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DETERMINATION OF QUALITY OF WATER USED BY STUDENTS OF COLLEGE OF EDUCATION, KATSINA-ALA THROUGH PHYSICAL AND ELECTRO-CHEMICAL PARAMETERS

A. Kur[1*], A.T. Alaanyi[2] and S.T. Awuhe[2]

[1]Department of Physics, College of Education, Katsina-Ala, Nigeria.
[2]Department of Integrated Science, College of Education, Katsina-Ala, Nigeria

*Corresponding Author Email Address antikur1@gmail.com Phone: +2347067858598

ABSTRACT
The aim of this work was to determine the quality of water used by students of College of Education, Katsina-Ala by measuring the parameters: temperature, colour, taste, pH, electrical conductivity (EC) and total dissolved solids (TDS). Five water samples from sources namely borehole, tap, hand-dug well, rain and river were checked using physical and electro-chemical methods. The results revealed that borehole water had the highest EC and TDS values of 382.30µS/cm and 256.14mg/l respectively. Whereas river water had the least EC and TDS values of 30.90µS/cm and 20.70mg/l respectively. Although these values fall within acceptable limits prescribed by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality and, therefore safe, it is recommended that water sanitizers be regularly used in order to eliminate biological contaminants.

Keywords: Electrical conductivity, ions, total dissolved solids, water quality, water samples.

INTRODUCTION

Water plays a significant role in maintaining the human health and welfare. The need for water in the daily activities of man includes for drinking, cooking, washing and for industrial uses. Especially, clean and safe drinking water is already a limiting resource in many developing countries. As a result, around 6-8 million people die each year due to water-related diseases (UN-Water, 2013). Therefore, water quality control is a top priority policy agenda in many parts of the world.

The sources of water supply in College of Education, Katsina-Ala are through hand-dug wells, bore-holes, rainwater and river water. These sources of water supply especially from the hand-dug wells and river water are polluted due to human activities. These activities include the use of pit latrines by some residents, and indiscriminate dumping of wastes which contribute to the contamination of water from different sources in the study area.

Quality of water generally refers to the component of water, which is to be present at the optimum level for suitable growth of plants and animals. Various factors like temperature, turbidity, nutrients, hardness, alkalinity, dissolved oxygen play an important role for the growth of plants and animals in the water body. On the other hand, biological oxygen demand, chemical oxygen demand indicates the pollution level of the water body. In natural aquatic system, various chemical parameters occur in low concentrations.

Ground water is usually assumed to be a very good source of potable water due to purification property of soil. However, groundwater may be subjected to pollution and may not be as safe as is generally assumed. Groundwater contamination comes about as a result of human activities such as the disposal or dissemination of chemicals and microbial matter at the land surface and into the soils, or through injection of wastes directly down the soils (Odeyemi, Akinjogunla & Ojo, 2011). The water for human consumption must not contain organisms and chemical substances in concentrations sufficiently high to affect health. The water supply for human intake is often directly sourced from groundwater without chemical, physical and biological treatment and the level of pollution has become a cause for main concern. Currently, there is no big industry in and around the study area, but household wastes and municipal sewage are directly dismissed into the area. Also, water sources are susceptible to contamination due to rainfall washout, slaughterhouse activities, pesticides, excreta and various organic wastes. It could therefore represent a dangerous source of diseases.

Rivers are the most important freshwater resources for man. Unfortunately, river waters are being polluted by indiscriminate disposal of sewage, industrial wastes and plethora of human activities, which affects their physiochemical characteristics and microbiological quality. Pollution of the aquatic environment is a serious and growing problem. Rainwater is relatively free from impurities except those picked up by rain from the atmosphere, but the quality of rainwater may deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and animals, insects and contaminated litter on the catchment areas can be sources of contamination of rainwater, leading to health risks from the consumption of contaminated water from storage tanks. Poor hygiene in storing water in and abstracting water from tanks or at the point of use can also represent a health concern.

Water quality is a measure of the suitability of water for particular use based on selected physical, chemical and biological characteristics (Bartram & Balance, 1996). The temperature of water affects some of the important physical properties and characteristics of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases, etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10°C. The temperature of water in streams and rivers throughout the world varies from 0 to 35°C.

Colour in water is primarily a concern of water quality for aesthetic reason. Coloured water gives the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, colour can indicate the presence of organic substances, such as algae or humic compounds. More recently, colour has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water.

Taste and odour are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However, sweet and bitter tastes are produced by more complex organic compounds. Organic materials discharged directly to water, such as falling leaves, runoff, etc., are sources of tastes and odour-producing compounds released during biodegradation.

PH is the term used to express the intensity of the acid or alkaline condition of a solution. The pH value is defined as the logarithm, to base 10, of the reciprocal of the concentration. The weathering of minerals, such as limestone or dolomite, by water becomes more rapid with a decrease in pH. Thus a decrease in pH increases the solubility of metals (Reeve, 2002). According to Obiefuna and Sheriff (2011), extreme (low and high) pH values in water affect the health of consumers of the water and its disinfection.

One of the factors that establish the quality of a water supply is its degree of hardness. Hard water is due to metal ions (minerals) that are dissolved in the ground water. These minerals include Ca^{2+}, Mg^{2+}, Fe^{3+} etc. Natural waters contain calcium and magnesium only in significant concentrations. So the hardness of such water is defined as characteristic of water which represents the total concentration of just the calcium and magnesium ions expressed as calcium carbonate (Ademoroti, 1996). Water could be considered to be very hard if the hardness exceeds the WHO maximum permissible level of 500mg/l (WHO, 2004). Very hard water is not good for drinking and is associated with rheumatic pains and gouty conditions. Such water does not lather well with soap and produces deposits and scaling in pipes and steam boilers, hardened vegetables and would not allow it to cook well (Okoye & Nyiatagher, 2009).

Conductivity or electrical conductivity (EC) and total dissolved solids (TDS) are frequently used physical parameters of water quality (Rusydi, 2018). EC is the measure of water's ability to conduct electric charge (current). Its ability depends on dissolved ion concentrations, usually measured as TDS. The TDS concentration arises from dissolved substances mainly of small amounts of organic matter as well as inorganic salts (principally calcium, sodium, nitrates and carbonates). The sources of material in TDS can come from natural geological conditions, or from human activities such as domestic, industrial wastes and agriculture (Appelo & Postma, 2005). Both EC and TDS are indicators of salinity level of water, which makes them very useful as one way in studying the intrusion of contaminants (Moujabber *et al*., 2006). However, TDS analysis is more important and principal in understanding the effect of the intrusion better than EC analysis (Khaki *et al*., 2015). The measurement of EC can be easily done by a portable conductivity meter. Whereas the measurement of TDS is more difficult and expensive as it needs more equipment and time (Rice *et al*., 2017). Fortunately, researchers have investigated to find out the precise mathematical correlation between these two parameters, so that TDS concentration can be simply calculated from the EC value as:

$$TDS = k \times EC \qquad (1)$$

The value of k which is the ratio TDS/EC will increase with increase of ions in water. The results of existing studies indicate that the value of k is in a particular range. For freshwater, the ratio is in the range 0.50≥ 1.00 (McNeil & Cox, 2000). Since the charge on ions in solution facilitates the conductance of electric current, the conductivity of a solution is proportional to its ion concentration. In some situations, however, conductivity may not correlate directly to concentration. This depends on the activity of specific dissolved ions in the water, and the ionic strength (Siosemarde *et al*., 2010). Ionic concentration can alter the linear relationship between conductivity and concentration in some highly concentrated solutions.

There are many standards that govern TDS and EC in water. For health reason, a desirable limit for TDS is between 500mg/l and 1000mg/l. And for EC, it is not more than 1500 μS/cm (WHO, 2011). TDS concentration outside of a normal range can affect water taste and often indicates a high alkalinity or hardness (Wetzel, 2001). An elevated level of TDS, by itself, does not indicate that the water presents a health risk. However, elevated levels of specific ions included in the TDS measurement, such as nitrates, arsenic, aluminum, copper, or lead, could present health risk (Hassinger *et al*., 1994). High TDS levels (>500mg/l) result in excessive scaling in water heaters, boilers, and household appliances such as kettles and steam irons. These imply that excessive TDS concentrations in water can have both health and economic costs.

The public water works which supply water to the College community is dysfunctional and moribund. As a result, residents look for alternative ways of providing their own domestic water such as shallow hand-dug wells, boreholes, rainwater and river water. There are yet no reported physiochemical studies of water resources in College of Education, Katsina-Ala Campus. Therefore, it is imperative to analyze samples of the water sources from this study area in order to ascertain the portability and safety of the water, and procure for the present quality status a baseline data for future periodic monitoring of the water quality in the area. Hence, the purpose of this study is to determine the physiochemical quality of the various sources of water within the College campus. For this study, the parameters that will be determined are temperature, colour, turbidity, odour, taste, electrical conductivity (EC), PH, and total dissolved solids (TDS).

MATERIALS AND METHODS

Study Area

Location: Katsina-Ala L.G.A is located in the North-Eastern part of Benue state and shares common boundaries with Ukum LGA in the North, Kwande LGA in the South, Takum LGA in the East and Buruku LGA in the West. It is also the location of an important archeological site where artifacts of the Nok culture have been found (Shaw, 1995). Approximately its location coordinates are

7°10'0''N 9°17'0''E. Katsina-Ala Township is the headquarters of the local government area where the A344 highways starts.

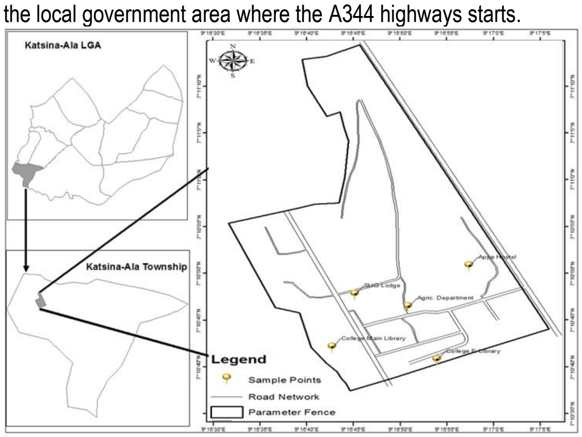

Fig. 1 Showing study area

Table 1 Water sampling points

S/n	Latitude (Northing)	Longitude (Easting)	Elevation	Location	Cardinal Point
1	7°10.657	9°16.769	138	College Main library (Rain)	South-West
2	7°10.759	9°16.799	135	Student Union Government Lodge (River)	Central
3	7°10.633	9°16.911	138	College e-Library (Well)	South-South
4	7°10.816	9°16.960	138	Apa Hostel (Tap)	South-East
5	7°10.733	9°16.874	137	Agricultural Science Department (Bolehole)	South

Katsina-Ala, a town in North-East senatorial zone of Benue State has low urban status. The only industry of note is the College of Education that is situated in the town. Once the students are on holidays, the commercial activities of the town become near comatose. The only pipe borne water was installed since the creation of the state in 1976 and its supply of water to the town is epileptic. An attempt to resuscitate the water works began since 2007 but up till now it has not been completed. The main supply of water to the town is from shallow hand-dug wells, boreholes, rainwater and the River Katsina-Ala.

Climate*:* Climate in Katsina-Ala LGA lies between the transition Zone of forest and savannah vegetation. That is the LGA falls within the transition belt between equatorial rain belt of the south and arid areas of the North. Like every part in Nigeria, it has two main seasons, the wet and the dry seasons. The wet season starts from April and endures till October with peaks in May and September. The distribution and amount of rain show great differences between years. The dry season is between November and April and it is the hottest after the harmattan winds; between January and April. The mean annual temperature is about 32.50°C. The hottest months are February and March with a temperature range of 35 to 40°C.

Vegetation*:* The predominant vegetation in the area is the Southern Guinea Savanna, interspaced with transition wood land. Along the valley of River Katsina-Ala is the open Guinea Savanna vegetation and grassland.

***Geology*:** Geologically, the study area is part of the Middle Benue Trough. In the Benue Basin, three broad hydrogeological groups were identified in the southern Benue Basin (Okafor & Mamah, 2012). These include the first hydro geological group underlain predominantly by shaly formations. The thickness is in the range of 10 to 40 m and water levels are generally < 20 m. The second hydrogeological group consists of mainly sandy and shaly horizons with yield in the range of 3 - > 30 L/s while the lower hydrogeological group consists predominantly of sands, sandstones and clays. The sedimentary sequence in the Benue Basin has been broadly divided into basal non-marine sandstones, siltstones, and mudstones; a middle marine shales and limestone intercalated with sandstones and siltstones and an upper sandstone sequence that is continental or paralic (Edet, Nganje, Ukpong & Ekwere, 2011).

The Benue Basin comprises four aquifers which are Nanka Sands, Enugu Shale, Agala Sandstone and Asu River Group (Edet, Nganje, Ukpong & Ekwere, 2011). The groundwater of Benue Basin is acidic and fresh. The hardness of the different groundwater bodies in the Benue Basin ranges from moderately hard for the Enugu Shale, through hard for the Agala Sandstones and very hard for the Asu River Group aquifer.

EXPERIMENTAL METHODS

The materials/apparatus used in this work included the following: water samples (borehole, tap, river, well and rain), potassium chloride (KCl) standard solution, magnetic stirrer, stirring bead, conductivity meter (DDS-307), electrode (of cell constant 0.1), electronic weighing balance, thermometer, standard volumetric flasks, measuring cylinder, 100g standard mass, beaker (250ml), spatula, glass rod, de-ionized water, filter and funnel.

Water samples were collected from borehole, tap, hand-dug well, rain and River Katsina-Ala (usually supplied to students by water vendors). The sampling was done between the hours of 8.30am-10:30am. Precautionary measures were taken to minimize or avoid contamination of samples. Firstly, samples were collected in well-labeled 150cl plastic containers pre-cleaned using non-ionic or phosphate free detergent. The choice of the plastic containers was to ensure that the level of contamination from it to the water sample especially from heavy metals was low, as suggested by Odoh *et al*. (2013). The containers were rinsed three times with sampled water and then de-ionized water before actual sample collection. Finally, the water samples were taken to the laboratory for measurements.

Physical Tests

Colours of water samples were individually observed, the nature of particles present noted. For odour, water samples were vigorously shaken and a portion of the water was poured into a clean separate beaker with each sample tested with the tongue. Temperature was measured using digital thermometer.

Chemical Test

The standard solution used for calibration of the conductivity meter was 0.01MKCl. Before the conductivity meter calibration, the electronic weighing balance was first calibrated in accordance with the manufacturer's recommendation using 100g standard mass. The principle by which instruments measure conductivity is simple. Plates/wires called electrodes are placed in the sample, a potential is applied across them (normally a sine voltage), and the current is measured. Conductivity, the inverse of resistivity is determined from the voltage and current values according to Ohm's law.

The basic unit of conductivity is the Siemens (S). Since cell geometry affects conductivity values, standardized measurements are expressed in specific units of S/cm to compensate for variations in electrode dimensions. In order to obtain the accurate readings with the conductivity meter, a standard calibration solution of KCl was used in determining the calibration constant of the instrument. This was done by dipping the electrodes of 0.1 cell constant into the beaker containing 200ml of standard solution, placed on the magnetic stirrer which stirred it for uniform distribution of ions. As the calibration process was automated at temperature compensation of 25°C, the conductivity meter displayed conductivity value of 1412μS/cm for the 0.01MKCl solution.

Therefore, the EC of water samples was determined by electrochemical method. Upon switching on the meter for 30 minutes to stabilize, the samples of water were measured with a measuring cylinder into 250ml beaker. The conductivity meter's probe was immersed into the sample in the beaker and the conductivity value was displayed on the digital readout. The experiment was repeated three times for each water sample after 10 minutes of steady reading, after which the average value was then taken. The experiment was carried out for all the samples and the readings recorded accordingly. The corresponding TDS values were determined by multiplying each measured conductivity value by an empirical factor used for natural water. The expression for TDS calculation is given as:

$$TDS\ (mg/l) = 0.67 \times EC\ (\mu S/cm) \quad (2)$$

Where k = 0.67 is frequently used as an approximate conversion factor for natural water (Liz, 2018). According to Atekwanaa *et al*. (2004), this approximation is proven to be suitable and valid up to 2000μS/cm

RESULTS AND DISCUSSION

Physiochemical parameter study is very important to get exact idea about the quality of water to enable comparing results of different physiochemical parameter values with standard values. The measured values of temperature, PH, EC and calculated TDS values are presented in Table 2

Table 2: Physiochemical parameters of the water samples

Water source	Temperature (°C)	pH	EC (μS/cm)	TDS (mg/l)
River	26.7	7.63	30.90	20.70
Rain	26.3	7.61	41.00	27.47
Well	26.1	7.33	216.70	145.19
Tap	25.6	7.42	241.70	161.94
Borehole	26.8	7.47	382.30	256.14

Generally, physical analysis of the borehole, tap, hand-dug well, rain and river water show that most of the samples were colourless, odourless and tasteless. Colour in water is primarily a concern of water quality for aesthetic reason. Coloured water gives the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, colour can indicate the presence of organic substances, such as algae or humic compounds. Colour has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water. Taste and odour are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However, sweet and bitter tastes are produced by more complex organic compounds. Human detect many more tips of odour than tastes. Organic materials discharged directly to water, such as falling leaves, runoff, etc., are sources of tastes and odour-producing compounds released during biodegradation.

The measured temperature values of the well water samples were between 26.1-26.8°C.The temperature of water affects some of the important physical properties and characteristics of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases and etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10 °C. The temperature of water in streams and rivers throughout the world varies from 0 to 35 °C.

The PH of the studied samples of water ranged from 7.33 to 7.63. pH is one of the parameters responsible for corrosivity of water because generally the lower the pH, the higher the level of corrosion (WHO, 1996). Cautious attention to pH is necessary to ensure satisfactory clarification and disinfection to minimize the corrosion of water. Exposure to extreme (pH >11) results in irritation in eyes, skin and mucous membrane and also cause hair fibers to swell in human. pH values less than 6.5 are considered too acidic for human consumption and can cause health problems such as acidosis.

Results from Table 2 shows that borehole water has the highest EC and TDS values of 382.30μS/cm and 256.14mg/l respectively. This suggests that the sample has the highest ionic concentration and activity than the rest of the samples. The reason for the higher TDS value in the borehole water may be traced to the local environment of the water point; in terms of geology and land use activities. This borehole is located close to a cattle pen where animal droppings and other wastes are concentrated. However, both the EC and TDS values fall within the permitted level for EC of not more than 1500μS/cm, and TDS of between 500-1000mg/l based on WHO guidelines for safe drinking water (WHO, 2011); and the maximum permitted TDS value of 500mg/l based on Nigerian standard for drinking water quality (SON, 2015). River water showed the least of the values for EC of 30.90μS/cm and TDS of 20.70mg/l. Fig. 2 and 3 respectively represent graphical variation of EC and TDS with water samples. Where A,B,C,D and E stand for river water, rain water, well water, tap water and borehole water, in that order. The TDS-EC characteristic for the water samples is shown in Fig. 4

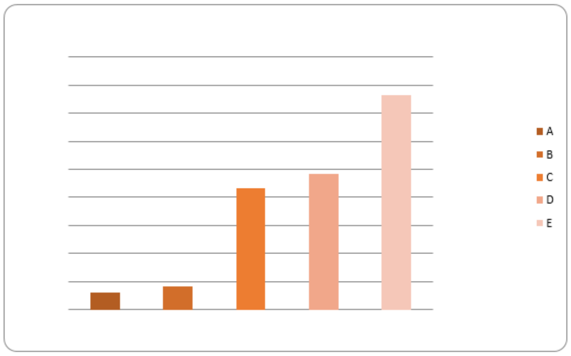

Fig.2: Chart of conductivity against water samples

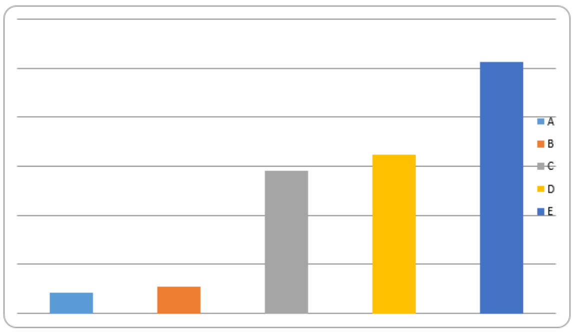

Fig.3: Chart of total dissolved solids against water samples

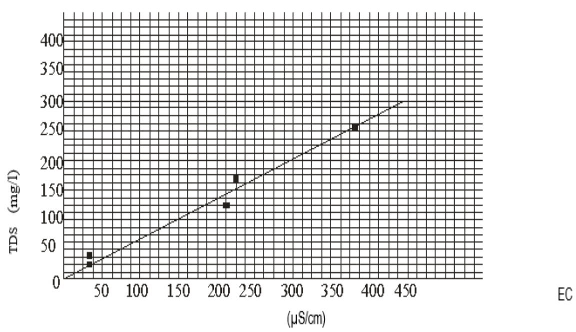

Fig.4: Graph of TDS-EC relationship

Conclusion

The aim of this work was to determine the quality of water used by students of College of Education, Katsina-Ala through the parameters of temperature, colour, taste, pH, electrical conductivity (EC) and total dissolved solids (TDS). The results reveal that values from water samples in the study area fell within WHO maximum allowable levels for drinking water. Although the values from all the samples fall within safe limits, it is recommended that water disinfectants be used regularly, especially for river and well water. This will adequately eliminate possible biological contaminants thereby guiding against water-borne infections. The TDS-EC characteristic (Fig. 4) shows a linear relationship between the two parameters. This agrees with the report of Thirumalini & Joseph (2009) and Siosemarde *et al.* (2010) for freshwater. This research may also serve as a preliminary study to provide baseline information that may direct future water quality assessment studies in the study area.

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REFERENCES

Ademorati, C.M.A. (1996). *Standard methods for water effluents analysis*. Ibadan: Foludex Press

Appelo, C.A.J. & Postma, D. (2005). *Geochemistry, groundwater and pollution*. Amsterdam: CRC Oress, Taylor & Francis Group

Atekwanaa, E.A., Estella, A., Roweb, R.S., Werkema Jr., Dale, D., & Legalld, F.D. (2004). The relationship of total dissolved solids measurements to bulk electric conductivity in an aquifer contaminated with hydrocarbon. *Journal of Applied Geophysics*, 56(4): 281-294

Bartram, J. & Balance, R. (1996). Water quality monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. http://www.who.int/iris/handle/10665/41851

dissolved solids in natural waters. *Malaysian Journal of Science*, 28: 56-61 UN-Water (2013). An increasing demand, facts and figures. UN-water, coordinated by UNESCO in collaboration with UNECE and UNDESA. http://www.unwater.org/water-cooperation-2013/en/ Retrieved 10 September, 2018

Edet, A., Nganje, A. J., Ukpong, A. J. & Ekwere, A. S. (2011). Groundwater chemistry and quality of Nigeria: A status review. *African Journal of Environmental Science and Technology, 5*(13), 1152-1169.

Hassinger, E., Doerge, T. & Baker, P. (1994). Test your well water for safety. *WaterFacts* (1) http://ag.arizona.edu/pubs/water/az9414.pdf Retrieved 8 June, 2018

Khaki, M., Yusof, I. & Islmalami, N. (2015). Application of the artificial neural network and neuro-fuzzy system for assessment of groundwater quality. *Clean-Soil, Air, Water,*43(4): 551-560

Liz, T. (2018). How to convert total dissolved solids to conductivity. *Sciencing* https://Sciencing.com/convert-tds-conductivity-7381015.html Retrieved, 10 August, 2018

McNeil, V.H. & Cox, M.E. (2000). Relationship between conductivity and analyzed composition in a large set of natural surface water samples, Queensland, Australia. *Environmental Geology,*39: 1325-1333

Moujabber, M.E., Samra, B.B., Darwish, T. & Atallah, T. (2006). Comparison ofdifferent indicators for groundwater contamination by seawater intrusion on theLebanese coast. *Water Resource Management,*20: 161-180

Obeifuna, G. I. & Sheriff, A. (2010). Assessment of shallow ground water of PindigaGombe area, Yola area, NE, Nigeria for irrigation and domestic purposes. *Research Journal of environmental and Earth Science, 3* (2), 131-141.

Odeyemi, A. T., Akinjogunla, O. J. & Ojo, M. A. (2011). Bacteriological, physiochemical and mineral studies of water samples from artesian borehole, spring and hand dug well located at Oke-Osun, Ikere-Ekiti, Nigeria. *Archives of Applied Science Research, 3*(3), 94-108. Retrieved from www.scholarsresearchlibrary.com

Odoh, R., Oko, O.J. Kolawole, S.A. & Oche, E.O. (2013). A comparative study of theheavy metal content of drinking water in different storage vessels. *International Journal of Modern Chemistry*, 5(3): 166-180

Okafor, P. & Mamah, L. (2012). Integration of Geo-physical techniques for groundwater.*The Pacific Journal of Science and Technology, 13*(2), 463-474.

Okoye, C. O. B. & Nyiatagher, T. D. (2009). Physicochemical quality of shallow well waters in Gboko, Benue state, Nigeria. *Bull. Chem. Ethiop., 23*(1), 001-006.

Reeve, R. N. (2002). Introduction to environmental analysis. Chichester: John Wiley & Sons, Ltd.

Rice, A., Baird, E.W. & Eaton, R.B. (2017). APHA 2017 Standard Methods for Examination of water and wastewater. Washington: American Public Health Association, American Water Works Association, Water Environment Federation

Rusydi, A.F. (2018). Correlation between conductivity and total dissolved solid in various type of water: A review. IOP Conference Series: *Earth and Environmental Science,* 118(2018)01201

Siosemarde, M., Kave, F., Pazira, E., Sedghi, H. & Ghaderi, S. (2010). Determination of constant coefficients to relate total dissolved solids to electrical conductivity .*International Journal of Environmental, Chemical, Ecological, Geological, and Geophysical Engineering,* 4: 457-459

Shaw, T. (1995). *The archaeology of Africa: Food, metals and towns*. Abingdom: Routledge

SON (2015). Nigerian standard for drinking water quality. Standards Organization of Nigeria, SON. https://africacheck.org/.../Nigerian-Standard-for-Drinking-Water-Quality-NIS-554-2015.pdf Retrieved 12 September, 2018

Thirumalini, S., & Joseph, K. (2009). Correlation between electrical conductivity and total

Wetzel, R.G. (2001). *Limnology: Lake and River ecosystem* (3rd ed.). San Diego, CA: Academic Press

WHO (1996). Guidelines for drinking water quality (2nd ed.): Health criteria and other supporting information. Geneva: World Health Organization.

WHO (2004). Guidelines for drinking water quality (3rd ed.). Geneva: World Health Organization

WHO (2011). Guidelines for drinking water quality. Geneva: World Health Organization.