Journal of Agriculture and Environment Vol. 15 No. 2, 2019: 195-203
ISSN: 1595-465X (Print) 2695-236X (Online)

EVALUATION OF WATER QUALITY OF TUBE WELLS IN SOKOTO-RIMA FLOODPLAINS FOR IRRIGATED RICE PRODUCTION

E.A. Manasseh[1,3], S.S. Noma[1], M. Audu[1], J. Alhassan[2], A. Danlami[3], A.M. Shema[4] and J.D. Daniel[1]

[1]Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto
[2]Crop Science Department, Usmanu Danfodiyo University, Sokoto
[3]National Agricultural Seeds Council, Km 29, Kwali-Lokoja High Way, Sheda, Abuja/ National Agricultural Seeds Council, North-West Region, Samaru, Zaria
[4]National Cereals Research Institute, Baddegi, Nigeria

ABSTRACT

Evaluation of water quality of tube-wells for irrigation purpose in Sokoto-Rima floodplains along Rima river in Kwalkwalawa village was conducted. Water samples were collected from 10 randomly selected tube-wells. Irrigation water quality were assessed in the laboratory based on most important water quality parameters according to FAO and some selected important trace elements. All tube-wells evaluated in the area were observed to be 2 inches in size. The results of the laboratory analysis for the Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Sodium Adsorption Ratio (SAR) of all the water samples were low, except the values of SAR of tube-wells at point C and E, whose values exceeds >13, thus, may pose a threat to irrigation. The pH of the tube-well water ranges from 6.33 to 7.45, indicating slightly acidic to slightly alkaline. The values of Carbonates, Bicarbonates, Mg, Ca, Na, Nitrates, Sulphates and Chlorides were all below the critical limits and are considered safe for irrigation. Also, the value of all micro-nutrients such as Boron, Fe, Zn, Mn and Ni were all considered safe. In conclusion, caution must be taken for the extreme values of Na and SAR in the irrigation water, which may cause threat to both the soil and crops in near future, when used continuously. Periodic evaluation of both the soil and irrigation water should be encouraged and appropriate management practices such as planting of crops that are highly tolerant to Na, deep tillage, periodic application of gypsum and incorporation of organic matter and crop residues after harvest should be encouraged.

Keywords: Irrigation; Water Quality; and Rice.

INTRODUCTION

Rice has become one of the leading food staples in Nigeria over the few decades, surpassing maize and even cassava both in cultivation, consumption and water utilization.

Water quality plays a crucial role in successful production of any crop, most especially rice that is a profligate user of water. It uses 3000-5000 Litres of water to produce 1Kg of paddy, which is about 2 to 3 times more than the quantity required to produce 1Kg of other cereals such as maize or wheat (Cantrell, 2002). Nigeria is present and future food security and sustainability depends largely on irrigated rice production, which to a very large extend is in the hands of small holder farmers using all forms of water for irrigation, thorough water analysis and evaluation is important for any successful irrigated rice production. Therefore, knowledge of irrigation water quality is critical to understanding what management changes are necessary for long term and sustainable rice production.

Conceptually, water quality refers to the characteristics of the water supply that will influence its suitability for a specific use i.e how well the quality meets the needs of the users and is defined by certain physical, chemical and biological characteristics (FAO, 1985). In 1985, Food and Agricultural Organization of the United Nation (FAO) produced guidelines for evaluation of water quality for irrigation. The key parameters include pH, electrical conductivity (EC), sodium content (Na) measured in (SAR) and bicarbonate (HCO_3^-) with other related parameters.

Despite the quantity of available water on our planet earth, the fresh water in the lakes, creeks, streams and rivers amount to only about 0.01% (Mauribs-LaRiviere, 1989). This resulted to inadequate quantity and poor quality of water, which has serious impact on sustainable development. One-fifth of urban dwellers in developing countries and three quarters of rural dwelling population do not have access to reasonably safe water supplies (Lioynd, 1992). The alternative use of hand dugged tube-wells have been one of the sources of water for people in Nigeria for ages and records shows that some of these tube wells were dug close to river banks and some of these rivers are the main source of the contamination of groundwater and lake (Karbassi and Ayazi, 2007). Tube wells are constructed by fixing a pipe below ground surface and passing through different geological formations consisting of non-water bearing and water bearing strata. Perforated pipes or well screens are placed against aquifers based on sizes in diameter; tube well can either be (1.5, 2, 2.5, 3 and 4) inches respectively. The depth of the tube well varies depending on the area and water table depth and in its design, choice of proper well diameter is important because it significantly affect the cost of the structure and invariably the more diameter and deep, the higher the yielding capacity (Michael, 1999)

For a long time, it has been found that the quality of groundwater supersedes that of most known surface water bodies, because its quality is affected less by anthropogenic activities. Though shallow groundwater is more affected by contamination compared with deep groundwater (Kinzelbach, 2002), the extent to which groundwater pollution will occur is dependent upon a number of complex and interlocking factors among which are wet and dry regimes, and in agricultural land where tube-wells are cited, pesticides and fertilizer residues are possible contaminants found on land surface and could be transported through run-off into tube-wells that have improperly sealed cover (Kinzebach, 2002).

The objective of this research work was to ascertain the water quality and micro nutrients contents of some selected tube wells used for irrigation purpose in Sokoto-Rima floodplains in order to ascertain its safety and sustainability for irrigated rice production without adverse effect to both the crop and the soil.

MATERIALS AND METHODS

Description of the Location

The research was conducted at Kwalkwalawa village around the rice field along the flood plain of Sokoto Rima River. According to (Noma, 2005), the area is classified as Rima series, with total area coverage of 428 hectares. Soils of Rima series were classified as Aeric Endo-aquepts at sub-group level in the USDA Soil Taxanomy System (USDA, 2014), which correlated with Gleyic cambisols in the World Reference Base for Soil Resources (FAO, 2015). The soil of the study area is clay loam (27% sand, 39% silt and 34% clay).

The climate of Sokoto is hot, semi-arid tropical type classification. Rainfall, temperature, evapotranspiration and relative humidity are key climatic factors affecting agricultural production in this area. The rainfall is concentrated within mid-June to mid-September, which is usually high intensity, short duration, erratic and uneven in distribution, with annual rainfall ranges of 550-750mm (Ojanuga, 2006). Mean maximum temperature increases from January onward reaching a peak of 38-40^{0}C or more in April. Mean minimum temperature is lowest in December-January (The harmattan months) 17^{0}C. Mean minimum and maximum temperature are generally highest from March to May with values reaching 23 and 40.2^{0}C or even more (Kowal and Knabe, 1972), while the mean value of relative humidity for Sokoto in the month of August ranges from 65 to 74% and the lowest value are normally recorded in December to January which was around 32-44%

Water Quality Analysis and Sampling Techniques

Irrigation water quality was assessed in the laboratory by determining most important water quality parameters that included; pH, total dissolved solids (TDS), electrical conductivity (EC), sodium content measured in sodium adsorption ratio (SAR), bicarbonate and carbonate, calcium, magnesium, chloride, nitrates, sulphates, and trace elements such as, iron, zinc, manganese, nickel and boron.

Ten (10) randomly selected tube-wells were selected from the rice field in the Rima series, around the Sokoto Rima floodplain in the year 2018. The coordinate of each of the tube-well was taken using global positioning system (GPS), its elevation and the size of the tube well was recorded as shown in Table 1. From each of the tube wells, two litres of water were collected, using bottles thoroughly washed with distilled water. The tube well water was pumped out for at least 20 minutes before sampling, so as to ensure that the collected sample was a true representation of water from the aquifer.

The water samples collected were taken to the soil and water laboratory, Department of Soil Science, Faculty of Agriculture/Institute for Agricultural Research in Zaria for the laboratory analysis according to standard procedures.

Table 1: Description of each tube-well sample point in the field

S/No.	Sampled Point	Coordinate	Altitude (m)	Size (Inches)
1	A	N13^{0}05.948\` E005$^0$12.635\`	252	2
2	B	N13^{0}05.959\` E005$^0$12.669\`	243	2
3	C	N13^{0}05.976\` E005$^0$12.644\`	242	2
4	D	N13^{0}05.986\` E005$^0$12.633\`	243	2
5	E	N13^{0}06.036\` E005$^0$12.698\`	244	2
6	F	N13^{0}05.993\` E005$^0$12.580\`	246	2
7	G	N13^{0}04.249\` E005$^0$13.113\`	244	2
8	H	N13^{0}04.079\` E005$^0$13.822\`	241	2
9	I	N13^{0}05.970\` E005$^0$12.571\`	238	2
10	J	N13^{0}04.709\` E005$^0$13.028\`	239	2

Source: Field work, 2018.

Data Analysis

Data generated in terms of water quality parameters and micro-nutrients were analyzed using descriptive statistics in form of ranges and means.

RESULTS AND DISCUSSION

The properties of the tube-wells from which the water samples were collected are presented in Table 1. The sizes of the tube-wells orifice were two inches.

The Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Sodium Adsorption Ratio (SAR) of all the water samples from the tube-wells were low (Table 2), indicating no potential threat of salinity as their EC, TDS and SAR values fell below the critical levels of 0 to 3 dSm^{-1}, 0 to 2000mgl^{-1} and <13 for irrigation water (Shahinasi and Kashuta, 2008). Except the values of SAR of tube wells at point C and E, whose SAR values exceeds >13, thus can pose threat to irrigation. Though the higher value of Na in some tube-wells may also pose threat to the soils and crops around the area in near future, hence the need to monitor both the soil and irrigation water periodically to ascertain their safety and quality.

The pH of the tube well water ranges from 6.33 to 7.45, indicating slightly acidic to slightly alkaline condition, this are safe pH ranges for irrigation (Omar, 2012).

Carbonates and bicarbonate levels in the tube well water did not exceed the limit proposed by Landon (1991), hence this makes the water suitable for irrigation. Lower values of Mg, Ca and moderate value of Na were observed in all the tube wells (Table 2). When Na is high in irrigation water, it tends to be absorbed by clay particles, displacing Ca and Mg, there by leading to reduce soil permeability and poor internal drainage (Belkhiri *et al*., 2010).

Although nitrate, sulphate, chloride and boron are essential to plants in a very low concentration, they can be toxic to sensitive crops at high concentration (Bauder *et al*., 2011). Nitrate concentration was in the range of 0.003 to 0.008, sulphate and chloride were in the ranges of 2.38 to 2.68 and 0.93 to 1.41, respectively. These values were not up to the critical limits of 960 mgl^{-1}, proposed by Landon (1991).

For the micro-nutrients (Table 3), Boron value ranges from 0.17 to 0.38 mgl^{-1} were considered suitable when compared to the critical values of 2.0 mgl^{-1} proposed by Landon (1991). Boron value of as low as 0.6 mgl^{-1} concentration was considered extremely toxic by FAO (2007).

Considering Fe, Zn, Mn and Ni with ranges from 0.228 to 0.397, 0.215 to 0.357, 0.012 to 0.031 and 0.018 to 0.031, respectively (Table 3) were all below the critical values detrimental to irrigation accord to Enwezor *et al.*, (1989) and Esu (1991).

Table 2: Irrigation water quality indicators in some selected tube wells in Sokoto-Rima flood plain, showing mean and ranges

Point	pH	$C0_3^-$	$HC0_3^-$	Na^+	Ca^{2+}	Mg^{2+}	SAR	Cl^-	$N03^-$	$S0_4^{2-}$	Ec (dS/m)	TDS (mg/L)
		MgL^{-1}										
A	7.32	0.00	3.07	28.0	10.0	2.60	11.15	1.23	0.006	2.38	0.30	192
B	7.22	0.00	2.93	20.0	9.0	2.43	8.37	0.93	0.005	2.42	0.32	205
C	7.12	0.00	2.73	26.0	6.0	1.62	14.58	1.13	0.003	2.63	0.30	192
D	6.33	0.00	1.13	16.0	6.0	1.58	8.22	1.03	0.003	2.68	0.17	109
E	7.10	0.00	2.67	34.0	8.0	2.16	14.01	1.07	0.005	2.41	0.30	192
F	7.42	0.00	3.02	32.0	12.0	2.66	11.82	1.41	0.003	2.45	0.38	203
G	7.45	0.00	2.99	24.0	13.0	2.39	8.65	1.03	0.007	2.51	0.37	198
H	7.26	0.00	2.86	23.0	7.0	1.68	11.07	1.12	0.005	2.66	0.29	210
I	6.46	0.00	1.67	18.0	7.0	1.87	8.55	1.09	0.008	2.62	0.22	121
J	7.31	0.00	2.53	13.0	9.0	2.41	5.44	1.21	0.006	2.49	0.34	200
Mean	7.10	0.00	2.67	23.4	8.7	2.14	10.19	1.13	0.005	2.53	0.30	182.2

Source: Field work, 2018

Table 3: Some selected micro-nutrient values in the tube-wells, showing mean and ranges

	Micro-nutrients (mgL^{-1})				
Point	Fe	Zn	Mn	Ni	B
A	0.388	0.326	0.012	0.021	0.30
B	0.296	0.285	0.022	0.018	0.32
C	0.228	0.274	0.024	0.031	0.30
D	0.298	0.312	0.015	0.022	0.17
E	0.321	0.246	0.024	0.028	0.30
F	0.397	0.357	0.018	0.029	0.38
G	0.317	0.324	0.024	0.020	0.37
H	0.368	0.337	0.031	0.024	0.29
I	0.307	0.276	0.023	0.018	0.22
J	0.341	0.215	0.019	0.023	0.34
Mean	0.326	0.295	0.021	0.023	0.30

CONCLUSION

From the evaluation of the tube wells water for irrigation purposes in the study area, the study revealed no restriction in the use of the tube-wells for rice cultivation. All parameters analysed for quality evaluation of the water source in Rima Series were within the FAO acceptable ranges for irrigation purposes except for water at points C and E with higher values of Na and SAR. Therefore, periodic monitoring of soils and irrigation water around the C and E locations for sodicity status should be encouraged and in addition, appropriate management practices such as planting crops that are tolerant to Na, deep tillage, periodic application of gypsum and regular pH evaluation and incorporation of organic matter and crop residue should be encouraged.

REFERENCES

Bauder, T.A., Waskom, R.M., Sutherland, P.L. and Davis, J.G. (2011). Irrigation water quality criteria. Colarado State University Extension.7/03. Revised 5/11. Fact sheet No. 0.506. www.ext.colosttate.edu.

Belkhiri, L., Boudoukha, A. and Mouni, L. (2010). Ground water quality and its suitability for drinking and agricultural use in Ain Azel plain. *Algeria. Journal of Geography and Regional Planning*, 3 (6), 151-157. (*http:www.academicjournals.org/jgrp*)

Cantrell, R.P. (2002). Water wise rice production. In: Bouman B.A.M., Hengsdijk H., Hardy B., Bindraban P.S., Tuong T.P. and Ladha J.K. (Eds). *Proceedings of international workshop on water wise rice production*. IRRI Los Banos, Phillipines pp 356

Enwezor, W.O., Udo, E.J., Usoroh, N.J., Ayotade, K.A., Adepetu, J.A., Chude, V.O. and Udegbe,C.E. (1989). Fertilizer use and management practices for crops in Nigeria. Series No 2 Federal Ministry of Agric. Water Resources and Rural Development. Lagos. 163pp.

Esu, I.E. (1991). Detailed soil survey of NIHORT Farm at Bunkure, Kano State, Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. 72pp.

FAO (1985). Water quality for agriculture. FAO Irrigation and drainage paper No. 29, Rome 174pp.

FAO (2007). Pressurized Irrigation Techniques. Hand book No. 33. ftp://ftp.fao.org/docrep/fao010/a1336/a1336e07.pdf.

FAO (2015). World Reference Base for Soil Resources 2015. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps.

Karbassi, A.R. and Ayaz, G.O. (2007). Flocculation of Cu, Zn, Pb, Ni and Mn during mixing of Talar River water with Caspian seawater. *International Journal of Environmental Resources, 1: 66-73*.

Kinzelbach, W. (2002). Groundwater modeling: In distribution of groundwater quality with introduction with sample program in basic, Case study of Yazd-ARDAKAN PLAIN. *Elsevier Geostatistics, World Applied Science Journal, 5: 80-83.*

Kowal, J.M. and D.T. Knabe (1972). An Agroclimatological Atlas of the Northern States of Nigeria. Institute of Agricultural Research, Samaru, Zaria.

Landon, J.R. (1991). *Booker Tropical Soil Manual. A Handbook for Soil Survey in the Tropics and Subtropics*. Longman Scientific and Technical Essex, England. Routledge publishers. 185p.

Lioynd, H.B. (1992). Pour plate technique for bacteria of enumeration, http//biology.clu.edu/fankhauser/labs/ microbiology/meat-milk plate HTML. Accessed 25th December, 2013.

Mauritis-La Riviere, J.W. (1989). Threats to the world`s water. *Science America*, September, pp 80.

Micheal A.M. (1999). Irrigation theory and practice, pp. 801, PUBLISHED BY Vikas publishing house, P.V.E Ltd. 576, Masjid road, Jangpura, New Dalhi, India.

Noma, S.S. (2005). Properties, genesis and classification of soils of Sokoto-Rima floodplains at Sokoto, Nigeria. An unpublished Ph.D thesis, submitted to the Department of Soil Science and Agricultural Engineering, Usmanu Danfodiyo University, Sokoto.

Ojanuga, A.G. (2006). Agro-ecological Zones of Nigeria Manual. FAO/NSPFS, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria, 124pp.

Omar, G. (2012). Evaluation of water quality for irrigation farming in fadama lands: A case study of south-western Bauchi state, Nigeria. *Proceedings of the 46th annual conference of the Agricultural Society of Nigeria (ASN), Kano* 2012.pp 964-967.

Shahinasi, E. and Kashuta, V. (2008). Irrigation water quality and its effects upon soil. Retrieved 26/01/ 2015. From *eshahinasi@yahoo.com.*

USDA (2014). *Soil Survey Staff: Keys to Soil Taxonomy* (12th ed.). Washington DC; USDA Natural Resources Conservation Services.