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QUALITY ASSESEMENT OF AMANGWU-EDDA STREAM AND ITS TRIBUTARIES FOR RICE PRODUCTION UNDER IRRIGATION

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Abstract
Rice is one food that has solved the food security problems of many densely populated countries like China, India, Thailand and South Korea, etc. Inadequate and uneven distribution of rainfall and declining soil fertility are among the major challenges militating against increase in rice production in Sub-Sahara Africa. The problems associated with rainfall can be addressed through irrigation, a concept that involves the artificial application of water to the land in accordance with 'crop requirement', throughout the 'crop period', for full-fledged nourishment of the crop. Water sources to be used for rice production under irrigation in Amangwu-Edda, Afikpo-South Local Government Area (LGA) of Ebonyi State, South-East Nigeria were evaluated for their quality in terms of salt content. Laboratory results revealed that the water samples had mean pH value of 7.04 and Ca, Mg and Na values of 18.03mg/l, 6.07mg/l, and 1.75mg/l respectively. Similarly, mean SAR, K, SO_4, CL, TDS, and EC were 0.913meq/l, 2.05mg/l, 202.5mg/l, 99.715mg/l, 1,001.4mg/l and $6.3x10^{-5}$respectively. The result indicates that the water quality is safe for irrigated rice production. Similarly the mapping units studied are predominantly clay loamy, which is very ideal for irrigated rice production, but primary nutrients were generally low, and should be supplemented with organic or inorganic fertilizer.

Keywords: Quality, Assessment, Rice, production, and Irrigation

Introduction
Irrigation water played a major role in the technology that drove green revolution, together withimproved seeds and fertilizer, which made food sufficiency possible in many densely populated countries like China and India.To adequately meet the ever growing food demand in Africa caused by population explosion will require gains in output that are only possible through food production at both on and off season, reducing farmers dependency on rain-fed agricultural systems. Essentially, food security entails the basic practices of conserving natural precipitation, drainage and supplementation of rainfall with irrigation. Four distinct rice production systems can be found across West Africa ecology: rain-fed upland (40%of the rice area), rain-fed lowlands (38–40%), irrigated (12–14%) and mangrove swamps (4%). Rice production is dominated by small holder farmers who rely on rain-fed conditions with limited use of irrigation facilities (Pamela *et al*., 2013).

Several studies have extensively reportedthe positive effect of irrigation on crop yield and increased productivity, (Bacha *et al*., 2011, Domenech and Ringler,2013, and Nguyen *et al*., 2017).However, adequate care should be taken to ensure that intended water source for irrigation is free from salt and other contaminants.The deployment of contaminated water for irrigating crop has somenegative consequences. Water with contaminants may contain unwanted pathogens and chemical constituents that pose health and environmental risks. Similarly contaminated water may contain high concentrations of salts which can affect the soil quality and prolonged use of saline, and sodium-rich water can deteriorate the soil structure which directly affects the soil productivity (Jaramillo *et al.,* 2017, Khalid*et al.,* 2017, and Li*et al.,* 2017).

Rice (*Oryza sativa* L.) is an important food security crop; it is a primary food source for over one third of world's population. Most people regard rice as their main staple food and it represents 19% of the world's per capita energy consumption (Maclean and Hettel, 2014). However, the demand for rice production is likely to increase especially in sub Saharan Africa mainly due to unavoidable population growth. Unfortunately most Africans countries such as Nigeria are among the least rice producing countries in the world (Sultana *et al.,* 2015; FAO 2018).

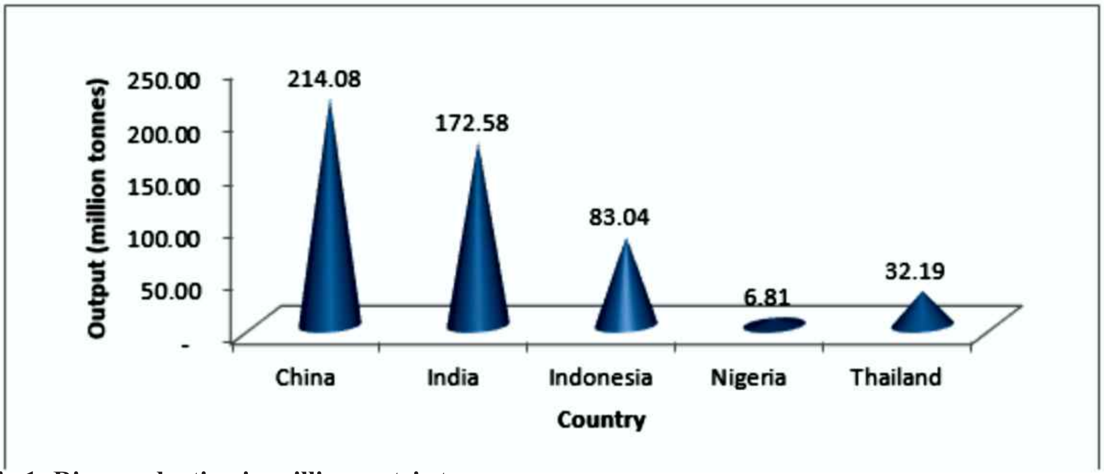

Fig.1: Rice production in million metric tonnes
Source: FAOSTAT (2018)

Irrigation water comprises of inorganic constituents; primarily, the dissolved nutrients and salts, and these salts differ greatly in concentration and composition. Connor *et al*. (2017) observed that the main component of dissolved salts are cations such as: magnesium (Mg^{2+}), sodium (Na^{+}), calcium (Ca^{2+}), and anions among which aresulphate (SO_4^{2-}), bicarbonate (HCO_3^{-}), and chloride (Cl^{-}). Irrigation water contributes substantial amount of cations, along with their salts such as: sulphates, phosphates, bicarbonates, and chlorides to the soil body (Alghobar *et al.,* 2015). Similarly, other studies have shown that the application of contaminated water modifies the cation concentration in soil, which affects the metal/nutrient balance between solid and aqueous soil phase (Khalid *et al*., 2017 and Murtaza *et al*., 2010).

The major objective of irrigating land is to increase the water content of the soil to a level considered optimal for growth. This promotes the soil drainage, water infiltration and percolation, and also reduces salinity by washing away soluble salts in the soil surface. Therefore, to maintain fertility, organic matter composition and soil available water, successful long term management of soils is crucial if soil conservation for sustainable use is to be achieved.The suitability of irrigation water depends on the nature of salts present in the water body. The main soluble constituents are calcium, magnesium, sodium as cations and chloride, sulphate, biocarbonate as anions. Other ions that could be present in minute quantities are boron, selenium, molybdenum and fluorine,which are harmful to animals feeding on plants grown with excess concentration of these ions. Therefore, consideration of water quality is fundamental for any irrigation crop production practices. The objective of this study was to assess the level of salt in irrigation water for rice production in Akwa-Etiti, Amangwu-Edda rice field in Ebonyi State, Nigeria.

Materials and Methods

Study Area

The study was carried out at Amangwu-Edda, Afikpo-South LGA,Ebonyi State. The area lies within latitude 5^{o} 83^{1} 57.1' and longitude 7^{o} 85^{1} 82.8', and on elevation of 82m above sea level, as measured with handheld Global Positioning System (GPS) receiver (Garmin, Ltd. Kansas, USA). It is bounded in the North by Ohazara LGA, in the South by Ohafia LGAAbia State, in the East by Afikpo-North LGA, and West by Ivo LGA.The study area is surrounded by Ofia-Chima, Akwa-Etiti and Owo-Ekpe streams (these are the tributaries of Ivo River).

Field Work

The water samples were collected with clean plastic bottles from the water sources (Akwa-Etiti, Ofia-Chima and Owo-Ekpe streams) for the irrigation activity, and taken to the Soil Science Laboratory of NRCRI,Umudike, for analysis. The water samples were later filtered using whatt man 41 and 42 filter papers to thoroughly remove particles, and at ambient temperature for analysis.Morphological (colour, texture, structures, consistency and inclusions) features were fully described, and used to establish soil boundaries and units. Based on similarities and differences from these morphological features, three mapping units were delineated, and soil samples collected from each mapping units using auger borings made at 25cm interval to a depth of 100cm.

Laboratory analysis

pH: The water pH was determined using Jan-way 3015 pH meter as described by Udo *et al.* (2009).

Sodium:Sodium concentration was determined using flame photometer adjusted to 589mm wave length as described by Udo *et al*. (2009).

Calcium:Calcium concentration was determined using EDTA titration method as described by Udo *et al.* (2009).

Magnesium: The concentration of magnesium was determined using EDTA titration methodas described by Udo *et al*. (2009).

Sodium Adsorption Ratio (SAR): The Sodium Adsorption Ratio (SAR) in the water sample was calculated thus:

$$\sqrt{\frac{Ca^{+} + Mg^{+}}{2}}$$

Sulphate:Spectrophotometer was used in determining sulphate using Colorimeter at 450mm wave length (DR 2010) as described by Udo *et al.* (2009).

Chloride:Chloride was determined by volumetric method using potassium chlorometer as indicator as described by Udo *et al*. (2009).

Total Dissolved Solid (TDS): In determination of the Total Dissolved Solid, the water samples were shaken thoroughly, and 50mls of the samples pipette into a petri-dish. The water in the petri-dish was taken to the oven for evaporation-drying to determine the total dissolved solid (Chopra and Kanwar, 1991).

Results and Discussion

The mean pH value of the water sample was 7.30 (Fig. 1). The water sources studied had a desirable pH quality for irrigation. The analytical result indicated that the mean value of calcium content of the water sources for irrigation is 18.03mg/l. The magnesium content of the water source for irrigation had a mean value of 6.08mg/l. The result of the calcium and magnesium content of the irrigation water sources follows the findings of Karen (2004), who reported that water and soil solution extracts contains two to five times more calcium than magnesium.Similarly, the mean value of potassium content of the irrigation water sources was 2.05mg/l, while sodium content of the irrigation water source had a mean value of 1.75mg/l. The value obtained were below 10mg/l, which is a value stated as low value of sodium content in irrigation water (London, 1991).

The results of the exchangeable cations confirm the finding of Onyekwere *et al.* (2010), who observed that the exchangeable cations content in irrigation water appear in the following proportion Ca> Mg > K > Na. Furthermore, the sodium content of the irrigation water source was less than 5% of the total exchangeable cations, indicating that sodium will not be a challenge to the irrigation water source (Santosh, 2005). However there is a balanced relationship between the Calcium and Magnesium content. Karen (2004), reported that water and soil extracts contain two to five times more Calcium than Magnesium. Onyekwere *et al.* (2010) emphasized that irrigation waterwith relatively higher calcium than magnesium are likely to increase soil productivity.

The sodium Adsorption Ratio (SAR) from the irrigation water sources studied had a mean value of 0.91. This result gives the indication that the water sources are of low sodium water, and are suitable for irrigation, as the mean value is far less than the standard safe minimum limits of 10 set by Food and Agriculture Organization (FAO, 1985). The mean value of the electrical conductivity of the water sources for irrigation presented in Table 1 is 6.12 micro mhos/cm.Thisimplies that the irrigation water sources are low salinity water (Fig 2), and can be used for irrigation for almost all crops, and for almost all kind of soils (Santosh, 2007).The mean value of the total dissolved solid in the irrigation water sources was 1,001.4mg/l (Fig 3), indicating that the water sources are moderately good for irrigation. With values below 2,000mg/l, is described as severe for irrigation (FAO, 1985). The mapping units studied were predominantly clay loam (CL) as shown in Table 2, which is very ideal for irrigated rice production, as such, soils are known for high water holding capacity, and would not allow water or nutrient run off. Similarly, primary nutrient as shown in Table 3 were generally low, and should be supplemented with inorganic fertilizer, as well as increase the organic carbon base of the mapping units by incorporating the rice husk, harvested residue and other organic input (Smith *et al.,* 2017).

Table 1: Mean Values of Some Chemical Composition of the Water Sources

Attributes	Values	FAO Acceptable range	Units
pH	7.30	6.0 – 8.5	
Ca^{2+}	18.03	0 – 20	me/l
Mg^{2+}	6.075	0 – 5.0	me/l
Na^{+}	1.75	0 – 40	me/l
K^{+}	2.05	0 – 2.0	mg/l
TDS	1,001.4	0 – 200	mg/l
EC	6.12	0 – 3.0	ds/m
SAR	0.913	0 – 1.0	me/l

TDS=Total Dissolved Solid, E=Electrical Conductivity, SAR=Sodium Adsorption Ratio

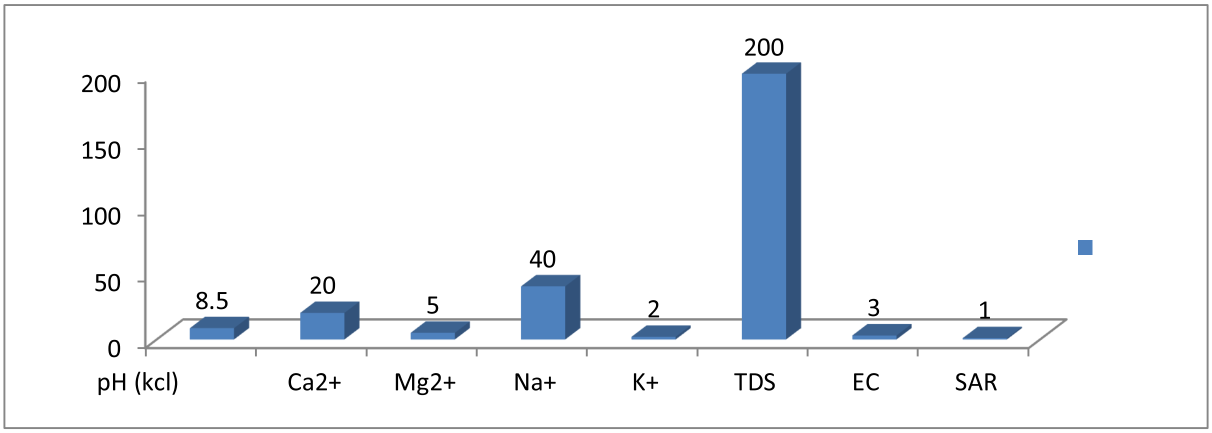

Fig. 2: FAO Permissible value for irrigation water

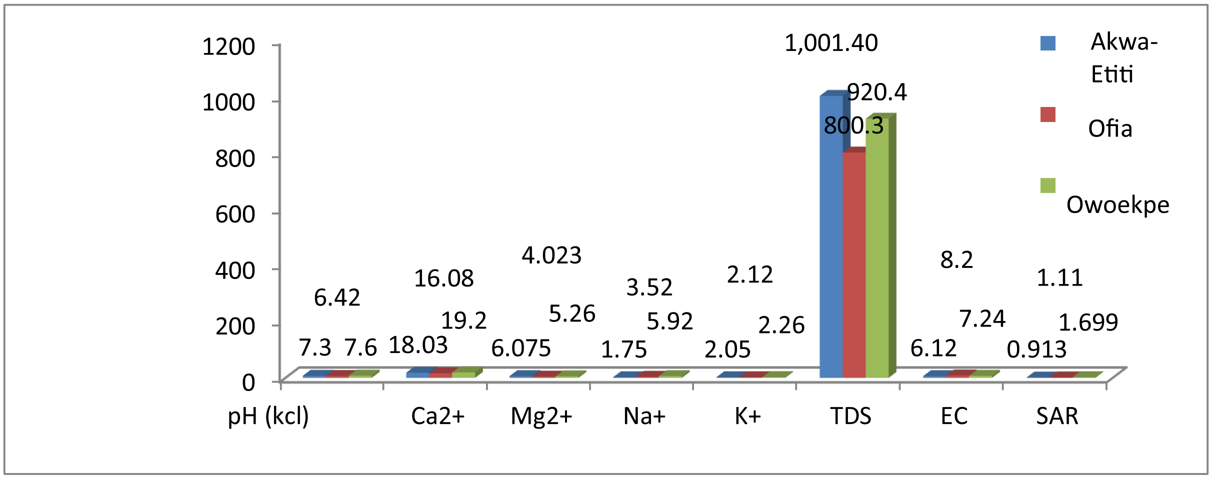

Fig. 3: Mean Values of Some Chemical Composition of the Water Sources for Irrigation

Table 2: Particle size distribution of the irrigation rice growing soils studied

Mapping Units	Sand (%)	Silt (%)	Clay (%)	Textural Class
I	33.47	40.07	26.47	CL
II	34.05	34.90	31.80	CL
III	23.80	50.40	25.73	SiL
Range	23.80-34.05	34.90-50.40	25.73-31.80	

Table 3: Primary Nutrients of the irrigation rice growing soils studied

Mapping Unit	N(%)	P(mg kg^{-1})	K(cmol$^{(+)}$kg^{-1})
I	0.16	24.30	0.34
II	0.17	22.45	0.33
III	0.17	28.82	0.36
Range	0.16-0.17	22.45-28.820	33-0.36
Mean	0.17	25.19	0.34

Conclusion

The data obtained from the water analysis showed that the water sources for irrigation of Akwa-Etiti, Amangwu-Edda rice field is suitable for irrigation, as well as the drainage system and water movement. It is therefore recommended that salt status investigation should be repeated every five years, because the present state of the water quality is not a guarantee that there will not be an accumulation of salts in distant future.However, the mapping units studied were predominantly clay loamy which is very ideal for irrigated rice production, and primary nutrient were generally low, and should be supplemented with inorganic fertilizer.

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