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RESEARCH ARTICLE

QUALITY ASSESSMENT OF SOME SURFACE WATER IN ISRAEL AND NIGERIA FOR MULTIPURPOSE USAGE

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Abstract:

The quality and suitability of some surface water from Dead sea, Jordan and Galilee in Israel and Opobo, Asarama and Otamiri in Nigeria were assessed for potability and irrigation purposes by analyzing the water for physico-chemical parameters, Mg, Mn, Fe and Pb and irrigation indices using standard methods. The results obtained were compared with standard limits provided by World Health Organization and Standard Organization of Nigeria. The results were pH 5.70 – 8.24; Electrical Conductivity 386.1µS/cm – >100,000 µS/cm ; Turbidity 0 – 58.6 NTU; Salinity 0.9 - >40mg/l; TDS 14.5 - > 70,000mg/l; SO_4^{2-} 26.5 – 302mg/l; PO_4^{3-} <0.05 – 0.55mg/l; NO_3^- <0.05 – 3.55mg/l; Total Hardness 0.11 – 259, 618mg/l; Total Alkalinity 24 – 235mg/l; Cl^- 19.08 – 197, 600mg/l; Ca^{2+} 0.60 – 188, 536.32mg/l; Mg^{2+} 0.007 – 12, 130.56mg/l; DO 1.6 – 23.6mg/l; BOD 0.4 –66.4mg/l; Na 5.56 – 14, 374mg/l; Mn 0.052 – 2. 320mg/l; Fe 0.084 – 15.319mg/l; Pb <0.01 – 0.063mg/l. The levels of Electrical Conductivity, TDS, Total Hardness and Cl^- in all the stations except Otamiri exceeded permissible limits suggesting high mineralization Except for Opobo and Otamiri rivers the concentrations of Ca^{2+} and Mg^{2+} exceeded permissible limits. The Total Alkalinity of Dead Sea, Jordan and Galilee exceeded permissible limit. The Turbidity of all the rivers except Opobo river were below permissible limit. The water in Israel had higher concentrations of Mn, Fe and Pb and exceeded permissible limits. The number of parameters that exceeded limits followed the decreasing order: Dead Sea > Galilee. > Jordan > Asarama > Opobo > Otamiri. Irrigation indices showed Soluble Sodium Percent values >50% and Kelly's ratio >1meq/l at Opobo and Otamiri rivers Also Sodium Adsorption Ratio of Opobo river was > 26. Thus Opobo and Otamiri rivers were considered unsuitable for irrigation. The surface water in the study areas especially in Nigeria should be regularly monitored to avoid serious pollution problems.

Keywords**:** Water Quality, Opobo, Irrigation, Potable, Dead Sea, Israel, Nigeria

Introduction

Fresh and clean water is of fundamental importance to the survival, protection and development of human needs. Surface water is an essential and vital resource for humans. It is a major source of water for drinking, farming and manufacturing. Surface water can be contaminated by several sources. In farming areas, the routine application o agricultural fertilizers is the major source (Altman and Parizek, 1995; Emongor et. al. 2005; Purushtotham et. al. 2011). The presence of some ionic contents beyond certain limits may make it unsuitable for irrigation, domestic or industrial use (Deshpande and Aher 2011). In rural areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of the water (Chindah et. al., Emongor, et. al., Furtado et. al., 1998, Ugochukwu, 2004).

People are attracted to lakes, rivers, and coastlines for diverse reasons. Clean water is a crucial resource for drinking, irrigation, industry, transportation, recreation, fishing, hunting, support of biodiversity, and sheer aesthetic enjoyment. Throughout human history, water has been used to wash away and dilute pollutants. Pollutant inputs have increased in recent decades and have degraded water quality of many rivers, lakes and coastal oceans. Degradation of these vital water resources can be measured as the loss of natural systems, their component species, and the amenities that they provide (USEPA, 1996; Postel and Carpenter, 1997).

In advanced countries, environmental monitoring agencies are more effective and environmental laws are strictly followed. General environmental quality monitoring is compulsory and the monitoring of the quality of water resources is done on a regular basis (Robson and Neal , 1997; USEPA 1991; USEPA, 1995; USEPA, 1996) as a result, any abnormal changes in the environmental or water quality can easily be detected and appropriate action taken before the outbreak of epidemics. The case is quite opposite in many developing countries. Environmental laws where there are any, are rarely observed. The level of contamination of the various water bodies by anthropogenic activities is evaluated by comparing levels of the parameters with international standards.

The effect of poor water quality on human health was noted for the first time in 1854 by John Snow, when he traced the outbreak of cholera epidermic in London to the Thames river water which was grossly polluted with raw sewage. Since then, the science of water quality progressed. In the third world countries, 80% of all diseases are directly related to poor drinking water and unsanitary conditions (Sharma et. al., 1995). The industrial units located at the outskirt in cities, intensive agricultural practices and indiscriminate disposal of domestic and municipal wastes are the sources for the river water and groundwater pollution. Thus constant monitoring of river water and groundwater quality is needed so as to record anyalteration in the quality and outbreak of health disorders.

The dependence on freshwater from streams in swamp forests raises issues of environmental concern, following the increase of unregulated waste discharges into any available water body which may constitute serious health problems (Jonnalagadda and Mhere, 2001). The perceived consequence of the unregulated waste deposition into water bodies (used as potable water) has evoked various studies on the aquatic ecosystems (Ogan, 1998; Akpan and Offem, 1993; Chindah, 1998). The principal objective of the present study is to examine the chemical status and pollution levels of the waters of the study areas with a view to providing information on the physical and chemical characteristics of the water systems as well as their suitability for multipurpose (domestic and irrigation) use.

Materials and Methods

I. **Sampling Locations**

Six water bodies Galilee, Jordan and Dead sea in Israel and Opobo, Asarama and Otamiri in Nigeria were selected for assessment. The Sea of Galilee is a lake 8km wide and about 200m below sea level. It provides 30% water used in homes. The Dead Sea is about 400m below sea level. It contains a lot of minerals on which many industries depend. Opobo river is within Opobo Nkoro Local Government Area of Rivers State. It lies along the lower reaches of the Imo River, entering into the Atlantic Ocean at Bonny. Asarama river is in Andoni local government area of Rivers State. It is bordered by vegetation comprising 98% Nipa palm and Red mangrove. Otamiri river is one of the rivers in Owerri, Imo State of Nigeria. During water scarcity, the river acts as a source of domestic water to inhabitants of Egbu and inhabitants of other neighboring communities. The river also receives wastes from Egbu abattoir, Rokana Industry and domestic wastes produced by the inhabitants of the area. The identification and geographical locations of the sampling stations are shown in Table 1.

Table 1: Identification and Geographical positions of sampling locations

Location	**Geographical Position**	
	Northing (N)	Easting (E)
Dead Sea	31° 45′ 44.04″	35° 30′ 15.5″
Jordan	33° 11′ 12″	35° 37′ 09″
Galilee	32° 50′ 38.5″	35° 31′ 32.6″
Opobo	04° 30′ 55.68 ″	07° 32′ 30.42″
Asarama	04° 32′ 37″	07° 26′ 47″
Otamiri	05° 28′ 25.56″	07° 03′ 10.7″

II. **Collection and preparation Of Samples**

Water samples were collected using plastic containers. Six plastic bottles of water samples were collected in the area and taken to the laboratory for analysis. Sample collection was done using a clean 2-

litre polyethylene container for physico-chemistry and a clean 100ml polyethylene container for heavy metal analyses. For the preservation of the heavy metals, the sample was acidified with 5ml of concentrated HNO_3 acid. 100ml of the acidified water sample was put into a conical flask and 5ml of 50% hydrochloric acid was added to the flask and heated for 30 minutes on a steam bath. The solution was allowed to boil to a final volume of 40ml. The content was then filtered through a Whatman No. 1 filter paper (11cm) into 100ml volumetric flask and made up to the mark with deionized water (APHA, 1995).

III. **Sample Analysis**

pH, Conductivity and Turbidity were measured using Horiba water checker (Model U-10) after calibrating the instrument with the standard Horiba solution. The chemical parameters in the water were determined using standard analytical methods for water analysis (APHA, 1995; Trivedi and Goyal, 1986). Total dissolved solids (TDS) were computed by multiplying the electrical conductivity (EC) by a factor (0.64). Total hardness (TH) as $CaCO_3$, and calcium (Ca) were analyzed titrimetrically, using standard EDTA. Magnesium (Mg) was calculated by taking the differential value between total hardness and calcium (Ca) concentrations. The contents of Sodium (Na) and Potassium (K) in the samples were measured using Elico Flame Photometer. Nitrate (NO_3^-) was determined using the Brucine method. Sulphate (SO_4^{2-}) was determined by the Turbidimetric method. Phosphate (PO_4^{3-}) was determined using the Stannous Chloride method. Chloride (Cl^-) was determined by the Argentometric ($AgNO_3$ titration) method in the presence of potassium chromate indicator. Total Alkalinity was determined by Acid-Base titration method. Dissolved oxygen (DO) was determined by the modified Azide (Winkler) method. Biochemical Oxygen Demand (BOD) was determined by the Azide modification method. The concentrations of the metals in the digested water sample were measured using a BUCK SCIENTIFIC Atomic Absorption Spectrophotometer-model 200A.

IV. **Assessment of Water Quality for Irrigation Purpose**

The water quality of the study rivers was accessed to determine the suitability for agricultural purposes. Water for this purpose is required to meet certain safety standards that have been set by either WHO or other agencies (Obiefuna and Orazulike, 2010).

Water for agricultural purposes should be good for both plant and animals. Good qualities of waters for irrigation are characterized by acceptable ranges of such as sodium Adsorption Ratio (SAR), Kelly's Ration (KR) and indices soluble sodium percentage (SSP).

(a) Sodium Adsorption Ratio (SAR) was calculated by the equation given below (Richard, 1954).

$$SAR = \frac{(Na^{*})}{\sqrt{\{^{1}/_{2}\,[(Ca^{2*}) + (Mg^{2})]\}}}$$

Where, all the ions are expressed in meq/L.

(b) Soluble sodium percentage (SSP) was calculated by the equation of (Aher and Deshpande, 2011):

$$SSP = [Na^{+} \,/\, \left(Ca^{2+} + Mg^{2+} Na^{+}\right) \times 100]$$

Where, all the concentration of Ca^{2+}, Mg^{2+}, and Na^{+} are expressed in meq/L.

(c) Kelly's Ratio (KR) was calculated using the equation by (Todd, 1995)

$$KR = Na^{+} / Ca^{2+} + Mg^{2+}$$

Where, all the ionic concentrations are expressed in meq/L.

Results and Discussions

The results of the parameters measured in the surface water are presented in Table 2.

pH

The pH of surface water ranged from 5.7 at Dead Sea to 8.24 at rivers except Dead Sea are alkaline in nature and all the samples are within the guideline range recommended by (WHO, 2006; SON, 2007). pH is an important parameter for determining the quality of drinking water. It indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution. The results agreed with the report that surface water generally tends to be alkaline. (McNeely et. al. 1979). The pH of Dead Sea is acidic and not good for drinking and domestic purposes.

Electrical Conductivity (EC)

Electrical conductivity is the ability of an object to conduct electric current. It gives the total concentration of the electrolytes; it depends upon the presence of various ionic species. The electrical conductivity of the surface water ranged from 386.1µS/cm at Otamiri river to >100,000 µS/cm at Dead Sea. All the rivers except the Otamiri exceeded permissible limit. These values indicate high presence of ionic species and pose serious concern.

Turbidity

Turbidity in surface water ranged from 0 NTU at Dead Sea and Jordan to 58.6NTU at Opobo. The levels at the stations except Opobo are within standard limit. The high turbidity at Opobo could be as a result of erosion, runoff and human activities also contributed to such effects. High turbidity adversely affects domestic, industrial and recreational uses of water.

Turbidity is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow and Brownian movement (WHO, 2006).

Salinity

The values of salinity in the surface water ranged from 0.9 at Galilee to > 40 at Dead Sea The EC of water is a useful and easy indicator of its salinity or total content. In this study, it was discovered that the EC of surface water in some areas were high, which could be due to some soluble minerals from the bedrocks in agreement with the report of (Oluyemi et. al., 2010). The salinity values are less than 1000mg/L set by the World Health Organization (WHO, 1979). This implies that the water is within limit.

Table 2: Physico-Chemical parameters measured in Surface Water around Israel and Nigeria

Parameter	Dead sea	Jordan	Galilee	Opobo	Asarama	Otamiri	WH	O	SON
pH	5.70	8.24	7.1	7.44	7.6	8.0	6.5-9	.5	6.5-8.5
Elec. Cond.(µS/cm)	>100,000	3010	2040	16,090	9,000	386.1	120	0	1000
Turbidity (NTU)	0	0	4	58.6	4.31	2.10	5.0		5.0
Salinity (mg/l)	>40	1.5	0.9	8.98	11.3	10.8	-		-
TDS (mg/l)	> 70,000	2,107	1,428	14.5	13,300	155.0	100	0	500
SO_4^{2-} (mg/l)	96.9	62.0	26.5	215.7	302	285.4	500		100
PO_4^{3-} (mg/l)	0.07	<0.05	<0.05	<0.05	<0.05	0.55	-		-
NO_3^- (mg/l)	0.78	1.21	0.09	1.19	<0.05	3.55	50		10
Total Hardness (mg/l)	259,618	528.8	441.6	1916	1916	0.11	500		100
Total Alkalinity (mg/l)	235	192	167	32	24	27.0	100		100
Cl^- (mg/l)	197,600	647.1	869.4	6,422	6175	19.08	250		100
Ca^{2+} (mg/l)	188536.32	169.3	122.88	6.2	383	0.60	-		75
Mg^{2+} (mg/l)	12130.56	26.1	32.8	3.8	233	0.007	20		0.20
DO (mg/l)	1.6	6.9	7.3	11.4	11.4	23.6	-		-
BOD (mg/l)	0.8	0.4	3.04	1.6	6.1	66.4	-		-
Na (mg/l)	$14.374x10^3$	8.70	9.39	335.91	7.35	5.56	200		
Mn (mg/l)	2.320	0.184	0.746	0.184	0.073	0.052	0.4		0.05
Fe (mg/l)	15.319	3.967	5.747	0.208	0.124	0.084	0.3		0.3
Pb (mg/l)	0.030	0.083	0.163	<0.01	<0.01	<0.01	0.0	1	0.01
SAR	8.651	0.085	0.194	26.091	0.102	1.955	-		-
KR	0.060	0.004	0.046	23.305	0.016	7.903	-		-
SSP(%)	5.649	5.008	4.394	95.886	1.615	88.768	-		-

Total Dissolved Solid (TDS)

Surface water TDS ranged between 14.8mg/l at Opobo and > 70,000mg/l at Dead Sea. These values except the value at Opobo and Otamiri exceeded the permissible limit prescribed by WHO. The high TDS levels in surface water could be attributed to municipal and industrial effluents, agricultural runoff, and aerosol fallout. Fishing activities could have also contributed to the high TDS values in the rivers. Total Dissolved solids (TDS) are index of the amount of dissolved substances in the water (McNeely et. al., 1979). In natural water dissolved solids are composed of carbonates, bicarbonates, chlorides, sodium, sulphate magnesium and phosphate. Concentrations of dissolved solids are important parameter in drinking water. The total dissolved solids (TDS) indicate the general nature of salinity of water (Aher and Deshpande, 2011). The levels of TDS in the rivers except Opobo and Otamiri indicate that the rivers are very saline and poor for irrigation.

Dissolved Oxygen (DO)

The DO in surface water varied from 1.6mg/l at Dead Sea to 23.6mg/l at Otamiri. Oxygen is one of the gases that are found dissolved in natural surface water. The amount of dissolved oxygen in natural water varies since it is dependent upon temperature, salinity, turbulence (mixing) of the water and atmospheric pressure (decreasing with altitude). Dissolved oxygen concentrations produce no adverse physiological effect on man; however, adequate amounts of dissolved oxygen must be available for fish and other aquatic organisms (McNeely et. al., 1979). Many aerobic organisms cannot survive below certain levels of dissolved oxygen. Drinking water criteria do not specify any guidelines for dissolved oxygen. However, waters saturated with dissolved oxygen are preferable for drinking as improved palatability results from dissolved oxygen's ability to precipitate substances such as iron and manganese, which produce undesirable tastes (McNeely et. al., 1979).

Biological Oxygen Demand (BOD)

BOD in surface water varied from 0.4mg/l at Jordan to 66.4mg/l at Otamiri. Water with high BOD values may be unsuitable for irrigation purposes, since they may restrict plant growth. The biochemical oxygen demand of water is the amount of oxygen required to oxidize the organic matter by aerobic microbial decomposition to a stable inorganic form.

No specific guidelines for BOD was proposed by (WHO, 2006; SON, 2007) but values in literature show that water with BOD levels less than 4mg/l are deemed reasonably clean. Waters with levels greater than 10mg/l are considered polluted since they contain large amounts of degradable organic materials (McNeely et. al., 1979). Otamiri River had higher BOD (10mg/l) than others indicating pollution.

Sulphate (SO_4^{2-})

Sulphate concentrations varied between 26.5mg/l at Galilee and 302mg/l at Asarama. The concentrations of Sulphate in the surface water in the study areas were below the permissible limit (500mg/l) recommended by (WHO, 2006; SON, 2007).

Phosphate (PO_4^{3-})

Phosphate levels ranged between <0.05 in most rivers and 0.55mg/l at Otamiri. The permissible limit found in literature ranged between 0.05 to 1.0mg/l (Fadiran et. al., 2008). This implies that the water is acceptable for drinking with respect to phosphate.

Nitrate (NO_3^-)

The concentrations of nitrate in the study rivers varied from 0.09mg/l at Galilee to 3.55mg/l at Otamiri. The highly soluble nitrate ion which is the most stable form of combined nitrogen in surface water, results from the complete oxidation of nitrogen compounds. The consumption of waters with high nitrate concentrations decreases the oxygen-carrying capacity of the blood. (McNeely et. al., 1979). The levels of nitrate in all the accessed were below permissible limits and indicate low presence of nitrogen compounds.

Chloride (Cl^-)

Chloride ions are generally present in natural waters and its presence can be attributed to dissolution of salts. The concentrations of chloride in the surface water ranged between 19.08mg/l at Otamiri and 197,600mg/l at Dead Sea. The chloride levels in all rivers except Otamiri exceeded the 250mg/l guideline set by (WHO, 2006; SON, 2007). The high chloride value in surface water samples could be due to the weathering and leaching of sedimentary rocks and soils (McNeely et. al., 1979). Chloride contamination can originate from sewage and industrial effluents and saline intrusion (Vengesh and Pankratov, 1998).

Total Hardness (TH)

Total Hardness in surface water at the study rivers varied from 0.11mg/l at Otamiri to 259618mg/l at Dead Sea. The TH levels at Dead Sea, Jordan, Opobo and Asarama rivers exceeded limit and are attributed to high presence of calcium, magnesium, carbonate, and hydrogen-carbonate in the water. Hard water results in the formation of scale on boilers and pipes and it adversely affects textiles, plating, and canning industries and also results in increased soap consumption, which affects both domestic and industrial cleaning and laundering activities (McNeely et. al., 1979).

Alkalinity

Total Alkalinity varied from 27mg/l at Otamiri to 235mg/l at Dead Sea. The levels at Dead Sea, Jordan and Galilee exceeded the standard limit of 100mg/l set by WHO, (2006). When water with high alkalinity is boiled over an extended time period, either a deposit may be formed or an unpleasant taste is created depending upon the chemical reaction. However, total alkalinity in this study can corrode pipes and plumping materials.

Alkalinity indicates the presence of carbonates, bicarbonates, and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances. (McNeely et. al., 1979).

Calcium (Ca)

The concentrations of calcium in surface water showed high concentrations at Dead Sea, Jordan, Galilee and Asarama and ranged from 0.60.mg/l at Otamiri to 188536.32.mg/l at Dead Sea. Although WHO has no standard for calcium, the concentrations in surface water are above the permissible limit of 75mg/l by SON (2007). The main source of calcium in natural water is leaching of rocks in the catchments (Raeshekhar, 2007). The values of calcium in surface water measured at all stations except Opobo and Otamiri were higher than 75mg/l, which is an indication that the water is polluted with calcium.

Magnesium (Mg)

Magnesium, an alkaline-earth metal, is an abundant element and a common constituent of natural water. Natural sources clearly outweigh all cultural inputs of this constituent to the natural environment. Ferromagnesian minerals in igneous rock and dolomitic sedimentary rocks are the principal contributors of magnesium to water. (McNeely et. al., 1979). The magnesium values in the surface water ranged from 0.007mg/l at Otamiri to 12130mg/l at Dead Sea. Surface water recorded very high levels of Mg^{2+} in most stations which is more than the permissible limit (20mg/l) of WHO (2006). The high concentration of magnesium indicates that the surface water in the study area is polluted.

Manganese (Mn)

The concentrations of Manganese in surface water ranged from 0.05mg/l at Otamiri to 2.320mg/l at Dead Sea. The concentrations of Mn in surface water from the rivers except Dead Sea were within the permissible limit of (0.4mg/l) by SON (2007) and 0.05mg/l by SON (2007). This is an indication that the surface water at Dead Sea is poor. Manganese is an essential element for the nutrition of both humans and animals. A manganese deficiency may inhibit growth, disrupt the nervous system, and interfere with reproductive function. It is an essential element for plant metabolism (McNeely et. al., 1979).

Total Iron (Fe)

Iron concentrations in surface water ranged between 0.084mg/l and 15.319mg/l. The concentrations of Fe in surface water from Nigeria were below SON and WHO guidelines (0.3mg/l) for Iron while those from Israel exceeded the limits. In water, Iron can discolor cloths, plumbing materials, and cause scaling which encrusts pipes. Iron is highly objectionable for drinking water because of the stringent taste (DNHW, 1969).

Sodium (Na)

The concentration of sodium in this study varied between 5.56mg/l at Otamiri and 14374mg/l at Dead Sea. The levels at Dead Sea and Opobo exceeded the limit (200mg/l) set by WHO (2006), SON (2007).

Lead (Pb)

The concentrations of lead in this study ranged from < 0.01mg/l in rivers from Nigeria and 0.163mg/l at Galilee. The values from Nigeria were below the limit value of 0.01mg/l by WHO (2006), SON (2007) while those from Israel exceeded the limit. Lead is the most significant toxin and if released into the environment can bio accumulate and enter the food chain. Lead has damaging effects on body nervous system. Lead being frequently used in the construction of water supply distribution systems like pipes, brass, bronze fixtures, these contaminate drinking water as a result of the corrosion that takes place when water comes in contact with (Bakarji and Krajo, 1999).

Sodium Adsorption Ratio (SAR)

The sodium adsorption Ratio is important in evaluating the suitability of water used for agricultural irrigation. This ratio is an estimate of the degree to which sodium will be adsorbed by soil from water. The value is calculated from the ionic concentration of sodium, calcium, and magnesium. The SAR value less than or equal 10 are said to be excellent quality; 10-18 are good, 18 to 26 are fair and about 26 are said to be unsuitable for irrigation (USDA, 1954). Sodium adsorption ratios of the water in all the stations are less than 10 indicating excellent quality of the water for irrigation. There are significant relationships between SAR values of irrigation water and the extent to which sodium is absorbed by soil. If the water used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium (Tatawat and Singh-Chandel, 2007).

Kelley's Ratio (KR)

A Kelley's Ratio of more than one (1meq/l) indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are suitable for irrigation (Deshpande and Aher, 2011). The values of Kelley's Ratio in all the rivers except Opobo and Otamiri were less than 1 and are suitable for irrigation. This implies that the Opobo and Otamiri rivers in Nigeria are not suitable for irrigation.

Soluble Sodium Percentage (SSP)

The soluble sodium percentage values less than 50% or equal to 50% indicates good quality water and if it is more than 50% indicates unsuitable water quality for irrigation (Deshpande and Aher, 2011). The soluble sodium percentage values obtained at Opobo (95.386%) and Otamiri (88.768%) were higher than 50%. This implies that of the rivers studied all in Isreal and Asarama in Nigeria are good for irrigation while Opobo and Otamiri rivers are not good for irrigation. High percentage sodium water for irrigation purpose may stunt the plant growth and reduce soil permeability (Joshi et. al., 2009).

Conclusion

The findings of this study showed that the surface water in the area had high levels of EC, TDS, SO_4^{2-}, Cl^-, Total Hardness, Ca^{2+}, Mg^{2+} and turbidity The contamination of the water can lead to contamination of aquatic lives on which the inhabitants depend. It is therefore concluded that the water in the area is not potable.

The levels of EC, TDS, Total Hardness, Cl^- in all the stations except Otamiri exceeded permissible limits suggesting high mineralization. Except for Opobo and Otamiri rivers the concentrations of Ca^{2+} and Mg^{2+} in the other rivers exceeded permissible limits. The total Alkalinity of Dead Sea, Jordan and Galilee exceeded permissible limit. The Turbidity of all the rivers except Opobo river were below permissible limit. The water in Israel had higher concentrations of Mn, Fe, Pb exceeding permissible limits than the water in Nigeria. The number. of parameters that exceeded limits followed the decreasing order: Dead Sea > Galilee > Jordan > Asarama > Opobo > Otamiri. This implies that the Otamiri river is comparatively clean. However Otamiri river had high BOD indicating large amounts of degradable organic materials. The irrigation indices showed Soluble Sodium Percent values >50% and Kelly's ratio >1meq/l at Opobo and Otamiri rivers which are considered unsuitable for irrigation. This was confirmed in Opobo river where Sodium Adsorption Ratio was > 26. Thus the water at Opobo and Otamiri are not suitable for irrigation. The surface water in the areas especially in Nigeria should be regularly monitored to avoid serious pollution problems.

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FIG. 1 Sectional Map of Israel showing Dead sea, Jordan River and Galilee

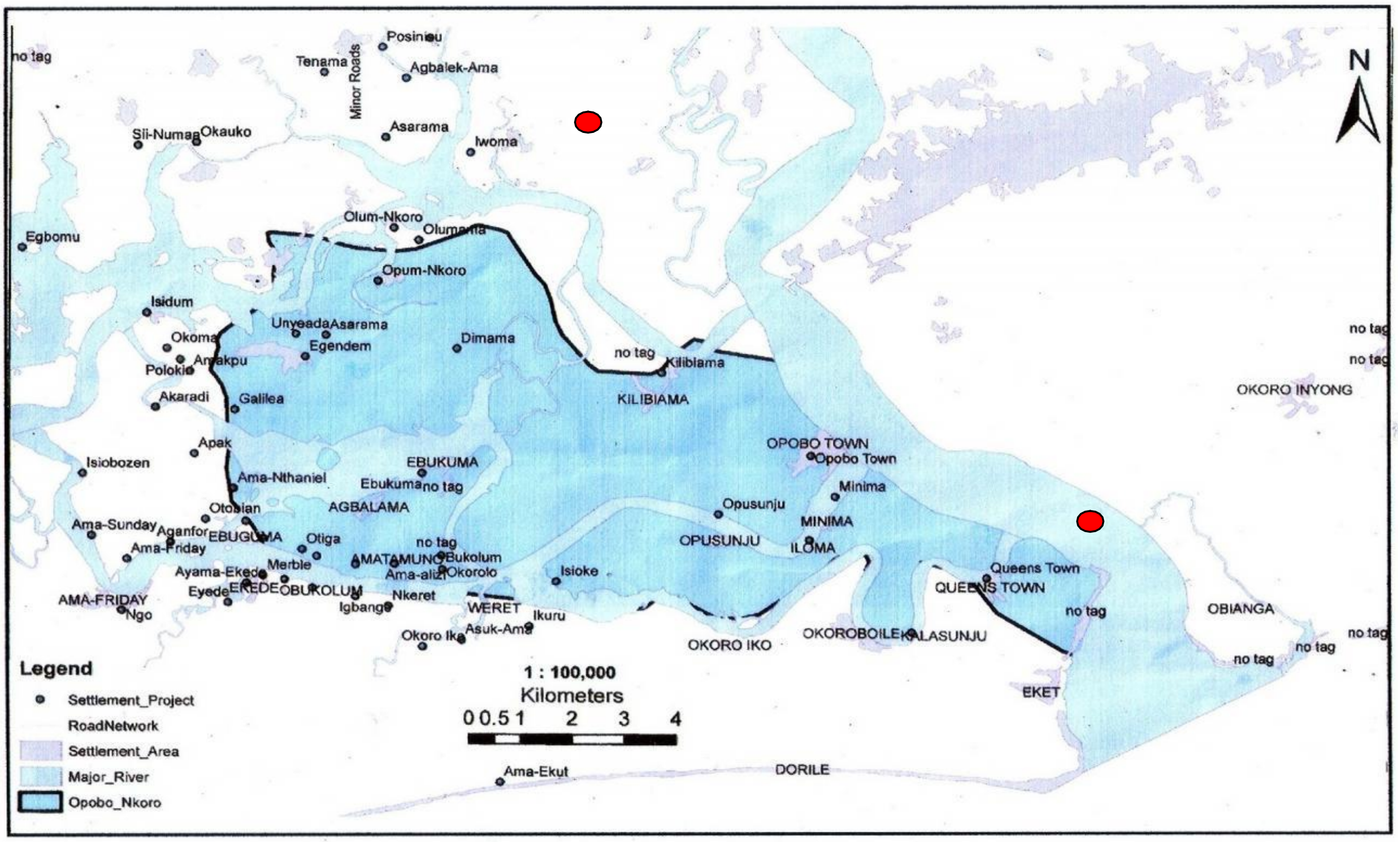

FIG. 2 Map showing Opobo and Asarama Rivers in Rivers State of Nigeria

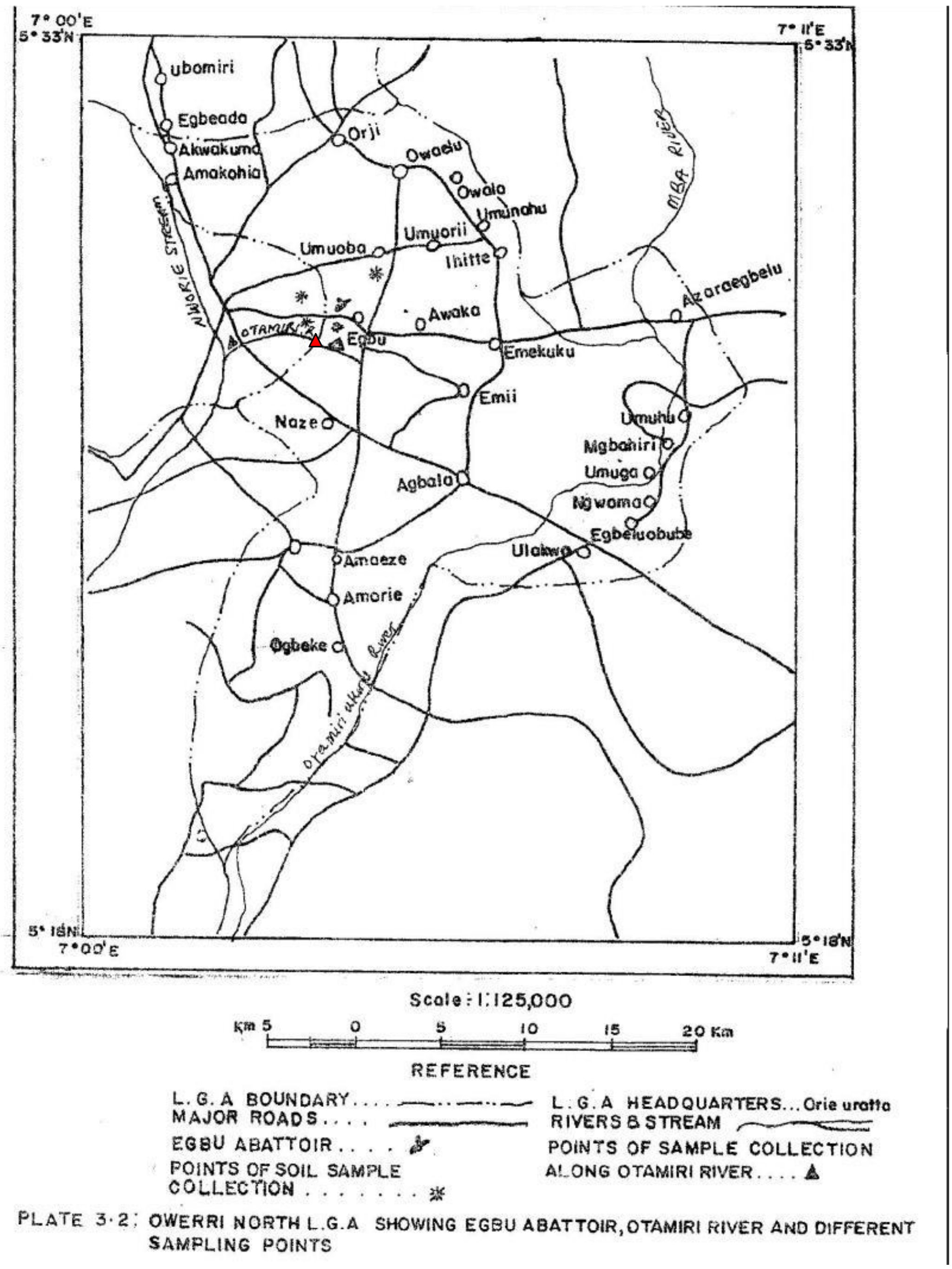

Fig. 3: Map showing Otamiri River in Imo State