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ASSESSMENT OF THE QUALITY OF WATER FROM RIVER ASE FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN DELTA STATE, NIGERIA.

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ABSTRACT

The study examines the quality of water from River Ase in Delta State with a view to assessing its quality for irrigation purposes in Delta North and South Senatorial Districts of Delta State. It is an experimental research survey that involves the collection of water samples from the surface and subsurface of the river. Laboratory analysis of water samples collected in six settlements located in the lower, middle and upper courses of the river, in order to ascertain the quality of water in line with approved standard for irrigation purposes was carried out. From the analysis it was discovered that there is variation in the quality of water along the course of the river. Also the water quality along the course of the river varies from a SAR value of 1.24 to 6.20 and EC value of 13.07us/cm to 68.99/cm. These values are within the SAR value of 10 and EC value of 750us/cm approved standard for irrigation purposes; hence the water from River Ase is good for the irrigation of crops. This when applied to farmlands will aid in the cultivation of crops throughout the year, especially in Delta North and South senatorial districts. This will boost food production and agricultural development in Delta State and Nigeria in general.
Keywords: Assessment, Sodium Adsorption Ratio, Irrigation, River Ase, Water quality, Sustainable

INTRODUCTION

Irrigation which is the application of water to assure sufficient soil moisture available for good plant growth as practiced during the dry season is used to augment the rainfall that occurs during the growing season. Irrigation is used on full season agronomic crop to provide a dependable yield every year. It is also used on crops where water stress affects the quality yield such as vegetables and fruit. During most years, it is not uncommon for some places in the Niger Delta to receive rainfall for good plant growth while other areas experience reduced yields or quality on non-irrigated crops because of water stress from insufficient soil nutrient or as a result of access or deficit in the elements contained in the water for irrigation.

Thus, the quality of some water is not suitable for irrigation crops. Irrigation water must be compatible with the crops to which it will be applied (Scherer, Seelig and Franzen, 1996). The quality of water for irrigation purposes is determined by its salt content. An analysis of water for irrigation should include the cations: magnesium, sodium and the anions: bicarbonate, carbonate, sulfate, boron and chloride, hence this study seeks to examine the quality of surface water of River Ase, Delta State, Nigeria and the suitability of the water for irrigation purposes along the bank of the river.

Irrigation Water Classification

The two most important factors to look for in an irrigation water analysis are the Total Dissolved Solids (TDS) and the Sodium Adsorption Ratio (SAR). The total dissolved solids (TDS) of a water sample is a measure of the concentration of soluble salts in a water sample and is commonly referred to as the salinity of the water. TDS is expressed in terms of the electrical conductivity (EC) and its units are either millimhos per centimeter (mmhos/cm), deci-siemens per metre (dS/m) or micromhos per centimeter (mmhos/cm.).

Where:

1000mmhos/cm = 1mmho/cm = 1dS/m (Scherer, Seelig and Franzen, 1996)

The SAR of a water sample is the proportion of sodium relative to calcium and magnesium. Since it is a ratio, the SAR has no units.

Irrigation water analysis are provided through a suitability classification based on a system developed at the U.S Salinity Laboratory in California (Table 1)

Table 1: Classification of Water Quality for Irrigation

Value	Salinity	Sodium	Rating
100 – 300	C1	S1	Low
301 – 3000	C2	S2	Medium
3000 – 9000	C3	S3	High
>9000	C4	S4	Very High

Source: US Salinity Laboratory Report (2002).

This classification system combines salinity and sodicity. For example, a water sample classified as C3 - S2 would have a high salinity rating and a medium sodium rating. A SAR of 8 is in the SI category if the salinity is from 100 to 300mmhos/cm, S2 if the salinity is from 300 to 3000mmhos/cm and S3 if the salinity is greater than 3000 mmhos/cm.

In their study of North Dakota, Scherer, Seelig and Franzen (1996) classified the waters of North Dakota as C2 to C3 salinity range and the S1 – S2 sodium hazard range. In general, any water with an EC greater than 2000 mmhos/cm or a SAR value greater than 6 is not recommended for continuous irrigation in North Dakota. In places where sporadic irrigation is practiced, lower quality water may be used. However, the lower quality water should not have an EC that exceeds 3000mmhos/cm or SAR greater than 10.

Thus, many vegetables need extra water when in flower or when fruiting. Legumes such as beans, peas, sweet potatoes and sweet corn require more water when in flower (Rottmann and Shireman, 2003). Tomatoes and pumpkins benefit from extra water when their fruit is developing. Peas and beans will develop heavier pods if watered regularly after flowering but too much water will result in extra leafy growth and fewer flowers and fruit. Leafy green and root vegetables require regular watering throughout their growth. Thus, the price of irrigation water has been shown to be an important water use determinant but the impact appears to be largely on the quality of water rather than on the amount of water applied (National Research Council, 1999).

Salinity, Sodium and Boron and Irrigation Water Quality

Several standards have been proposed for evaluating the quality of irrigation water. The most widely used criteria are those established by the U.S. Salinity Laboratory, California. While these standard serve as general guides, their interpretation in any particular case is dependent upon knowledge of the characteristics of the soil upon which they are to be used, the quality of water available, presence or absence of an adequate system, the crops to be grown and other factors (Wilcox,1994). Since these factors cannot be incorporated into a single set of standards, the water quality criteria presented in Table 2 represent maximum limits of salt, sodium, and boron that permit unrestricted use of an irrigation water for most soils and crops.

Table 2: Standards for Irrigation Water Quality

Parameter	Satisfactory Level/Water
Salinity	Less than 750EC X 10^6 ……………………….…(1)
	Less than 500ppm …………………………….… (2)
Sodium	Less than 10 SAR …………………………..…..(3)
	Less than 1me/1RSC ………………………..….(4)
Boron	Less than 0.3ppm …………………………………. (2)

1. EC x 10^6 = electrical conductivity (mhos) x 10^6 = micromhos
2. PPM = parts per million
3. SAR = Sodium adsorption ratio = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$
4. RSC = Residual Sodium Carbonate
   = $(CO^3 + HCO_3) - (Ca + Mg)$
   Ion concentration are in Me/l

Source**:** U.S. Salinity Lab. Research (2002).

This standard for irrigation water quality was adopted for use because it has enjoyed wide usage amongst researchers. Some researchers who have adopted it include Schott, (2005), Sahu, (2008) and Pereira, (2008). In addition, the standard allows for proper water management. Also the efficiency, conservation and compatibility of water use is created, hence its application to this study.

Statement of the Problem:

There have been several studies on the quality of water from the surface for domestic purposes of such rivers as Ethiope, Ovwuvwe, Warri, Benin, Ramos, Escravos and Forcados (Egborge and Benka-Coker, 1986; Ikomi, 1992; Ikomi and Owabor, 1997; Adiotomre, Adaikpo and Erhisere, 1999; Ekakitie, 2008) to the neglect of studies on the quality of surface water for irrigation purposes. Similarly, studies on River Ase in Southern Nigeria are lacking. As such there is dearth of information on the quality and uses of this river water, particularly the assessment of the quality of water for irrigation purposes in order to boost food production in Delta State.

This neglect of studies on the quality of water for irrigation purposes has negative impact on crop production in the area, since its potential agro-resource potentials are not been harnessed. It becomes imperative therefore that a study be conducted to fill in the obvious gap. As a result of this impingement, there has been a growing concern among the inhabitants of the area served by the river as to the quality of the water for irrigation purposes. Some of the inhabitants complained that the water from the river is not good for irrigation of crops; while others were of the view that the quality of water fluctuates with the seasons, hence detrimental to crop yield. It is therefore against this backdrop that this study assesses the quality of water from River Ase for sustainable agricultural development in Delta North and South Senatorial districts of Delta State, Nigeria.

Aim, Objectives and Hypothesis

The study is aimed at assessing the quality of water from River Ase for sustainable agricultural development in Delta North and South Senatorial districts of Delta State. The specific objectives are to:

1. assess the quality of water along the course of River Ase.
2. ascertain the level of variation (if any) in the quality of water
3. ascertain if the water from River Ase is good for irrigation purposes in the area
4. suggest ways of improving the water quality in order to boost agricultural production in the area

Hypothesis

Ho: The quality of water from River Ase does not differ significantly from approved standard for irrigation purposes

RESEARCH METHODOLOGY

This study is an empirical research. It involves field collection of water samples along the course of the river and laboratory analysis of the water collected.

Study Area

The area of study is River Ase in Southern Nigeria. River Ase is located at approximately on latitudes 5^0 17 and 5^0 53 North of the Equator and longitude 6^0 17 and 6^0 31 East of the Greenwich Meridian (Federal Surveys, Nigeria, Sheet 78 (Kwale), 1970). The river is approximately 292 kilometres in length and flows through such settlement as Obikwele Osemele, Iselegu in Delta North Senatorial district to Ivrogbo, Ibredeni, Ase and Asaba-Ase in Delta South Senatorial district. River Ase is a tributary of the Forcados River, the western branch of River Niger in the Niger Delta region of Southern Nigeria. River Ase marks the geological boundary of the Somberairo-Warri formation and the meander belts of the upper deltaic plains of the Niger Delta (Arimoro, Ikomi and Efemuna, 2007) The river is approximately 292 kilometres in length (Arimoro, Ikomi and Efemuna, 2007). The river flows through freshwater swamp and swampy forests of the Niger Delta region of Nigeria and through such settlements as Asaba-Ase, Ase, Ivrogbo, Ibredeni, Awah, Ibrede, Igbuku, Ashaka, Umusedeli, Kwale, Osemele, Obetim-uno, Iselegu and Obikwele among others. The inhabitants of these settlements depend on the water from the river for domestic purposes, recreational purposes, transportation, industrial and agricultural purposes (Idodo-Umeh, 2002). However, the river water suffers from contamination caused by the use of detergents, solid waste disposal, effluent discharges, industrial waste and sewer leakages (Idodo-Umeh, 2002; Aghoghovwia, 2011).

Method of Data Collection

The data for this study were derived from water sample collected along the course of the river from six different settlements of two settlements each in the upper, middle and lower courses of the river. The settlements are located at 10-15 kilometres apart. The United States Salinity Laboratory Research (2002), which used the Electrical Conductivity (EC) of analyzed water samples and the Sodium Adsorption Ratio (SAR) was adopted as impact criteria. The water samples were collected from six different points (settlements) once in the months of January to December, 2011 from the surface and sub-surface of the river. The collection was done using sterilized 2-litre plastic cans.

The sterilized plastic cans were fitted with information tags for identification. Collected water samples were securely corked and stored in ice packed container before being transported to the laboratory. This was done within 6 hours of collection. All samples were allowed to settle down for about 4 hours before any form of laboratory analysis. This was done to eliminate any form of turbidity influence on tests.
In addition, the materials and equipment used for the analysis and assessment of the water samples were based on the analytical equipment recommended and validated by the World Health Organization (WHO), United States Public Health Service (USPHS), the American Society for Testing Materials and the Federal Ministry of Environment for testing of water quality.

RESULTS AND DISCUSSIONS

Determination of water quality for Irrigation

In the determination of the water quality for irrigation purposes, the United States Laboratory Research (2002) as standard for irrigation water quality was adopted. The model uses the Electrical Conductivity (EC) of analyzed water samples and the Sodium Adsorption Ratio (SAR), calculated as follows:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

Where:

SAR = Sodium Adsorption Ratio
Na = Sodium values
Ca = Calcium values
Mg = Magnesium values

Having determine the test results of each measured parameter in each of the settlement as shown in appendix A, the following results were obtained as shown in Table 3-

Table 3**:** Variation in irrigation water quality along the course of River Ase.

Location	EC	Standard	SAR	Standard	Remarks
Asaba-Ase	68.99	750	6.20	10	Satisfactory
Ivrogbo	64.65	750	6.08	10	Satisfactory
Kwale	26.42	750	2.08	10	Satisfactory
Igbuku	24.78	750	1.97	10	Satisfactory
Obikwele	13.07	750	1.25	10	Satisfactory
Osemele	13.17	750	1.24	10	Satisfactory

From Table 3, the electrical conductivity values range from 13.07us/cm at Obikwele to 68.99us/cm at Asaba-Ase. Values of 64.65us/cm, 26.42us/cm, 24.78us/cm and 13.17us/cm were recorded at Ivrogbo, Kwale, Igbuku and Osemele. These values are within the 750us/cm recommended standard for irrigation water quality. The implication of this is that the surface water in the light of electrical conductivity is ideal for irrigation purposes.
While the Sodium Adsorption Ratio (SAR) of the water samples range from 1.24 at Osemele to 6.20 at Asaba-Ase. SAR values of 6.08, 2.08, 1.97 and 1.25 were recorded at Ivrogbo, Kwale, Igbuku and Obikwle respectively. These values are within the recommended standard value of 10 SAR for irrigation

water quality by the United States Salinity Laboratory Research (2002). This implies that the water along the course of the river is good for irrigation purposes. This finding corroborates the results of the SAR values of 0.9 – 2.5 observed by Omo-Irabor and Olobaniyi (2007) in their studies of the investigation of the hydrological quality of Ethiope River wathershed in Southern Nigeria; thus implying that the water from the river is of excellent irrigation quality.

Classification and Interpretation of water quality for Irrigation Purposes along the bank of the river

The classification and interpretation adopted in this study is based on the United States Salinity Laboratory Report (2002) as shown in Table 4.

Table 4: Classification of water quality for Irrigation

Value	Salinity	Sodium	Rating
0 – 300	C1	S1	Low
301 – 3000	C2	S2	Medium
3001 – 9000	C3	S3	High
> 9000	C4	S4	Very High

Source: US Salinity Laboratory Report (2002).

Based on these ranges, the calculated Sodium Adsorption Ratio (SAR) of sampled settlements along the course of the river is shown in Table 5. The study showed that the SAR values of the sampled settlements along the bank of the river ranges from 1.24 at Osemele to 6.20 at Asaba-Ase. The areas with the lowest SAR values correspond with the areas with the lowest electrical conductivity values (upper course of the river) at Obikwele and Osemele; while areas with the highest SAR values correspond with areas of high electrical conductivity (lower and middle courses of the river) values at Ivrogbo. The middle course of the river (Kwale) recorded medium SAR values which corresponded with the electrical conductivity values recorded in the middle course of the river.

Table 5: Classification of water quality for Irrigation based on SAR values

Settlement	0 – 300 C1 – S1 Low	301 – 3000 C2 – S2 Medium	3001 – 9000 C3 – S3 High	>9000 C4 – S4 Very High
Asaba-Ase	6.20	-	-	-
Ivrogbo	6.08	-	-	-
Kwale	2.08	-	-	-
Igbuku	1.97	-	-	-
Obikwele	1.25	-	-	-
Osemele	1.24	-	-	-

Source: Fieldwork, 2011

Thus, the water in the area is classified into the C1 to S1 category, where low salinity and low sodium concentration is observed. It implies that the water in the area can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop (Scherer, Seelig and Franzen, 1996). Also, the low sodium (S1) concentration observed implies that the water can be used for irrigation on almost all soils with little danger of development of harmful levels of exchangeable sodium (Scherer, Seelig and Franzen, 1996). Thus, leguminous crops such as beans, peas, sweet potatoes, tomatoes, root vegetables and pumpkins which require more water when in flower can be planted along the bank of the river (Rottamann and Shireman, 2003).

Test of Hypothesis

The analysis of variance (ANOVA) was used to test the hypothesis, "that the quality of water from River Ase does not differ significantly from approved standard for irrigation purposes".

Ho: That the quality of water from River Ase does not differ significantly from approved standard for irrigation purposes.

Hi: That the quality of water from River-Ase differs significantly from approved standard for irrigation purposes.

From the model summary in table 6, the calculated F (1.434) is less than the critical table value (3.10) at $P<0.05$ and thus the model is not significant. Therefore, we accept the null hypothesis which states that the quality of water from River-Ase does not differ significantly from approved standard for irrigation purposes in the area (see Table 6).

Table 6: Result of ANOVA analysis

	Sum of square	Df	Mean Square	F	Sig
Between Groups	339.911	3	113.304	1.434	192
Within Groups	304.835	20	15.242		
Total	644.746	23			

Conclusively, the quality of water from River Ase3 is good for irrigation purposes in the area

FINDINGS

Based on the aim and objective of the study and the hypothesis posited, the following findings have been made:

1. There is variation in the quality of water for irrigation purposes along the course of the river. The calculated Sodium Adsorption Ratio (SAR) of the water samples ranged from 1.24 at Osemele to 6.20 at Asaba-Ase
2. The study also revealed that the mean electrical conductivity values of the water vary from 13.07 us/cm at Obikwele to 68.99us/cm at Asaba-Ase
3. The study also revealed that the water from the river can be classified as C1 – S1; thus low in salinity and sodium based on the US Salinity Laboratory Report (2002)
4. The test result of the posited hypothesis showed that the calculated F(1.434) is less than the critical value (3.10) at $P<0.05$. Thus, the water quality is in line with approved water quality standard for irrigation purposes
5. The water quality from River Ase is good for irrigation purposes as is falls within the approved standard.

CONCLUSION AND RECOMMENDATIONS

The assessment of the quality of water for agricultural uses is essential for human health and survival. Indeed, a combination of potable water, adequate sanitation and food security are pre-conditions for human health and overall reduction in morbidity and mortality rates among men, women and children.

Water is also critical to sustainable development through environmental protection and food security to increased tourism and investment in transportation and hydro-power generation. Thus, there is the need to monitor, protect and safeguard this resource for the benefit of mankind and for sustainable agricultural development.

In line with the laboratory result of the water samples analyzed and the hypothesis tested, the researchers recommended:

1. Human needs for water must be balance with the need for food and economic development. The quality of water from the river is ideal for irrigation purposes and hence, it is strongly recommended that the water be used to irrigate the dry lands along the bank of the river throughout the year; especially during the dry season.
2. Canal irrigation can be practiced in the area through the channelisation of the water from the river to the farmlands. This will encourage the growth of crops, especially vegetables throughout the year. By so doing agricultural productivity will be boosted in the area and an increase in food security
3. The water along the course of the river should be monitored and tested from time to time in order to identify impairments and also to determine whether the physico-chemical parameters of the water quality in line with approved standard are increasing or decreasing.

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Appendix A: Result of Physico-Chemical Analysis of Sampled Settlements

Field code	Asaba-Ase				Ivrogbo				Kwale				Igbuku				Obikwele				Osamele			
	E.C (us/cm)	Na	Mg	Ca	E.C (us/cm)	Na	Mg	Ca	E.C (us/cm)	Na	Mg	Ca	E.C (us/cm)	Na	Mg	Ca	E.C (us/cm)	Na	Mg	Ca	E.C (us/cm)	Na	Mg	Ca
Jan	91.45	15.10	7.10	8.05	85.00	15.20	7.20	7.10	20.66	5.50	4.00	2.00	20.42	5.36	4.25	2.64	10.87	2.30	2.50	1.80	10.80	1.95	2.15	1.82
Feb	80.20	15.05	7.30	8.00	75.15	16.20	9.40	7.20	20.61	6.00	4.06	2.50	19.46	5.34	4.35	3.20	10.90	2.20	2.52	1.82	12.00	2.00	2.15	1.75
March	75.10	14.10	7.15	7.45	70.10	14.20	8.30	7.10	21.42	6.00	4.06	2.15	20.14	6.10	5.32	3.16	12.00	2.10	2.42	1.50	12.75	1.75	2.15	1.70
April	48.56	12.21	2.66	3.90	44.30	12.15	0.85	1.75	39.20	2.50	3.00	2.80	34.10	2.40	2.00	2.76	14.50	1.04	1.20	1.40	14.75	1.05	0.95	1.44
May	40.45	12.00	2.60	3.50	37.20	12.00	0.90	1.95	40.20	2.46	3.00	2.46	34.10	2.36	1.96	2.74	14.72	1.00	1.02	1.36	14.90	1.04	1.02	1.33
June	38.40	11.20	2.30	3.40	39.00	12.30	1.00	2.00	42.43	2.31	3.00	2.30	25.26	2.40	2.14	2.52	14.90	1.02	1.05	1.46	14.90	1.10	1.11	1.32
July	37.40	12.00	2.45	3.45	38.00	11.45	1.45	2.15	40.46	2.04	3.00	2.14	41.69	2.00	2.20	2.16	15.00	1.00	1.04	1.40	14.78	1.06	1.20	1.14
Aug	52.30	13.00	2.30	3.15	50.15	11.30	1.50	2.14	18.00	2.04	4.26	1.46	19.00	3.00	6.42	3.20	15.22	0.96	1.02	1.20	14.85	0.92	1.10	1.10
Sept	91.69	19.39	7.30	8.22	81.98	15.32	6.88	6.90	18.00	4.20	4.00	3.50	19.00	4.45	4.05	3.45	14.95	0.69	1.02	1.01	14.70	0.98	0.96	1.20
Oct	90.50	18.50	7.45	8.25	82.92	15.35	7.00	7.00	18.20	4.00	4.20	3.40	20.00	4.45	10.20	3.46	11.07	2.15	2.16	1.07	17.00	2.42	2.00	1.70
Nov	91.45	17.40	7.30	8.03	85.00	16.04	7.05	7.15	17.62	3.75	4.20	3.20	16.04	4.45	9.75	3.24	11.25	2.20	2.15	1.70	10.90	2.15	2.02	1.77
Dec.	90.40	18.02	7.20	8.10	87.00	16.20	7.15	7.20	20.22	4.01	4.20	3.40	17.42	5.25	8.76	3.24	10.86	2.25	2.45	1.72	10.70	2.00	2.11	1.80
$\bar{X}$	68.99	14.82	5.26	6.13	64.65	13.89	4.89	4.97	26.42	3.73	3.75	2.66	24.78	3.96	5.12	2.98	20.17	1.58	1.71	1.45	13.17	1.54	1.58	1.51

Source: Fieldwork, 2011