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APPLICATION OF REGRESSION AND CORRELATION ANALYSIS FOR THE PREDICTION OF GROUNDWATER QUALITY VARIABLES IN BENIN CITY, EDO STATE, NIGERIA

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APPLICATION OF REGRESSION AND CORRELATION ANALYSIS FOR THE PREDICTION OF GROUNDWATER QUALITY VARIABLES IN BENIN CITY, EDO STATE, NIGERIA

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Abstract

Purpose*:* Groundwater is the major source of drinking water in Benin City. The focus of this research is to encourage regular monitoring of groundwater parameters for the assessment of the level of water quality for health benefits.

Methodology: This was carried out by studying interrelationship between parameters measured on spot and those measured in the laboratory. This research attempts to establish regression equations using pH, TDS and DO that are measured on site for prediction of cations and anions prior to their measurement in the laboratory within the study area. Water samples were analyzed for the following parameters pH, Total Dissolve Solids (TDS), Dissolved Oxygen (DO), Bicarbonate (HCO_3), Sodium (Na), Potassium (K), Magnesium (Mg), Chloride (Cl^-), Nitrate (NO_3), Sulphate (SO_4). Correlation analysis with ±0.25value was performed first to investigate the relationship between independent variables (pH, TDS, DO) and dependent variables (cations and anions). Multiple regression models was used to determine significant predictors (with p-value < 0.05) for the prediction of each ion.

Findings: TDS is a significant predictor with more than 95% confidence level for predicting all the ions in both seasons. DO and pH contributed in predicting Cl^- and NO_3^{2-} respectively in wet season. The independent variables (predictors) can easily be done using meter on site. The use of prediction equations will give an over view of groundwater quality, save time, money and resources.

Unique contribution to theory, practice and policy: Awareness programs and enlightenment should be continuously done to educate the people. Government and stake holders should make funds available for more research and enact laws that will improve groundwater quality for human health.

Keywords: *Regression, Correlation, groundwater quality, pH, Total dissolved solids*

1.0 INTRODUCTION

Water is an essential resource for the survival of both man and animals. The effect of water especially on humans cannot be quantified. The quality of water provided for human consumption need assessment to ensure safety of human lives. Assessment of water quality is basically on the determination of physico-chemical and biological characteristics of water which is further compared with the recommended limits set by regulatory bodies like World Health Organization (WHO) etc., based on health implication. Each of the water quality parameter is expected to be within recommended value otherwise it poses health risk on the consumer(s). Due to increase and higher level of man-made activities, water bodies including groundwater are contaminated. Therefore, there is need for continuous monitoring and evaluation of water quality especially water used for drinking purposes. But regular monitoring of all the water quality variables may be very hectic, material and time consuming coupled with our country where basic laboratory facilities are not available. The few available are quite expensive for private water providers to explore. According to Kumar (2007), cations and anions of groundwater are used to estimate the characteristics and origin of groundwater. So this research work attempts to use some of the parameter that are measured on the spot like pH, Dissolved oxygen and Total Dissolved solids (TDS) to establish regression equations which can be used to predict the cations and anions that determine quality of groundwater in Benin City. This will help to provide information on the status of water quality prior to detailed laboratory investigation. TDS are compounds of organic and inorganic matter that are soluble in water and gives the general nature of groundwater quality and extent of contaminant (Ramesh and Elango, 2006), using it in prediction of the ions is a significant predictor.

2.0 DESCRIPTION OF STUDY AREA

The study area is Benin City, the capital of Edo state, in Nigeria. It is a city about 40.2km north of the Benin River. It is situated at 321.8km east of Lagos. It is bounded by geographical coordinates 6° 06'N to 6° 30'N and 5° 3'E to 5° 45' E, with an area coverage of about 500square kilometers (Erah et al., 2002). The area is characterized by dry and rainy seasons. The rainy season commences in March and ends in October while the dry season is from November to February. The average annual rainfall is about 2025mm with an average annual temperature of 26.1°C and relative humidity of 82%. The driest month is January with 9mm of average rainfall. Most precipitation falls in September with an average of 338mm. In July, the average temperature is 24.5°C. It is the lowest average temperature of the whole year (Cimate-Data.org-Benin City).

3.0 METHODOLOGY

3.1 Experimental Procedure

Hundred (80) Boreholes were randomly sampled from different location within Benin City during wet and dry season in 2017 in order to determine the physico-chemical parameters of the groundwater sources selected. These water samples were collected and analyzed in triplicates to obtain the mean value of the parameters. Collection, preservation and transportation of the water samples to the laboratory followed the standard guideline recommended by APHA (1999). The laboratory used for the water quality analysis is MacGill Engineering and Technical Services located at No 234 Murtala Mohammed Way, Benin City, Edo state, Nigerian. Water samples were transported to this laboratory on daily basis after collection. Ten (10) physico-chemical parameters were analyzed for each sampled domestic borehole to provide a broad picture of the quality of water in the boreholes. The physico-chemical parameters tested were pH, Total Dissolve Solids (TDS), Dissolved Oxygen (DO), Bicarbonate (HCO_3), Sodium (Na), Potassium(K), Magnesium (Mg), Chloride(Cl^-), Nitrate (NO_3), Sulphate (SO_4). pH and Total dissolved solids were measured using multi portable meter (HI 9813-6) while Dissolved Oxygen was examined using DO meter (Lutron DO-5509,Range 0 – 20mg/l) on site because the parameters change with storage time (APHA, 1999). The multi portable meter probe was submerged in the water at 4cm and pH mode selected. Water sample was stirred gently and pH value displayed on the meter was allowed to adjust and stabilize before recording. 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. APHA, (1999) standard procedure were followed in the laboratory for the determination of cations and anions of groundwater samples collected.

Data Analysis

Experimental result obtained from the laboratory is given in Table 1. Data analysis package in Microsoft office excel was used to explore the interrelationship between on-site water quality parameters (pH, TDS, and DO) and laboratory water quality parameters of water samples (Na, Mg, Ca, HCO_3, NO_3, SO_4, and Cl).

Multiple Regression model is an extension of linear regression which covers situations where dependent variables (e.g., Na^+ parameter in domestic borehole) are affected by several controlled variables (pH, TDS and DO). When the significant factor p-value (probability value) is less than 0.05, then there is at least a 95% chance (confidence) that there is a true relationship between the variables. But if p-value is > 0.05, the particular independent variable is discarded on the basis that there is no true relationship.

Regression model used for this study is given in equation 1

$$y = a_0 + a_1 TDS + a_2 pH + a_3 DO \qquad (1)$$

a_0 = intercept, a_1, a_2, a_3 = co-efficients

pH, TDS,DO = Chemical parameters measured on site (independent variables)

y = each of chemical parameters measured in laboratory (dependent variables)

To perform linear or multiple regression analysis, a correlation analysis is always performed first to determine the degree of relationship between variables. It seeks to determine how well a linear or nonlinear equation describe or explain the relationship between variables (Nwaogazie, 2006). A positive correlation indicates that higher value for one variable tend to be related to higher values for the other variables. Correlation analysis was performed first with correlation value of ±0.25. Parameter with poor correlation was not considered in building the regression model. Trendline tool in Microsoft excel was used to develop the regression equation models

4.0 RESULTS AND DISCUSSIONS

4.1 Experimental Result

The ranges (minimum and maximum) concentration of groundwater quality parameters analyzed were presented in Table 1 showing the mean and standard deviation.

Table 1: Groundwater Quality Statistics of physico-chemical parameters of water samples.

	Wet season				Dry Season			
	Range				Range			
Parameter(mg/l)	Min	Max	Mean	SD	Min	Max	Mean	SD
PH	3.4	6.3	4.50	0.59	4.1	6.5	5.36	0.627
T.D.S	25.88	399.91	132.50	108.76	22	368	115.5	96.19
DO	1.90	10.20	5.14	2.65	1.0	8.4	3.76	1.893
HCO_3	3.10	92.20	28.25	25.01	3.1	85.5	25.28	22.95
Na	1.40	36.10	12.34	9.18	1.3	34.4	10.96	8.296
Ca	4.10	90.20	27.96	25.15	4.0	81.2	24.2	21.7
Mg	0.10	2.40	0.71	0.52	0.1	2.1	0.583	0.441
Cl	12.30	147.10	49.53	39.11	10.3	138	44.1	35.69
NO_3	0.01	4.55	1.28	1.29	0.02	3.49	0.993	0.943
SO_4	0.11	8.120	1.66	1.96	0.1	5.92	1.274	1.407

The pH ranges from 3.4 to 6.5 with mean values of 4.5 for wet season and 5.36 for dry season respectively. The pH of groundwater in Benin City is low. The observed lower pH values during wet season may be due to interaction of rain water with rocks, acid rain, and wastewater/sewage discharges that infiltrate into the groundwater. The increase in pH values observed in dry season can be attributed to no precipitation of acid rain and infiltration of substances into water table. In General, groundwater in Benin City is acidic (Ocheri et al., 2014). The total dissolved solids ranged between 22mg/l to 399.9mg/l with average values of 132.5mg/l for wet season and 115.5mg/l during dry season respectively. The concentration of TDS was high during wet season. This may be due to addition of solids from sewage, surface runoff and industrial effluents. The amounts of TDS are influenced by organic materials (Ramesh and Elango, 2006). Excluding pH, all water parameters analyzed are within the recommended standard set by WHO.

4.2 Correlation and Multiple Regression Analysis

Multiple correlations were done using cations and anions interchangeably as dependent variables and pH, TDS and DO as independent variables. Table 2(a-g) is the correlation matrix for each of the ions.

Table 2 (a) Sodium Correlation matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	Na	pH	TDS	DO	Na
Ph	1				1			
TDS	-0.1336	1			-0.086	1		
DO	-0.0081	0.250038	1		0.070	0.249	1	
Na	-0.15379	0.939283	0.229612	1	-0.074	0.946	0.230	1

Table 2 (b) Calcium correlation matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	Ca	pH	TDS	DO	Ca
pH	1				1			
TDS	-0.1336	1			-0.0856	1		
DO	-0.0081	0.250038	1		0.0699	0.2487	1	
Ca	-0.12972	0.99033	0.250586	1	-0.0768	0.9921	0.2566	1

Table 2 (c) Magnesium Correlation Matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	Mg	pH	TDS	DO	Mg
pH	1				1			
TDS	-0.13426	1			-0.0856	1		
DO	-0.00809	0.237828	1		0.0699	0.2487	1	
Mg	-0.07803	0.9160	0.2637	1	-0.0643	0.9049	0.3031	1

Table 2 (d) Bicarbonate Correlation Matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	HCO3	pH	TDS	DO	HCO3
pH	1				1			
TDS	-0.1336	1			-0.0856	1		
DO	-0.0081	0.250038	1		0.0699	0.2487	1	
HCO3	-0.12904	0.97817	0.209493	1	-0.0970	0.9774	0.2081	1

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Table 2(e) Chloride Correlation Matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	Cl	pH	TDS	DO	Cl
pH	1				1			
TDS	-0.1336	1			-0.086	1		
DO	-0.0081	0.250038	1		0.070	0.249	1	
Cl	-0.12724	0.9936	0.2718	1	-0.078	0.993	0.268	1

Table 2 (f) Nitrate Correlation Matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	NO3	pH	TDS	DO	NO3
pH	1				1			
TDS	-0.1336	1			-0.086	1		
DO	-0.0081	0.250038	1		0.070	0.249	1	
NO3	-0.2504	0.8967	0.139354	1	-0.199	0.882	0.144	1

Table 2 (g) Sulphate Correlation Matrix

	WS(Wet Season) Independent variables				DS(Dry season)			
Dependent variables	pH	TDS	DO	SO4	pH	TDS	DO	SO4
pH	1				1			
TDS	-0.1336	1			-0.0856	1		
DO	-0.0081	0.250038	1		0.0699	0.2487	1	
SO4	-0.0534	0.950409	0.225588	1	-0.1161	0.9091	0.1849	1

From Tables 2a to 2g, TDS is the best predictor for Na^+, HCO_3^- ,SO_4^{2-},Ca^{2+}, Mg^+, Cl^- and NO_3^{2-} with coefficient of correlation values ranging from 0.882 to 0.9936 for wet and dry season. In tables 2b, 2c and 2e, DO had correlation coefficient ranging from 0.2506 to 0.3031 for Ca^{2+}, Mg^+, and Cl^- for both season, therefore DO was also used in regression analysis for Ca^{2+}, Mg^+, and Cl^-. Mulitiple regression was done using correlated significant predictors. When a significant predictor has p-value > 0.05, it is removed from the regression on the basis that its contribution lacks 95% confidence (Nwaogazie, 2006).

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The predicted regression model for the ions are given in Figures 1- 12 using microsoft excel trendline tool package.

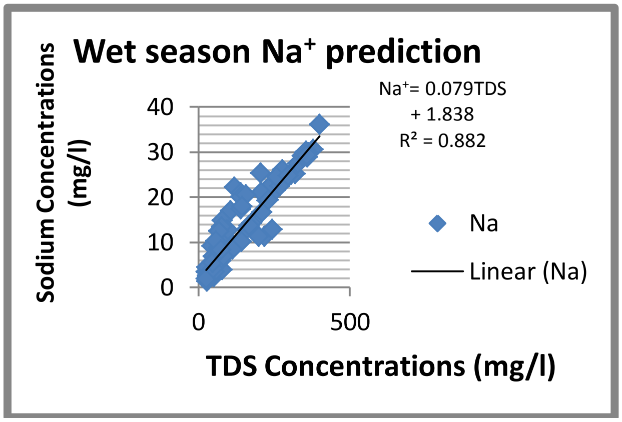

Figure 1: Regression Model Prediction for Na^+ in wet season

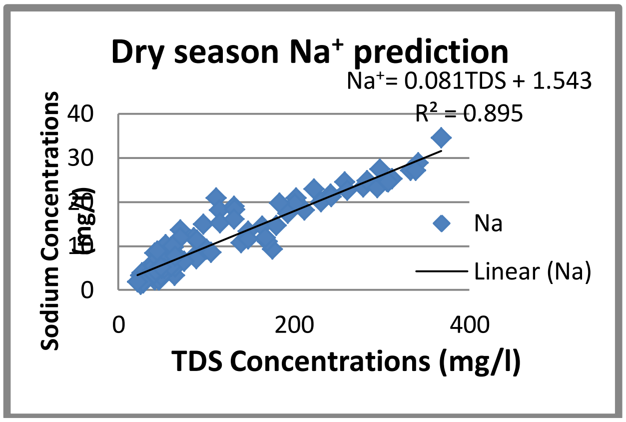

Figure 2: Regression Model Prediction for Na^+ in dry season

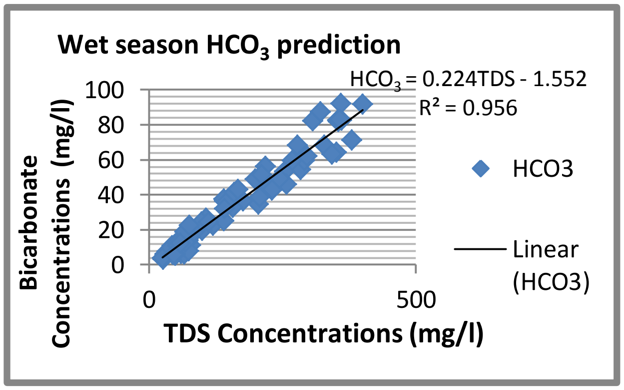

Figure 3: Wet Season Regression Model Prediction for HCO_3^-

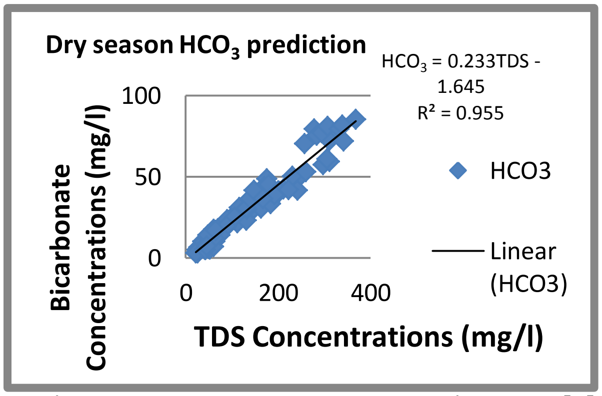

Figure 4: Dry Season Regression Model Prediction for HCO_3^-

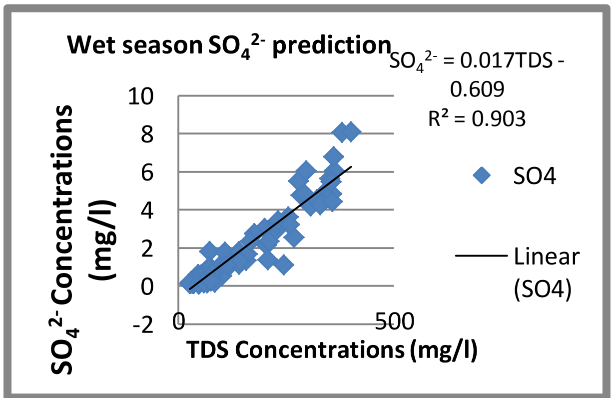

Figure 5: Wet Season Regression Model Prediction for SO_4^{2-}

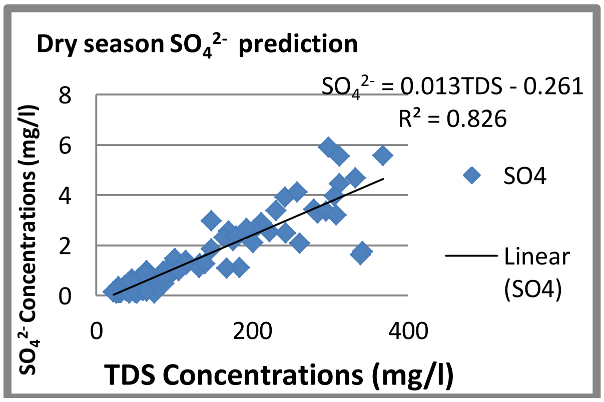

Figure 6: Dry Season Regression Model Prediction for SO_4^{2-}

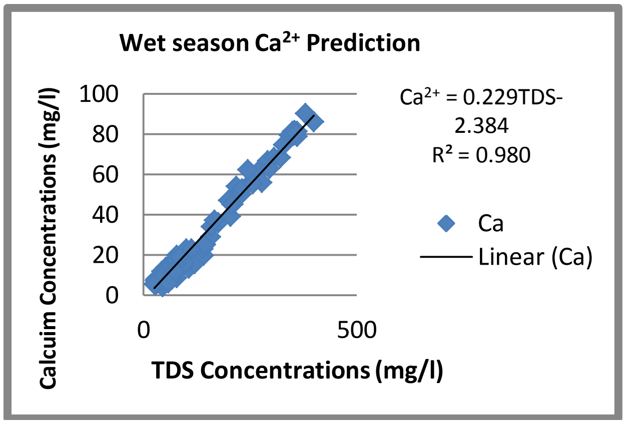

Figure 7: Wet Season Regression Model Prediction for Ca^{2+}

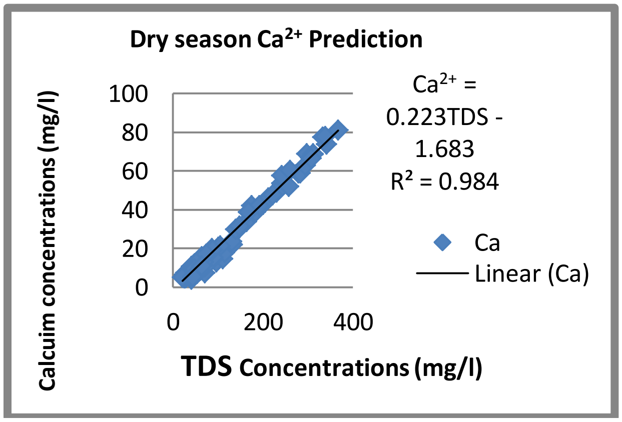

Figure 8: Dry Season Regression Model Prediction for Ca^{2+}

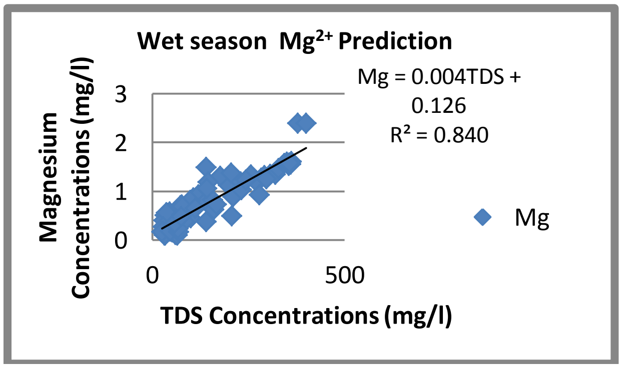

Figure 9: Wet Season Regression Model Prediction for Mg^{2+}

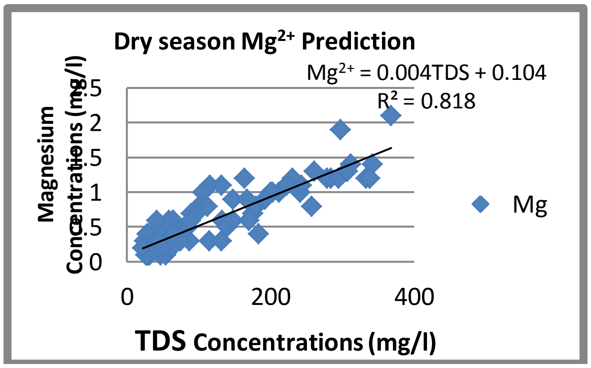

Figure 10: Dry Season Regression Model Prediction for Mg^{2+}

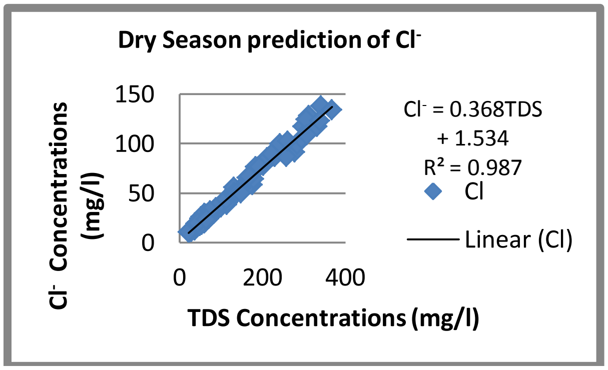

Figure 11: Regression Model Prediction for Cl^{-} in dry season.

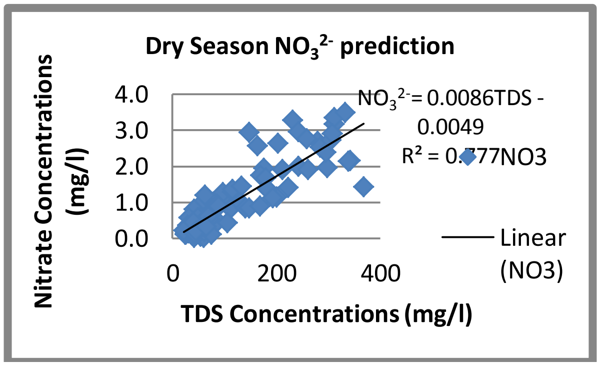

Figure 12: Regression Model Prediction for (NO_3^{2-}) in dry season.

For Cl^{-} and NO_3^{2-}, their regression analysis for wet season were presented in regression statistics Table 3 and 4 respectively because they have two significant predictors with probability value (p-value) < 0.05.

Table 3: Regression Statistics of Chloride (Cl^-) for wet season

Multiple R	0.9939							
R Square	0.9879							
Adjusted R Square	0.9876							
Standard Error	4.3472							
Observations	100.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	2.0000	149594.783	74797.391	3957.8313	0.0000			
Residual	97.0000	1833.1623	18.8986					
Total	99.0000	151427.945						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.5885	1.0090	0.5832	0.5611	-1.4141	2.5910	-1.4141	2.591
TDS	0.3550	0.0041	85.5767	0.0000	0.3468	0.3633	0.3468	0.363
DO	0.3692	0.1704	2.1665	0.0327	0.0310	0.7074	0.0310	0.707

From Table 3, R^{2-} = 0.988, intercept is 0.5885, TDS coefficient is 0.3550 and DO coefficient with p-value of 0.0327 is 0.3692. Therefore regression equation for prediction of Chloride is given in equation 2.

$$Cl^- = 0.5884 + 0.355TDS + 0.369DO \qquad (2)$$

Table 4: Regression Statistics of Nitrate (NO_3^{2-}) for wet season

Multiple R	0.906							
R Square	0.821							
Adjusted R Square	0.818							
Standard Error	0.549							
Observations	100							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	2	134.30	67.15	223.18	0.0000			
Residual	97	29.19	0.30					
Total	99	163.48						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.209	0.441	2.742	0.0073	0.334	2.084	0.334	2.084
pH	-0.289	0.094	-3.072	0.0028	-0.475	-0.102	-0.475	-0.102
TDS	0.010	0.001	20.305	0.0000	0.009	0.011	0.009	0.011

R^{2-} = 0.821, intercept is 1.209, TDS coefficient is 0.010 and pH coefficient with p-value of 0.0028 is -0.289. Therefore regression equation for prediction of Nitrate is given in equation 3.

$$NO_3^{2-} = 1.209 + 0.010TDS - 0.289pH \qquad (3)$$

From the analysis, regression equations for prediction of ion concentrations using on-site parameters are summarized in Table 5 for both seasons.

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Table 5: Established Regression Equation for predicting ions concentration

S/N	Parameters	Predicting Equations	
		Wet Season	Dry Season
1.	Na^+	$Na^+ = 0.0792TDS + 1.838$ $R^{2-} = 0.882$	$Na^+ = 0.081TDS + 1.543$ $R^{2-} = 0.895$
2	Ca^{2+}	$Ca^{2+} = 0.229TDS – 2.384$ $R^{2-} = 0.980$	$Ca^{2+} = 0.223TDS – 1.683$ $R^{2-} = 0.984$
3	Mg^{2+}	$Mg^{2+} = 0.004TDS + 0.126$ $R^{2-} = 0.840$	$Mg^{2+} = 0.004TDS + 0.104$ $R^{2-} = 0.840$
4	HCO_3^-	$HCO_3^- = 0.224TDS – 1.552$ $R^{2-} = 0.956$	$HCO_3^- = 0.233TDS – 1.645$ $R^{2-} = 0.955$
5	SO_4^{2-}	$SO_4^{2-} = 0.017TDS - 0.609$ $R^{2-} = 0.903$	$SO_4^{2-} = 0.013TDS - 0.261$ $R^{2-} = 0.826$
6	Cl^-	$Cl^- = 0.5884 + 0.355TDS + 0.369DO$ $R^{2-} = 0.988$	$Cl^- = 0.368TDS +1.534$ $R^{2-} = 0.987$
7	NO_3^{2-}	$NO_3^{2-} =1.209 – 0.289pH + 0.010TDS$ $R^{2-} = 0.821$	$NO_3^{2-} = 0.0086TDS – 0.0049$ $R^{2-} = 0.777$

Multiple and Linear equation have been carried out among significantly correlated parameters taking pH, TDS and DO as independent variables and Ca^+, Na^+, Mg^{2+}, $HCO3^-$, Cl^-,NO_3^{2-},SO_4^{2-} as dependent variables. It was observed that only TDS is a significant predictor for Ca^+, Na^+, Mg^{2+}, $HCO3^-$, and SO_4^{2-} during both seasons. TDS and DO are significant predictors for Cl^- concentration while pH and TDS are the predictors during wet season only for NO_3^- The independent variables (predictors) can easily be done using meter on site. The use of prediction equations will give an over view of groundwater quality, save time, money and resources.

4.3. Validation of Regression Equation.

Validation of predicted equations was done by conducting laboratory analysis on eight boreholes randomly selected different from the previously sampled boreholes within the study area. Table 6 is the addresses and GPS coordinates of sample points coded from A - H. The samples were subjected to physico-chemical analyses and the results are given in Table 7.

Table 6: Locations and GPS coordinates of sample points used for validation

S/N	SAMPLING CODE	GPS LOCATIONS	
		NORTHING	EASTING
1	A	06 19 262	005 36 910
2	B	06 20 261	005 36 712
3	C	06 20 650	005 35 759
4	D	06 26 195	005 35 632
5	E	06 21 582	005 37 261
6	F	06 20 913	005 40 396
7	G	06 20 943	005 39 745
8	H	06 19 059	005 37 922

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Table 7. Dry Season Physico-Chemical Parameters data for Validation.

	Code							
Parameters↓	A	B	C	D	E	F	G	H
pH	5.8	5.2	4.9	5.3	5.9	5.1	5.7	4.9
TDS	138	105	217	155	26	31	198	109
DO	6.4	5.9	6.5	5.9	5.5	6.3	6.9	5.2
HCO3	30.5	23.1	47.7	34	5.7	6.9	43.5	24
Na	12.7	9.5	19.7	15	2.4	2.8	18	9.9
Ca	29.7	22.3	46.1	32.9	5.5	6.7	42.2	23.2
Mg	0.63	0.49	1.03	0.74	0.12	0.15	0.94	0.52
Cl	52.1	38.9	80.3	57.4	9.97	11.8	73.6	40.9
NO_3	1.10	0.84	1.79	1.36	0.33	0.39	1.8	0.89
SO_4	1.5	1.16	2.41	1.81	0.29	0.34	2.2	1.21

Excluding pH, all measured water quality parameters are within the recommended value set by WHO for human consumption. Using prediction equations, the predicted values are compared with the measured values as shown in tables 8a – 8g.

Table 8a: Prediction of Na^+ using Regression Equation Na^+= 0.081TDS + 1.543

Sampling Code	TDS	0.081 TDS	Constant 1.543	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	11.178	1.543	12.72	12.7	-0.02
B	105	8.505	1.543	10.05	9.5	-0.55
C	217	17.577	1.543	19.12	19.7	0.58
D	155	12.555	1.543	14.10	15	0.9
E	26	2.106	1.543	3.65	2.4	-1.25
F	31	2.511	1.543	4.05	2.8	-1.25
G	198	16.038	1.543	17.58	18	0.42
H	109	8.829	1.543	10.37	9.9	-0.47

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Table 8b: Prediction of Ca^{2+} using Regression Equation Ca^{2+} = 0.223TDS – 1.683

Sampling Code	TDS	0.223 TDS	Constant 1.683	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	30.774	1.683	29.09	29.7	0.61
B	105	23.415	1.683	21.73	22.3	0.57
C	217	48.391	1.683	46.71	46.1	-0.61
D	155	34.565	1.683	32.88	32.9	0.02
E	26	5.798	1.683	4.12	5.5	1.38
F	31	6.913	1.683	5.23	6.7	1.47
G	198	44.154	1.683	42.47	42.2	-0.27
H	109	24.307	1.683	22.62	23.2	0.58

Table 8c: Prediction of Mg^{2+} using Regression Equation Mg^{2+}= 0.004TDS + 0.104

Sampling Code	TDS	0.004 TDS	Constant 0.104	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	0.552	0.104	0.66	0.63	-0.03
B	105	0.42	0.104	0.52	0.49	-0.03
C	217	0.868	0.104	0.97	1.03	0.06
D	155	0.62	0.104	0.72	0.74	0.02
E	26	0.104	0.104	0.21	0.12	-0.09
F	31	0.124	0.104	0.23	0.15	-0.08
G	198	0.792	0.104	0.90	0.94	0.04
H	109	0.436	0.104	0.54	0.52	-0.02

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Table 8d: Prediction of HCO_3^- using Regression Equation $HCO_3^- = 0.233TDS - 1.645$

Sampling Code	TDS	0.233 TDS	Constant 1.645	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	32.154	1.645	30.51	30.5	0.01
B	105	24.465	1.645	22.82	23.1	0.29
C	217	50.561	1.645	48.92	47.7	-1.22
D	155	36.115	1.645	34.47	34	-0.47
E	26	6.058	1.645	4.41	5.7	1.29
F	31	7.223	1.645	5.58	6.9	1.32
G	198	46.134	1.645	44.49	43.5	-0.99
H	109	25.397	1.645	23.75	24	0.25

Table 8e: Prediction of SO_4^{2-} using Regression Equation $SO_4^{2-} = 0.013TDS - 0.261$

Sampling Code	TDS	0.013TDS	Constant 0.261	Predicted Value (mg/l) (1)	Measured Value(mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	1.794	0.261	1.53	1.5	-0.03
B	105	1.365	0.261	1.10	1.16	0.06
C	217	2.821	0.261	2.56	2.41	-0.15
D	155	2.015	0.261	1.75	1.81	0.06
E	26	0.338	0.261	0.08	0.29	0.21
F	31	0.403	0.261	0.14	0.34	0.20
G	198	2.574	0.261	2.31	2.2	-0.11
H	109	1.417	0.261	1.16	1.21	0.05

Table 8f: Prediction of Cl^- using Regression Equation $Cl^- = 0.368TDS + 1.534$

Sampling Code	TDS	0.368 TDS	Constant 1.534	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	50.784	1.534	52.32	52.1	-0.22
B	105	38.64	1.534	40.17	38.9	-1.27
C	217	79.856	1.534	81.39	80.3	-1.09
D	155	57.04	1.534	58.57	57.4	-1.17

E	26	9.568	1.534	11.10	9.97	-1.13
F	31	11.408	1.534	12.94	11.8	-1.14
G	198	72.864	1.534	74.40	73.6	-0.80
H	109	40.112	1.534	41.65	40.9	-0.75

Table 8g: Prediction of NO_3^{2-} using Regression Equation NO_3^{2-} = 0.0086TDS – 0.0049

Sampling Code	TDS	0.086 TDS	0.0049	Predicted Value (mg/l) (1)	Measured Value (mg/l) (2)	Residual (mg/l) (2) – (1)
A	138	1.1868	0.0049	1.19	1.10	0.03
B	105	0.903	0.0049	0.91	0.84	0.07
C	217	1.8662	0.0049	1.87	1.79	0.08
D	155	1.333	0.0049	1.34	1.36	-0.02
E	26	0.2236	0.0049	0.23	0.33	-0.10
F	31	0.2666	0.0049	0.27	0.39	-0.12
G	198	1.7028	0.0049	1.71	1.8	-0.09
H	109	0.9374	0.0049	0.94	0.89	0.05

From above Tables 8a – 8g, the difference between the measured value and the predicted value (residual) of the concentration did not exceed 1.5 which shows that there is no much variation between the predicted concentration and the measured concentration.

5.0 CONCLUSION AND RECOMMENDATION

Conclusions

Correlation and regression analysis showed that on-site parameters (pH, DO and TDS) are interrelated with ions (Ca^{2+},Na^{+},Mg^{2+},Cl^{-},HCO_3^{-},SO_4^{2-} and NO_3) measured in the laboratory. TDS is a significant contributor with more than 95% confidence level for predicting all the ions in both seasons. DO contributed in predicting Cl^{-} while pH contributed in predicting NO_3^{2-} in wet season. Correlation and regression model are effective tool in exploring interrelationship between on-site water quality parameters (pH, DO and TDS) and ions concentrations (HCO_3, Na, Ca. Mg, Cl, NO_3, SO_4). The developed equations can be utilized for prediction of the mentioned constituents in order to have firsthand information on water quality before detailed laboratory analysis. This will encourage monitoring of groundwater quality within Benin City. The on-site parameters (pH, TDS, and DO) of the water sample for a particular location must be determined first before using the predicting equations.

Recommendation

Awareness programs and enlightenment should be continuously done to educate the people. Government and stake holders should make funds available for more research and enact laws that will improve groundwater quality for human health.

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