International Journal of Research in Agriculture and Forestry
Volume 1, Issue 2, December 2014, PP 13-17
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Assessment of the Suitability of Water Quality for Irrigation in Minna, Niger State

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Abstract: *Irrigated agriculture is dependent on an adequate water supply of usable quality. Therefore, water samples were collected from Chanchaga River and Mechanic Village River in Minna, Niger State, Nigeria to evaluate their suitability for irrigation purpose. The analytical results shows that the Electrical conductivity (EWc), Total dissolve solids (TDS), Sodium adsorption ratio (SAR) and specific ion toxicities of water from Chanchaga River (ECw = 0.60 ds m^{-1}, TDS = 384 mg $L^{-1}$and SAR = 4.72) were of excellent quality and considered to be highly suitable without any restriction on the use. Water from Mechanic Village River (ECw = 1.02 ds m^{-1}, TDS = 653 mg $L^{-1}$and SAR = 7.09) will be highly suitable under proper management such as improved irrigation system and schedule, light soil with good infiltration and internal drainage and plant with good salt tolerant. The variation in chemical composition of the two irrigation water sources could be attributed to the fact that the Mechanic Village water source is located within Minna metropolis. The additions from waste waters (domestic sewage and municipal), dirt and suspended inorganic matter and automobile effluents from Mechanic workshops could contributes to the high levels of salinity, SAR and specific ion toxicities of the irrigation water.*

Keywords: *Electrical conductivity; Total dissolve solids; Sodium adsorption ratio; Specific ion toxicities; waste waters*

1. INTRODUCTION

Water is the most important input required for plant growth in agricultural production. Bulk weight of all living organisms consists of 80 to 90 % water [1]. Where the available soil moisture derived from rain is deficient, this lack can be made up by irrigation [2]. Conceptually, water quality refers to the characteristic of a water supply that will influence its suitability for a specific use, i.e, how well the quality meets the needs of the user. To evaluate the suitability of water supply for irrigation, information is required on its quality and quantity.

Irrigation water quality is a key environmental issue faced by agricultural sector as well as it is very important for every agricultural use, passing through such activities as irrigation to livestock watering, from safe household family drinkable water on farms. [3]. [4] reported that human activities that involved urbanization, agricultural activities, over use of fertilizers / chemicals, inadequate management of land use and sewage disposal have directly or indirectly affected the quality of water and making it unsuitable for irrigation. Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the soil due to excess sodium or calcium leaching, or by containing pathogens or contaminants which are directly toxic to plants or to those consuming them [5], [6]. Agricultural water sources may be of poor quality because of natural causes, contamination or both, and often requires improvement before it is acceptable for a given use [7], [8]. A major concern for water use for irrigation is decreased crop yields and land degradation as a result of excess salts being present in water and soils.

The soil problems most commonly encountered and used as a basis to evaluate water quality are those related to salinity hazard, water infiltration rates (sodium hazard), specific ion toxicities and a group of other miscellaneous problems. And of these, salinity and / or sodium hazard is the most prevalent problem associated with irrigation water.

Therefore, the objective of the present study was to evaluate the chemical status of the waters of the study area with respect to pH, Electrical Conductivity (ECw), Total Dissolve Solids (TDS), Sodium Adsorption Ratio (SAR) and specific ions such as Sodium (Na^+), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Potassium (K^+), Boron (B), Bicarbonate (HCO_3^-), Chloride (Cl^-) and Nitrate (NO_3^-) and hence to ascertain their suitability for irrigation purpose.

2. MATERIALS AND METHODS

The study area comprises two different locations. These locations were Mechanic village river in Keteren- Gwari ($9^0$36'N, $6^0$33'E) and Chanchaga ($9^0$41'N, $6^0$38'E) in Minna, Niger State, southern Guinea savanna of Nigeria. Irrigation water samples were taken from the fasted flowing part, the mid-way along the width of the river. About 2 liters (upper 50 cm) of water was collected in PVC bottles. Samples were brought to the Laboratory and analyzed immediately to prevent biological transformation.

Water samples were analyzed for pH using electrometric pH meter according to procedure described by [9]. Concentration of total dissolve solids, electrical conductivity, boron and chloride were determined using standard methods [10]. Calcium and magnesium ions were determined by Atomic Adsorption Spectrophotometer (AAS), sodium and potassium ions were determined by flame photometry. Phosphorus was determined by the Bray P 1 method [11] while nitrate and bicarbonate was determined by titration method.

3. RESULTS AND DISCUSSIONS

The analytical results of the quality parameters of the irrigation water samples of the studied location are given in Table 1, while Table 2 shows the recommended guidelines for the interpretation of water quality for irrigation. The present investigation of the water samples studied indicates that they are slightly alkaline in nature and their pH values were found to be within the standard limit of 6.5 – 8.5. Most water samples have a pH greater than 7.0 as acidic water (6.0) could cause corrosion of metal parts in irrigation equipment [2]. The electrical conductivity (ECw) is a measure of the total soluble salt concentration in water, and they were found to be 1.02 and 0.60 ds m^{-1} for Mechanic Village and Chanchaga River water samples respectively. Higher salinity results in higher ECw and as the salt level increases, the plant must expend more energy to take in nutrients dissolved in the water from fertilizer and the soil. A wide range of crops including vegetables, fruits, fodder and grain crops were reported to tolerate these levels (0 – 3.0 ds m^{-1}) of salinity water [2], [12]. Total dissolve solids (TDS) indicates the general nature of water quality. In the present investigation, the TDS values of the water samples were 653 mg L^{-1} for Mechanic Village water and 384 mg L^{-1} for Chanchaga water.

Although the guidelines (Table 2) indicates that the salinity (ECw) and TDS levels of water from Chanchaga river present no plant problem, their levels in Mechanic Village river are just in the zone of increasing problem. The relatively higher values of ECw and TDS of water samples Mechanic Village River as compared to Chanchaga River could be attributed to the discharge of waste waters (domestic sewage and municipal), dirt and suspended inorganic matter and automobile effluents from Mechanic workshops as a result of the location of the source of the water. [13] reported that high levels of TDS in irrigated water may be an indication of seepage of filthy surface waters into the ground water and soil beneath the ground surface as water percolate through them. Increase in dissolve solids in irrigation water affects soil efficiency and growth and yield of crops [12]. [2] had establish that when a water quality parameter is in the range of increasing problems, 75 – 300 mS m^{-1}, increasing care is required in the selection of plant species and proper management (improved irrigation system and proper irrigation schedule) are needed to minimize salt damage.

Sodium adsorption ratio (SAR) is a measure of tendency of the irrigation water to cause the replacement of calcium (Ca) ions and magnesium (Mg) ions attached to the soil minerals with sodium (Na) ions. SAR is used to estimate the sodicity or sodium hazard of irrigation water and higher SAR values will potentially cause damage to the soil structure [14]. The result of the analyzed water samples shows that the Chanchaga River water has low SAR value of 4.72 which presents no irrigation problem (Table 2) and will be highly suitable for irrigation of a wide range of crops. While Mechanic Village River water has higher SAR value of 7.09 and is in the range of increasing irrigation problem. Mechanic Village River has a medium sodium level indicating that the water is highly suitable when used in coarse – textured soils or organic soils with good permeability and the

use of good sodium tolerant crop species [15], [12]. Sodium hazard can be reduced under proper management especially in light soils with good infiltration and internal drainage with no impermeable layer.

Results of the specific ion toxicities (Table 1) revealed that their concentrations were higher in Mechanic Village River water compared to Chanchaga River water. However, the guidelines (Table 2) indicates that the concentrations of these ions (Na, Cl, HCO_3 and B) in Chanchaga water presents no plant problem, their concentrations in Mechanic Village are in the zone of increasing problem.

Although specific ion toxicities rarely occurs in irrigation water, in most cases they accumulate in the plants themselves and when the plants are consumed by human and livestock, possible health hazards can developed [4]. Toxicity problem may be created by excess Cl, Na, B, HCO_3, NO_3 and an abnormal pH. [7], [6] observed that different crops vary in their tolerance for toxic elements and the actual toxic concentration of the elements vary from crop to crop. These authors concluded that most tree crops and woody ornamentals are sensitive to specific ion toxicities especially Na, Cl, B and HCO_3. Most annual crops are tolerant. It was observed that in both locations with their various levels of specific ion concentrations, a wide range of crops including vegetables, fruits, fodders and grain crops can be grown.

Many management options are available to reduce the effects of specific ion toxicities. Na ions can be avoided by adding Ca and or Mg to the water to reduce SAR. Foliage uptake will be a problem with most fruit crops, so it is vital that they should not be irrigated with over head sprinklers but the use of trickle (drip) irrigation would avoid toxicity problems with many crops.

Table 1. *Maximum parameter values registered in irrigation water samples.*

Potential Irrigation problem	**Symbols**	**Units**	**Locations** **Mechanic Village**	**Chanchaga**
Alkalinity/Acidity		pH	7.42	7.23
Electrical conductivity	ECw	ds m^{-1}	1.02	0.60
Total Dissolve Solid	TDS	mg L^{-1}	653	384
Sodium Adsorption Ratio	SAR		7.09	4.72
Sodium	Na	meq L^{-1}	18.10	10.81
Magnesium	Mg	meq L^{-1}	5.01	6.21
Calcium	Ca	meq L^{-1}	8.00	4.30
Potassium	K	meq L^{-1}	0.52	0.67
Phosphorus	P	mg L^{-1}	3.30	3.61
Bicarbonate	HCO_3	meq L^{-1}	4.61	1.42
Chloride	Cl^-	meq L^{-1}	4.02	2.33
Nitrate	NO_3^-	mg L^{-1}	17.70	4.81
Boron	Bo	mg L^{-1}	0.98	0.56

Table 2. *Guidelines for interpretation of water quality for irrigation*

	Degree of Problem		
Irrigation Problems	**No Problem**	**Increasing Problem**	**Severe Problem**
Salinity (affects crop water availability)			
ECw (ds m^{-1})	□ 0.7	0.7 – 3.0	□ 3.0
TDS (mg L^{-1})	□ 450	450 - 2000	□ 2000
Permeability (affects infiltration rate into soil)			
ECw	□ 0.5	0.5 – 0.2	□ 0.2
adj.SAR	□ 6.0	6.0 – 9.0	□ 9.0
Specific ion toxicity (affects sensitive crops)			
Sodium (adj.SAR) (meq L^{-1})	□ 3.0	3.0 – 9.0	□ 9.0
Chloride (meq L^{-1})	□ 4.0	4.0 – 10.0	□ 10.0
Boron (mg L^{-1})	□ 0.7	0.7 – 3.0	□ 3.0
Miscellaneous (affects susceptible crops)			
NO_3-N (mg L^{-1})	□ 5.0	5.0 – 30	□ 30
HCO_3 (meq L^{-1})	□ 1.5	1.5 – 8.5	□ 8.5
pH		Normal range 6.5 – 8.5	

4. CONCLUSION

Based on the guidelines for the interpretation of water quality for irrigation, the results of analysis and assessments of water quality from Rivers of Chanchaga and Mechanic Village in Minna, Niger State revealed that they are suitable for irrigation purposes. However, water from Chanchaga River is of excellent quality and considered to be highly suitable without any restriction on the use. Water from Mechanic Village River will be highly suitable under proper management such as improved irrigation system and schedule, soil with good infiltration and internal drainage and plant with good salt tolerant. Water quality 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 yield under irrigation.

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