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Quality Evaluation of Earth Dam and Pond Water in Gella, Mubi South Local Government Area

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Authors' contributions

This work was carried out in collaboration between all authors. Author IYS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FAB, MUA, HBG and MZZ managed the analyses of the study. Authors IYS and FAB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The present work was to evaluate the quality of ponds and earth dam water of Gella town in Mubi South Local Government Area of Adamawa State in order to examine its suitability for drinking and domestic purposes. Four ponds and an earth dam water samples were collected each during dry seasons between the months of November to April 2015/2016. The samples were analyzed using arithmetic mean and standard deviation which was then compared with the World Health Organization (WHO) and NAFDAC standard. Physicochemical parameters were studied using standard methods, concentrations of heavy metals determined using atomic absorption spectroscopy and bacteriological analysis conducted using standard methods. Result of the analyses revealed that the water samples were slightly acidic to slightly alkaline (pH 5.60 ± 0.17 – 7.20 ± 0.12). The calcium concentration in water studied ranged between 19.79±01 to 28.21±00 mg/L while that of magnesium ranged between 0.94±0.01 to 2.18±0.06 mg/L and these concentrations were within permissible WHO and NAFDAC recommended standard limits. While the

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coliform count were above WHO and NAFDAC standards for drinking water, and the water samples were good for drinking and domestic purposes. Water treatment and regular monitoring of the water quality of the area and provision of industrial motorized borehole water for easy distribution to the community have been strongly recommended.

Keywords: Gella; coliform; pond; physicochemical; water.

1. INTRODUCTION

Water quality is fundamental to health, poverty alleviation and community development. Safe water has been explicitly recognized by the Covenant on Economic, Social and Cultural Rights (CESCR) as a fundamental human right in November 2002. According to the United Nations, over 1.1 billion people lack access to safe drinking water, of which nearly two thirds live in Asia (World Health Organization [1]. As a result of inadequate access to safe drinking water over 10,000 people die each day from avoidable water-related diseases [2]. Reports by Food and Agricultural Organization revealed that in African countries, particularly Nigeria, water related diseases had been interfering with basic human development [3]. The common sources of water that are available to local communities in Nigeria are fast being severed by a number of anthropogenic factors, of which pollution remain the most dominant problem. Water pollution occurs when unwanted materials with potentials to threaten human and other natural systems find their ways into rivers, lakes, wells, streams, boreholes or even reserved fresh water in ponds, dams, homes and industries. The pollutants are usually pathogens, silt and suspended solid particles such as soils, sewage materials, disposed foods, cosmetics, automobile emissions, construction debris and eroded banks from rivers and other waterways. Some of these pollutants are decomposed by the action of micro-organisms through oxidation and other processes. The major problem is the re-concentrations of these harmful substances in natural food chain [3,4]. During the decomposition process, natural bacteria and protozoan in the water source utilize the oxygen dissolved in the water. This could significantly reduce the oxygen level to less than two parts per million (<2 ppm), therefore the respiratory conditions of aquatic species would be seriously affected. Consequently, fishes, bottom-dwelling animals and even marine plants can be contaminated and/or killed, creating significant disruption in the food chain. On the other hand, when this contaminated water is directly consumed without proper treatment (a common practice in local communities), spread of diseases such as typhoid, dysentery, cholera, hepatitis etc. will occur. Among the chemical pollutants of health importance are iron, cadmium, lead, copper, nickel, zinc, etc. Lead corrosion increases its solubility from lead piping and lead-joined copper tubes. This makes lead and copper enter water bodies through dissolution of the corrosion product. While presence of nickel and chromium in water may arise due to their leaching from nickel and chromium plated taps [5]. Gella area have no access to pipe borne water. Presence of these metals in water in Gella is not expected and therefore their assessment is not within the scope of present study.

In Nigeria today research indicates that, majority of the common water sources are polluted, resulting to serious outbreak of these and other diseases. The major issues of national and international interest are how these water pollution problems could be fully assessed and mitigated, proper knowledge and planning are thus essential. This paper is aimed at evaluating the quality of ponds and earth dam water in Gella town, Mubi South Local Government Area of Adamawa State in order to provide data and information on the physical properties, chemical properties and heavy metals (such as iron, manganese and zinc), concentration of ponds and dam water in this area. The data information that will be generated can serve as a guide in monitoring water contamination; it will also be useful in creating a baseline data of pond and dam water quality in the area under study.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Gella, Mubi South Local Government Area of Adamawa State situated at the lower contour of Mandara Mountains, which separates Nigeria from Cameroon. Gella is the Headquarter of Mubi South Local Government Area lying at the Southern part of Mubi town, Adamawa State and located at latitude 10°09’ 06.33’’ N and longitude 13° 18’ 10.53’’ E [6]. Mubi is about 240 km from the State capital, Yola (Fig. 1). According to the 2003 population projection, the population of Mubi South is about 187.2 per square kilometers. The climate controls the amount of water that is available at the surface and subsurface at a given time. Virtually all rivers in Gella, Mubi South Local Government Area are dry, during the dry seasons. The people of Gella are predominantly farmers. Their major economic activity is crop production and livestock husbandry. Among the major crops cultivated include cereals such as maize, sorghum and legumes such as cowpea and ground nuts and potato tubers. Their subsidiary activity is extensive livestock production using range-land, crop residues and stored fodder. They keep large variety of animals among which are cattle, poultry, and sheep /goats.

2.2 Sample Collection

There are five ponds and one earth dam in Gella used by the community as a source of drinking water. Only four ponds and one Bogga earth dam (Fig. 1) water samples were collected randomly in triplicate at Gella, Mubi South Local Government Area Adamawa State. Water samples were collected during the dry season between the months of November to April 2015-2016, using sterile 1000 cm^3 polyethene bottles. The water samples were preserved with HNO_3.

2.3 Temperature and pH

The temperature and pH of the water samples were measured at the point of collection according to the method described by Alexander [7]. The pH was measured using pocket sized pH meter while the temperature was measured with the help of mercury-in-glass thermometer graduated up to 110°C.

2.4 Measurement of Color

The color of water samples was determined spectrophotometrically using the method of Gimba [8]. A DR 2000 (HACH) Spectrophotometer at wavelength of 450 nm was used.

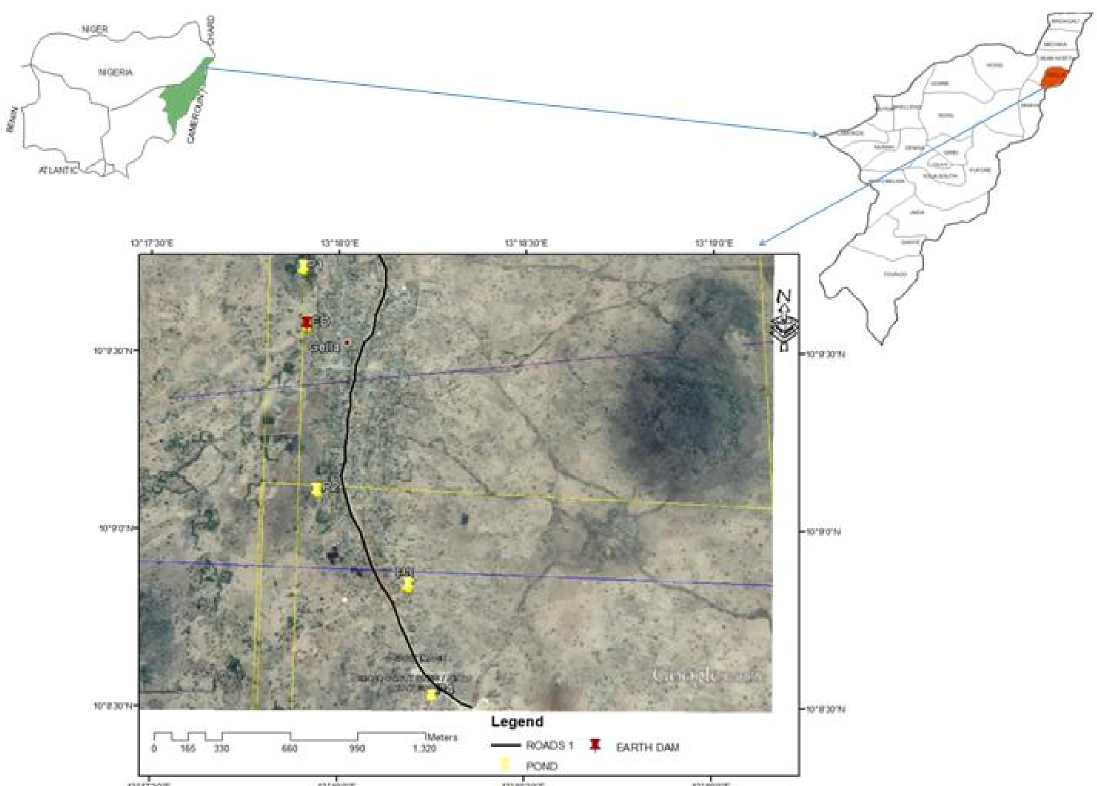

Fig. 1. Map of Gella showing water sample collection sites, field work 2017

2.5 Measurement of Total Dissolved Solid (TDS) and Electrical Conductivity (EC)

The Total Dissolved Solids and Electrical conductivity was measured using a TDS/conductivity meter as described by Ishaku et al. [9]. 200 mls of distilled water and 200 mls of water sample was poured into two separate beakers. The TDS / conductivity meter switched on, and its sensor rod was dipped into the beaker containing distilled water which was given a reading 0.00 mg/L TDS. After that, the sensor rod was dipped into the second beaker containing water sample, the TDS/conductivity then display the TDS value in mg/Liter.

2.6 Measurement of Turbidity

Turbidity was measured using DR 2000 (HACH) spectrophotometer using the method of Mustafa et al. [10].

2.7 Measurement of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Dissolved Oxygen (DO)

Biochemical oxygen demand (BOD), Chemical oxygen demand (COD) and Dissolve oxygen (DO) were determined as describe by Onwughara et al. [11]. Five-day Biochemical Oxygen Demands (BOD_5) was determined titrimetrically after incubation in tightly stoppered BOD bottles in the dark at 20°C. Dissolved oxygen content of the sample water was determined using digital dissolved oxygen meter

Calculation of COD:

$$\text{COD (mg/L)} = \frac{\text{mL of blank} - \text{mL of sample } 100}{\text{A X volume of sample used}}$$

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

2.8 Determination of Heavy Metals

Magnesium, calcium and some selected heavy metals (iron, manganese and zinc) were determined using Atomic Absorption Spectrophotometer (Buck Scientific 210) as described by Babagana et al. [12]. In determination of magnesium, calcium and heavy metals concentration using Atomic Absorption Spectrophotometer (Buck scientific 210) was used. The water sample was aspirated into the instrument after all the necessary set up and standardization procedures. Atomic vapor was produced as the sample drop on the acetylene flame, a beam of monochromatic light with a wavelength at which only the element of interest was absorbed, passed through the flame. The atom of the element in flame absorbed some amount of light which was corresponding to its concentration. This was detected on the display unit read as the absorbance. A calibration curve of each element was plotted using the absorbance of the standard against their corresponding concentration and was used to determine the concentration of the elements in the samples.

2.9 Bacteriological Analysis

The bacteriological analysis was carried out according to Owuama [13]. Five sterile test tubes were placed on a test tube rack. 9 ml of sterile saline was prepared and added into each of the five sterile test tubes. m1:10 serial dilution of *E. coli* broth up to 10^5 was made and 0.2 ml of 10^{-5} dilutions was transferred into duplicate nutrient agar plate and the plate was labelled. A sterile glass spreader was used for sterilizing, by dipping it into alcohol and burn off alcohol over flame. The 0.2 ml of 10^5 dilution was spread evenly over the plate and allowed to dry. The agar plate was incubated by inverting it at 37°C for 24 hours this was repeated for 10^{-6}, 10^{-7} dilutions. The total Coliform Unit (CFU) was examined and counted. The results were recorded. The number of coliform unit was calculated using the formula

Number of CFUs per mL =1/vol. plated × dilution factor × average no. of colonies.

2.10 Statistical Analysis

Mean and standard deviation were used for statistical analysis and the results were presented as mean ± standard deviation.

3. RESULTS AND DISCUSSION

3.1 Results

The result of physicochemical parameters of ponds and earth dam waters of Gella, compared with NAFDAC and WHO values shows that pH 5.60±0.17-7.20±0.12, temperature 30.00±0.00-25.00±2.28°C, electrical conductivity 3.56±0.33-6.40±0.04 µS/cm, total dissolve solids 4.75±0.06-8.27±0.15 mg/L, color 2.0±0.0-3.0±0.00 TCU, turbidity 5.00±0.89-226.17±21.0 NTU, chemical oxygen demand 1.59±0.23-4.27±0.27 mg/L, biochemical oxygen demand 2.31±0.13-

5.17±0.21 mg/L, dissolve oxygen 9.91±0.19-19.40±0.33 mg/L (Table 1).

The result of heavy metals concentration (ppm) of ponds and earth dam waters of Gella compared with NAFDAC and WHO values shows that calcium 19.79±0.01-28.21±0.00, magnesium 0.94±0.01-2.17±0.01, iron BD-1.14±0.01, manganese 0.11±0.03-1.70±0.03 (Table 2).

The result of the total coliform count in earth dam and pond waters in Gella ranged from 510 to 6100 CFU/100 mL (Table 3).

3.2 Discussion

The community drinks their water from the ponds and earth dam in the area without treatment (Fig. 2). The pH of the study area ranges from 5.60±0.17 to 7.20±0.12 at Pond 4 and Bogga earth dam respectively (Table 1). The result which is within the range of the WHO and NAFDAC standard for drinking water. The factors that affect pH are acidic rainfall, presence of hard water as well as presence of soap; thus high pH recorded at Bogga earth dam may be due to presence of soap and heavy elements such as calcium and magnesium.

The results of temperature (Table 1) were within the range 29.00±0.00-25.00±2.28. The lowest temperature was recorded at Bogga earth dam while the highest was recorded at Pond 2 this were also within the range of similar work carried out [14]. It has been suggested that solar radiation, clear atmosphere and low water level increase the temperature of water body [7]. This was so because pond 1 and Bogga earth dam are directly subjected to sun ray but the volumes of water in Bogga earth dam are more than that of the pond this could be why the temperature of the Ponds is higher than that of the earth dam.

In this study the electrical conductivity varies from 3.56±0.33 μS/cm (pond 4) - 6.40±0.04 μS/cm (earth dam). High level of electrical conductivity is an indication of high TDS. The electrical conductivity of the study area was all within WHO and NAFDAC standard for drinking.

The total dissolve solid (Table 1) were between 4.75±0.06 mg/L for ponds and 4 -8.27±0.15 mg/L for earth dam. In natural water total dissolved solid (TDS) consist mainly of inorganic salts such as carbonates, chlorides, sulphates, phosphates, nitrates, magnesium, calcium, sodium, iron etc. and small amount of organic matter and dissolved gases [14].

The turbidity of the water in study area ranged from 5.00±0.89 - 226.17±21.0 mg/L. The water turbidity is the physical parameter, which measures the cloudiness of water. It is arise as a result of particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. Generally, turbidity has no direct health effects; however, it can interfere with disinfection and provide a growth medium for microbes [15]. The high turbidity value in earth dam and other ponds was because they were open and dusts were blown into the water during dry season causing suspension on the water with a corresponding increase in turbidity of the water. In this study only the water from pond 4 is within WHO and NAFDAC standard for drinking water.

The biochemical oxygen Demand (BOD), and dissolved oxygen (DO) had the highest concentration at earth dam. The biochemical oxygen demand (BOD) values ranged from 2.31±0.13 mg/L to 5.17±0.21 mg/L and dissolved oxygen (DO) was from 9.91±0.19 mg/L to 19.40±0.33 mg/L while the BOD was within WHO permissible limit. However, the DO were all above the WHO and NAFDAC permissible standards respectively. The high level of DO (19.40±0.33 mg/L) observed is an indication of a slight pollution of the surface water which might be attributed to washing of organic wastes by rainfall into the water body. The COD values fell below WHO permissible limit.

The land soil in Gella is generally luvisols soils derived from basement rock parent material made up of low organic matter, low cation exchange capacity and low water retention ability [11]. It has an undifferentiated basement rock complexes with exposed surface [10]. The rocks are gnesis and migmatites complex. The geological structures of the area mostly include dykes, quartz veins, folds, sheer zones, etc. [11]. Calcium is known to be essential for nervous system, cardiac function and coagulation of blood. Its standard desirable limit in drinking water is 75 mg/L [16]. Calcium hardness has been classified as 0-20 mg/L (Soft); 20-40 mg/L (moderately soft); 40-80 mg/L (moderately hard); 80-120 mg/L (hard), >120 mg/L (very hard) [17]. Calcium distribution in the water samples showed that all the samples COD lies within the standard permissible limit of drinking water.

Table 1. Physicochemical parameters of Gella ponds and earth dam water

Parameters	Pond 1	Pond 2	Pond 3	Pond 4	Earth Dam	NAFDAC	WHO
pH	6.40±0.10	5.80±0.00	5.90±0.00	5.60±0.17	7.20±0.12	6.5-8.5	6.5-8.5
Temp (^oC)	28.70±1.03	30.00±0.00	29.00±0.07	25.30±2.42	25.00±2.28	NA	30-32
E.C (µS/cm)	5.83±0.19	3.87±0.51	4.12±0.01	3.56±0.33	6.40±0.04	1000	1000
TDS (mg/L)	7.88±0.27	3.87±0.51	6.33±0.12	4.75±0.06	8.27±0.15	500	500
Color (TCU)	2.0±0.00	3.0±0.00	2.0±0.00	2.0±0.00	3.0±0.00	15	15
Turbidity (NTU)	92.83±5.04	138.00±1.41	28.50±2.12	5.00±0.89	226.17±21.03	5	5
DO (mg/L)	12.08±0.34	10.95±0.09	10.12±0.18	9.91±0.19	19.40±0.33	7.5	7.5
COD (mg/L)	2.29±0.42	3.68±0.91	28.50±2.12	1.59±0.23	4.27±0.27	7.5	7.5
BOD (mg/L)	3.35±0.36	4.56±0.61	5.00±0.01	2.31±0.13	5.17±0.21	6.0-9.00	6.0-9.00

All measurement are mean ± standard deviation of 3 replicate analysis and are in mg/L except for pH, temperature (^oC), electrical conductivity (µS/cm), color (TCU), turbidity (NTU)

NAFDAC =National Agency for Food Drug and Control

WHO =World Health Organization

NA = Not available

Table 2. Heavy metal concentration in Gella ponds and earth dam water

	Calcium	Magnesium	Iron	Manganese	Zinc
Pond 1	23.43±0.18	2.18±0.06	0.58±0.01	1.25±0.02	BDL
Pond 2	28.21±0.00	1.11±0.00	0.77±0.00	0.89±0.00	BDL
Pond 3	26.61±0.00	2.17±0.01	1.12±0.01	0.11±0.03	BDL
Pond 4	19.79±0.01	0.94±0.01	BDL	0.12±0.01	BDL
Dam	24.48±0.01	2.11±0.05	1.14±0.01	1.70±0.03	BDL
Range	19.79±0.01-28.21±0.00	0.94±0.01-2.17±0.01	BDL-1.14±0.01	0.11±0.03-1.70±0.03	
NAFDAC	75	75	0.3	0.05	5.0
WHO	75	75	0.3	0.05	5.0

All measurement are mean± standard deviation of 3 replicate analysis and are in ppm
NAFDAC =National Agency for Food, Drug and Control
WHO =World Health Organization
BDL= Below Detectable Limits

Table 3. Bacteriological counts of Gella ponds and earth dam waters

Sample	Dilution	Average (cfu)
Pond 1	10^{-1}	5.1×10^{2}
Pond 2	10^{-2}	5.21×10^{4}
Pond 3	10^{-3}	6.1×10^{3}
Pond 4	10^{-4}	5.2×10^{3}
Dam	10^{-5}	1.9×10^{3}

Fig. 2. Water fetching and use at Gella earth dam

The concentration of magnesium in water is comparatively less than calcium possibly due to lesser occurrence of a laxative effect result, and relative abundance in rocks [7]. The WHO standard maximum permissible concentration of magnesium in drinking water is 50 mg/L. In this study, the magnesium concentration were between 0.94±0.01 to 2.17±0.01 mg/L and the magnesium concentration of the samples were within similar study done by Ishaku et al. [9] and were within WHO and NAFDAC standard limit.

Iron concentration (Table 2) varies from BD-1.14±0.01 mg/L. Iron in drinking water may be present as geological sources, industrial waste and domestic discharges and also from mining products. Excess amount of Iron (more than 10 mg/kg) causes rapid increase in respiration, pulse rate, coagulation of blood vessels and hypertension [7]. Iron is one of the heavy metal which is necessary for health it play a role in human nutrition; it help in the formation of protein hemoglobin, which transport to all cells of the body [13]. The standard desirable and the maximum permissible limits of iron in drinking water is 0.3 ml/L and 1.0 mg/L respectively according to WHO [18].

Total hardness takes into account both Ca^{2+} and Mg^{2+} ions with, on average, magnesium hardness representing about 1/3 of total hardness. Other cations that can cause hard water included Fe^{2+}, Fe^{3+}, Sr^{2+}, but as their levels are much lower, they are not typically included total hardness measurements. Calcium, in the form of Ca^{2+} ions, is a major inorganic ion in freshwater as water flows over limestones ($CaCO_3$), Gypsum ($CaSO_4.2H_2O$) and other calcium containing rocks and minerals. Magnesium, in the form of Mg^{2+} ion occur from water flowing over Dolomite ($CaCO_3^{-}MgCO_3$) and other magnesium containing rocks and minerals. Calcium carbonate is relatively insoluble in water but dissolve better in water containing high level of carbon dioxide the concentration of Ca^{2+} in fresh water is generally in the range of 0-100 mg/L. The recommended upper level for drinking water is 50 mg/L but higher level does not cause health risks. If the calcium ion concentration in fresh water drops below 5mg/L, the ability of the water to support life is dramatically decreased, resulting in oligotrophic condition. Sea water contains Ca^{2+} ions at levels of about 400 mg/L. Calcium is an important component of cell walls of aquatic plants and of bones and shells of aquatic animals. Magnesium is a component of chlorophyll in plants and therefore an essential nutrient [19].

Manganese occurs naturally in many surface water and ground water sources and in soils that may erode into these waters. However, human activities are also responsible for much of the manganese contamination in water in some areas. Manganese compounds may be present in the atmosphere as suspended particulates resulting from industrial emissions, soil erosion, volcanic emissions and the burning of MMT-containing petrol [20]. In this study the value of manganese concentration varies between 0.11±0.03-1.70±0.03 mg/L which were similar to the study by Maitera and Sudi [21]. The entire samples were within WHO and NAFDAC standard for drinking water.

The color of the water sample was between 2.0±0.00-3.0±0.00 TCU and all the samples were within WHO and NAFDAC standard of 15 TCU for drinking water. Drinking water should ideally have no visible color. Color in drinking-water is usually due to presence of colored organic matter (primarily humic and fulvic acid) associated with humus fraction of soil. Color has also been strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion product. It may also result from the contamination of water source with industrial influents and may be the first indication of hazardous situation [18].

The result of the total coliform count (Table 3) ranges from 510 to 6100 CFU/100 ml. The result was similar to the one obtained by Maitera et al. [21]. These results showed that the earth dam and ponds were grossly polluted with coliform organisms. It may be as a result of indiscriminate dumping of waste and human feces passed around the earth dam and pond which were washed into the pond and dam during rains. These values were higher than the WHO and NAFDAC [22] recommended standards.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

This study has provided information on the level of physicochemical and heavy metal concentration of water sample from ponds and earth dam in Gella town Mubi Local Government Area of Adamawa State. The study was aimed at determining the concentration of some physicochemical parameters and heavy metal concentrations (such as pH, temperature, total dissolve solid, turbidity, electrical conductivity, color, DO, BOD, COD, manganese, zinc, iron, calcium and magnesium) from ponds and earth dam and comparing them with WHO and NAFDAC standard for drinking water. Considering the result of the study the following conclusion were made:

The water from ponds were slightly more acidic than the water from dam that was slightly neutral. The water from ponds were slightly below WHO and NAFDAC standard limit. Other water physicochemical parameters and heavy metals were within WHO standard except the turbidity of ponds that were above WHO standard.

4.2 Recommendation

The water bed of Gella lies on solid rock, the only solution to perennial water shortage in the area is industrial borehole and or dam equipped with treatment/motorized distribution facility. The authors wish to recommend for water treatment and regular monitoring of the water in the study area as human activity are regularly changing the concentration level of these water parameters. It is also recommend that the Adamawa State, Federal Government and non-governmental organizations (NGO's) to provide an industrial motorized bore hole water for easy distribution to the community in order to avoid waste of life and cost of treatment of waterborne diseases.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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