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ANALYZING THE WATER QUALITY OF RIVER NIGER FOR IRRIGATED FARMING AT THE SHONGA IRRIGATION SCHEME

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ABSTRACT

In order to assess the water's appropriateness for crop production at Shonga Irrigation Scheme (250 hectares have been currently used), the study was conducted to look into a number of parameters required to assess common irrigation water quality issues. Twelve water samples were taken at random from River Niger; six each at upstream and downstream, thoroughly mixed in two separate bottles, making a total of two representative samples. Both physical and chemical parameters were assessed. Total nitrogen was measured using a modified micro Kjedahl method, colour was analyzed visually using a set of platinum-cobalt standards in Nessler tubes, and pH was measured using a glass electrode pH meter in soil-water and soil-KCL filtrates. Nephelometric turbidity units (NTU), exchangeable cations using a flame analyzer following extraction with neutral ammonium acetate, and sodium adsorption ratio (SAR) using an empirical model were used to measure turbidity. Results of analysis revealed that water samples 1 and 2 have electrical conductivities of 3.00 and 0.20 ds/m, total dissolved solids of 120.0 and 330 mg/l, sodium adsorption ratio (SAR) are 3.8 and 2.2, chloride are 1.95 mg/l and 1.50 mg/l, and boron are 1.50 mg/l and 1.80 mg/l, and sodium are 11.3 and 9.12 mg/l, nitrate ($N0_3$-N) are 0.60 mg/l and 0.20 mg/l, phosphate ($P0_4$-P) are 1.57 mg/l and 0.50 mg/l, and ammonium (NH_4-N) are 0.0 mg/l and 0.30 mg/l, respectively. Thus, it can be stated that the water from River Niger in Shonga Irrigation Scheme is acceptable for irrigation and of good quality for irrigated farmland.

Keywords: Irrigation, Water quality, Chemical properties, Physical properties, Water samples

1.0 INTRODUCTION

The growing demand for vegetables and other food items during the off-farming season has led to a significant growth in irrigation farming practices. Continuous use of river water for irrigation without careful quality assessment and monitoring can lead to salt buildup in the soil, impact groundwater quality and crop yield potential, and negatively impact the physical and chemical characteristics of the soil, fertility, and sustainable productivity. Optimizing agricultural resources to meet human needs while simultaneously preserving environmental quality and protecting natural resources is the global push for sustainable agriculture systems. Over the past 50 years, millions of people's quality of life has improved and food production has increased because of irrigated agriculture. However, irrigated agricultural development also has detrimental effects on the environment, and there is a growing movement to hold it responsible for these effects and to enhance its environmental performance in order to guarantee long-term sustainability (Stockle 2001). Nigeria's irrigation systems are rapidly growing as a result of the country's growing population. Reduced crop yields, environmental degradation, and salinization of the soil are all common consequences of using irrigation water for agricultural purposes. This issue affects small-scale farmers' livelihood strategies in addition to lowering agricultural output (Tanwir *et al.*, 2003). Measurable amounts of dissolved chemicals, collectively referred to as salts, are always present in irrigation water. These include the dissolution of lime, gypsum, and other salt sources as water flows over or percolates through them, as well as comparatively small but significant volumes of

dissolved solids that result from weathering or dissolution of the rocks and soil. The kind and quantity of salts in the water will decide whether it is suitable for irrigation. Numerous issues with the land and crops are likely to arise when water quality is low. Then, in order to sustain full crop output, special management techniques could be needed. There should be very few or no issues reducing productivity when using high-quality water (FAO, 2010). Water quality is highly subjective and difficult to define. It's not just a matter of the cleaner or purer the better. For instance, distilled water is very pure chemically and can be regarded as having high quality because it doesn't contain any pollutants or toxicants, but it isn't suitable for portable use and doesn't contain the trace elements required for freshwater biota. Only a prospective application for which the limiting concentration of different characteristics can be determined can be used to define water quality (Gray, 1994). Water is used for many different purposes, each of which has unique quality standards (criteria). The World Health Organization first suggested this classification scheme (WHO, 1978).

Among other things, crop productivity is strongly correlated with irrigation water quality. The state of a water source's chemical composition has a significant impact on its appropriateness. Electrical conductivity (ECW), total dissolved salt (TDS), and cations and anions (Na^+, Mg^{++}, Ca^{++}, Cl^-, CO_3^-, HCO_3^-, and SO_4^-) are the parameters of concern for determining the quality of irrigation water. Ammonium-nitrogen (NH_4^-N), nitrate-nitrogen (NO_3^-N), phosphate-phosphorus (PO_4^-P), acidity and basicity (pH), and boron (B) are a few more (Loveday, 1997). The rainy season in the study area is limited to March through September, for the rest of the months; farming operation has to depend on the alternative sources of water to maintain continuous farming practices. The irrigation system surrounding the study region must rely on River Niger as the available water source because there are less options for water during the dry season. Therefore, it makes sense to determine whether the existing water source is suitable in terms of its quality condition in order to attain appropriate crop yields.

2.0 MATERIALS AND METHODS

2.1 Description of the Study Area

In Kwara State's Edu Local Government Area, the Shonga irrigation scheme is situated between Shonga and Tada in the River Niger's flood plain. The North Eastern side and boundary lies within Longitude 5^0 06' E and 5^0 11' E while the South Eastern boundary lies approximately between 5^0 05' E and 9^0 06' N and; 5^0 11' E and 9^0 03' N. This area is traditionally known for rice cultivation. The plan is to use a system of canals to directly remove water from the River Niger. As a result, twelve 24-inch hydro-flow pumps with large volume and low heads that are appropriate for lift-and-gravity irrigation were set up on the Niger River's bank. In this region, 32,000 hectares of arable land have been cleared for rain-fed farming and irrigation, and seven kilometers of major canals and 192 kilometers of distribution channels have been built. At full operation, this can be expanded to 5000ha, but N960 million is required by the authority. Only 250 hectares have been used for active irrigation thus far (LNRBDA, 2010). Today Nigeria consists of 36 states and the

Federal Capital Territory located at Abuja as shown in Figure 1 and Figure 2 is the map of the study area located in Kwara State, Nigeria.

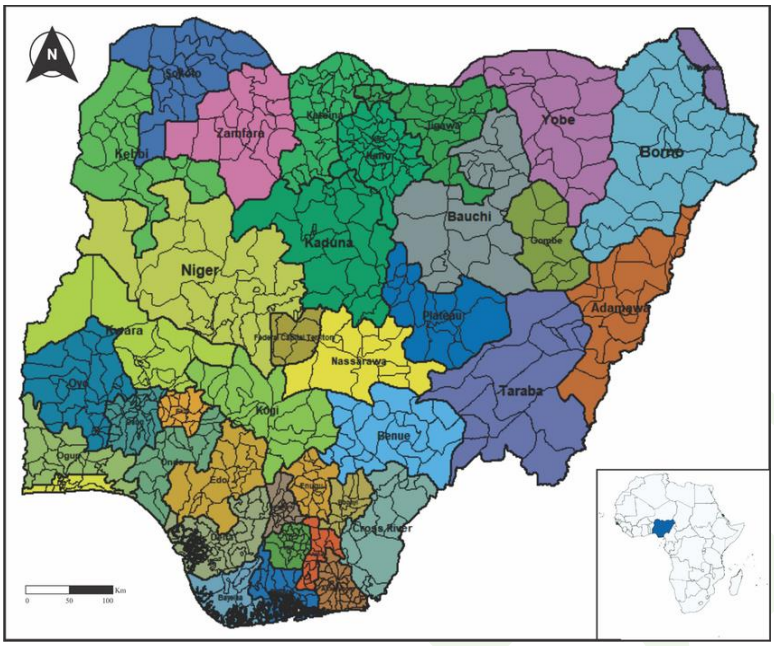

Figure 1: Map of Nigeria showing the different states and LGA.

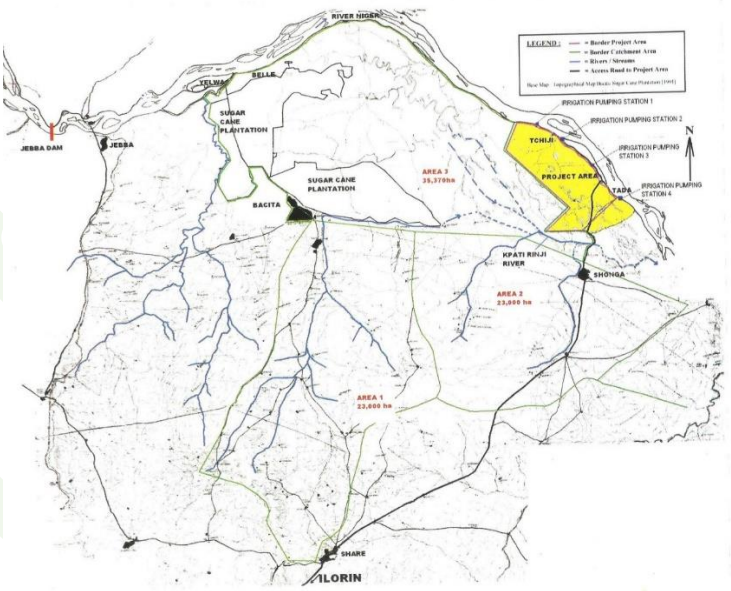

Figure 2: Map of the Study area. ***Source:*** *Construction Products Nigeria Limited (CPN 2000)*

2.2 Water Sampling Procedure

Water samples were taken from the River Niger, which serves as the study area's primary irrigation source, in order to investigate the surface water quality of the area. For the purposes of this study, twelve water samples were taken at random; six each at upstream and downstream, placed in clean, rinsed bottles, chilled for several hours, and then transported to the laboratory for examination.

2.3 Analysis of Water Samples

The six water samples for each upstream and downstream were thoroughly mixed in two separate bottles, making a total of two representative samples. The testing methods and parameters are classified into physical and chemical categories. The following methods were used to analyze water samples chemically, and the findings were compared to FAO guidelines for interpreting water quality in irrigated agriculture:

(i) A set of platinum-cobalt standards in Nessler tubes are visually compared to analyze color.
(ii) The modified micro Kjedahl technique was used to calculate total nitrogen.
(iii) pH in soil-water and soil-KCL filtrates using a glass electrode pH meter.
(iv) Nephelometric turbidity units (NTU) were used to measure turbidity.
(v) Exchangeable cations using a flame analyzer following neutral ammonium acetate extraction.
(vi) Equation 1 was used to calculate the Sodium Adsorption Ratio (SAR).

$$SAR = \frac{\mathrm{Na}}{\sqrt{\mathrm{Ca+Mg}\ /2}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Where:

Na = Sodium in me/l
Ca = Calcium in me/l
Mg = Magnesium in me/l

Source: *FAO, 1994*

3.0 RESULTS AND DISCUSSION

3.1 Results of Irrigation Water Quality Analysis

Table 1 displays the results of the laboratory study of the two representative water samples 1 (Upstream) and 2 (Downstream) and Table 2 is the FAO standard for comparison purpose. The common irrigation water quality issues in the river water samples were assessed using the metrics that were examined. Salinity, infiltration rate, toxicity, sodicity, and accessible nutrients are among the issues with water quality in irrigated agriculture (FAO, 1994).

Table 1: Analytical results of the two representative water samples

S/N	Parameter	Symbol	Unit	Sample 1 (Upstream)	Sample 2 (Downstream)
1	**SALT CONTENT**				
	Electrical Conductivity	EC_W	ds/m	0.30	0.20
	Total Dissolved Salt	TDS	mg/l	120.0	330.0
2	**CATION / ANION**				
	Calcium	Ca^{++}	me/l	14.0	24.0
	Magnesium	Mg^{++}	me/l	5.00	12.0
	Sodium	Na^{+}	me/l	11.7	9.12
	Carbonate	CO_3^{-}	me/l	0.0	0.20
	Bicarbonate	$HC0_3^{-}$	me/l	4.50	2.30
	Chloride	Cl^{-}	me/l	1.95	1.50
	Sulphate	SO_4^{-}	me/l	6.98	10.0
3	**NUTRIENTS**				

	Nitrate - Nitrogen	$N0_3$-N	mg/l	0.60	0.20
	Phosphate -Phosphorous	PO_4^-N	mg/l	1.57	0.50
	Ammonium -Nitrogen	NH_4^-N	mg/l	0.0	0.30
	Potassium	K^+	mg/l	1.50	0.70
	Boron	B	mg/l	1.50	1.80
4	**MISCELLANOUS**				
	Acidity/Basicity	pH	-	7.20	6.90
	Sodium Adsorption Ratio	SAR	me/l	3.80	2.20

Table 2: FAO guidelines for interpretation of water quality for irrigation

			Degree of Restriction on Use		
Potential Irrigation Problem		**Units**	**None**	**Slight to Moderate**	**Severe**
Salinity *(affects crop water availability)*[2]					
EC_w		dS/m	<0.7	0.7-3.0	>3.0
(or)					
TDS		mg/l	<450	450-2000	>2000
Infiltration *(affects infiltration rate of water into the soil. Evaluate using EC_W and SAR together)*[3]					
SAR = 0-3 and	EC_w =		>0.7	0.7-0.2	<0.2
SAR =3-6	EC_w =		>1.2	1.2-0.3	<0.3
SAR =6-12	EC_w =		>1.9	1.9-0.5	<0.5
SAR =12-20	EC_w =		>2.9	2.9-1.3	<1.3
SAR =20-40	EC_w =		>5.0	5.0-2.9	<2.9
Specific Ion Toxicity *(affects sensitive crops)*					
Sodium (Na)[4]					
	surface irrigation	SAR	<3	3-9	>9
	sprinkler irrigation	me/l	<3	>3	
Chloride (Cl)[4]					
	surface irrigation	me/l	<4	4-10	>10
	sprinkler irrigation	me/l	<3	>3	
Boron (B)		mg/l	< 0.7	0.7 - 3.0	> 3.0
Miscellaneous Effects *(affects susceptible crops)*					
Nitrogen (NO_3 - N)[5]		mg/l	<5	5-30	>30
Bicarbonate (HCO_3) *(overhead sprinkling only)*		me/l	<1.5	1.5 - 8.5	> 8.5
pH			Normal Range 6.5-8.4		

Source: *Ayers and Westcot (1985)*

3.2 Discussion of Results of Analysis

3.2.1 Salinity

Irrigation water's electrical conductivity (EC_W) and total dissolved solids (TDS) are direct indicators of salinity. Water samples have electrical conductivities of 3.00 and 0.20 ds/m, respectively, and total dissolved solids of 120.0 and 330 mg/l, respectively. The two samples' Total Dissolved Salt (TDS) values are 120 mg/l and 330 mg/l, respectively, and the TDS values differ significantly from other parameters. This difference could be because the water sample 2 was taken at the downstream end of the River Niger, where people wash their clothes and take baths. When these are compared to FAO irrigation water quality guidelines, it is evident that water sample 1's electrical conductivity is unrestricted, while water sample 2's salinity is low to moderate. The total dissolved solids in River Niger water samples 1 and 2 do not go below the FAO standard level, making the water suitable for agriculture.

3.2.2 Infiltration

When the typical infiltration rate for the applied water is significantly decreased and water stays on the soil's surface for an extended period of time or infiltrates too slowly to provide the crop with enough water to sustain acceptable yields, this is known as a water quality infiltration problem. EC_w and Sodium Adsorption Ratio (SAR) can be used to assess infiltration problems (FAO, 1994). The computation displayed in Table 2 was done using Equation 1. For water samples 1 and 2, the computed SAR values are 3.8 and 2.2, respectively. The two samples were determined to be within the acceptable limit category by comparing the EC_w and Sodium Adsorption Ration (SAR) values with the FAO standard limit. As a result, use is unrestricted and appropriate for irrigation techniques.

Table 2: Calculation of SAR for sample 1 and 2

SAR for Sample 1	SAR for Sample 2
$SAR = \frac{\text{Na}}{\sqrt{\text{Ca} + \frac{Mg}{2}}}$	$SAR = \frac{\text{Na}}{\sqrt{\text{Ca} + \frac{Mg}{2}}}$
Substitution:	*Substitution:*
$SAR = \frac{11.7}{\sqrt{14 + \frac{5}{2}}}$	$SAR = \frac{9.12}{\sqrt{24 + \frac{12}{2}}}$
$SAR = 3.8$	$SAR = 2.2$

3.2.3 Toxicity

Any crop can have a toxicity issue if there is enough of it, depending on the crop's sensitivity and longevity, however perennial crops are primarily impacted. The three most dangerous ions in irrigated agriculture are boron (B), sodium (Na+), and chloride (CL-). According to the analysis's findings, the water samples 1 and 2 had chloride levels of 1.95 mg/l and 1.50 mg/l, respectively, and boron values of 1.50 mg/l and 1.80 mg/l. These don't interfere with irrigation practices because they were within the FAO standard limit. Nevertheless, samples 1 and 2 have sodium levels of 11.3 and 9.12 mg/l, respectively, which are beyond the FAO recommendation limit, suggesting excessive sodicity and making them unsuitable for irrigation techniques. Washing clothes could transfer sodium elements downstream of the River Niger, where sample 1 is located, which could explain the difference in sodium levels between samples 1 and 2.

3.2.4 Nutrients

These include the amounts of potassium, phosphorus, ammonium, and nitrate in irrigation water. The amount of nitrogen present in irrigation water can be expressed in terms of equivalent electrical nitrogen as well as nitrate ($N0_3$-N) and ammonium (NH_4-N). Equivalent elemental phosphorous can be used to report phosphate ($P0_4$-P). The findings showed that all of the water sources' nutritional contents are appropriate for irrigation techniques and fall below the FAO recommended range. Therefore, monitoring soil nutrients in the research region is not necessary.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusions

Two water samples were collected for this study—one upstream and one downstream of the River Niger—and brought to a facility for physico-chemical examination. The analyses' findings were compared to the FAO standard. All parameters taken into account are found to be within the FAO standard limit, with the exception of sodium, which showed a high amount. It is also discovered that the two water samples' nutritional contents fall under the FAO limit. High levels of sodicity (exchangeable sodium) will, however, have little to no effect on annual crops; nonetheless, unless prescribed management practices are followed, it is not ideal for perennial crops. Thus, it can be stated that the water from River Niger in the Shonga Irrigation Scheme area is acceptable for irrigation techniques and of good quality for irrigated farmland.

4.2 Recommendations

The study led to the following recommendations;

(i) In order to ensure the overall sustainability of this river for irrigation, it is necessary to educate the communities surrounding the research area on the importance of resource conservation, maintenance culture, and effective community participation.

(ii) In order to prevent the excessive entry of chemicals into the river channel, farmers should be trained to control the input and release of nutrients (nitrogen, phosphorus, and potassium) from fields.

(iii) To stop the amount of sodium and other harmful ions from rising further, the local government authority in the study area should control the river's pollution.

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