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Physicochemical Analysis of Groundwater Quality In Owerri Municipal, Imo State, Nigeria Using MATLAB and ANN Models.

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ABSTRACT

The physicochemical analysis of groundwater quality in Owerri Municipal council, Imo state, Nigeria was carried out. Fifteen water samples were randomly selected from the five villages that make up Owerri municipal council were anlayzed for physicochemical parameters using standard methods. The results from the study area showed that the temperature ranged between 26.5-28.0^{o}C; pH ranged between 4.80-5.32. Electrical conductivity ranged between

77-166 μS/cm. The total dissolved solids were between 35.4-168.4mg/l; total suspended solids ranged between 4-5mg/l and alkalinity ranged between 6-10mg/l. The chloride ranged between 18.7-37.2mg/l which depicts corrosive properties of the water. The total hardness ranged between 6.0-44.4mg/l indicating soft water. Calcium hardness ranged between 3.7-38.8mg/l and magnesium hardness ranged between 2.3-5.6mg/l. Phosphate ranged between 0.18-0.40mg/l; Nitrate 18.5-114.1mg/l and Sulphate ranged between 16.1-32.7mg/l. The metallic ions like iron, lead, copper, manganese and zinc are in traces of between (0.1432-0.2166), (<0.0001-0.0711), (0.3678-1.1006), (0.01018-0.1755), (0.5716-1.3179) respectively. There is no trace of arsenic concentration. The results of the analysis carried out were compared to the World Health Organization and was found unfit for human consumption. MATLAB and ANN models were introduced using the results to ascertain the behaviour of the pollutants.

This is to protect the groundwater agricultural activities which are aimed at reducing soil acidity are recommended. This will help in increasing the pH and in reducing the corrosive nature of the groundwater. It is essential to measure and monitor the levels of nitrate pollution due to environmental and other anthropogenic imparts on periodic basis.

Keywords: Groundwater, MATLAB, ANN, Water Quality, Pollution Index

1.0 INTRODUCTION

Groundwater is the main source of water [1]. About half of the groundwater occurs within 800meters of the earth's surface and the remainder below this depth. Not all of it is usable, some for example are saline and some can be regarded as inaccessible because of the great depth at which it occurs. Groundwater is an essential natural resource for the ecosystem and living things which is utilized for drinking and irrigation purposes worldwide [2] [3].

Groundwater get polluted easily due to increased human activities and the consequences of urbanization and industrialization and has become a global issue of concern and the impurities that enter the groundwater as a result of man's socio-economic and technological activities due to urbanization and industrialization are very toxic to human especially when they exceed tolerable limits and has led to the decrease availability of good-quality water [4,5,6,7].

Water from the lakes, streams and reservoirs percolate through the soil and enter the underground water table. During its percolation the water carries along with dissolved organic and inorganic materials.

The quality of groundwater is affected by the geological condition of the soil through which it flows. During its flow, it absorbs some of the soluble gases and salts from the soil. The quality of groundwater has reduced due to pollution from domestic, agricultural, industrial effluents as well as nutrients leaching from the soil. The ease and extent at which they permeate reflect the number of leachates and effluents in the underlying groundwater [8]. More than 90% of the rural population uses groundwater for domestic purposes as a consequence of the presence of few and polluted streams in their area.

The physico-chemical analysis can be used to assess the quality of water [4,9,10].

1.1 THE STUDY AREA

Owerri municipal is inhabited by the Igbos. Owerri municipal is located on latitude $5^0 28^1$ 60.00" North and longitude $7^0 1^1$ 60.00" East. It is traditionally called Owerri Nchi-ise revealing that Owerri has five communities which are Umuoronjo, Amawom, Umuonyeche, Umuodu and Umuoyima in their order of seniority. Its mean annual rainfall of about 2250-2500mm. the mean temperature is $25\text{-}27^0$c and the relative humidity is 80%.

According to the 2006 National population census, Owerri municipal has a population of 127,213 inhabitants, 62,990 males and 64,223 females. The inhabitants are mainly traders, few farmers who are predominantly natives, artisans and civil servants. The early inhabitants made use of surface water like Nworie River and Otamiri River; tap borne water and also well water that were dug few meters from the land surface. But in recent years the inhabitants now rely mostly on groundwater popularly called borehole water for their domestic, industrial and agricultural use. The water is accessed from the aquifer by digging about 90-200feet (27-60meters), depending on the topography of the land.

The need for potable water in Owerri municipal makes it necessary to determine the amount of various substances in the groundwater and to ascertain its level and nature of contaminations. In recent years, there has been inefficient supply of tap borne water by the water board cooperation in Owerri municipal and the surface water within the environment are contaminated with urban wastes and sewage which make them unfit for human use and consumption. As a result, the borehole water systems which are drilled from groundwater are widely used as the main source of water for domestic, agricultural and industrial purposes. Most of the times, the groundwater are taken by man directly without purification and also most water factories package and bottle the water without treatment or purification. However, there is need to analyze the quality of the groundwater to ascertain the physical, chemical, and metallic ion compositions in Owerri Municipal.

2.0 MATERIALS AND METHOD

2.1 COLLECTION AND STORAGE OF SAMPLES

PROCEDURE: Fifteen water samples were collected from the five villages that make up Owerri municipal and three sampling points were randomly selected from each village. The samples were collected from the different boreholes by the use of thoroughly washed and rinsed plastic containers. Before the collection of the waters samples, the borehole taps were allowed to rinse the containers severely before collection. The samples were collected, preserved and kept for analysis. The physical parameters like temperature, pH, electrical conductivity and total dissolved solved were measured and recorded in situ.

2.2 TEMPERATURE DETERMINATION (^{O}C)

The measurement was done on the spot after the collection of the sample and the thermometer was immersed into the Can containing the water sample for five minutes to ensure a complete equilibrium. The mercury-in-glass thermometer was calibrated in degree Celsius with the standard range of 0-100^{o}C.

2.3 pH DETERMINATION

PROCEDURE: The pH meter was used for the determination of the pH of the sample and the one used was LABTECH pH meter. The pH meter was calibrated or standardized using buffer standards at pH4, pH7 and pH9. After the calibration, the electrode was rinsed with distilled water and cleaned with soft tissue paper. The electrode was then dipped into each of the water samples in turn and the respective pH readings obtained from the digital readout.

2.4 ELECTRICAL CONDUCTIVITY DETERMINATION

PROCEDURE: The conductivity meter used was HANNA EC 215 conductivity meter. The conductivity meter was calibrated with 0.01 KCl to give the expected conductivity reading of 1413µS/cm. the conductivity meter probe was rinsed with deionised water. The probe was then dipped into the water samples in turn to obtain the respective conductivity reading from the digital readout.

2.5 TOTAL DISSOLVED SOLIDS (TDS) DETERMINATION

PROCEDURE: The total dissolved solid was determined with HM Digital TDS meter 4. This was done by dipping the TDS meter probe into the water sample and obtaining the reading directly from the readout.

2.6 TOTAL SUSPENDED SOLIDS (TSS) DETERMINATION

This was done by evaporation method.

2.7 ALKALINITY DETERMINATION

PROCEDURE: 25cm^3 of the sample was pipette into a 250cm^3 conical flask and 2 drops of methyl orange indicator was added. The solution was titrated with 0.1M HCl acid until the colour changed from yellow to orange. The titre values were recorded and the total alkalinity of the water samples is calculated from the standard expression below;

Alkalinity (mg/l) = $\frac{\text{titre value x molarity x 100 x 1000}}{\text{2(Vol of sample)}}$

2.8 CHLORIDE CONTENT DETERMINATION

PROCEDURE: This was done by the Mohr’s method using potassium chromate indicator and silver nitrate as titrant [11].

2.9 TOTAL HARDNESS DETERMINATION

PROCEDURE: This was determined by titrimetric method using Erichrome black-T as indicator and EDTA as titrant [12].

2.10 CALCIUM HARDNESS DETERMINATION

PROCEDURE: This was determined by titrimetric method using solochrome Blank-T as indicator and EDTA as titrant [13].

2.11 MAGNESIUM HARDNESS DETERMINATION

PROCEDURE: Magnesium hardness was got by difference method that is subtracting calcium hardness from the total hardness.

Therefore: Magnesium hardness = Total hardness – calcium hardness.

2.12 PHOSPHATE DETERMINATION

PROCEDURE: Pipette $2cm^3$ of the clear sample solution into a test tube. Add $5cm^3$ deionised water and $2cm^3$ of ammonium molybdate solution. Mix content properly and add $1cm^3$ of stannous chloride dilute solution and mix again. After 5minutes but not later than 20mins, measure the absorbance on the spectrophotometer at 660nm wavelength. Prepare a standard curve within the range of 0-5 ppm (mg p/l) containing the same concentration of reagents as the sample solution. Plot the absorbance of standard solution against the mg/l or ppm and calculate the phosphate content of your sample.

2.13 DETERMINATION OF NITRATE AND SULPHATE

These were done using the u-visible spectrophotometer of model DR 2000. These were determined using the Hatch corporation method. Sulphate was determined using sulfaver 4 sulphate, while nitrate was determined using the nitraver 5 nitrate, [14, 15, 16].

2.14 METALLIC ION DETERMINATION

PROCEDURE: The metallic ions Fe, Pb, As, Cu, Mn and Zn were detected using the atomic absorption spectrophotometer Unican solar 969 model. The stock solutions from which working standards were prepared by serial dilution as reported by Technical Bulletin [17] using various cathode tubes specific for each element determined.

2.15 POLLUTION INDEX

This was determined using methods developed by Horton [18]. The overall pollution index is computed using the equation:

$$Pij = \sqrt{\frac{(\max Ci/Lij)^2 + (\text{mean } Ci/Lij)^2}{2}}$$

Where

Pij = Pollution Index = f{C_1/L_{1j}, C_2/L_{2j}, C_3/L_{3j},..., C_i/L_{ij},}

C_i = concentration of each parameter

L_{ij} = WHO Specification for each parameter

I = the number of ith item of the water quality

J = the number of C_1/L_{1j} shows the relative pollution contributed by the single item

$$\frac{\sqrt{(5.514)^2 - (0.324)^2}}{2}$$

$$= \frac{\sqrt{30.404196 + 0.104976}}{2}$$

$$= \frac{\sqrt{30.509172}}{2}$$

= 15.254586

Table 1- 7 below gives the summary of the various values of the parameters obtained in the study.

Figures 1- 19 below shows the Matlab Models Of The Underground Water Parameters

Figures 20- 38 below shows the Ann Models Of The Underground Water Parameters

Figures 39- 57 below shows the Comparative Plots Of Ann Model And Actual Data Of The Underground Water Parameters

3.0 RESULTS

TABLE : 1 RESULT OF ANALYSIS PERFORMED ON GROUNDWATER IN AMAWOM VILLAGE.

PARAMETER	1	2	3	MEAN	WHO
Temperature (^{O}C)	26.5	26.6	26.4	26.5	25
pH	5.34	5.30	5.32	5.32	6.5-8.5
Conductivity (µS/cm)	75	78	78	77	1400
Total dissolved solids (mg/l)	35.4	35.4	35.4	35.4	1000
Total suspended solids(mg/l)	5	5	5	5	
Alkalinity (mg/l)	10	9	11	10	100
Chloride (mg/l)	18.86	18.6	18.6	18.7	250
Total hardness (mg/l)	6.1	5.9	6.0	6	500
Calcium hardness (mg/l)	3.7	3.6	3.8	3.7	70
Magnesium hardness (mg/l)	2.4	2.2	2.3	2.3	70
Phosphate (mg/l)	0.40	0.42	0.38	0.4	0.1
Nitrate (mg/l)	18.3	18.6	18.6	18.5	45
Sulphate (mg/l)	26.0	26.2	26.1	26.1	400
Iron (mg/l)	0.1709	0.1707	0.1710	0.1709	0.3
Lead (mg/l)	< 0.0001	<0.0001	<0.0001	<0.0001	0.05
Arsenic (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Copper (mg/l)	0.5411	0.5412	0.5410	0.5411	1.0
Manganese (mg/l)	0.01019	0.01017	0.01018	0.01018	0.05
Zinc (mg/l)	0.5864	0.5864	0.5864	0.5864	0.1

TABLE 2: RESULT OF ANALYSIS PERFORMED ON GROUNDWATER IN UMUORORONJO VILLAGE.

PARAMETER	1	2	3	MEAN	WHO
Temperature (^{O}C)	28.0	28.0	28.0	28	25
pH	5.16	5.20	5.13	5.16	6.5-8.5
Conductivity (μS/cm)	145	144	146	145	1400
Total dissolved solids (mg/l)	66.6	66.8	66.7	66.7	1000
Total suspended solids(mg/l)	5	5	5	5	
Alkalinity (mg/l)	10	10	10	10	100
Chloride (mg/l)	20.0	20.2	20.4	20.2	250
Total hardness (mg/l)	12.5	12.3	12.4	12.4	500
Calcium hardness (mg/l)	9.0	9.3	9.3	9.2	70
Magnesium hardness (mg/l)	3.0	3.3	3.3	3.2	70
Phosphate (mg/l)	0.35	0.36	0.39	0.37	0.1
Nitrate (mg/l)	49.3	49.1	49.5	49.3	45
Sulphate (mg/l)	32.6	32.8	32.7	32.7	400
Iron (mg/l)	0.1873	0.1872	0.1871	0.1872	0.3
Lead (mg/l)	0.0209	0.0209	0.0209	0.0209	0.05
Arsenic (mg/l)	<0.0001	<0.0001	<0.00001	<0.0001	0.05
Copper (mg/l)	0.6585	0.6584	0.6583	0.6584	1.0
Manganese (mg/l)	0.1055	0.1057	0.1055	0.1056	0.05
Zinc (mg/l)	0.8620	08621	0.8619	0.8620	0.1

TABLE 3: RESULT OF ANALYSIS PERFORMED ON GROUNDWATER IN UMUODU VILLAGE.

PARAMETER	**1**	**2**	**3**	**MEAN**	**WHO**
Temperature (^{O}C)	27.0	27.1	26.9	27	25
pH	4.88	4.93	4.86	4.89	6.5-8.5
Conductivity (µS/cm)	368	364	365	366	1400
Total dissolved solids(mg/l)	168.3	168.4	168.5	168.4	1000
Total suspended solids (mg/l)	4	4	4	4	
Alkalinity (mg/l)	6	6	6	6	100
Chloride (mg/l)	37.0	37.1	37.5	37.2	250
Total hardness (mg/l)	44.4	44.5	44.3	44.4	500
Calcium hardness(mg/l)	38.8	38.7	38.9	38.8	70
Magnesium hardness(mg/l)	5.8	5.5	5.6	5.6	70
Phosphate (mg/l)	0.19	0.18	0.17	0.18	0.1
Nitrate (mg/l)	106.4	106.2	106.3	106.3	45
Sulphate (mg/l)	16.3	16.1	16.0	16.1	400
Iron (mg/l)	0.1432	0.1432	0.1432	0.1432	0.3
Lead (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Arsenic (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Copper (mg/l)	0.3677	0.3678	0.3679	0.3678	1.0
Manganese (mg/l)	0.0832	0.0832	0.0832	0.0832	0.05
Zinc (mg/l)	0.5716	0.5717	0.5715	0.5716	0.1

TABLE 4: RESULT OF ANALYSIS PERFORMED ON GROUNDWATER IN UMUOYIMA VILLAGE.

PARAMETER	1	2	3	MEAN	WHO
Temperature (^{O}C)	27.0	27.1	26.9	27	25
pH	4.88	4.93	4.86	4.89	6.5-8.5
Conductivity (µS/cm)	368	364	365	366	1400
Total dissolved solids (mg/l)	168.3	168.4	168.5	168.4	1000
Total suspended solids (mg/l)	4	4	4	4	
Alkalinity (mg/l)	6	6	6	6	100
Chloride (mg/l)	37.0	37.1	37.5	37.2	250
Total hardness (mg/l)	44.4	44.5	44.3	44.4	500
Calcium hardness (mg/l)	38.8	38.7	38.9	38.8	70
Magnesium hardness (mg/l)	5.8	5.5	5.6	5.6	70
Phosphate (mg/l)	0.19	0.18	0.17	0.18	0.1
Nitrate (mg/l)	106.4	106.2	106.3	106.3	45
Sulphate (mg/l)	16.3	16.1	16.0	16.1	400
Iron (mg/l)	0.1432	0.1432	0.1432	0.1432	0.3
Lead (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Arsenic (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Copper (mg/l)	0.3677	0.3678	0.3679	0.3678	1.0
Manganese (mg/l)	0.0832	0.0832	0.0832	0.0832	0.05
Zinc (mg/l)	0.5716	0.5717	0.5715	0.5716	0.1

TABLE 5: RESULT OF ANALYSIS PERFORMED ON GROUNDWATER IN UMUONYECHE VILLAGE.

PARAMETER	**1**	**2**	**3**	**MEAN**	**WHO**
Temperature (^{O}C)	28.1	27.9	28.0	28.0	25
pH	4.83	4.78	4.79	4.80	6.5-8.5
Conductivity (µS/cm)	328	324	326	326	1400
Total dissolved solids (mg/l)	150.0	150.3	149.8	150.0	1000
Total suspended solids(mg/l)	5	5	5	5	
Alkalinity (mg/l)	7	9	8	8	100
Chloride (mg/l)	30.9	31.2	31.4	31.2	250
Total hardness (mg/l)	39.0	39.4	39.2	39.2	500
Calcium hardness (mg/l)	34.9	34.6	34.9	34.8	70
Magnesium hardness (mg/l)	4.5	4.3	4.4	4.4	70
Phosphate (mg/l)	0.31	0.33	0.32	0.32	0.1
Nitrate (mg/l)	114.2	114.0	114.1	114.1	45
Sulphate (mg/l)	22.9	21.2	21.0	21.0	400
Iron (mg/l)	0.2003	0.2002	0.2004	0.2003	0.3
Lead (mg/l)	0.0541	0.0542	0.0540	0.0541	0.05
Arsenic (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	0.05
Copper (mg/l)	1.0777	1.0778	1.0779	1.0778	1.0
Manganese (mg/l)	0.1292	0.1290	0,1294	0.1292	0.05
Zinc (mg/l)	0.9750	0.9750	0.9750	0.9750	0.1

Table 6: AVERAGE CONCENTRATION OF PHYSIOCHEMICAL PARAMETERS DETERMINED ON GROUNDWATER IN OWERRI MUNICIPAL IMO STATE

PARAMETER	AMAWOM	UMUORORONJO	UMUODU	UMUOYIMA	UMUONYECHE	RANGE	MEAN ± SD	STD DEVIATION	WHO
Temperature (^{O}C)	26.5	28.0	27.0	27.5	28.0	26.5-28.0	27.4 ±0.29	0.652	25
pH	5.32	5.16	4.89	5.05	4.80	4.80-5.32	5.04 ±0.09	**0.208**	**6.5-8.5**
Conductivity (µS/cm)	77	145	166	135	126	77-166	129.8 ±14.8	**33.056**	**1400**
Total dissolved solids (mg/l)	35.4	66.7	168.4	108.1	150.0	35.4-168.4	105.7 ±24.7	**55.594**	**1000**
Total suspended solids (mg/l)	5	5	4	5	5	4-5	4.8 ±0.2	**0.447**	
Alkalinity (mg/l)	10	10	6	8	8	6-10	8.4 ±0.75	**1.673**	**100**
Chloride (mg/l)	18.7	20.2	37.2	25.8	31.2	18.7-37.2	26.6 ±3.45	**7.7059**	**250**
Total hardness (mg/l)	6.0	12.4	44.4	27.4	39.2	6.0-44.4	25.9 ±7.41	**16.580**	**500**
Calcium hardness(mg/l)	3.7	9.2	38.8	23.0	34.8	3.7-38.8	21.9 ±6.9	**15.377**	**70**

Magnesium hardness (mg/l)	2.3	3.2	5.6	4.4	4.4	2.3-5.6	3.98 ±0.57	**1.266**	**70**
Phosphate (mg/l)	0.40	0.37	0.18	0.36	0.32	0.18-0.40	0.33 ±0.04	**0.086**	**0.1**
Nitrate (mg/l)	18.5	49.3	106.3	64.7	114.1	18.5-114.1	70.6 ±17.5	**39.905**	**45**
Sulphate (mg/l)	26.1	32.7	16.1	20.7	21.0	16.1-32.7	23.3 ±2.8	**6.326**	**400**
Iron (mg/l)	0.1709	0.1872	0.1432	0.2166	0.2003	0.1432-0.2166	0.1836 ±0.01	**0.028**	**0.3**
Lead (mg/l)	<0.0001	0.0209	<0.0001	0.0711	0.0541	<0.0001-0.0711	0.02926 ± 0.01	**0.026**	**0.05**
Arsenic (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		**0.05**
Copper (mg/l)	0.5411	0.6584	0.3678	1.1006	1.0778	0.3678-1.1006	0.74914 ±0.15	**0.327**	**1.0**
Manganese (mg/l)	0.01018	0.1056	0.0832	0.1755	0.1292	0.01018-0.1755	0.10074 ±0.03	**0.061**	**0.05**
Zinc (mg/l)	0.5864	0.8620	0.5716	1.3179	0.9750	0.5716-1.3179	0.86258 ±0.14	**0.309**	**0.1**

TABLE 7: COMPUTATION OF POLLUTION INDEX OF THE GROUNDWATER OF OWERRI MUNICIPAL, IMO STATE

PARAMETER	**QUANTITY C*i***	**PERMISSIBLE LEVEL, (WHO) *Lij***	**C*i*/L*ij***
Temperature (^{O}C)	2 7.4	25	1.096
pH	5.04	8.5	0.593
Conductivity (µS/cm)	129.8	1400	0.093
Total dissolved solids (mg/l)	105.7	1000	0.106
Total suspended solids(mg/l)	4.8	-	-
Alkalinity (mg/l)	8.4	50	0.168
Chloride (mg/l)	26.6	250	0.1064
Total hardness (mg/l)	25.9	500	0.052
Calcium hardness (mg/l)	21.9	500	0.044
Magnesium hardness (mg/l)	3.98	70	0.057
Phosphate (mg/l)	0.33	250	0.0013
Nitrate (mg/l)	70.6	45	1.569
Sulphate (mg/l)	23.3	250	0.093
Iron (mg/l)	0.1836	0.3	0.612
Lead (mg/l)	0.0487	0.05	0.974
Arsenic (mg/l)	-	0.5	-
Copper (mg/l)	0.7491	1.5	0.4994
Manganese (mg/l)	0.1007	0.05	2.015
Zinc (mg/l)	0.8626	1.5	0.575
Total ∑(**C***i*/L*ij*)			5.514
Mean∑(**C***i*/L*ij*)/n			0.324

MATLAB MODELS OF THE UNDERGROUND WATER PARAMETERS

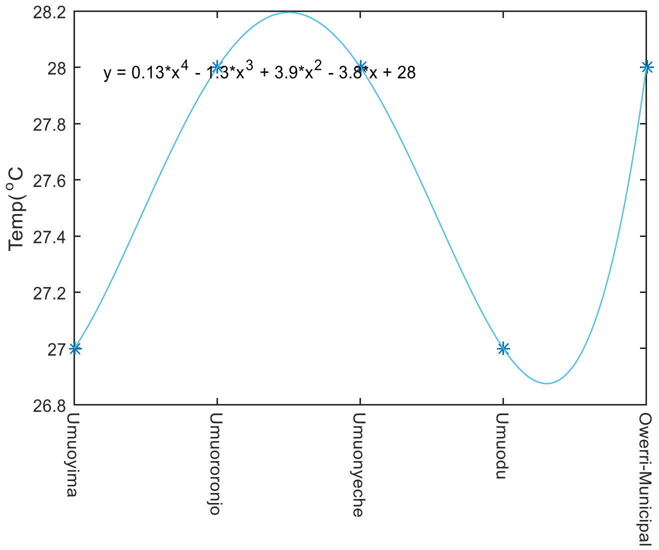


Fig 1.

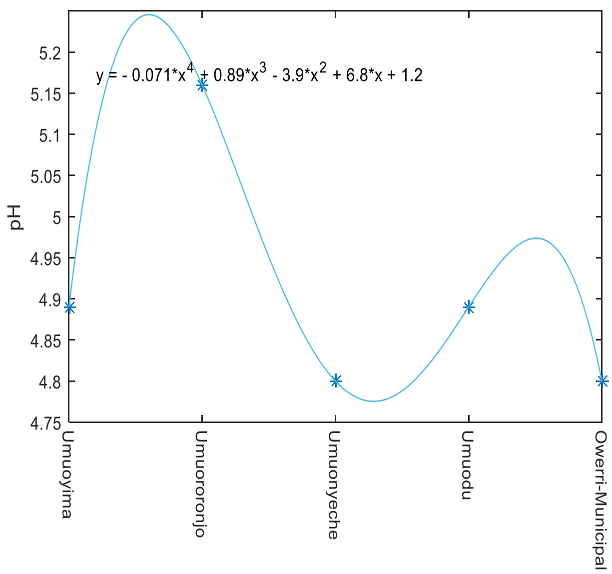


Fig2

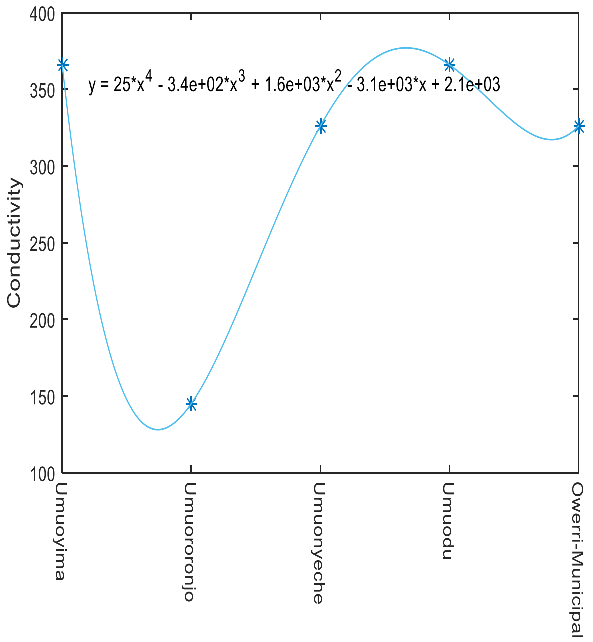


Fig 3.

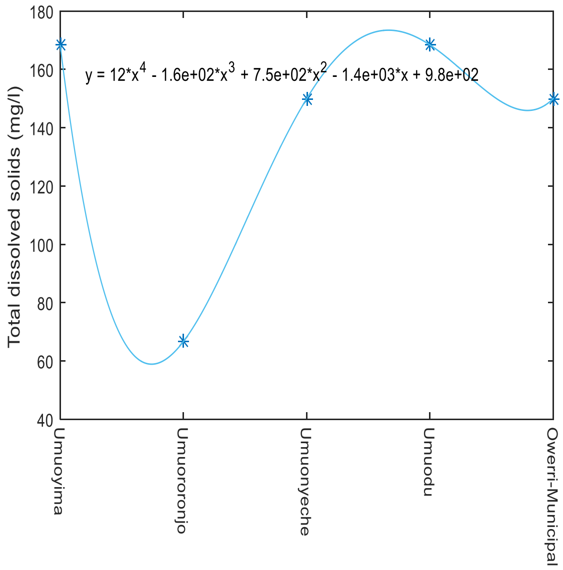
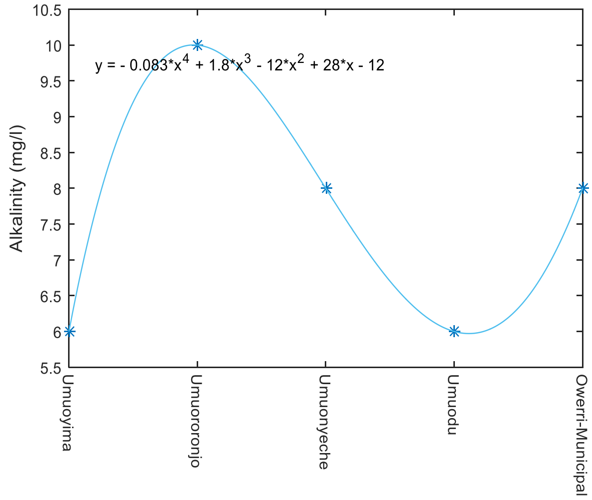


Fig 4.



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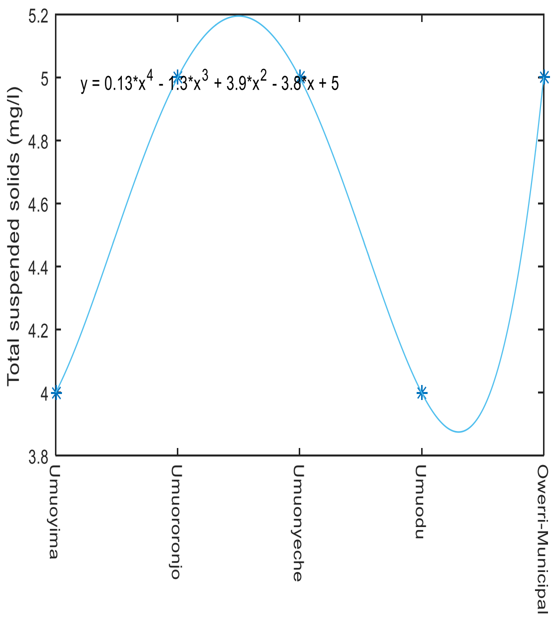

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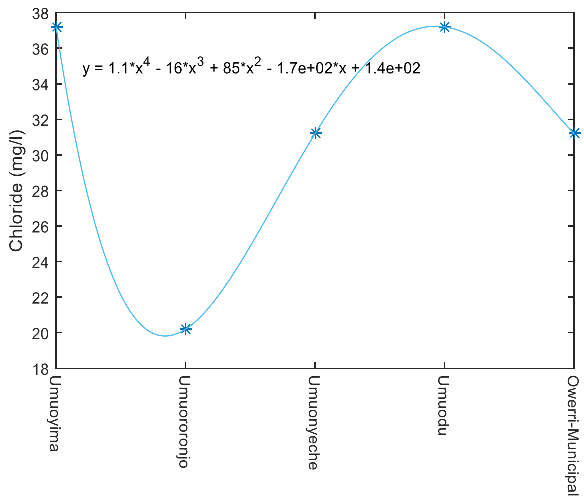

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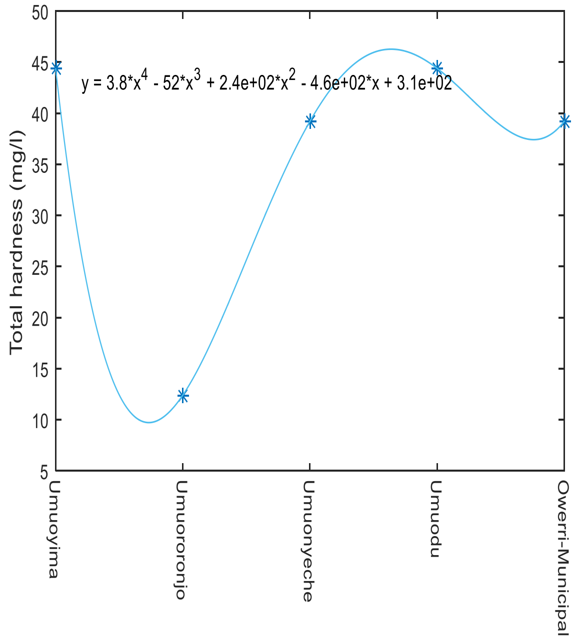

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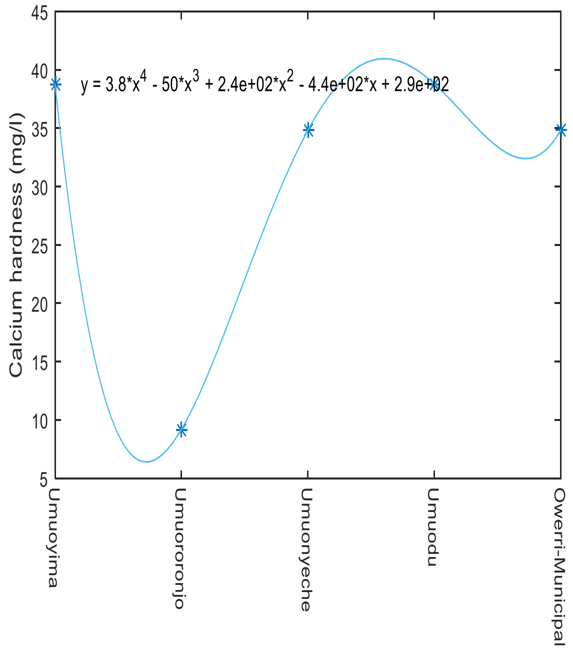

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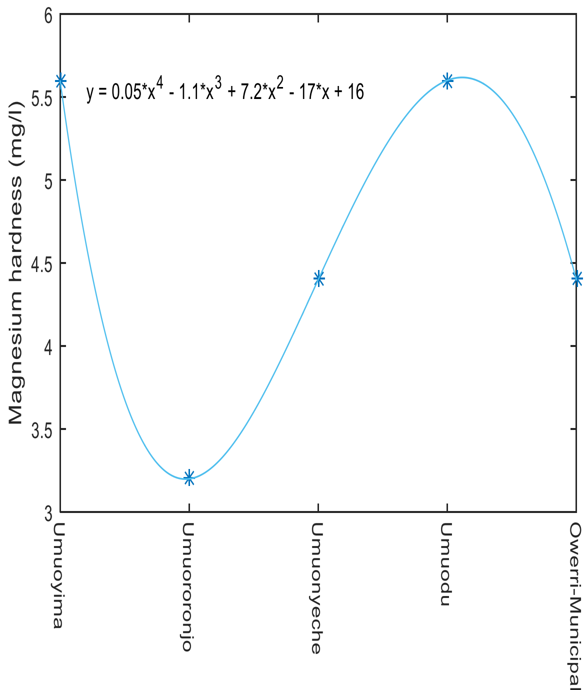
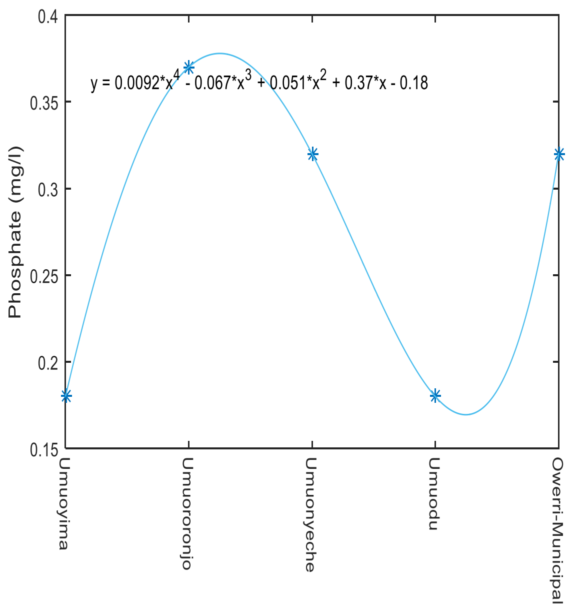
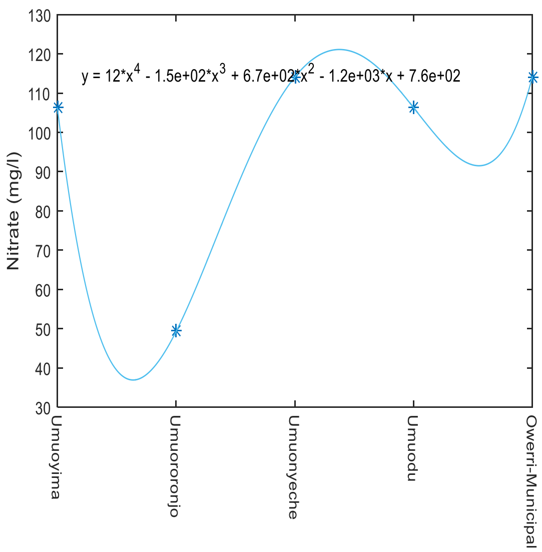


Fig 10.



y = 0.0092*x^4 - 0.067*x^3 + 0.051*x^2 + 0.37*x - 0.18
Phosphate (mg/l)
0.4
0.35
0.3
0.25
0.2
0.15
Umuoyima
Umuororonjo
Umuonyeche
Umuodu
Owerri-Municipal

Fig 11



y = 12*x^4 - 1.5e+02*x^3 + 6.7e+02*x^2 - 1.2e+03*x + 7.6e+02
Nitrate (mg/l)
130
120
110
100
90
80
70
60
50
40
30
Umuoyima
Umuororonjo
Umuonyeche
Umuodu
Owerri-Municipal

Fig 12**.**

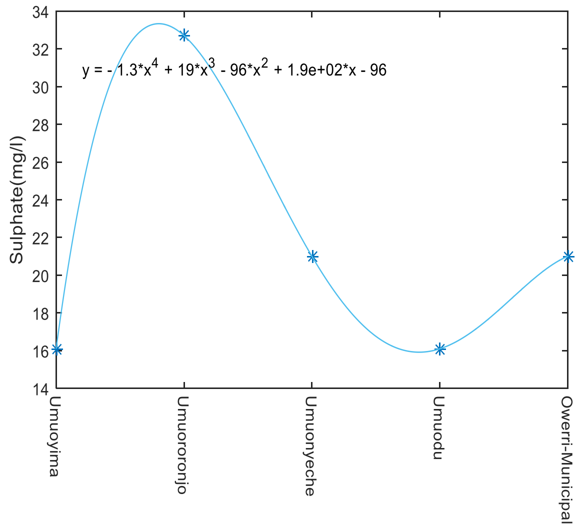


Fig 13.

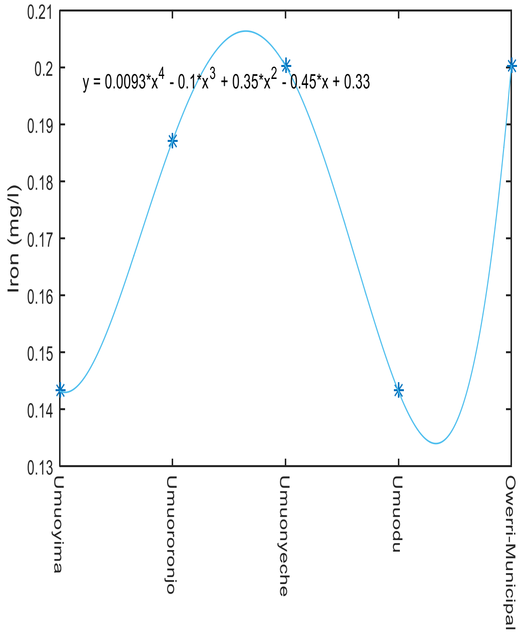


Fig 14.

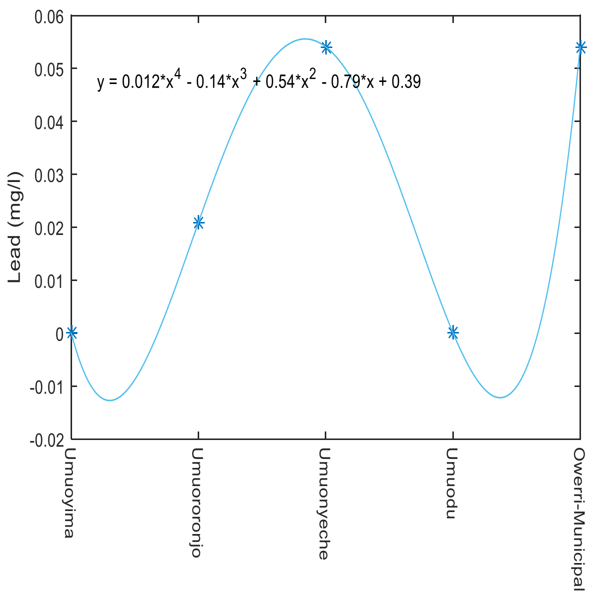


Fig 15.

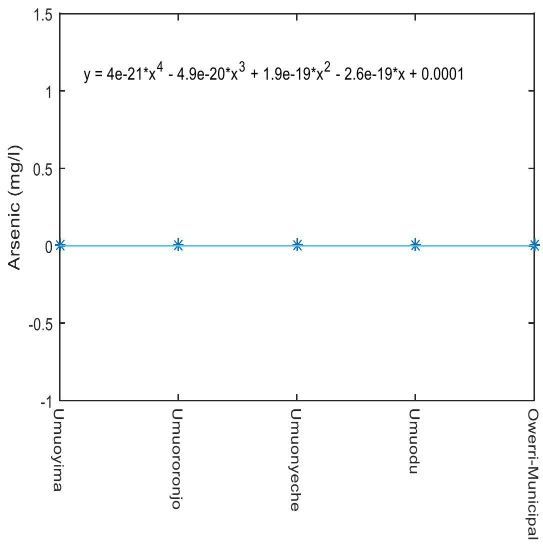


Fig 16.

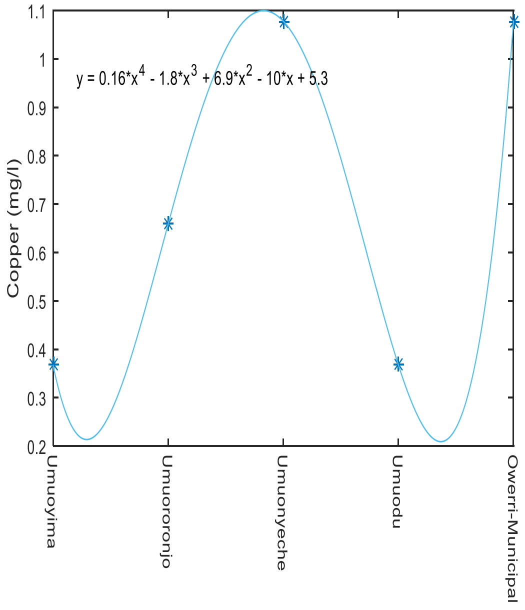


Fig 17.

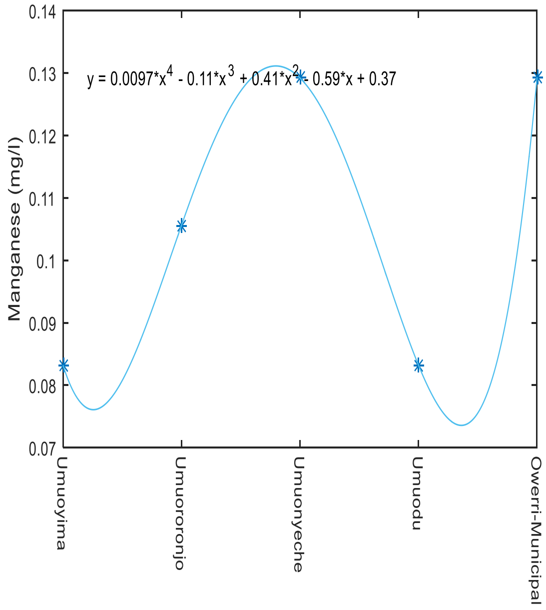


Fig 18.

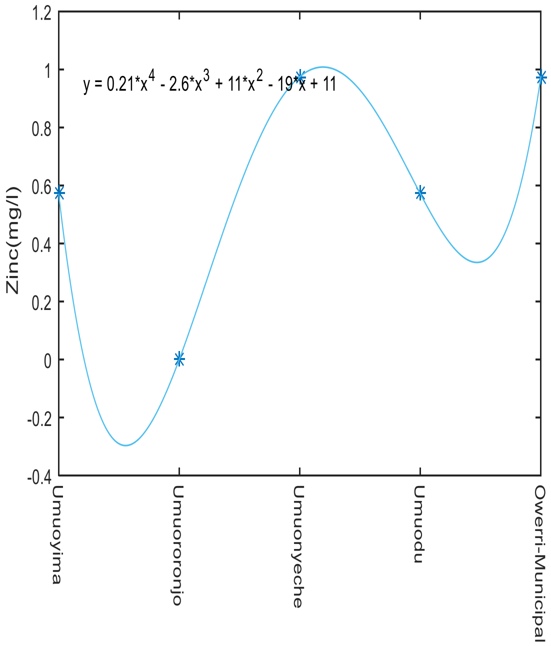


Fig 19.

ANN MODELS OF THE UNDERGROUND WATER PARAMETERS

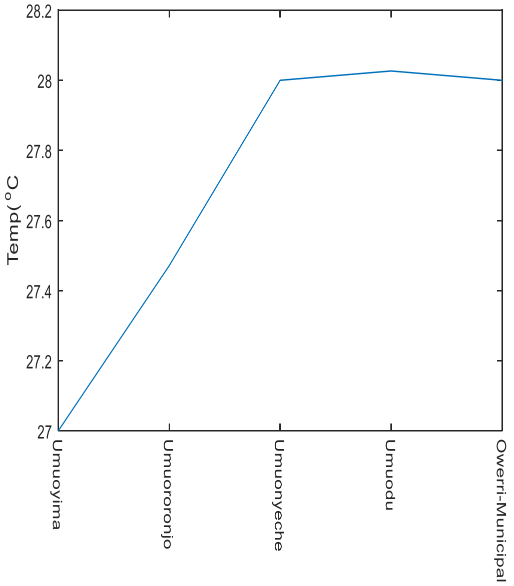
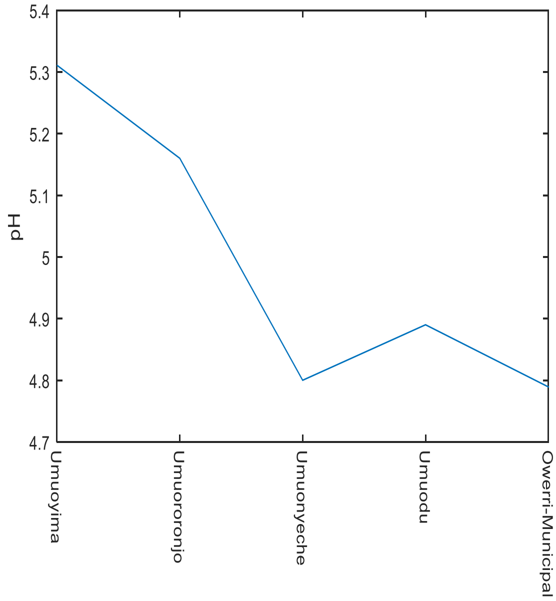


Fig 20



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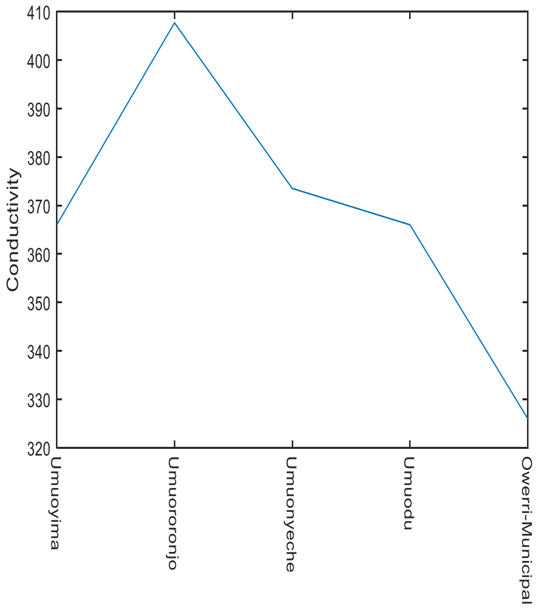

Fig 22

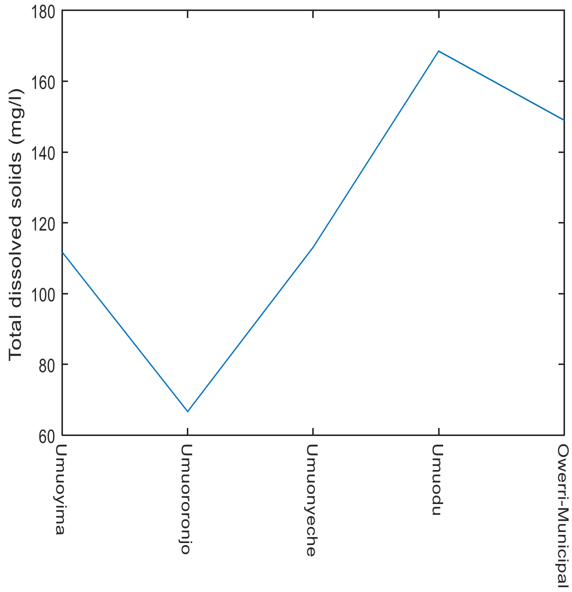

Fig 23

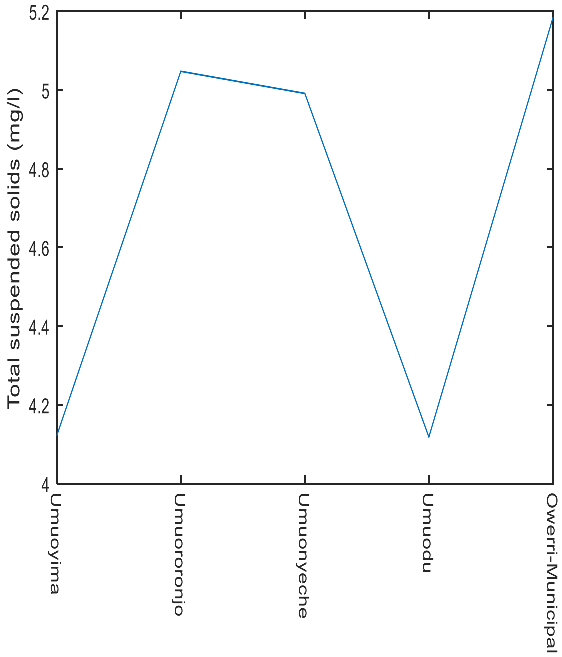

Fig 24

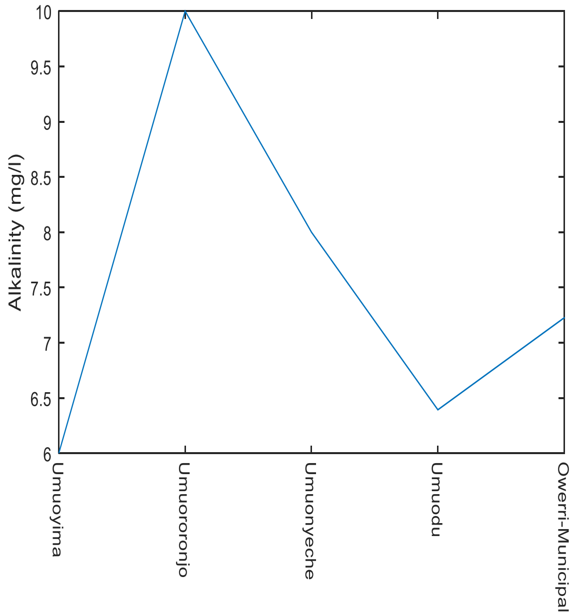

Fig 25

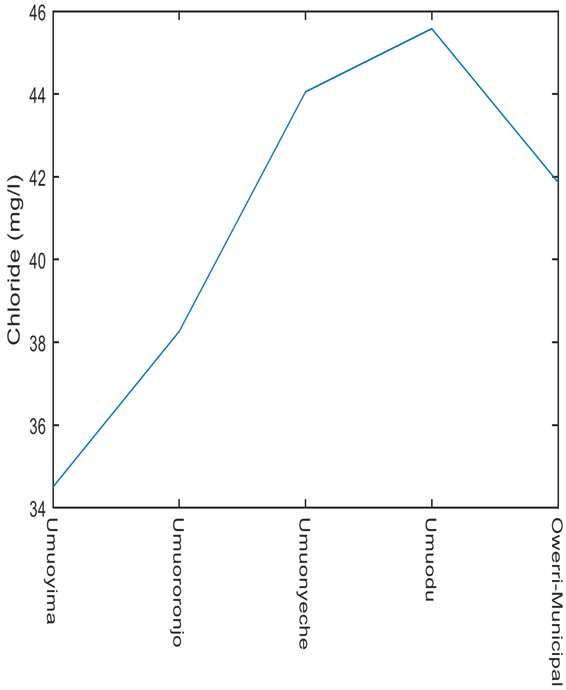

Fig 26

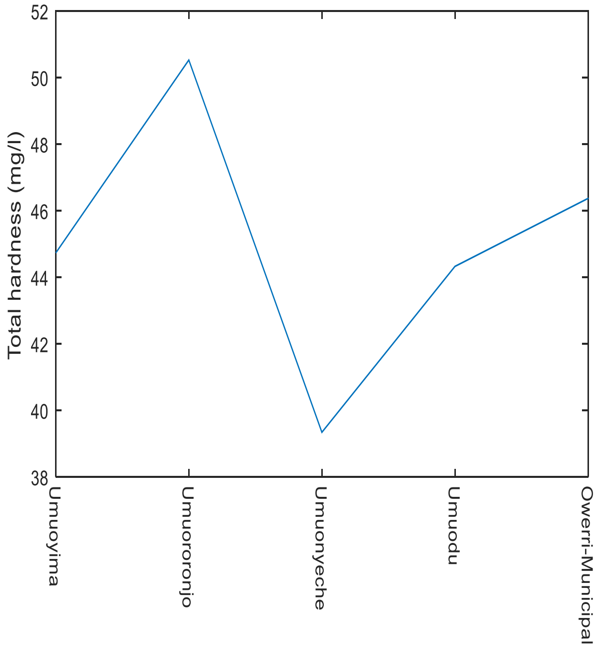

Fig 27

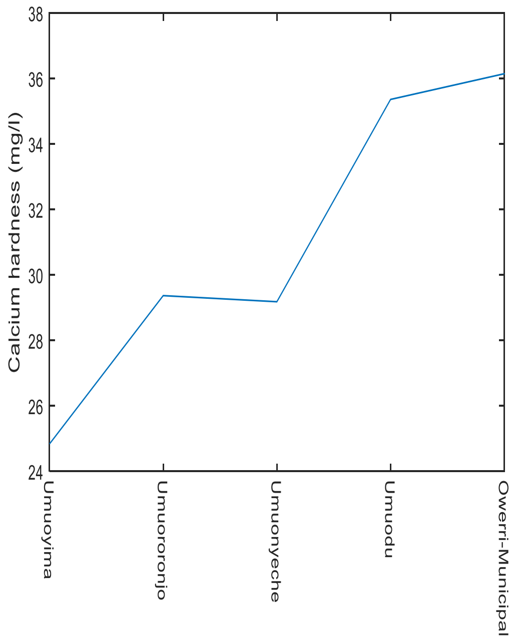

Fig 28

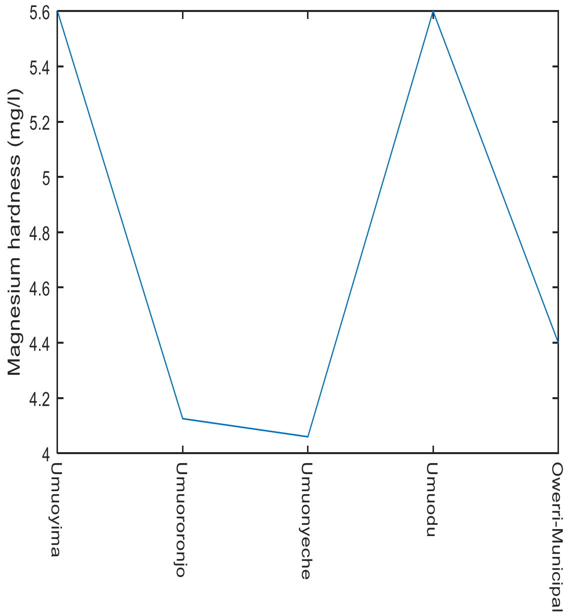

Fig 29

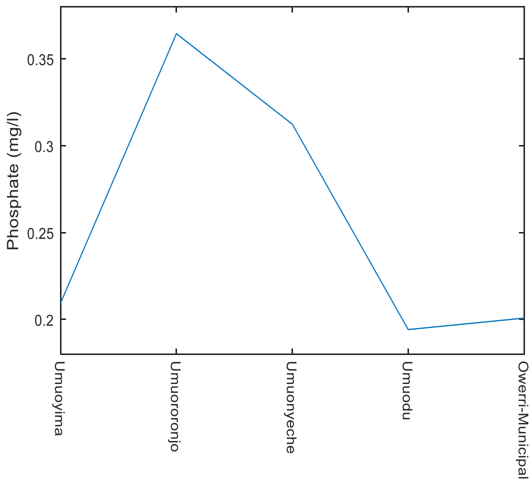

Fig 30

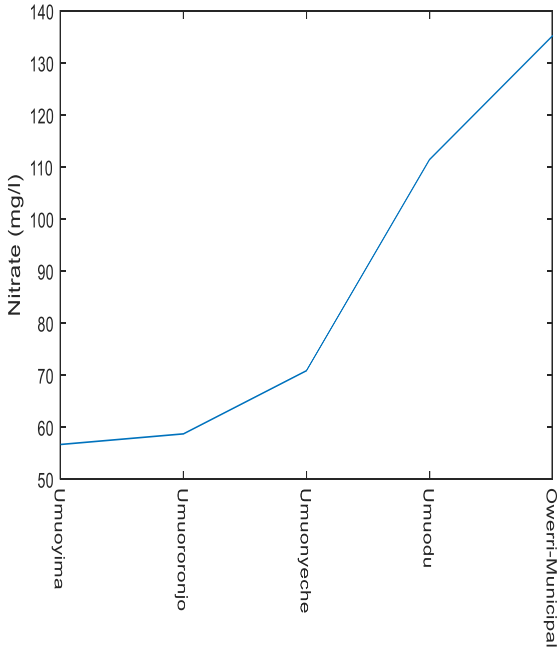

Fig 31

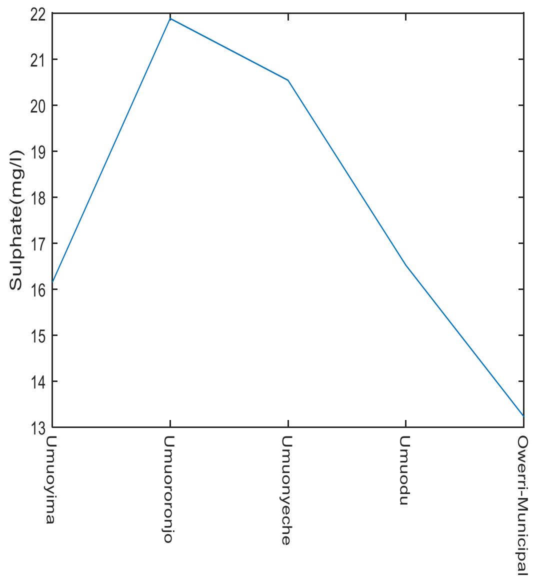

Fig 32

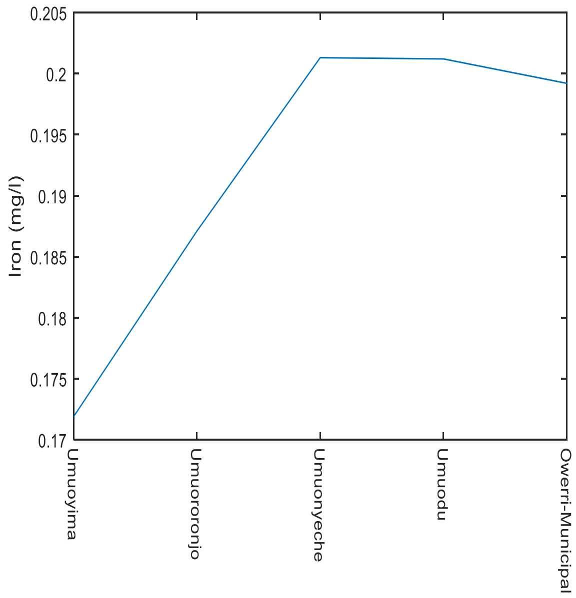

Fig 33

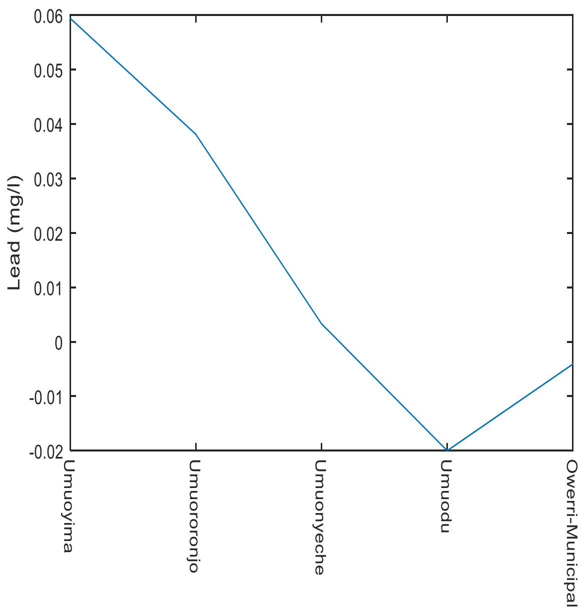

Fig 34

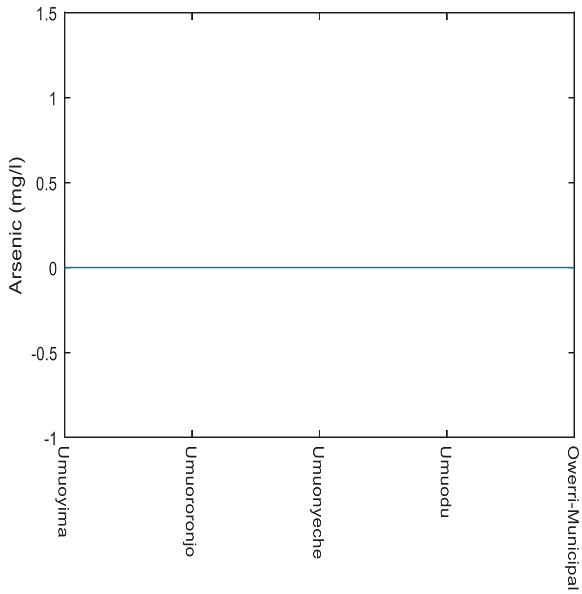

Fig 35

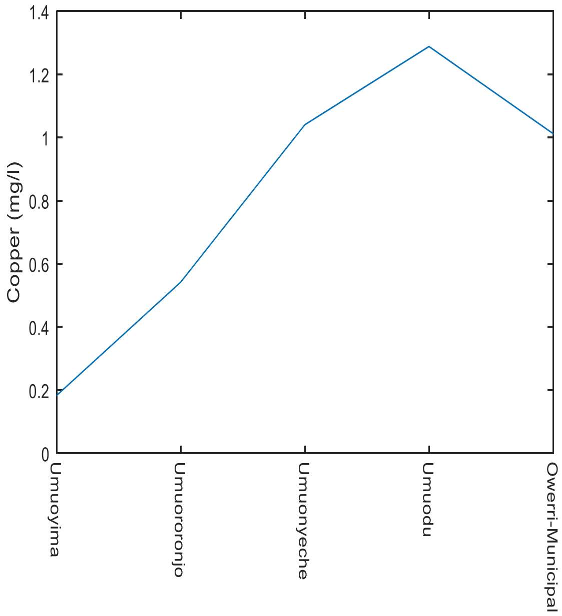

Fig 36

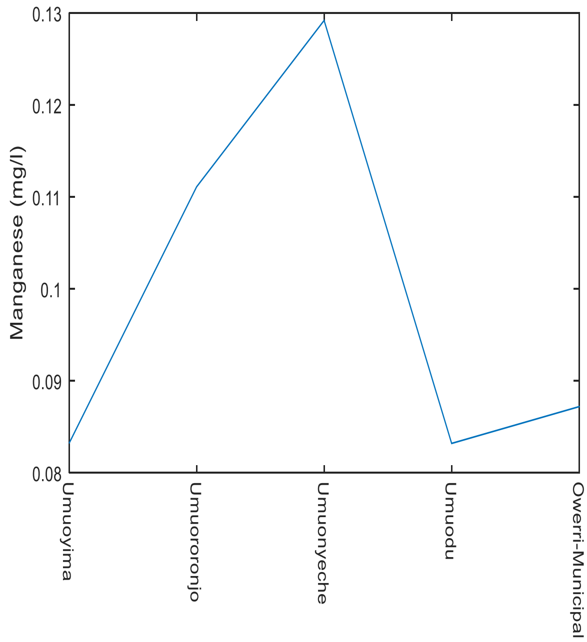

Fig 37

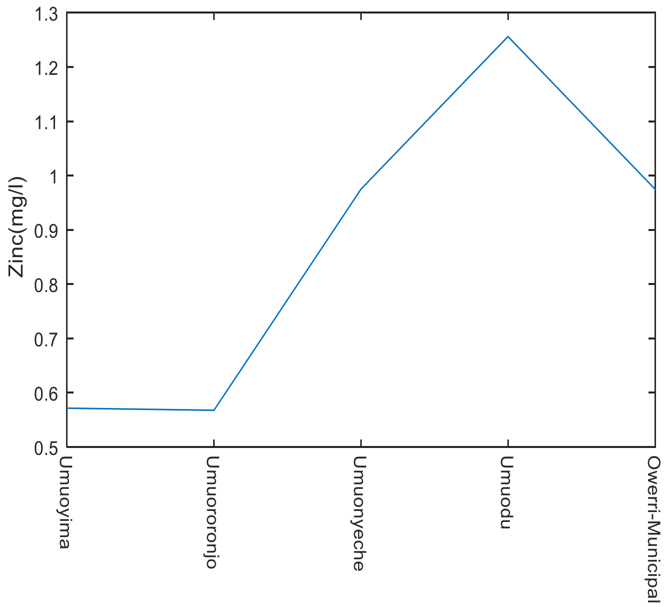

Fig 38

COMPARATIVE PLOTS OF ANN MODEL AND ACTUAL DATA OF THE UNDERGROUND WATER PARAMETERS

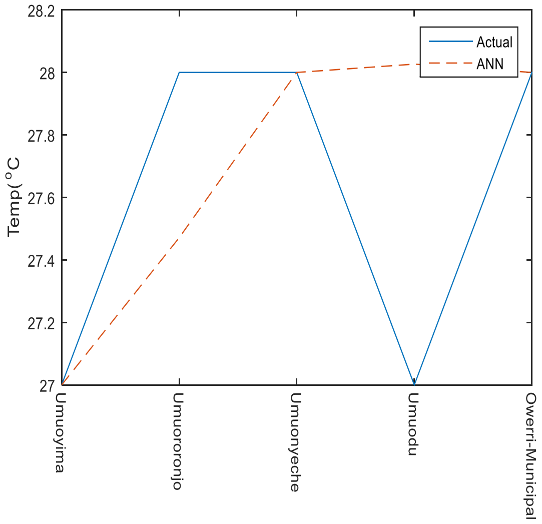

Fig 39

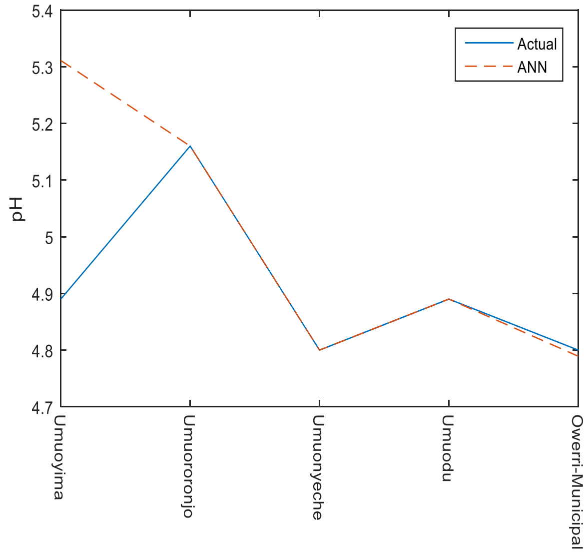

Fig 40

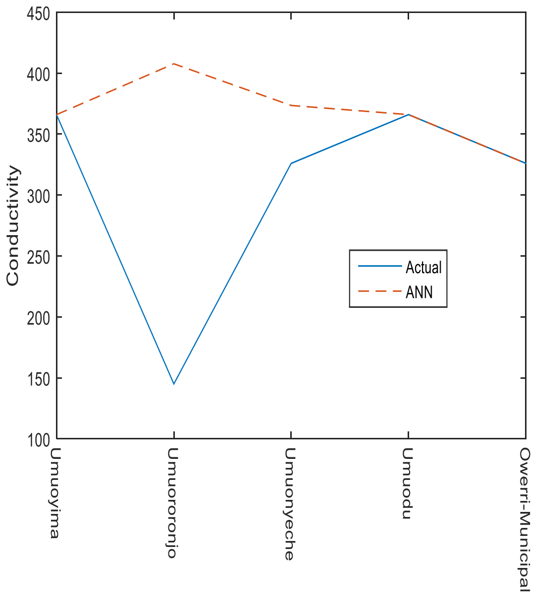

Fig 41

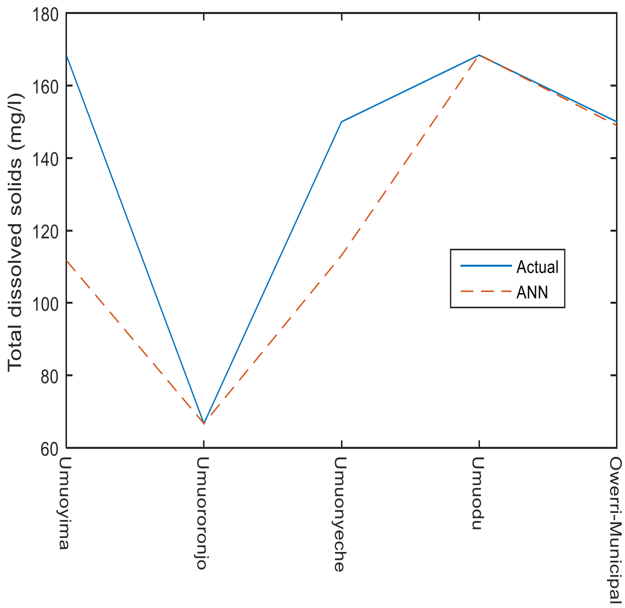

Fig 42

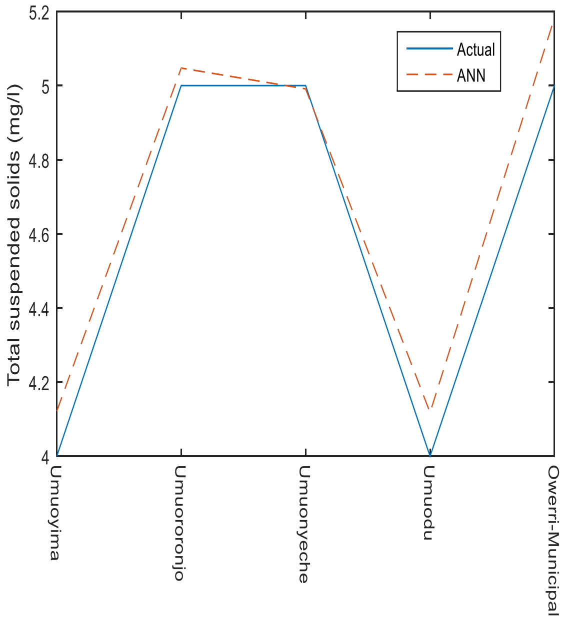

Fig 43

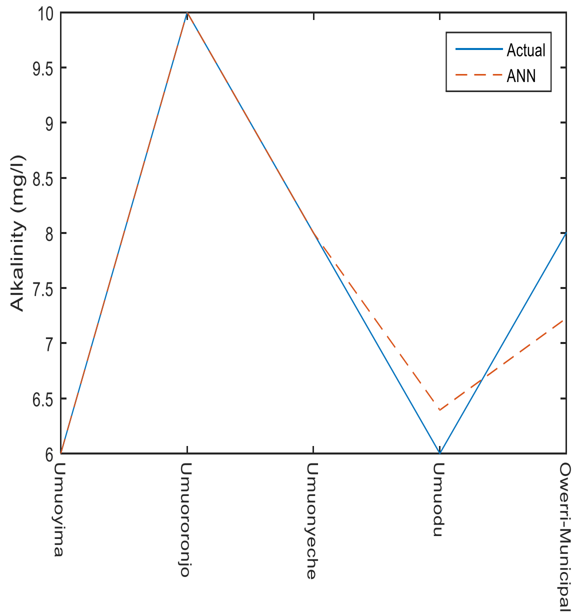

Fig 44

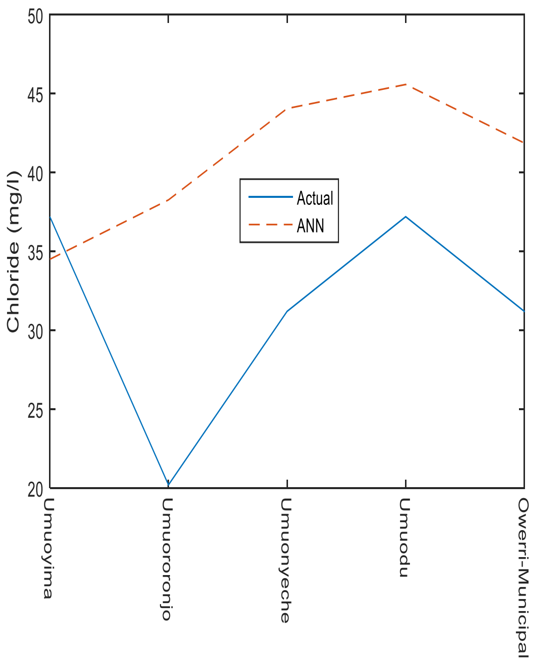

Fig 45

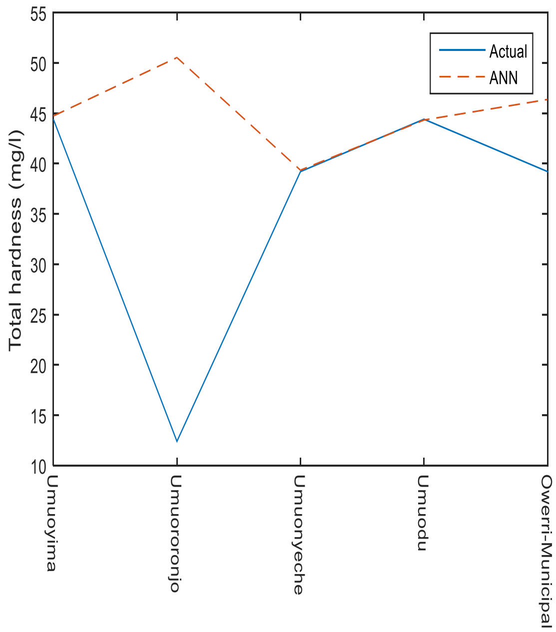

Fig 46

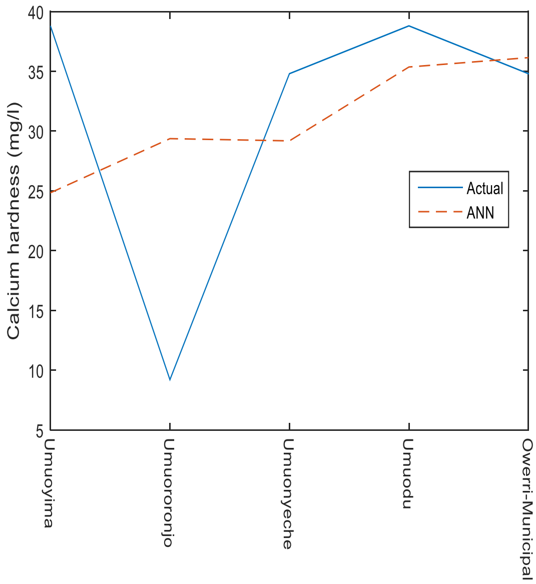

Fig 47

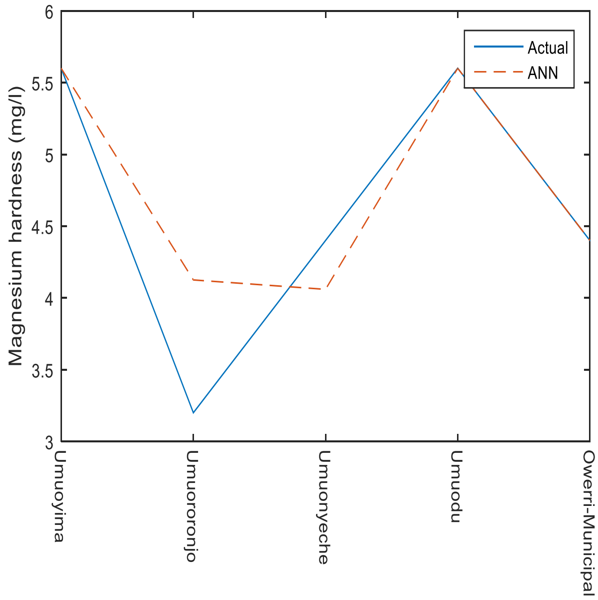

Fig 48

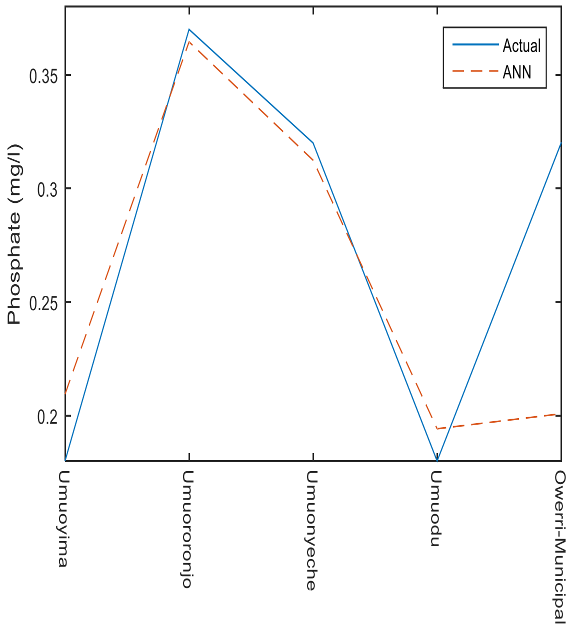

Fig 49

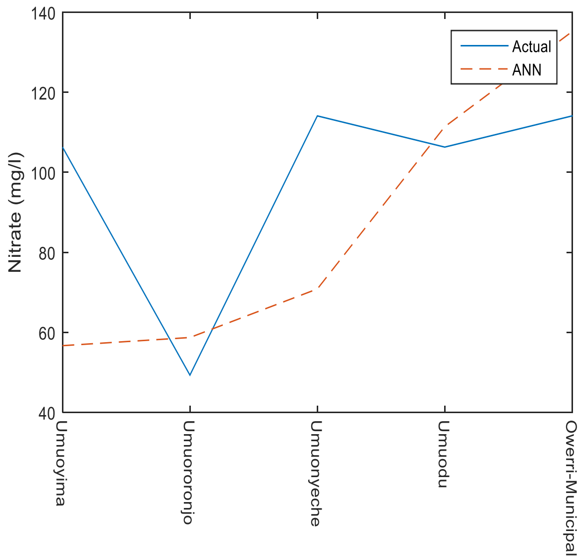

Fig 50

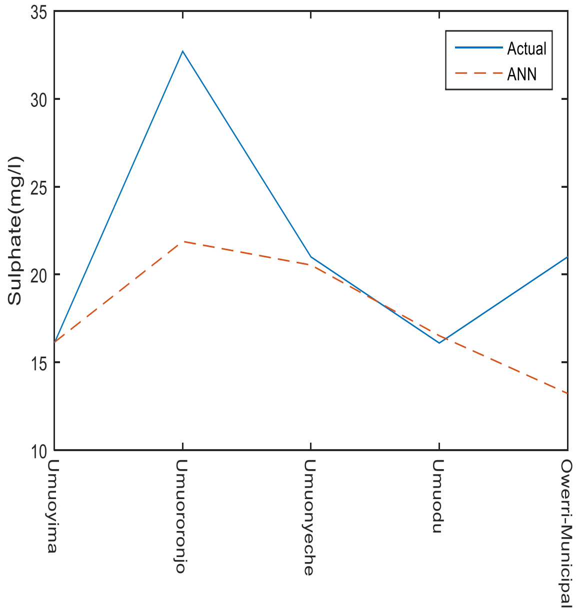

Fig 51

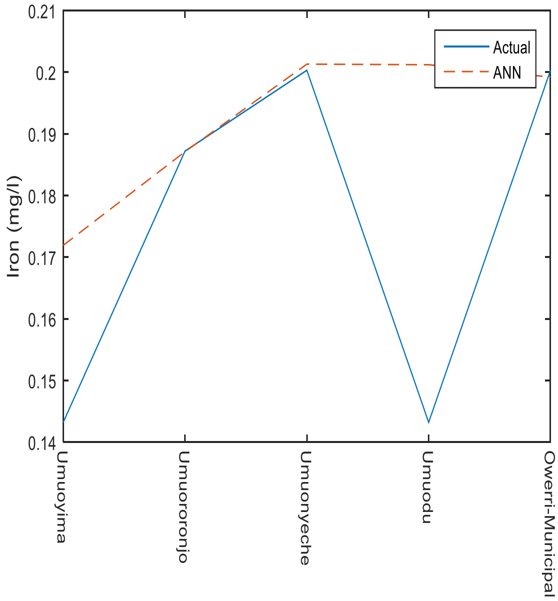

Fig 52

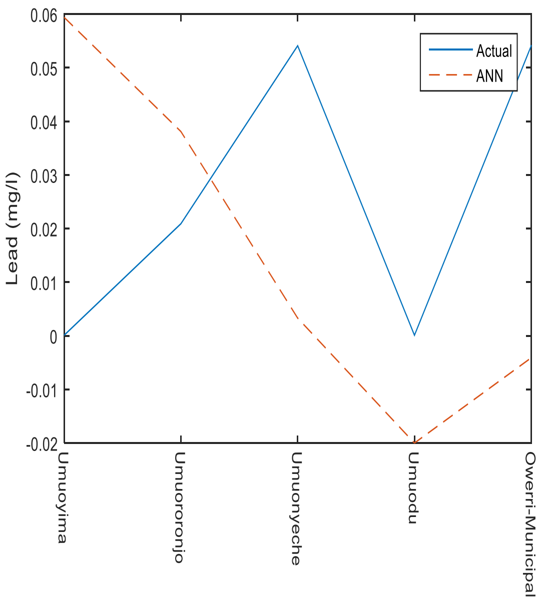

Fig 53

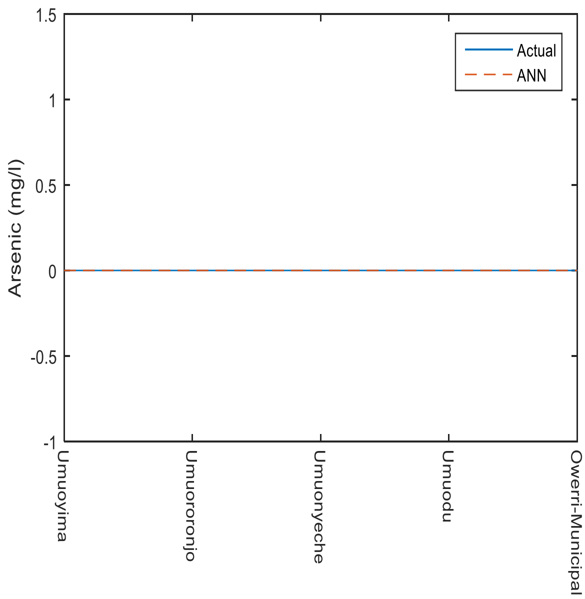

Fig 54

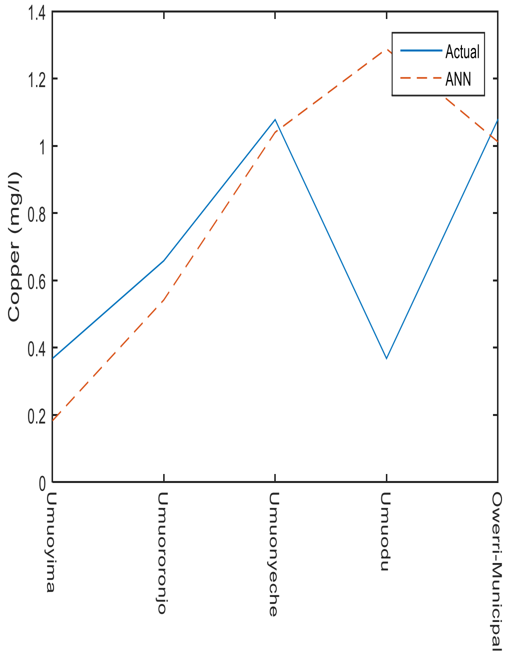

Fig 55

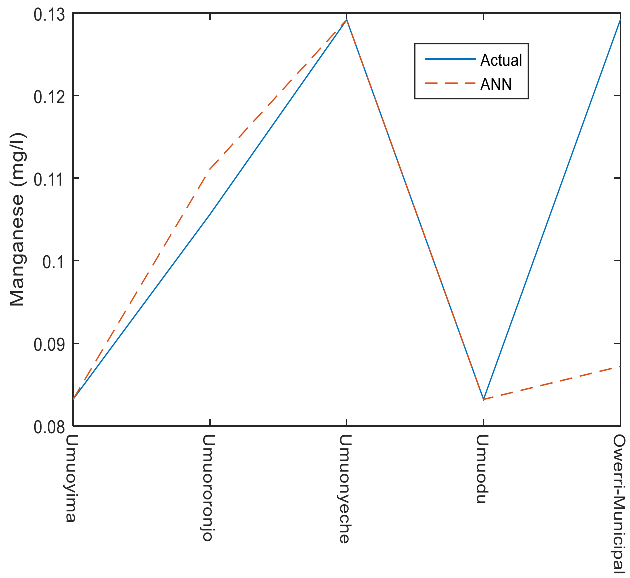

Fig 56

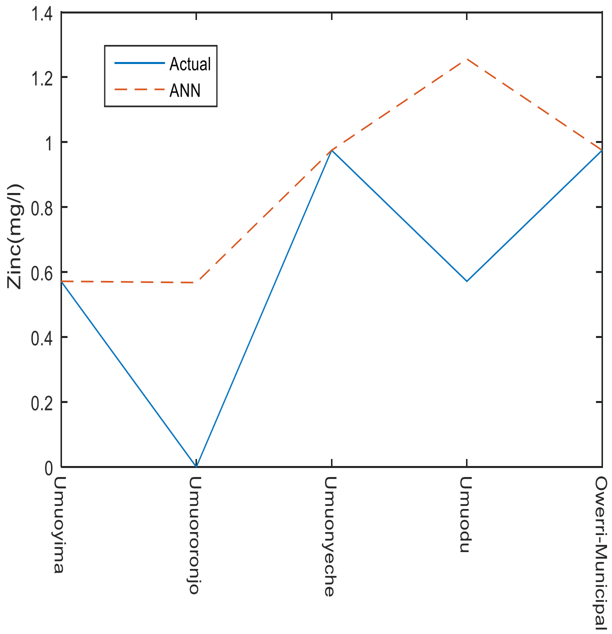

Fig 57

4.0 DISCUSSION

The results of the physicochemical analysis of selected groundwater in Owerri municipal council are presented in table 4.1-4.7 above. The levels of various parameters varied from one point to another and were compared with the World Health Organization standard. For water to be classified safe for drinking, the concentration of substances that are not desired should not exceed the WHO set standard.

The temperature of the water samples varied between 26.5^{o}C to 28.0^{o}C, with the mean value of 27.4.

The mean pH of 5.04 showed that the groundwater in Owerri municipal council is acidic. The lowest pH value of 4.80 was recorded in Umuonyeche while the highest pH value of 5.32 was recorded in Amawom. The pH values in these areas depict high hydrogen ion concentration and it serves as an index of degree of acidity which indicates the amount of hydrogen ion present and alkalinity or basicity [19]. Thus the pH values of the groundwater of the areas can cause corrosion of pipes and other corrodible materials [14].

The electrical conductivity values in this study area ranged between 77-166μScm^{-1} with a mean average of 129.8μScm^{-1}, which is below the WHO maximum permissible limit of 1400μScm^{-1}. As ionic concentration increases, conductance of the solution also increases; therefore the conductance measurement provides an indication of ion concentration. It has been reported that seasonal conductivity fluctuations are closely related to rainfall. High conductivities are expected in the dry season because of evaporation and concentration of soluble salts. Low conductivity values recorded as compared to the WHO standard of 1400 μScm^{-1} might as well explain that the study was carried during the wet season. However, the high values recorded in Umuodu and Umuororonjo, that is 166μScm^{-1} and 145μScm^{-1} respectively are presumably due to an enriching effect from inland runoff which might contain some dissolved ions dislodged from the sedimentary bedrock of rainfall after many months of dryness [20]. The lowest conductivity was recorded in Amawom as a result of the dilution effect of rainwater on the land as rainfall progresses.

Total dissolved solids (TDS) which increases with the hardness of water varied between 35.4-168.4mg/l with a mean value of 105.7mg/l. Amawom has the lowest value of 35.4mg/l and Umuodu has the highest value of 168.4mg/l. The greater the electrical conductance the greater the total dissolved solids, [15].

Total suspended solids (TSS) varied between 4-5mg/l with the mean value of 4.8mg/l. These are substances that are not dissolvable and remain as solutes in water [21].

The total alkalinity of the water samples lie between 6-10mg/l with Umuodu having the least value of 6mg/l and Amawom and Umuororonjo with the highest value of 10mg/l each. The alkalinity of groundwater is the ability to neutralize acid. The main ions which contribute to alkalinity are CO_3^{2-} and bicarbonates, HCO_3^-, [11].

The range of chloride concentration of 18.7-37.2mg/l was recorded for the study area with the mean value of 26.6mg/l. This depicts that the groundwater has corrosive properties which may contribute to the corrosion of wells, pipes and other materials. The highest chloride content of 37.2mg/l was recorded in Umuodu while the least chloride content of 18.7mg/l was recorded in Amawom.

The total hardness for the groundwater ranged between 6.0-44.4mg/l, with the mean value of 25.88mg/l. Amawom has the least value of 6.0mg/l while Umuodu has the highest total hardness of 44.4mg/l. The hardness of water relates to its reaction with soap and to the scale and encrustations which form in boilers and pipes where water is heated and transported. It is attributable to the presence of divalent metallic ions; Ca^{2+} and Mg^{2+} being the most abundant in groundwater. [22]. It has been suggested that about 25ppm of extra soap is consumed per ppm of hardness, [23]. Using Sawyer's classification [13]; Nigerian groundwater can be generally classified as soft water (0-55ppm), slightly hardwater (56-100ppm) and moderately hardwater (101-200ppm). The southern part of the country including Owerri and its environs generally has soft groundwater.

Calcium hardness ranged from 3.7-38mg/l with the mean value of 21.9mg/l. Amawom, has the least value of 3.7mg/l while Umuodu has the highest value of 38.8mg/l. The water samples having calcium hardness less than 100mg/l is described as soft water.

The study showed magnesium hardness had range of 2.3-5.6mg/l with the mean value of 3.98mg/l. Amawom has the least value of 2.3mg/l while Umuodu has the highest value of 5.6mg/l.

Phosphate value in the study area ranged between 0.18-0.40mg/l with the mean value of 0.33mg/l. Values greater than 0.3mg/l is as a result of pollution [24].

The nitrate content of groundwater from the study area lie between 18.5-114.1mg/l; with the mean value of 70.58mg/l. It is highest in Umuonyeche and lowest in Amawom. Most nitrates in water come from agricultural and industrial wastes. And additional source is from NO_2 produced by lightening discharges and from bacterial actions. [11]. High nitrates concentration in drinking water at levels shows leaching from dumpsites and auto-mechanic workshops [20].

Sulphate concentration ranges between 16.1-32.7mg/l with the mean value of 23.3mg/l. Umuodu have the least concentration of 16.1mg/l and Umuorornjo the highest value of 32.7mg/l.

The analysis showed the traces of metallic ions like Iron, Lead, Copper, Manganese and Zinc but there was little or no trace of Asenic in all the water samples since it showed concentration value of <0.0001mg/l which is below the detection limit.

Values of Iron obtained in the study ranged between 0.1432-0.2166mg/l. The values fall below the recommended value of 0.3mg/l, [25]. Hence water in this area is safe for drinking.

Lead ion was detected in Umuonyeche, Umuororonjo and Umuoyima with concentration of 0.0541, 0.0209 and 0.0711 respectively but there was little or no trace of lead in Amawom and Umuodu.

The Copper ion in the water samples ranged between 0.3678-1.1006mg/l with the mean value of 0.74914mg/l.

The Manganese ion detected ranged between 0.01018-0.1755mg/l with the mean value of 0.10mn074mg/l.

Zinc ion concentration detected ranged between 0.5717-1.3179mg/l with the mean value of 0.86258mg/l.

Table 4.3 gives the pollution index of the groundwater of Owerri municipal. This expresses the pollution quality of water as developed by Horton [18]. The result revealed that the water has a value greater than 1.0 which indicates that the water should be purified before use. This is in with [26] and [27]. The result revealed that water level is very close to the ground surface and hence water is prone to pollution, this is in agreement with [28]

5.0 CONCLUSION

From the results it was found that the quality of groundwater resources has degraded as a result of human activities, urbanization, rapid population growth, industrialization and agricultural activities.

The slightly lower pH values showed that the level of acidity of the waters. The concentrations of the electrical conductivity are very high indicating that they have high amount of dissolved materials. The water samples have low hardness concentration which shows that the water in this area is generally soft water. The nitrate concentrations in all the areas apart from Amawom are high which can cause methemoglobinamia especially in infants and carcinogenic nitrosamines.

The concentration of the heavy metal arsenic in the water samples were below detection limit. Lead ion was detected in three areas of the study which are Umuonyeche, Umuororonjo and Umuoyima while the concentrations of Lead were below detection limit in Umuodu and Amawom, The pollution index calculated shows that the groundwater is polluted with the pollution index of 1.13; this signifies a critical value which requires proper treatment to reduce the impurities.

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