possible point and non-point sources of pH pollution to groundwater. Average phosphate ranged from 0.19 to 0.28 mg/l, Nitrate in the investigated samples were found to be in a range of 0.83 to 1.06 mg/l and sulphate 1.00 to 1.20 mg/l respectively in the dry and wet seasons.

The average range of chloride in the samples was 34.89 to 39.41 mg/l throughout the sampling periods. Concentrations were all below the WHO permissible limits for TH, TDS, BOD, COD, Na, Ca, K, SO_4, NO_3, Cl, HCO_3, NH_4, Fe, Cr, Cu and Pb for both seasons. The concentrations of the EC, Turbidity, DO, Total Coliform and PO4 were within standard limits while Temperature and Cd were above the required limits for the dry season and wet seasons [28]. The lowest and the highest levels of the iron detected ranged between 0.21 to 0.22 mg/l. Average Hardness levels were found in the water samples to be below the WHO permitted limit, which is 20.77 mg/l. On the whole, EC, Turbidity, DO, Total Coliform and PO_4 were within the set limit for the dry season, when Temperature and Cd were above the limits for the wet season. Also, observed values of Temperature, pH, Mg and Cd were above the limits for the dry season while EC, Turbidity, DO, Total Coliform, Ca, Mg, PO_4 and Fe parameters were within the standard limits for the wet season. There is no guideline for TSS.

TABLE VIII: DRY AND WET SEASONS MULTIPLE REGRESSION EQUATIONS FOR PREDICTING SOME IONS CONCENTRATION USING MEASURED IN-SITU PARAMETERS

S/N	Parameters	Predicting Equations	
		Dry Season	Wet Season
1.	Na	-0.2430EC+0.5204TDS+ 1.3990	-1.2177EC+2.2548TDS+ 1.9928
2.	K	-0.1012EC + 0.1899TDS + 0.4638	0.0836EC – 0.1385TDS + 0.6094
3.	Ca	0.4032EC – 0.4974TDS – 1.7477	0.7937EC – 1.1875TDS – 2.6207
4.	Mg	0.0016EC + 0.0017TDS + 0.0568	-0.0514EC+0.0967TDS + 0.0796
5.	SO_4	- 0.0276EC + 0.0641TDS – 0.3626	-0.1237EC+ 0.2379TDS – 0.5743
6.	NO_3	- 0.0717EC + 0.1381TDS – 0.0938	0.0917EC – 0.1519TDS – 0.1840
7.	Cl	0.2378EC – 0.0540TDS + 1.1129	0.3682EC – 0.2984TDS + 1.8571
8.	PO_4	- 0.0058EC + 0.0122TDS + 0.0135	0.0494EC – 0.0856TDS + 0.0140
9.	HCO_3	- 0.0183EC + 0.2576TDS – 0.8940	0.4042EC – 0.5013TDS – 1.1427
10.	Fe	- 0.0001EC + 0.0002TDS + 0.1945	-0.0043EC+0.0077TDS + 0.2117
11.	Cd	- 0.0032pH + 0.0201	– 0.0032pH + 0.0201
12.	Cr	– 0.0024pH + 0.0146	- 0.0024pH + 0.0146
13.	Cu	– 0.3393pH + 2.0357	- 0.3393pH + 2.0357
14.	Pb	– 0.0310pH + 0.1859	- 0.0310pH + 0.1859

The groundwater quality parameters varied from place to place and season to season and was dependent on both the surface and subsurface characteristics. The presence of open dumps, usage of fertilizer, disposal of industrial wastes, leakages from septic tanks and hydrocarbon contaminants, etc., changes the quality of groundwater.

B. Correlation and Multiple Regression Modelling of Water Quality Parameters

Correlation and regression analysis are quite useful in characterizing the relationship and dependence between the parameters analyzed. This could be used in the study to explain the nature of the dependent variables and how they are influenced by the independent variables. Only correlation coefficients above 0.7 were chosen since these indicates very high positive correlation.

C. Correlation Matrix Analysis

Correlation matrix for different water quality parameters along with the significance level are shown in Table IV (a-o) for both dry and wet seasons. Results of the statistical analysis gives an indication that EC and TDS have significantly high and positive correlation with Na, K, Ca, Mg, SO_4, NO_3, Cl, PO_4 and HCO_3 in both seasons but weak and moderate correlation with NH4 in the dry and wet seasons respectively. The R values between EC/TDS and the water quality parameters are: Na (0.8876/ 0.888), K (0.7218/ 7228), Ca (0.9823/ 0.9821), Mg (0.8574/ 0.8574), SO4 (0.9356/ 0.9359), NO3 (0.8985/0.8993), Cl (0.9906/ 0.9906), PO4 (0.8072/0.8075 and HCO3 (0.9622/0.9622) in the dry season and Na (0.8801/ 0.8805), K (0.7462/ 746), Ca (0.9845/ 0.9845), Mg (0.9062/ 0.9064), SO4(0.9456/ 0.9458), NO3 (0.9292/ 0.929), Cl (0.9922/ 0.9922), PO4(0.8753/ 0.8749) and HCO3 (0.9722/ 0.9791) in the wet season. The EC/TDS R values for NH4 are (0.3534/0.353) and (0.573/0.574) for dry and wet seasons respectively. The study showed good correlation between EC and other water quality parameters and also showed that multiple regression model can predict EC at 5% level of significance. Only pH showed significantly strong but negative correlation with the heavy metals in both seasons except for Fe that is positive. The results of R values of pH for the heavy metals (dry/wet seasons) are Fe(0.9541/0.9542), Cd(-0.914/-0.914), Cr(-0.928/-0.928), Cu(-0.852/-0.852) and Pb(-0.848/-0.848).

Also, from the correlation results, it is observed that EC and TDS are strongly correlated with a correlation coefficient of one (1), [30]. The relationship is not always linear and is strongly influenced by salinity and material content. The analysis of TDS concentration from EC value can be used to give an overview of water quality.

D. Regression Statistics Analysis

Results of multiple regression model in predicting cations, anions and heavy metals are presented in Table 7a and Table b. Regression coefficients represent the mean change in the response variable for one unit of change in the predictor variable while holding other predictors in the model constant. The independent variables such as EC and TDS were significant in predicting values of the dependent variables. The multiple R^2 values indicate the variability in Na, K, Ca, Mg, SO_4, NO_3, Cl, PO_4 and HCO_3 in both seasons could be ascribed to the combined effect of EC and TDS. This is in line with a study by [29]. He studied statistical approaches for hydro geochemical characterization of groundwater in west Delhi, India. The study showed good correlation between EC and other water quality parameters. The regression multiple correlations (R) of all dependent variables with some insitu groundwater independent variable parameters obtained were well above 0.7000 and suggests that EC and TDS have strong relationship with dependent variables but with the exception of NH_4 which is less than 0.4 and 0.6 in both seasons respectively. pH showed a strong negative relationship with Cd, Cr, Cu and Pb. This is supported in the regression equation (model) obtained for each groundwater parameter.

VI. CONCLUSION

The present study provides significant information on the quality of groundwater which is most important source of water supply in urban as well as rural areas in developing countries. Variations noticed in specific water quality substance among the water samples drawn from various bore holes may be attributed to various land use and land cover factors. The statistical regression analysis model has been found to be a highly useful technique for monitoring drinking water and has a good accuracy. The results of the statistical analysis gave an indication of the interrelationship amongst various parameters. From Tables VI (a–k), EC and TDS are the only predictors for the tested cations and anions in the dry and wet seasons while pH correlates with the heavy metals (Cadmium, Chromium, Copper and Lead) and are presented in Tables VI (l–o). The correlation coefficient (R) values of the predictors show strong correlation values of 0.7000 to

0.9922 in all the cations, anions and heavy metals except for ammonium which is in the range of 0.353 and 573. The correlation values are higher in the wet season. EC had very strong correlation with TDS. The regression models can be used to predict the concentration of anions, cations and heavy metals thereby giving a realistic groundwater situation. The study gives the easiest and rapid method of monitoring the quality of water.

VII. Recommendation

The groundwater in Warri should be treated before use. It is recommended that water analysis should be carried out periodically to monitor the rate and kind of contamination and to prevent further contamination. It is important to expand awareness among the people to maintain the cleanness of water at their highest quality and purity levels to achieve a healthy life. Suitable strategies to groundwater recharge, controlled groundwater usage, measures to reduce ground water pollution and awareness of the importance of water quality for private bore hole users are recommended.

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