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Evaluation of Groundwater Quality for Fadama Irrigation Lands in River Niger-Benue Confluence of Lokoja-Nigeria

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Abstract- Groundwater samples from three (3) tubewells located on Sarkin-noma fadama farm, on the bank of River Niger in the Confluence town of Lokoja were collected randomly between March and September 2011 and investigated to ascertain the quality status and suitability for irrigation. Physico-chemical properties were determined using appropriate analytical methods. The water samples were neutral with pH values ranging from 6.9 to 7.2. They had very low salinity values (ECw 250 to 385S/m). The Sodium Adsorption Ratio (SAR) ranged from 1.05 to 1.55. This indicates a low risk of sodium build up in the soils. Irrigation water of very low salinity and low SAR can lead to problems of water infiltration into the soils. Other groundwater hydrological investigations need to be done to profer suitable management advice.

Index Terms**-** Fadama Irrigation, Groundwater Quality, Lokoja, River Niger- Benue Confluence

I. Introduction

Irrigation and drainage have been practiced since antiquity 1). Unfortunately, the problems that contributed to the demise of several ancient civilizations are still present today. According to 2), eighteen percent (18%) of the world's agricultural land is irrigated but it produces thirty-three percent (33%) of total harvest. 3), posits that it is a relatively recent recognition that salinization of water resources is a major widespread phenomenon of possibly greater concern to the sustainability of irrigation than is that of the salinization of soils per se. Although irrigation is useful for sustaining/increasing agricultural production, it is imperative that good quality water be used 4). Regardless of its source, soluble salts are always dissolved in irrigation water which could affect the physical and chemical properties of soils 5). However, the nature and quantity of dissolved salts depend upon the source of water and its course before use 6). Among the soluble constituents, calcium, magnesium, sodium, chloride, sulphate and bicarbonates and boron are of prime importance in determining the quality of irrigation water and its suitability for irrigation purposes. Other factors like texture, structure of the soil, its drainage characteristics, nature of the crop grown and climatological conditions, depth of water table, presence of hard pan of lime or clay, are equally important in determining the suitability of irrigation water in agriculture. 6).

Groundwater is a major source of supplemental irrigation water. The most potential groundwater reservoirs lie in the alluvial formations of major rivers 7). This is a major reason why emphasis is being placed on small-scale fadama irrigation schemes in Nigeria and the river niger-benue confluence at Lokoja, in particular. Fadama is a Hausa word which refers to low lying, relatively flat areas either in streamless depressions or adjacent to seasonally or perennially flowing streams 8). They have been classified as Eutric/Dystric Fluvisols by 9). To ensure all-year-round farming, groundwater from wells is used in irrigating farms on fadama lands by small scale farmers. The quality of ground water is the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies from place to place and with the depth of the water table 10). Evaluation and regular monitoring of groundwater quality in the fadama lands is therefore imperative in order to detect changes in water quality so that effective irrigation and drainage may be adopted and changes in management can be planned.

The quality of irrigation water is generally judged by its total salt concentration, relative proportion of cations or sodium absorption ratio and contents of bicarbonates and boron 11). Quality of groundwater varies from place to place, from stratum to stratum and from season to season. The bases used for determining the suitability of groundwater for irrigation includes chemical analyses requiring the determination of the concentrations of inorganic constituents-chlorides, fluorides, sulphates, nitrates, iron, manganese and dissolved gases, measurement of pH and specific electrical conductance, total dissolved solids and evaluation of the sodium adsorption ratio; 12).

This study is specifically aimed at determining the quality (physical and chemical parameters) of the groundwater used for irrigation on the Sarkin-Noma small scale irrigation Farm, located on the fadama lands by the confluence of Rivers Niger and Benue in Lokoja – Nigeria. There are no recent records of groundwater quality studies in this fadama project of Lokoja and there is also the need for routine studies of the water qualities which will serve as checks to forestall hazards leading to poor yield and subsequent loss of agricultural land. This work makes appropriate recommendation for best cultural practice that can be adopted to enhance optimum productivity and maximum yield whilst improving the soil conditions for sustained all-year round cropping.

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II. MATERIAL AND METHOD

Study area

Sarkin-Noma Fadama farm the study area, is geographically located between longitude 7°50′ and latitude 6°45′ North. It is bounded by the River Niger to the east and Sarkin-Noma village to the west in North-Western Lokoja, North-Central Geo-political Zone of the Federal Republic of Nigeria (Figs. 1.0).

This farm which is approximately 70 hectares 13) is totally dedicated to all-year-round agricultural production with a few population of nomads and agriculturists settled within the area. Common crops such as tomatoes, garden eggs, pepper, spinach, cassava and other vegetable/leguminous crops are grown in the dry season while crops like rice, sugar-cane, maize, guinea-corn are also mixed with the above crops in rainy season.

The climatic data from the Nigeria Meterological Agency 14) indicates that the study area falls within the tropical climate zone and is characterized by two distinct seasons: rainy season (April to October) and dry season (November to March). Mean annual rainfall in the dry season ranges from 0mm to 42mm; the mean annual rainfall during the rainy season ranges between 105mm and 1560mm while peak rainfalls occurs between July to September annually. Mean annual temperature oscillates between 26°C (July or August) to 35°C in February or March while relative humidity ranges from 50 – 63% 17). WARDA 15) classified the vegetation in this study area as Guinea Savannah grassland. Characteristic vegetation includes shrubs with scattered orchard bush. Several streams delineate the large low-lying, moderately sloppy landscape of the area. These streams-which are seasonal- flow from the western flank (where the land rises from 200 to 1000 above sea level) to eastern flank of the farm. Streams and rainwater drain fast directly into the River Niger due to the moderate sloping nature of the land. Most streams dry up in the non-rainy period and re-appear again during the wet season. The wet season also shows its own peculiar problem of making the low lying area 'waterlogged', poorly drained and liable to flood thereby making it difficult to cross on foot and unfit for certain cropping or building activities.

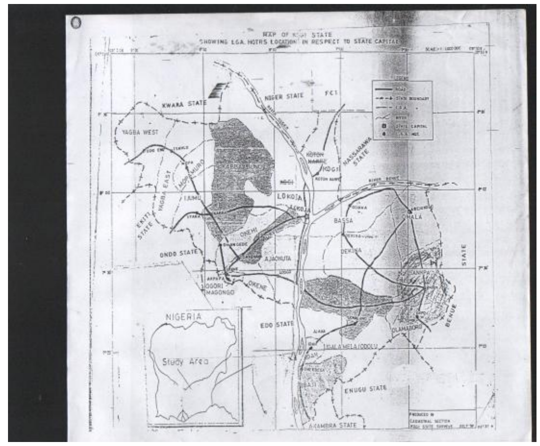

Fig. 2.0: Map of Kogi State showing the confluence of Rivers Niger and Benue

III. SURVEY METHODS

Three (3) already existing tube well were identified within the bakori fadama prpject, water samples were collected from each of the three (3) existing tubewells on the farm under preserved condition to avoid climatic influence that may alter quality parameter. The water quality parameters were determined for each sample at the UNICEF laboratory Lokoja.

Analytical Methods

The collected water samples were analysed for the following parameters: pH, Electrical Conductivity (ECw), Total Dissolved Solids (TDS), Na^+, Ca^{2+}, Mg^{2+}, Cl^- and SO_4^{2-} using appropriate technology and technique as shown in table 1.

Table 1; technolgy/techniques for determinig quality parameter

Parameter	Technology	Make
pH	pH meter	
Electrical conductivity	CO 150 conductivity meter	M50150hatch company
TDS	CO 150 Conductivity/TDS/°C/pH meter	M50150 hatch
Na^+, Ca^{2+}, Mg^{2+}	Flame photometry	
SO_4^{2-}	spectrophotometer	DR 2000 hatch company
Cl^-	Sectrophotometer	

A soil-water suspension and irrigation water was prepered in the ratio 1:2.5 and a standard pH meter was used to determine the pH. The Electrical Conductivity (ECw) was read (in S/m) using the CO 150 conductivity meter, Model 50150 while the total dissolved salts(TDS) was determined by evaporation-drying method using the CO150 Conductivity/TDS/Temperature/pH meter, Model 50150 by Hach Company. The cations of **Na^+, Ca^{2+} and Mg^{2+}** were determined using flame photometry. The determiantion of **SO_4^{2-}** was carried out using plastic measuring tube (DR2000 Spectrophotometer produced by Hach Company) filled with the water to be tested (5.83mL) and the contents poured into a mixing bottle. One satchet of the sulfate powder pillow was added to the sample and thoroughly mixed. The mixture was then placed in the spectrophotometer and the readings were taken at a wavelength of 450nm, 680. **Cl^-** Was determined using the Spectrophotometer at a wavelength of 455nm, 70

Sodium absorption ratio (SAR) was calculated using the equation below:

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

IV. RESULTS AND DISCUSSION

Table 2.0 below shows the mean values of pH, electrical conductivity (ECw), total dissolved solids (TDS) and sodium absorption ratio (SAR) results obtained from the analysis of the water samples.

From the table, it can be seen that the waters were neutral with pH values falling between the narrow range of 6.8 to 7.3 which falls within the normal range in irrigation water quality given by 16).

However, the salinity levels were generally very low with mean values of Ecw falling between 250S/m and 385S/m. Low salinity water tends to leach surface soils free of soluble minerals and salts, especially, Calcium reducing the strong stabilizing influence on soil structure. Without salts and without Calcium, the soil disperses and the dispersed finer soil particles fill many of the smaller pore spaces, sealing the surface and greatly reducing the rate at which water infiltrates the soil surface. Infact, very low salinity water (<200S/m) almost invariably results in water infiltration problems, regardless of the Sodium Adsorption Ratio 16).

If the soils become waterlogged and temporarily flooded due to the low infiltration rate for even short periods of a few days, much of the nitrate-nitrogen present may be quickly denitrified and lost from the soil to the atmosphere as N_2 gas due to poor aeration.

All the water samples had very low levels of SAR with a range of 1.05 to 1.55 and would generally not pose any hazards with respect to Na buildup in the soils.

Table 2.0:pH, Ecw, TDS and SAR obtained from water samples

Sample location	pH	Ecw(s/m)	TDS(mg/l)	SAR
W1	7.1	250	42.4	1.55
W2	6.9	385	40.1	1.05
W3	7.2	319	38.6	1.49
Mean	7.06	318	40.36	1.63

The Cationic and anionic concentrations of the waters sampled are presented in Table 2. The table shows the respective mean values for Na^{+}, Ca^{2+}, Mg^{2+}, SO_4^{2-} and Cl^{-} (mg/L) corresponding to tubewells W_1, W_2 and W_3 respectively.

The Ca: Mg ranged from 0.49 to 1.15 and its values generally fell below 1.In Magnesium-dominated water, the potential effect of sodium may be slightly increased 16).

The mean SO_4^{2-} and Cl^{-} values for all samples fell within the safe limits, respectively ranging from (in mg/L) 8.5 to 10.8 and 6.9 to 24. Available literature suggests that irrigation waters within this range of values are considered safe for irrigation.

Table 3.0: Ionic concentrations (in mg/L) obtained for the water samples

Sample location	Ca^{2+}	Mg^{2+}	Na^{2+}	$Ca^{2+}:Mg^{2+}$	SO_4^{2-}	Cl^{1-}
W1	6.9	9.2	4.4	0.75	10.8	24.0
W2	5.8	11.8	3.1	0.49	8.5	17.0
W3	7.1	6.2	3.8	1.15	9.3	6.9
Mean	6.6	9.1	3.7	0.73	9.2	15.9

V. CONCLUSION

The groundwater quality analysis revealed that the Electrical Conductivity ranges from 250S/m to 385S/m while the SAR varies between 1.47 and 1.55. The groundwater used for irrigation in Sarkin-Noma Fadama farm has low salinity and is still safe for irrigation but there may be problem of low infiltration due to the low salinity level. The SAR values show that the land will witness little or no potentials of hazardous sodium build up overtime. Sodium sensitive crops may be cultivated because the sodium adsorption ratio is small and there is little or no sodium build up in the soils. It is however recommended that other hydrological parameters and site investigations like determination water table fluctuation, infiltration, hydraulic conductivity etc should be done to aid management and provide data required for surface and/or subsurface drainage, if required.

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