COMPARATIVE EVALUATIONS OF SURFACE AND SUBSURFACE WATER AT NCRI IRRIGATION SCHEME IN BADEGGI AND EDOZHIGI NIGER STATE, CENTRAL NIGERIA:

OLAGOKE, OLORUNTOBA*, ABUBAKAR YUNUSA, ETHAN SAUL

National Cereals Research Institute Badeggi P.M.B 8 Bida, Niger State, Nigeria.

** Correspondence author contact:*

tobaolagoke@gmail.com, +234-070-327-39743

ABSTRACT

Comparative evaluation of surface and subsurface water quality was carried out in some selected points in Badeggi and Edozighi irrigation Schemes located at Lat, 9°06 N, Long.5° 59' E; and Lat.9°0.525'N, Long 5°5.900'E respectively, in the Southern Guinea Savanna of Nigeria to assess the quality of irrigation waters. The results obtained from the chemical analysis of the waters, have shown that the total dissolved solids (TDS) for the surface water is on the average of 270.55 mg/l. The sub-surface water had higher concentration of dissolved solids with mean of 303.15 mg/l. The sodium adsorption ratio (SAR) which relates the sodium content with the dicationic-cations calcium and magnesium ranged between 37.05 and 20.85 mg/l for surface water and 54.05 and 22.25 mg/l for sub-surface water respectively. The results indicate that the quality of both water are good for irrigation purposes according to FAO standard.

KEYWORD: *Comparative evaluation, irrigation scheme and subsurface water.*

INTRODUCTION:

Agricultural practices like crop production, food processing, aquaculture, and livestock production are common in towns and villages around central Nigeria. The aforementioned activities are majorly dependent on water especially during the dry season which normally lasted for about six months yearly. All the above agricultural activities affect the chemistry of the soil and water (Naseem et. al., 2010). Natural sources of fresh water for irrigation are rivers, lakes, streams, dams and groundwater. Water is the most important input required for plant growth in agricultural production.

Irrigation water quality refers to its suitability for use. Good irrigation water quality has the potential to allow maximum yield of crops under good soil and water management conditions (Omotosho and Ojo, 2012). However, poor quality of irrigation water may cause salinity of soil and toxicity to the plant. This will result in impaired growth and reduced yields, unless special management practices are adopted to maintain or restore maximum soil production.

Knowledge of irrigation water quality is critical to understanding management for a long-term productivity. Irrigation water quality is evaluated based upon total salt content, sodium and specific iron toxicities. Salt affected soils develop from a wide range of factors, including soil types, field slopes and drainage, irrigation system type and management, fertilization and manuring practices and other soil and water management practices (Ethan et al, 2014).

All irrigation waters contain dissolved salts which dissociate into ions. Ions are electrically charged particles made up of individual elements or combination of elements which are taken up by the plant roots. In the majority of irrigation waters these ions are quite diluted, but in low quality waters can be significant. The addition of fertilizer to irrigation waters increases the concentration of positively charged ions (cations) and negatively charged ions (anions).

Total salt concentration of irrigation water should not be used as single criteria to prevent its use in irrigation. Even water with considerable high salt concentration can be used for irrigation without endangering soil productivity, provided selected irrigation management could take into account all other factors affecting crop production. The key point is how to maintain existing salt balance in plant root zone.

LOCATIONS/CLIMATE OF THE STUDY AREA

The research was carried out in Niger State, Nigeria. Niger State is located between latitude 8^0 22'N and $11^0$30'N and Longitude 3^o 30'E and 7^o 20'E in Nigeria, The region experiences two distinct seasons, the dry and wet season, with annual rainfall varying from 1,100mm in the northern part to 1,600mm in the southern parts (Olagoke and Olatunji, 2014). Mean maximum temperature remains relatively high throughout the year, averaging about 32°C, particularly in March and June. The lowest minimum temperature occurs usually between December and January (Iloeje, 1982). Generally, the fertile soil and hydrology of the State permit the cultivation of most of Nigeria's staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development.

Niger State shares boundaries with Kaduna State and Federal Capital Territory, in the East and South-East respectively, Kebbi and Kaduna in the North, Kwara and Kogi States in the South and Benin Republic in the West (Fig.1).The landscape consists mostly of wooded savannas and includes the flood plains of the Rivers Niger and Kaduna (Iloeje, 1982). Niger State has an area of 76,363 square km. Generally, agricultural activities form the mainstay of the people's economy and engage directly or indirectly more than 80 percent of the population.

Estimated potential irrigated land in Nigeria is about 356,000ha, only about 185,000ha was planned of which about 32,000ha have been completed and irrigated. In addition, the development of about 146,000ha of fadama is underway and out of this about 99,000ha falls under middle lower Niger.

MATERIALS AND METHODS:

River water (surface) and Tube-well (subsurface) water were collected in clean PVC bottles of 1 litre at various locations in the study area. They were properly labeled, filtered with Whiteman paper to remove particles and were analyzed immediately, the samples that were not analyzed the same day were kept in a refrigerator for analyses the next day. The analyses were done using Atomic Absorption Spectrometer (AAS) for cations, EDTA titration for anions and pH meter and electrical conductivity meter for conductivity.

The following Parameters were determined to evaluate the suitability of both surface and sub-surface water for Agricultural production:

- Sodium Adsorption Ratio, SAR (Richards, 1954)
- Permeability Index (PI) (Doneen, 1964)
- Residual Sodium Carbonate (RSC)
- Total Hardness (TH) (Todd, 1980)
- Soluble Sodium Percentage (SSP)

(Todd, 1995)
- Magnesium Adsorption Ratio (MAR) (Paliwal, 1972)
- Kelly Ratio (KR) (Kelly, 1951)
- Potential Salinity (PS) (Doneen, 1964)

METHODOLOGY

The qualities of the water for agricultural purposes are determined by using the following Indexes:

SAR= $Na^{+}/((Ca^{2+}+Mg^{2+})/2)^{1/2}$ *(ions in meq/l)*

Residual Sodium Carbonate (RSC)=$(CO_3+HCO_3)-(Ca^{2+}+Mg^{2+})$ *(ions in meq/l)*

Permeability Index (PI)=100× [([Na] + [HCO3]1/2) / [Na] + [Ca] + [Mg]

Magnesium Adsorption Ratio (MAR)= Mg^{2+} * 100/ $(Ca^{2+} + Mg^{2+})$

Kelly Ratio (KR)=$Na^{+}/(Ca^{2+} + Mg^{2+})$

Soluble sodium% (SSP) = $((Na^{+}+K^{+})/(Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}))$*100

Potential Salinity (PS) =Cl^{-} 0.5*SO_4

RESULT AND DISCUSSION

The summary of analyses for surface water and subsurface are presented in table 1 and table 2 respectively. The sequences of the abundance of the major ions are in the following orders: Ca^{2+} > Mg^{2+} > Na^{+} > Fe, B > K^{+} and HCO_3^{-} > Cl^{-} > SO_4^{2-} > PO_4^{-} > NO_3 for Rivers, while the sequence for Tube-well is in this order Ca^{2+}>Na^{+}>Mg^{2+} >B >Fe > K^{+} and HCO_3^{-} > NO_3 >Cl^{-}>SO_4^{2-} >PO_4^{-} as shown in figure 2 and 3 below. The dominant hydro-chemical facies(water type) for both sources of water is Ca-Mg-HCO_3 water type as revealed by figures 2 and 3.

The average value of SAR for both the Rivers and Tube-well water are 0.36 and 1.08 respectively which makes both water excellent irrigation water, inference from table 4.

Table 3 shows that average Percentage of sodium for Rivers and Tube-well water are 11% and 25% respectively, and it falls under permissible class for irrigation (Ishaku et al.,2011).Average KR is 0.2556 and 0.0862meq/l for Rivers and Tube-well water respectively, which confirms its suitability for irrigation purposes.

Residual Sodium Carbonate (RSC) is less than 1meq/l for both water sources, safe for irrigation water and other agricultural uses. Potential Salinity (PS) is also less than 3meq/l for both water sources, hence, safe for irrigation water (Tathy et. al., 2011). Boron is <0.55ppm, therefore suitable for irrigation water with no problem for sensitive plants.

CONCLUSION AND RECOMMENDATIONS

Irrigation water quality alone is not enough to evaluate potential salinity hazard which may be confronted under irrigated agriculture. It is not possible to classify different qualities of irrigation water with clear cut boundaries, and therefore, one must consider; plant, soil, climatic conditions as well as existing agronomic and irrigation practices in a given region in the final evaluation of water quality.

Agronomist and irrigation specialists should advice farmers for appropriate management practices to overcome potential salinity hazard if the quality of available water would pose any problem. Water quality criteria should be used as a guideline to define appropriate management practices in irrigated agriculture to maintain existing soil productivity with the benefits of high crop yields under irrigation (Ethan et. al 2014).

Based on the results of this research, both the Rivers and Tube-well water in middle lower River Niger in central Nigeria are suitable for irrigation because no clogging of soil, no salinity hazards and no adverse effect on soil properties are envisaged. The water is equally suitable for consumption of domestic animals.

Micro irrigation should be encouraged in middle

Niger as there is no complication arising from the qualities of the water. Also, simple technology on water storage and extraction involving women and children should be encouraged. Lastly, Introduction of modern farming and cropping system should be introduced to farmers with the aid of extension officers.

List of Tables

Table 1:Summary of the Analyses for Rivers Water in mg/l

Parameter	Average	Min	Max	Standard Deviation
pH	7.35	6.46	8.24	0.89
Ec_w	1.24	0.90	1.58	0.34
Temp ^0C	34.25	32.8	35.7	1.45
TH	25.85	24.1	27.6	1.75
Ca	37.05	35.4	38.7	1.65
Na	7.7	6.9	8.5	0.8
K	0.2	0.1	0.3	0.1
Mg	20.85	17.2	24.5	3.65
Fe	2.05	1.7	2.4	0.35
B	1.4	1.2	1.6	0.1
SO_4	35.6	27.1	44.1	8.5
NO3	0.15	0.1	0.2	0.05
PO_4	1.35	1.2	1.5	0.15
HCO_3	55.2	50.1	60.3	5.1
Cl	38.8	26.4	51.2	12.4

Table 2: Summary of the Analyses for Tube-well Water in mg/l

Parameter	Average	Min	Max	Standard Deviation
pH	8.03	7.15	8.92	8.885
Ec_w	0.57	0.27	0.88	0.30
Temp ^0C	34.5	32.4	36.6	2.1
TH	54.7	51.2	58.2	3.5
Ca	54.05	32.4	75.7	21.65
Na	26.4	7.2	45.6	19.2
K	0.05	0.03	0.07	0.02
Mg	22.25	12.0	32.5	10.25
Fe	0.57	0.1	1.03	0.465
B	1.65	1.2	2.1	0.45
SO_4	2.15	0.2	4.1	1.95
NO3	11.5	7.5	14.5	3.5
PO_4	0.42	0.38	0.45	0.035
HCO_3	23.55	15.0	32.1	8.55
Cl	9.58	1.16	18.0	8.42

Table 3: Calculated Indices for both Rivers and Tube-well (meq/l)

Indexes	Rivers	Tube-well
Potential Salinity (PS)	0.3996	0.0054
Sodium Absorption Ratio (SAR)	0.36	1.08
Magnesium Absorption Ratio (MAR)	55.88	40.26
Permeability Index (PI)	16.02	13.58
Kelly Ratio (KR)	0.10	0.25
Soluble Sodium % (SSP)	8.84%	20.03%
Residual Sodium Carbonate (RSC)	0.2556	0.0862
Total Dissolve Solid (TDS)	270.55	303.15

Table 4: Guideline for Interpreting Chemical Quality of Irrigation Water

Characteristics	Desirable limits	Maximum allowable limits	Average in the Study Area	
			Rivers	Tube-well
Salinity				
EC_w	0.75	0.75 – 3.0	1.24	0.57
Toxicity				
SAR	3.0	3 – 9	0.36	1.08
Boron (mg/l)	0.75	0.75 – 2.0	1.4	1.4
Chloride (mg/l)	4	4 – 10	38.8	38.8
Others				
pH	Normal range	6.5 – 8.4	7.35	8.03
Nitrate (mg/l)	5	5 – 30	0.15	11.5
Bicarbonate	46.5	46.5 – 263.5	53.2	23.5

Adopted from FAO, 2000

List of Figures

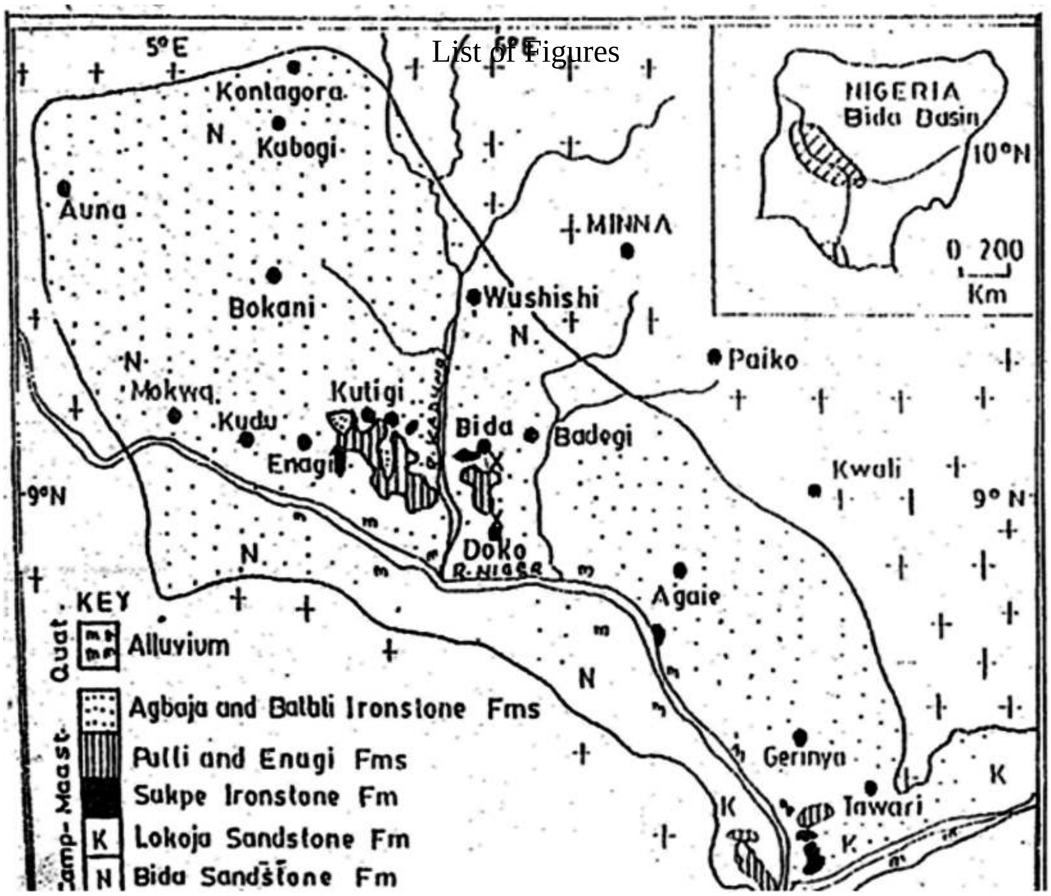

Fig 1: Geology and Locations Map of the Study Area

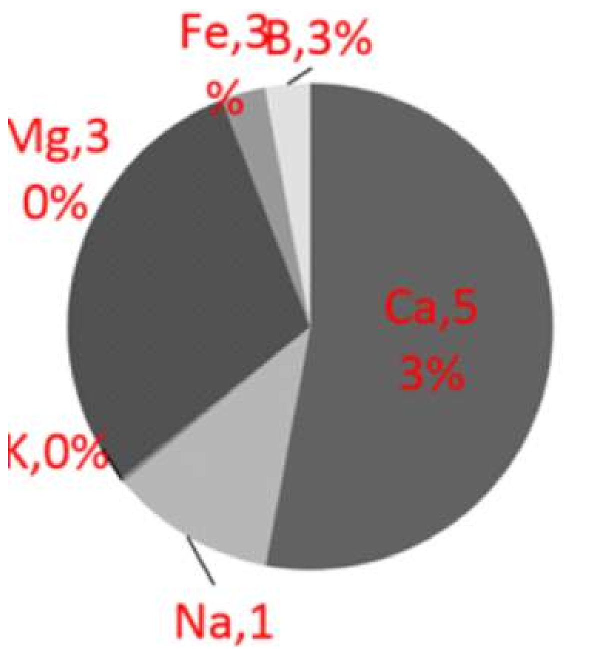

Figure 2a: % average of major cations (abundance of the major cations) for Rivers water.

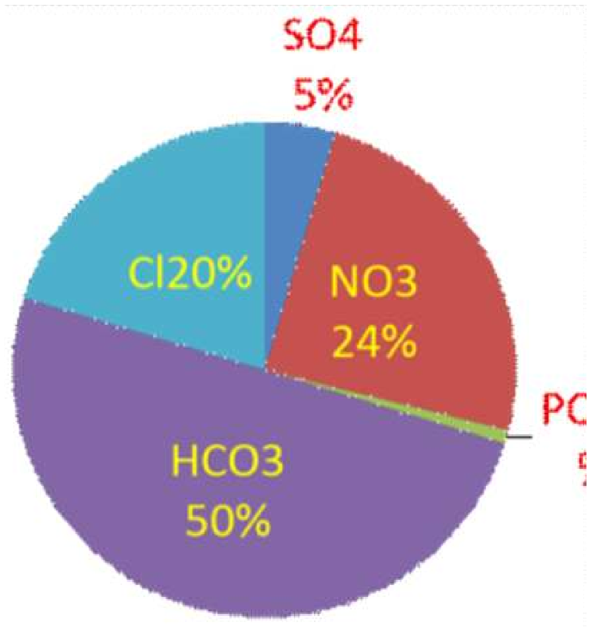

Figure 3a: % average of major cations (abundance of the major cations) for Tube-well water.

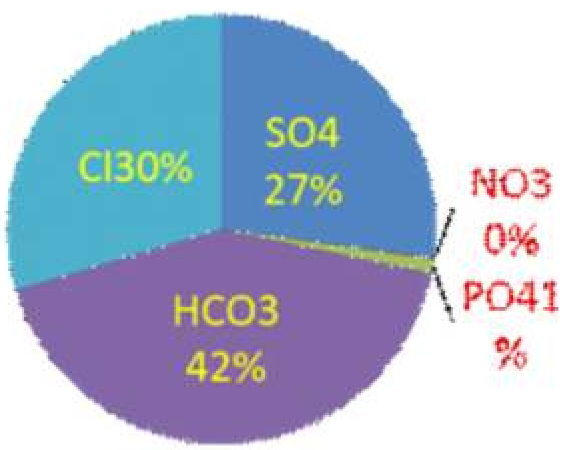

Figure2b: % average of Major Anions (abundance of the major anions) for Rivers waters

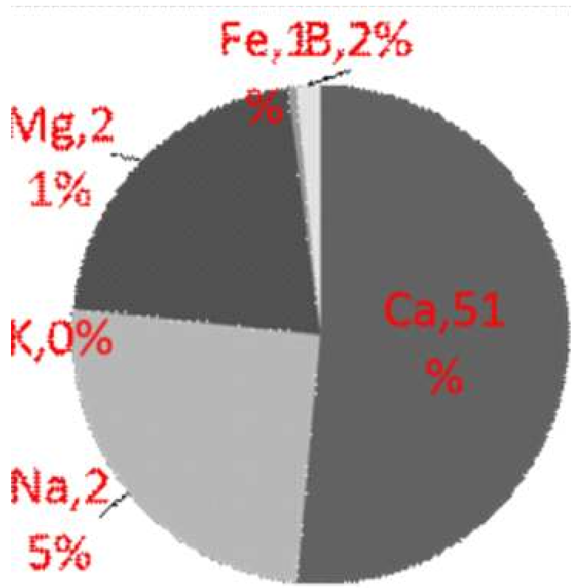

Figure 3b: %average of major anions(abundance of the major anions) for Tube – well water

REFERENCES

Doneen, I.D., (1964). Notes on water quality in Agriculture. Published as a water Science and Engineering. Paper 4001.Department of Water Sciences and Engineerring, University of California.

Ethan, S., Olagoke, O., Abubakar, Y. (2014). Assessment of the quality of Irrigation water at the Badeggi and Edozighi Irrigation Schemes. International Journal of Geology, Agriculture and Environmental Sciences. Vol. 2 Issue – 3, June 2014

Iloeje, N.P., (1982). A New Geography of Nigeria. Lagos, Longman, Nigeria Limited

Ishaku J. and Matasu I.H. (1998). Evaluation of water resources in Numan, North East Nigeria. Journal of Environmental Sciences 8(1) 20- 25.

Kelly, W.P., (1951). Alkali Soils-Their Formation, properties and Reclamation.3rd edition. Reinhold Publ., New York, USA. 92.

Naseem, S., Hamza, S. and Bashur, E. (2010).Groundwater Geochemistry of Winder Agricultural Farms, Balochistan Pakistan and Assessment for Irrigation Water Quality. European Water, 31:21-32.

Olagoke, O. and Olatunji, J.A. (2014) Evaluation of Water Resources of Bida Town in Central Nigeria J. of Environmental Sciences and Resources Management.Vol. 6. No. 1 pp. 44 – 55.

Omotosho, O.A. and Ojo, O.J. (2012). Assessment of quality of River Niger Flood plain water at Jebba, Central Nigeria: Implications for Irrigation. Water Quality Journal 4; 13 – 24, 2012.

Paliwal, K.V., (1972). Irrigation with saline water. Monogram no. 2 (New series). New Delhi, IARI, 198.

Richards, L.A.(1954). Diagnosis and Improvement of Saline and Alkali Soils Agric Handbook 60, USDA and IBH Pub. Coy Ltd., New Delhi, India, pp: 98-99.

Tathy, C. Matini, L. Moukandi Nkaya, G. and. Mabiala, B. (2011). Assessing Factors Controlling the Hydrochemistry and Suitability for Irrigation Purposes of Aquifer AQ-2 in Pointe-Noire, South-West Congo-Brazzaville. Research Journal of Applied Sciences, Engineering and Technology 3(7): 617-624.

Todd, D.K. (1980). Groundwater Hydrology.2nd. ed., John Wiley and Sons, New York, 535.