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Physicochemical Assessment of Water from Selected Wells in Enugu South Local Government Area of Enugu State, Nigeria

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ABSTRACT

The water quality parameters in well water samples from ten (10) selected wells located in four different communities in Enugu South Local Government Area were analyzed in order to access the well water quality of the area. Water samples were analysed for a period of six months. The first samples were collected in November, December (2013) and January (2014). The second sampling was done in May, June and July (2014). Among the parameters for quality check include: pH, temperature, turbidity, Dissolved Oxygen, Chemical Oxygen Demand, Total Suspended Solids, conductivity, nitrate, hardness, calcium and magnesium. Physicochemical parameters were determined using standard methods of analysis. Most of the parameters analyzed were within the WHO limits. The following parameters showed slight elevation above WHO standard from their calculated mean: the pH of all the samples depicted acidity, samples 7 and 8 showed turbidity 31.10 and 14.5 NTU respectively which is far above WHO values. Sample 3 had the highest value of nitrate (51.4mg/l), followed by sample 1(44.2mg/l), then sample 2 (30.4) and sample 9(13.3mg/l). Sample 7 had the highest TDS value (279mg/l) and conductivity (470µS/cm). This study showed that these well samples are not fit for human consumption without treatment. Thorough water treatment is needed accordingly to reduce turbidity and bring pH to level of portability.

Key words: *well, water, quality, physicochemical, properties, contaminants, Enugu South.*

INTRODUCTION

Water indeed is an essential component of life[1]. It plays a significant role in the continuity of life due to its unique qualities[2,3]. Pure water needed for human consumption does not always occur in nature, due to the presence of dissolved or suspended impurities in most natural water bodies[4].

There is a global recognition that groundwater quality is as important as its quantity. Current emphasis is not only on how abundant water is, but also on whether its quality status is good enough to sustain its various uses[5]. The quality of groundwater determines its usability for domestic, industrial and agricultural purposes.

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The chemical composition of groundwater and the water types found in an environment are determined greatly by local geology, types of minerals found in the environment through which the recharge and groundwater flows[6]. An array of environmental pollution and degradation problems currently besiege Nigeria and other developing nations. These are occasioned from socio economic ventures such as oil exploration /exploitation, industrialization, agriculture, and infrastructural development, transportation and solid mineral extraction [7]. Since the Government was unable to supply pump borne water to all the communities in Enugu State, people resorted to use of well water as the alternative source of water.

In Nigeria today, several studies have been carried out in urban areas on groundwater contamination[8,9]. These studies are that groundwater is highly contaminated and clinically unsafe for human consumption. With the increasing population densities of urban areas, it is increasingly difficult to meet all the water requirements in quantity, regularity and quality[10]. There are three broad types of contaminants present in leachates that can pollute groundwater and subsequently affects public health. These are hazardous chemicals, conventional and non-conventional contaminates[10]. The cost of cleaning up groundwater contaminated by Municipal Solid Waste landfill leachates requires a large sum of money and technology, which are presently not available in our society[10]. Thus, it is important that efforts are geared towards preventing pollution that will arise from leachate. The leachate from some landfills is highly concentrated that small amount of leachate can pollute large amount of groundwater rendering it unsuitable for use in domestic activities[10]. Most of the infections can be attributed to lack of safe drinking water (like cholera, typhoid, Hepatitis, Poliomyelitis etc)[11]. The source of water contamination responsible for the spread of infectious diseases is almost invariably faeces[12, 13]. Drinking contaminated groundwater can have serious health effects. Diseases such as hepatitis and dysentery may be caused by contamination from septic tank waste. Poisoning may be caused by toxins that have leached into well water supplies [14]. Many water resources are unhealthy because they contain harmful physical, chemical and biological agents. To maintain a good health however, water should be safe to drink, meet the local standards, ensure sustainability of national and internal criteria and guidelines established for water quality standards[15, 16].

Safe location of borehole or well requires a careful consideration of factors such as where the borehole or well is in relation to surface drainage and groundwater flow[17]. Pollution of groundwater stems from different sources[18].These include insanitary condition during borehole construction, splashing of runoff into open wells, flooding at borehole site, leachate from buried waste pit or latrine, industrial wastes and sewage into the hole through cracks in aquifer and annular of the hole[19,11]. This study is intended to assess the physical and chemical qualities of well water in Enugu South local Government Area of Enugu state based on World Health Organization (WHO) guideline for drinking water standard.

MATERIALS AND METHODS

STUDY AREA

Enugu south local government area is located within the coordinates 7^o 24’40.54”E – 7^o 30’53.5”E and 6^o 24’14.62”N – 6^o 24’26.94”N in the Southeastern part of Nigeria. Enugu state in general encompasses an area of about 7161 km^2 with elevation ranging from 32.01m to 590.24m above mean sea level [7].

The study area falls within the humid tropical rain forest belt of Southeastern Nigeria.

Table 1: sampling points and denotations

Sampling number	Sample location	Representation
1	Amechi community	**Sample 1**
2	Kenneth community	**Sample 2**
3	Akowa community	**Sample 3**
4	Unubi community	**Sample 4**
5	Uzamduno community	**Sample 5**
6	Uzamduno phase 2	**Sample 6**
7	Amaokwu community	**Sample 7**
8	Amaokwu Isaiah community	**Sample 8**
9	Onwudiwe community	**Sample 9**
10	Eze community	**Sample 10**

SAMPLE COLLECTION AND PRESERVATION

Water samples were collected from ten wells located in four different communities in Enugu south, namely: Amechi, Obeagu, Uwani and Achara layout. Table 1 showed the description of the sampling areas. These samples were collected at one month interval for each six months. The sampling was done between the hours of 6.30 am and 9.30am. The water samples from the wells were collected using sterile 750 ml containers. Before collection, the mouth and the outer parts of the borehole taps were sterilized with the flame of a cigarette lighter, and allowed to cool by running the water for about one minute. Thereafter, the sample bottles were rinsed with the sample water before filling them. The bottles were held at the bottom while filling, to avoid contamination of water from the hands or fingers. After recording the time of collection, the samples were labeled with code names before going to the laboratory for analysis.

Physicochemical Analysis:

The physicochemical parameters of the water samples were determined using standard methods. The physical and chemical parameters determined include: pH, temperature, turbidity, dissolved oxygen (DO), alkalinity, acidity, conductivity, total hardness, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), chemical oxygen demand (COD), salinity and nitrate. The presence of minerals (such as magnesium and calcium) was determined using EDTA titration method.

pH determination: The pH was determined in situ at the site of sample collection using portable Hanna microprocessor pH meter. It was standardized using the standard solution with pH range 4-9.

Conductivity determination: This was done using a conductivity meter. The probe was dipped into the beaker containing the samples until a stable reading was got and recorded.

Alkalinity determination: About 50ml of the sample was pipette into a clean 250ml conical flask. Two drops of methyl red indicator were then added and the solution titrated against a standard 0.01M HCl solution to a pink end point [20].

Calculation:

Total alkalinity = {V X M 100.000}/ml of sample used.

Where V = volume of acid used

M = Molarity of acid used.

Acidity determination: This was done by titration according to American society for testing and materials, 1982 [20]. About 50ml of sample was pipetted into a 250 ml conical flask. Two drops of phenolphthalein indicator were then added and the solution was titrated against 0.01M NaOH solution to a pink end-point.

Calculation:

Acidity (mg/l) = [V X M X 100,000]/ml of sample used

Where V = volume NaOH used

M =molarity of NaOH used.

Turbidity determination: This was done using a standardized Hanna model Lp 2000 turbidity meter. The samples were poured in the measuring bottle which was cleaned using soft paper. The bottle was then inserted into the turbid meter and the reading was obtained.

Total solids (TS) determination by Gravimetric method: About 10 ml of sample was measured into a pre-weighed evaporating dish and dried in an oven at a temperature of 103 to 105^0C for two hours ,thirty minutes. The dish was transferred into a desiccator and allowed to cool at room temperature and was weighed. The total solids are taken to be the difference in the weights of the evaporating dish.

Total soilds (mg/l) = [(W2 – W1) mg x 1000]/ml of sample used

Where W1 = initial weight of evaporating dish.

W2 = final volume of the dish (evaporating dish + residue).

Total dissolved solids (TDS) determination by Gravimetric method: Small quantity of water sample was filtered and 10ml of the filtrate was measured into a pre-weighed evaporating dish. The procedure is the same as in total solids above. The total dissolved solids content of the water was calculated thus:

Total dissolved solids (mg/l) = [(W2 – W1) mg x 1000]/ml of filtrate used

Where W1 =initial weight of evaporating dish.

W2 = final weight of the dish (evaporating dish + residue).

Total suspended solids (TSS) determination: This was obtained simply by calculation, i.e.

Total suspended solids = total solid – total dissolved solids.

Dissolved oxygen determination: This was done using Winkler's method. In the analysis, an excess manganese (II) salt, iodide (I^-) and hydroxide (OH^-) ions were added to the samples thus causing a white precipitate of Mn $(OH)_2$ to form . The precipitate was oxidized by the dissolved oxygen in the water samples to a brown manganese precipitate. Then, a strong acid (either hydrochloric acid or sulphuric acid) was added to acidify the solution. The brown precipitate then converted the iodide ion (I^-) to iodide. The amount of dissolved oxygen was directly proportional to the titration of iodine with a thiosulphate solution.

About 300ml BOD bottles were filled with the samples respectively, 2ml of manganese sulphate and 2ml of alkali- iodide-azide solution added by inserting a pipette below the surface of the liquid. The bottles were stoppered to avoid the introduction of air and were mixed by inverting several times. The bottles were left to stand for a few minutes. The presence of oxygen was indicated by the formation of a brownish – orange precipitate. Two millimeters (2ml) of H_2SO_4 was added to the samples. The bottle was inverted again to ensure uniform mixture of the dissolved precipitate. Finally, about 201mlof the samples was measured into a clean 250ml conical flask and titrated against sodium thiosulphate solution ($NaS_2O_3.5H_20$) using starch indicator until colorless solution was obtained [17].

Calculation:

DO (mg/L) = [16000 x M xV] / [V2/V(V1-2)]

Where = Molarity of thiosulpahte used.

V = volume of thiosulphate used for titration

V1 =Volume of bottle with stopper

V2 = Volume of aliquot taken for titration.

Determination of Chemical Oxygen Demand (COD): 250ml of borehole water was warmed to 27ºCand transferred to cleaned flask. 10ml of 0.0125MKMnO4 was added and 10ml of 20% V/VH_2SO_4 was added. It was mixed gently and incubated at 27ºC for 4 hours. The mixture was examined at intervals, when the pink colour of permanganate tends to disappear. After 4 hours, 1mlKI solution was added and titrated with 0.0125M $Na_2S_2O_3.5H_2O$ using starch as an indicator, until the blue colour just disappears.

Calculation: COD (mg/l) = [(ml of Blank-ml required of sample) x 1000] / A x Volume of sample used.

Where A = Total Volume of $KMnO_4$ 0.0125M added to samples.

RESULTS AND DISCUSSION

A summary of the results of the well waters physicochemical analysis were compared with the World Health Organization[16] standards (Table 2).

Table 2: The Mean values of physicochemical analysis

Parameters	Samp1	Samp2	Samp3	Samp4	Samp5	Samp6	Samp7	Samp8	Samp9	Samp10	WHO standard
Temperature (^{0}C)	28.8	28.0	28.0	28.8	28.5	28.5	29.5	28.5	28.8	28.5	30-32^{0}C
PH	4.20	4.01	4.31	4.70	5.30	5.2	5.9	5.02	5.90	4.02	6.5-8.5
Turbidity (NTU)	2.80	3.30	5.10	4.90	4.6	3.84	31.10	14.50	3.69	1.18	5NTU
DO (mg/L)	4.9	5.9	4.9	5.0	4.9	4.9	3.9	4.0	2.4	6.5	7.5mg/l
COD (mg/L)	2.10	1.98	1.54	2.5	0.8	4.00	3.02	0.60	1.82	2.12	7.5mg/l
Alkalinity (mg/L)	0.16	20.0	1.2	1.6	20.0	18.0	40.8	2.4	20.0	2.5	100mg/l
Acidity (mg/l)	22.0	19.0	20	24.0	18.0	26.0	16.0	20.0	11.8	12.2	
TSS (mg/l)	5.0	4.98	4.95	5.6	3.8	3.9	8.7	2.9	5.8	5.4	30mg/l
TDS (mg/l)	147.8	135.3	124.0	167.2	50.4	39.3	279.0	29.9	140.0	122.6	259-500mg/l
TS (mg/l)	152.8	152.8	140.2	128.9	172.8	54.2	43.2	287.7	31.8	145.8	500mg/l
Ec. (µS/cm)	312.0	290.0	280.0	340.0	50.1	60.6	450	56.2	250.2	233	500 µS/cm
T-hardness (mg/l)	55.0	42.0	50.0	60.0	36.0	44.0	62.0	50.0	70.0	52.0	200mg/l
Nitrate (mg/l)	44.2	30.4	51.4	25.3	4.1	9.1	0.01	5.0	13.3	7.2	10mg/l
Ca^{2+}(mg/l)	1.2	6.0	0.70	2.01	2.33	2.52	4.24	0.22	12.80	8.12	75mg/l
Mg^{2+} (mg/l)	8.2	7.4	9.01	7.6	2.04	0.20	2.54	3.04	24.0	18.0	150mg/l

The values of the temperature (Table 3) of the well water samples ranged 28.0 - 29.5^{0}C showed slight difference, but fell within the WHO acceptable limit. The analysis result of the pH values range 4.01-5.90 showed that all the well samples are acidic, hence below the acceptable standard (6.5-8.5). The high pH may be attributed to pollution by waste discharge in the environment that sinks into the water aquifer and microbial decomposition of organic matters[22]. The results of the turbidity level showed that most of them are within the WHO permissible range (Table 3, Fig.5). Sample 7 has the highest value which was (31.10 NTU) followed by sample 8 (14.50NTU). This was over and above the acceptable range and as such need thorough water treatment. The conductivity tests showed marked difference at different locations. Sample 7 has the highest value followed by samples 4, 1, 2, 3, 6 and 5 respectively as in fig 5. These values are still within the WHO standard of (500 µS/cm).The values of dissolved oxygen and COD for all the samples are within the acceptable limit fig. 4. Sample 7 has the highest alkalinity value of 40.8mg/l hence still falls within the standard limit of (100mg/l). The total suspended solids (TSS) values generally are within the WHO permissible limit. The levels of total dissolved solids (TDS), fig. 2, are generally low in all the water samples (range 39.3-279mg/l) and fall within acceptable value. T DS in groundwater originate from natural sources, sewage, urban run-off and industrial wastes. With the exception of samples 5, 2 and 6 which had total hardness values of 36, 42 and 44mg/l respectively, all the remaining water samples have total hardness values above 50mg/l but below WHO value (200mg/l) fig. 3. From this study, it shows that samples 2, 5 and 6 fell into the class of soft water while other water samples are classified as moderately hard water. According to World Health Organization (WHO) International Standard for Drinking Water (1988),water with a total $CaCO_3$ hardness less than 50mg/l is termed soft water, 50 to 150mg/l as moderately hard water while above 150mh/l is classified as hard water. All the water samples are good for domestic use in terms of harness. Moderately hard water is better for drinking purposes than hard water. This is because hard water is associated with heart disease that leads to death[23]. The nitrate value for samples 3, 1,2 ,4 and 9 are 51.21,44.2,30.4,25.3 and 13.3mg/l respectively as seen in Table 3 and figure 1, which are above the WHO recommended limit of 10.0 mg/l. Methemoglobinemia is a disease caused by nitrate, which is converted to nitrite in the intestines[24]. The safe nitrate limit for domestic water is set at 45mg/l. Nitrate cannot be removed from water by boiling but must be treated by distillation. The values for calcium and magnesium in all the water samples are low below the WHO limit of (75mg/l and 150mg/l).

Table 3: Descriptive Analysis of the Results

PARAMETERS	MEAN	STDEV.	RANGE	VARIANCE	CV%
Temp (^{0}C)	**28.59**	**0.4332**	**28.0 - 29.5**	**0.1876**	**1.5152**
PH	**4.856**	**0.7218**	**4.01- 5.9**	**0.5209**	**14.8640**
Turbidity(NTU)	**7.501**	**9.0337**	**1.18-31.1**	**81.6077**	**120.43**
DO (mg/L)	**4.73**	**1.1225**	**2.4-6.5**	**1.2600**	**23.73**
COD (mg/L)	**2.048**	**0.9964**	**0.60-4.00**	**0.9928**	**48.65**
Alkalinity (mg/L)	**12.666**	**13.335**	**0.16 -40.8**	**177.82**	**105.28**
Acidity (mg/L)	**18.9**	**4.6305**	**11.8 -26.0**	**21.4415**	**24.5**
TSS (mg/L)	**5.103**	**1.5566**	**2.9- 8.7**	**2.4230**	**30.50**
TDS (mg/L)	**123.55**	**73.2478**	**29.9-167.2**	**5364.09**	**59.2798**
TS (mg/L)	**131.02**	**75.2834**	**31.8 -172.8**	**5667.6**	**57.459**
Conductivity (µ S/cm)	**232,21**	**135.3838**	**50.1 -450**	**18327.7**	**58.300**
Total-hardness(mg/CaCo3/L)	**52.1**	**10.137**	**36.0– 70**	**102.75**	**19.456**
Nitrate (mgNO3/L)	**19.001**	**17.9592**	**0-01-51.4**	**322.53**	**94.517**
Ca^{2+} (mg/L)	**4.0779**	**3.794**	**0.22 – 12.8**	**14.394**	**93.03**
Mg^{2+} (mg/L)	**7.8360**	**7.703**	**0.2– 24.0**	**61.4028**	**98.30**

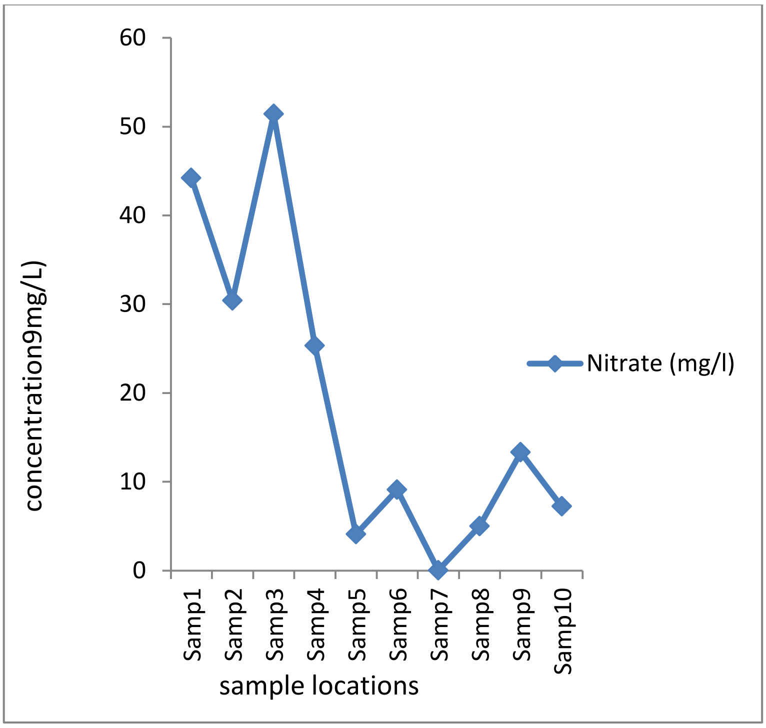

Fig. 1: Distribution of Nitrate

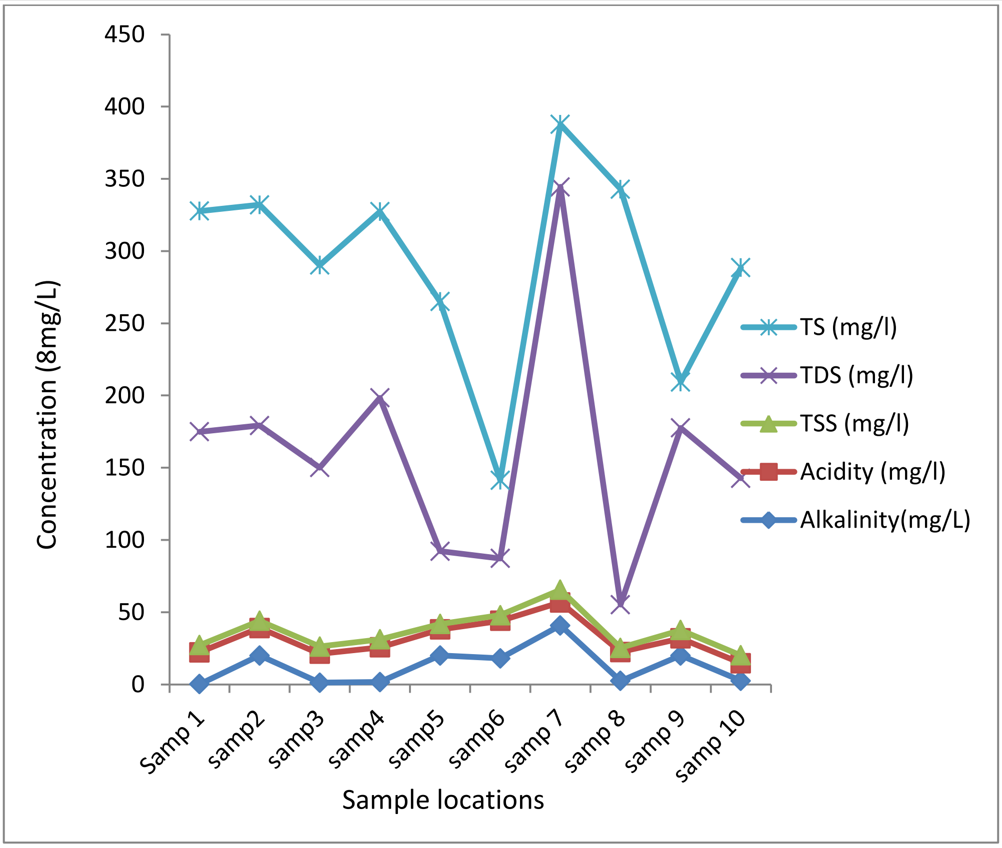

Fig. 2: Distribution of Solids

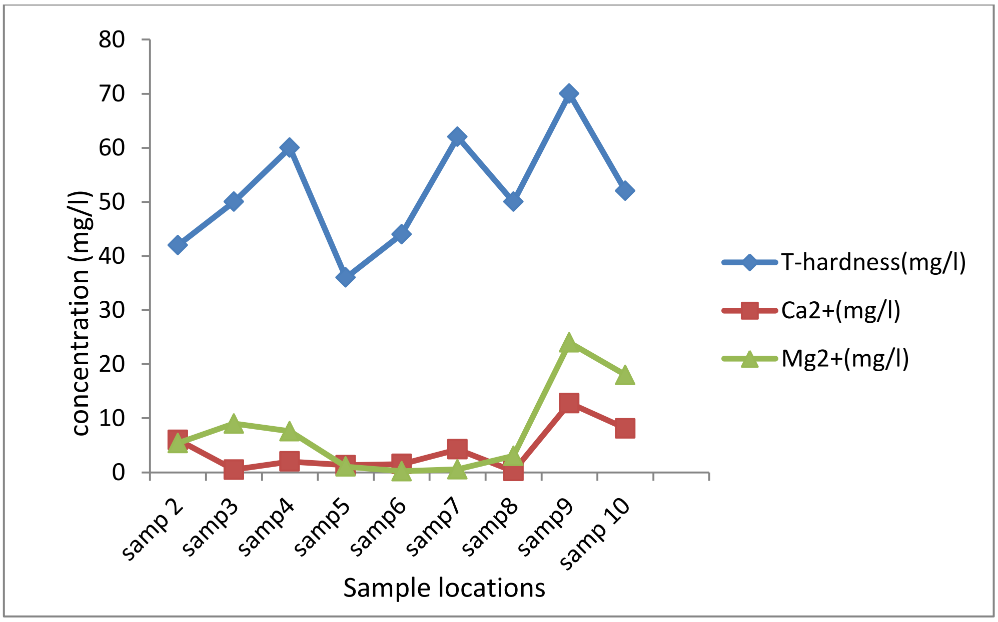

Fig. 3: Distribution of hardness

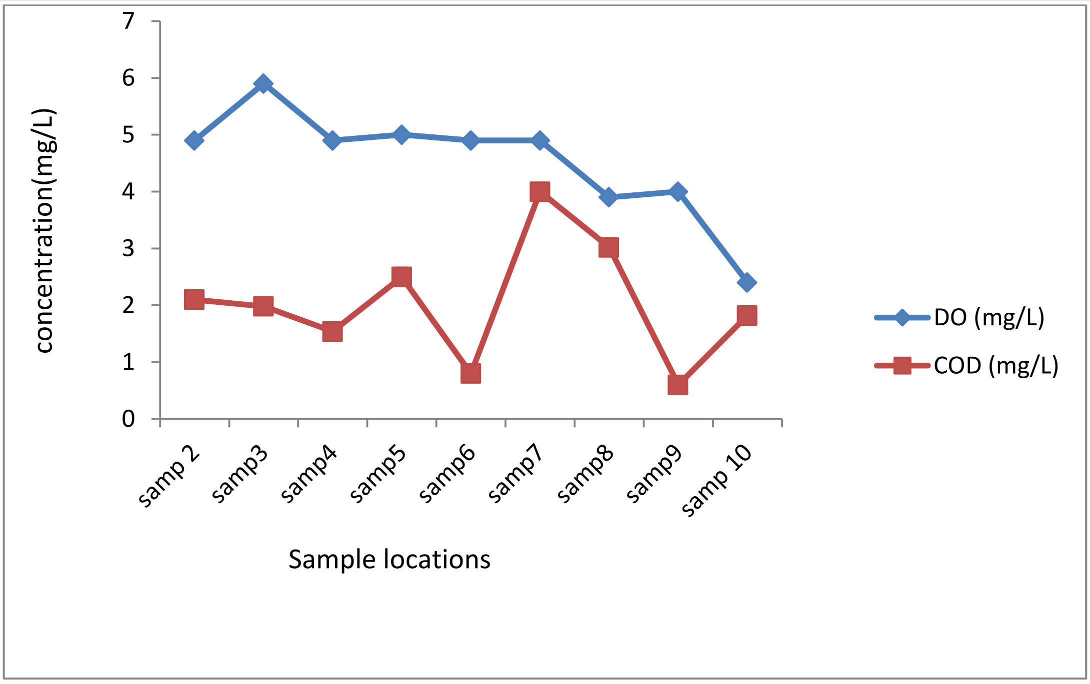

Fig.4: Distribution of Oxygen Demands

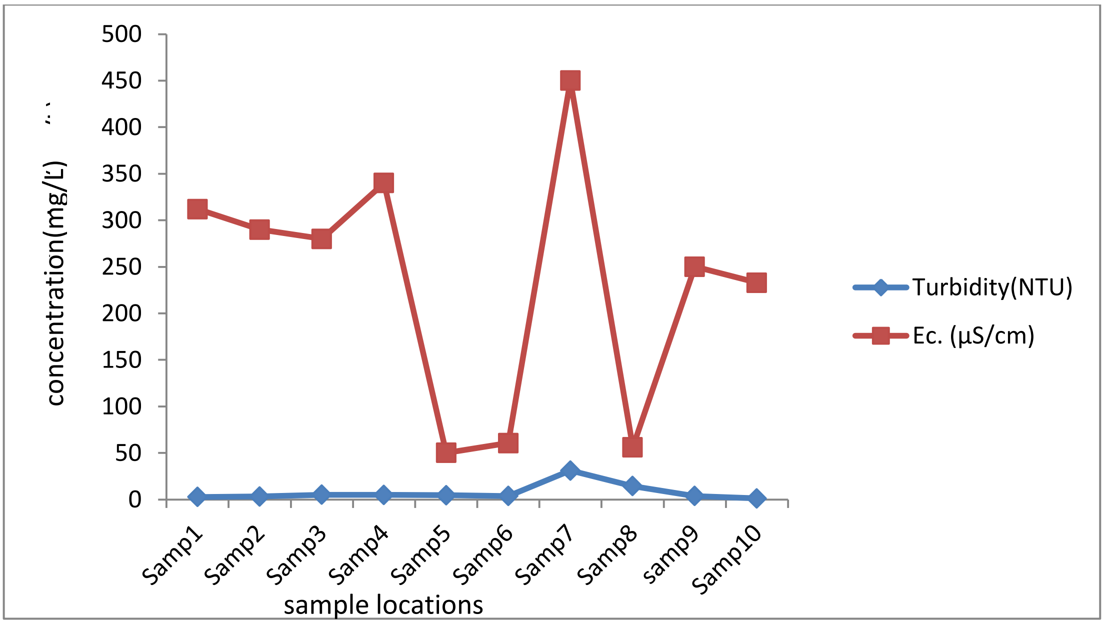

Fig. 5: Distribution of turbidity and E. conductivity

CONCLUSION

The high level of nitrate in the well water samples may be traced to dissociation of their metallic compounds, oxidation of other forms of the compounds, high degree organic pollution and decomposition, type of minerals in the bedrock, agricultural activities and use of detergents. Nitrate concentration above 10mg/l is dangerous to pregnant women and poses a serious health threat to infants between two to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen. This implies that groundwater in Enugu south is polluted with organic and inorganic substances and therefore unfit for drinking without treatment. Low values of pH are most often caused by lack of carbonate minerals, such as calcium and magnesium found in limestone and dolomite rocks. Water leaking from a landfill may also cause low pH. *).* High turbidity can be attributed to the effects of runoff from construction, agricultural practices, logging activities, and wastewater discharge. Turbidity often increases during rainfall; especially in developed watersheds, which typically have relatively high proportion of impervious surface. Turbidity can also rise sharply during dry weather if earth- disturbing and activities are occurring in or near a stream without erosion control practices in place.

Since anthropogenic activities has been found to be the major pollutant of the groundwater in the study area, policy initiatives and awareness programme will help in a small way to solve water pollution problems that emanate from anthropogenic activities. This should be vigorously pursued because the drinking of safe water means good health. A healthy society implies great productivity and sustainable development Groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the industrial waste and sewage contamination.

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