CHEMICAL PREDICTION OF GROUNDWATER QUALITY IN PARTS OF OWERRI IMO STATE IN SOUTH EASTERN NIGERIA

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ABSTRACT: *The Chemical prediction of groundwater quality in parts of Owerri in Imo State was carried out. The chemical parameters of groundwater samples from Nekede, Ihiagwa, Eziobodo, Obinze and Avu were subjected to chemical analysis using standard laboratory techniques . In the study, an equation was formulated that will predict the chemical concentrations of contaminants of the groundwater aquifer at any given distance in Owerri in Imo State. A total of three replicates of fifteen different borehole water samples were collected based on distances from closest potential sources of contamination. All parameters were detected up to 60m from pollution source and most of them increased in concentration during the periods, pointing to infiltrations from storm water. The results for concentration of Mn, Zn, Mg, and Hardness decreased as distance increases while further increase in distance may decrease or increase the values of Cu. Results also showed that most of the boreholes were polluted and not suitable for human consumption without adequate treatment. This study accentuates the need to set standards for the siting of wells from septic tanks, abolishment of unhealthy waste disposal practices and introduction of modern techniques are recommended.*

KEYWORDS: Groundwater, Owerri West, Distance, Chemical.

INTRODUCTION

As population grows and urbanization increases, more water is required and greater demand is made on ground and surface water. The rate of urbanization in Nigeria is alarming and the major cities areas are growing at rates between 10-15% per annum (Yusuf, 2007) and thus, human activities including soil fertility remediation, indiscriminate refuse and waste disposal, and the use of septic tanks, soak-away pits and pit latrines are on the increase. Thus constant monitoring of groundwater quality is needed so as to record any alteration in the quality and outbreak of health disorders. Groundwater quality depends, to some extent, on its chemical composition (Wadie and Abduljalil, 2010) which may be modified by natural and anthropogenic sources. Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater due to waste disposal practice, especially in urban areas. Once groundwater is contaminated, its quality cannot be restored by stopping the pollutants from source (Ramakrishnaiah et al., 2009).

As groundwater has a huge potential to ensure future demand for water, it is important that human activities on the surface do not negatively affect the precious resource (Sarukkalige, 2009). Poor environmental management creates havoc on the water supply, hygiene and exacerbating public health (Okoro et al., 2009). Tay and Kortatsi (2008) emphasize on the importance of groundwater globally as a source for human consumption and changes in quality with subsequent contamination can, undoubtedly, affect human health. It has been estimated that the total volume of waste disposed off via septic tanks is approximately 800 million gallon per year, virtually all of which is disposed in the subsurface (USEPA, 1977). This makes septic tanks the leading contributor to the total volume of waste discharged directly to ground water. Assessment of water is therefore very crucial to safeguard public health and the environment (Lin *et al.*, 2010).

Climatic conditions, land use patterns, vegetative cover, topography, soil and geologic characteristics, well condition, location of potential pollution sources, and agricultural management practices can affect the transport and contamination of groundwater by bacteria (Bourne, 2001). Various factors affect the microbiological quality of groundwater. In areas where the depth to bedrock is shallow, there is little interaction with the soil and, therefore, contaminants are not effectively removed (Conboy and Goss, 2000). It is noteworthy that Individual houses in Owerr west, are closely parked together in an in orderly fashion with high number of inhabitants. Refuse dumps, pit latrines and open sewers are common. Environmental sanitation is almost nil. All these suggest possible chances of pollutants and contaminants entering these wells. Improving the quality of groundwater resources offers an important economic opportunity for the gradual improvement of the quality of life (Valenzuela *et al*., 2009).

MATERIALS AND METHODS

Study area

Samples were collected from the Nekede, Ihiagwa,Eziobodo, Obinze and Avu in the Owerri west Local Government Area of Imo state, Nigeria. Owerri west which is located on latitude 5^{o}34 and 5 ^{o}34’ N and longitude 6 ^{o}52’ and 7^{o}05’E. is largely occupied by students and staff of the Federal University of Technology and Federal Polytechnic Nekede as well as other Inhabitants.

Sample collection

Forty five groundwater samples with replicates were collected from boreholes for chemical analysis. . Three samples each were collected from each borhole after which they were transported to the laboratory for chemical analysis. The bottles were labeled with masking tapes and the identification details were written on them according to sampling location as shown in Table 2.1. The Distance from the borehole to a potential source of contamination which includes landfills, septic tank (sewers) and pit toilet (latrines) was measured with a standard meter rule and recorded. **Table 2.1**. Selected location areas within Owerri West L.G.A and their distances from sources of contamination.

Ward	Area	Sample	Depth to static water level (m)	Distance From closest potential Sources contamination (meters)	NAFDAC	Closest contamination source
					30m	Septic tank
A	Nekede	W_1 W_2 W_3	47	3.0 12.6 14.9		Septic tank Septic tank Septic tank
B	Eziobodo	W_4 W_5 W_6	46	11.0 30.2 20.5		Septic tank Landfill Open site
C	Ihiagwa	W_7 W_8 W_9	47	26.4 13.6 13.9		Pit latrine Septic tank Septic tank
D	Obinze	W_{10} W_{11} W_{12}	46	48.6 13.3 60.4		Septic tank Septic Septic tank
E	Avu	W_{13} W_{14} W_{15}	46	50.4 61.3 13.4		Septic tank Pit latrine Pit latrine

Test for Chemical Parameters

The samples were analyzed for the following chemical parameters: Zinc (Zn), Manganese (Mn), Magnessiun (Mg), Hardness and copper (Cu), according to the procedures described by APHA (2005).

2.3 Quadratic Regression Model

The quadratic regression model was used to predict the chemical parameters with respect to the distances from the source of contamination.

Considering a polynomial of the form

$$Y = a_o - a_1 x + a_2 + x^2 \qquad (2.1)$$

where x= distance from the borehole to a potential source of contamination

Y= experimental value obtained from the laboratory

The sum of squared deviations of the observed values of y from the predicted values is given by

$$S = \Sigma(y - a_o - a_1 x - a_2 x^2)^2 \qquad (2.2)$$

Minimizing Eq 3.2 by setting its partial derivatives with respect to a_o, a_1, a_2 equal to zero, we have

$$\left.\begin{aligned} \Sigma y &= a_o n + a_1 \Sigma x + a_2 \Sigma x^2 \\ \Sigma Xy &= a_o \Sigma x + a_1 \Sigma x^2 + a_2 \Sigma x^3 \\ \Sigma x^2 y &= a_o \Sigma x^2 + a_1 \Sigma x^3 + a_2 \Sigma x^4 \end{aligned}\right\} \qquad (2.3)$$

Data analysis

Descriptive statistics (means and standard deviations) were used to interpret the raw data on the chemical parameters using SPSS Version 17.0 software.

RESULTS AND DISCUSSION

The predicted equations and values of chemical parameters of the water samples obtained from Boreholes in parts of Owerri West are presented in Table 3 to Table 3.5. Also the graph of predicted parameters are shown from Fig1.to Fig.5.

Figure 1.0 is a graph showing copper values against measured distances sources of contamination. Copper value of 0.055mg/L was observed at a distance close to 3m and copper value of 0.038mg/L was recorded at a distance of 60m.

This indicates that siting a borehole at distances above 60m would be beneficial to the locality in terms of reduced copper contamination. However, the graph has also shown that further increase in distances may not necessarily decrease or increase the values of copper occurence in sources of water supply.

Figure 2.0 shows the graph of manganese (Mn) against measured distances from sources of contamination. The graph is parabolic in shape, which has an observed Mn value of -0.013mg/L at a distance of 3m, and a Mn maximum value of 0.025mg/L at a further distance of 48m which gradually decreases to 0.022mg/L at a distance of 60 m. Further away distances from the source of contamination at the distance of 48m, the borehole water source could still be sited because of the decrease of Mn presence in the water source.

Figure 3.0 is a parabolic graphical representation of zinc against measured distances from sources of contamination. The zinc values starts to increase from 0.4mg/L at distance of 3 metres. At distance of 35m, the Zn values recorded the maximum value of 1.64mg/L. After this distance, the Zn values decreased with distances from the source of contamination. Therefore, drilling of borehole at about 61m from any source of contamination would be appropriate for location of water supply system.

Fig. 4.0 is a parabolic graphical representation of magnesium (Mg) against measured distances from sources of contamination. A maximum Mg value of 10.4 mg/L was recorded at a distance of 35m. Mg values start to increase at 4.32mg/L at a distance of 3m and later decreased to 6.98mg/L at a distance of 60.2m. Further away distances from (about 35m) of the source of contamination will be beneficial in the siting of borehole water supply system since there is decrease of Mg presence in water source.

Fig 5.0 shows a parabolic representation of hardness against measured distances from the sources of contamination. An increase in hardness values (32.6mg/L) was recorded at a distance of 3m which later decreased in value to 34.1mg/L at a distance of 61.3m. Hardness values showed a maximum value of 34.2mg/L at a distance of 50.4m. So Therefore, further away distances (50.4m) from source of contamination showed a decrease in hardness values. It is therefore advisable to site a borehole water supply source from distances of 50.4m.

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Table 3.0: The various chemical Parameters, Equation of Curves and Regression Parameters

Parameters	**Model Equation curves for Determination of distances**	**Regression parameters**
Cu(mg/L)	$Y_{Cu} = e - 0.6x^2 – 0.000x + 0.056$	GF =-0.998 CC =-0.999
Mn (mg/L)	$Y_{Mn} = -2e - 05x^3 + 0.001x – 0.09$	GF = 0.909 CC = 0.953
Zn(mg/L)	$Y_{Zn} = 0.001x^2 + 0.086x + 0.180$	GF = 0.135 CC = 0.367
Mg (mg/L)	$Y_{Mn} = 0.00x^2 – 0.032x + 6.456$	GF = 0.338 CC = 0.581
Hardness (mg/L)	$Y_{Hardness} = -0.000x^2 + 0.070x + 32.43$	GF = 0.931 CC = 0.965

Regression parameter:
GF = Goodness of fit   CC = correlation coefficient, e = starndard error.

Table 3.1: Values of Copper with measured distances from all sources of contamination

Distance (X)	$(CU_e)y$	X^2	X^3	X^4	Xy	X^2y	$Cu_p = a_0 + a_1x + a_2x^2$
3	0	9	27	81	0	0	0.05518
12.6	0	158.76	2000.376	25204.74	0	0	0.0519
14.9	0.3	222.01	3307.949	49288.44	4.47	66.603	0.051147
11	0.02	121	1331	14641	0.22	2.42	0.052432
30.2	0	912.04	27543.61	831817	0	0	0.046453
20.5	0.02	420.25	8615.125	176610.1	0.41	8.405	0.049365
26.4	0.02	696.96	18399.74	485753.2	0.528	13.9392	0.047567
13.6	0.04	184.96	2515.456	34210.2	0.544	7.3984	0.051571
13.9	0	193.21	2685.619	37330.1	0	0	0.051473
48.6	0	2361.96	114791.3	5578855	0	0	0.04154
13.3	0.08	176.89	2352.637	31290.07	1.064	14.1512	0.05167
60.4	0.06	3648.16	220348.9	13309071	3.624	218.8896	0.03881
50.4	0.06	2540.16	128024.1	6452413	3.024	152.4096	0.041102
61.3	0.04	3757.69	230346.4	14120234	2.452	150.3076	0.038615
13.4	0.08	179.56	2406.104	32241.79	1.072	14.3648	0.051637
Σ393.5	Σ0.72	Σ15582.61	Σ764695.2	Σ41179041	Σ17.408	Σ648.8884	

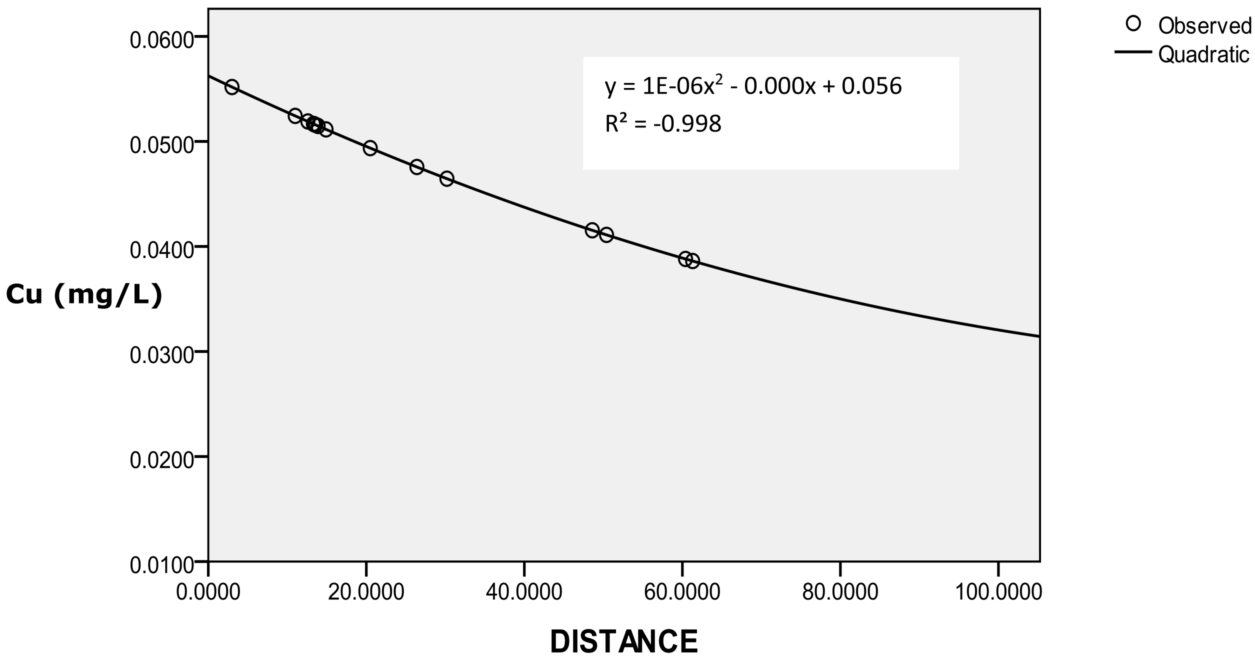

Table 3.2: Values of manganese with measured distances from all sources of contamination

Distance (X)	$(Mn_e)y$	X^2	X^3	X^4	XY	X^2y	$Mn_p = a_0 + a_1x + a_2x^2$
3	0	9	27	81	0	0	-0.01379
12.6	0	158.76	2000.376	25204.74	0	0	0.000944
14.9	0	222.01	3307.949	49288.44	0	0	0.003954
11	0.01	121	1331	14641	0.11	1.21	-0.00127
30.2	0	912.04	27543.61	831817	0	0	0.018857
20.5	0	420.25	8615.125	176610.1	0	0	0.010441
26.4	0	696.96	18399.74	485753.2	0	0	0.015986
13.6	0	184.96	2515.456	34210.2	0	0	0.002277
13.9	0	193.21	2685.619	37330.1	0	0	0.00267
48.6	0.1	2361.96	114791.3	5578855	4.86	236.196	0.024999
13.3	0	176.89	2352.637	31290.07	0	0	0.001881
60.4	0	3648.16	220348.9	13309071	0	0	0.022167
50.4	0.02	2540.16	128024.1	6452413	1.008	50.8032	0.024909
61.3	0.01	3757.69	230346.4	14120234	0.613	37.5769	0.021734
13.4	0	179.56	2406.104	32241.79	0	0	0.002014
Σ393.5	Σ0.14	Σ15582.61	Σ764695.2	Σ41179041	Σ6.591	Σ325.7861	

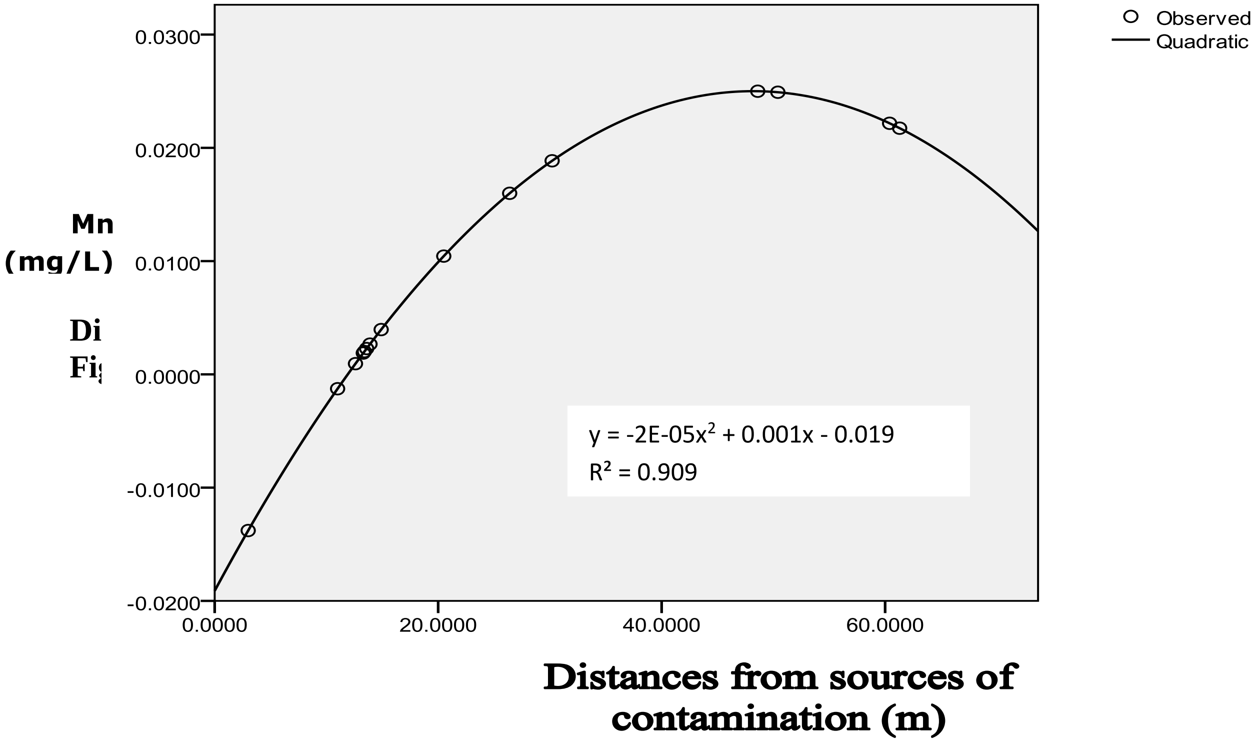

Table 3.3: Values of Zinc with measured distances from all sources of contamination

Distance (X)	$(Zn_e)y$	X^2	X^3	X^4	Xy	X^2y	$Zn_p = a_0 + a_1x + a_2x^2$
3	0.8	9	27	81	2.4	7.2	0.429375
12.6	1.2	158.76	2000.376	25204.74	15.12	190.512	1.075618
14.9	1.6	222.01	3307.949	49288.44	23.84	355.216	1.196235
11	0.4	121	1331	14641	4.4	48.4	0.983911
30.2	2.2	912.04	27543.61	831817	66.44	2006.488	1.661997
20.5	1.8	420.25	8615.125	176610.1	36.9	756.45	1.43461
26.4	0.6	696.96	18399.74	485753.2	15.84	418.176	1.600943
13.6	0.8	184.96	2515.456	34210.2	10.88	147.968	1.129685
13.9	1.2	193.21	2685.619	37330.1	16.68	231.852	1.145418
48.6	2	2361.96	114791.3	5578855	97.2	4723.92	1.44703
13.3	1.3	176.89	2352.637	31290.07	17.29	229.957	1.113728
60.4	0.6	3648.16	220348.9	13309071	36.24	2188.896	0.863721
50.4	1.3	2540.16	128024.1	6452413	65.52	3302.208	1.380551
61.3	0.8	3757.69	230346.4	14120234	49.04	3006.152	0.804944
13.4	0.8	179.56	2406.104	32241.79	10.72	143.648	1.119072
Σ393.5	Σ17.4	Σ15582.61	Σ764695.2	Σ41179041	Σ468.51	Σ17757.04	

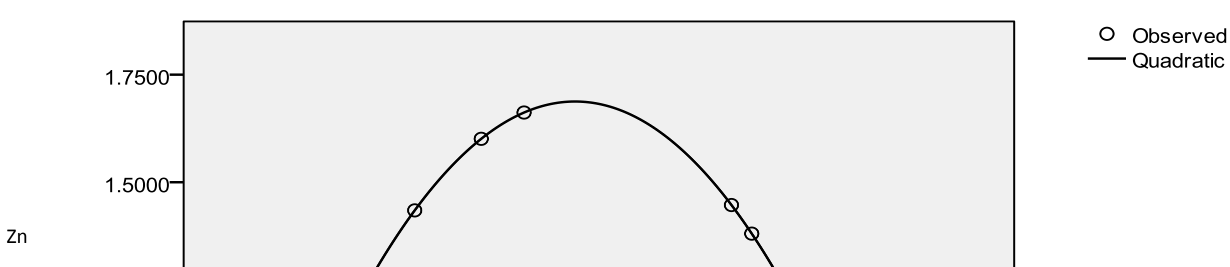

Fig. 3 Graph of Zinc against measured distances

Table 3.4: Values of magnesium with measured distances from all sources of contamination

Distance (X)	$(Mg_e)y$	X^2	X^3	X^4	Xy	X^2y	$Mg_p = a_0 + a_1x + a_2x^2$
3	2.1	9	27	81	6.3	18.9	4.321933
12.6	13.6	158.76	2000.376	25204.74	171.36	2159.136	7.434829
14.9	4	222.01	3307.949	49288.44	59.6	888.04	8.024344
11	6.1	121	1331	14641	67.1	738.1	6.989101
30.2	6.7	912.04	27543.61	831817	202.34	6110.668	10.40831
20.5	6	420.25	8615.125	176610.1	123	2521.5	9.207076
26.4	12.7	696.96	18399.74	485753.2	335.28	8851.392	10.06574
13.6	11.3	184.96	2515.456	34210.2	153.68	2090.048	7.698563
13.9	10.7	193.21	2685.619	37330.1	148.73	2067.347	7.775456
48.6	10.7	2361.96	114791.3	5578855	520.02	25272.97	9.734653
13.3	7.3	176.89	2352.637	31290.07	97.09	1291.297	7.620642
60.4	5.1	3648.16	220348.9	13309071	308.04	18605.62	7.267816
50.4	10.2	2540.16	128024.1	6452413	514.08	25909.63	9.461136
61.3	8.6	3757.69	230346.4	14120234	527.18	32316.13	7.014402
13.4	5.6	179.56	2406.104	32241.79	75.04	1005.536	7.64673
Σ393.5	Σ120.7	Σ15582.61	Σ764695.2	Σ41179041	Σ3308.84	Σ129846.3	

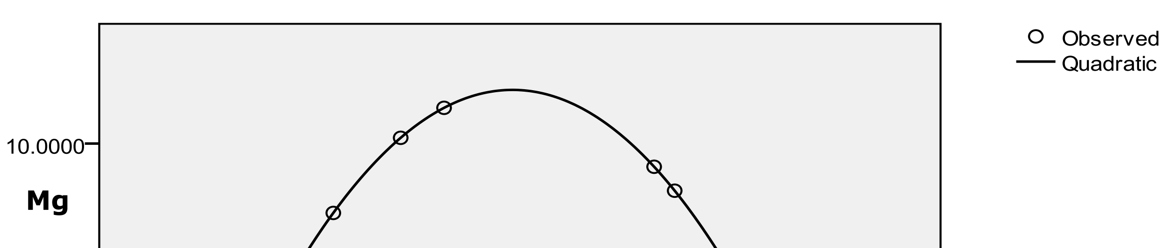

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Fig. 4 Graph of Magnesium against measured distance

Table 3.5: Values of Hardness with measured distances from all sources of contamination

Distance (X)	(Hardness) Y	X^2	X^3	X^4	Xy	X^2y	$Hardness_p = a_0 + a_1x + a_2x^2$
3	38.3	9	27	81	114.9	344.7	32.64422
12.6	36.2	158.76	2000.376	25204.74	456.12	5747.112	33.21997
14.9	22.4	222.01	3307.949	49288.44	333.76	4973.024	33.33875
11	31	121	1331	14641	341	3751	33.13297
30.2	38	912.04	27543.61	831817	1147.6	34657.52	33.94041
20.5	36	420.25	8615.125	176610.1	738	15129	33.59699
26.4	29.1	696.96	18399.74	485753.2	768.24	20281.54	33.82157
13.6	33.4	184.96	2515.456	34210.2	454.24	6177.664	33.27253
13.9	36.8	193.21	2685.619	37330.1	511.52	7110.128	33.28802
48.6	44.3	2361.96	114791.3	5578855	2152.98	104634.8	34.22992
13.3	36.2	176.89	2352.637	31290.07	481.46	6403.418	33.25691
60.4	36.4	3648.16	220348.9	13309071	2198.56	132793	34.16613
50.4	31	2540.16	128024.1	6452413	1562.4	78744.96	34.23279
61.3	28	3757.69	230346.4	14120234	1716.4	105215.3	34.15326
13.4	26.4	179.56	2406.104	32241.79	353.76	4740.384	33.26213
Σ393.5	Σ503.5	Σ15582.61	Σ764695.2	Σ41179041	Σ13330.94	Σ530703.6	

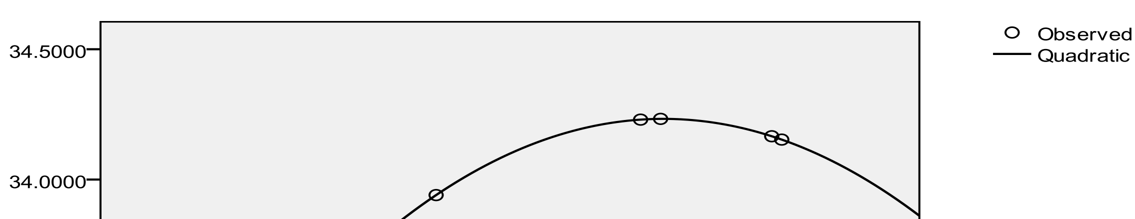

Fig 4.11: Graph of Hardness against measured distances

Fig 5: Graph of Hardness against measured distances

CONCLUSION AND RECOMMENDATIONS

The chemical prediction of groundwater quality in parts of Owerri was evaluated using standard laboratory techniques for testing chemical parameters was moderately high. Based on the result obtained from the regression model in the areas, the following conclusion can be made. The quadratic regression model gives a goodness of fit and correlation coefficient in most of the predicted parameters. The predicted parameters give best fit curves to regretted data this is evident from the very high positive values of goodness of fit of the curve as stated in Table 3. Most of the graph of Predicted parameters increased with increase in distance from the borehole well source. As a preventive measure to reduce the concentrations as contained in the ground water in the areas, the practice of pit latrines should be abolished, followed by the construction of cheap but efficient ecological sanitary system in rural areas where these practices still find use. There is need for proper treatment of water before consumption. Also, general upgrade of the waste disposal units and overall land use activities to modern best practices is highly recommended to guarantee the integrity of the groundwater quality in these areas.

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