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Salinity And Elemental Properties of Irrigation Water Supplies of Ebonyi State Southeast Nigeria

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Abstract

An investigation to evaluate and characterize the soil salinity and elemental toxicities of the surface and ground water sources of Ebonyi State, Nigeria was carried out. This investigation involved water sampling of ground and surface water of the three Geopolitical Zones of Ebonyi State. The surface water was collected from Akpala, Ohinya Ezza and Eziekwu rivers. The ground water was collected from 30m deep tube wells located at Ebia, Ogboji and Akaeze areas. The water samples were analyzed for salinity, chloride, boron and iron concentration C: N and SAR were calculated. Statistical analysis revealed that the concentration of Fe, Cu and Zn were well above the permissible limits for irrigation in all the samples, while Cd concentrations ranged from 0.0475 to 0.087 $mg.L^{-1}$ in the surface water to 0.0013 and 0.011 $mg.l^{-1}$ in the ground water of the three locations studied, while Zn concentrations ranged from 3.713 to 5.467 $mg.l^{-1}$ in the surface water samples of all the locations. The ground water samples revealed concentration range of 2.205 to 2.503$mg.l^{-1}$. These concentrations are considered safe when compared with established safety standards for irrigation practice.

Key Words: Salinity, Boron, Elemental, Irrigation Ebonyi, Nigeria

1.0 Introduction

Salinity problem exists if salt accumulates in the crop root zone to a concentration that causes a loss in yield. In irrigated areas, these salts often originate from a saline high water table or from salts in the applied water. Yield reductions occur when the salts accumulate in the root zone to such an extent that crop is no longer able to extract sufficient water from the salty soil solution, resulting in a water stress for a significant period of time (Bhumbla*et al*., 1971). Water uptake problems resulting from water salinity problems are similar in appearance to those of drought. These problems are wilting, darker, bluish-green coloration and sometimes thicker, waxier leaves. Symptoms vary with the growth stage, being more noticeable if the salts affect the plant during the early stage of growth. In some cases, mild salt effects may go entirely unnoticed because of a uniform reduction in growth across an entire field (FAO\UNESCO, 1973).

Salts that contribute to salinity problem in irrigated rice production are water-soluble and readily transported by water. A portion of the salts that accumulate in the rooting zone of the crop prior to irrigation (if any) can be leached below the rooting depth by applying additional water beyond the irrigation requirement (Paliwal and Gandhi, 1976). Leaching is the key to controlling a water quality-related salinity problem. Over a period of time, salt removal by leaching must equal to or exceed the salt additions from the applied water to prevent salt building up to a damaging concentration. The amount of leaching required depends on the irrigation water quality and the salinity tolerance of the crop grown (Rhoades and Merrill, 1976).

Sodium toxicity is not as easily diagnosed as chloride toxicity but clear cases of the former have been recorded as a result of relatively high sodium concentrations in the water (High Sodium Absorption Ratio (SAR). Typical toxicity symptoms are leaf burn, scorch and dead tissue along outside edges of leaves in contrast to symptoms of chloride toxicity, which normally occurs initially at the extreme leaf tip. An extended period of time (many days or weeks) is normally required before accumulation reaches toxic concentrations. Symptoms appear first on the older leaves starting at the outer edges and, as the severity increases, move progressively inward between the veins towards the leaf center.

Leaf tissue analysis is commonly used to confirm or monitor sodium toxicity but a combination of soil, water and plant tissue analyses greatly increases the probability of a correct diagnosis.Rice (*Oryza sativa)* is semi-tolerant to sodium toxicity. Particular care in assessment of a potential toxicity due to sodium is needed with high SAR water because apparent toxic effects of sodium may be due to or complicated by poor water infiltration.

Boron, unlike sodium is an essential element for healthy growth of rice. Boron is needed in relatively small amounts, however, and if present in amounts appreciably greater than needed, it becomes toxic for some crops such as rice. In rice production 0.2 mg/L boron in water is essential but, 1 to 2 mg/L may be toxic. Surface water rarely contains enough boron to be toxic but well water or springs occasionally contain toxic amount, especially near geothermal areas and earthquake faults. Boron problems originating from the water are probably more frequent than those originating in soil. Boron toxicity can affect nearly all crops but, like salinity, there is a wide range of tolerance among crops(Beale & Humphreys, 2001). The swift move to industrialize agriculture will require that information on salinity situation and other elemental toxicity of the water supplies in Ebonyi State for irrigation be documented. This information will be a veritable tool in the hands of farmers and researcher alike when managing irrigation water for the state. The aim of the research was to determine salinity and elemental properties of irrigation water supplies of Ebonyi State Southeast Nigeria

2.0 Materials and Methods

2.1 Site Description

The study was conducted within the 13 local government areas of the state. The areas Ebiaunuhu within Abakaliki area council lies within 6^{0} 19^{1} 59.76^{11} N and 8^{0} 05^{1} 59.12^{11} E by 286 Ft above sea level and is situated at the northern part of the state: Ezza North with head quarters at Onueke is locate within 5^{0} $54^{1}50.20^{11}$ N and 7^{0} 40' 50.72^{11} E , stands at 265 Ft above sea level; while Akaeze is located within 6^{0} 07^{1} 15^{11} N and 8^{0} $01^{1}20.97^{11}$ E by 145 Ft above sea level lies at the southern fringe of the state. The mean annual rainfall of the state for the period was 1466.32-2,000 mm obtained from 87-108 rain days with a fairly bimodal rainfall pertain with peaks at June and August each year. The maximum and minimum temperatures were 32.18 and 17.40 ^{o}C respectively while the relative humidity ranged from 50-87 % with a mean of 68.42 %. Parts of the southern zone, some parts of Edda the entire Ekoli community lies within the high rainfall zone of Nigeria. The soil textural class of the high rainfall zone is sandy loam.

2.2 Water Sampling

Water samples were collected from two possible sources of irrigation water (the surface and ground water). About one litre of water samples from the streams adjacent to the ground water source was collected from the surface; at mid depth and from the bottom of the stream with water sampling cups. The three samples were mixed and a representative sample collected for analysis. Water samples were collected at all irrigation sites located in the three zones. A total of 72 water samples were collected (3 samples from each zone weekly for six months each for the two years). Another set of water samples were collected from tube wells at 30m depths as approved by National Special program on Food Security (NPFS) for the same period of time as stated above. The water samples were used for determining of other elements such as sodium, boron, chloride, iron according to the procedure outlined by AOAC (1999)and salinity was determined using conductivity meter according to Rhoades, (1982). Sodium Absorption Ratio was calculated from equation 1.

SAR adj= SAR (1+ (8.4-PHc)

Where,

PHc is $(PK^1{}_2 – PK^1c) + P(HCO^{-3}) + (Ca^{2+} + Mg^{2+})$

$PK^1{}_2 – PK^1c$ is concentration of $Ca^{2+} + Mg^{2+} + Na^+$

$P(HCO^-3)$ is concentration of $CO^{2-}{}_3 + HCO^{-3}$

$(Ca^{2+} + Mg^{2+})$ is Concentration of $Ca^{2+} + Mg^{2+}$

The Exchangeable Sodium percentage (ESP) is given by Equation 2.

$$\frac{\text{Exchangeable Sodium}}{\text{cation exchange capacity}} \times 100 \qquad \text{Equation 2}$$

2.3 Statistical Analysis

The raw data emanating from the laboratory work were analyzed for mean and percentages according to Gomez & Gomez, (1984).

3.0 Results And Discussion

3.1 Salinity

The results of the analysis of the surface and underground water sources of Ebonyi North (Akpala river (A)) , Ebonyi Central (OhinyaEzza river (O)) and Ebonyi South, (Eziekwu river (E)) measured as salinity (Electrical Conductivity (Ec)) ,C:N ratio ,Iron (Fe), Boron (B), Chlorine (Cl), and Sodium (Na) are presented in Table 1 while the interpretation table for Salinity adopted from Rhoades, (1972) is presented in Table 2.

The EC of the surface water ranged from 13.22 to 13.94 ds/m and 8.66 to 9.92 ds/m for the underground water. The values of salts in the water sources are rated high (Table 2). The salts that contribute to salinity problem in irrigated rice production are water-soluble and readily transported by water. A portion of the salts that accumulate in the rooting zone of the crop prior to irrigation (if any) can be leached below the rooting depth by applying additional water beyond the irrigation requirement (Paliwal & Gandhi, 1976).

Table 1: The mean values of Na, Cl, B,C:N ratio C and SAR of the Water quality of Rivers and Bore in Ebonyi State.

Location	Na mg/L	Cl mg/L	B mg/L	Fe mg/L	C:N	Salinity	SAR	Cd	Zn
River Water									
A	1.78	117.44	0.33	17.00	7.21	13.94	10.86	0.087	3.713
O	1.33	131.23	0.38	19.12	5.82	13.22	8.78	0.081	4.067
E	1.70	146.50	0.40	17.01	4.36	13.22	13.99	0.047	5.467
Ground Water									
A	0.70	99.36	0.12	6.44	2.45	8.66	1.30	0.0013	2.503
O	0.80	84.23	0.24	10.11	3.81	9.92	2.37	0.0014	3.270
E	0.80	77.32	0.30	8.41	7.61	8.70	2.49	0.0110	2.203

Leaching is the key to controlling a water quality-related salinity problem. Over a period of time, salt removal by leaching must equal to or exceed the salt additions from the applied water to prevent salt building up to a damaging concentration (Rhoades & Merrill, 1976).

3.2 Sodium Absorption Ratio (SAR)

The values of SAR and electrical conductivity (EC) used to measure the water infiltration rate into the soil ranged from 8.78 to 13.99 and 13.22 to 13.94 ds/m respectively for surface water and 1.30 to 2.49 ds/m and 8.66 to 9.92 ds/m for underground water respectively. The two most common water quality factors,

Table 2: Permeability hazards standards/interpretation of Irrigation water using Ec (ds/m) and SAR together.

Concentration		Degree of Restriction on use		
	None	slight	to moderate	severe
SAR	*0.3*	*and EC > 0.7*	*0.7-0.2*	*<0.2*
	3-6	> 1.2	1.2-0.3	<0.3
	6-12	> 1.9	1.9-0.5	< 0.5
	12-20	> 2.9	2.9-1.3	< 1.3
	20-40	> 5.0	5.0-2.9	< 2.9

SAR means sodium absorption ratio: At a given SAR, permeability rates increase as water salinity increased.

Which influence the normal infiltration rate, are the salinity of the water and its sodium content relative to the calcium and magnesium content? High salinity

Water will increase infiltration. A low salinity water or water with high sodium to calcium ratio will decrease infiltration due to clay particle dispersion (Brady & Weil, 2012). Secondary problems may also develop if irrigation must be prolonged for an extended period of time to achieve adequate infiltration.

3.3 Chloride

The values of the results of the analysis of surface and ground waters of the state are presented in Table 18. There is high chloride value in the range of 117.44-146.50 mg/L in river water and 77.32-99.36 in the borehole water (safe value being < 3 mg/L). The use of this water for irrigation calls for only the use of chloride tolerant crops (Table 3) if no management system to reduce concentration before application is practiced. High concentration of chlorine in irrigation water is known to cause thick burns in rice plants (FAO, 1979, Guy, 2003). High concentration could also lead to defoliation of rice crops.

Table 3. Elemental toxicity hazard of irrigation water

Specific ions	Degree of Restriction on use			
	None	slight to moderate		severe
Sodium (SAR)	< 3	3-9		> 9
Chlorine (Cl) me/L	< 4	4-10		> 10
Boron (B) me/L	< 0.7	0.7-3.0	> 3.0	

Adopted from Rhoades, 1972

Normally, chloride injury occurs first at the leaf tips (which is common for chloride toxicity), and progresses from the tip back along the edges as severity increases. Excessive necrosis (dead tissue) is often accompanied by early leaf drop or defoliation. With sensitive crops like rice, these symptoms occur when leaves accumulate from 0.3 to 1.0 percent chloride on a dry weight basis but sensitivity varies among other crops. Many tree crops for example, begin to show injury above 0.3 percent (dry weight). Chemical analysis of plant tissue is commonly used to confirm chloride toxicity. The part of the plant generally used for analysis varies with the crop, depending upon which of the available interpretative values is being followed. Leaf blades are most often used for cereal crops such as rice. For irrigated areas the chloride uptake depends not only on the water quality but also on the soil chloride, controlled by the amount of leaching that has taken place and the ability of the crop to exchange chloride (Brady& Weils, 2012).

3.4 Boron (B)

The results of the Boron concentrations in the water sources (surface and underground) revealed a range of concentration in the river water from 0.33-0.40 and 0.21-0.3 mg/L in the surface and underground water respectively. These values are very low and boron toxicity is unexpected.(Toxic level being > 3.0 mg/L (Table 3). Boron, unlike sodium is an essential element for healthy growth of rice. Boron is needed in relatively small amounts, however, and if present in amounts appreciably greater than needed, it becomes toxic for some crops such as rice. In rice production 0.2 mg/L boron in water is essential but, 1 to 2 mg/L may be toxic. Surface water rarely contains enough boron to be toxic but ground water or springs water occasionally contain toxic amount, especially near geothermal areas and earthquake faults. Boron problems originating from the water are probably more frequent than those originating in soil. Boron toxicity can affect nearly all crops but, like salinity, there is a wide range of tolerance among crops

3.5 Iron (Fe)

The content of iron in the surface water ranged from 17.00 to 19.12 mg/L while that of the underground water sample was in the range of 6.44 to 10.11 mg/L. excessive quantities will cause undesirable accumulations in plant tissue and will lead to growth reductions. There have been few field experiments from which toxic limits could be established, especially irrigation water for rice production. However, research dealing with disposal of wastewater has gained sufficient experience to prove useful in defining limitations (USBR, 1975). It is now recognized that most trace elements like iron are readily fixed and accumulate in soils and because this process is largely irreversible, repeated applications of amount in excess of plant needs eventually contaminate the soil and may either render it non – productive or the product unusable. Recent surveys (Taylor, 1977) of wastewater use have shown that more than 85 percent of the applied trace element accumulates in the soils (most within the surface few centimeters).

3.6 Sodium (Na)

The concentration of sodium in the river water at the three zones of Ebonyi ranged from 1.33 – 1.78 mg/L while those of the ground water supplies revealed very low and safe concentration of 0.7 – 0.88 from the North to the South of the sampling locations. The values recorded are low for elemental problem of sodium. High concentrations of sodium are undesirable in water because sodium adsorbed onto soil cation exchange sites can cause soil aggregates or beds to break down or disperse, sealing the pores of the soils.

Conclusion

The results of the water analysis revealed that without human intervention, most of the water sources of the state will support sustainable irrigated rice production or any other irrigated agriculture for that matter based on the parameters determined. With water sources blending, since the ground water is very safe, some level of irrigated agriculture can be practiced.

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