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An Assessment of Irrigation Water Quality Around Lake Chad Basin Northeast Nigeria

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ABSTRACT
This study was carried out to assess the irrigation water quality around Lake Chad Basin in Borno, Northeast Nigeria. Water samples were collected from 5 different locations around the areas. The samples were collected from boreholes; hand dug well, rivers, ground and shallow wells in cleaned plastic bottles. The water samples were analyzed for indices pH and EC values ranged from 6.12-7.45; EC 0.63-3.77 dSm^{-1}. The soluble cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) values ranged from Ca^{2+} 0.08-0.70 meq/l, Mg^{2+} 0.05-0.54 meq/l; K^{+} 10.51-18.50 meq/l; Na^{+} 1.21-8.10 meq/l. On the other hand, the soluble anions (Cl^{-}, P, SO_4^{-}, HCO_3^{2-}, CO_3^{2-}) values ranged from CO_3^{2-} 0.00-5.81 meq/l; HCO_3^{-} 0.60-6.20 meq/l; Cl^{-} 0.57-9.03 meq/l; P 2.35-8.45 ppm; SO_4 0.02-0.35 meq/l. Conversely the salinity indices (RSC, SAR and TDS) values also ranged from RSC 1.89-6.07 meq/l; SAR 2.67-5.81 and TDS 125.00-146.67 respectively. The results from this research indicated that the water samples are saline. Also, the Cl^{-} and SAR posed low salinity hazards, and therefore the water are not suitable for irrigation.

Keywords: Words; Assessment, Irrigation, Water Quality And Lake-Chad Basin

INTRODUCTION

One of the musts challenging problems to crop production in arid and semi-arid regions is the availability and quality of water sources. In this region water availability is not only scanty but erratic in distribution. Under this scenario crop production is usually affected by the amount and distribution of rains during the season. Where ground water sources are not available, irrigation could be used to improve crop growth and yields. However, ground water is known to contain dissolved salts which when present in excess amounts could affect water quality for irrigation purposes (Abdullahi and Philip, 1989). In order to achieve the maximum utilization of the abundant agricultural lands in Nigeria, Borno state in particular especially in the arid and semi-arid parts is indispensable. It is against this background that the federal government invested 15% of agricultural sector allocations to the river basin development authority (Obasi, 2012).

Water is the most important input required for plant growth in agricultural production. Water need for plant growth is met with soil water storage in plant root zone. Under rain fed condition soil water is storage is continually replenished with natural rainfall, however irrigation is essential in arid and semi-arid climates to maintain soil water storage at an optimum level to get higher yield (kirda, 2002). In Borno state, rainfall is inadequate for growing of annual crops like wheat, rice and vegetables, these crops are usually grown during cold dry harmattan season under irrigation. Their entire water requirements are met wholly through irrigation. All water sources used in irrigation contain impurities and dissolved salts irrespective of whether they are from surface or underground water source. However, quality of irrigation has meaning only with respect to its particular use.

Water which can be considered of good quality for household use may not be ideal for irrigation. In agriculture, water is related to its effects on soil and management necessary to compensate problems linked to water quality. It is important to note that all problems of soil degradation like salinity, permeability, toxicity etc can be related to irrigation water quality.

MATERIALS AND METHODS

Study Area

The Lake Chad basin is located between latitude 6^0 and 24^0N and longitude 7^0 and 24^0E. The basin covers and areas of 2434000km^2 and estimated 8% of the total African land surface area (UNEP, 2004). The Lake Chard Basin Commission, which was created under the fourth loamy convention in 1964. Lake Chad is situated on the edge of the Sahara Desert and precedes a vital source of water to human, livestock and farming.

Sample Collection

The experiment was conducted in the soil science laboratory department. Water samples were collected from five (5) locations (Baga, Cikin-Baga, Garin-Mata, Dauran naira, College of fishery) around the Lake Chad basin. The samples were collected from borehole, hand-dug, river, and shallow wells in a cleaved plastic bottle. All the water samples were analyzed for irrigation quality parameters in the laboratory.

Laboratory Analysis

The water quality parameters, soluble cat ions were analyzed (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) and soluble anions also which are (HCO_3^{-}, $CO3^{-}$, Cl^{-}, PO_4^{-}, and SO_4^{--}), PH and EC (electrical conductivity) were also analyzed using the standard procedures (Fred Kruis, 2002).

Determination of pH and EC

Electrical conductivity (EC) and PH water samples were determined using the electric PH meter and the calibrated EC respectively for all samples.

Carbonate and bicarbonate determination

The carbonate (CO_3^2) and bicarbonate (HCO_3) content of the water samples were determined by titrimetry method. The

concentration is in meg/L of the carbonate and bicarbonate in the water samples were calculated as follows.

CO_3^{2-} Meg/L = $\frac{2v-b\ x\ 0.006\ x\ 1000\ x\ 1000}{a\ x30}$

HCO_3^- Meg/L = $\frac{T-2v-b\ x\ 0.006\ x\ 1000\ x1000}{a\ x\ 61}$

Residual Sodium Carbonate and Total Dissolve Solid

The residual sodium carbonate content in the water samples was calculated from the relationship below.

$RSC = [HCO_3^- + CO_3^{2-}] – [Ca^{2+} + Mg^{2+}]$

Both, HCO_3^-, CO_3^{2-}, Ca^{2+}, and Mg^{2+} are all in Meq/L.

Determination of Chloride

The chloride content of the samples was determined by the titrimetry method. The concentration of chloride in the samples is in Meq/L was calculated as.

CL^- meq/l = $\frac{v-b \times 0.0035 \times 1000 \times 1000}{a \times 35.5}$

Determination of Sulphate (SO_4^{2-})

Sulphate was determined by the colourmetry method using spectrophotometer. The sulphate content in the water samples was determined at a wave length of 420 nm.

Determination of Phosphorus

The determination of phosphorus content of the water samples was determined by the colourmetry method using spectrophotometer at a wave length of 660 nm.

Sodium, Potassium, Calcium and Magnesium Determination

The soluble cations Ca^{2+} and Mg^{2+} were determined by the titrimetry method while Na^+ and K^+ were determined by using flame photometer. The concentration of Ca^{2+} and Mg^+ in the samples was calculated from the following relationship.

Ca^{2+} Meq/L = $\frac{a\ x\ Tca\ x\ 1000\ x\ 1000}{v\ x\ equivalent\ weight\ of\ ca}$

Mg^{2+} Meq/L = $\frac{a\ x\ Tmg\ x\ 1000\ x\ 1000}{v\ x\ equivalent\ weight\ of\ mg}$

Sodium Adsorption Ration (SAR),

The SAR of the water samples was estimated from the relationship given below;

Na^+

SAR = $\frac{\sqrt{ca^{2+} + mg2+}}{2}$

RESULTS AND DISCUSSION

Chemical Composition of the Water Samples

The chemical composition of the water samples is presented in Table 1. The result showed that the different water quality parameters vary from location to location. The pH values ranged from a low of 6.12 at location E and high value of 7.45 in location C. The range of the pH suggest that the water samples vary from slightly acid to slightly alkaline which are all significantly difference from one another. The pH value obtained in this study falls within the normal range of 6.0-85 for irrigation water (Burmamu *et.,al* 2009).

Also the results in Table 1 indicates that salt content (EC) ranged from a low value of 0.63 dSm^{-1} at location A to a high of 3.77 dSm^{-1} at location E. The result suggests that all the water samples in different location of A-E are significantly difference and do not pose any serious salinity problem to both the soil and crops, since the EC value are less than the threshold value of 4.0 dSm^{-1} (Richards 1989). Although the EC value of the water samples range for irrigation is less than 4.0dSm^{-1} (Richards 1989), but the continuos use of such water for irrigation purpose may lead to soil salinity problems especially in north and southern Borno (Prof A.B.Alhassan, 2014), adding that 57 and 50% 0f the water samples are potential sources of salinity compared to only 9% in Maiduguri.

Table 1: Chemical Composition of the Water Samples

Location	pH	EC (dSm^{-1})	CO_3^{2-} (meq/l)	HCO_3 (meq/l)	Cl^- (meq/l)	Ca^{2+} (meq/l)	Mg^{2+} (meq/l)	Na^+ (meq/l)	K^+ (meq/l)	PO_4 (ppm)	SO_4(mg/l)	RSC (meq/l	SAR	TDS
A	6.68 a	0.63 a	0.00 a	2.03 a	0.57 a	0.08 a	0.06 a	1.53 a	12.03 a	2.35 a	0.02 a	1.89 a	5.67 a	137.3 a
B	7.02 b	1.75 b	0.00 b	6.20 b	4.61 b	0.08 b	0.05 b	6.21 b	18.50 b	8.45 b	0.17 b	6.07 b	5.81 a	141.7 a
C	7.45 c	2.71 c	5.81 c	0.60 c	9.03 c	0.12 c	0.40 c	8.10 c	16.51 c	4.10 c	0.35 c	5.89 c	2.94 b	125.0 a
D	7.20 d	2.32 d	2.60 d	2.64 d	5.07 d	0.09 cd	0.54 d	7.30 d	15.53 d	6.96 d	0.43 d	4.61 d	2.67 c	144.7 a
E	6.12 e	3.77 e	3.41 d	0.60 d	3.60 e	0.70 d	0.30 d	1.21 e	10.51 e	7.38 e	0.02 d	3.64 e	3.47 d	146.7 a
Mean	6.89	2.24	2.37	2.42	4.58	0.21	0.27	4.89	14.6	5.85	0.12	4.42	4.11	139.1
SE±	3.33× 10^{-3}	2.23×1 0^{-3}	4.23×1 0^{-3}ns	0.02	0.03	2.98×1 0^{-3}	3.33×1 0^{-3}	0.02	0.02	0.03	3.33× 10^{-3}	0.02	0.06	13.27

The soluble cation of the water samples is presented in Table 2. The result of soluble cations content of the water samples which is in (meq/l) varies from location to location 0.08-0.70, 0.05-0.54, 1.21-8.10 and 10.52-18.50 for Ca^{2+}, Mg^{2+}, Na^+ and K^+ respectively. From the result it can see that both Ca^{2+} and Mg^{2+} are all within the normal range for irrigation as suggest by Edlira and vasil (2008). The result showed that they are not significantly difference from one another. Also Table indicated that the Ca^{2+} values are low (0.08meq/l) in location A and B and high (0.70meq/l) in location E, Mg^{2+} values is also low (0.05meq/l) in location B and high at 0.54meq/l in location D. Further the range of K^+ values is within the normal range of 0-2 meq/l for irrigation water (Edlira and vasil, 2008), while for Na^+ is within the normal range of 0-40 meq/l. They further reported that, the K^+ result showed that they are significantly difference from one another. Also K^+ values where low (10.51meq/l) at location E and high (18.50 meq/l) in location B. In a similar vein low Na^+ values (1.21 meq/l) was recorded in location E and high (8.10 meq/l) in location C, it was observed that in order of abundance as $K^+ > Na^+ > Ca^{2+} > Mg^{2+}$.

Table 2: Soluble Cation of Water Samples

LOCATION	Ca^{2+}meq/l	Mg^{2+}meq/l	K^{+}meq/l	Na^{+}meq/l
A	0.08 a	0.06 a	12.03 a	1.53 a
B	0.08 b	0.05 b	18.50 b	6.31 b
C	0.12 c	0.40 c	16.51 c	8.10 c
D	0.09 cd	0.54 d	15.53 d	7.30 d
E	0.70 d	0.30 d	10.51 e	1.21 e
Mean	0.21	0.27	14.62	4.89
SE±	2.98×10^{-3}	3.33×10^{-3}	0.02	0.02

The soluble anion content of the water samples is presented in Table 3. The result of soluble anion content of the water samples (meq/l) varies from location to location. The values are low (0.00 meq/l) in location A, B and high (5.81 meq/l) in location C, (0.60 meq/) l in location C, E and high (6.20meq/l) in location B, low (0.57meq/l) in location A and high (9.03 meq/l) in location C, (0.02 mg/l) in location E and high (0.43 mg/l) in location D and (2.35 ppm) in location A and high (0.845 ppm) at location B respectively for CO_3^{2-}, HCO_3^{-}, CL, SO_4 and P respectively.

The mean results obtained for CO_3^{2+}, HCO_3^{-}, Cl^{-}, SO_4 and PO_4 in table 3 are (2.37 meq/l, 2.42 meq/l, 4.58 meq/l, 0.12 mg/l and 5.85 ppm) respectively. This shows that all the soluble anion of the water samples is high (saline) and are not suitable for irrigation purpose. This is in conformity to the findings of Edlira and Vasil, (2008) who reported that the normal range of soluble salts for irrigation water as follows, CO_3^{2+}(0.1 meq/l), HCO_3^{-}(0.10 meq/l), Cl^{-}(0.30 meq/l), SO_4(0.20 mg/l) and P (0.2 ppm).

Table 3: Soluble Anion of Water Samples

Location	**CO_3^{2-}meq/l**	**HCO_3^{-}meq/l**	**CL^{-}meq/l**	**SO_4^{2-}mg/l**	**PO_4ppm**
A	0.00 a	2.03 a	0.57 a	0.02 a	2.35 a
B	0.00 b	6.20 b	4.61 b	0.17 b	8.45 b
C	5.81 c	0.60 c	9.03 c	0.35 c	4.10 c
D	2.60 d	2.64 d	5.07 d	0.04 d	6.96 d
E	3.41 d	0.60 d	3.60 e	0.02 d	7.38 e
Mean	2.37	2.42	4.58	0.12	5.85
SE±	4.23×10^{-3}	0.02	0.03	3.33×10^{-3}	0.03

The RSC, SAR, EC and TDS values for water samples are presented in Table 4. The result shows that they vary from 1.89-6.07, 2.67-5.81, 0.63-3.77 and 125.00-146.67 for RSC, SAR, EC and TDS respectively. The low value is from location A and high at B for RSC, low in C and high at B for SAR, low in A and high at E for EC and low in C and high at E for TDS respectively. Arabi *et.,al* (2010) also reported that the SAR value falls within the normal threshold of 13 which are suitable for irrigation.

The RSC values suggest that all the water samples from all the location have values greater than the threshold of 1.25meq/l as reported by Eaton (1950). This suggest that the use of such water with high RSC values will further aggravates the adverse effects of excess sodium on both the soil and crop. The TDS values suggest that the result vary from 125.00 to 146.67 respectively, which is higher in location E than the other location but little high compared to location D with the value of 144.67. The result for TDS shows that there are no significant pair wise differences among the means. While the RSC and EC are significantly difference from one another and for the SAR, in which the means there are no significantly different from one another.

Table 4: Suitability Classification of Water Samples

LOCATION	**RSC(meq/l)**	**SAR**	**EC(dSm^{-1})**	**TDS**
A	1.89 a	5.67 a	0.63 a	137.33 a
B	6.07 b	5.81 a	1.75 b	141.67 a
C	5.89 c	2.94 b	2.71 c	125.00 a
D	4.61 d	2.67 c	2.32 d	144.67 a
E	3.64 e	3.47 d	3.77 e	146.67 a
Mean	4.42	4.11	2.24	139.07
SE±	0.02	0.06	2.23×10^{-3}	13.27

CONCLUSION

A laboratory analysis was carried out to assess the quality of water samples for irrigation purpose. Five water samples were collected from different location in Lake Chad Basin Borno State and were analyses for water quality parameters. The water samples were generally low in total soluble salt content with EC value from 0.63 to 3.77 dSm^{-1} across the study area of location (A-E). Two of the locations have the same values greater than 0.61 and 1.75 dSm^{-1}. However, the sodium content of the water samples is varying from 1.21-8.10 meq/l. these water is considered saline as they have SAR values as low as 2.67-5.81 in location D and location B. all the water samples have SAR values less than the threshold of 13 respectively while the TDS varies from 125.00-146.67. The residual sodium carbonate content of the water samples values ranged from 1.89 to 6.07 meq/l. Only location A has values less than the threshold value of 1.25 meq/l. the soluble cation concentration in the water samples are in order of $K^{+} > Na^{+} > Ca^{2+} > Mg^{2+}$ while the soluble anion concentration is in the order $CL^{-} > P > HCO_3^{-} > CO_3^{2-} > SO_4^{2-}$Based on the water quality parameters (EC, SAR, RSC and TDS) it was concluded that all the water from different locations are saline. Also, the Cl^{-} and SAR posed low salinity hazards, and therefore the water are not suitable for irrigation.

Farmers should cultivate salt-tolerant crop varieties and blend saline or sodic irrigation water with suitable calcium- and magnesium-rich water to minimize sodium-related soil degradation.

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