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APPLICATION OF ANN AND MATLAB IN PHYSICOCHEMICAL EVALUATION OF GROUNDWATER IN SELECTED COMMUNITIES IN ABA, ABIA STATE NIGERIA

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ABSTRACT

This study focused on groundwater quality in Aba Metropolis. Analysis of physicochemical characteristics of groundwater such as pH, conductivity, total dissolved solids (TDS), alkalinity, anions and cations and some heavy metals were determined using titrimetric, spectrophotometric and atomic absorption spectroscopic methods to obtain concentrations of the physicochemical parameters results in mg/L. The results compared favourably with WHO standard limit except in most of the parameters under consideration. The results of WHO standard error of limit of these parameters were below WHO permissible limit, however the percent deviation for Lead is 2 for groundwater from Umuchichi and Umueme while the percent deviation for Uratta was far much low. The waste disposal of the companies around Umueme region includes antiknock agents such as Tetraethyllead (TEL) used in their heavy-duty machines. When these waste are not properly treated before disposal it seeps down into aquifers and affects groundwater quality leading to high pollution levels. The value for Iron concentration in groundwater in Umuchichi is much within WHO permissible limit while for Umueme and Uratta the values indicated 1.33% increase. The results varied from 6.3 ± 1.44, 7.97 ± 0.47 to 7.27 ± 0.94 in the case of pH for Umuchichi, Umueme and Uratta respectively, whereas the conductivity level in μS/cm, varied from 0.5 ± 0.23, 0.75 ± 0.12 to 0.51 ± 0.22. The pH values for the three communities are all within the tolerable range according to WHO (2006). It is highly recommended that the lead level of groundwater in Umuchichi and Umueme is closely monitored. Since surface lead seeps down to aquifers determining the level of lead on the surrounding surface can help determine safe level of lead in the groundwater. Furthermore, Artificial Neural Network (ANN) and MATLAB were employed to support the data analysis and predict pollution patterns. The integration of ANN technique demonstrated high predictive accuracy, highlighting their effectiveness in water quality assessment and environmental monitoring of groundwater. In conclusion data from this study can serve as a guide to current groundwater quality and areas of improvement when making feasibility studies when it comes to well-drilling on these sites.

Keywords: ANN, MATLAB, Groundwater, Physicochemical, Aba

1. INTRODUCTION

Groundwater management is a comprehensive term that encompasses both routine day to day aspect of well field operation and long-term considerations relating to future water demand, potential source of supply economics and quality of water. According to the most recent statistics 2.3 billion people (One third of the global population) obtain their drinking water directly from groundwater [1a]. This assumes that at least another 1.7 billion people (One quarter of the world's population) representing 40% of those who enjoy piped water are also supplied from groundwater. Of the 780 million not yet served, the majority of these are predominantly rural people who will need to be supplied from groundwater [1b].

From the above statement it can be deduced that humanity relies heavily on sustainable groundwater development and for good reason: water is directly linked to human and animal health. The presence of adequate supply of quality water for human consumption is essential for sustainable development program of any society. Nevertheless, the quality and suitability of water are of great concern to the society because of the much water borne diseases ravaging human health [2]. Groundwater sources are found in most places and are relatively easy and cheap to install. They are also not prone to pollution as other sources of water. To bridge the gap in water supply coverage, it is crucial that boreholes are delivered in a cost-effective manner. Cost effectiveness does not necessarily mean cheaper boreholes but rather that optimum value is derived over the long term for money invested. This should result in borehole continuing to function through their designed lifespan of 20 to 50 years.

Studies carried out in some parts of the country revealed a high failure rate of boreholes [3]. This can be attributed in part to poor borehole construction practices. One way of tackling this problem is to improve the quality and professionalism of water well drilling. It is important to recognize that there are many other factors that lead to failures of wells. These factors range from the topography of soil down to human activities in the area.

Groundwater contamination is nearly always the result of human activity. In areas where population density is high and human use of the land is intensive; groundwater is especially vulnerable. Virtually any activity whereby chemicals or wastes may be released to the environment, either intentionally or accidentally, has the potential to pollute ground water. When groundwater becomes contaminated, it is difficult and expensive to clean up.

To begin to address pollution prevention or remediation, we must understand how surface waters and groundwater interrelate. Groundwater and surface water are interconnected and can be fully understood and intelligently managed only when that fact is acknowledged. If there is a water supply well near a source of contamination, that well runs the risk of becoming contaminated. If there is a nearby river or stream, that water body may also become polluted by the groundwater.

Depending on its physical, chemical and biological properties, a contaminant that has been released into the environment may move within aquifer in the same manner that groundwater moves. (Some contaminants because of their physical or chemical properties, do not always follow groundwater flow). It is possible to predict, to some degree, the transport within an aquifer of those substances that move along with groundwater flow. For example, both water and certain contaminants flow in the direction of the topography from recharge areas to discharge areas. Soil that are porous and permeable tend to transmit water and certain types of contaminants with relative ease to an aquifer below [4 - 10].

Just as groundwater generally moves slowly, so do contaminants in groundwater. Because of this slow movement, contaminants tend to remain concentrated in the form of a plume that flows along the same path as the groundwater. The size and speed of the plume depend on the amount and type of contaminant, its solubility and density, and the velocity of the surrounding groundwater. Any place where surface water makes its way into the groundwater, organic chemicals and pathogens potentially can enter [10 - 14]. Inorganic chemicals that occur naturally in soils, sediments and rocks for example, dissolved minerals matter can also degrade the quality of groundwater. Even though groundwater may be plentiful in a particular area, if the quality of the groundwater has been degraded by the entry of contaminants, the aquifer may not be usable as a water supply or use for any aquatic system. [10 - 15].

Many surface water reservoirs used as drinking water supplies are fenced to keep people from contaminating it, signs warn, for example, that the reservoir is a municipal drinking water supply and that no human access is permitted. Unfortunately, groundwater reservoirs typically are not protected this effectively. Often land is zoned and developed (or farmed) without considering the underlying groundwater aquifers and the necessity of protecting the aquifer's recharge areas. [15]. Even aquifers that serve, as municipal water supplies for thousands of people often are left mostly or entirely vulnerable. Contaminants can enter aquifers by several means including;

- Infiltration of surface water through soil, sediments and rocks.
- Direct flow from surface (especially in fractured rock terrain or karts terrain).
- Direct flow through improperly built wells that become conduits for contamination, or
- Cross contamination below the ground and surface from other aquifers via the casings (piping) of improperly built wells.

The aim and objectives of this research is to study the physicochemical properties and parameters of groundwater in selected communities in Aba, Abia State based on the following objectives: To determine the concentration of total dissolved solids in groundwater, to determine the concentration of cations and anions. to determine the concentration of heavy metals through comparison with World Health Organisation on heavy metal ions, to determine the pH of groundwater in Aba, to evaluate the health implication of using groundwater in the selected areas, to evaluate the quality of water being used by both agricultural (fishery and poultry) farms in the area

2. MATERIALS AND METHODS

Research instruments used in this study include pH meter Hanna Model H199300 (APHA, 1998), electrical conductivity meter, PD303 UV Spectrophotometer, Atomic Absorption Spectroscopy (AAS) (Shimadzu AA -7000), 50 cm^3 burette, 250 cm^3 Erlenmeyer Flask, two Retort Stands and clamp, filtration apparatus, 50 cm^3 vials for groundwater samples, 50 cm^3 of groundwater from Umuchichi, Umueme and Uratta, standard hydrochloric acid, analytical reagent grade tetraoxosulpate(VI) acid (98.3%, 1.84g/cm^3), 10% $BaCl_2$ solution , distilled water, bromocresol blue, methyl orange and solochrome black T as indicators..

2.1 STUDY AREA

The study area, Aba City in Abia State, Nigeria is a commercial nerve center as well as a fast, industrializing centre in Abia State, Nigeria. (Fig 3.5). It serves the commercial needs of important cites in the South-Eastern, and South-Southern geopolitical regions of Nigeria. Over one million people are estimated to be living in the 236 km^2 area. The vegetation climate conditions are humid equatorial rainforest. with annual mean rainfall ranging from 2150 to 2460 mm, and mean daily temperatures ranging between 22 °C end 33 C for the average minimum and maximum daily temperature. Aba is a level ground that lies approximately within longitude 7°19' E to °37 E and latitude of 5°3' N to 5°12' N in the Niger Delta Basin and is under the Benin Formation that is highly aquiferous. The aquifer type is mostly unconfined and the water table elevation range 26m - 33m below ground level, with an average elevation depth of 28.6 m (15, 12). The water table elevation implies that the wells are deep, and the groundwater is usually abstracted from tube-wells with submersible motor pumps. The area is predominantly flat, with poor drainage networks.

The growing population is putting pressure on the poorly implemented urban land-use in the area. Refuse dumpsites are sporadically sited and are used as municipal waste disposal, public water supply system is dysfunctional, and the central sewage system is non-existent to manage residential and industrial effluents. The dysfunctional state of the public water supply System has tied to the proliferation of private pumps, which provide groundwater for domestic, commercial and industrial purposes in the absence of the central sewerage, use of cesspools, septic systems, direct discharge of effluents into the aquifer system have been observed in the area. These current practices have the potential to contaminate the aquifer.

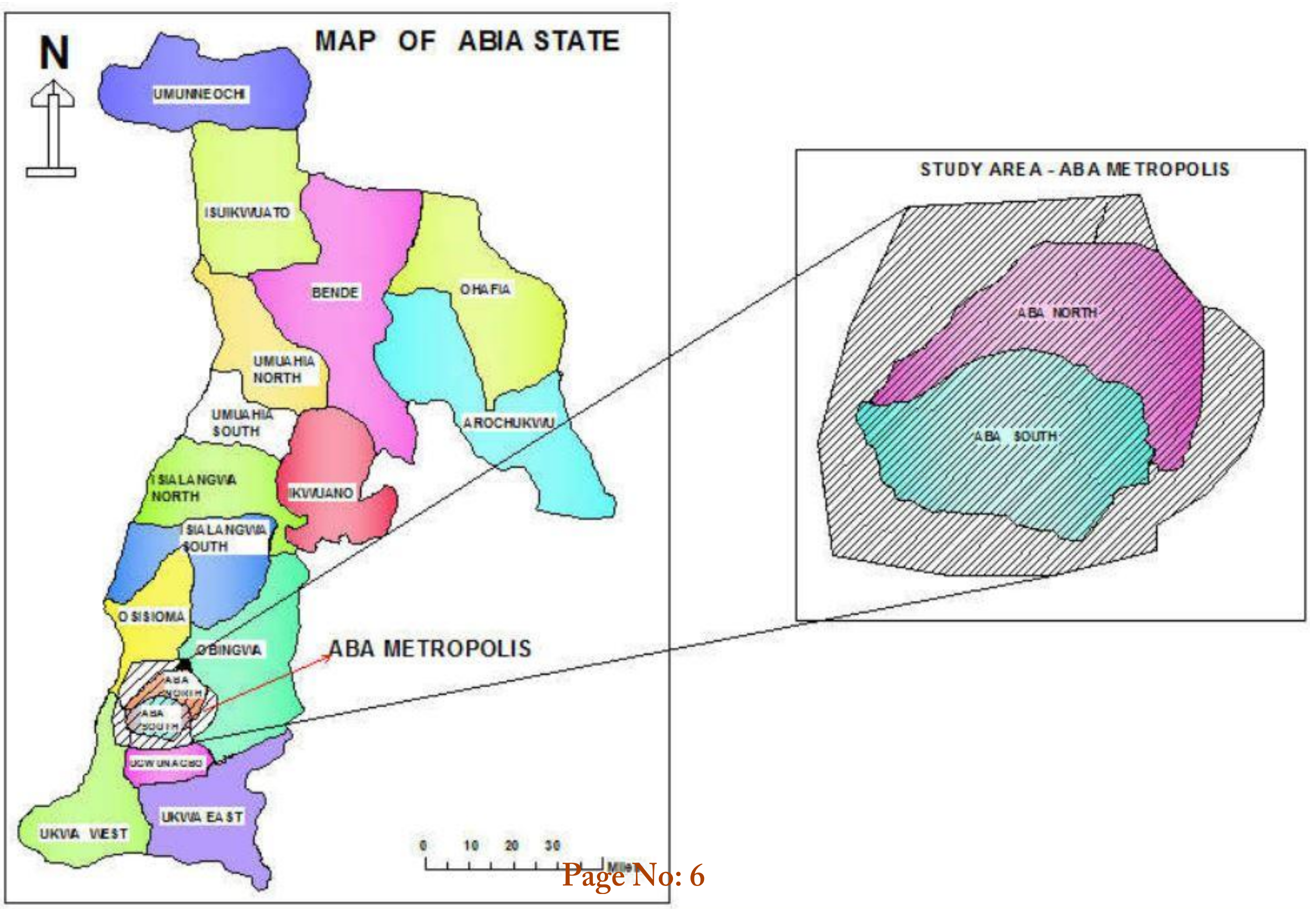


Fig 1: Map of Abia State Showing the area of focus (Source: GIS NDA, 2017

2.2 Collection of Samples

This experimental research was systematically embarked on and scientific approach was used to evaluate physicochemical parameters of the groundwater. Three samples from each of the three communities studied namely Umichichi, Umueme and Uratta were randomly collected. The research was conducted in a Rivers State University of Science and Technology laboratory using the samples collected from the above-mentioned areas one week after collection. For each month one of the samples was tested for a particular parameter. In the first month the pH of each of the samples was tested using a digital pH meter. Thereafter inferences or deductions were drawn based on the prevailing conditions to determine possible reasons for a spike in the pH or for a low pH. The same experiment was performed monthly against the different parameters of interest for a period of 5 months. The researcher recognized the nature of the analytical materials when preparing each sample, using scientifically approved pieces of apparatus, chemical and equipment which were set to analytical grade and under valid laboratory condition. Data obtained were subjected to statistical analysis using statistical tools such as mean, standard deviation to obtain standard error of limit. The percent deviations from World Health Organization Standards for each parameter was determined.

2.3 Determination of pH

The pH of the water samples was measured by electrometric method using laboratory pH meter Hanna Model H199300 [16]. The electrodes were first rinsed with distilled water and blot dry. Then the pH electrodes were then rinsed in a small beaker with a portion of the sample. Sufficient amount of the sample was poured into a small beaker to allow the tips of the electrodes to be immersed to a depth of about 2 cm. The electrodes was at least 1 cm away from the sides and bottom of the beaker. The temperature adjustment dial was adjusted accordingly. The pH meter was turned on and the pH of the sample recorded.

2.4 Determination of Electrical Conductivity

Analysis of electrical conductivity was carried out according to APHA 2510B guideline model DDS- 307 [16]. The conductivity cell was rinsed thrice using portions of the sample. The temperature of the sample was then adjusted to 20 $\pm$ 0.1 °C. The conductivity cell containing the electrodes was immersed in sufficient volume of the sample. The conductivity meter was turned on and the conductivity of the sample recorded.

2.5 Alkalinity

The alkalinity was determined by titration. 50 ml burette was rinsed severally with 0.02 N HCl. The burette was filled the with the HCI solution, making sure there are no air bubbles in the tip. The meniscus is readable at close to 0.00 ml on the burette scale. 100.0ml of the water sample to be analysed was measured into a 250 ml. Erlenmeyer flask. The sample was titrated to a bromocresol green (pH = 4.5) end point. Triplicate titrations were done on each sample being investigated.

Calculation: Alkanity of the samples in milligrams of calcium carbonate per litre was calculated as:

$$\text{Alkalinity} = \frac{(\text{ml HCI titrant}) \times (\text{Normality of HCI}) \times (50{,}000)}{\text{ml of water Sample}}$$

2.6 Determination of Total Hardness

Total hardness was measured using standard analytical methods of APHA. [16]. 50 cm of the water sample was introduced into a beaker and buffer solution of NH_3; added. Three drops of Solochrome Black T indicator was also added and the solution swirled properly.

The mixture was titrated with standard 0.01M EDTA solution until colour changed from wine red to pure blue with no bluish tinge remaining. The total hardness of the water sample was calculated as:

$$\text{Total hardness (mg/CaCO}_3) = \frac{\text{Volume of Titrate x 1000}}{Volume\ of\ Sample\ (cm^3)}.$$

2.7 Titrimetric Determination of Calcium Hardness

When EDTA is added to water containing both calcium and magnesium, it combines first with the calcium, calcium can be determined directly with EDTA.

When the pH is made sufficiently high that the magnesium is largely precipitated as that of hydroxide and an indicator is used that combines with calcium only.

50 ml of the water sample was first measured, then 2 ml of NaOH solution was added to produce a pH of 12 to 13 (20 ml of NaOH to produce 12 to 13 pH). The solution was stirred 0.1 to 0.2 ml of the indicator was added. EDTA titrant was added slowly with continuous stirring to the proper end point. Solochrome Black T powder was used as an indicator.

Calcium hardness as calculated thus;

$$\text{Calcium hardness (CaCO}_3\text{/1)} = \frac{\text{A x 1000}}{\text{volume of Water used}}$$

A = ml of titrant

2.8 Titrimetric Determination of Chloride

Chloride was analyzed according to APHA standard method [16].

100 ml of the clear sample was pipetted into an Erlenmeyer flask and the pH adjusted to 7 -10 with either H_2SO_4, or NaOH solution. Then 1 ml of K_2CrO_4, indicator solution was added and titrated against with standard solution of $AgNO_3$, in a permanent reddish brown

colouration. This $AgNO_3$ titrant was standardized and a reagent blank established. A blank of 0.2 -0.3 ml is usual for the method.

Calculation:

Chloride Concentration (mg/L) = (A-B) X N X 35450 /mL of sample

Where:

A = Volume of $AgNO_3$ used for the sample

B = Volume of $AgNO_3$ used for the blanks

N = Normality of the $AgNO_3$ titrant

35450 = equivalent weight of chloride (35.45) multiplied by 1000 mL/L

mL of sample = volume of the sample used for titration

2.9 Determination of Total Dissolved Solids (TDS)

Total Dissolved Solids was determined using [16]. Procedures

The fiber filter disc was prepared by placing it, wrinkled side up, in the filtration apparatus. Vacuum was applied and the disc washed with three successive 20 ml washings of distilled water continuous suction was then applied to remove all traces of water. A clean evaporating dish was heated to 180 $\pm$ 2 °C in an oven for 1 hour. Cooled and stored in a desiccator until needed. It was usually weighed immediately before use. A sample volume was chosen to yield between 2.5 and 200 mg dried residue. 50 ml of well mixed sample was filtered through the glass-fiber filter; it was washed with three successive 10 ml volumes of distilled water, allowing complete draining between washings. Suction was continually applied for about 3 minutes after filtration is complete. Filtrate was transferred to a weighed evaporating dish and evaporated to dryness on a stream bath. The evaporating dish was finally dried for at least 1hr in an oven at 180 $\pm$ 2 °C, cooled in a desiccator to balance temperature and weigh.

Calculation:

$$\textbf{TDS} = \frac{(A-B) \times 107 \text{ mg/l}}{\text{Sample volume in ml}}$$

Where A = weight of dish + Solids (mg)

B = Weight of dish before use (mg)

2.10 Determination of Sulphate

Sulphate analyzed according to APHA standard method [16].

A 250 cm^3 of the water sample was evaporated to dryness on a dish. The residue was moistened with a few drops of conc. HCI and 30 cm^3distilled water was added. This was boiled and then filtered.

The dish was rinsed and the filter paper washed with several portions of distilled water and both filtrate and washings added together. This was heated to boiling and then 10 cm^3 of 10 % $BaCl_2$ solution was added, drop by drop with constant stirring. The mixture was digested for about 30 minutes, filtered and the filter paper washed with warm distilled water. It then ignited, cooled and weighed in an already weighed crucible.

Calculation:

Mg/dm^3 $SO^2{}_4$, = Mg $BaSO_4$ x 411.5 cm^3 of water sample

2.11 Determination of Nitrate Method:

Nitrate is determined using PD303 UV spectrophotometer [16].

50 ml of the sample was pipetted into a porcelain dish and evaporated to dryness on a hot water bath. 2 ml of phenol disulphonic acid was added to dissolve the residue by constant

stirring with a glass rod. Concentrated solution of sodium hydroxide and distilled water was added with stirring to make it alkaline. This was filtered into a Nesters tube and made up to 50 ml with distilled water, the absorbance was read at 410 nm using a spectrophotometric after the development of colour. 10 mg/l of standard potassium nitrate was prepared and absorbance read.

$$\text{Concentration of Sample} = \frac{\text{Absorbance x Concentration of Standard}}{\text{Absorbance of Standard}}$$

2.12 Determination of Phosphate

Phosphate was measured using standard method 4500 - P B.5 and 4500 - PE [16]. Using PD303 UV spectrophotometer.

Exactly 100 ml of the homogenized and filtered sample was pipetted into a conical flask. The same volume of distilled water (serving as control) was also pipette into another conical flask. 1ml of 18 m H_2SO_4 and 0.89 g of ammonium per sulphate were added to both conical flasks and gently boiled for $1^1/_2$hrs, keeping the volume of 25 - 50 cm^3 with distilled water. It was then cooled, one drop of phenolphthalein indicator was added and after neutralized to a faint pink colour with the 2M NaOH solution. The pink colour was discharged by drop wise addition of 2M HC1 and the solution made up to 100 ml with distilled water for the volumetric analysis. 20ml of the sample was pipetted into the test tubes. 10 ml of the combined reagent added, shaken and left to stand for 10 minutes before reading the absorbance at 690nm on a spectrophotometer, using 20 ml of distilled water plus 1 ml of the reagent as reference.

Standard phosphate Solution: 10 mg of dried AR potassium hydrogen phosphate was dissolve in distilled water and made up to 1000 ml. Standard treated like samples and absorbance read.

$$\text{Concentration of Sample} = \frac{\text{Absorbance of Sample x Concentration of Standard}}{\text{Absorbance of Standard}}$$

3. RESULTS AND DISCUSSION

Table 1. Physicochemical Characteristics of Groundwater from Umuchichi

		SAMPLE			
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**
pH	3.5	7.1	8.3	6.3 ± 1.44	6.5-8.5
Conductivity (µS/cm)	0.46	0.13	0.92	0.5 ± 0.23	100
Magnesium Hardness (mg/L)	28	28	58	38 ± 10.00	70
Alkalinity (mg/L)	38.5	21	9.5	23 ± 8.43	500
Total Hardness (mg/L)	60	58	94	70.7 ± 11.68	500
Calcium Hardness (mg/L)	32	30	36	32.7 ± 1.76	70
Chloride (mg/L)	95	74	86	85 ± 6.08	250
TDS (mg/L)	1.32	1.5	1.42	1.97 ± 0.05	1000
Sulphate(mg/L)	218.51	249.78	251.02	239.8 ± 10.64	400
Nitrate (mg/L)	1.48	1.62	1.77	1.62 ± 0.08	50
Phosphate (mg/L)	9.25	6.42	8.39	8.02 ± 0.84	10

WHO STD = World Health Organization Standard (2006)

Table 1 gives the various levels of parameters against the WHO standard. The mean level of conductivity result for the groundwater in Umuchichi is 0.5 µS/cm. This is below the WHO Standard of 100 µS/cm. This is not a threat as low conductivity level indicates purity of the water sample, however, caution is necessary as very low conductivity would indicate lack of essential minerals needed for human health. Hence the groundwater from Umueme with mean conductivity level of 0.75 µS/cm, though not of much difference, offer better health benefits compared with that for Umuchichi and Uratta because it has higher mineral content. The mean pH level of groundwater from Umuchichi with a value of 6.3 which is a little below the WHO standard (6.5). However, that of Umueme (7.97) and Uratta (7.27) are higher WHO standard (6.5), hence groundwater from Umuchichi is more acidic than that in Umueme and Uratta. From the results borehole water will be safe for household uses and industrial purposes in Aba city and also the failure rate of boreholes in the town will predictably be very low in Umuchichi, however, caution needs to be taken when borehole drilling in Umueme where there is high rate of dumpsite located there (Fig.2.2; [17]).

Open dumps, in particular, are sited indiscriminately in the study area without consideration to the protection of the underlying aquifers. However, the mean pH result obtained in Umuchichi (6.3) is not consistent with that of [18] who observed a higher mean pH value of 6.5.

Table 2 Physicochemical Characteristics of Groundwater from Umueme

		SAMPLE			
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**
pH	8.7	7.1	8.1	7.97 ± 0.47	6.5-8.5
Conductivity (µS/cm)	0.59	0.68	0.98	0.75 ± 0.12	100
Magnesium Hardness (mg/L)	30	21	43	31.33 ± 6.39	70
Alkalinity(mg/L)	38.5	31	9.4	26.3 ± 8.72	500
Total Hardness (mg/L)	51	58	96	68.3 ± 13.98	500
Calcium Hardness (mg/L)	32	35	36	34.33 ± 1.20	70
Chloride (mg/L)	95	70	80	81.67 ± 7.26	250
TDS (mg/L)	1.3	1.7	3.06	2.02 ± 0.53	1000
Sulphate (mg/L)	203.41	230.12	251.02	228.18 ± 13.78	400
Nitrate (mg/L)	1.48	1.57	1.35	1.47 ± 0.06	50
Phosphate (mg/L)	9	8.65	8.01	8.55 ± 0.29	10

WHO STD = World Health Organization Standard (2006)

Table 2 shows the mean level of total dissolved solid of the groundwater for Umueme which is the highest of the three communities. It has a mean level of 2.02 mg/L. This accounts for its high conductivity of 0.75 µS/cm the high level total dissolved solids indicate the high level of mineral content in the groundwater from Umueme which is really good for the health. Groundwater suitable for drinking, household purposes and industrial purpose need to have a certain degree of conductivity in order for the pipes in the plumbing system not to corrode faster. Drinking water of high purity can lead to corrosion of wells and lack the necessary minerals for building bones and body tissues. Hence ground water from Umueme has the best properties when it comes to mineral content. It contains good levels of ions. However, the sample I is highly alkaline out of the three communities. The likely reason is due to the companies GZI and Glassforce surrounding it that disposes its alkaline waste chose to the stream. The groundwater form there needs close monitoring and treatment.

In a comparative study in Enugu state [19] obtained a mean pH value of 6.6 showing that the ground water from this location being more acidic than the groundwater from Umueme (7.97)

Table 3: Physicochemical Analysis of Groundwater from Uratta

	SAMPLE				
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**
pH	8	5.4	8.4	7.27 ± 0.94	6.5-8.5
Conductivity (µS/cm)	0.5	0.13	0.9	0.51 ± 0.22	100
Magnesium Hardness (mg/L)	28	25	47	33.33 ± 6.89	70
Alkalinity (mg/L)	36.5	20	10	22.16 ± 7.73	500
Total Hardness (mg/L)	60	50	91	67 ± 12.34	500
Calcium Hardness (mg/L)	32	36	25	31 ± 3.21	70
Chloride (mg/L)	86	70	68	74.67 ± 5.70	250
TDS (mg/L)	1.98	1.9	2.02	1.97 ± 0.04	1000
Sulphate (mg/L)	210.2	236.3	240.05	228.85 ± 9.39	400

Nitrate (mg/L)	1.35	1.8	1.68	1.61 ± 0.13	50
Phosphate (mg/L)	8.45	6.56	8.36	7.79 ± 0.62	10

WHO STD = World Health Organization Standard(2006)

As shown in Table 3 The groundwater from Uratta has a mean pH of 8.4 which is within the WHO standard and has a mean total hardness of 91 mg/L which is the lowest of the three communities. This low hardness property is really good as this will make the groundwater from this area good for washing/household purposes) and industrial (dry cleaning services) purposes.

A comparative study was made in Anambra state with respect to few physicochemical properties of the underground water Godspower *et. al*., (2020) observed the mean nitrate content to be 2.2 mg/L which is higher than the mean nitrate content of groundwater from Uratta being 1.61 mg/L which are all below the WHO standard of 50 mg/L.

Table 4: Analysis of Heavy metals on Groundwater from Umuchichi

	SAMPLE					
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**	**% DEV**
Manganese (mg/L)	0.03	0.02	0.07	0.04 ± 0.02	0.3	0.13
Iron (mg/L)	0.02	0.04	0.03	0.03 ± 0.01	0.03	1.00
Copper (mg/L)	0.05	0.05	0.05	0.05 ± 0.00	2	0.025
Arsenic (mg/L)	0	0	0	0.00 ± 0.00	0.01	0.00
Chromium (mg/L)	0.06	0.03	0.03	0.04 ± 0.01	0.05	0.80

Lead (mg/L)	0.01	0.02	0.01	0.01 ± 0.00	0.005	2.00

% DEV. = Percent Deviation
WHO STD = World Health Organization Standard(2006)

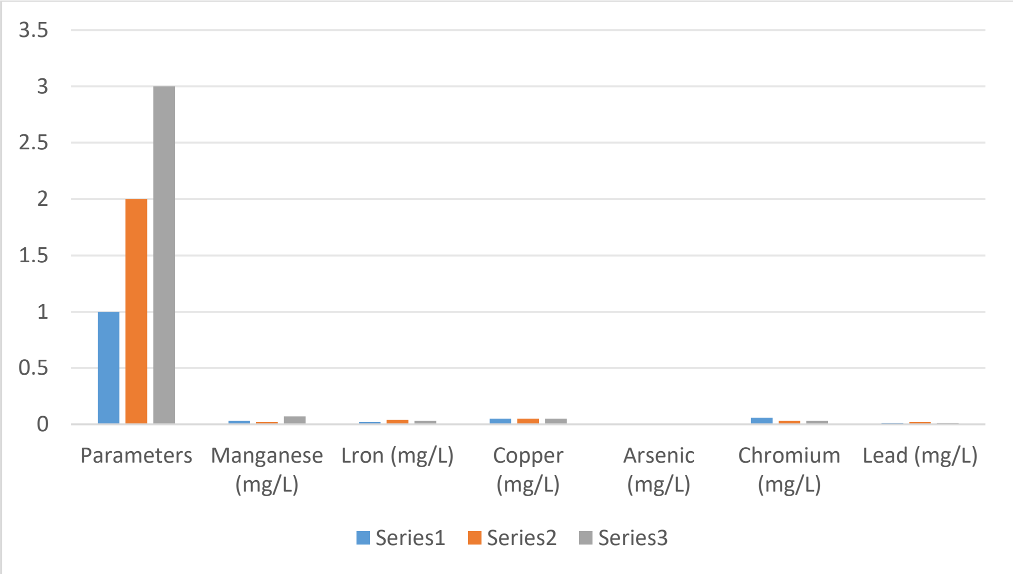


Fig 2: Concentration of heavy metals in groundwater from Umuchichi

The metal ions characteristics of the groundwater results from Umuchichi (Table 4) showed that Arsenic, is not found in the groundwater from Umuchichi, this is equally the same for all the two other communities, Umueme and Uratta. Worth of note is the fact that Arsenic is classified as a human carcinogen by the International Agency for Research on Cancer, hence, groundwater from Umuchichi, Umueme and Uratta being free of Arsenic, is good for household purposes. However, it has lead level up to 2% more than the recommended WHO level. This can be a cause for concern if it is not monitored, since lead in drinking water can lead to lead poisoning which can cause neurological damage and increased risk of cardiovascular and kidney issues in human beings that use them.

The level of Mn and Fe are 0.13% and 1% respectively of the WHO recommended level. These values are tolerable. Iron is a trace mineral. It is found in groundwater of Umuchichi, however trace elements are toxic at an intake far above the estimated requirements [21].

In Akwa Ibom State a few selected boreholes were analyzed for heavy metal content it was observed that all water samples contained iron concentration 0.551 mg/L which is much higher than that observed in Umuchichi groundwater with Iron content of 0.03 mg/L [22].

Table 5: Heavy metals characteristics on ground water from Umueme

	SAMPLE					
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**	**% DEV**
Manganese (mg/L)	0.04	0.01	0.07	0.04 ± 0.02	0.3	0.13
Iron (mg/L)	0.06	0.03	0.03	0.04 ± 0.01	0.03	1.33
Copper (mg/L)	0.05	0.05	0.05	0.05 ± 0.00	2	0.025
Arsenic (mg/L)	0.00	0.00	0.00	0.00 ± 0.00	0.01	0.00
Chromium (mg/L)	0.06	0.03	0.03	0.04 ± 0.01	0.05	0.80
Lead (mg/L)	0.01	0.02	0.01	0.01 ± 0.00	0.005	2.00

% DEV. = Percent Deviation
WHO STD = World Health Organization Standard (2006)

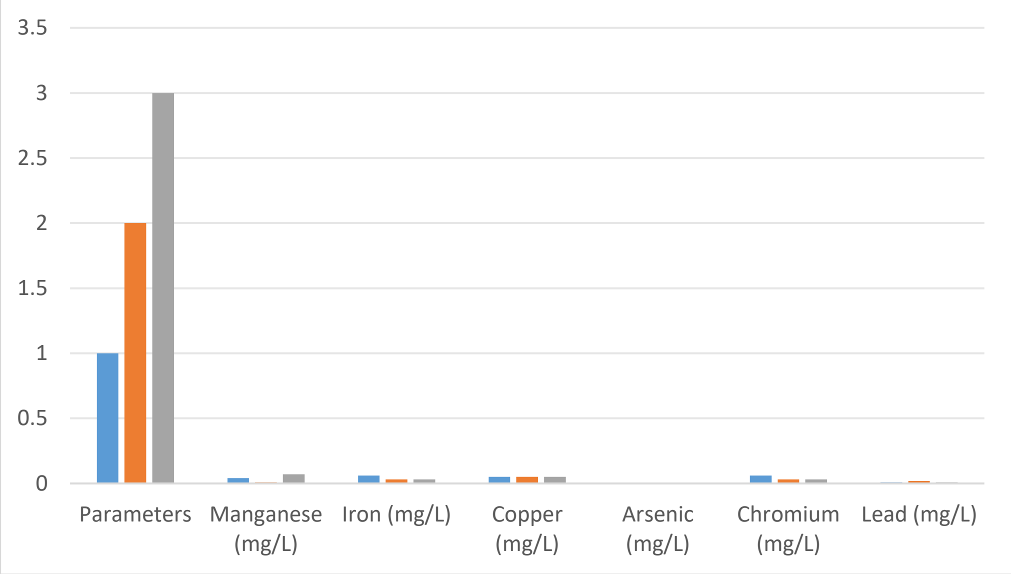


Fig 3: Concentration of heavy metals in groundwater from Umueme

The values for the level of heavy metals present in Umueme is as presented in Table 4.5. Just as in the case of Umuchichi the as level is 0.00Mg/L ad the mean Pb level is 0.01 mg/L which is 2% above the WHO recommended Level. The Iron level is 1.33% of the WHO recommended level, this is a substantial percentage. Trace elements like Iron are toxic at an intake far above the estimated requirements however this is not as critical as the level of Lead, Pb, present in the groundwater from Umueme Since a high level of Pb. Present in the groundwater from Umueme since a high level of Pb level is most likely from the antiknock agents such lead tetraethyl used in the heavy machine in these factories.

In Ifite Ogwari, Anambra State a study of few heavy metals were carried out on the underground water [23] observed the mean Copper content to be 0.07 mg/L which is higher than the concentration level of Copper in groundwater from Umueme of value 0.05 mg/L.

Table 6: Analysis of Heavy metals on Groundwater from Uratta

	SAMPLE					
Parameters	**1**	**2**	**3**	**MEAN**	**WHO STD**	**% DEV**
Manganese (mg/L)	0.03	0.01	0.06	0.03 ± 0.01	0.3	0.13
Lron (mg/L)	0.05	0.02	0.03	0.03 ± 0.01	0.03	1.33
Copper (mg/L)	0.02	0.01	0.04	0.02 ± 0.01	2	0.01
Arsenic (mg/L)	0.00	0.00	0.00	0.00 ± 0.00	0.01	0.00
Chromium (mg/L)	0.01	0.03	0.02	0.02 ± 0.01	0.05	0.60
Lead (mg/L)	0.00	0.00	0.07	0.003 ± 0.02	0.005	0.60

% DEV. = Percent Deviation
WHO STD = World Health Organization Standard (2006)

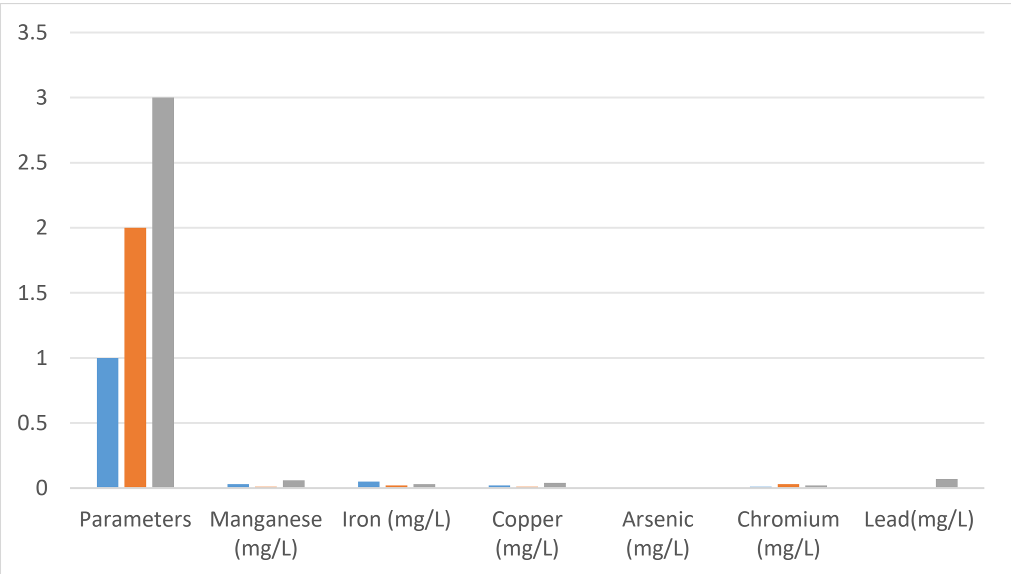
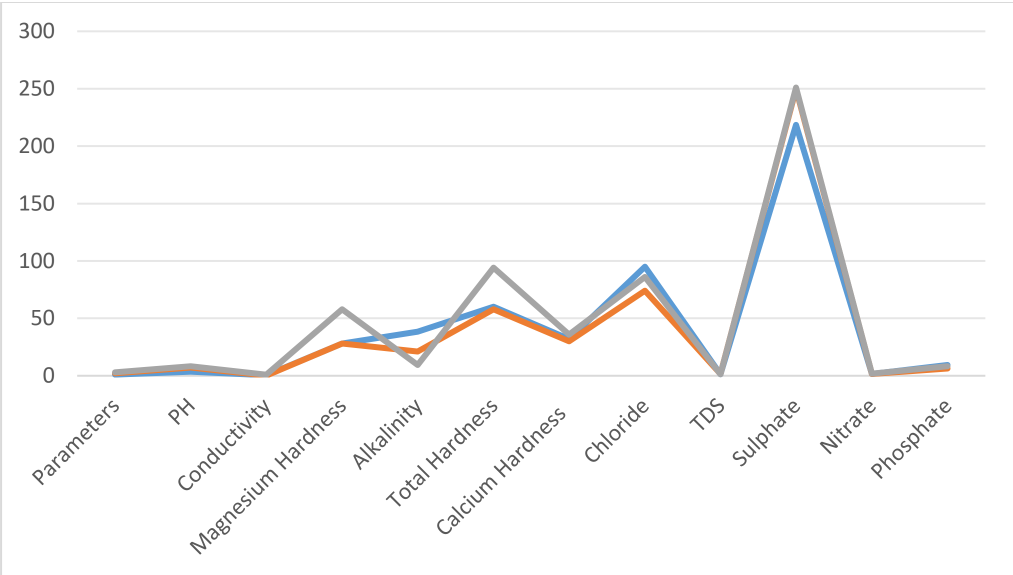


Fig 4: Concentration of heavy metals in groundwater from Uratta

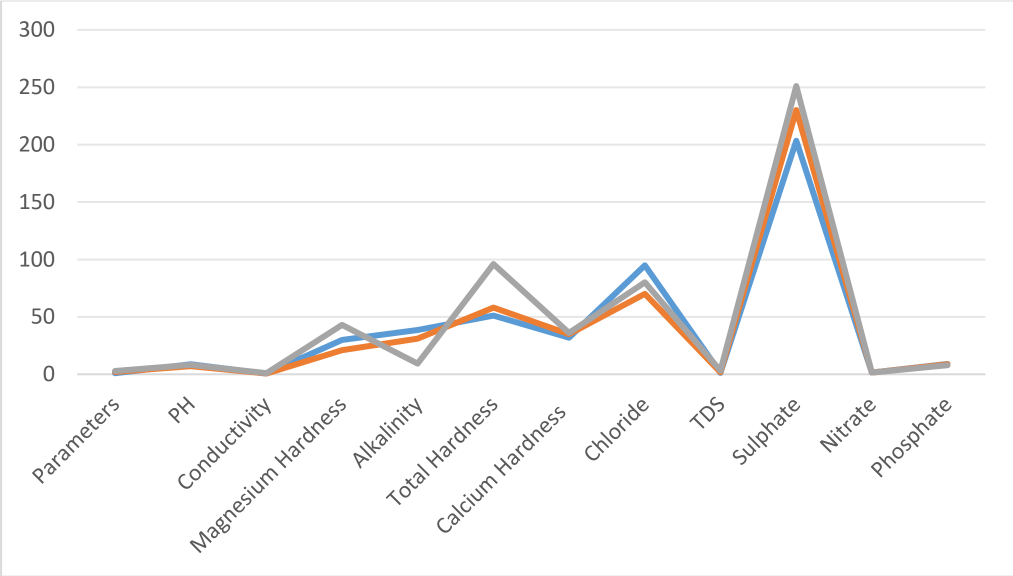
The levels of heavy metals in the groundwater from Uratta is presented in table here the Pb, level is 0.6% of the WHO recommended level which is a safe level. Out of all the metals tested it has as its highest concentration Fe which is at 1.33% of the WHO recommended level. Hence of the three communities' level of groundwater from Uratta has the safest Level of heavy metal composition,

A similar study was made in Zamfara state. [24] observed that the manganese level of 0.01 mg/L was lower than that observed in groundwater from Uratta of mean concentration level 0.03 mg/L.

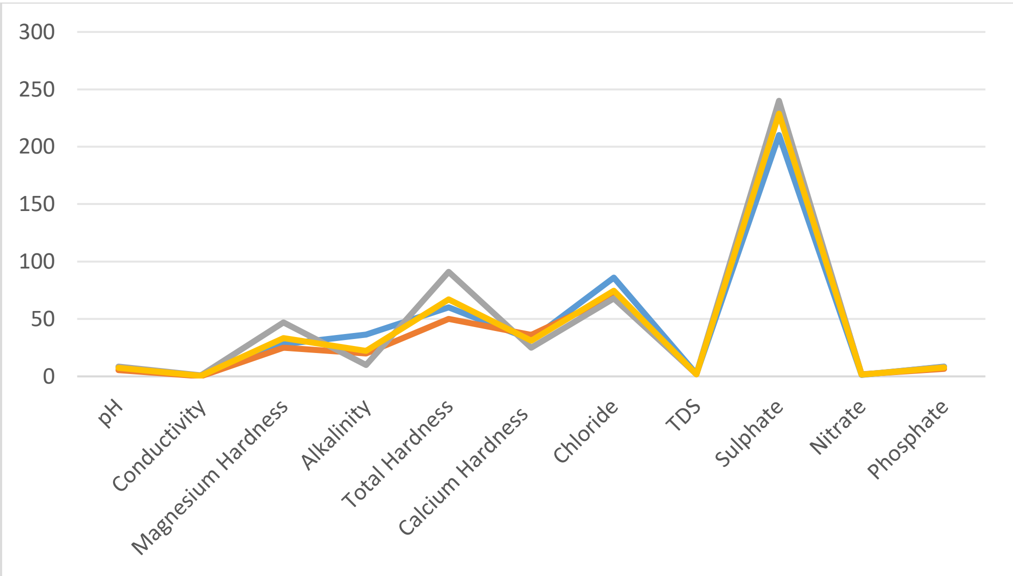
MEAN PLOTS OF PHYSICOCHEMICAL PARAMETER OF GROUNDWATER IN UMUCHICHI



MEAN PLOTS OF PHYSICOCHEMICAL PARAMETER OF GROUNDWATER IN UMUEME



MEAN PLOTS OF PHYSICOCHEMICAL PARAMETER OF GROUNDWATER IN URATTA



RESULTS OF MATLAB AND ANN

MATLAB GRAPHS

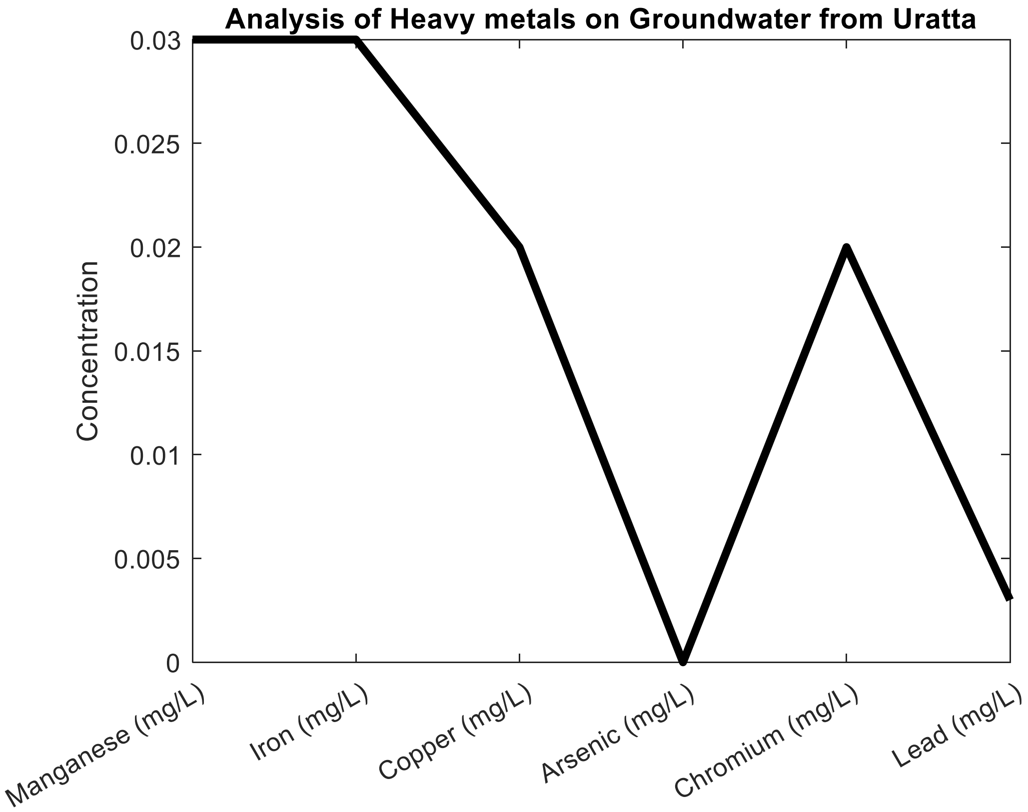


Figure 1; heavy metal analysis on groundwater from uratta using MatLab

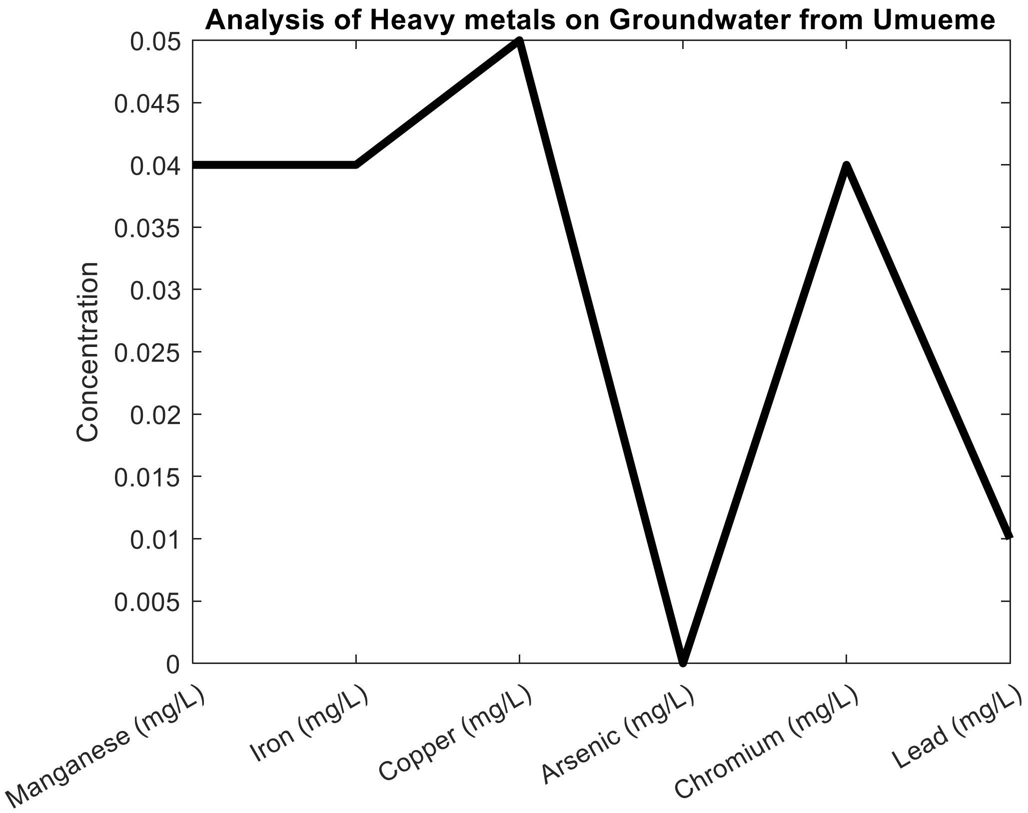


Figure 2; heavy metal analysis on groundwater from umueme using MatLab

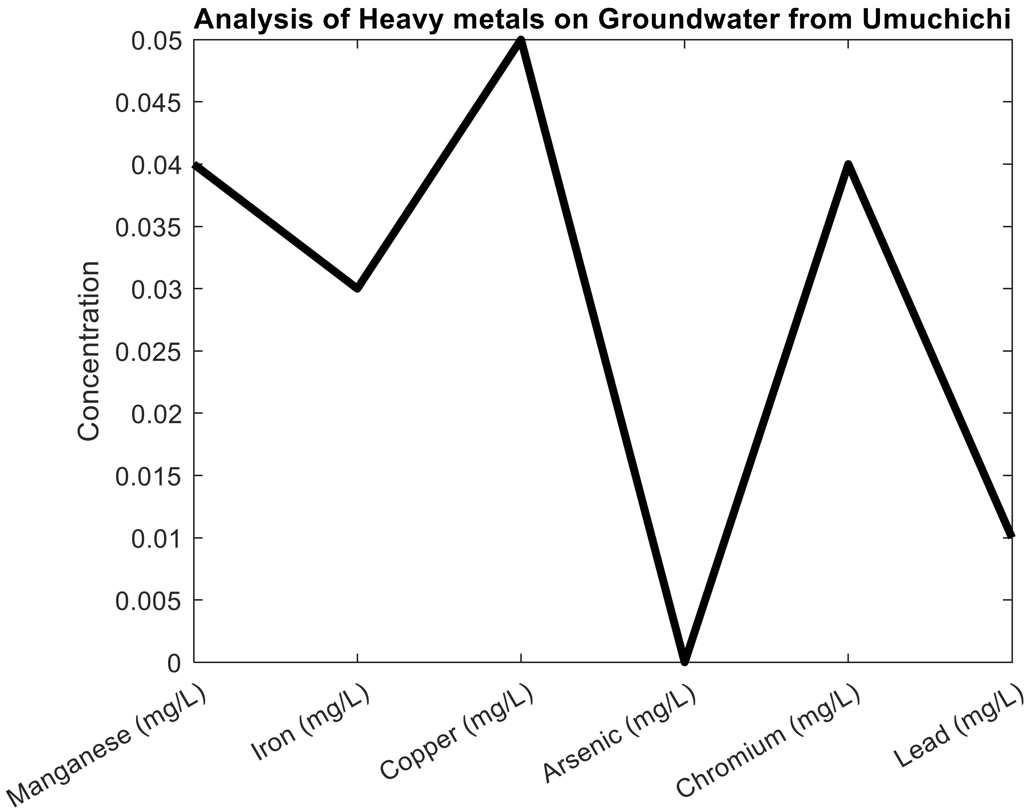


Figure 3; Heavy metal analysis on groundwater from umuchichi using MatLab

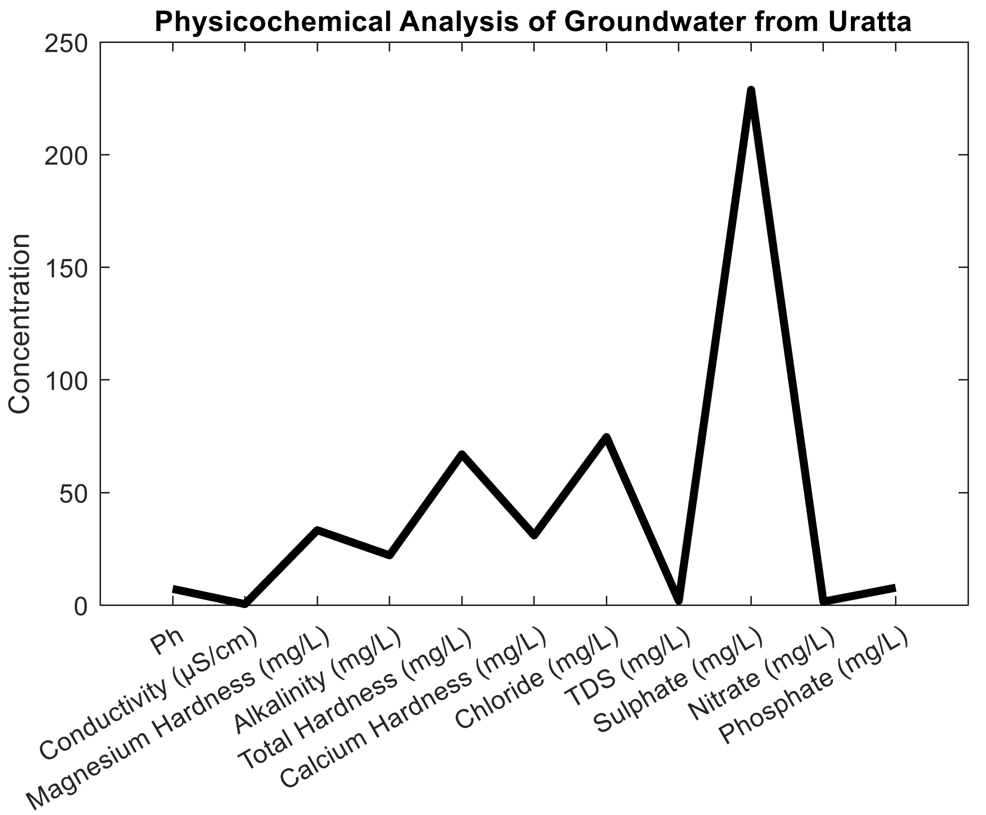


Figure 4; physicochemical analysis on groundwater from uratta using MatLab

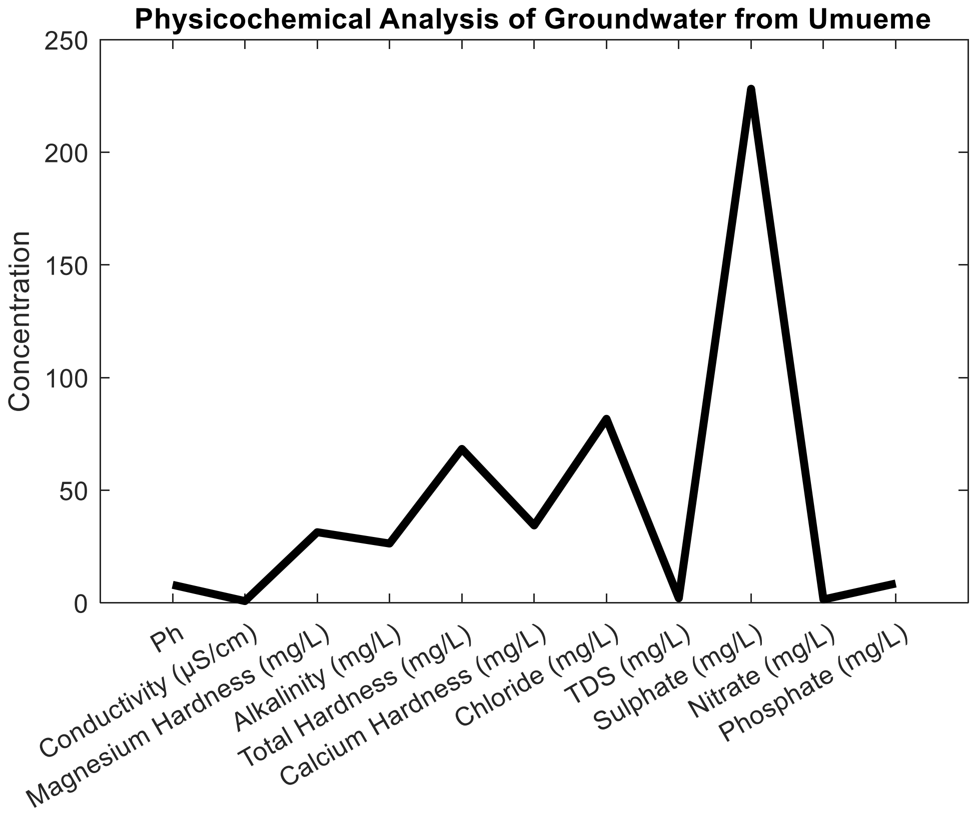


Figure 5; physicochemical analysis on groundwater from umueme using MatLab

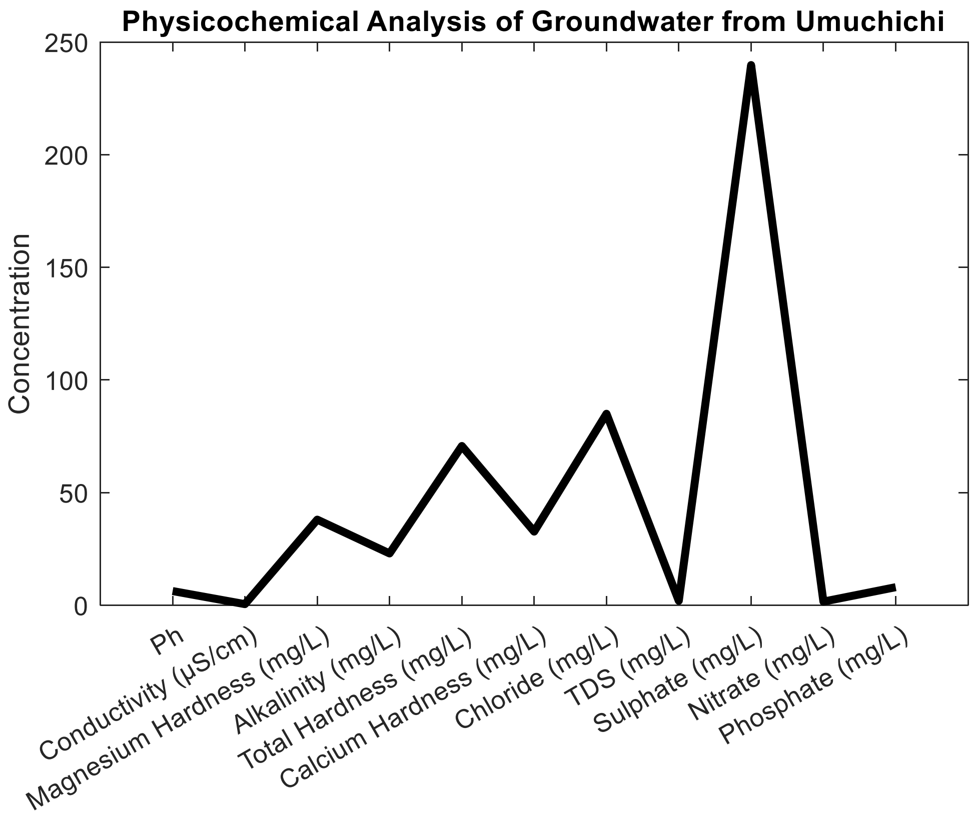


Figure 6; physicochemical analysis on groundwater from uratta using MatLab

FOR ANN

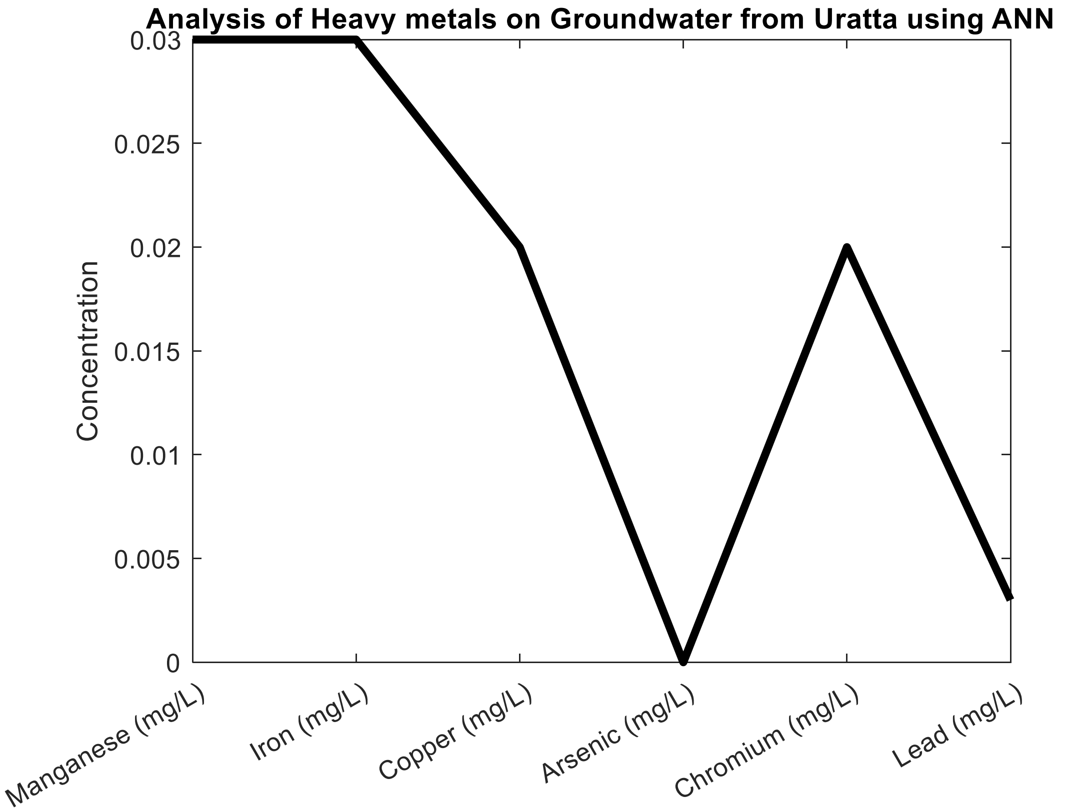


Figure 7; Heavy metal analysis on groundwater from uratta using ANN

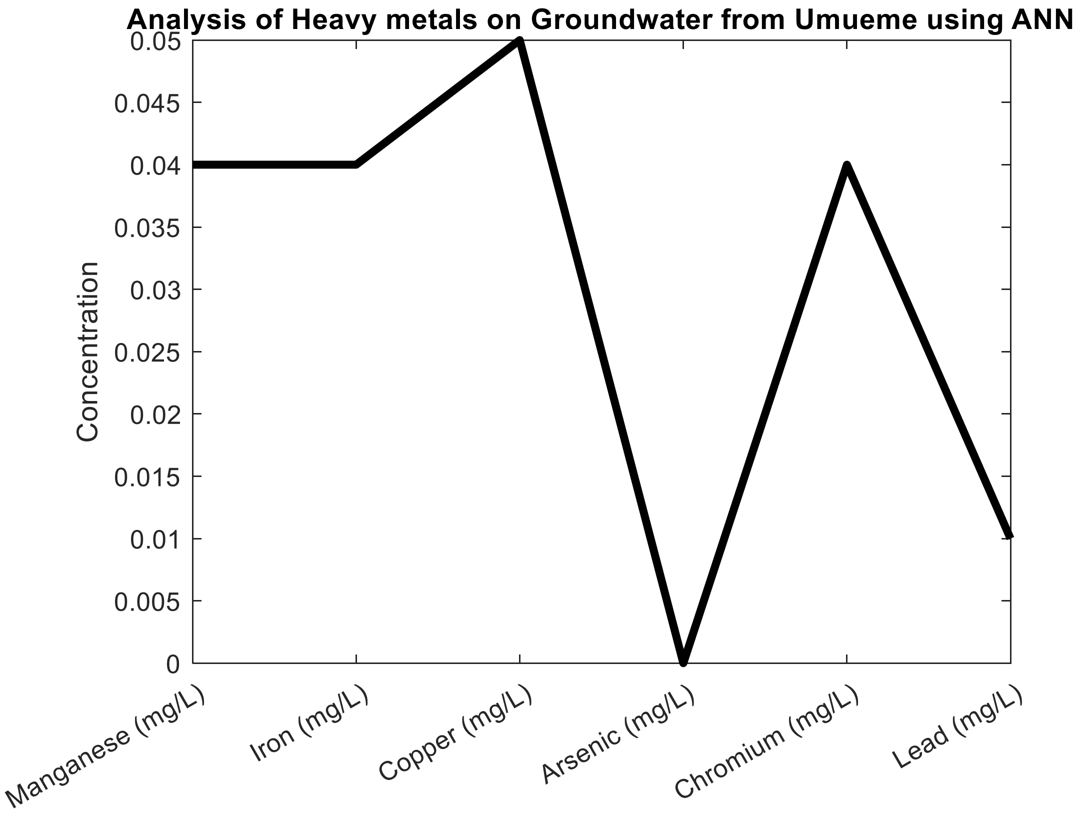


Figure 8; Heavy metal analysis on groundwater from umueme using ANN

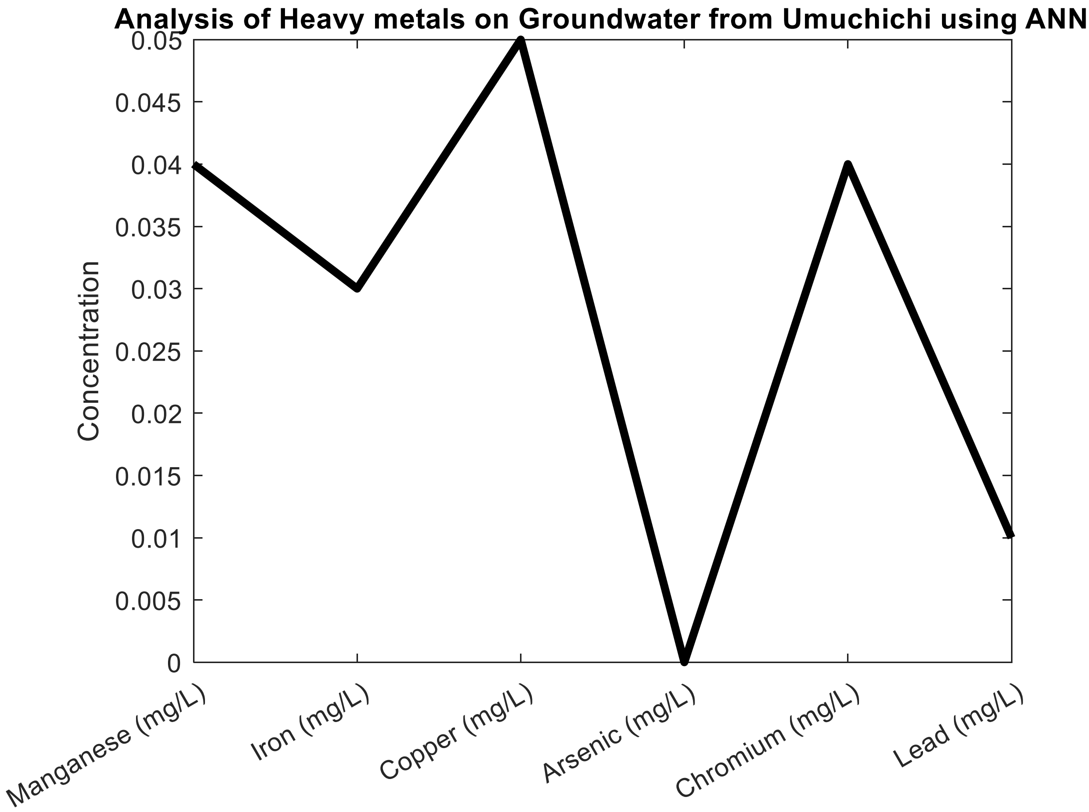


Figure 8; Heavy metal analysis on groundwater from umuchichi using ANN

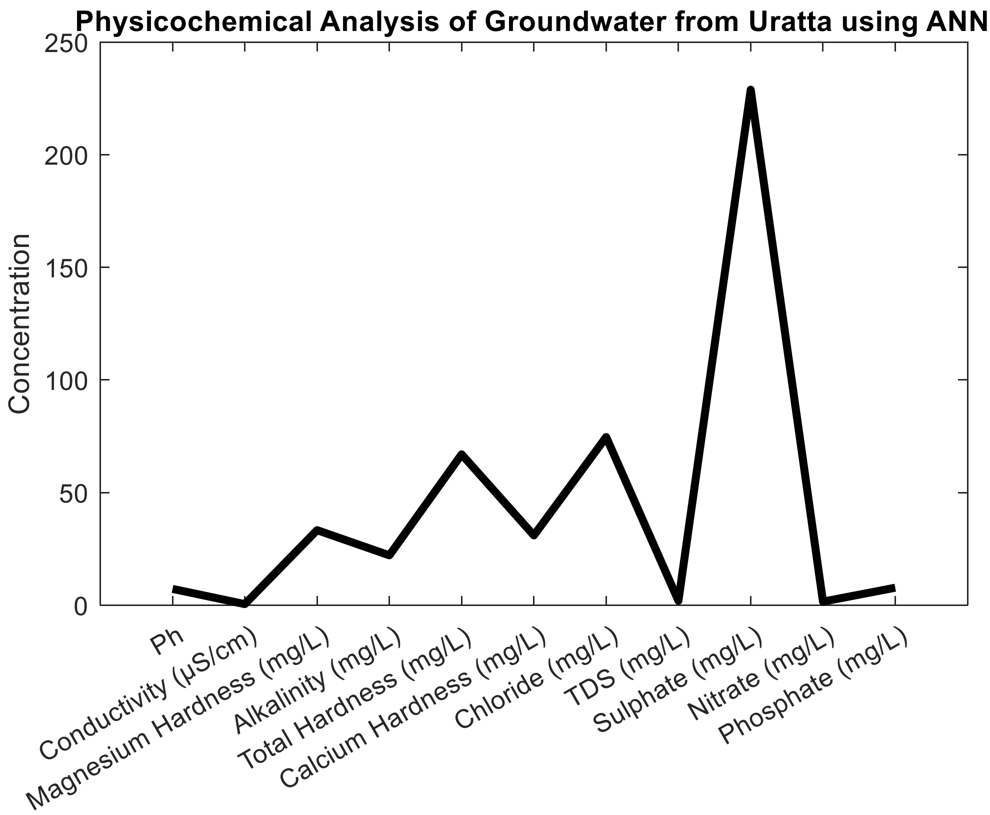


Figure 10; physicochemical analysis on groundwater from uratta using ANN

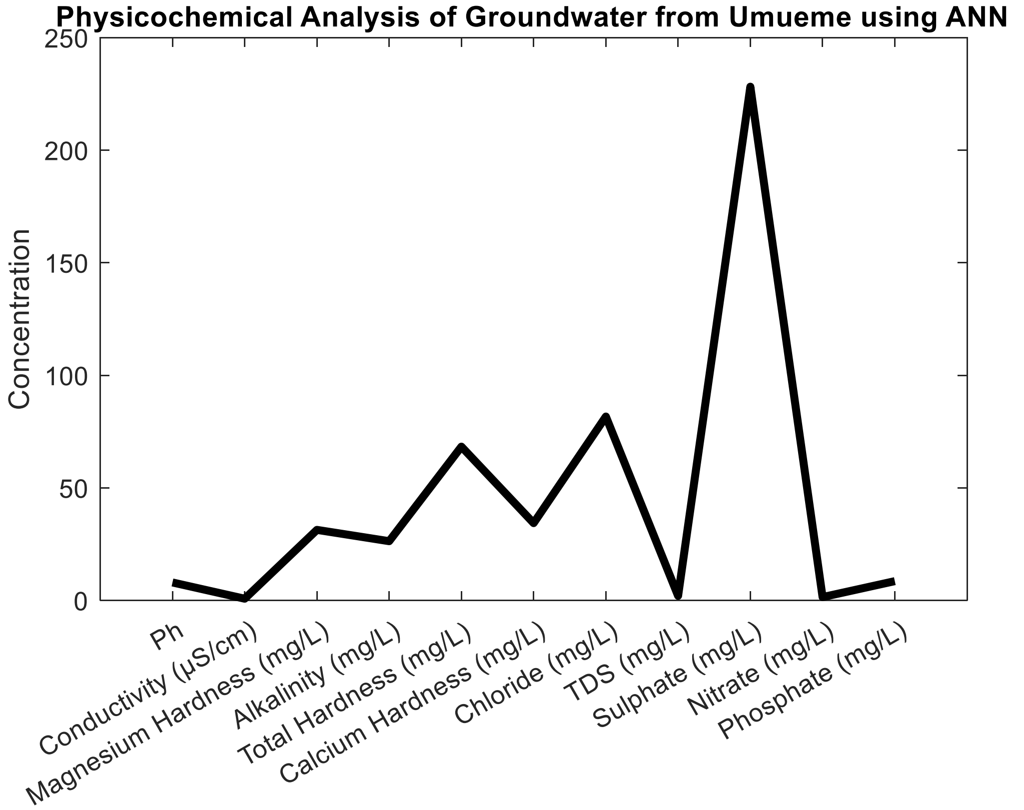


Figure 11; physicochemical analysis on groundwater from umueme using ANN

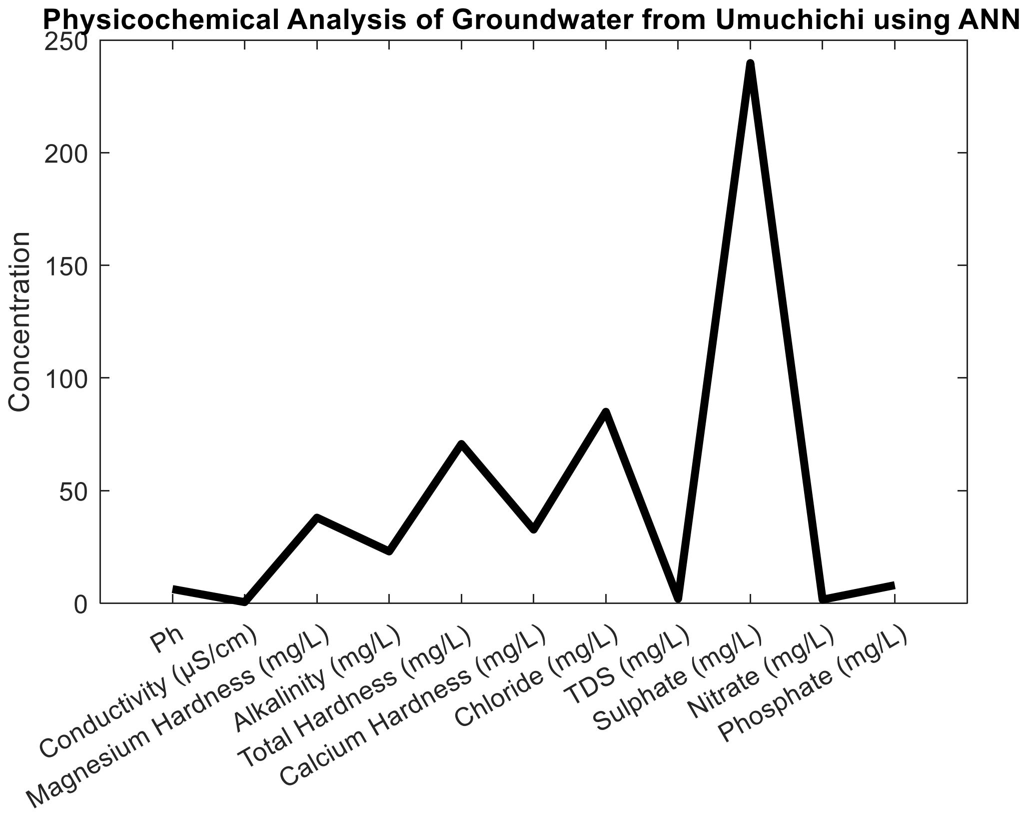


Figure 12; physicochemical analysis on groundwater from umuchichi using ANN

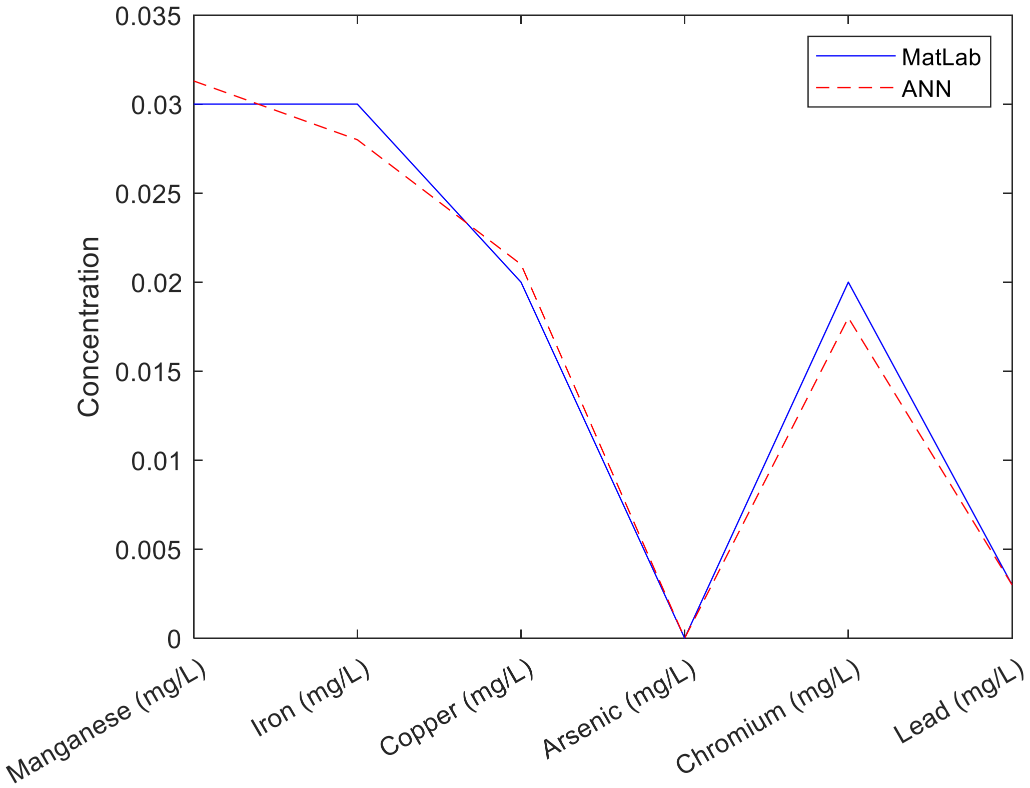


Figure 13; Comparative Plots of Heavy metal analysis on groundwater from **uratta** using MatLab and ANN

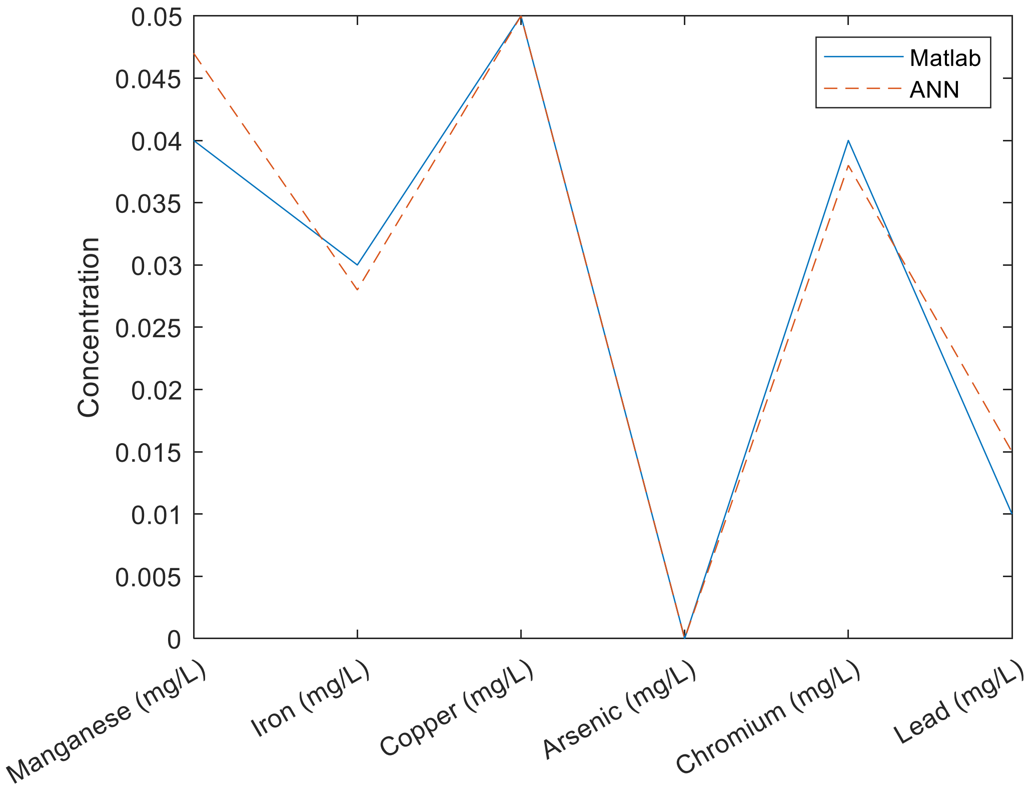


Figure 14; Comparative Plots of Heavy metal analysis on groundwater from umueme using MatLab and ANN

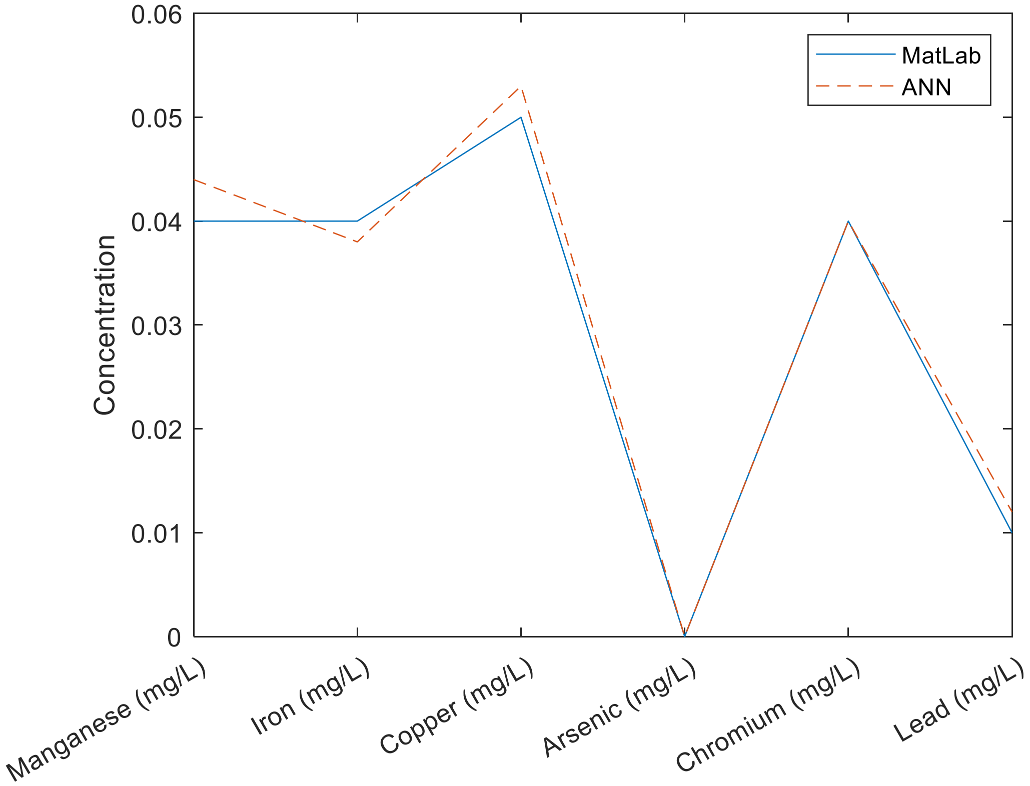


Figure 15; Comparative Plots of Heavy metal analysis on groundwater from umuchichi using MatLab and ANN

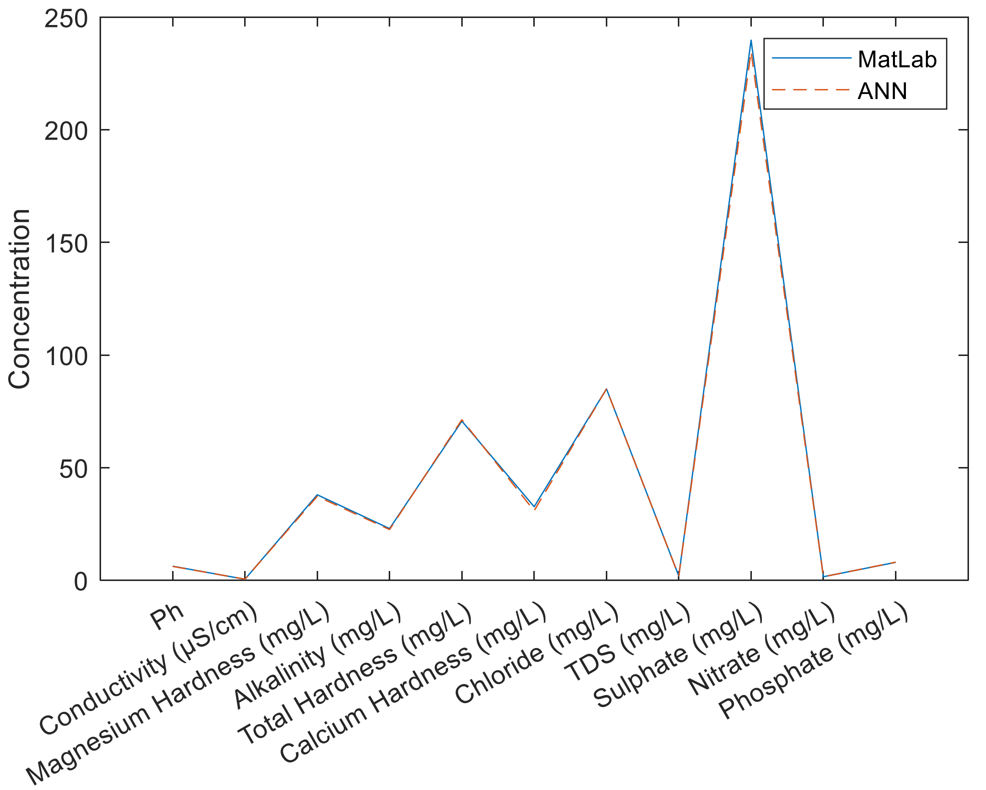


Figure 16; Comparative Plots of physiocochemical analysis on groundwater from uratta using MatLab and ANN

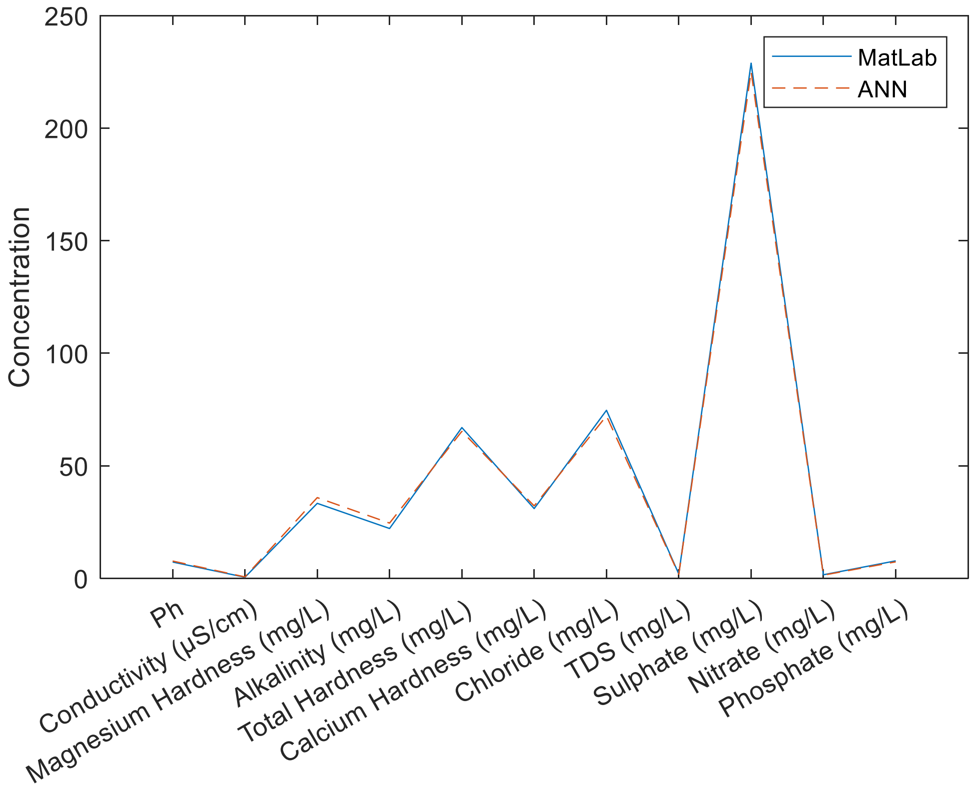


Figure 17; Comparative Plots of physiocochemical analysis on groundwater from umueme using MatLab and ANN

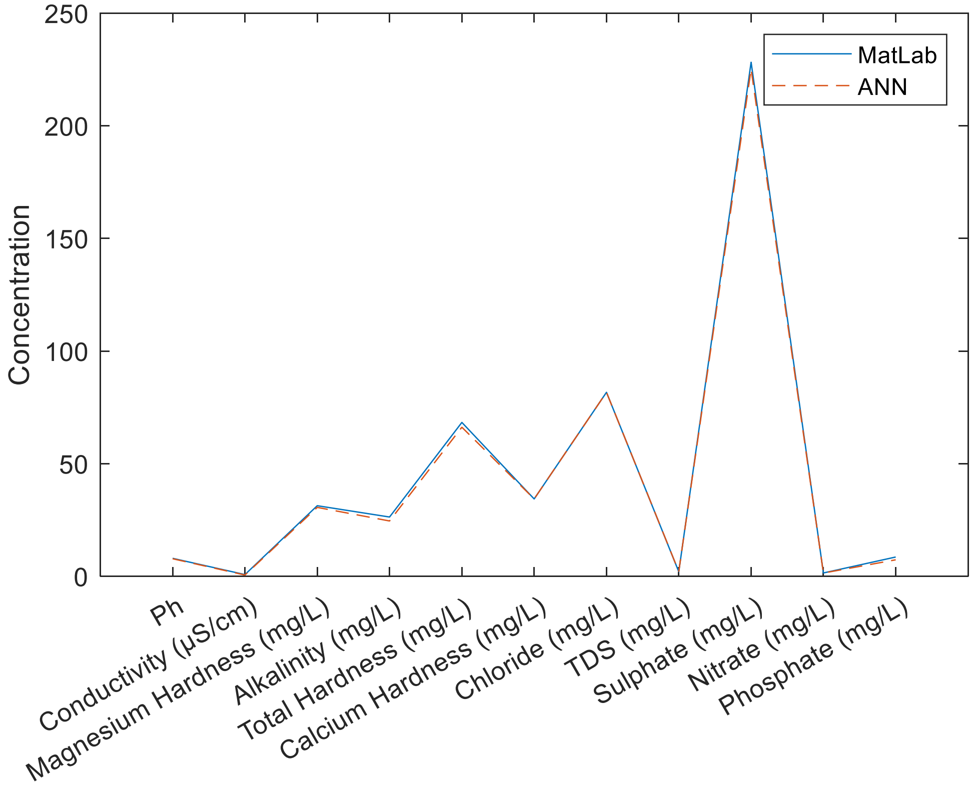


Figure 18; Comparative Plots of physiocochemical analysis on groundwater from umuchichi using MatLab and ANN

4. CONCLUSION

The results showed that the deviations of the important parameters such as pH, conductivity, magnesium hardness, alkalinity, total hardness, calcium hardness, chloride, total dissolved solids, sulphate, nitrate, phosphate and the key heavy metals in the groundwater compared with standard in line with World Health Organization are not above the World Health Organization permissible limit, except the groundwater in Umuchichi and Umueme. Hence groundwater in Aba and its environs is good for both domestics/household and industrial purposes. Umueme and Umuchichi groundwater must be monitored for its high level of Pb content.

Recommendations

1. Regular pH testing should be instituted in areas like Umuchichi 1 and Umueme where acidic water (pH 3.5-4.48) was observed. Such low pH values may contribute to pipe corrosion and metal leaching, posing health risks.
2. Acidic water sources should be treated using neutralizing agents such as limestone filters or soda ash dosing systems to raise the pH to the WHO-recommended range (6.5–8.5).
3. Educate residents of affected communities, particularly in Umueme and Umuchichi, about the potential health implications of consuming acidic water.
4. Since high alkalinity was observed in several samples (e.g., Uratta 3 and Umuchichi 3), infrastructure upgrades like lining wells and boreholes can help prevent infiltration of acidic materials to forestall borehole failure.
5. Although EC levels were within acceptable limits across all locations, continuous monitoring is advised to detect any future increase in dissolved solids or salinity, especially as urbanization and industrial activities increase in Aba.

Contribution to Knowledge

This study has revealed that lead levels should always be monitored as it is a risk factor, and could, if not checkmated lead to high pollution levels. Hence this data accumulated in this study can assist well/borehole drillers. This would guide them to know the current level of heavy metals in the aquifers and know what instruments and technical know-how to employ to achieve the best results during the well drilling process in the area.

AUTHORS' CONTRIBUTION:

1. **S.K. Egereonu:** Performed Basic Computation, Generated the ANN, MATLAB graphs, Writing, Review and Editing.
2. **U.U. Egereonu:** Supervision, Conceptualization, Prepared Manuscript, Methodology, Writing, Review, Editing, Generated the ANN and MATLAB graphs
3. **C. O Alisa:** Data Analysis, Prepared Manuscript, Supervision, Writing Review, Editing, Generated the ANN and MATLAB graphs.
4. **U.C. Onyeije:** Supervision, Data Curation, Performed Basic Computations, Generated the ANN and MATLAB graphs.
5. **E.C. Amadi**: Validation, Writing, Review, Editing and Data Curation.

6. **O.C. Nwokonkwo:** Writing, Review, Editing and Data Curation.
7. **A. I. Otuonye:** Writing, Review, Editing and Data Curation.
8. **O. Okwum:** Conceptualization, Prepared Manuscript, Methodology, Writing, Review and Editing.
9. **M.N. Uyanwa:** Performed Basic Computation, Generated the ANN, MATLAB graphs, Writing, Review and Editing.
10. **I.B Omenihu:** Performed Basic Computation, Generated the ANN, MATLAB graphs, Writing, Review and Editing.
11. **J.C. Egereonu:** Validation, Writing, Review, Editing and Data Curation

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