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ASSESSMENT OF IRRIGATION WATER QUALITY OF RIVER OKURA IN DEKINA LOCAL GOVERNMENT AREA OF KOGI STATE, NIGERIA

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ABSTRACT: *The analysis of physicochemical quality of Okura River in Dekina Local Government area of Kogi State was undertaken in this study to assess its suitability for irrigation purposes by considering three different locations along the river, consisting of the upper, middle and lower locations. In order to achieve the objectives, water samples were taken from each location, and the samples collected were analyzed in the laboratory using appropriate methodThe important parameters considered were: electrical conductivity (EC), total dissolved solid (TDS), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), contents of magnesium* Mg^{2+}*, boron and chloride. The results showed that the parameters' values fell within the safe limits for irrigation purposes. Thus, Okura river water can be developed for all year round crop production. However, the need to continuously monitor and assess water quality of the river for irrigation purposes is recommended.*

KEYWORDS: Irrigation, Water quality, physicochemical quality, Suitability, River Okura.

INTRODUCTION

Water is one of the most important inputs required for plant growth in agricultural production. Bulk weight of living organisms consists of 70 to 90% water (Beecroft, 1982). Water need for plant growth is met with soil water storage in plant root zone. Under rain fed conditions, soil water storage is continuously replenished with natural rainfall, however, irrigation is essential in arid and semi-arid climates to maintain soil water storage at an optimum level for crop growth. Therefore, irrigation can be defined as replenishment of soil water storage in plant root zone through methods other than natural precipitation. All water sources used in irrigation contain impurities and dissolved salts irrespective of whether they are surface or underground water. However, quality of water has meaning only with respect to its particular use. Water which can be considered good quality for household use may not be ideal for irrigation. In Agriculture, water quality is assessed with respect to its effects on soils and crops (Michael 1992). High quality crops can be produced only by using high-quality irrigation water while keeping other inputs optimal (Ayers and Westcot, 1985).

Irrigated agriculture is dependent on adequate water supply of usable quality. In irrigation water evaluation, emphasis is placed on the chemical and physical characteristics of the water and only rarely is any other factors considered important. Here attempt has been made to assess the irrigation water quality of river Okura in Okura district. The quality characteristics studied in the present investigations are as follows: Total dissolved solid (TDS), Electrical conductivity (EC), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Potassium (K^+), Sodium(Na^+), Boron (B), Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-),pH, Temperature, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC).

MATERIALS AND METHODS

Okura district lies within Lat 7^o 26^{1}N to 7^o 36N and Long 7^o 18E to 7^o 30E, in Dekina local government area of kogi state. Okura lies within the warm humid climate of the middle belt zone of Nigeria, with distinctive dry and wet seasons. Okura has a mean annual rainfall and temperature of about 1260mm and 28^{o}C respectively (Amhakhian and Osemwota, 2010).

Water samples were collected from three different locations along the river at intervals of about 20m, namely, the upper location, middle location and the lower location, designated as UL, ML and LL respectively. The water samples were collected using air-tight and clean plastic containers, transported to the laboratory and analyzed immediately. The chemical properties determined include, concentration of sodium (Na^+), boron (B), calcium (Ca^{2+}), potassium (k^+), chloride (Cl^-), sulphate (SO_4^{2-}), magnesium (Mg^{2+}), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), nitrate (NO_3^-).Other parameters are pH, electrical conductivity (EC), total dissolved solid (TDS) and temperature.

Some determinants, such as EC, pH and temperature of the water samples were measured at the points of sample collection using portable EC-meter, pH-meter and thermometer, respectively. The ionic TDS was simply determined by multiplying the measured EC values (in µS/cm) by 0.64 as there exists an approximate relation between EC and TDS for most natural water in the range

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of 100 to 500 µS/cm leading to the equivalencies 1 meq/l of cations=100 µS/cm and 1 meq/l=1.56 µS/cm (Todd, 1980). Samples collected from the study area were carefully transported to the laboratory for analysis.

The analysis of the physio-chemical parameters of the water samples were carried out following the established analytical methods. Na^+ and K^+ were determined by flame photometry, Ca^{2+}, Mg^{2+} and B by visible spectrophotometry (Jackson, 1967 and Page *et al*., 1982); Cl^-, HCO_3^-, CO_3^{2-}, SO_4^{2-} and NO_3^- by titration method (Jackson, 1967); the sodium adsorption ratio (SAR) was estimated using the values obtained for Ca^{2+}, Mg^{2+} and Na^+ in me/l (Richards, 1954); the residual sodium carbonate (RSC) was determined using the values obtained for CO_3^{2-}, HCO_3^-, Ca^{2+} and Mg^{2+} in me/l (Eaton, 1950.)

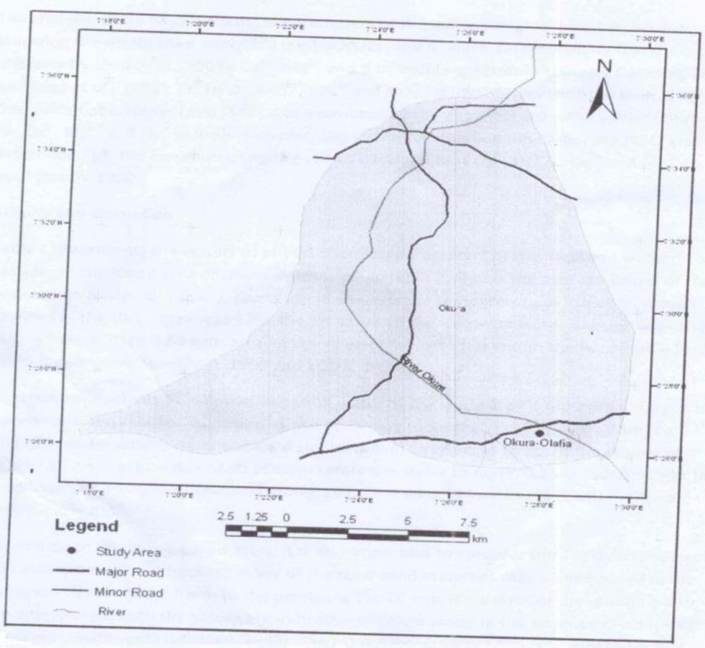

FIG 1 Map of Okura Showing the Study Area

Source: Department of Geography and Planning, KSU (2012)

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RESULTS AND DISCUSSION

Table 1 Represents the results of physico-chemical parameters of the irrigation water samples of the study area of Okura River, while Table 2 shows the average values of the parameters analyzed. Table 2, shows that, the average temperature of irrigation water samples of the study area was 27^{o}c, the pH value of the water samples range from 6.70 to 6.80 with an average value of 6.7, which is within the permissible limit for irrigated agriculture (FAO, 1990, USDA, 1954).

Electrical conductivity EC value of irrigation water of the study area was uniform at 0.02ds/m. Which according to Karmel (1972), falls within the irrigation water quality classification stand excellent in terms of the degree of restriction on use. The EC value of <0.25ds/m refers the water to none, 0.25-0.75ds/m; slight to moderate and >0.75ds/m (severe) (Karmel, 1972) the value falls within the safe limit for irrigation.

In addition to the above parameters, it is also important to consider the Total Dissolved Solid (TDS) in irrigation water because many of the toxic solid materials may be imbedded in the water which may cause harm to the plants. As the EC and TDS values of the ground water are interrelated, both the values are indicative of saline water in the absence of non- ionic dissolved constituents (Michael, 1992). The total dissolved solid (TDS) values of the water samples analyzed ranged from 21.0mg/l to 22.0mg/l with the average value of 21.0mg/l. (FAO, 1990) gave limits for TDS in irrigation water as <450, 450-2000 and >2000mg/l, with restriction on its use as none, slight to moderate and severe respectively. Based on the criteria cited above, the water could be classified as good' for irrigation purposes with no restriction on its use.

Sodicity is the amount of sodium, relative to the amount of calcium and magnesium. In other words, how much sodium is present in irrigation water compared to calcium and magnesium? From the tables, the principal cations in water samples were calcium, magnesium, sodium, with small quantities of potassium, while the principal anions were carbonate, bicarbonate, sulphate, chloride with nitrate occurring in low concentration. If the amount of sodium relative to other cations (especially calcium and magnesium) is high, then the sodicity hazard of the water is high and is estimated by Sodium Adsorption Ratio (SAR), which is the ratio of sodium concentration to the concentration of the square root of the average calcium plus magnesium concentrations in irrigation water. High SAR in any irrigation water implies hazard of sodium (alkali) replacing Ca and Mg of the soil through cation exchange process. The situation eventually causes damage to soil structure by causing the soil aggregate to break down (deflocculation), thereby sealing the pores of the soil and making it impermeable to water flow, which ultimately affects the fertility status of the soil and reduces crop yield, (Gupta, 2005). The values of SAR from the calculation ranged from 0.125 to 0.135, with the average value of 0.129, the value is low and such a low SAR value is expected in view of the fairly low sodium concentration.Irrigation water with SAR value of <10 is considered safe for use, (Kanwar, 1961).

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Table 1. Physicochemical properties of irrigation water of the study area.

s/n	Parameters	Upper location (UL)	Middle location (ML)	Lower location (LL)
1	Temperature (^oC)	27	27	27
2	EC ds/m	0.02	0.02	0.02
3	Ph	6.80	6.70	6.70
4	TDS mg/l	22.0	21.0	21.0
5	Na^+mg/l	0.74	0.70	0.68
6	SAR	0.14	0.13	0.13
7	Mg^{2+} mg/l	0.93	0.92	0.92
8	B mg/l	0.27	0.26	0.26
9	Cl^- mg/l	131	131	130
10	SO_4^{2-} mg/l	0.81	0.77	0.78
11	NO_3^- mg/l	0.03	0.02	0.02
12	CO_3^{2-} mg/l	4.91	5.04	5.03
13	HCO_3^- mg/l	4.05	4.02	4.05
14	RSC meq/l	0.116	0.121	0.122
15	Ca^{2+} mg/l	0.73	0.71	0.70
16	K^+ mg/l	0.07	0.07	0.06

Table 2. Average results of water samples

s/n	**Parameters**	**Average values**
1	Temperature (^oC)	27
2	EC ds/m	0.02
3	pH	6.7
4	TDS mg/l	21.3
5	Na^+ mg/l	0.71
6	SAR	0.129
7	Mg^{2+} mg/l	0.92
8	B mg/l	0.26
9	Cl^- mg/l	130.7
10	SO_4^{2-} mg/l	0.79
11	NO_3^- mg/l	0.02
12	CO_3^{2-} mg/l	4.99
13	HCO_3^- mg/l	4.04
14	RSC meq/l	0.120
15	Ca^{2+} mg/l	0.71
16	K^+ mg/l	0.07

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Salinity classification was done using a quality diagram (Figure 1) given by the U.S. Salinity Laboratory (Richards, 1954). The diagram classified 16 classes, with reference to SAR as an index of sodium hazard and EC as an index of salinity hazard (Mirsha and Ahmed, 1987).

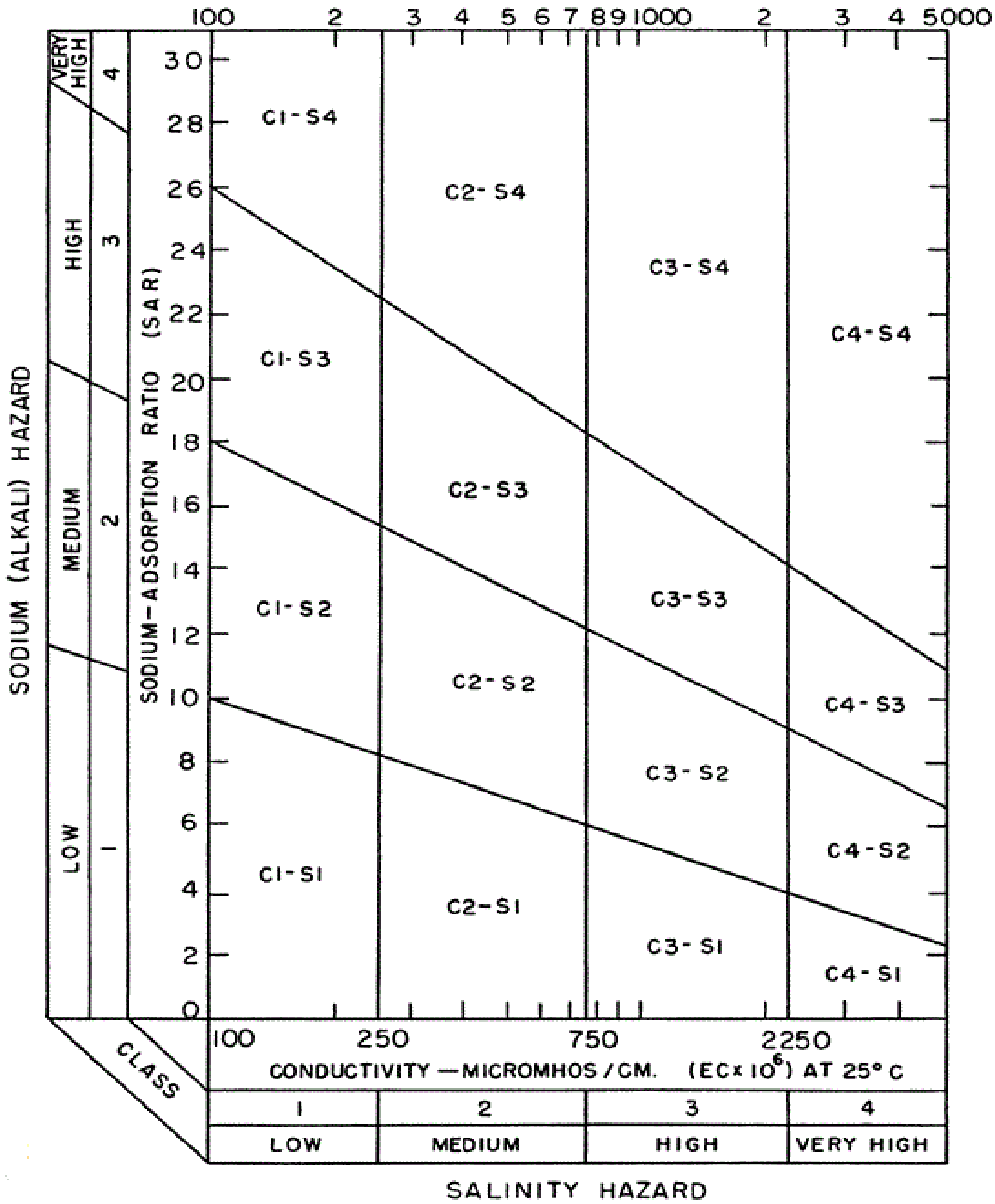

Fig 2: Diagram for irrigation water quality Classification (USSLS, (1954)

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According to the quality diagram, (USSLS,1954), the values for EC and TDS fell in C1 indicating low salinity, SAR value also fell in S1 indicating low sodium hazard.

Magnesium content; of irrigation water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yields as the soils become more alkaline. In the present study, the magnesium content of the water of river Okura varied from 0.92 to 0.93mg/l with the average value of 0.92mg/l, the values are low and fall within the safe limit <2.5mg/l as suggested by Christenson *et al.*(1977).

It is evident that boron is essential for the normal growth of plants but the amount required is very small. The occurrence of boron in toxic concentration in certain irrigation water makes it necessary to consider this element in assessing water quality. The concentration of boron of irrigation water of the study area varied from 0.26 to 0.27mg/l with the average value of 0.26mg/l. the values fall within the safe range of 0-1mg/l (FAO, 1990); Concentrations higher than 1mg/l are toxic to plants.

The occurrence of chloride ions in irrigation water increases with increase in EC and sodium ions, therefore, these ions are most dominant in very high salinity water. From the study, chloride concentration in the water samples of river Okura varied from 130 to 131mg/l with the average value of 130.7mg/l, the values fall within the acceptable range of 0-140mg/l (FAO, 1990).

Sulphate salts are less harmful when compared to chlorides, this is because, when both the ions occur at high concentrations, only half of the sulphate ions contribute to the salinity due to the fact that approximately half of the sulphate gets precipitated as $CaSO_4$ while the other half remains in soluble form as Na-$MgSO_4$ in the soil. The sulphate content of water samples of river Okura varied from 0.77 to 0.81mg/l with the average value of 0.79mg/l. the values fall within the safe limit of 0-30 me/l when converted for irrigation (FAO, 1990). Very frequently, ground waters contain high amounts of nitrate, when such irrigation water is applied on soils continuously; various properties of soils are affected. From the present study, nitrate content varied from 0.02 to 0.03mg/l with the average value of 0.02mg/l, the values are low and fall within the safe range of 0-10mg/l (Ayers and Westcot, 1985).

The effect of CO_3^{2-} and HCO_3^- on Ca^{2+} and Mg^{2+} by removing them from the soil water and increasing the relative proportion of Na^+ to Ca^{2+} and Mg^{2+}, has been evaluated separately by the residual sodium carbonate RSC. Water with high RSC has high pH and land irrigated with such water becomes infertile owing to the deposition of sodium carbonate. The suitability of water for irrigation is classified as good, fair and bad, when the RSC is < 1.25, 1.25-2.5 and >2.5 meq/l respectively (Bhumbla, 1969). When appreciable RSC occurs (perhaps above 2.5Meq/l), special precautions are needed in irrigation to prevent lime accumulation or possible soil alkalinisation. From the calculations, the values fell within the range of 0-1.25meq/l, and therefore, no CO_3^{2+} or HCO_3^- hazard in the water samples. The concentration of calcium Ca^{2+} of the water samples of the study area varied from 0.70 to 0.73 mg/l with an average value of 0.71mg/l. the values are low and fall within the safe limit (< 3mg/l) as suggested by Christenson *et al.* (1977). The concentration of potassium K^+ in the water samples also varied from 0.06 to 0.07mg/l, with an average value of

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0.07mg/l. the values are also low and fell within the permissible limit of < 3mg/l for irrigation as suggested by Mehrotra (1969).

CONCLUSION

The assessment of the water quality of river Okura showed that the water is suitable for irrigation because, the quality parameters fell within the low salinity and low sodium hazards as compared to national and international water quality standards set for irrigation.

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