IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 15, Issue 3 Ser. II (March 2022), PP 54-58
www.iosrjournals.org

Assessment of Water Quality for Irrigation Purposes in Jibia Irrigation Project, Katsina State, Nigeria.

[1]S. Sani, [1]A. Abdulkadir and [2]S. A. Pantami
*[*1]Department of Soil Science, Faculty of Agriculture, Federal University Dutsin-Ma, P.M.B. 5001 Dutsin-Ma, Katsina State, Nigeria.*
[2]Department of Soil Science, Faculty of Agriculture, Bayero University Kano, Nigeria
[*]Corresponding author: ssani2@fudutsinma.edu.ng; sufiyanusanii@gmail.com

Abstract
Irrigated Agriculture heavily depends on adequate water supply of good quality. This research was carried out in Sector F1 of the Jibia Irrigation Project, Jibia Local Government Area, Katsina State, North West, Nigeria, with the aim of assessing water quality for irrigation purposes. A total of twenty (20) representative samples were randomly collected from the dam and main canals supplying water to the field. The samples were treated and analyzed for physical and chemical parameters. Generally, the main characteristics used to assess the quality of irrigation water are Total dissolved solids (TDS), Sodium adsorption ratio (SAR), Electrical conductivity (EC) and Residual Sodium Carbonate (RSC). The Findings revealed that the mean pH of the irrigation water was 6.4, ranging from 6.09 to 6.68, while the EC values have a mean of 0.15 dSm^{-1} with values ranging from 0.096 dSm^{-1} to 0.436 dSm^{-1}.The Mean quantities of Metal cations in the water samples ranged from 0.031 to 0.59; 0.012 to 0.14; 9.19 to 20.42; 0.58 to 8.4 mg/l for Na^{+}, K^{+}, Ca^{2+} and Mg^{2+} respectively. Sodium adsorption ratio (SAR) had a mean of 0.03, with the minimum and maximum values of 0.008 and 0.103 respectively; while the mean of TDS was found to be 147 Mg/l. RSC was found to be 91.46. Chloride ions (Cl^{-}) had a mean of 38.16 with 17.75 and 88.75 mg/l as minimum and maximum values respectively. Sulphates (SO_4^{2-}) Boron, $N0_3^{-}$ and phosphates (PO_3-) had a mean value of 38.09, 0.30, 53.06 and 0.28 mg/l respectively. No detectable bicarbonate CO_3^{2-} was observed in all the water samples.

Key Words: *Water quality, Irrigation, Jibia Irrigation Project,*

Date of Submission: 12-03-2022 Date of Acceptance: 28-03-2022

I. Introduction

The development of water resources especially for irrigation purposes in Nigeria dates back to the pre-colonial era traced back to around 700 AD (Adelodun and Choi, 2018; Olubode-Awosola and Idowu, 2004). As a result of the FAO and US Bureau of Reclamation studies conducted in the early 1970s, three pilot public irrigation schemes were developed all in the sub-arid and dry sub-humid agro-ecological zones, namely: The Bakolori Irrigation Scheme, the Kano River Irrigation Scheme and the Chad Basin Irrigation Scheme. The success of these pilot schemes coupled with a five-year drought between 1970 and 1975 led to the establishment of eleven (11) River Basin Development Authorities (RBDAs) in the country (NINCID, 2015).

According to SRRBDA (1991), Jibia Dam was constructed across Gada River to boost agricultural production and supply portable drinking water for the people living within and around the area. It has a maximum height of about 20 m and a length of approximately 3,680 m, which created an impounding reservoir with full storage capacity of 142 x 106 m^3, dead storage capacity of 21 x 106m^3 and an active storage capacity of 121 x 106 m^3. The dam consists of a pumping station and two compensation reservoirs. Water from the pumping station is taken directly from the valve chamber to the reservoirs, from where the water is supplied to the main canals, then to the lateral canals and finally to the fields for irrigation (SRRBDA, 1991). The irrigation method is of two types; gravity irrigation covering 206 ha and irrigation by pumping covering 3,266 ha. This gives a total area of 3,472 ha. The irrigation area is divided into six parts (hydrological boundaries), based on six main canals (F1 to F6) that supply water to sub-canals and then to the irrigation plots (SRRBDA, 1982).

The history of irrigated agriculture has shown that irrigation can cause severe deterioration of soil productivity (Khan *et. al.*, 2014). The most common reasons for the failure of irrigation projects are associated with water logging, salinization and alkalization (Ghassemi *et. al.*, 1995). Increased use of irrigation leads to increase in yield and agricultural productivity with a negative effect on the ecology of the area, as a result of transformation that takes place when water and salt balances in the area increases (Oriola, 2004). These problems appear gradually and are influenced by the quality of irrigation water, condition of irrigated lands and other soil environmental factors. As the problems developed, they may cause failure of the irrigated lands to maintain high yields or if allowed to continue, could become severe that the irrigated area will no longer be productive (Curie, 2006; Kovda, 1973).

Irrigation, even with water of high quality often represent a large increase in the amount of water which passes through a soil profile under natural condition and thus, has the capacity to accelerate mineral weathering, leach soluble colloidal materials that can change soil structure and other soil physical properties and also raises local water table thereby reversing soil preparation measures such as tillage (Curie, 2006; Murray and Grant, 2007). Therefore, proper irrigation management practices are required to avoid soil deterioration as much as possible (Kovda, 1973)

Since Irrigation water quality is a key environmental issue faced by agricultural sector today (Tsado *et al.,* 2014; Garba and Mohammed, 2014) knowledge of water quality is therefore critical to understanding the management changes necessary for long term productivity (Bauder *et al.*, 2013; Garba and Mohammed, 2014). The main objective of this paper is to assess the quality of dam water for irrigation purpose in Jibia Irrigation Project, Katsina State, Nigeria.

II. Materials and Methods

STUDY AREA

The study was carried out in Sector F1 of the Jibia Irrigation Project located in Jibia Local Government Area (Latitudes $13^0$04'18" N - $13^0$10'27" N and longitudes $07^0$15'06" E - 07^0 18'.15" E). Jibia Local Government Area is bordered by Katsina and Batsari Local Governments Areas (LGAs) to the South, Kaita LGA to the East, and Zurmi LGA in Zamfara State to the West and Maradi State in the Niger Republic to the North. The landscape is nearly level to gently undulating with 0 - 2% slope and averaging 442 meters above sea level (FDLAR, 1990).

Climate

The study area is within the semi-arid region which falls within the Sahel savannah zone of Nigeria with a mean annual temperature and precipitation of about 25 ^{0}C and 600 -700 mm, respectively. Rainfall pattern is seasonal and occurs between the months of June and September with the peak rainfall occurring in the month of August. The dry season last between October and May (KTARDA, 2010).

Irrigation water Sampling

Irrigation water samples were collected from the channels supplying water to the field. A total of twenty (20) water samples were collected randomly from the main canals across the field. The water samples were collected in the morning in prewashed plastic bottles and packed in coolers containing ice blocks to keep the temperature at about 4 ^{0}C and immediately transported to the laboratory for analyses. The transported water samples were kept in the refrigerator prior to analysis.

WATER ANALYSIS

The pH, Total Dissolve Solids (TDS) and Electrical conductivity (EC) of the water samples were determined using pH, TDS and EC meters, respectively, while basic cations were determined using flame photometer for Na^+ and K^+; and Atomic Absorption Spectrophotometer (AAS) (Buck Scientific Model 210 VGP) for Ca^{2+} and Mg^{2+}. Nitrate was determined using Kjeldahl distillation method. SO_4^{2-} BO_3^{2-} and PO_4^{3-} were determined using spectrophotometer (JENWAY PFP 7). HCO_3^- and Cl^- were determined using titrimetric method. SAR and RSC were computed using appropriate formulae as described in FAO (2013).

III. Data Analyses

Data analyses were performed using descriptive statistics. The Measured variables were analyzed to obtain Mean, Median, Range, Maximum, Minimum, Variance, and Coefficient of variation using SPSS 16.0 (IBM-SPSS, 2017). The results obtained from the analysis were compared with FAO irrigation water quality standards.

Table 1: Descriptive Statistics for water quality indicators of Jibia irrigation project

Variables	Mean	Minimum	Maximum	SD	CV (%)
PH	6.439	6.09	6.68	0.142	2.208
EC (dSm^{-1})	0.15	0.096	0.436	0.101	69.30
NO_3^- (mgl^{-1})	53.06	31.52	161.115	29.68	55.94
PO_3^-(mgl^{-1})	0.28	0.049	1.132	0.258	90.96
SO_4^{2-}(mgl^{-1})	38.09	11.90	95.24	22.38	58.77
HCO_3^- (mgl^{-1})	108.27	30.50	274.5	50.91	47.03
Cl^- (mgl^{-1})	38.16	17.75	88.75	21.75	57.01
Na^+ (mgl^{-1})	0.12	0.031	0.598	0.133	114.04
K^+ (mgl^{-1})	0.05	0.012	0.1444	0.033	61.21
Ca^{2+} (mgl^{-1})	13.00	9.19	20.427	2.818	21.67
Mg^{2+} (mgl^{-1})	3.81	0.58	8.3577	1.999	52.48
SAR	0.03	0.008	0.103	0.032	106.32
BO_3^{2-} (mgl^{-1})	0.30	0.015	0.473	0.127	41.98
RSC	91.46	20.33	245.67	0.137	36.13
TDS (mgl^{-1})	146	119	163	0.157	54.5

SD= Standard deviation; CV= Coefficient of variations; SAR; Sodium Adsorption Ratio

Table 2: Guidelines for the interpretations of water quality for irrigation based on FAO

Water Parameter	Unit	Degree of Restriction on use		
		None	Slight to Moderate	Severe
EC_w	dSm^{-1}	<0.7	0.7 – 3.0	> 3.0
TDS	mgl^{-1}	< 450	450 – 2,000	>2,000
NO_3^-	mgl^{-1}	< 5	5 - 30	> 30
SO_4^{2-}	mgl^{-1}	<200	200 - 600	>600
HCO_3^-	$Meql^{-1}$	<1.5	1.5 – 8.5	>8.5
Cl^-	$Meql^{-1}$	<4	4 - 10	>10
Na^+	$Meql^{-1}$	<3	3 – 9	>9
SAR		0 - 3	3 - 6	6 - 12
B	mgl^{-1}	<0.7	0.7 – 3.0	>3.0
pH	Normal range =	6.5 – 8.4		

Ayers and Westcot (1985)

IV. Results and Discussion

The pH values of the irrigation water in the study has a mean of 6.44 ranging from 6.09 to 6.68 which is essentially a normal range required for irrigation water. The pH values indicated that the irrigation waters in the study area were slightly acidic and were found to be within standard limits of 6.5 – 8.5 (FAO, 2013). Normally, values above 7.0 are considered of increasing hazard and could causes corrosion of metals part in irrigation equipment (Singh *et al*; 1996; Danko,1997,Tsado *et al*., 2014; Bauder *et al*., 2000). Abnormality in plant functions can be observed when the pH is not suitable (Ayers and Westcot, 1985).

The concentration of total salt content in irrigation waters were estimated in terms of EC and TDS. It may be the most important parameter for assessing the suitability of irrigation waters (Belan, 1985, Ajayi *et al*., 1990). The EC_W had a mean of 0.15 dSm^{-1} with values ranging from 0.096 dSm^{-1} to 0.436 dSm^{-1}. Electrical Conductivity (EC) gives an estimate of the total amounts of dissolved salts in the water and the total amount and kinds of salts determine the suitability of the water for irrigation use (Belan, 1985). Generally, the ranges considered for irrigation water suitability are 20 to 70, 70 to 300 and >300 μScm^{-1} being normal, increasingly severe and severe with respect to salinity hazards (Schoeneberger, 1998). From this perspective, the sectors could be described as within the normal range (safe limit). A wide range of crops including vegetables, fruits, fodder and grain crops were reported to tolerate these levels (0 – 3.0 dSm^{-1}) of salinity water. This observation agrees with the work of Adamu (2013) on the quality of irrigation water and soil characteristics of Watari Irrigation project, Kano State, Nigeria.

TDS values ranged from 119 to 163 mgl^{-1} and a mean of 146 mgl^{-1}. TDS levels below 700 mgl^{-1} and SAR below 4 are considered safe; and hazardous if the level of TDS and SAR above 1,750 mgl^{-1} and 9 respectively (Ayers and Westcot, 1985). Based on this, the TDS values of irrigation water in the study are within permissible limit and as such safe for cultivation of wide range of crops.

Parameters for specific ion toxicities for Na, Cl, B, HCO_3 and NO_3 had mean values of 0.12, 38.16, 0.30, 108.27 and 53.06, all measured in mgl^{-1}, respectively. Sodium ions ($Na^{+)}$ had a minimum value of 0.031 and a maximum of 0.598(mgl^{-1}).

Sodium ions are important criteria for irrigation water quality because of its effect on soil permeability and water infiltration (Ajayi, 1990). Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. Generally, values greater than 9.0 $cmoll^{-1}$ in terms of Na concentrations are regarded as posing increasing severity of sodicity especially in soils high in clay content (Davis and Dewest, 1966). The values recorded (0.031 – 0.598 $cmoll^{-1}$) is therefore within the safe limit.

Sodium adsorption ratio (SAR) which is a measure of irrigation water to cause the replacement of Ca and Mg attached to the soil minerals with Na (Landon,1991). SAR in the study area had a mean of 0.03. The minimum and maximum values obtained were 0.008 and 0.103, respectively. The low SAR values obtained (0.03) present no problems and will be highly suitable for irrigation and production of wide range of crops (Fipps, 2003) .

Ca^{2+} and Mg^{2+} with mean values of 13.00 and 3.81 mgl^{-1} were found to be within the low range. The normal range of Ca^{2+} in irrigation water should be 0 – 20 $cmoll^{-1}$, while that of Mg^{2+} should bebetween 0 – 5 $cmoll^{-1}$ (Christenson *et al.*, 1977). By these criteria, the calcium content within the sector could be described as within safe limit. This also applies to the magnesium content. The relatively lower amounts of magnesium compared to the calcium may be good, because Mg deteriorates soil structure particularly where waters are sodium-dominated and highly saline. The reason for this structural degradation is that high level of Mg^{2+} usually promotes a higher development of exchangeable Na in irrigated soils. The Magnesium content of water is also considered as important qualitative criteria in determining the quality of water for irrigation because more magnesium in water will adversely affect crop yields, as the soils become more alkaline. Generally, calcium and magnesium maintain a state of equilibrium in most waters (Christenson *et al*., 1977).

Chloride concentration in the study area has a mean of 38.16 mgl^{-1} with values ranging from 17.75 and 88.75 mgl^{-1}. High concentration of chloride causes toxicity to sensitive crops especially when applied with sprinklers. According to Mass (1990) Chloride concentration below 70 mgl^{-1} is considered safe and can only cause severe problems when its concentration is above 350 mgl^{-1}. Chloride concentration in the study area was much lower than 70 mgl^{-1} and the values obtained (38.16 mgl^{-1}) is generally safe for all plants (Tsado *et al*., 2014; Adamu, 2013; Singh, 2000).

Boron Concentration in the study area had a mean of 0.30 mgl^{-1} with values 0.0015 and 0.472 mgl^{-1} as minimum and maximum values, respectively. Boron is an element that is required in low amount, but maybe toxic at higher amount (Mass, 1990; Ayers and Westcot, 1985). Boron concentration in the study area falls within the safe limit as Boron concentration less than 0.7 mgl^{-1} falls under no degree of restriction on use (Ayers and Westcot, 1985)

No detectable carbonate CO_3^{2+} was observed in all the water samples. Sulphates (SO_4^{2-}) and phosphates (PO_3^-) had a mean value of 38.09, and 0.28 mgl^{-1} respectively).

The range value of NO_3^- in the water samples of the study area was 31.52 - 161.12 mgl^{-1} and a mean of 53.06 mgl^{-1}. According to FAO, the NO_3^- value falls within severe degree of restriction on use limit (>30 mgl^{-1}) (Ayers and Westcot, 1985). If NO_3^- content is high in irrigation water, it results in fast plant vegetative growth and delay of plant's reproductive stage.

Phosphate concentration ranged from 0.049 to 1.132 mgl^{-1} and a mean of 0.28 mgl^{-1} and falls within the permissible limit for irrigated agriculture (0.2 - 5 mgl^{-1})

V. Conclusion

Based on the FAO guidelines for the interpretation of water quality for irrigation, the result of the analysis for assessment of water quality from Jibia irrigation project, Katsina state revealed that is siutable for irrigation purpose. Finally, despite the variations in all the observed quality indicators it could be concluded that the water of Jibia Irrigation Project is suitable for irrigation purpose. This is based on FAO standard for irrigation water quality.

References

[1]. Adamu, G. K. (2013a). An Assessment of Soil Properties of Watari Irrigation Project, Kano State Nigeria. Academic Research International 4(4), 258–266.

[2]. Adamu, G. K. (2013b). Quality of Irrigation water and Soil Characteristics of Watari Irrigation Project. American Journal of Engineering Research (AJER), 2(3), 59–68.

[3]. Adelodun, B., and Choi, K.S. (2018). A review of the evaluation of irrigation practice in Nigeria: Past, present and future prospects. African Journal of Agricultural research 13(40): 2087-2097.

[4]. Adesoji, S.A., Farinde, A.J. and Ajayi, O.A. (2006). Assessment of the Training Needs of Fadama Farmers for Future Agricultural Extension Work in Osun State, Nigeria. Journal of Applied Sciences, 6(15): 3089-3095.

[5]. Anderson, J. M. and Ingram, J.S. (1993). Tropical soil biology and fertility: A hand book of Methods 2nd edition. C. A. B International Wallingford, UK PP. 221.

[6]. Ajayi, F.M., Nduru, A. and Oningue, A. (1990). Halting the salt that kills crops. African Farmer, 4, 10–12.

[7]. Ayers, R.S. and Westcot, D. W. (1985). Water Quality for agriculture, irrigation and drainage. Paper No. 29, FAO.

[8]. Bauder, T. A., Waskom, R. M., Sutherland, P. L., & Davis, J. G. (2000). Irrigation Water Quality Criteria. In Colorado State Unversity Extension (p. 4). Retrieved from www.ext.colostate.edu

[9]. Bauder T.A, Waskom,R.M; Sutherland,P.L; and Davies J.G (2013). Irrigation Water quality Criteria,Colorado State University, Fact sheet No. 0.506.

[10]. Belan, F. I. (1985). Water treatment. MIR Pulishers Moscow, USSR, 232pp.

[11]. Christenson, J.E., E.C. Olsen, and L.S. Willardson,(1977). Irrigation water quality evaluation. Journal of irrigation and Drain Div. A and CIR 2.proc. paper 13015

[12]. Currie, D.R. 2006 Soil Physical Degradation due to Drip Irrigation in Vineyards: Evidence and Implications. Ph.D. thesis. The University of Adelaide.

[13]. Danko, M.M (1997). Comparative analysis of variables of irrigation water quality along river Rima. B.Agricultural project, Department of soil science and Agricultural engineering,Usman Danfodio Sokoto.pp.45

[14]. Davis, S.W. and Dewest, R. . (1985). Hydrology. John Wiley and sons. New york. 177pp

[15]. Dexter, A. R. (1997). Physical Properties of tilled soils. Soil and Tillage Research, 43, 41–63.

[16]. FAO, (1985). Guidelines. Land evaluation for Irrigated Agriculture. Soil Bull. No 55, FAO Rome, Italy.

[17]. FAO, (2005). The importance of soil organic matter. FAO soils bulletin No. 80. Rome, Italy.

[18]. FDALR (1990).The Reconnaissance soil survey of Nigeria (1:650,000) Soil Survey Report. Volume2. 316pp

[19]. Fipps, G. (2003). Irrigation water quality standards and salinity management strategies. Texas A and M Agrilife Extension, 4(3), 1–18.

[20]. Garba, U.A.and Mogammed, D. (2014). Spatial and temporal variation of irrigation water quality in watari Irrigation scheme JORIND 12(2) 337- 343 www.transcampus.org/journals; www.ajol.info/journals/jorind

[21]. Katsina State Agricultural and Rural Development Authority (KTARDA). (2010). Agricultural Based Data of Katsina State. 26pp

[22]. Khan, M.J., M. Rashid, S. Ali, I. Khattak, S. Naveed, and Z. Hanif, (2014). Mapping of Variability in Major and Micro Nutrients for Site-Specific Nutrient Management, International Journal of Plant & Soil Science 3(3): 303-329.

[23]. Kovda, V. A. (1973). Some effects of irrigation and drainage on soils, Irrigation, Drainage and Salinity. In FAO/UNESCO International source book (pp. 387–408).

[24]. Kundel, J. (2007). Water Profile of Nigeria. Accessed from the website of the FAO www.fao.org on 24th November, 2017.#

[25]. Landon, J. R. (ed) (1991).Booker Tropical Soil Manual, John Wiley and Sons Inc.; New York.

[26]. Murray, R. S., & Grant, C. D. (2007). The impact of irrigation on soil structure. Canberra: The National Program for Sustainable Irrigation (Land and Water Australia), 31.

[27]. Nigeria National Committee on Irrigation and Drainage (NINCID) (2015).Country Profile - Nigeria. Federal Ministry of Agriculture and water resources, Abuja, Nigeria. Retrieved June 12, 2018, from www.NINCID.org/cp_nigeria.html.

[28]. Olubode-Awosola, OO and Idowu, E.O (2004).Social-Economic Performance of Sepeteri Irrigation Project in Nigeria. Water resources of Arid Areas 287-299. Proceedings of International Conference on water resources of Arid and Semi-Arid Regions of Africa, Gaborone, Botswana, 3-6, August 2004.

[29]. Oriola, E. O. (2004). The Impact of Irrigation Project on the Soil Environment and Socio-economic Status of Farmers in Oke-Oyi Community, Ilorin. Nigeria. Unpublished Ph.D. Thesis, Dept. of Geography, University of lbadan.

[30]. Singh, B. R. (2000). Quality of irrigation water in Fadama lands North-western Nigeria. I. Ground and Surface Water in Kebbi State. Nig. J. Basic. And Apl. Sci. 9:133-148

[31]. SRRBDA.(1991). Jibiya irrigation cum water supply project, progress report.Katsina: ENPLAN Group,consulting Engineers and planners (Vol. 59). 22pp

[32]. SRRBDA (2013). Agricultural Revolution Imminent in North West. January – April, 1st quarter. 19pp.

[33]. Schoeneberger, P J., Wyosocki, D.A., Benham, E.C. and Broder-son, W. . (1998). Field Book for describing and sampling soils: NCRS, USDA National Soil Survey Center, Lincoln, NE.

[34]. Tsado, P. A., Lawal, B. A., Eze, P. C., Afolabi, S. G.and Saidu, O. I. (2014). Assessment of the Suitability of Water Quality for Irrigation. International Journal of Research in Agriculture and Forestry 1(2) 13–17.

[35]. Yahaya M.K. (2002) Development and Challenges of Bakolori irrigation Project in Sokoto State Nigeria. Nordic Journal of African Studies 11(3):411-430.