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Evaluation of Soil and Water Quality of Small-Scale Irrigated Tomatoes Farm at Lake Toba, Taraba State North Eastern Nigeria.

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ABSTRACT
The soil and water quality of small-scale irrigated tomatoes farms at Lake Toba were investigated for a period of five months from November to march being the irrigation period. Representative samples of soil and water were taken in three locations i.e. phase 1,11 and Hyuku plots. Soil samples were taken at the depths of 0-10, 10-20, and 20-30 and were analyzed for percentage sand, silt, clay, texturalclass, and total nitrogen. The water samples collected were analyzed for total dissolved solid (TDs), electrical conductivity (EC) etc.Soil particle analysis was also carried out and the result indicates that sand content was found to decrease with depth, while silt and clay were found to increase with increase in depth and were significant at probability level of 0.05% level of significance. The texture of the soil was found to range from fine to medium with a total nitrogen content of 0.22%. The irrigation water quality was found to be acceptable for use, while the most probable number (MPN) value of 240/100m/along the phase 11 main canal had a high degree of contamination or pollution.

Key Words: Soil, Water, Irrigation, and Surface

I. INTRODUCTION

1.1 Background of the Study

To boost food production for the ever-increasing population of Nigeria today demands the stimulation of agricultural and water resources sector of the national economy. The realization of self-sufficiency in Nigeria Agricultural and Rural Development largely depend on the effective development of the inadequate agro technical man power and water resources.

Agriculture and water quality are linked because of agriculture's requirement for land and water, (Copper and Lappi, 1992; Agunwamba, 2000). Various derivative forces such as erosion (by wind and water), compaction due to heavy machine traction etc affect the soil quality. In semi-arid areas of theworld, rainfall is often inadequate in amount, thus necessitating irrigation in order to satisfy the moisture requirement of the crops, needed to meet the demand for food and fiber (FAO, 1986). According to Barrow (2005), out of 1 million hectares of irrigated land world-wide during the late 80s, at least 30-46 million hectares were in poor states due to Stalinization. (Ajai et al, 1990; Anikwe,2006; Abubakar, 2013) observed that in the most Arid part of Africa, the salinity problem has worsened in recent decades as the extent of land under irrigation has increased. According to them, some 80 million hectares suffers from salinity development often due to faulty irrigation. The rapid growth of irrigation in Nigeria and subsequent salinization in some projects (Ibrahim et al, 1995; All African, 1995) shows the need to give attentions to salt affected soils (Anikwe, 2006; Benstein 2006 and 2008). A number of soil properties are adversely affected due to salinity development. They include structural destruction leading to decrease in filtration, permeability as well as aeration, soil fertility depletions and reduction in overall productivity. These can make the agricultural land marginal. Saline soil varies in chemical, physical, and hydrological properties in addition to variability in water regime. Malgwi and Abdulkadir, (2020b).

Spatial and seasonal variability in salt content are not common. Soil salinity increases when the influx of salt is greater than the efflux. This is especially so in poorly drained clay soilunder irrigated agriculture.

Irrigation is practiced on large- and small-scale basis in Taraba State. The small-scale irrigation farms (1-hectare) mostly done on lands in close proximity to fairly large rivers and streams or domestic effluent waters are used to grow tomatoes species. Farmers practicing small scale irrigated farming often complain of decline in crop yield presumably due to deterioration in soil and water qualities, (Bernstein et al, 2003).It has been concluded that in LakeTobaefficient control and use of water is limited through technical and socio-economic constraints. Secondary salinization occurs in large- and small-scale irrigation schemes, which is as a result of the use of water containing dissolved salts. When this water is used, the water is taken up by plants and salt are left behind in the root zone causing deterioration of plant and soil productivity. Also, the qualities of Tomatoes produced by irrigationusing sewage effluent waters like lettuce that are eaten raw are questionable. They maybe responsible for water related diseases like cholera, dysentery, typhoid etc. This study is therefore intended to evaluate the soil and water quality status under small scale irrigated Tomatoes farms in Lake Toba. This will enable ameliorative measures to be taken in good time and also advice on the health hazard from microorganisms associated contaminated water used for irrigation.

This work was intended to investigate the causes of soil and water quality under irrigation in order to provide solution to the problems of the findings of the study. The studyalso attempts to provide answer for what is responsible for the decline in yield of tomatoes grown in the study area, and to suggest useful and sustainable strategies of the findings that may be related to the poor quality of soil and water(Rawat and Daverey, 2018). The findings of this work will also address the probable health risks posed by bacteriaassociated with contaminated water used for irrigated tomatoes.The work will also contribute to the overalldevelopment of knowledge in the areas of sustainable irrigation farming in Lake Toba.

II. MATERIALS AND MMETHODS

2.1 The Study Area

Lake Toba irrigation scheme is one of the projects under the Upper Benue River Basin Development Authority (UBRBDA). The place is located between Longitude 12^{o} 22^{1} and 12^{o} 28^{1}and latitude 9 ^{o} 16^{1} and 9^{o} 19^{1} North which is bounded to Northeastby River Benue which flows in a westerly direction. While to the South andsoutheast,boundary is Wukari,The west area was marked off by Hyuku forest reserve and the northwest hills formed the boundary. The work covers three selected irrigated tomatoes farms located in phase I, II and Hyuku irrigation plots in Wukari village.The area experiences dry and wet season with temperature and humidity varying with season. The wet season is between April and November. 70% of the rainfallin the area falls within 4 months (May-August). The area has an average of 62 rainy days while amount of annual rainfall recorded in the area is 972mm.Temperatures within the area vary with season. Although temperature is relatively high almost all year around, ranging from 27^{o}c to 40^{o}c. The major source of irrigation water is the River Benue

2.2 Soil Sampling and Analysis

The soil and water samples were sampled within a period of five mouths beginning from November to March being the period for irrigation in Lake Toba. The study site was arbitrarily demarcated into three sections based on the apparent similarity in physical features. The demarcated areaswere designated as TA, TB and TD. Random samples each at depths of 0-10, 10-20, 20-30cm of the soil were collected using auger. Each soil sample collected was also air dried grounded where necessary, screened through a 2mm sieve and parameters were then analyzed following the procedures, (Page, 1986 and HATCH, 1982). The particle size analysis was performed using the BOUYOUCOS hygrometer method by weighing 51 grams of air-dried soil samples, passed through 2mm sieve. 50ml of 50%sodium hexametaphosphate was added along with 100ml of distilled water mixer for 15 minutes with magnetic stirrer and transferred to one litre (1000m^{3}) cylinder were filled with distilled waterfirst and second hydrometer reading were recorded after 40 seconds and 2 hours. Temperatures were also taken after each of the two reading.Percentagessand,silt,and clay were calculated and the textural class determined on the USDA triangle.

2.3 Water Sampling and Analysis

A 1.5-literplastic water bottle container fitted with a plastic cover was used for each sample collection. Representative samples from the Lake,Pond and main canal were collected and taken to the laboratory for analysis.

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Table 2.1 Physical and Chemical Parametersof Water and their method of analysis.

Parameters	Method of analysis
TDS	Evaporation-drying
EC	EC meter
pH	pH meter
CA21	EDTA Titration
MG2	"
K	Flame photometer
N	"
CO3	Volumetric titration
HCO3	"
CI	LED Photometer
NO3	"
SO4	"
Boron	Indigo carmine
RSC	Calculated
SAR	Calculated

III. RESULTS AND DISCUSSIONS

3.1 Soil Textural Classification

The predominately-sandy texture in the surface is in conformity with observation of Graham et al, (1997), that the Savannah soils are sandy at least in the surface layer. Sand content decreases after a surface depth of 0-10cm and then there is a corresponding decrease with depth down the soil profile witha probability of 0.05% level of significance.Thiscould be attributed to sedimentation of soil by flooding and soil erosion from the catchment areas of Toba irrigation plots.The result obtained from particles size analysis using the Bouyoucos hydrometer method and the classification of soils in phase I,II and Hyuku irrigation plots of the three locationsare presented in table 3.1. Sand particles had mean values of 39.3% at the depth of 0-10cm, 10-20cm and 20-30cm respectively. The mean value ranged from 30-39.3% which is close to the range of 28-40% earlier reported by Graham et al, (1990) for soils of Lake Toba irrigation project and the mean value of 34.8% is dose to 32%earlier reported in UBRBDA, (1983). The greater percentage of sand particles recorded

The mean values of silt observed at each level of the soilprofile were 32.9%, 36.8% and 35.2% which indicates a slight increase in silt soil particles content down the soil profile in all the three locations of the soil. The silt soil particles range from 21.6-52.2% higher than the range of 27.5-33.5% earlier reported by Nwanka (2000). Increase in silt content could be as a result of deposition of silt materials by flood water, silt and clay particles are smaller and therefore can easily be transported and get deposited by flood water and excessive deposition of silt may lead to loss of farmland.

The clay soil content observed in the three locations range from 20.2%-61.2% while the mean values ranged of 30-41% as reported by Graham et al, (1997) for soils of Toba irrigation project. Ibrahim et al, (1995) also reported that clay content on the surface of some fadama soils in southeast Nigeria ranged between 25.9-47.9%. Clay soil particle was found to increasewith depth due to seasonal flooding and the increase was highly significant at probability of 0.05% level of significance.

The textural classification of phase I irrigation plot are clay loam, while that of phase II were clay at all the three depths but that of Hyuku plots changes in texture from loamy soil to sandy loam which means that the soil nutrient might be lost through leaching. Tomatoes growing on such soils would experience frequent moisture stress.The dominantly clay soil in phase II plots means that the soils would be poorly drained and poor permeability will lead to water logging and drainage problems.

Table 3.1: Particle-size Distribution, Texture, and Total N in Phase I, II and Hyuku plot of Toba Irrigation Project

		Particle-size Distribution (%)				
Location	**Depths (cm)**	**Sand**	**Silt**	**Clay**	**Texture**	**Total N (%)**
Phase 1	01-10	58.0	21.6	20.4	Sandy Clay Loam	0.21
Irrigation	10-20	54.0	25.8	20.2	Sandy Clay Loam	0.16
Plots	20-30	50.0	28.8	12.2	Sandy Clay Loam	0.11
Phase II	0-10	24.0	34.4	41.6	clay	0.22
Irrigation	10-20	18.0	40.4	41.6	clay	0.18
Plots	20-30	14.0	24.8	61.2	clay	0.10
Hyuku	0-10	36.0	42.8	21.2	loam	0.23
Irrigation	10-20	34.0	44.4	21.6	loam	0.14
Plots	20-30	26.0	52.2	21.8	clay	0.12
LSD (0.05) Depth		3.02**	15.08*	14.32**		0.8**

* = Significant at P=0.05 **= Highly Significant at P=0.01
ns = Not Significant
LSD = Least Significant Difference

3.2 Soil Quality in Terms of Salinity/Sodicity

The values of soil pH, EC and ESP, the indicator of salinity/sodicilty status, are given in table 3.2, the surface soil pH range from 5.66-7.66 (mean 6.7), this indicates a slightly alkaline PH which favors the growth of most vegetables especially that of lake Toba.

The EC values for surface soils ranged from 1.32-2.74 (mean 2.0) in site I and II.According to FAO (1976), soil with EC range of 0-2 dsm^{-1} are classified as field salt free soils and 4-6 dsm^{-1} as slightly saline restricting the yield of many crops. Most of the EC values fall within the range where no salinity problem is expected.

3.3 Irrigation Water Quality

The suitability of water for irrigation purpose is judged to be based on its total dissolved solids (TDS), electrical conductivity (EC), sodium adsorption ratio (SAR), and residual sodium carbonate (RSC). Besides this concentration, which some elements may accumulate, the photoxic levels are also considered. The data on this quality indicator for water from River Benue,main canal, and wastewater effluent given in table 3.3.

Table 3.3 shows the indicators of quality of irrigation water in the area. According to (U.S Salinity Laboratory Staff, 1984; Afolayan et al, 2012 and Chopra et al, 2010), the irrigation water can be placed in the following classes based onEC (dsm^{-1}) with corresponding TDS values (mg/l) as given by London (1991) which agree with the work of Malgwi et al., (2020).

C1-low salinity water: $\mathrm{Ec}, 0 - 0.25\ \mathrm{TDS} < 200$

C2 - Medium salinity water: $\mathrm{Ec}\ 0.25 - 0.75, \mathrm{TDS}\ 200 - 500$

C3 - Medium salinity water: $\mathrm{Ec}\ 0.75 - 2.2.25, \mathrm{TDS} > 500 - 1{,}500$

C4 - Very high salinity water: $\mathrm{Ec} > 2.25, \mathrm{TDS} > 1500$

Accordingly,the waters from various sources in the irrigation area with TDS (mean 192) <200, Ec (mean 0.2 dsm-1), SAR (mean 2.38) < 10, RSC. (mean 3.6) < 0 and PH about neutral table 3.3 can be placed into C1 S1 – low salinity, low sodium water category. They appear free from salinity/sodicity problems and safe for irrigation purposes.

3.4 Physical Properties of Water Sample

The suitability of water for irrigation purpose is judged on the basin of its content of total dissolved solids (TDS), electrical conductivity (EC), sodium adsorption ration (SAR) and residual sodium carbonate in soils to phototoxic levels, Graham et al, 1997). The data on this quality indicator for water from main canal, tertiary canal and the main drain are given in table 3.3.

The results of the examined canal water, ponding and effluent from waste water as sources of irrigation water were slightly coloured except that of the effluent from waste water and are odourless. The turbidity of water samples ranged from 5-15 NTU which is slightly outside the WHO acceptable limit for turbidity of 10 NTU, for ponded water and effluent from waste water of the canal are within acceptable limit. Temperature values are moderate. High temperature may not be desirable for samples as it encourages the growth of organism, which has the potential of altering the odour, taste and colour. The PH values ranged from 7.15 – 8.05 with an average of 7.04, which is within the WHO standard limit of 8.5. agrees with

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Ankidawa et al., (2018) and Malgwi and Abdulkadir, (2020a).

Table 3.2 Exchange Properties and Salinity/Sodicity indicators for Soils in Lake Toba Irrigation Project Exchangeable Based in Cmol (+) Kg-[1]

Location	Depth (cm	Ca	Mg	K	Na	Total Base	PH	EC	HCO3 (dsm1)	CO3	SAR
Phase 1	0-10	11.02	20.1	0.1	0.04	31.2	5.75	1.37	20	2.64	0.01
Irrigation	10.2	0.9	23.5	0.09	0	24.4	5.49	1.42	18	5.3	0
Plot soil	20-30	11.5	24	0.05	0.16	35.7	7.66	1.32	30	9.01	0.04
Phase II	0-10	10.8	28.2	0.62	0.16	39.8	6.72	1.35	38	9.42	0.04
Irrigation	10.2	10.5	28.3	3.5	1.2	43.5	6.69	1.36	37	12.8	0.27
Plot soil	20-30	9.5	25.1	1	3.21	38.8	6.82	2.74	30	9.43	0.77
Phase III	0-10	8.6	20.3	2.2	0.98	32	6.8	1.95	30	5.54	0.26
Irrigation	10.2	10.1	22.9	3.6	0.32	36.9	5.66	2.04	35	8.02	0.08
Plot soil	20-30	8.21	22	3.3	0.32	33.8	5.15	1.54	32	7.04	0.08
LSD (0.05)		8.70^{ns}	10.2^{ns}	1.80^{ns}	2.20^{ns}	2.20^{ns}	1.30^{ns}	11.65^{ns}	4.50^{ns}	4.50^{ns}	0.60^{ns}

* Significant at p = 0.05
^{ns}= Not Significant
LSD Least Significant Difference

Table 3.3 Indicators of the Quality of Irrigation Waters in Lake Toba Irrigation Project

Parameter	Location/Water Samples Phase I Plot WW1	Phase II Plot WW2	Hyuku Plot WW3	Mean	USDA Standard	Water Class	Remark
TDS (Mg/1)	82	296	198	192	5-1000	Good	Acceptable for use
EC (dsm-2)	0.13	0.34	0.15	0.21	0 - 0.25	Good	Low salinity Water
Ca (mg/1)	25	28.2	18.5	23.9			
Mg(mg/1)	18	20.4	13.8	17.4			
Na(mg/1)	6	5	0.34	3.78			
K(mg/1)	8	1	0.06	3.02			
CT	20	17	8	15			
HCO3	28	35	23.6	28.7			
SO2	72.4	75	64	70			
NO3	21	23	8	17.3			
CO3	12	10.5	4.83	8.83			
B	0.4	0.08	0.02	0.2	<0.7(>2)	Permissible for use	Satisfactory for most crops
SAR	1.29	1.01	0.08	2.38	<10-(>26)	Excellent	The water can be used No problem
RSC	-3.0	-3.1	-4.7	-3.6	<0	Low RSC	The water is safe for categories of soil
PH	5.56	8.09	6.68	6.78	6.5-8.5	Good	Less risk of Salinity

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IV. SUMMARY AND CONCLUSION

4.1 Summary of Major Finding

The soil textural classification in phase I, II and Hyuka irrigation plots at the depth of 0-1, 10-20 and 20-30cm were sandy clay loam in phase I and clay in phase II while the texture changes from loam to clay soil in Hyuka irrigation plots. The total nitrogen content in the soils of the three locations was determined to be 22%. The cation present in the soil were calcium, magnesium, sodium and potassium while the anions were chloride, bicarbonate, carbonate, sulphate, nitrate and other parameters which includes total exchangeable base, cation exchange capacity, Boron content, base saturation and sodium adsorption ratio. The soils pH, electrical conductively and exchangeable sodium percentage were all within the limit and standards of WHO.

4.2 Conclusion

From the soil textural classification in the three locations of irrigation plots, it could be concluded that the sandy clay loam texture of phase I at all the three depths means that the higher percentage of sand recorded are expected to present difficulties in their management. Their low moisture retention and high infiltration capacities will lead to losses of crop nutrient through leaching. The clay texture in phase II plots means there will be a drainage and permeability problems.

The water quality parameters determined in phase I, II and Hyuku irrigation waters are total dissolved solid, electrical conductivity PH. The cations are calcium, magnesium, sodium and potassium. The anions are chloride, bicarbonate, carbonate, sulphate, nitrate and boron. Others are sodium adsorption ratio and residual sodium carbonate. All the cautions fall within the acceptable limit of WHO standards (WHO, 1989).

Results obtained shows that water from canal andpound are alkaline with values within WHO acceptable limit and water from effluent is slightly acidic. The turbidity is within WHO acceptable limit for canal and pound water.The temperatures values for all the water samples correspond with previous studies across the basin.Generally, values of water quality indicator were within the acceptable limit of no salinity/sodicity problem.

4.3Recommendations

The following recommendations could be made based on the findings of this study

i. Periodic monitoring of soil and water qualities in terms of physical, chemical and bacteriological qualities is essential so as to embark on appropriate ameliorative measures when necessary and also further research work necessary.
ii. Tomatoes farmers should be educated on the dangers posed by the use of untreated sewage effluent for irrigation, since both the farmers and the public would be at risk health wise.
iii. The water for irrigation from savage effluent should be disinfected to destroy the pathogenic micro-organism by chlorination if the waters are to be used for irrigation especially for lettuce which is eaten row.

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