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Assessment of Physicochemical Properties of Groundwater for Irrigation Purposes from Difa, Dadinkowa and Gwani Communitiesof Yamaltu-Deba Local Government Area of Gombe State, Nigeria

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ABSTRACT: The demand for quality water free of pollutants that can be maximally utilized by soil for crop production is on the societal increase. The study is aimed at examining some physico-chemical indices of groundwater for irrigation purposes from Difa, Dadinkowa and Gwani of Yamaltu-Deba Gombe State, Nigeria using standard methods. Samples collected were analysed ad data for mean concentration range presented aspH (6.00 - 6.80), temperature (23.95 - 25.78 ^{o}C), total dissolved solids (106.98 - 149.51 mg/L), total suspended solids (0.60 -1.28 mg/L), total alkalinity (17.00 - 19.25 mg/L) and dissolved oxygen (1.18 - 2.98 mg/L). The water samples recorded significant different (p<0.05) in pH values and were all below the permissible limits. However, cations and anions; NaCl, $CaCO_3$, PO_4^{3-}, CO_2, NO_2^- and NH_4^- showed no significant difference p<0.05 and were below the permissible limit, except $CaCO_3$ which exceeds the maximum permissible limits. These results suggest that the studied water samples are suitable for consumption and irrigation purposes.

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Keywords: Physicochemical properties; Irrigation water; Groundwater; Water quality

Groundwater is an essential source for drinking, domestic, irrigation, and industrial uses in most developing countries like Nigeria (Sulaiman *et al*., 2019; Barambu *et al*., 2020).Water is one of the most abundant natural resources in the world is water which forms about 80% constituent of the ecosystem (Sulaiman *et al*., 2018). It covers about 85% of the total landmass of the earth making it an essential part of the requirement by living things considering the nutritive and ecological roles it plays in both plants and animals (Nitasha and Sanjiv, 2015; Sulaiman and Maigari, 2016). Because of its potential resilience to climate variability in many areas of sub-Saharan Africa, groundwater plays a vital role in sustaining access to safe water in pursuit of the United Nations Sustainable Development Goal (SDG) 6-water and sanitation for all by 2030 (Diaw *et al*., 2020, Gbati *et al*., 2021). However, the rise in population, industrialization, and other deleterious human activities by man results in depletion of the normal water content by either decreasing or increasing them against a normal concentration of the available physical and chemical properties that cannot be sustained by living things (Jessica *et al*., 2020). Recent observations and studies observed the rapid alterations of the normal limits of water properties especially by human activities such as farming and industrial activities while the physical and chemical properties of water immensely influence its use, distribution and richness of biota (Unanam and Akpan, 2006).

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Considering the rise in population and the inability of the government to provide a modern method of increasing soil fertility and crop production to meet the demand of the rising population (Giller *et al*., 2021), other alternative sources are been initiated to meet these rising demands but faced with the challenge of physical and chemical deterioration of the initiated water sources that affect the soil (Loucks and van Beek, 2017). Zhao *et al.* (2002) reported the contamination of drinking water and other sources of water for agriculture with heavy metals and other pollutants shave a considerable impact on world crop production. In the past few decades, public concerns over the quality of drinking water have grown considerably. These concerns have arisen as a result of increased awareness about environmental pollution and episodes of waterborne disease outbreaks (Anadu and Harding, 2000). In developing countries, there are many people without safe drinking water, which resulted in many water borne disease infections. It is predicted that by the year 2025 many African countries will experience water scarcity (WMO, 2002). The availability of good quality water is an indispensable feature for preventing diseases and improving the quality of life (Dinrifo *et al*., 2010). With a large number of people depending on the earth's limited fresh water reserves increasing every day; in fact, scarcity of clean fresh water is one of the world's most environmental problems (Arms, 2008). Today, both the quantity and quality of our planet's fresh water are under threat. We should not be misled by the abundant supply in some fortunate parts of the world (Kofi, 2001). However, the extent of contamination is not well known. This study, therefore, aims to determine the variations in physicochemical properties of groundwater for irrigation purposes from Difa, Dadinkowa and Gwani Communities of Yamaltu-deba Local Government Area of Gombe State, Nigeria and to examine their impact on soil fertility and crop production.

MATERIALS AND METHODS

Description of Study Area: Yamaltu-deba L.G.A occupies a landmass of 1,981 km and is located 7 km east of Gombe town with major tribes including Tera, Fulani and minor tribes like Kanuri, Hausa, Jara and Waja with an approximated population of 255,726 (NPC, 2007). Areas under study within Yamaltu-Deba are Difa, Dadinkowa and Gwani located Gwani located at a latitude of 11^0 3^0N, longitude 10^0 2^0E, and latitude of 24 m above sea level, the area received a total annual rainfall of about 760-1100 mm per annum and temperature ranges between 24 ^{0}C to 40 ^{0}C (Figure 1). The area predominantly has two seasons; the rainy season commencing from April-October and the dry season from October-March. A rich fertile soil of loam, clay, clay-loam soil that is suitable for most crops enables them to be involved in both rainy and dry season farming for both subsistence and commercial purpose. The result of the high temperature around the area gives room for high evaporation and thus less moisture available for the plant. The main occupation of the inhabitant is mostly farming and trading very few are civil and public servants (Erie *et al*., 2019).

Sample Collection: Water samples were collected from three different towns namely; Difa, D/kowa and Gwani of Y/Deba LGA. A total of eighteen groundwater samples for irrigation purposes were collected in each of the three selected study areas. Water samples were collected in sterilized plastic bottles. The bottles were rinsed with tap water and thereafter soaked in 10% HNO_3 for 24 h and finally rinsed with de-ionized water and ready for use (Akan *et al*., 2010). The parameters such as pH, temperature, TDS and TSS were analyzed immediately on the spot of collection whereas. The sampling bottles were rinsed with the water sample three times at the point of collection before taking samples and were covered, labeled and transported the laboratory prior to other analysis.

Physicochemical Parameters: Analysis was carried out for some water quality parameters including;

Temperature: The temperature of the water samples was taken on the spot using a mercury thermometer as described by APHA (1999).

pH: The pH meter (Hanna HI9024) was calibrated according to the instructional manual provided by the manufacturer. The electrode of the pH was dipped into water samples for 2-3 minutes and the final reading was recorded (APHA, 1999).

Total Dissolved Solids (TDS) and Electrical Conductivity (EC): These parameters were analyzed by Hanna conductivity meter model EC 215. Water samples were placed in clean beakers, conductance cell of the meter was immersed in the sample solution. The resistance was measured and the readings of conductivity and total dissolved solids were recorded with the conductivity meter by changing the measurement to TDS. The cell was rinsed in a beaker after each reading was taken.

Free Carbon dioxide: Ten drops of phenolphthalein indicator were used added to 100 mL of water sample and titrated against sodium carbonate until a weak pink color end product was observed as described by Needham and Needham (1975).

Total Alkalinity (TA), Total suspended solids (TSS), Dissolved Oxygen (DO), dissolved sodium chlorides (NaCl), dissolved calcium carbonate ($CaCO_3$), Total phosphate ions (PO_4^{3-}), Nitrate (NO_2^-), Ammonium ions (NH_4^+) as per standard procedures (APHA, 2003).

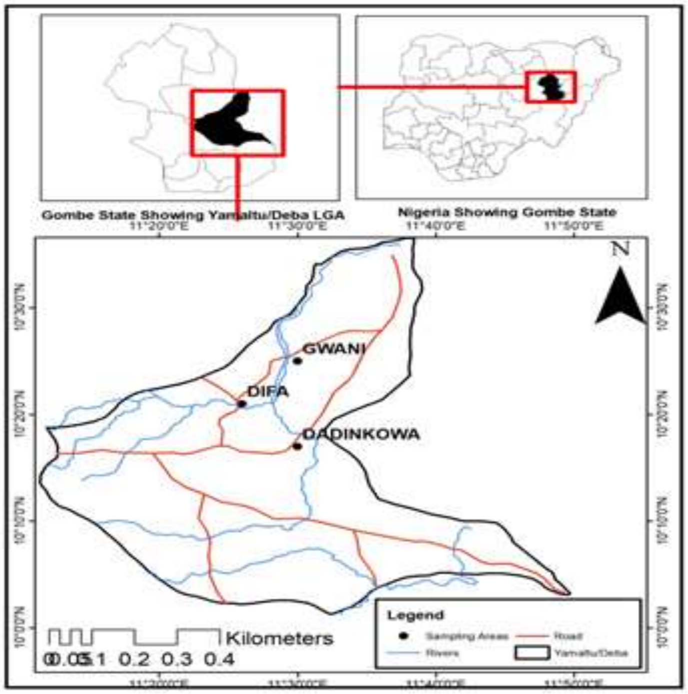

Fig 1: Map of study area showing the sampling areas

Statistical Analysis: The data collected were analyzed using SPSS software version 25 for Windows. One-way analysis of variance (ANOVA) was used to test for a significant difference in the mean of the physicochemical parameters among the three study sites and Turkey's multiple comparison test was used to compare their significant difference at $p<0.05$.

RESULTS AND DISCUSSION

Results of physicochemical analysis obtained from three sites; Difa, Dadinkowa and Gwani of Yamaltu-Deba Local Government Area of Gombe State are presented in Table 1 and Figure 2. The pH level is a measure of the acid or basic content of the water. Water containing a great load of organic pollution will normally tend to be somewhat acidic. Water with a pH of 7 is considered neutral. If the pH is below 7, it is classified as acidic, while pH greater than 7 is said to be alkaline. The pH has no direct adverse effect on health but it alters the taste of water as well as soil status, all organo-chemical reactions are sensitive to variation of pH. Regulatory mechanism serves the purpose of pH normality by water animal said in balancing the pH while photosynthesis, and other biological cycles by plants. There was a significant difference at $p<0.05$ between the pH of the water sample from Difa and Dadinkowa whereas there was no significant difference $p<0.05$ between the pH of the water sample from Gwani to that of Difa and Dadinkowa. Water sources from Difa indicated higher pH values while those from Dadinkowa with lowest pH but all within normal range values in comparison with a standard by WHO (2011), and agreement with 4.9-7.2 reported by Masse and Masse (2002), these further has a directly proportional effect on soil quality and productivity.

Temperature exerts a major influence on biological activities and growth, temperature values across the three collection sites did not show any significant difference at $p<0.05$ with a range of 23.95 ^{0}C to 25.78 ^{0}C and did not exceed the maximum permissible limit of 30.3 ^{0}C set by NIS (2008). The higher value of water temperature observed in the present study could be attributed to the peak summer months that prevailed during the period of investigation. This complies with reports of Dwivedi *et al*. (2002). The temperature provides an insight into the soil anthropogenic activities and other organic matter decay since the temperature is within the permissible range; the soil water is considered safe for plant growth. Furthermore, TDS is a measure of dissolved organic and inorganic substances in liquid samples

Table 1: Physicochemical parameters of water samples from Difa, Dadinkowa and Gwani

Parameter/Source	Difa	D/Kowa	Gwani
pH	6.80±0.36[a]	6.00±0.55[b]	6.18±0.60[ab]
Temp °C	25.78±3.04[a]	24.68±3.98[a]	23.95±2.69[a]
TDS (mg/L)	149.51±107.01[a]	171.60±157.78[a]	106.98±79.63[a]
TSS (mg/L)	1.28±1.74[a]	0.88±0.35[a]	0.60±0.32[a]
T. Alkalinity (mg/L)	17.00±16.39[a]	17.25±15.08[a]	19.25±19.88[a]
DO (mg/L)	2.20±1.70[a]	2.98±2.29[a]	1.18±0.54[a]

Values with different superscripts along rows are statistically significant at p<0.05

The results of TDS as contained in Table 1 did not show any significant difference at $p<0.05$ between the three sites of sample collection with a mean range of 106.98 mg/L from Gwani to 171.60 mg/L at Gwani, Dadinkowa and Difa with 149.51 mg/L, lower TDS values is an indication of the degree of corrosiveness or toxicity of the sample, while the TSS values from these sites did not show any significant difference at $p<0.05$ with maximum mean values of 1.28 mg/L at Difa and lowest at Gwani with 0.60 mg/L; both TDS and TSS did not exceed the permissible limit of 200 mg/L and 20 mg/L set up by (WHO, 2011) respectively. TDS is an indication of the degree of dissolved substances such as metal ions in the water (Efe *et al*., 2005), thus the results portray an appreciable amount of dissolved substance in the water from these areas while TSS is a measure of the physical observable dirtiness or suspended particles in the water resource; the least values for TDS indicates for Gwani may give a potent toxicity status to the soil than Dadinkowa and Difa but all within the permissible limit. TSS indicates the cleanliness of the water samples and this can be attributed to the control of human activities in the area, lower TSS values are a good indicator of water quality which aids normal aeration and maximum photosynthetic activities by plants in the soil. Alkalinity is an important parameter because it measures the water's ability to resist acidification. The major portion of alkalinity in natural water is caused by hydroxide, carbonate and bicarbonate. Alkalinity in itself is not harmful to human beings, soil, or plants (Surve *et al*., 2005). The standard permissible limit by NIS is 200 mg/L. Mean values obtained from the three collection sites did not exceed this standard limit and also did not any significant difference at $p<0.05$ with Gwani having the highest values while sources from Difa with the least values, but further degeneration of pH, which alternately disrupts soil fertility and the survival of underground animals that aids decompositions, this affects soil quality negatively. These may be due to less or little decay of organic matter, weathering of rocks and minerals around these areas. DO is the single most important gas for most aquatic organisms, low DO may results in anaerobic that causes a bad odour to the water samples. Standard permissible limits by NIS are 4-6 mg/L. Mean values obtained from all the site falls within the permissible range except Gwani with 1.18 mg/L indicating some signs of low aquatic activity and odour. No significant difference was observed between the values at $p<0.05$. Dadinkowa is with the highest indication of favorable station for aquatic activities and soil efficacy. The results are in line with that reported by Yerima *et al.* (2018).

Table 2 show results for; Total dissolved salts (NaCl) are usually markers of salinity in water samples. The mean values were 1.36 mg/L and 0.33 mg/L for Dadinkowa and Gwani while Difa with 0.58 mg/L indicated that the permissible limit of 20 mg/L by NIS was not exceeded. Furthermore, a significant difference was not observed between these values at $p<0.05$. This can be attributed to the low level of salts deposited around these areas. But a rise in water levels can contribute significantly to salinity especially around the rainy season (Khan and Akram, 1986) accompanied by fertilizer application which makes the soil saline.

Table 2: Cations and anions from Difa, Dadinkowa and Gwani

Parameter/Site	Difa	D/kowa	Gwani
NaCl	0.58±0.42[a]	1.36±1.70[a]	0.33±0.25[a]
$CaCO_3$	462.50±207.42[a]	375.00±277.90[a]	602.50±235.43[a]
PO_4^{3-}	16.88±7.69[a]	16.52±4.11[a]	18.00±2.83[a]
CO_2	1.76±1.06[a]	1.54±1.22[a]	1.43±0.66[a]
NO_2^-	5.89±1.41[a]	5.49±3.23[a]	5.26±1.52[a]
NH_4^+	0.04±0.02[a]	0.05±0.03[a]	0.06±0.03[a]

Values with different superscripts along rows are statistically significant at p<0.05

The hardness of water caused by insoluble $CaCO_3$ was also observed in these areas, the standard permissible limit of 150 mg/L by NIS was exceeded with Gwani with the mean value of 602.50 mg/L while Dadinkowa with 375.00 mg/L. Values from total hardness from the three sites did not show any significant difference at $p<0.05$. With these results, the soil around these areas is considered rich in carbonates, gypsum. This aid abruptly inhibits the utilization of soil microbes by plants thus soil fertility s reduced, this report agreed with NLWRA (2002). Phosphates ions were found at all three collection sites and there was no significant difference between the values at $p<0.05$ across the site. All mean values from the three study sites were relatively higher than the maximum permissible limit of 10 mg/L by NIS (2008). This may be due to access of waterways to human, animal waste and other sources like industrial effluents, fertilizer run-off. Thus, a rise in phosphates levels in water increases the potential growth of troublesome algae as reported by Esry (1991) but enhances soil fertility. There was no significant difference at $p<0.05$ between the mean values for free carbon dioxide among the three sites of collection and all mean values do not exceed the maximum permissible limit. The availability of free carbon dioxide is a favorite for most plants for their photosynthetic activities thus the soils from these areas showed a good environment for plant growth. There was no significant difference at $p<0.05$ between nitrogen mean values across the three sites with the higher range of 5.89 mg/L at Difa and the lowest at 5.26 mg/L Gwani. The values did not exceed the maximum permissible limit of 10 mg/L by NIS (2008). The availability of nitrogen serves as a precursor for other biological processes such as the nitrogen cycle to be achieved and other beneficial bacterial activities. The amount of ammonium ions is an indication of the extent of decay of organic matter by nitrogen-fixing bacteria and its efficiency. The mean values showed no significant difference at $p<0.05$ between these three sites. The maximum permissible limit was not exceeded 5 mg/L. The indication of a balanced activity of the nitrogen cycle via the utilization of ammonium ions by bacteria makes it beneficial to plants' growth in the soil. This is also reported in the work of shah and shah (2011) that ammonium ions values not exceeding the permissible limit are an indication of efficient soil microbial activities.

Conclusion: From the result of this study, it can be concluded the concentration of some of the physicochemical properties from groundwater from Difa, Dadinkowa and Gwani were within the permissible limit except $CaCO_3$ exceeding the maximum permissible set by NIS and WHO. Furthermore, the lower concentration of DO, NaCl, CO_2 and ammonia indicates the low pollution by industrial products and farming practices. However, regular motoring should be encouraged to detect early changes in the physicochemical properties to preserved water sources in these communities of Yamaltu-deba**.**

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