Assessment of the Suitability of River Rutu for Irrigation purposes in Kokona, Nasarawa State, Nigeria

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Abstract: **The utilization of water high in ionic content may eventually lead to build up of substances in the soil at a level likely to affect the soil productivity and reduce in yields of crops. With this point, the suitability of River Rutu for irrigation purposes was attempted to ascertain the level of concentration of some of the parameters used in assessing water for irrigation. The study employed sampling at different points where 3 samples each were taken at the up stream, mid-stream and down stream of the river for both dry and wet seasons. The parameters analysed in the laboratory were pH, HCO_3, CO_3, Ca, Mg, TDS, B, EC, N, Na, NO_3, SO_4 and the suitability of the concentration of the parameters were determined through RSC, SAR, KI, MR. The results shows the mean values for SAR in both dry and wet seasons as 0.654meq/l and 0.6211meq/l respectively. RSC mean value for dry season is -16.85meq/l. However, the mean value for wet season was pegged at 10.9388meq/l. Based on the findings from the analysis on MR, the mean value was seen as 32.8711meq/l, for wet season and the dry season had 35.8950meq/l mean value. Kelley's Ratio was measured at mean value of 0.073meq/l for dry season and wet season stood at 0.0542meq/l mean value. The study concluded that the results from the sampled water of River Rutu is good for irrigation regardless of seasonal variations and recommended that the water quality is good and can support all types of crops. Therefore, the Local and State Governments should provide loans and support farmers in Rutu to boost irrigation in the area in order to improve the nation's agricultural value chain.**

Keywords**: Assessment, Suitability, Ions, concentration and irrigation.**

I. INTRODUCTION

The role of irrigation programs in global food security cannot be overemphasized. In the developing world where agriculture constitutes a significant stake in the national economies, irrigation schemes play pivotal roles in the delivery of both commercial and staple crops. Different crops have different tolerable limits for specific ions and the general salinity. It is imperative that the quality of irrigation water be assessed against the type of crop that will be irrigated. In addition to specific ion toxicities, it has been globally accepted that the proportion of the sodium ion against the major alkaline earth metals (Calcium and Magnesium) in irrigation water play key roles in determining its quality for use on irrigation schemes (Ayers,1997). The sodium adsorption ratio, SAR, is an index which measures the relative proportions of the sodium ion on one hand and the sum of calcium and magnesium ions on the other. This index is used together with the electrical conductivity (EC) (which provides a quantitative measure of the salinity of irrigation waters), to comprehensively classify irrigation waters (Rutharvel et. al, 2010).

Human activities however, have introduced into the natural drainage system wastes which by their volume, composition or both cannot readily be disposed through the natural recycling process resulting in water pollution problems. The utilization of water high in ionic substances may eventually lead to build up of the substances in the soil at a level likely to affect the soil productivity and reduce in yields of crops (Folorunso, *et.al*., 2005). In most irrigation schemes in Nigeria the assessment of the quality of water used in irrigation has not been given serious attention as such this poses serious threat to health of both farmers and the consumers of the crops (Samaila,*et.al.*, 2011). Though irrigation use of water has the advantage of potential treatment mechanisms in soils such as biological oxidation, ion exchange, chemical precipitation, adsorption and assimilation into growing plants, however, the concentrations contaminants should be ascertained to reduce the effects of long term impact on irrigation. It should be noted that the suitability of particular water for irrigation will depend on the adequacy of the drainage, the method of irrigation, salt tolerance of the crop and the management of irrigation and drainage. Therefore, before any water is used for irrigation its suitability must be ascertained and compared with existing water quality and or standards. Water when directly used for irrigation can increase the quantities of solutes there by raising the concentration of certain ions and eventually lowering the quality of the water for irrigation (Ayers and Westcots, 1994). Though irrigation is not new to most communities in Nasarawa State, however, knowledge about the quality of water and the implication on crop development has not been given sufficient attention, as a result, farmers practice irrigation with water likely to pose threat to human health, soil productivity and low crop yields (Samaila et al, 2019). Most studies on water quality in Nasarawa State evaluated surface

water for domestic use (Gyar and Joseph 2009, Abiola, *et.al.* 2010, Usman, *et.al.* 2010 and Samaila, et al, 2019).

II. MATERIALS AND METHOD

The sampling of the study area was conducted at different points where 3 samples each were taken at the upstream, mid-stream and downstream of the river for both dry and wet seasons. The parameters analysed in the laboratory were pH, HCO_3, CO_3, Ca, Mg, TDS, B, EC, N, Na, NO_3, SO_4 and the suitability of the concentration of the parameters were determined through SAR, RSC, MR, and KI.

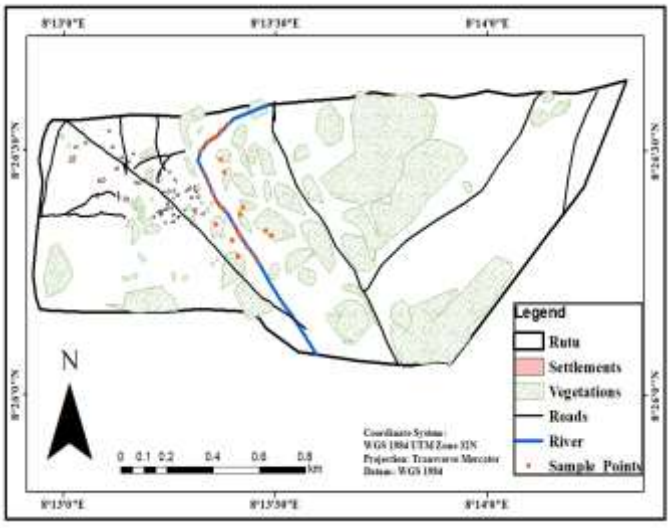

Fig. 1 Study Area

III. RESULTS AND DISCUSSION

Table 1 and 2 present results of the analyses of different parameters in respect to water classification for irrigation purposes using water quality indices such as Sodium Adsorption Ratio(SAR), Residual Sodium Carbonate(RSC), Magnesium Ratio(MR) and Kelley's Index(KI) as seen below.

Table 1. Wet season classification of river rutu water

S/N	MR	KI	RSC	SAR
1	31.10	0.0558	-11.95	0.638
2	32.56	0.0512	-11.37	0.594
3	32.92	0.0543	-10.74	0.620
4	33.06	0.0546	-10.76	0.626
5	33.29	0.0547	-10.55	0.628
6	32.86	0.0557	-11.03	0.626
7	33.93	0.0533	-10.39	0.616
8	33.06	0.0547	-10.69	0.630
9	33.06	0.0535	-10.97	0.612
Mean	32.87	0.0542	-10.94	0.638

Table 2. Dry season water classification of River Rutu

S/N	MR	KI	RSC	SAR
1	36.3128	0.0663	-16.94	0.6210
2	36.8132	0.0747	-17.28	0.6376
3	35.5411	0.0679	-16.00	0.6517
4	35.5556	0.0739	-17.06	0.6270
5	35.0000	0.0756	-17.07	0.6411
6	36.1486	0.0822	-16.78	0.6929
7	35.3468	0.0710	-16.96	0.6764
8	36.2245	0.0710	-16.73	0.6714
9	36.1127	0.0800	-16.83	0.6741
Mean	35.8950	0.0736	-16.85	0.6540

Sodium Adsorption Ratio(SAR)

The very important chemical parameter especially used for estimating the degree of suitability of water for irrigation regarding Sodium content or alkali hazard for crops is expressed basically in Sodium Adsorption Ratio (SAR). SAR is calculated from the ratio of sodium to Calcium and Magnesium. Calcium and Magnesium ions are important since they are tended to counter the effect of Sodium.

The SAR recommended by the salinity laboratory of the US Department of Agriculture is calculated using the formula:

$$SAR = \frac{Na}{\frac{\sqrt{Ca+Mg}}{2}} \qquad (Ayers\ and\ West \cot s, 1994)$$

The results presented in table 1 and 2 shows the mean values for SAR in both dry and wet seasons as 0.654meq/l and 0.6211meq/l respectively. The dry season's maximum value is 0.6929meq/l and minimum value at 0.621meq/l. For the wet season, the maximum value was recorded at 0.638meq/l and minimum value at 0.594meq/l. The results indicate that the water quality is good and siutable for irrigation purpose as prescribed by Sodium hazard which is expressed in terms of classification of irrigation water as low (S1: <10), medium (S2: 10 to 18), high (S3: 18 to 26) and very high (S4: >26).

High concentration of SAR results in breakdown of the physical structure of soil. Sodium is adsorbed and will become attached to soil particles. The soil then become hard and compact when dry and impervious to water penetration. Sodium replacing adsorbed Calcium and Magnesium is a hazard as it causes damage to the soil structure. The degree to which irrigation water tends to enter into cation exchange reaction in soil can be indicated by the SAR.

There is a close relationship between SAR values in irrigation water and the extent to which Na is absorbed by soils. If water used for irrigation is high in Na and low in Ca, the ion-exchange complex may become saturated with Na, which

destroys soil structure, because of dispersion of clay particles. As a result, the soils tend to become deflocculated and relatively impermeable and rendering such soils very difficult to cultivate.

Residual Sodium Carbonate(RSC)

RSC is an important parameter to evaluate the suitability of irrigation water, calculated using the formula.

Generally, >2.5 meq/l of RSC is unsuitable for irrigation purposes.

$RSC=(CO^{2-}+HCO^{-})-(Ca^{2+}+Mg^{2+})$

From the caluculated analysed data, the RSC values for wet and dry seasons were within the set limit and described suitable for irrigation whereas the relative abundance of cations and anions was deducted. The mean value for dry season -16.85meq/l, maximum value at -16meq/l and minimum value at -17.28meq/l. However, the mean value for wet season was pegged at 10.9388me/l while the maximum value was at 11.95me/l and minimum value at 10.39meq/l

The excess sum of carbonate and bicarbonate in groundwater over the sum of calcium and magnesium also influences the suitability of groundwater for irrigation. When the excess Carbonate concentration becomes too high, the Carbonate combines with Calcium and Magnesium to form solid materials which settles out of the water. The relative abundance of sodium with respect to alkaline earths and the quantity of Bicarbonates and Carbonate in excess of alkaline earths also influence the suitability of water for irrigation.

Magnesium Ratio

Magnesium Ratio helps to identify the dominant alkaline earth element in water. Generally, calcium and magnesium maintain a state of equilibrium in most waters. In this equilibrium, more magnesium in water adversely affects the crop yield. The formula for calculating Mg ratio is;

$$\text{Magnesium Ratio} = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \times 100$$

From the samples taken and analysed, Magnesium and Calcium seems to have an equilibrium at various points of the river water. In a natural state, the higher the amount of Magnesium in water, the higher the adverse effect on soil quality when applied, which could render it alkaline, resulting in reduced crop yield. Paliwal (1972) introduced an important ratio called index of magnesium hazard. Magnesium ratio with more than 50% would adversely affect the crop yield as the soils become more alkaline. Based on the findings from the analysis on Magnesium Ratio, the mean value was seen as 32.8711meq/l, the maximum and minimum values for MR are 33.93meq/l and 31.10meq/l respectively for wet season and the dry season had 35.8950meq/l as the mean value while maximum and minimum values were 36.8132meq/l and 35.3486meq/l. The analyses of the water samples of both seasons showed that the results are within FAO set limit for irrigation which means that there won't be poor internal drainage of the plants and the water quality will support healthy agricultural activities.

Kelley's Index

Kelley's Ratio method is used to classify water for irrigation. Usually, Sodium measured against Calcium and Magnesium is used by Kelley (1940) and Paliwal (1967) to determine water quality for irrigation as formulated below.

$$Kelley's\ Ratio = \frac{Na^{2+}}{Ca^{2+} + Mg^{2+}}$$

The results of the water quality analysis as regards Kelley's Ratio was measured at mean value being 0.073meq/l, maximum value at 0.080meq/l and minimum value at 0.0663meq/l for dry season and wet season stood at 0.0542meq/l mean value, 0.0512meq/l minimum value and 0.0557meq/l maximum value. However, this indicates that the sampled waters of River Rutu are good for irrigation regardless of seasonal variations. The Kelly coefficient (KC), on the other hand, is an important parameter that measures the ease of use of irrigation water. Waters with a KC < 1 are classified as "suitable" for crop irrigation, while waters with a KC > 1 are considered "unsuitable'. Thus, the KC values calculated at the level of water samples taken from River Rutu are all below 1, for all seasons, indicating that the waters of the sampled river are "suitable" for crop irrigation.

IV. CONCLUSION

The surface water quality of the study area was evaluated for its suitability to irrigation whereby 9 samples were taken at various points to understand the concentrations of major cations and anions present in the water. The surface water suitability for irrigation purpose examined was done through the use of water quality indices such as Sodium Adsorption Ratio, Residual Sodium Carbonate, Magnesium Ratio and Kell's Ratio. The results indicate that the water of River Rutu is go/od for irrigation regardless of seasonal variations.

V. RECOMMENDATION

The water quality is good and can support all types of crops. Therefore, the Local and State Government should provide loans and support farmers in Rutu to boost irrigation in the area in order to improve the nation's agricultural value chain.

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