Analysis of soil properties on irrigated lands along Farin Ruwa, Mada and Antau Rivers in Northern Nasarawa State, Nigeria.

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Received January, Accepted March, and published March, 2019

Abstract

The quality of water used for irrigation if not properly managed, may result in the build-up of ionic substances at levels to reduce the productive capacity of soils and yields of many crops. This study therefore analysed soil properties on irrigated lands along Rivers Farin Ruwa, Mada and Antau in Northern Nasarawa State, Nigeria. Data for this study involved collection of 60 water samples and 24 soil samples from both dry and rainy seasons respectively. Both the water and soil samples were analysed for the concentrations of the physico-chemical properties affecting irrigation such as pH, sodium, potassium, calcium magnesium, phosphates, nitrates, chloride, nitrogen%, soil texture, carbonate and bicarbonate, trace elements such as boron, lead, iron and salinity caused by soluble salts. Indices such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Exchangeable Sodium Percent (ESP) were employed in determining sodium hazards of the irrigation water on soils of the study area. Results from the study showed a mean high value of electrical conductivity on soils along Farin Ruwa River ranging from 202-490uS/cm for the seasons. The Sodium Adsorption Ratio recorded for the rivers was between 0.27-0.45 and was within the 0-3 considered suitable with no problem for irrigation. Residual Sodium Carbonate (RSC) was between -29.8-17.0 due to the high values of calcium and magnesium recorded for this study. Though pH was generally alkaline for the water, it was acidic (4.92-6.12) for the soils. Exchangeable sodium percent was low for the soils ranging between 2.4 to 5.1%. The concentration of iron in the soils was from1.7 mg/kg to 2.2 mg/kg. Phosphate was from 2.0 mg/kg to 3.9 mg/kg while nitrate was between 0.05 mg/kg and 0.09 mg/kg. The results of soils from irrigated lands along the rivers covered by this study were generally low for most of the properties except for pH which was acidic for all the soils along the irrigated fields and the high salinity observed for soils along River Farin Ruwa. The study therefore recommends that there is the need to raise the pH of the soils by increasing the application of organic matter and fertilizers and increasing the frequency of irrigation water on soils along Farin Ruwa River to leach the high salts concentration observed for the soils.

Keywords: *Soil properties, irrigated lands, sodicity permeability, osmotic pressure, irrigation and build-up*

Introduction

Soil is a component of the ecosystem and the interface on which the atmosphere, biosphere and the lithosphere blend to provide a conducive medium for plants developmental processes. The soil is one of the most important natural resources without which human survival on planet earth could have been difficult. Most human activities therefore revolve around the soil providing the necessities required for human survival. Unfortunately, over 65 percent of the soils on the earth have been subjected to degradation from human activities (FAO, 1984).

In environments faced with discrepancy in climate it is only through irrigation that the water requirement of crops can be assured. Irrigation therefore involves the artificial application of water with good economic return and with no damage to land and soil, to supplement the natural resources of water and meet the water requirement of crops (Majumdar, 2004). The application of water high in ionic substances during irrigation may introduce into the soil solutes at levels to affect the quality of the soil and reduce its potentials for irrigation. The weathering of primary minerals from rocks and the subsequent release into water receiving sources may lead to accumulation of minerals at intensities likely to be injurious to human health and low productive capacity of soils (Samaila, *et.al,* 2011).

The use of environmental resources such as forests, water and soils requires proper utilization so as to offer opportunity for future generations who incidentally also have their survival tied to these resources (Wright, 2007). The potential of soils to produce crops as observed by Gururuthy *et.al* (2009) is largely determined by the environment they provide for root growth. The quality of the soil therefore, is very essential if it is to perform its function in a sustainable manner. Though soils have the ability to restore their life support processes if given enough time to regenerate, human activities however are likely to interfere and render the soils unproductive.

Though the irrigation use of water has the advantage of potential treatment mechanisms in soils, however, the amount and kinds of impurities present in particular water should be determined as necessary guide for the use of the water for irrigation. Water when used directly for irrigation can increase the quantities of solutes thereby raising the concentration of certain ions in the soil and eventually lowering the quality of the water for irrigation (Ayers and Westcots, 1994). Though irrigation may offer a viable option for management of otherwise poor quality water, studies have shown that excessive concentration of ionic elements in water may lead to the build-up of salts in the soil colloids at levels to be detrimental to crops developmental processes (Majumdar, 2004, Samaila, *et.al.* 2011 & Fawaz, *et.al,* 2013).

High amounts of soluble salts reduce the ability of plants to absorb water through their root hair membranes, at very high concentration water actually starts to move out of plant roots into the soil leading to the death of plants, it also results to plasmolysis, stunting and defoliation. Wright, (2007) estimated 1.5 million hectares of agricultural land lost yearly to salinization and waterlogging worldwide. The use of water with high salinity will require soils which must be permeable, drainage must be adequate, water must be applied in excess to provide considerable leaching and crops that can withstand high salinity should be selected.

When irrigation water does not have the proper proportions of sodium, calcium and magnesium, significant problems with water infiltration and breakdown of soil structure can develop (Tanko, 1994). This is because sodium when present in the soil in exchangeable form, replaces calcium and magnesium adsorbed in the soil colloids and causes dispersion of soil particles. The dispersion results in breakdown of soil aggregates, the soil becomes hard and compact when dry and reduces infiltration of water and air into the soil thus affecting its structure. This impedes internal drainage leading to reduced soil permeability and consequently renders the soil impervious to water.

The concentration of trace metals may appear minute in water but constitute some of the most hazardous substances that can bio-accumulate (Zwieg *et.al,* 1999) and given that trace metals are not biodegradable and have a density of at least five times that of water. One serious threat of their persistence in aquatic environment is their biological amplification in the food chain, which causes ecological damage and health problems to humans.

Materials and Methods

The study covered three rivers which cascade the undulating terrains of Northern Nasarawa State with large exposure of basement complex rocks forming the geology overlain by these rivers. The rivers include Farin Ruwa, Mada and Antau. A total of 60 water samples and 24 soil samples were taken for both the dry and rainy seasons. About ten water samples were taken from each of the three rivers per season. Four soil samples were also taken from each irrigated land covered by this study, totaling 12 for the three irrigated fields along the rivers per season. At each sampling point a Garmin etrex GPS (Global Positioning System) was used to geo-reference the position at which the samples were taken as shown in tables 1 and 2..

Table1: Sampling points of water on the Rivers Antau, Mada and Farin Ruwa

River Farin Ruwa	River Mada	River Antau
Lat. 09^{0} 03.56'N Long. 08^{0} 43.86'E	Lat. 08^{0} 55.46'N Long. 08^{0} 15.89'E	Lat. 08^{0} 49.13'N Long.07^{0} 53.16'E
Lat. 09^{0} 03.58'N Long. 08^{0} 43.90'E	Lat. 08^{0} 55.43'N Long. 08^{0} 15. 92'E	Lat. 08^{0} 49.20'N Long. 07^{0} 53.26'E
Lat. 09^{0} 03.32'N Long. 08^{0} 43.92'E	Lat. 08^{0} 55.41'N Long. 08^{0} 15. 96'E	Lat. 08^{0} 48.50'N Long. 07^{0} 53.29'E
Lat. 09^{0} 03.60'N Long. 08^{0} 43.95'E	Lat. 08^{0} 55.40'N Long. 08^{0} 15. 99'E	Lat. 08^{0} 48.41'N Long. 07^{0} 53.26'E
Lat. 09^{0} 03.60'N Long. 08^{0} 43.97'E	Lat. 08^{0} 55.40'N Long. 08^{0} 15. 99'E	Lat. 08^{0} 48.32'N Long. 07^{0} 53.21'E
Lat. 09^{0} 03.59'N Long. 08^{0} 43.99'E	Lat. 08^{0} 55.41'N Long. 08^{0} 16.00'E	Lat. 08^{0} 48.19'N Long. 07^{0} 53.22'E
Lat. 09^{0} 03.60'N Long. 08^{0} 44.01'E	Lat. 08^{0} 55.33'N Long. 08^{0} 16.04'E	Lat.08^{0} 48.06'N Long. 07^{0} 53.22'E
Lat. 09^{0} 03.59'N Long. 08^{0} 44.02'E	Lat. 08^{0} 55.32'N Long. 08^{0} 16.08'E	Lat. 08^{0} 48.00'N Long. 07^{0} 53.25'E
Lat. 09^{0} 03.58'N Long. 08^{0} 44.04'E	Lat. 08^{0} 55.32'N Long. 08^{0} 16.10'E	Lat. 08^{0} 47.45'N Long. 07^{0} 53.29'E
Lat. 09^{0} 03.58'N Long. 08^{0} 44.07'E	Lat. 08^{0} 55.31'N Long. 08^{0} 16.12'E	Lat. 08^{0} 47.26'N Long.07^{0} 53.21'E

Table 2: Sampling points for soils on irrigated fields in Mangar, Riri and Keffi

Mangar (Farin Ruwa)	Riri (River Mada)	Keffi (River Antau)
Lat.09^{0} 0 3.55'N Long.08^{0} 43.87'E	Lat.08^{0} 55.45'N Long.08^{0}15.88'E	Lat.08^{0} 51.36'N Long.07^{0} 53.16'E
Lat.09^{0} 03.59'N Long.08^{0} 43.94'E	Lat.08^{0} 55.40'N Long.08^{0} 15.95'E	Lat.08^{0} 51.13'N Long.07^{0} 53.18'E
Lat.09^{0} 03.59'N Long.08^{0} 43.98'E	Lat.08^{0} 55.31'N Long.08^{0}16.10'E	Lat.08^{0} 50.90'N Long.07^{0} 53.44'E
Lat.09^{0} 03.60'N Long.08^{0} 44.04'E	Lat.08^{0} 55.31'N Long.08^{0} 16.13' E	Lat.08^{0} 50.88'N Long.07^{0}53.43'E

Both water and soil samples were subjected to laboratory analyses to establish the concentrations of the physico-chemical properties of water affecting irrigation. These included water pH, sodium, potassium, calcium and magnesium, phosphates, nitrates, chloride, carbonate and bicarbonate, trace elements such as boron, lead, iron and salinity caused by soluble salts. Indices such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Exchangeable Sodium Percent (ESP) were employed in determining sodium hazards of the irrigation water on soils of the study area. Soil properties analysed included salinity, texture, pH, nitrogen percent, Calcium, Magnesium, Sodium, Nitrates, Chlorides, Phosphates and trace elements such as, Lead, Boron, and Iron.

Results and Discussion

The results in table 3 give the mean concentrations of chemical properties of soils on irrigated lands along the rivers. The mean pH values varied for the soils for the seasons on irrigated lands along River Antau recording 6.06 and 6.23, River Mada 6.12 and 5.97 while along Farin Ruwa River it was 4.87 and 4.92 for dry and raining seasons respectively. The pH values on irrigated soils along River Farin Ruwa were highly acidic and were likely to affect solubility of most elements in the soil. As observed by Brady, (1990) a pH 6.0 to 6.8 are ideal for most crops as it coincides with optimum solubility of the most important plant nutrients. Low pH observed for the soils could be attributed to erosion which leached basic cations and replacing them with hydroxyl ion. Luo, et.al (2004) observed similar pH range of 5.9 to 6.4 for Horotiu soils in China.

The highest concentration of electrical conductivity was on soils along Farin Ruwa River ranging between 170 uS/cm to 920 uS/cm and with means of 202uS/cm and 490 uS/cm for both dry and rainy seasons. The mean electrical conductivity for rainy season soils along River Antau was 77.5 uS/cm and 122.5 uS/cm in the dry season. The mean values for River Mada were low (52.5 and 75.0uS/cm) for both dry and raining seasons soils. The high concentration of electrical conductivity observed for soils along Farin Ruwa couldn’t have been as a result of the use of water for the area for irrigation as the electrical conductivity of water used in irrigation was generally low. Fawaz, *et.al* (2013) recorded a low range electrical conductivity of 13 to 124 uS/cm for rainy season soils and 37 to 105.7 uS/cm for dry season in Malaysia.

Table 3: Chemical properties of soils on irrigated fields of rivers for dry and raining seasons

Variables	Unit	**Dry season**			**Rainy season**		
		(Keffi) Antau	(Riri) Mada	(Mangar) Farin Ruwa	(Keffi) Antau	(Riri) Mada	(Mangar) Farin Ruwa
pH	-	6.06	6.12	4.87	6.23	5.97	4.92
ECe	uS/cm	77.5	52.5	202.5	122.5	75.0	490
Ca	me/kg	34.0	31.0	28.0	25.9	25.2	23.9
Na	me/kg	1.08	1.02	0.92	0.90	1.02	0.95
Mg	me/kg	6.5	3.5	4.52	2.98	2.75	5.48
K	me/kg	2.8	3.78	1.38	3.50	3.50	2.13
PO_3	ppm	3.3	3.9	3.0	4.12	3.01	3.19
NO_3	ppm	0.08	0.09	0.06	0.09	0.06	0.05
Cl	ppm	32.0	18.0	21.5	15.0	15.25	18.8
Pb	mg/kg	0.1	0.08	0.11	0.12	0.1	0.15
Fe	mg/kg	2.2	2.0	1.8	2.2	2.0	1.7
B	mg/kg	0.39	0.45	0.42	0.37	0.41	0.42
CEC	%	44.7	39.0	33.6	30.9	28.8	18.59
N	%	0.18	0.19	0.26	0.11	0.14	0.14

Calcium for soils along River Antau has the highest recording 34.0meq/kg in the rainy season and 25.9meq/kg for dry season. River Mada had mean values of 31.0meq/kg and 25.2meq/kg while along River Farin Ruwa it was 28.0meq/kg and 23.9meq/kg for dry and rainy seasons respectively. Calcium mean values were higher for the dry season soils which was likely due to high evaporation and the application of organic manure and chemical fertilizers during irrigation. The same trend was observed for calcium in water of the rivers as shown in table 2. Luo, *et.al* (2004) recorded 6.5 mg/kg for Horotiu soils on irrigated lands in China. The high calcium observed for both water and the soil implies that sodium ion will not accumulate to a level in the soil to impact negatively on internal drainage and affect plants growth.

The mean concentration of sodium for dry season soils on irrigated lands were 1.08meq/kg along River Antau, 1.02meq/kg for River Mada and 0.92 meq/kg along Farin Ruwa. The raining season mean values were 0.9meq/kg for River Antau, River Mada 1.02 meq/kg while Farin Ruwa was 0.95meq/kg. The mean values for the seasons varied slightly with higher concentration recorded for dry season soils, except for those on irrigated fields along Mada River which showed slight increase. Sodium is very soluble and a large amount in the clay fraction will affect the physical properties for plant growth (Fawaz *et.al,* 2013).

The mean values of magnesium were relatively higher to that of sodium for soils on irrigated fields along the rivers. The highest mean value of 6.5meq/kg was recorded for dry season soils of River Antau while River Mada and Farin Ruwa River had 3.5 and 4.52meq/kg respectively. The rainy season mean values dropped for River Antau (2.98meq/kg) and River Mada (2.75me/kg) while an increase (5.48me/kg) was observed for Farin Ruwa River. The decrease of calcium for rainy season soils was likely due to leaching from the soil, while the increase observed for Farin Ruwa for the same season could have been due to high organic matter and high use of chemical fertilizers on farmlands. Magnesium ion (table 2) was higher for water compared to the soils (table 1). The increase use of water for irrigation is likely to raise magnesium concentration in the soil. The presence of magnesium in appreciable concentration will help in improving the structure of the soil and counter sodicity likely to be caused by the accumulation of sodium ion.

The mean values of potassium for soils on irrigated lands along the rivers in the dry season were 2.8meq/kg for Antau, 3.78meq/kg for Mada while Farin Ruwa was 1.38me/kg. The rainy season mean values were Antau 3.50 meq/kg, Mada 3.50 meq/kg and Farin Ruwa 2.13 meq/kg. There was an increase in the rainy season concentrations for potassium in the soils except for the slight decrease for River Mada. The values of potassium observed for soils on irrigated fields along the rivers for the seasons were generally higher for mean values recorded of water. This implies that the application of water for irrigation in the area will not raise potassium at levels likely to impact on the internal drainage of the soil. Luo, *et.al* (2004) observed a very low range of potassium (0 to 0.17mg/kg) for Manawata soils in China.

The mean values of phosphate for dry season soils along the rivers were 3.3mg/kg for Antau, Mada was 3.9mg/kg and Farin Ruwa was 3.0mg/kg. The mean rainy season concentrations were 3.12mg/kg for Antau River, River Mada 3.01mg/kg while Farin Ruwa River recorded 3.19mg/kg. Except for the slight increase for Farin Ruwa River there was a drop in the concentration of phosphate for raining season soils on the irrigated fields which could be attributed to leaching and assimilation into growing plants during this period. The concentration of phosphate in water for the rivers (table 2) was generally low for all seasons when compared to the concentrations for the soils. Afshi, et.al (2007) recorded a relatively higher value of phosphate for soils of Shiraz sub-urban area of South West, Iran.

Nitrate had mean values for dry season soils of 0.08mg/kg for River Antau, River Mada 0.09mg/kg and Farin Ruwa River was 0.06mg/kg, while the rainy season mean values were 0.09mg/kg for Rivers Antau, Mada 0.06mg/kg and Farin Ruwa was 0.05mg/kg. The mean values for both seasons were generally low for the soils on the irrigated lands. The same low concentration of nitrate was observed for the water in rivers for the seasons. High values of nitrate was recorded for water in Makera drain, Kaduna was attributed to the effluents from federal superphosphate company which discharge wastewater to enrich the drain with this substance (Samaila and Gimba, 2007).

Mean chloride concentration in dry season soils was 32.0kg/kg for River Antau, River Mada 18.0mg/kg and Farin Ruwa River 21.5mg/kg. The rainy season means were Rivers Antau 15.0mg/kg, Mada 15.25mg/kg while Farin Ruwa had 18.8mg/kg. Chloride concentration observed for the soils on irrigated fields for the area was low when compared to over 300 mg/kg recorded for soils on irrigated lands in Makera, Kaduna Township (Samaila, 2011). Results of chloride was low both for the soils and water in the study area. Lead, was generally low for water of the rivers and as well for the soils on the irrigated fields. The concentrations for the dry season were 0.1 mg/kg for River Antau, River Mada 0.08 mg/kg and Farin Ruwa River 0.11 mg/kg. The rainy season values were River Antau 0.12mg/kg, River Mada 0.1mg/kg and Farin Ruwa River 0.15 mg/kg of soil. Ogundiran and Osibanjo, (2008) observed that the range of lead in the soils on abandoned auto battery dumpsites was as high as 1310-19600 mg/kg. The concentration of lead was lower in water when compared to the soils for this study. The low values observed for both the soil and water indicates that the present level of lead is within the limit considered safe and with no degree of problem on human health for irrigation (Ayers and Westcots, 1994).

Mean dry season iron values were 2.2 mg/kg for soils along River Antau, 2.0 mg/kg for River Mada and Farin Ruwa River 1.8 mg/kg. The rainy mean concentrations were River Antau 2.2 mg/kg, River Mada 2.0 mg/kg while Farin Ruwa River had 1.7 mg/kg. The mean concentration of iron for the soils in the seasons showed no variation though slightly higher than the concentration observed for water of the rivers. Okere and Kakalu, (2011) observed high concentration of iron 6.0 to 7.0mg/kg in the wet season and 7.6 to 8.5mg/kg for dry season soils from mining and agricultural areas respectively in Nasarawa state.

The mean concentration of Boron for rainy season soil was 0.39 mg/kg for River Antau, River Mada 0.45 mg/kg and Farin Ruwa River 0.42 mg/kg while dry season values were River Antau 0.37 mg/kg, River Mada 0.41 mg/kg and 0.42 mg/kg for Farin Ruwa River. The concentration of boron in the soil was low that even sensitive plants will not be affected by its presence. Afshin, *et.al* (2007) observed a high mean concentration of 5.5 mg/l of boron in soils of Shiraz, Iran which serious danger to growth of many crops. The mean cation exchange capacity of the soils in the dry season was 44.7% for River Antau, River Mada 39.0% and Farin Ruwa River 33.6%. The rainy season concentrations were 30.9% for River Antau, River Mada 28.8% while Farin Ruwa River had 18.6%. Cation exchange capacity dropped for raining season soils which was likely due to the leaching of the bases from the soils as a result of storm run-off during the season, assimilation into growing plants of the bases in the soil and clay type. Luo *et.al* (2004) observed very low cation exchange capacity (6.2 to 7.7) for soils in Manawata, China.

Nitrogen percent for the soils during the dry season was 0.18% for River Antau, River Mada 0.19% and Farin Ruwa River 0.26% while rainy season was for River Antau 0.11%, River Mada, 0.14% and Farin Ruwa River 0.14%. Nitrogen percent was generally low for the soils in both seasons. The low percentage of nitrogen observed for the soils was low like in many West African soils (Essiet, 1988). The low nitrogen observed for the area may be attributed to farming methods practiced in the area which, involved removal of crop residues for domestic purposes after harvest and the burning of whatever is left especially during land clearance to prepare the farm for the next planting season.

Evaluation of suitability of soils for irrigation

The evaluation of the suitability of soils for irrigation, took into consideration the properties of the soil that are likely to be injurious to plants developmental processes. Hence the study took into consideration properties such as salinity from excess salts, sodicity caused by imbalance in the proportion of sodium to calcium and magnesium ions, carbonates and bicarbonates, pH and specific ions toxicity of elements that are potential problems in the growth of plants.

Salinity

The electrical conductivity and total dissolved solids for the rivers in the dry season as shown in table 4 were generally low except for River Antau that recorded 280.9 uS/cm. All the values of electrical conductivity of water fall within the limit considered low without limitation to use by Ayers and Westcots, (1994). The electrical conductivity of the soils was low for Rivers Antau and Mada for the seasons. River Farin Ruwa however recorded a mean value of between 202 to 490uS/cm. Though the electrical conductivity of the water was low however, high concentrations were observed for the soils on irrigated lands along Farin Ruwa River. The high electrical conductivity observed for the soils on irrigated soils along Farin Ruwa indicated that it is likely to cause severe hardships in the ability of plants to extract water and nutrients from the soil and as result will affect the yields of crops.

The mean pH values for water for the rivers were slightly above neutral (alkaline) while the values observed of the soils on the irrigated fields were acidic. Though pH was generally high for the water, it was however low for the soils. This indicated that soils in the area have not been affected directly by the application of water for irrigation, while pH of water was alkaline, the soils on the irrigated lands were acidic. Low pH recorded for soils along Farin Ruwa River will affect availability of nutrients to plants and reduces the activities of microorganisms.

Sodium Hazard

Table 4: Carbonate, bicarbonate and cations for water in Rivers Antau, Mada and Farin Ruwa

Parameter	Unit	**Dry season**			**Rainy season**		
		Antau	Mada	Farin Ruwa	Antau	Mada	Farin Ruwa
EC.	uS/cm	280.9	58.5	58.1	59.7	44.5	64.9
TDS	mg/l	168.6	34.2	33.4	35.8	26.2	37.7
pH	-	7.13	7.27	7.29	7.50	7.42	7.23
Sodium	meq/l	1.83	1.32	1.02	0.99	1.83	0.95
Calcium	meq/l	22.6	11.4	18.3	20.3	22.6	14.3
Magnesium	meq/l	10.2	6.5	8.7	8.1	10.2	7.5
Potasium	meq/l	0.2	1.4	2.8	0.1	0.1	2.8
Carbonate	meq/l	00	00	00	00	00	00
Bicarbonate	meq/l	3.13	0.96	0.48	0.55	0.45	0.48
SAR	-	0.45	0.43	0.31	0.41	0.25	0.27
RSC	meq/l	-29.8	-17.0	-23.5	-21.9	-22.5	-22.2

The sodium adsorption ratio recorded for the rivers were low and within the 0-3 considered suitable with no problem when used for irrigation. This implies that the use of the water in the rivers for irrigation will not have marked influence with infiltration of water into the soil to cause permeability problem. The result of exchangeable sodium percent showed the soil to be low in (2.4 to 5.1%) Exchangeable Sodium Percent (ESP). This therefore showed that that soils have not witnessed sodium accumulation to impact negatively on soil productivity and plants developmental processes.

The values of Residual Sodium Carbonate were very low indicating that carbonate and bicarbonate concentration in the rivers have not reach chronic levels to impact on the soil as to precipitate calcium and magnesium ions and interfere with internal drainage of the soil. The textural classes of the soils on the irrigated lands as shown in table 5 were mostly sandy loams. This therefore implied that the soils will be able to store water and nutrients and reduce the exposure of the subsurface soil to erosion. The texture of the soils showed them to be better textured and therefore can allow the free flow of water and reduce the unnecessary accumulation of ions at levels to affect plants growth especially during irrigation. The relatively moderate Cation Exchange Capacity recorded for the rivers especially in the dry season indicates that the concentration of cations will satisfy the requirements of many crops. This therefore implies that soil fertility will be affected by the present state of cation exchange capacity observed for the soils.

Table 5: Mean particle size analysis of soils on irrigated fields along Rivers Antau, River Mada and River Farin Ruwa

	Dry season			**Rainy season**		
	Antau	Mada	Farin Ruwa	Antau	Mada	Farin Ruwa.
% Sand	72.6	75.0	73.4	83.3	67.5	70.9
% Silt	3.3	2.6	3.1	2.7	3.6	3.4
% Clay	25.1	22.4	23.5	15.0	29.2	25.7
Textural class	SL	SL	SL	SL	SC	SL

NB: SL- Sandy Loam while SC-Sandy Clay.

Specific ions toxicity on soils

Table 6: Trace elements and anions in water for Rivers Antau, Mada and Farin Ruwa.

Parameter	Unit	**Dry season**			**Rainy season**			
		Antau	Mada	Farin Ruwa	Antau	Mada	Farin Ruwa	
Iron		mg/l	2.68	1.25	1.00	2.51	1.98	1.22
Lead		mg/l	0.03	0.04	0.03	0.03	0.02	0.04
Boron		mg/l	0.52	0.49	0.32	0.43	0.33	0.23
Phosphate	mg/l	1.72	0.05	0.52	1.04	1.72	0.26	
Nitrates	mg/l	0.70	0.07	0.42	0.09	1.72	0.23	
Chloride	mg/l	25.9	16.00	25.6	20.9	18.1	16.4	

The concentration of iron in the soils of irrigated fields along the rivers ranged from1.7 mg/l to 2.2 mg/l. This showed that iron in soils on the irrigated lands was low and the use of water for irrigation will not result in iron toxicity in the soil. Lead was generally low for the water of the rivers and soils in the seasons. None of the values of lead was above 0.05 mg/l. Reed, (2004) recommended 5.0 mg/l of lead as permissible in irrigation water. The result has shown that lead accumulation has not resulted in the soil from irrigation in the area. Boron is an essential element required by many plants at small concentration for their growth. Food and Agricultural Organization (1985) recommended 0.7 mg/l as having no degree of restriction on use. The present level of concentration of Boron for the rivers in the season is below the 0.7 mg/l. Boron concentration in the soil was also very low just as in water (0.37 mg/kg to 0.45 mg/kg). This showed that Boron in the soil had not accumulated at levels to be injurious to plants.

Conclusion

The analyses of soils on the irrigated lands along the rivers covered by this study showed most of the properties were generally low for the soils in all the seasons. However, pH of the soils along Farin Ruwa River was acidic for both the seasons. The soils on irrigated lands along River Farin Ruwa for both seasons also indicated salinity built at levels likely to affect the osmotic pressure of crops and reduce crops yield in the area. Generally the soils on the irrigated lands were suitable for irrigation as most of the properties evaluated were low. The results of the properties of water have shown that most of the parameters covered by this study were within the threshold considered safe for irrigation as such will not accumulate in the soil to impact negatively on the productivity of the soils and growth of plants.

Recommendations

Based on the findings from this study the following recommendations were proffered

Since the soils are considered suitable for irrigation, farmers in the area should take advantage of the quality of the soil and engage in both dry and rainy season agriculture to boost food production in the area.

There is the need to increase the frequency of application of irrigation water to leach the excess salts observed of the soils along Farin Ruwa River.

The acidic soils observed on soils along Farin Ruwa River can be raised by the application of organic manure and chemical fertilizers.

The water in the rivers covered by this study is of good quality and therefore farmers in the area should have no fear in the use of the water for irrigation as this will not affect the soils and yields of crops.

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