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Assessment of Water Quality for Irrigation of Some Selected Soils/Areas in Yola, Adamawa State, North East, Nigeria

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Abstract

The study was carried out to assess the quality of irrigation water in Yola, North-East Nigeria. The study area comprises five locations: Doubeli, Bajabure, Bwaranji, Lake Gerio, and Jabbore. One water sample was collected from each of the five locations to analyze the chemical properties of the water quality for irrigation purposes. The data generated data were subjected to Analysis of Variance (ANOVA). The coefficient of variation (CV) and Least Significant Difference (LSD) were used to separate the means at the (P< 0.05) level of significance to test the relationship between and within soil properties using Statistical Analysis System (SAS version 9) statistical software. Based on laboratory results, irrigation water across the five locations indicated a pH range from slightly acidic to neutral conditions (6.45 to 7.28). EC ranged from 0.13 to 0.28 d Sm^{-1}, SAR ranged from 0.57 to 0.67 cmol $(+)kg^{-1}$ and RSC, $CO^{2-}{}_3$, $HCO^-{}_3$ and Cl^- contents were also low, ranging from 0.40 to 0.56 meq/l, 0.18 to 0.29 meq/l, 0.83 to 0.91 meq/l, and 145.94 to 168.56%,respectively. Hence, ANOVA for water quality showed that there was a highly significant difference between TDS (493.2**), Na (0.006**), SAR (0.003**), $CO^{2-}{}_3$ (0.003**), $HCO^-{}_3$(0.003**), RSC (0.009**) and Cl^-(489.4**) across the locations, respectively. Although EC (0.006*) and Ca (0.075*) at (P <0.05) showed a significant difference in all five locations, pH and Mg did not show any significant difference across the five locations. However, the water in the study area is free from toxicity, and there is no danger of salinity. Therefore, it is suitable for irrigation and can be classified as good quality water.

Keywords: Water, Irrigation, Quality, Toxicity, North-East. Ph, SD, TDS.

Introduction

The ever-increasing human population, climate change resulting from increased greenhouse gas emissions, and farming activities exert severe pressure on land resources and water (Bezner et al., 2022). Meeting the present demand of the growing population for food is a significant challenge (FAO, 2015). Rising temperatures and changing weather patterns often result in lower crop yields due to water scarcity caused by drought, heat waves and flooding. The primary challenge in sustainably strengthening agriculture is meeting the food demands of a fast-growing human population (FAO. 2017). Therefore, irrigation is the solution to supplement the necessary water for plant growth during water scarcity and dry season farming. Irrigation refers to the artificial application of water to soil

(Georgios et al., 2020). Irrigation water is used to aid in growing crops, maintaining landscapes, and revegetating disturbed soils in dry areas and during periods of inadequate rainfall. It is also used to aid in growing crops, maintaining landscapes, and revegetating disturbed soils in dry areas and during periods of inadequate rainfall. Irrigation is the artificial application of water to land or soil. It is used to assist in growth agricultural crops, maintaining landscapes, and revegetating distressed soils in dry areas with inadequate rainfall. In the current challenge of improving plant growth and reducing costs, it is crucial to minimize water waste, reduce labour, and monitor overhead (Shikha et al. 2020).

Irrigation has other uses in crop production, such as protecting plants against frost and suppressing weed growth in grain fields (Snyder and Melo-Abreu, 2005). Therefore, The quality of irrigation water influences soil properties, nutrient contents, and availability for plant uptake and subsequent utilization (Suarez et al., 2011, Rasyid et al 2016). However, the various water sources used for irrigation in large volumes have a significant impact on soil properties and the plants being produced (Ilesanmi et al., 2019). The chemical contents of this water depend on its source, which may release certain nutrient elements in higher concentrations. This can be toxic to plants and can also cause health hazards for people consuming farm products (Yidana et al., 2011). The composition of the irrigated water, reduction, and dissolution of Fe oxides, as well as Fe^{2+} ions on exchange sites of the clay minerals, caused an increase in alkalinity and Mg concentration in arid vertisol soil, as reported by (Boivin et al. 2002). Efforts are being made globally to improve the effectiveness of water used in irrigated crop production (Ndegwa and Kiiru, 2011). The increased emissions of greenhouse gases, and farming activities are posing severe pressure on land resources and water, and hence facade a big challenge to produce adequate food to meet the current food demand of the increasing population caused by the ever-increasing human population and climate change. Water scarcity is considered the major constraint to sustainably strengthen farming and meet the food demands of a fast-growing human population.

The main issues with irrigation water are salinity, sodicity, and toxicity. In arid areas where rainfall is insufficient to remove salts from the soil, a buildup will occur in the crop's root zone. Thus, it is necessary to periodically monitor soils and waters to observe changes in salt content. Nevertheless, salinity and sodicity can limit soil productivity, resulting in reduced fertility. As the level of Na+ ions in the soil is high, the behavior of the colloidal fraction changes. The level of Na+ ions in the soil is quantified by Na% exchange or the sodium adsorption ratio (SAR). An increase in the sodium adsorption ratio leads to an increase in sodicity. The rate of the soil sodicity process also increases, as reported in the literature (Herrero and Covetta, 2005). This increase, caused by irrigation water, affects water infiltration for clay and loam (Suarez et al.). 2006). However, a significant increase in the infiltration rate for clay soil increases the sodium adsorption ratio from two to four. Whereas the increase in infiltration time was significant in loam soil. The careless use of saline water is associated with the deterioration of soil salinity, sodicity, ion toxicity, and groundwater pollution (Shahinasi and Kashuta, 2008). Considering these negative effects, it is crucial to examine how water quality affects the supervision of irrigated crops, particularly in arid and semi-arid regions. Infiltration problems occur when the sodium content in irrigation water is high enough to increase the exchangeable sodium in the soil exchange complex, leading to rapid soil dispersion (Hussain et al. 2014). This leads to soil particles covering the soil macro pores. with a high exchangeable Na % and low electrolyte concentration, clay, and organic matter. These particles begin to swell and disperse and are unavoidable after irrigation with low-quality water, causing drawbacks such as restricted aeration and permeability. Damage to physical properties appears at low salt concentrations, in clay, and in organic matter (Suarez et al., 2011). Therefore, this study aims to comprehensively evaluate the true nature of the irrigation water used in the study areas.

Materials and Methods

Location and Extent of the Study Area

The experimental site covers Geriyo latitude 9° 14'12" to 9° 26'30" N and longitude 12° 25'12" to 12° 18'33" E, Doubeli latitude 9.3° 14'24" to 9.3° 34'24" N and longitude 12.4° 23'33" to 12.4° 45'32" E, Bajabure latitude 9° 12'16" to 9° 32'18" N and longitude 12° 15'32" to 12° 25'54" E, Jabbore latitude 9.4° 8'42" to 9.4° 43'54"N and longitude 12° 6'51" to 12° 43'35" E, and Bwaranji latitudes 9.5° 7'36" to 9.5° 43'45" N and longitude 12.4° 15'17" to 12.4° 18'46" E in Yola, Adamawa State, Nigeria.

Sample collection and preparation

Five (5) water samples were collected in plastic bottles with screw caps that were thoroughly washed to avoid any contamination. The water samples were collected from ground (wash borehole) and surface water sources used by farmers in the study area. Groundwater was collected from Doubeli, Bajabure, and Jabbore, while surface water was collected from the lake and stream in Gerio and Bwaranji for water quality assessment. The samples obtained in the study areas underwent standard water quality tests for the following parameters: pH, EC, TDS, SAR, Ca, Mg, Na, CO^{2-}_3, HCO^-_3, RSC and Cl as described by Jaiswal (2003).

The data generated from laboratory analysis of collected samples were subjected to Analysis of Variance (ANOVA): Coefficient of variation (CV) and Least Significant Difference (LSD) were used to separate the means at the (P< 0.05) level of significance to test the relationship between and within soil properties using Statistical Analysis System (SAS version 9) statistical software for advanced analytics.

Chemical Properties of Irrigation Water in the Study Area

The results of the water samples collected from the five locations (Jabbore, Doubeli, Bajabure, Lake-Gerio, and Bwaranji) were presented in Table 1. The chemical properties indicated that the pH levels of the irrigation water ranged from 6.65 – 6.81 with a mean value of 6.80 which is slightly acidic, while the EC ranged from 0.11 – 0.26 dSm^{-1} with a mean value of 0.18 dSm^{-1}. Total Dissolved Solids (TDS), ranged from 70.4 – 108.5 ppm with a mean value of 106.8ppm while the calcium and magnesium contents of the irrigation water ranged from 2.89 - 3.31 cmol(+)kg^{-1} with a mean of 3.10 cmol(+)kg^{-1} and 1.29 – 1.5 cmol(+)kg^{-1} with a mean of 1.4cmol/kg, respectively. Sodium ranged from 0.587 – 0.712cmol(+)kg^{-1} with a mean value of 0.635 cmol/kg, while the Sodium Absorption Ratio SAR, ranged from 0.543 – 0.638cmol(+)kg^{-1} with a mean value of 0.598 cmol(+)kg^{-1}. Carbonate (CO^{2-}_3) ions ranged from 0.16 – 0.26meq/l with a mean value of 0.22meq/l. Bicarbonate (HCO^-_3) ions ranged from 0.79 – 0.89meq/l with a mean value of 0.84meq/l. Residual sodium carbonate (RSC), ranged from 0.407–0.533meq/. Chloride levels ranged from 145.20% to 191.40%, with a mean value of 168.52ppm.

From the result, the chemical analysis of the water sample indicated that the values obtained were within the recommended rates for good quality water for irrigation, according to Westcot (1985). Therefore, the water can be used for irrigation without any problems (Westcot, 1985 and WHO, 1984). The results also show that there is no danger of salinity since all the values are below the standard ranges of salinity; Electrical conductivity (< 0.7 dSm^{-1}), Total Dissolved Solids (< 450 mg/l), Carbonates (<1.5 meq/l), Bicarbonates (< 1.5 meq/l), Chloride (< 4 meq/l) and Sodium (< 3 meq/l). These findings also agree with those of Ayer (1997).

However, studies by Nata *et al.* In Debre Kidane watershed, Ethiopia, (2009) opined that water suitability for irrigation purposes indicated that the groundwater was suitable for irrigation with some minor exceptions. During the rainy season, 89% of the samples were in the 'good,' and 11% were 'permissible.' However, during the irrigation season, only 30% were classified as 'good,' and 70% were in the 'permissible,' according to the Irrigation Water Quality Index calculation.

Table 1: Chemical Properties of Irrigation Water in the Study Areas

Location	pH 1:2	EC (dS m^{-1})	TDS (ppm)	Ca^{2+}	Mg^{2+}	Na^{+}	SAR	CO_3^{2-} (meq/l)	HCO_3^{-} (meq/l)	RSC (meq/l)	Cl^{-} (%)
				Cmol(+)kg^{-1}							
JABBORE	6.81	0.11	70.40	2.89	1.29	0.59	0.54	0.16	0.79	0.41	191.40
DOUBELI	6.75	0.22	140.80	3.21	1.46	0.65	0.64	0.26	0.89	0.51	145.20
BAJABURE	7.12	0.17	105.60	3.05	1.38	0.62	0.59	0.21	0.84	0.45	168.30
LAKE GERIYO|	6.65	0.17	105.60	3.05	1.38	0.61	0.59	0.21	0.84	0.45	168.30
BWARANJI	6.66	0.26	108.50	3.31	1.50	0.71	0.63	0.25	0.85	0.53	169.40
Min	6.65	0.11	70.40	2.89	1.29	0.59	0.54	0.16	0.79	0.41	145.20
Max	7.12	0.26	140.80	3.31	1.50	0.71	0.64	0.26	0.89	0.53	191.40
MEAN	6.80	0.18	106.20	3.10	1.40	0.64	0.60	0.22	0.84	0.47	168.52

Key: pH = Log of hydrogen ion concentration, EC = Electrical conductivity, TDS = Total dissolved solids, Ca = Calcium, Mg = Magnesium, Na = Sodium, SAR = Sodium absorption ratio, CO_3 = Carbonate, HCO^-_3= Bicarbonate, RSC = Residual sodium carbonate, Cl = Chloride.

Chemical properties of the water in the study area

The results of the water's chemical properties, in Table 2, indicate that there is a significant difference in pH at Bajabure, while in the other locations it is not significantly different. EC is significantly different in Jabbore and Bwaranji, while TDS is significantly different in Doubeli, with no significant difference in the other four locations. Ca, Mg, and Na are significantly different in Bwaranji, but not statistically different in the other locations. SAR, CO^{2-}_3, HCO^-, RSC and Cl^- were significantly different among the five locations.

Table 2: Mean water chemical properties of the study area.

	Ph	EC	TDS	Ca	Mg	Na	SAR	CO^{2-}_3	HCO^-_3	RSC	Cl-
Location		(dSm-1)	(ppm)	(cmol(+)kg^{-1})				(meq/l)	(meq/l)	(meq/l)	(%)
BJ	7.28^{a}	0.21^{ab}	105.20^{b}	3.11^{bc}	1.38^{b}	0.62^{b}	0.62^{b}	0.23^{c}	0.85^{b}	0.44^{c}	168.12^{b}
DB	6.60^{b}	0.21^{ab}	140.65^{a}	3.24^{ab}	1.44^{ab}	0.66^{b}	0.67^{a}	0.29^{a}	0.91^{a}	0.55^{a}	145.94^{c}
GY	6.76^{ab}	0.19^{bc}	104.40^{b}	2.99^{c}	1.43^{ab}	0.61^{b}	0.63^{b}	0.23^{c}	0.83^{bc}	0.46^{b}	168.53^{b}
JB	6.91^{ab}	0.13^{c}	105.35^{b}	2.95^{c}	1.30^{b}	0.61^{b}	0.57^{c}	0.18^{d}	0.80^{c}	0.40^{b}	190.18^{a}
BR	6.45^{b}	0.28^{a}	107.60^{b}	3.42^{a}	1.60^{a}	0.73^{a}	0.64^{ab}	0.27^{b}	0.86^{ab}	0.56^{a}	168.14^{b}
MEAN	6.80	0.20	112.64	3.14	1.43	0.65	0.63	0.24	0.85	0.48	168.18
LSD	0.67	0.08	9.47	0.24	0.19	0.06	0.04	0.01	0.04	0.08	3.47

Key: Means with the same letters are not significantly different at ($P< 0.05$).
LSD = Least Significant Difference. LOC. * DEPTH = Location and Depth.

Conclusion

Based on laboratory analysis, the water samples tested were slightly acidic to neutral and non-saline, as determined by the EC and TDS values. There is no risk of salinity since all values were below the standard ranges for salinity: Electrical conductivity (< 0.7 dSm^{-1}), Total Dissolved Solids (< 450 mg/l), Carbonates (<1.5 meq/l), Bicarbonates (< 1.5 meq/l), Chloride (< 4 meq/l), and Sodium (< 3 meq/l). However, there was an appreciable trace of Na^+ ions in some locations, Gerio and Jabbore, as indicated by the sodium content and SAR values. Therefore, it can be concluded that the water quality in the studied area is suitable for irrigation purposes with proper soil management practices that reduce sodium accumulation.

Recommendation

Water quality should be studied in the area prior to irrigation.

There should be proper soil management to avoid excess sodium accumulation.

Conflict of interest

Authors declare no conflicts of interest.

References

Al-Zubi, Y., (2007). Effect of Irrigation Water on Agricultural Soil in Jordan Valley. Journal of!

Ayers, R.S., (1997). Quality of Water for Irrigation.*Journal of The Irrigation and Drainage* Div., ASCE.Vol 103, No. IR2, P.140.

Boivin, A., Cherrier, R., Schiavon, M. (2005). A Comparison of Five Pesticides Adsorption and Desorption Processes in Thirteen Contrasting Field Soils. George E. Brown, Jr. Geoderma, USDA-ARS, 450 West Big Springs Road, Riverside, CA 92507-4617, USA,

Herrero, J. And Coveta, O. P. (2005). Soil Salinity Changes Over 24 Years in A Mediterranean Irrigated District. Geoderma,125:287-308.

Hussain, M.H., Mohammed, J.S.A, Nadhit, A And Sven K., (2014).Evaluation And Mapping Groundwater Suitability For Irrigation Using GIS. Najaf Governorate, Iraq. Journal of Environmental Hydrology.22:1 -7.

-Nata, T. K., Bheemalingeswara And Asmelash B. (2009). Groundwater Suitability for Irrigation: A Case Study from Debre Kidane Watershed, Eastern Tigray, Ethiopia. (MEJS) Volume 1(1):36-58 Mekelle University, Mekelle, Ethiopia,

Ndegwa George M. And Kiiru Isaac M. (2011). Investigations on Soil and Water Quality as Affected by Irrigation in Turkana District, Kenya.

Shahimasi,E And Kashuta, V. (2008). Irrigation Water Quality and Its Effects Upon Soil.Tirana Agricultural University, Tirana, Albania. BALWOIS 2008-Ohrid, Republic of Macedonia.

Snyder, R. L.; Melo-Abreu, J. P. (2005)."Frost Protection: Fundamentals, Practice, And Economics" (PDF).Volume 1.Food And Agriculture Organization of The United Nations.ISSN 1684-8241.

Suarez, D.L., Wood, J.D., Lesch, S.M., (2006). Effect of SAR on Water Infiltration Under A Sequential Rain-Irrigation Management System.Agricultural Water Management 86 (1-2), 150-164.

Suarez, D.L., Letey, J., Hoffman, J.W., Grattan, S.R., Crown, D.L. (2011). Evaluation of Soil Salinity Leaching Requirements Guidelines.Agricultural Water Management. 98(4), 502-506.

WHO., (1984). International Standards of Drinking Water. World Health Organization, Geneva

Westcot, D.W., (1985). Water Quality for Agriculture.FAO Irrigation and Drainage. 29. Rome. 13-56, 1985.

Yidana, M. S., P. A. Sakyi And G. Stamp, (2011) "Analysis of The Suitability of Surface Water for Irrigation Purposes: The Southwest and Coastal River Systems in Ghana," *Journal of Water Resources and Protection*, Vol. 3, No. 1, Pp. 695-710. Http://Dx.Doi.Org/10.4236/Jwarp.2011.310080.

Bezner Kerr, R., T. Hasegawa, R. Lasco, I. Bhatt, D. Deryng, A. Farrell, H. Gurney-Smith, H. Ju, S. Lluch-Cota, F. Meza, G. Nelson, H. Neufeldt, And P. Thornton, (2022): Chapter 5: Food, Fibre, And Other Ecosystem Products. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to The Sixth Assessment Report of The Intergovernmental Panel on Climate Change

Food and Agriculture Organization of The United Nations Rome, (2017).

Georgios Nikolaou, Damianos Neocleous, Anastasis Christou, Evangelini Kitta And Nikolaos Katsoulas (2020). Implementing Sustainable Irrigation in Water-Scarce Regions Under the Impact of Climate Change. Agronomy Vpl. 10. Pp. 120 - 153

Shikha Jain, Naina Bhatt, Riya Barthwal, And Bheru Lal Kumhar (2020). Irrigation Management in Various Crops to Improve Productivity.

M Rasyid, N. Shahidan, M.O Omar, N. Hazwani, C. Choo (2016). Design and Development of Irrigation System for Planting Part. 2 Nd Integrated Design Project Conference (IDPC) Pp 1 -22.

Ilesanmi Afolabi Daniyan, Lanre Daniyan, Khumbulani Mpofu, Ramatsese Boitumelu (2019). Development and Performance Evaluation of Automated Irrigation System. 2 Nd Integrated Design Project Conference (IDPC) Pp 1 – 33.