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Determination of Some Physicochemical Parameters of Water from the Bank of Komadugu River in Gashua, Yobe State

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Abstract: *This study was aimed at determining the pH, ammonia, nitrite, nitrate, alkalinity, chloride, electrical conductivity, dissolved and total organic and inorganic carbon of water. Water samples were collected at four different points S1, S2, S3 and S4 at the bank of Komadugu River in Gashua, Yobe State. The pH was measured using Jenway 3505 pH meter. The chloride, ammonia, nitrite, nitrate and alkalinity were measured with Lamotte smart3 calorimeter using chlorine tablet (025, DPD and DPD 3), ammonia- nitrogen reagent tablet (007), nitrite test tablet (068), nitrate test tablet 066 and alkalinity tablet (001) respectively. The total organic carbon (TOC) and total inorganic carbon (TIC) were determined from unfiltered water from the river, while dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) were determined from filtered water by first oxidation with acidified potassium dichromate followed by titration with ferrous ammonium sulphate using diphenylamine indicator. The pH of the water sample, 6.28 ± 0.04, is below the recommended value of 6.5 -9.5 set by the World Health Organization. Nitrite causes the formation of methaemoglobin, for which its level in potable water and foods is restricted by regulations. Concentration of nitrite obtained in this study is 26.40 ± 0.69 mg/L, which is far above the maximum permissible limits of 3 and 0.5mg/L set by the World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) respectively. The WHO and USEPA permissible limits for ammonia are 0.3 and 0.5mg/L respectively. The nitrate content of the water is 131.38 ± 5.48 mg/L, which is above the 45 and 50mg/L permissible limits set by the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA). Total alkalinity in the water sample analyzed is 316.32 ± 10.69, which is above the 120 and 200mg/L permissible limits set by WHO and USEPA respectively. The electrical conductivity value for the water sample in this study is 414.17± 9.97 µS/cm which is below the WHO and USEPA permissible limits of 750 and 1500 µS/cm for drinking water. The concentration of chloride ion in the water sample in this study is 623.89 ± 6.12, which is above the permissible limit of 250 mg/L set by WHO and USEPA. The mean concentrations of total organic carbon, TOC (10.71±0.24 mg/L), total inorganic carbon, TIC (25.06 ± 0.20 mg/L), dissolved oxygen carbon, DOB (9.30 ± 0.14 mg/L) and dissolved inorganic carbon, DIC (22.95±0.38 mg/L) in the water samples are much higher than the permissible limits for organic carbon (0.5 mg/L) and inorganic carbon (0.1 to 1mg/L) in drinking water set by USEPA.*

Keywords: *Jenway 3505 pH meter; Lamotte smart3 calorimeter; Permissible limits; World Health Organization (WHO); United States Environmental Protection Agency (USEPA);*
Methaemoglobin

1. Introduction

Water is one of the most important and abundant compounds of the ecosystem. Living organisms on the earth need water for their survival and growth. The earth is the only planet now with about 70% of water. But due to increased human population, industrialization, use of fertilizers in agriculture and manmade activity, it is highly polluted with different harmful contaminants (Basavaraja-Simpi *et al.,* 2011). High levels of organic matter in river water cause increase in biological oxygen demand, chemical oxygen demand, total dissolved solids, total suspended solids, making water unsuitable for drinking, irrigation and other purposes (Hari,1994). It is very essential to test for water quality before it is used for drinking, domestic, agricultural and industrial purposes. Selection of water quality parameters for testing is solely dependent on the purpose for which water is used. Water contains different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some tests are performed on physical parameters such as temperature, colour, odour, pH, turbidity and total dissolved solids (TDS). The chemical parameters include Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), dissolved oxygen, alkalinity and other characteristics .For quality and purity, water should be tested for its trace and heavy metals, as well as organic contents. It is obvious that drinking water should pass these tests and it should also contain required mineral levels. These criteria are only monitored strictly in developed countries. Due to very low concentrations of heavy metals and organic pesticide impurities present in water, analysis requires highly sophisticated analytical instrument and well trained manpower (Hari, 1994).

2. Materials and Methods

2.1 The Study Area

The Yobe River, also known as the Komadugu Yobe River is a river in West Africa that flows into Lake Chad through Nigeria and Niger. In Yobe State, it is located on longitud12º52´N and latitude 10º58´E in Gashua, Bade Local Government Area. Its tributaries include River Hadejia , River Jama'are and the Komadugu Gana River. The river forms a small part (150 km) of the international border between Niger and Nigeria and flows a total of 320km (KYBP, 2006). There are concerns about changes in the river flow, economy and ecology due to upstream dams, the largest at present being the Tiga Dam in Kano State, with plans for the Kafin Zaki dam in Bauchi State (NPC, 2006). The River Yobe provides a means of subsistence for hundreds of thousands of people who work in a variety of commercial and agricultural endeavors along its almost 200 km length in the states of the northern region, which spans seven local government areas (LGAs) from Nguru to Yunusari. Notable towns near the river include Gashua, Geidam and Damasak in Nigeria and Diffa in Niger (Wakawa *et al*, 2017).

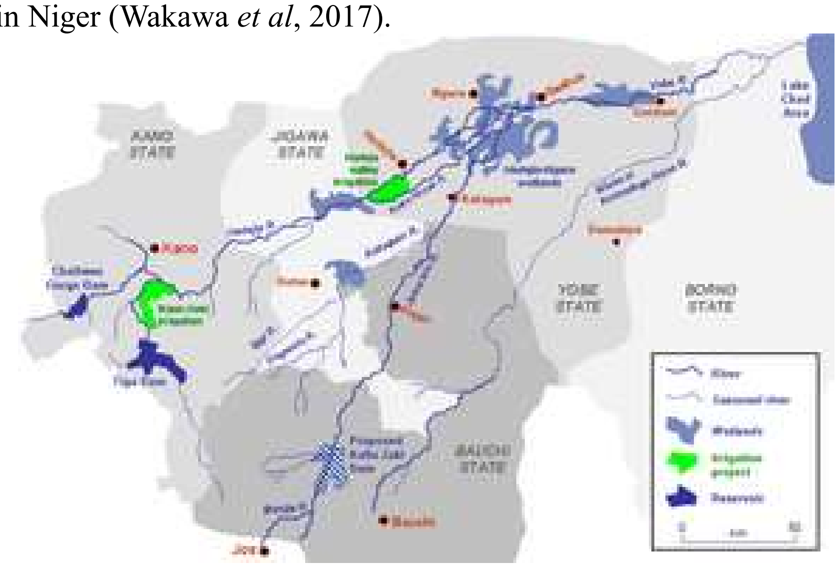


Figure 1: Catchment Area of the Komadugu River

2.2 Instruments, Apparatus and Reagents

All equipment and instruments used in this research were calibrated before conducting the experiments. All glassware used were thoroughly washed with detergent and tap water and then rinsed with deionized water. Suspected contaminants were cleaned with 10% concentrated nitric acid (HNO_3) and metal surfaces rinsed with deionized water. The digestion tubes were soaked in 1% (w/v) potassium dichromate in 98% (v/v) H_2SO_4.

In preparation of reagents, chemicals of analytical grade purity and distilled water were used. All glassware and plastic containers were washed with detergent.

2.3 Collection of Water Samples

Prior to sample collection, 500ml plastic bottle (four in number) were washed with hot detergent solution, soaked in 50% nitric acid for 24hrs, rinsed with tap water and finally rinsed thoroughly with deionized water. Water samples collected at four different points S1, S2, S3 and S4 at the bank of Komadugu River in Gashua, Yobe State were stored in the bottles. The water samples were preserved with 0.80mL sulphuric acid per litre (Dawson *et al*., 2022).

2.4 Determination of Physicochemical Parameters of Water

The pH was measured using Jenway 3505 pH meter. The chloride, ammonia, nitrite, nitrate and alkalinity were measured with Lamotte smart3 calorimeter using chlorine tablet (025, DPD and DPD 3), ammonia- nitrogen reagent tablet (007), nitrite test tablet (068), nitrate test tablet 066 and alkalinity tablet (001) respectively. The total organic carbon (TOC) and total inorganic carbon (TIC) were determined from unfiltered water from the river, while dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) were determined from filtered water by first oxidation with acidified potassium dichromate followed by titration with ferrous ammonium sulphate using diphenylamine indicator.

2.5 Statistical Analysis

The data were analyzed in triplets and expressed as mean and standard deviation. The mean of all treatments was subjected to One-way analysis of variance (ANOVA) using IBM SPSS Statistics 23 software and mean differences were performed using the Tukey test. All graphs were plotted using Microsoft Excel 2013.

3. Results and Discussion

3.1 Water Quality Analysis

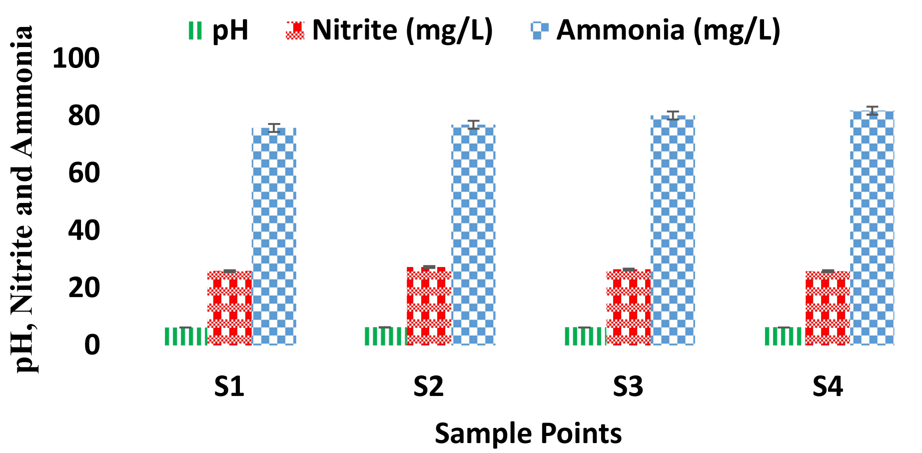
Quality drinking water is essential for life. Contaminants such as heavy metals, organic compounds, bacteria and viruses have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-use of limited water resources. Assessment of water quality involves determination of contamination levels of contaminants and analysis of physicochemical parameters (Tesfaye *et al.,* 2018). The physicochemical parameters analyzed in this study include pH, nitrate, nitrite, alkalinity, ammonia, chloride, electrical conductivity, dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), total organic carbon (TOC) and total inorganic carbon (TIC).

3.2 Assessment of Water Quality Parameters

3.2.1 pH, Nitrite and Ammonia of Water

Figure 2 shows the pH, nitrite and ammonia levels of water collected at the bank of Komadugu River in Gashua town of Yobe State.

Figure 2: pH, Nitrite and Ammonia in Water Samples



3.2.1.1 pH of Water

pH is the indicator of acidic or alkaline condition of water . The pH of water sample collected from Gashua bank of Komadugu River is 6.28 ± 0.04, which is below the recommended value of 6.5 - 9.5 set by the World Health Organization. The value obtained in this study is in consonance with 6.90 ± 0.33 to 8.20 ± 0.36 reported by Gebresilasie *et al.* (2021) in hand-dug well water samples of Kafta Humera Woreda, Tigray, Ethiopia; 8.19 reported by Kepuska *et al.*,(2014) for water samples in Lake Radoniq, Tirana, Albania;6.5 – 8.5 reported by Nigam *et al.,* (2013); 6.9 – 7.4 for potable water and 8.3 – 8.8 for lake water reported by Shukla *et al.*, (2013); 6.9 – 7.0 for potable water and 8.3 – 8.8 for lake water reported by Keerthika *et al.,* (2019); 6.9 – 7.5 reported by Nagamani and Devi (2015) for water samples taken from Urban and rural locations of Bangalore and 7.3–7.7 reported by Jannat *et al.* (2019) for surface water of Mokeshbeel, Gazipur, Bangladesh.

pH is the most important parameter in determining the corrosive nature of water. The lower the pH value, the higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Gupta *et al.,* 2009). Reduced rate of photosynthetic activity, assimilation of carbon dioxide and bicarbonates are responsible for increase in pH. Various factors bring about changes in pH of water. Higher pH values suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition (Karanth, 1987).

3.2.1.2 Nitrite Content of Water

The levels of nitrite, NO_2^- in potable water and foods is restricted by regulations, because it gives rise to the formation of methaemoglobin. Concentration of NO_2^- obtained in this study is 26.40 ± 0.69 mg/L, which is far above the maximum permissible limits of 3 and 0.5mg/L set by the World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) respectively. Kepuska *et al*. (2014) reported a NO_2^- level of 0.0045mg/L in water samples from lake Radoniq, Tirana, Albania. As a preservative and fertilizing agent, NO_2^- has been widely used in the food industry. It is also an important intermediate in biological systems, participating in many physiological processes including inflammation, vasodilatation, neurotransmission, cell proliferation, and apoptosis. However, high levels of NO_2^- can lead to a series of negative health effects, especially in infants and children (Adnan *et al.*, 2005).

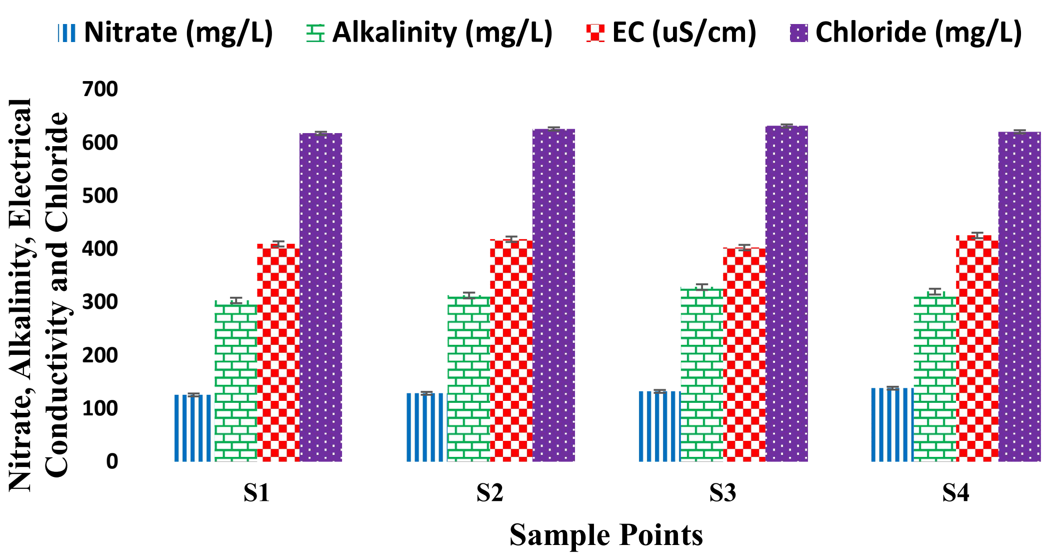
3.2.1.3 Ammonia Content of Water

The WHO and USEPA permissible limits for ammonia are 0.3 and 0.5mg/L respectively. The level of ammonia obtained in this study is 78.71±2.26 mg/L. Kepuska *et al*. (2014) reported ammonia level of 0.09mg/L in water samples from lake Radoniq, Tirana, Albania. Long term ingestion of water with a high ammonia concentration can cause damage to human body, including damage to organ systems. The symptoms of ammonia poisoning include coughing, chest pain, wheezing and difficulty in breathing.

3.2.2 Nitrate, Alkalinity, Electrical Conductivity and Chloride in Water

Figure 3 shows the nitrate, alkalinity, electrical conductivity and chloride levels of water collected at the bank of Komadugu River in Gashua town of Yobe State.

Figure 3: Nitrate, Alkalinity, Electrical Conductivity and Chloride in Water



3.2.2.1 Nitrate Content of Water

Nitrate, NO_3^- is one of the various factors that cause diseases. It is generally believed that NO_3^- plays a significant role in the occurrence of methemoglobinemia. The NO_3^- content of water analysed is 131.38±5.48 mg/L, which is above the 45 and 50mg/L permissible limits set by the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA). Various levels of NO_3^- in water were reported by some workers; Gebresilasie *et al.,* (2021): 1.86 ± 0.03 to 5.43 ± 0.06 mg/L, Kepuska *et al*. (2014): less than 0.6 mg/L and Nagamani and Devi (2015): 28 – 45mg/L. Early studies have shown that NO_3^- pollution in groundwater may originate from several different sources, including point source pollution (such as industrial pollution and intensive animal husbandry) and non-point source pollution (such as fertilizers, fungicides, atmospheric deposition, etc.) (Almasri, 2007). Babiker *et al.* (2004) used the Geographic Information System (GIS) to study the NO_3^- pollution in ground water. It was found that NO_3^- content in groundwater of vegetable-growing farmland increased significantly due to the large-scale use of chemical fertilizers . Excessive use of chemicals and fertilizers (Adimalla, 2019) in agriculture can increases the risk of surface and groundwater pollution, which has adverse effects on human health and the environment (Pisciotta *et al.*, 2015).

3.2.2.2 Alkalinity of Water

Alkalinity is a measure of the ability of water to neutralize acids and it mainly occurs due to the presence of carbonates and bicarbonates in water. The total alkalinity in the water sample analyzed is 316.32±10.69, which is above the 120 and 200mg/L permissible limits set by WHO and USEPA respectively. Alkalinity values reported by some workers are; Gebresilasie *et al.* (2021): 75±5.0 to 215±5.0 mg/L for hand-dug well water samples of Kafta Humera Woreda, Tigray, Ethiopia, Kepuska *et al*. (2014); 0.09mg/L in water samples from lake Radoniq, Tirana, Albania, Shukla *et al.*, (2013) and 150 – 170 mg/L for lake water samples. Alkalinity acts as a stabilizer for pH. Alkalinity, pH and hardness affect the toxicity of many substances in water. It is determined by simple dilute hydrochloric acid titration in presence of phenolphthalein and methyl orange indicators. Alkalinity in boiler water essentially results from the presence of hydroxyl and carbonate ions. Hydroxyl alkalinity (causticity) in boiler water is necessary to protect the boiler against corrosion. Too high a causticity causes other operating problems, such as foaming. Excessively high causticity levels can result in a type of caustic attack of the boiler called embrittlement (Patil *et al.,* 2012).

3.2.2.3 Electrical Conductivity of Water

Electrical Conductivity is a measure of the conducting ability of water and it is determined by the presence of ionic species in the water. Electrical conductivity value for the water sample obtained in this study is 414.17±9.97 μS/cm which is below the WHO and USEPA permissible limits of 750 and 1500 μS/cm for drinking water. The electrical conductivities of water samples as reported by some workers are; Gebresilasie *et al.,* (2021): 148.50±0.89 to 932.00±0.98 μS/cm for hand-dug well water samples of Kafta Humera Woreda, Tigray, Ethiopia and Kepuska *et al*. (2014): 172 μS/cm for water samples from Lake Radoniq, Tirana, Albania.

High value of electrical conductivity in the water sample shows that contaminations due to dissolve ions are high, because electrical conductivity is directly proportional to the total dissolved solids (Gebresilasie *et al.,* 2021).

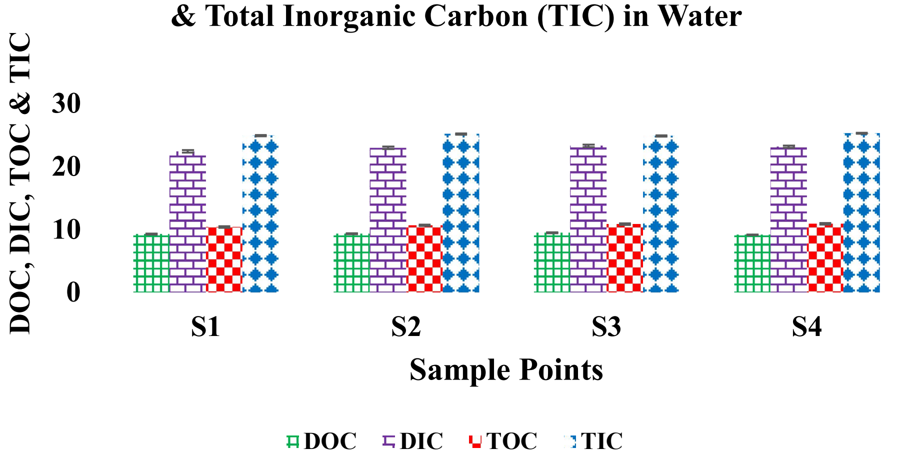
3.2.2.4 Chloride Content of Water

Chloride enters into surface and groundwater from both anthropogenic and natural sources such as from run-off wastes from human activities, discharges of wastewater into water bodies, use of inorganic fertilizers, landfill leachates, and septic tank effluents (Gupta and Gupta, 1999).The concentration of chloride ion in the water sample in this study is 623.89±6.12, which is above the permissible limit of 250 mg/L set by WHO and USEPA. The high chloride concentration might be due to different levels of chloride salts in the soil and sediments or a result of differences in degree of wastes entering into the hand-dug wells (Obasi and Talabi (2015). The chloride levels of water samples as reported by some workers are; Gebresilasie *et al.,* (2021):12.86±0.02 to 42.72±0.20 mg/L for hand-dug well water samples of Kafta Humera Woreda, Tigray, Ethiopia, Kepuska *et al*. (2014):4.89 mg/L for water samples from Lake Radoniq, Tirana, Albania, Shukla *et al.* (2013): 30 – 58mg/L for potable water and 60 – 84mg/L for lake water, Nagamani and Devi (2015): 140 – 200 mg/L.

3.2.3 Dissolved and Total Organic and Inorganic Carbon of Water

Figure 4 shows the dissolved and total organic and inorganic carbon of water collected at the bank of Komadugu River in Gashua town of Yobe State.

Figure 4: Dissolved Organic Carbon (DOC), Dissolved Inorganic Carbon (DIC), Total Organic Carbon (TOC) & Total Inorganic Carbon (TIC) in Water



The mean concentrations of total organic carbon (TOC), total inorganic carbon (TIC), dissolved oxygen carbon (DOB) and dissolved inorganic carbon (DIC) in the water samples were 10.71±0.24, 25.06±0.20, and 9.30±0.14 and 22.95±0.38 mg/L respectively. The permissible limits set by United States Environmental Protection Agency (USEPA) for organic and inorganic carbon in drinking water are 0.5 and 0.1 to 1mg/L respectively. The transfer of total and dissolved, organic and inorganic carbon from the land to the oceans via river systems is a key link in the global carbon cycle (Likens et al. 1981; Meybeck, 1987; Ludwig *et al.,* 1996; Amiotte-Suchet *et al.,* 2003; Brunet *et al.,* 2005; Richey, 2005). It has been estimated that globally rivers transport on average 0.8 to

1.2×1015 g of carbon annually (Ludwig *et al.,* 1996). Dissolved and total organic carbon (DOC, TOC) is produced through the mobilization of natural and anthropogenic organic matter, derived from the solution of autochthonous, within stream generation of organic material; or from anthropogenic sources such as effluents and industrial discharges. Total and dissolved inorganic carbon (TIC, DIC) is produced by weathering of carbonate and silicate rocks, although they may also be present as CO_2 generated by the decomposition of dissolved organic matter (Das *et al.,* 2005). These processes generate the alkalinity of the river water, and also influence the pH of water, which governs the subsequent partitioning of DIC between dissolved CO_2, bicarbonate, and carbonate ions. The fraction of DIC present as dissolved CO_2 is almost always at concentrations much greater than the atmosphere (Kempe, 1982; Cole and Caraco, 2001), which demonstrates that rivers are a source of CO_2 to the atmosphere (Cole and Caraco, 2001).

4. Conclusion

Results of this study revealed that the pH and electrical conductivity of water collected from the Gashua bank of Komadugu River were below the permissible limits set by WHO and USEPA. Other parameters which include ammonia, nitrite, nitrate, total alkalinity and electrical conductivity and the various forms of carbon which include TOC, TIC, DOC and DIC were much higher than the USEPA permissible limits set for drinking water. Since the Komadugu river is used for irrigation and other purposes, it is necessary to carry out periodic check on its quality parameters.

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Authors' Contributions
Dagari M.S.: Conceptualization, design and supervision of the research work; Editing of the write-up
Ibrahim H. and Adamu U.: Undertaking the research work, write-up and data analysis.

References

Adimalla, N. (2019). Spatial Distribution, Exposure, and Potential Health Risk Assessment from Nitrate in Drinking Water from Semi-Arid Region of South India. *Human Ecol Risk Assessment Int J.*, https://doi.org/10.1080/10807039.2018.1508329.

Adnan, A., Özgen, E. and Taşcıoğlu, S. (2005). A Novel Method for the Spectrophotometric Determination of Nitrite in Water, *Talanta,* 66(5): 1181 – 1186.

Almasri, M. N. (2007). Nitrate Contamination of Groundwater: a Conceptual Management Framework. *Environ Impact Assess Rev.*, 27(3):220–42.

Amiotte-Suchet, P., Probst, J. L. and Ludwig, W. (2003). Worldwide Distribution of Continental Rock Lithology: Implications for the Atmospheric/Soil CO_2 Uptake by Continental Weathering and Alkalinity River Transport to the Oceans *Global Biogeochemical Cycles,* 17(103):1-7.

Babiker, I. S., Mohamed, M. A. A., Terao, H., Kato, K. and Ohta, K. (2004). Assessment of Groundwater Contamination by Nitrate Leaching from Intensive Vegetable Cultivation Using Geographical Information System, *Environ Int.*, 29(8):1009–17.

Basavaraja-Simpi, S. M., Hiremath K. N. S., Murthy K. N., Chandrashekarappa, A. P. N. and Puttiah, E. T. (2011). Analysis of Water Quality Using Physico-Chemical Parameters of Hosahalli Tank in Shimoga District, Karnataka, India. *Global Journal of Science Frontier, Research,* 1(3):3134.

Brunet, F, Gaiero, D., Probst, J. L., Depetris, P. J., Gauthier, L. F. and Stille, P. (2005). ^{13}C Tracing of Dissolved Inorganic Carbon Sources in Patagonian Rivers (Argentina), *Hydrological Processes,* 19:3321-3344.

Cole, J. J. and Caraco, N. F. (2001). Carbon in catchments: connecting terrestrial carbon losses with aquatic metabolism *Marine and Freshwater Research,* 52:101–10.

Das, A, Krishnaswami, S. and Bhattacharya, S. K. (2005). Carbon Isotope Ratio of the Dissolved Inorganic Carbon (DIC) in Rivers Draining the Deccan Traps, India: Sources of DIC and their Magnitudes, *Earth and Planetary Science Letters,* 236:419-429.

Dawson J. J. C., Billett M. F., Neal C. and Hill S. (2022). A Comparison of Particulate, Total, Organic and Inorganic, Dissolved and Gaseous Carbon in Two Contrasting Upland Streams in the UK; *Journal of Hydrobiology*, 257; 22 - 246.

Gebresilasie, K. G., Berhe, G. G., Tesfay, A, H., and Gebre, S. E. (2021). Assessment of Some Physicochemical Parameters and Heavy Metals in Hand-Dug Well Water Samples of Kafta Humera Woreda, Tigray, Ethiopia, *Hindawi International Journal of Analytical Chemistry,* 2021:1 -9.

Gupta, B. K. and Gupta, R. R. (1999). Physicochemical and Biological Study of Drinking Water in Satna Madhya Pradesh. *Pollution Research*, 18(4):523–525.

Gupta, D. P., Sunita and Saharan, J. P. (2009).Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India, *Researcher*, 1(2):1-5.

Hari, O. S., Nepal, M., Aryo, S. and Singh, N. (1994). Combined Effect of Waste of Distillery and Sugar Mill on Seed Germination, Seeding, Growth and Biomass of Okra. *Journal of Environmental Biology,* 3(15):171-175.

Jannat, N., Abdul, Mottalib, M. D. and Muhammad, N. A. (2019). Assessment of Physicochemical Properties of Surface Water of Mokeshbeel, Gazipur, Bangladesh, *J. Environ Sci. Curr. Res.,* 2(014):2– 6.

Karanth, K. R, (1987). *Groundwater Assessment Development and Management*.Tata McGraw Hill publishing company Ltd., New Delhi, 725-726.

Keerthika, D., Gokulpriyan, K., Harini, I. and Karthikeyan, V. (2019). Studies on Physicochemical Analysis of Water from Different Sources, *International Journal of Environment, Agriculture and Biotechnology (IJEAB),* 4(2):310 -313.

Kempe, S. (1982). Long-term Records of CO_2 Pressure Fluctuations in Fresh Water in Degens E. T. (ed), *Transport of Carbon and Minerals in Major World Rivers, Part 1*, Hamburg 52 91–332.

Kepuska, X., Daija, L. and Kristo, I. (2014). Determination of Physico-chemical Parameters of Water in Biological Minimum in Lake Radoniq, Tirana, Albania. *European Scientific Journal, Special Edition*, 3:63- 70.

KYBP (2006).*Komadugu Yobe Basin Water Audit Report* by Afremedev Consultancy Services Limited for FMWR IUCN-NCF Komadugu Yobe Basin Project, Kano, Nigeria

Likens, G., Mackenzie, F., Richey, J., Sedell, J. and Turekian, K. (1981). *Flux of Organic Carbon by Rivers to the Oceans,* National Research Council/DOE Conf-8009140.

Ludwig, W., Amiotte-Suchet, P. and Probst, J. L. (1996). River Discharges of Carbon to the World's Ocean: Determining Local Inputs of Alkalinity of Dissolved and Particulate Carbon, *Comptes Rendus,* 323:1007-1014

Nagamani, C. and Devi, C. S. (2015). Physico-Chemical Analysis of Water Samples. *International Journal of Scientific and Engineering Research*, 6(1):2149 – 2155.

Nigam, V., Behl, N. and Kanchan, M. C. (2013). Physico-Chemical Parameters for Testing of Water- A Review, *Int. J. Pharm. Bio. Sci.,* 3(3):523-527.

NPC (2006).National Population Commission, http://www.population.gov.ng

Obasi, R. A. and Talabi, A. O. (2015). Physiochemical Characteristics of Water in Hand Dug Wells around Ekiti State University, Ado-Ekiti, Southwest Nigeria," *British Journal of Earth Sciences Research*, 4(2):8–15.

Patil, P. N, Sawant, D. V. and Deshmukh, R. N. (2012). Physico-Chemical Parameters for Testing of Water – A Review, *International Journal of Environmental Sciences*, 3(3):1194 -1207.

Pisciotta, A., Cusimano, G. and Favara, R. (2015). Groundwater Nitrate Risk Assessment Using Intrinsic Vulnerability Methods: A Comparative Study of Environmental Impact by Intensive Farming in the Mediterranean Region of Sicily, Italy. *J. Geochem. Explor.,* 156:89–100.

Richey, J. E. **(**2005). Global River Carbon Biogeochemistry in Anderson M. G. **(**ed) *Encyclopedia of Hydrological Sciences,* 184.

Shukla, D., Bhadresha, K., Jain, N. K. and Modi, H. A. (2013). Physicochemical Analysis of Water from Various Sources and Their Comparative Studies, *Journal of Environmental Science Toxicology and Food Technology (IOSR-JESTFT),* 5(3):89-92.

Tesfaye, E., Berhe, A. and Terle, D. (2018). Physicochemical Analysis of Baro River Water and Other Potable Water of Gambella Town, Ethiopia. *Int. J. Adv. Res.,* 6(12):628-637.

Wakawa L.D., Suleiman A.A., Ibrahim Y., Adam L.I. (2017). Tree Species Biodiversity of a Sahelien Ecosystem in North-East Nigeria, *Bartın Orman Fakültesi Dergisi,*, 19(2): 166-173.