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Original Article

Assessment of River Umabolo water quality for Irrigation in Ankpa Local Government of Kogi State, Nigeria

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ABSTRACT

This study assessed the suitability of River Umabolo water for irrigation based on ion concentration and water quality indices.The study sought to determine the suitability of the Umabolo river in the study area for irrigation scheme and assess the ion concentrations in the river. The water samples were collected from three points, namely; lower course, middle course and upper course. The chemical properties analyzed from the samples include sodium, calcium, potassium, magnesium, chorine, sulphate, pH, carbonate, bicarbonate, nitrate, electrical conductivity, total dissolved solids, alkalinity, salinity, boron and sodium adsorption ratio using appropriate parameters as stated in Mclean (1965). The results obtained showed the following values; 0.94 mg/l, 0.95 mg/l, 0.07 mg/l, 1.36 mg/l, 0.012 mg/l, 0.080 mg/l, 6.00, 4.85 mg/l, 4.40 mg/l, 0.10 mg/l, 0.09ds/m for Sodium, calcium, potassium, magnesium, chloride, sulphate, pH, carbonate, bicarbonate, nitrate and electrical conductivity. The total dissolved solids were 56.6mg/l while the alkalinity was 2.62mg/l. The salinity was 0.14mg/l while the sodium adsorption ratio 0.87. The study found that the water is suitable for irrigation purposes as the concentrations of the cations fall within the acceptable range for irrigation.

Keywords: *Irrigation, Quality, Ions, Salinity, Alkalinity, Electrical conductivity*

1.0 INTRODUCTION

The importance of irrigation in any given environment cannot be overemphasized as a vital agricultural activity. This is because; it supplies sufficient water for agricultural production. One of the most important factors in any Agricultural venture is the availability of water which should be dependable in both quality and quantity. The quality of crops produced is influenced by the water quality.

The assessment of irrigation water quality is crucial for ensuring sustainable agricultural practices and mitigating environmental impacts. As global water scarcity and food security concerns continue to escalate, the importance of evaluating irrigation water sources for their suitability, safety, and potential risks has become increasingly evident (Singh, 2022; WWAP, 2020). Recent studies have highlighted the need for comprehensive assessments of irrigation water quality, taking into account factors such as salinity, nutrient levels, and microbial contaminants, to prevent soil degradation, crop damage, and environmental pollution (Hamilton, 2021). Effective assessment and management of irrigation water resources are essential for promoting water conservation, improving crop yields, and protecting ecosystem health.

Ensuring food security remains a persistent challenge in Nigeria, a country with a rapidly growing population and heavy reliance on rain-fed agriculture. Effective irrigation water management is crucial to improving agricultural productivity and addressing this critical issue, particularly in the face of climate change and increasing water scarcity (Adeyolanu and Okelola, 2024). Irrigation water quality assessment is vital for sustainable agricultural practices and environmental protection. Poor water quality can lead to soil degradation, reduced crop yields, and environmental pollution, ultimately affecting human health and ecosystem balance. According to Ayers and Westcot, evaluating irrigation water quality helps identify potential problems related to salinity, water infiltration rate, specific ion toxicity, and other miscellaneous effects (Ayers and Westcot, 1985

Studies have shown that irrigation water quality assessment is essential for ensuring sustainable agriculture and environmental protection (Adagba, *et al*., 2022). For instance, a study in Nigeria's Kazaure area used Geographic Information System (GIS) and irrigation water quality indices to evaluate groundwater suitability for irrigation purposes. The results showed that the groundwater was generally fit for irrigation. In conclusion, assessing irrigation water quality is crucial for promoting sustainable agriculture, ensuring crop health, and protecting the environment. Regular monitoring and evaluation of irrigation water quality can help mitigate risks and support long-term agricultural productivity.

It is very necessary therefore, to assess the quality of water used for irrigation. The research was necessitated by the introduction of irrigation project as a modern farming technique in Ankpa Local Government using Umabolo River as its source of water. It is expected that this project has the potential of increasing crop yield and improving the living condition of the people. Thus, the objective of the research was to assess river Umabolo water quality for irrigation in Ankpa Local Government of Kogi State, Nigeria

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Ankpa Local Government Area of Kogi State, Nigeria. The Local Government is located between latitudes 8^0 6^1 N and 9^0 15^1 N and longitudes 6^0 06^1 E and 7^0 54^1 E. It has a mean annual rainfall of 1000 mm. The temperature ranges from an average minimum of 13.80^0C to average maximum of 27.5^0C. Ankpa has two climatic seasons (rainy and dry seasons). The area has a relative humidity varying between 64% and 75% during the rainy seasons and less than 40% during the dry season (Kogi State Agricultural Development Projects, ADP, 2011). Farming is the major source of livelihood of the people in the area.

Sampling Procedure

Three water samples were collected from River Umabolo in Ankpa Local Government Area. The samples were collected from three different points, namely; the upper, middle and lower course. Point designation was as follows; UR1, UR2 and UR3 representing upper, middle and lower course of the River, respectively. The samples were collected using clean air-tight plastic containers, and transported to the laboratory for the necessary analyses.

Laboratory Analyses

Water samples were analyzed for chemical properties. The chemical properties include sodium, calcium, potassium, magnesium, chorine, sulphate, pH, carbonate, bicarbonate, nitrate, electrical conductivity, total dissolved solids, alkalinity, salinity, boron and sodium adsorption ratio using appropriate parameters as stated in Mclean (1965). Sodium was determined using flame photometer. Calcium was determined using EDTA titration method. Magnesium was determined using the EDTA titration method while Potassium was determined using flame photometer. Mehrs method was used to determine the chlorine concentration in which 50 ml of water sample was pipetted into 250 ml conical flask. 1ml of the indicator was added and titrated with silver nitrate solution until a permanent brick red precipitate persisted. The titrate value was recorded. The titration was repeated and the value for each sample was recorded. Sulphate was determined by pipetting 25ml of water into 50ml standard flask followed by 20ml of distilled water. 2ml of Galatine Bad solution and the solution was made up to 50ml mark. The solution was allowed to settle for 30 minutes. The absorbance of standard solution was read from the spectrometer at 420 cm.

A pH Hach comparator was used in the determination of the pH. Two glass sample tubes were filled to 5ml mark with the sample water for analysis. Eight drops of bromothymol blue indicator solution were added to one of the tubes and stirred to mix. The tube of the prepared sample was inserted into the top right opening colour on purgatory. The comparator was then held up to a light source of the window and viewed through the opening in front. The disc was rotated and a colour match was obtained and the pH was red through the scale window. A prepared H_1S0_4 (tetraoxosulphate VI acid) standard solution was added in 0.5ml increment and the pH value against the volume of titrant was recorded after each addition until pH is below 8.0 values. It was allowed for 15-20 minutes for equilibrium. The most sensitive part of the titration curve is usually between pH 4.8 pH 4.3. A titration curve was constructed to determine the volume of the titrant added against the resulting pH values which showed the carbonate. The procedure used in determining for carbonate ($C0_3^-$) was used for bicarbonate ($HC0_3^-$)

In determining nitrate, 0.5ml of each sample was pipette into test tubes; 1ml of 5% salicylic acid solution was added to each test tube and mixed thoroughly. This was allowed to stand for 30 minutes, after which 10ml of 4m Na0H solution was added. It was allowed to sand for 1 hour for colour development and 12 hours for coloursabilisation, the absorption was red from spectrophotometer at 410Nm. A HACH model 44600 conductivity/TDS meter was used in the determination of electrical conductivity. The appropriate range was selected. The probe was inserted into the sample solution. The tip was immersed beyond the vent holes and agitated vertically to ensure that air bobbles were not entrapped. Time was allowed for the reading stabilize and the value was read. The same procedure used in determining electrical conductivity described above was also used for total dissolved solids. Factor 0.5 is used by this model i.e. total dissolved solid value is one half the conductivity values.

In the determination of alkalinity of the samples, 50ml of the water sample was measured into the conical flask, two drops of mixed acid was added and shaken thoroughly. The acid was standardized with 0.01ml of $NaC0_3$ and was titrated with 0.02 ml of the standard acid until the colour changed from light green to faint pink the volume of standard acid was noted. The titration was repealed to obtain an average titer value. The salinity of the samples was also determined using the procedures used for alkalinity. In this procedure for the determination of boron, 2-5 ml aliquots of the sample were taken into 25ml polypropylene tube and 20ml of the buffer masking solution was added. The content was mixed thoroughly with an electric stirrer. 2ml of azonethine reagent was added, thoroughly and was allowed to stand at room temperature for 30 minutes. The transmittance was measured at Nm. Boron concentration was determined in the sample from the standard curve.

Sodium adsorption ratios were calculated using the appropriate formulae below;

$$SAR = \frac{N^{+}}{\sqrt{\frac{Ca2+ + Mg2+}{2}}} \text{ ....Eq 1}$$

Statistical Analysis

The data generated from the laboratory were subjected to descriptive statistics, using the Microsoft Excel Software.

3.0 RESULTS AND DISCUSSION

Table 1 shows the result of the analysis of water samples taken from River Umabolo in Ankpa Local Government Area. It shows the results of chemical concentration of the various parameters measured in the lower course (LC), middle course (MC), upper course (UC) and their average. Sodium (Na) concentration is 0.94 mg/l at LC, 0.93 mg/l at MC and 0.95 mg/l at UC, with an average of 0.94 mg/l. irrigation water containing sodium concentration greater than 5 mg/l is considered unsafe for irrigation (Davies and Dewest, 1996).

Table 1: Chemical properties of the water samples taken from River Umabolo, Kogi State

Parameter	Lower Course (LC)	Middle Course (MC)	Upper Course (UC)	Mean
Sodium (Na) mg/l	0.94	0.93	0.95	0.94
Calcium (Ca) mg/l	0.97	0.90	0.93	0.95
Potassium (K) mg/l	0.09	0.06	0.06	0.07
Magnesium (mg/l)	1.37	1.36	1.35	1.36
Chloride (C1) mg/l	0.01	0.01	0.01	0.012
Sulphate (S04) mg/l	0.08	0.08	0.08	0.080
pH	6.00	6.00	6.00	6.0
Carbonate $(C0_3)^2$ mg/l	4.87	4.85	4.86	4.85
Bicarbonate ($HC0_3$) mg/l	4.42	4.40	4.38	4.40
Nitrate ($N0_3$) mg/l	0.01	0.01	0.01	0.01
Electrical conductivity dS/m	0.10	0.09	0.08	0.09
Total dissolve solute mg/l	57.0	56.5	56.3	56.60
Alkalinity mg/l	2.64	2.61	2.61	2.52
Salinity mg/l	0.14	0.14	0.1	0.14
Boron (B) mg/l	0.34	0.32	0.30	0.32
SAR	0.87	0.87	0.89	0.87

Calcium (Ca) concentration at LC is 0.97 mg/l, MC is 0.95 mg/l, and UC is 0.93 mg/l, with an average value of 0.95. The values are generally low and fall within the safe concentration limit of 3mg/l as established by Christenson *et al.* 1977. Magnesium concentration at LC is 1.37 mg/l, MC 1.36 mg/l and UC 1.35 mg/l (1.36). The values are low and fall within the safe limit (< 2.5 mg/l) for irrigation as suggested by Christenson *et al.* (1977). Chloride concentration at LC is 0.01 mg/l, MC is 0.01 mg/l and UC is 0.01 mg/l, with average of 0.012. The values are generally low and fall within the acceptable range of 0-525 mg/l. Sulphate has a concentration of 0.08 mg/l at UC, MC 0.08 mg/l and UC of 0.08 mg/l. the average value is 0.080mg/l. The pH of the water at LC is 6.00; MC is 6.00 and UC 6.00. The average value is 6.00. the values indicate a slight acidity condition. The P^H of 8.5 and above suggests appreciation exchangeable sodium (Michael, 1978). While Udo and Ogunwale (1986), reported permissible pH value ranges from 4.8-9.0. Carbonate concentration in the water in LC is 4.87mg/l, MC 4.85mg/l and UC is 4.86mg/l. the average value is 4.86. according to (Singh, 2022), a concentration of 4.5-6.0mg/l is considered suitable for irrigation under normal condition. Bicarbonate concentration in LC is 4.42 mg/l, MC is 4.40mg/l and U is 4.38mg/l. the average value is 4.40mg/l. According to Ayers (1975), a concentration 4.0-5.0mg/l is considered safe for irrigation water under normal condition. However, when irrigation water contains high bicarbonate concentration, it tends to precipitate calcium and magnesium in the soil as their bicarbonate (Michael, 1985). Nitrate concentration in the water in LC has 0.01mg/l, MC has 0.01mg/l and UC has 0.01mg/l. The average value is 0.01mg/l. The value falls within the acceptable range of 0-10mg/l.

Electrical conductivity of the water in LC is 0.10 dS/m, MC is 0.09 dS/m and UC is 0.08 dS/m. the average value is 0.09 dS/m. the electrical conductivity value in the water is generally low and falls within the acceptable range of 3 dS/m (Hamilton (2021). Karnel (1972) and Schoenebeger *et al*. (1998) gave 2.00dS/m as the highest safe limit of electrical conductivity for irrigation water. Total dissolve solids in the water in LC is 57.0mg/l, MC is 56.5mg/l and UC is 56.3mg/l. The average value is 56.60mg/l. FAO (1985), gave limits for TDS-based on irrigation water categories as <450-2000 (acceptable region) and >2000mg/l (unacceptable region). Alkalinity concentration in the water at LC is 2.64mg/l, MC is 2.61 and UC is 2.61mg/l. The average value is 2.62mg/l. While the salt concentration (salinity) in the water at LC is 0.14mg/l, 0.14mg/l at MC and 0.14 at UC, with an average value of 0.14mg/l. According to Hamilton (2021). from table 1, in classification of irrigation water with regards to sodium and salinity hazards, the value falls within the low salinity hazards and as such suitable for irrigation purposes.

Boron concentration in the water at LC is 0.34mg/l, MC is 0.32mg/l and UC is 0.30mg/l, with an average of 0.32mg/l. The value falls within the acceptable range. Toxicity in terms of boron concentration in water sample should not be more than 0.75mg/l or 4 ppm for water used continuously on all soils. Sodium adsorption ratio value in the LC is 0.87, MC is 0.87 and UC is 0.89 and an average value of 0.87.

Irrigation water with SAR value of 2-6 is considered to have low sodium and therefore considered fit for irrigation purposes (London 1991). Based on the properties of the water sample in terms of the parameter analyzed in Table 4.1 above, the water sample fall within the low salinity, low sodium water category (Adagba *et al*., 2022). Irrigation water with low EC and low SAR as in the case of study area could be used on almost all soils with little danger of the development of harmful levels of exchangeable sodium and with little livelihood of salinity problems developing.

4.0 CONCLUSION

The analysis of River Umabolo water shows that the water is suitable for irrigation, because the water sample results fall within low salinity and sodium hazards. The results in Table 1 show that magnesium (Mg) is the dominant basic cation. The values of the parameters investigated were low and as such cannot cause salinity problems. Based on the research findings, the following recommendations were made: Farmers around the river bank should be encouraged to embark on all year round farming with irrigation system. Government should provide credit facilities to farmers to allow them embark on irrigation practices as this will help to check for low agricultural production and low income of farmers. Extension services should be provided for the rural farmers in order to help check excess salt problem.

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