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EVALUATION OF CHEMICAL PROPERTIES OF THE IRRIGATION WATER AND SOIL AT GWARI RIVER IN KADUNA

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KEYWORDS:
Salinity, Soil Analysis, Irrigation, Water Analysis.

Abstract

The knowledge of the chemical composition of irrigation water and soil is very crucial for the sustainability of irrigation project and practice. This research aimed at the evaluation of chemical properties of the irrigation water and soil in the study site, in order to ascertain its quality and suitability for agricultural production. The irrigation water used by Masaba Village (Mando) Kaduna and the irrigation soil were collected and evaluated to assess the quality of water and the soil used for irrigation. The electrical conductivity, sodium adsorption ration, boron, magnesium, calcium, potassium, sodium chaloride, nitrate sulphate and bicarbonate measurements were carried out, using volumetric and calorimetric methods, on all the samples collected. Comparing the results of the analysis with that of the standard limits (acceptable level), it was discovered that the electrical conductivity was very low, indicating no likelihood of the development of salinity and sodicity problem. The sodium adsorption ratio tested for both the water and soil samples were found to be within the standard limits (acceptable level), indicating that the soil and water are safe for irrigation purposes. The pH values in both water and soil samples favour good condition for crops. Furthermore, it was concluded from the results of the tests that the water can be used for irrigation on almost all soils with little danger of developing harmful exchangeable sodium.

Introduction

Of any one of these links can bring hardship or even disaster to an irrigation enterprise (Mohamed and Tessema, 2013).

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Sources of irrigation water may be river, dam, lakes, and open well or tube well. Whatever, may be the source, some soluble salts always dissolved in it. However, the nature and quantity of dissolved salts depends upon the sources of water and its course before used. Soil is the natural material formed from a variable mixture of broken sand weathered materials and decay organic matter which cover the earth in a thin layer.

It supplies nutrients, when it contains the proper amount of air and water, mechanical support and partial sustenance for plant.

The nature and quality of soil depend on the original parent material and can be identifie by well defined physical, biological and chemical changes and also by the quality of water used for irrigation (White, 1989).

The development of irrigation is also likely to bring about changes in the existing natural ecosystem including the soil. The soil is the basic resource for agricultural production (Brandy and Weil, 1999).

The main soluble constituents in water are calcium, magnesium, sodium and some times, potassium as cation and chloride, sulphate, bicarbonate and sometimes carbonate as anions.

However, ions of some other elements such as lithium, silicon, bromine, iodine, copper, nickel, fluorine, boron, molybdenum, lead, phosphate and organic matter are present in minor quantities.

The soluble salts that occur in soils consist mainly of ions, such as sodium (Na^{+}), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^{+}), Chloride (Cl), Sulphate (So_4^{2}), Bicarbonate (Hco_3), Carbonate (Co_3^{2}), borate (Bo_3^{2}) and nitrate (No_3^{-}).

The original sources of these salts are the exposed rocks and minerals of the earth's crust. As a result of this decomposition and physical weathering, the soluble constituents are gradually released (Reeve and Fireman, 1984).

The excess of these elements in either soil or irrigation water is harmful for plant growth and even the animals life, when taken through drinking water, feed or forage.

In most irrigation filed, the main problem encountered is the high concentration of salts in the soils and irrigation water. However, the problems that result from using poor quality irrigation water are:

Salinity

Salinity problem related to water quality occurs if the total quality of salts in the irrigation water is high enough for the salts to accumulate in the crop root zone to

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the extent that yield are affected. If excessive qualities of soluble salts accumulate in the root zone, the crops has difficulty in extracting enough water from the salty soil solution.
This reduces water up take by plant usually results in slow or reduces growth.

Sodicity (Permeability)
Permeability is define as the readiness with which a soil transmit fluids.
However, permeability of soil decreases with the increase of the dispensability of exchangeable sodium percentage of the soil.
A permeability problem related to water and soil quality occurs when the rate of water infiltrate into and through the soil is reduced by the effect of specific salts in the water to such an extent that the crop is not adequately supplied with water and the yield is reduced. It generally causes destruction of soil structure, resulting in decrease of water infiltration and hydraulic conductivity.

Toxicity
A toxicity problem occurs when certain constituents in the water and soil are taken up by the crops and they accumulate in amounts that result in reduced yield. This is usually related to one or more specific ions in the water or soil namely boron, chloride and sodium (Othman, 2006).
Industrial wastes are the most harmful and hazardous source of water pollution, which affect the quality of water and possibly the relevant soil.
The waste from these sources may include toxic and unaesthetic matter. Furthermore, other factors such as irrigation method and management practices, soil, climate and nature of crops grown are equally important in determining irrigation water suitability (Audu, 2002).
The knowledge of the quality of irrigation water and soil are important in assessing its suitability for irrigation.
Irrespective of the nature of the source of irrigation water, soluble salts are always present which affect the physical properties of the soil and ultimately. The crop growth.
For crop production under irrigation, there is a relationship between the quality of the soil and water for the continuity of the irrigation. Therefore, water and soil quality analysis is required to appraise the efficiency of the irrigation practice within the 'fadama' around Mando Kaduna (Masaba village).

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OBJECTIVE OF THE STUDY

- To determine the level of cation and anion concentration of the irrigation site.
- To determine the level of Sanity, Sodicity, and toxicity of the irrigation water and the irrigation soil.
- To promote good irrigation farming that will enhance crop production in the study area.

MATERIALS AND METHODS

The material and method s used in the analysis of water and soil samples, are listed below:

Electrical conductivity meter, conductivity cup, atomic absorption spectrometer, flame photometer, conical flask, plastic bottle, pH meter, 2mm sieve, weighing balance, auger and mortar with rubber head covered pestle soil samples were extracted using ammonium acetate.

The methods used in these analyses were volumetric and colorimetric determination.

THE STUDY AREA

The study area is Masaba village, Mando Kaduna, which is located at Nnamdi Azikwe western by-pass close to National Eye centre. The study area lies between latitude 10^{0} $34^{0'}$ 28.92″ East and longitude 7^{0} 24^{1} 15.12″.It constitutes a fadama land area of about 26.85 hectares. It is located in the southern savannah belt of the northern Nigeria.

It had two (2) main seasons.

- A rainy season from May to October
- A dry season from November to April

The harmatten local laden winds blow from the sahara desert between November to January. This period is very dry and hot during the day time and cold in the night (David, 2002). The study area, that is Mando (Masaba site) Kaduna, which is part of igabi local Government Area of Kaduna state, is one of the major producers of the following crops; Sugar cane, maize, tomatoes, pepper, spinach etc in Kaduna metropolis by using river water as irrigation water source,

The major types of irrigation systems Practiced are:- Furrow, border, basin and to a limited extend sprinkler.

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COLLECTION OF WATER AND SOIL SAMPLES

Water and soil samples were each collected from six sampling point (stations) at random in the irrigation size, as detailed below:

WATER SAMPLE COLLECTION

The water sample was collected during the irrigation period of February to march. Water samples were taken from the source at various positions in the farm and immediately after the irrigation farm outlet.

Furthermore, two samples were collected from the main source of water, which is the river and the remaining four samples were collected at random in various positions (Station) in the farm.

Each water sample was collected in a plastic bottle and were labelled alphabetically from A-F.

Then the six (6) samples were transferred promptly to the laboratory for analysis.

SOIL SAMPLES COLLECTION

Soil samples were taken at various positions or stations in the farm.

However, six (6) soil samples were collected, once at each station. Soil samples were labelled alphabetically from A to F.

LABORATORY ANLYSIS OF THE IRRIGATION WATER SAMPLES.

The water samples were analyzed for their chemical constituents.

All samples were tested for the salinity and Sodicity concentration for irrigation purpose. The following elements have been tested; the pH, electric conductivity (EC), boron (B), the cations (based) such as calcium (ca), magresium (mg), sodium (Na), potassium (k) and the anions (Acid) such as chloride (d), sulphate (So_4), Nitrate (No_3) and bicarbonate (Hco_3)

BICARBONATE

The amount of bicarbonate present in a given solution can easily be determined by titrating with a standard solution of a strong acind

It was determined by titrating 30ml of each sample with 0.025ml of sulphuric acid of which methyl orange was used as an indicator

Electrical conductivity (EC)

The electrical conductivity of the samples were determined using wheat stone

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bridge (Conductivity meter). The instrument was warmed for 30 minutes, and the conductivity cup was washed to avoid any contamination and then filled with the sample. The resistance conductances of the sample were determine by reading on by graduated knob.

Calcium and Magnesium

The concentration of each of these elements in the water sample was determined using the atomic absorption spector-photometer method. The instrument was warmed for 30 minutes and distilled water was aspired into the instrument to flush any leftover material. The lamp for the element was inserted and the wave length set and lit up. The sample was then aspirated in to the instrument and the reading was taken (mg/l)

Calculation: (mg/l) = $\frac{\text{ppm graph x VE x DF x x100}}{\text{1000 x w x eqwt of element}}$ - - - I

Where:

VE = initial volume of the sale

DF = dilution factor

W = weight of the sample

Sodium and potassium

These were determined using flame photometers, the were length of each of the element was set and the instrument was and allowed to warm up for 30 minutes. The sample was then aspirated into flame and the reading was referred to a graph to get the actual concentration of the element in the sample. The same formular for Ca and mg was used for the calculation.

Chloride

Silver Nitrate method was used to determine the chloride concentration in the samples. 10ml of the sample was taken into conical flask and water was added to make 50ml, 2ml of 0.lm k_2crO_2 (molar potassium chromate) was added and mixed. The mixture was then titrated against 0.1 No_3 (nitrate) till the end point was reached.

Cl (mg/l) = $\frac{\text{meg x 35.5 x } 10^3}{\text{Sample of liquit (ml)}}$ - - - - - - II

Nitrate (No_3)

The kjeldal method was used for testing Nitrate concentration. 10ml of the sample

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was taken at the distillation sert 2-3g of Devada alloy was added into the flask and distilled off into a conical flask containing Boric acid which trap the Nitrate. This collected up the volume of 3,5-50ml and titrated against 0.01 H_2S0_4

Sulphate

10ml of the sample and 5ml of $S0_4$ppm were taken and extracted out in – to 50ml vaits and shacked very well to be mixed. 1ml of gelatine was added and shacked very well and make-up to work. The mixture was allowed to settle for one (1) hour for the colour to develop. The spectronic 20 was warned for 30 minutes and the wavelength set to 420mm (nanometer)

Boron Determination

For the boron concentration in the samples, the Azomethine H method was used. Some amount of the sample were taken into a beaker and hydrolyzed. This was then heated on a hot plate up to 10ml. it was then left into a vail and allowed to stay for one (1) hour before taken the reading.

pH Determination

The pH of a solution can be obtained directly by using a pH meter. These electronic instruments, has an electrode consisting of an extremely thin walled glass bulb filled with dilute hydrochloric acid into which a silver wire coated with silver chloride is connected to the electrode lead. The pH sample were Measured using a pH meter. The meter was first calibrated using buffers of pH 4 and 7, after which the pH of the sample were obtained by dipping it's electrode into solution and reading directly from a counter.

Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio was determined by the following equation using the values obtained for Ca^{2+} and Mg^{2+} in mg/l

$$SAR = \frac{Na}{\sqrt{\frac{Ca + mg}{2}}} \quad - - - - - - \text{III}$$

Where:

Na^{+} = concentration of sodium in mg/l

Ca^{++} = calcium concentration in mg/l

M^{++} = magnesium concentration in mg/l

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Exchangeable Sodium Percentage (ESP)

The exchangeable sodium percentage was determined by this equation

$$ESP = \frac{Na \times 100}{Ca + mg} \quad - - - - - - - - IV$$

(Michael, 1999)

Laboratory analysis of the Irrigated soil samples

Soil samples were air – dried ground and sieved through a 2mm sieve. Soil particles of less than 2mm fraction were used to determine the chemical properties. Exchangeable base (Ca, Mg, K, Na) were extracted using ammonium Acetate in NH_4 at pH7 and Ca and Mg were read on the atomic adsorption spector photometer while Na and K were determined by flame emission photometry.

Cation Exchange Capacity (CEC)was determined by the 1m of ammonium acetate (pH7) (Van Reeuwijk, 1993). From the CEC and exchangeable bases saturation, exchangeable sodium percentage (ESP).

Sodium adsorption ratio and adjusted SAR were calculated according to this expressions;

$$ESP = \frac{Na \times 100}{Ca + mg} \quad - - - - - - - - V$$

$$SAR = \frac{Na}{\sqrt{\frac{Ca + mg}{2}}} \quad - - - - - - - - VI$$

Soil PH was determined in water and 0. 01m $cacl_2$ solution, at a 1:2:5 soil to liquid ratio by weight.

The electrical conductivity [E C] was determined on 1:1 soil saturation extract using a conductivity meter.

Carbonate and bicarbonate were determined by the rapid acid neutralization method. (Donatiua *et al,* 1990).

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TABLES 1: GUIDELINE FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

Potential problems irrigation			**Degree of restriction on use**		
		Units	None	Slightly moderate	Severe
Salinity [affect crop water availability] ECW		ds/m	<0.7	0.7-3.0	> 3.0
Infiltration [affect infiltration rate of water in to the soil. Evaluation using ECW and SAR together]					
0.3 **3-6** **6- 12** **12-20** **20-40**		Ds/m	>0.7 >12 >19 >2.9 >5.0	0.7-0.2 1.2-0.3 1.9- 0.5 2.9-1.3 5.0-2.9	<0.2 <0.3 <0.5 <1.3 <2.9
Specific ion toxicity	(Affects				
Sensitive crops) **Sodium[Na] SAR** **Sprinkler irrigation** **Chloride [Cl]** **Surface irrigation** **Sprinkler** **Boron [B]**		Me/1 Me/1 Mg/1	<3 <3 <4 <3 <0.7	3-9 >3 4-10 >3 0.7-3.0	 >9 >10 >3.0
Miscellaneous effects susceptible crops]	[affect				
Nitrogen [No_3- N] **Bicarbonate [HCo_3] Cover head sprinkling pH**	only	Mg/1 Me/1	<5 <1.5	5-30 1.5-8.5 Normal range 6.5-8.4	>30 >8.5

(Ayers and Westcot, 1985)

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TABLE 2 ACCEPTABLE LIMITS FOR IRRIGATION WATER

Water	ECmm hos/cm	ESP (%)	pH
Saline	> 4	< 15	< 8.5
Alkaline	< 4	> 15	> 8.5
Saline/Alkaline	> 4	> 15	

(Christianasen *et al*, 1977)

RESULTS AND DISCUSSION

The result of the chemical analysis of water and soil samples collected from six sampling points each of the study site are, given in table 3 and table 4 respectively.

TABLE 3: AVERAGE VALUES OF CHEMICAL COMPOSITION OF IRRIGATION WATER AT THE SITE

Sample	ds/ m	Cations (mg/I)				Anions (mg/I)						%	
Site Stations	P H	EC	Ca 2+	M g2 +	N a +	K+	So2-4	Cl-	NO-3	Hc 0-3	Co -3	B	SAR	ESP
AW	7.40	0.01	16.45	2.05	1.20	2. 50	0. 36	0. 90	0.0035	2. 40	0. 00	2. 12	0.4	6.5
B W	7.30	0.095	19.08	4.98	0.91	1. 70	0. 42	3. 45	0.00053	1. 80	0. 00	2. 33	0.3	1.0
CW	7.60	1.10	11.20	4.20	1.40	0. 20	0. 36	0. 85	0.00035	2. 00	0. 00	2. 24	0.5	9.1
DW	7.50	0.25	18.42	4.48	0.61	2. 00	0. 48	0. 85	0.00035	1. 80	0. 00	2. 41	0.2	2.7
EW	7.30	0.20	15.79	4.20	1.10	1. 00	0. 97	0. 80	0.00053	1. 40	0. 00	2. 54	0.4	5.5
FW	7.60	0.24	13.20	5.14	1.30	2. 20	0. 85	0. 85	0.00053	1. 40	0. 00	2. 54	0.4	7.1
Average Values	7.45	0.32	15.69	4.18	1.09	1. 60	0. 57	1. 28	0.002	1. 80	0. 00	2. 36	0.4	5.3

TABLE 4: AVERAGE VALUES OF CHEMCAL COMPOSITION OF IRRIGATION SOIL AT THE SITE

Sample	ds /m	Cations (mg/l)				Anions (mg/l)						%	
Site Station	pH	EC	Ca2+	Mg^{2+}	Na+	K^{+}	$So_4$2-	Cl^{-}	No3-	Hco-3	Co^{-}3	B	SAR	ESP
A_s	6. 80	0.041	1. 70	1. 24	0. 19	0. 15	0.402	0. 75	0.0056	0. 60	0.931	0.931	0.2	6.5
B_s	4. 80	0.025	6. 10	2. 80	0. 31	0. 13	0.492	0. 50	0.0084	0. 80	0.085	0.085	0.2	3.5

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C_s	5. 00	0.040	5. 30	2. 04	0. 25	0, 12	0.850	0. 45	0.0084	0. 60	1.27	1.27	0.1	3.4
D_s	5. 20	0.080	4. 20	1. 78	0. 30	0. 16	0.581	0. 45	0.0056	0. 80	1.52	1.52	0.2	5.0
E_s	6. 00	0.10	3. 50	1. 91	0. 17	0. 93	1.12	0. 45	0.0056	0. 60	0.508	0.508	0.1	3.0
F_s	6. 30	1.20	1. 40	1. 10	0. 31	0. 42	1.32	0. 60	0.112	0. 80	0.34	0.34	0.3	12. 4
Average Values	5. 65	0.25	3.7	1. 81	0. 26	0. 32	0.79	0. 53	0.007	0.7	0.78	0.78	0. 2	5.6

DISCUSSION OF THE RESULTS

The result of the chemical analysis of irrigation water and soil are shown in table 3 and table 4 above. Which clearly shown that the irrigation water and the soil are of good quality and suitable for irrigation farming purposes.

Electrical conductivity (E C)

The electrical conductivity value of the water and soil were less than the critical limit of 4 ds/m necessary to classify the water or soil as saline.

The water sample has 0.01 ds/m as the lowest value and 1.10 ds/m as the highest value with a mean of 0.32 ds/m.

The soil sample has 0.025 ds/m as the lowest value and 1.20 ds/m as the highest value.

According to the guide line for interpretations of water quality for irrigation in table 1, the irrigation water studied was classified as none in degree of restriction on use.

pH

The pH value of both water and soil are within the acceptable limit which will not have any adverse effects to the crops and also favour good growing condition for the crops.

The water pH ranges from 7.30 to 7.60 with the mean of 7.45 it is within the acceptable limit recommended in the guideline.

The soil pH value ranges from 4.80 to 6.30 with a mean of 5.65.

The values are a little bit lower than the recommended ones in the guideline.

Exchangeable Sodium percentage (ESP)

Exchangeable sodium percentage values in the water and soil samples were normal within the recommended limit, shown in table 2.

Water sample have the value that ranges from 1.0%to 9.1% with a mean of 5.3% and also soil sample have the values that range from 3.0% to 12.4% with a mean of 5.6%.

Test of calcium and magnesium shows a concentration of each of these elements in both water and soil which gave a (S A R) lying between 0.20 and 0.50 for water and 0.12 and 0.22 for soil respectively.

Bicarbonate and carbonate contents of the soil ranged from low to moderate. However, boron content of the irrigation water and the soil are also low, making the sample boron excellent.

This statement shows that the quality of the irrigation water and the irrigation soil of Masaba village (Mando) area Kaduna metropolis with respect to soluble salts is high in quality for irrigation purposes.

Conclusion

Based on the results obtained from the laboratory analysis, the study showed that the irrigation water and soil of the studied site was found to be of good quality with respect to universally acceptable limit.

Thus, safe for irrigation without any probable salinity and alkalinity problem development.

Furthermore, the result clearly revealed that the water and the soil are considered suitable for irrigation.

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