Malaysian Journal Of Civil Engineering

Full Paper

# ASSESSMENT OF SURFACE WATER QUALITY OF ERO DAM FOR IRRIGATION PURPOSE

**Article history**
Received
*07 October2019*
Received in revised form
*26 November 2019*
Accepted
*26 November 2019*
Published online
*30 November 2019*

Olorunwa Eric Omofunmi[a], Folasade Atinuade Fasiku[a], Kayode Samuel Ogunleye[b]

[a]Department Of Agricultural And Bioresources Engineering, Federal University Oye-Ekiti, Nigeria
[b]Department Of Soil Science And Land Management, Federal University Oye-Ekiti, Nigeria

*Corresponding author
olorunwa.omofunmi@fuoye.edu.ng

**Abstract**

The physicochemical parameters of surface water surface of Ero Dam for irrigation were assessed. Water samples were selected from three locations (upstream, downstream and control). Tested parameters for water samples are pH, electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca2+), magnesium (Mg2+), sodium (Na+), potassium (K+), chloride (Cl-), carbonate (C03-), bicarbonate (HC03-), boron (B), sulphate (S042-), nitrate (NO3-N) and phosphate (PO4-P). The samples were determined in accordance with the American Public Health Association standards. Data were analysed using descriptive statistics. Evaluation of surface water quality of Ero Dam was carried out using different irrigation indices methods such as sodium adsorption ratio (SAR), residual sodium carbonate (RSC), sodium percentage (Na %), potential salinity (PS), The Soluble sodium percentage (SSP), Kelly ratio (KR), magnesium adsorption ratio (MAR) and permeability index (PI) and compared with standard limits. The findings indicated that the concentrations of the Ca2+, Mg2+, Na+, K+, Cl-, C03-, HC03-, B, S042-, NO3-N and PO4-P were within the acceptance limits for irrigation purposes except K+ that above the limits specified. Results indicated that majority, 87.5% of irrigation indices fall under excellent or suitable and classified as salinity (C1) and SAR (S1) which was known as (CISI). Hence, there are none degree of restriction in the application Ero Dam water quality for irrigation. Therefore, the results were concluded, that the study area surface water quality was suitable for irrigation.

*Keywords*: Assessment, Ero Dam, irrigation indices, suitability, water quality



## 1.0 INTRODUCTION

Water is one of natural resources that sustaining life. Any form of life cannot survive without water. Survival of its people particularly of those living in rural areas especially semi-arid and arid regions and they engaging in farming activities, lie on the resources it generates from the agricultural practices. Application of water (irrigation) is highlighted by FAO, 2011 are as follows:

(i) It uses has been an essential factor in raising productivity of agriculture and ensuring predictability in outputs.
(ii) It is raising productivity, sustainable water management (especially when combined with adequate soil husbandry) helps to ensure better production both for direct consumption and for commercial disposal,

(iii) It is enhancing the generation of necessary economic surpluses for uplifting rural economies.
(iv) It promotes dry session farming which enhances agricultural sustainability.

Several researchers such Prasad et al (2001), Van de Graff and Patterson (2001), Jaji et al (2007), Joshi et al (2009) and Nishanthiny (2010) reported that water used for irrigation depends primarily on quantity and type of dissolved salts, which influences its quality and suitability. Researchers such as Ayers and Westcot (1994), Bauder et al. (2004) reported that assessing water quality for irrigation purposes, the following key water qualities such as pH, EC, TDS, Ca2+, Mg2+, Na+, K+, Cl-, C03-, HC03-, B, S042-, NO3-N and PO4-P concentrations must be measured. Richards (1954), Ayers and Westcot (1994), Prasad et al. (2001), Van de Graff and Patterson (2001), Seilsepour et al. (2009) and Bauder et al. (2004) reported that irrigation index parameters are based on the following parameters which includes electrical conductivity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), sodium percentage (Na %), potential salinity (PS), The Soluble sodium percentage (SSP), Kelly ratio (KR), magnesium adsorption ratio (MAR) and permeability index (PI). They are major parameters determining necessary management requirement and influenced soil productivity (Talukder, et al., 1999, Bauder, et al., 2004, Al-Omran, et al., 2010). Joshi et al (2009) and Kankal et al (2012) reported that SAR, KR and RSC are the most important irrigation indexes that influence the water quality suitability. Permeability hazard of irrigation water is attributed to the combinations of SAR and EC (UCC, 1974; Ayers and Westcot, 1994). Guidelines for the assessment of salinity and sodium hazards of irrigation water were reported by Wilcox (1955), Kelly (1963), Doneen (1964), and Ayers and Westcot (1985) and are presented in Tables 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively.

**Table 1** Classification of Irrigation water based on salinity hazard

| Measure Parameter | Limitation | | |
|---|---|---|---|
| | Not any | Moderately | Severe |
| ECw (dS/m) | <0.7 | 0.7 – 3.0 | >3.0 |
| TDS (mg/l) | <450 | 450 – 2000 | >2000 |

Source: Ayers and Westcot (1985)

**Table 2** Irrigation water quality based on Electrical Conductivity (EC) values

| EC(μs/cm) | Salinity Class | Water Class/Interpretation |
|---|---|---|
| <250 | C1 | Excellent or Low |
| 250 – 750 | C2 | Good or Medium |
| 750 – 2250 | C3 | Permissible or High |
| 2250 - 5000 | C4 | Unsuitable or Very high |

Source: Ayers and Westcot (1985)

**Table 3** Classification of water quality based on chloride, boron, nitrate and bicarbonate values (Cl, B, N03- N and HC03-)

| Potential Irrigation Problem | Limitation | | |
|---|---|---|---|
| | Not any | Moderately | Severe |
| Chloride (meg/L) | <4 | 4 – 10 | >10 |
| Boron (mg/L) | <0.7 | 0.7 – 2 | >2 |
| Nitrate (mg/L) | <5 | 5 – 30 | >30 |
| Bicarbonate (meg/L) | <1.5 | 1.5 – 8.5 | >8.5 |

Source: Ayers and Westcot (1985)

**Table 4** Classification of irrigation water based on boron concentration relation to plant tolerance

| Classification | Sensitive Plants | Semi-tolerant Plants | Tolerant Plants |
|---|---|---|---|
| Excellent | <0.3 | <0.6 | <1.0 |
| Good | 0.4 – 0.6 | 0.7 – 1.3 | 1.0 – 2.0 |
| Fair | 0.7 – 1.0 | 1.4 – 2.0 | 2.1 – 3.0 |
| Poor | 1.1 – 1.3 | 2.1 = 2.5 | 3.1 – 3.8 |
| Unsuitable | >1.3 | >2.5 | >3.8 |

Source: Ayers and Westcot (1985)

**Table 5**Classification of water based on sodium Adsorption ratio values (SAR)

| SAR | Classification | Water Class/Interpretation |
|---|---|---|
| 0 - 10 | S1 | Excellent or Low |
| 10 - 18 | S2 | Good or Medium |
| 18 - 26 | S3 | Permissible or High |
| >26 | S4 | Unsuitable or Very high |

Source: Ayers and Westcot (1985)

**Table 6** Classification of water based on residual sodium carbonate values (RSC)

| RSC (meg/L) | Water Class/Interpretation |
|---|---|
| <1.25 | Safe |
| 1.25 – 2.50 | Permissible |
| >2.50 | Unsuitable |

Source: Ayers and Westcot (1985)

**Table 7** Classification of water based on sodium percentage values (Na %)

| (%Na) | Water class/Interpretation |
|---|---|
| <20 | Excellent |
| 20 – 40 | Good |
| 40 – 60 | Permissible |
| 60 – 80 | Doubtful |
| >80 | Unsuitable |

Source: Wilcox (1955)

**Table 8** Classification of water based on Potential Salinity values (PS)

| PS (meg/L) | Water Class/Interpretation |
|---|---|
| <20 | Excellent |
| 20 – 40 | Good |
| 40 – 60 | permissible |
| 60 - 80 | Doubtful |
| >80 | Unsuitable |

Source: Ayers and Wescot (1985)

**Table 9** Classification of water based on SSP, KR and MAR values

| Water Class | SSP | KR | MAR (%) |
|---|---|---|---|
| Suitable | <60 | <1 | <50 |
| Unsuitable | >60 | >1 | >50 |

Source: Kelly (1963)

**Table 10** Classification of water based on permeability index (PI) values

| PI (%) | Classification | Water Class/Interpretation |
|---|---|---|
| <25 | C3 | Unsuitable or low |
| 25 – 75 | C2 | Good or Medium |
| >75 | C1 | Excellent or High |

Source: Doneen (1964).

For agricultural sustainability in Nigeria, both Federal and State Governments have set up regional irrigation scheme through the construction of dams and reservoirs in order to make water available to the farmers with small charges. Ero Dam is serving dual purposes include drinking and irrigation. Hence, this study is aim to determine the concentrations of physicochemical parameters of surface water of Ero Dam and its suitability for irrigation

## 2.0 MATERIAL AND METHODS

### 2.1 Description of the Study Area

Ero dam is located at Ikun – Ekiti in Moba Local Government Area of Ekiti State as shown in Figure 1. The dam is constructed on Ero River which takes its source from the highland region of Orin-Ekiti in Ido-Osi Local Government. The enlargement of the dam water as it flows is as a result of the contributions of the river tributaries as it is usually small at its source. These tributaries include Afintoto, Ayo, Igo, Igbegbe, Ipu, Irara, Ilogbe eran and Ofu rivers (Adedeji, 1993). Geographically, Ero Dam is located on intersect of latitude 70 351N and 70 301N of the equator and on longitude 50 311E and 50 281E of the Greenwich meridian. The dam site at Ikun Ekiti is bounded in the North by Kwara state, in the West by Ikosu-Ekiti, in the South by Ijesamodu-Ekiti and in the East by Ilejemeje Local Government Area. Ikun –Ekiti is a border town between Ekiti state and Kwara state and it is located at about 70 km from Ado, the Ekiti state capital. The impoundment area is about 4.5 km, the water surface area is about 450 hectares and it has a maximum capacity of about 20.9 million cubic metres.

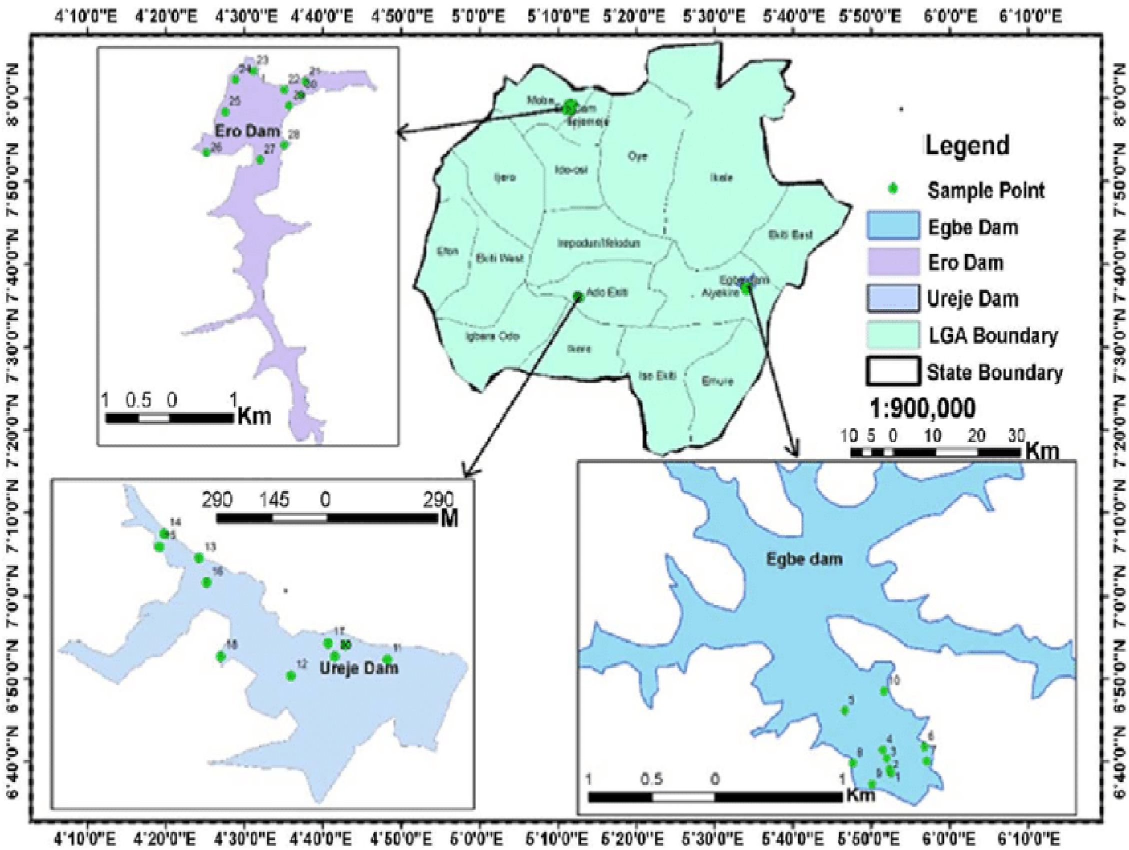


**Figure 1** Map of Ekiti State showing the study area.

### *2.1.1. Geology*

Geologically, the study area consisted basement complex sedimentary rock known as dolostone and metamorphic rock known as feldspar. The rock is generally even textured and homogenous with mineral aggregates mainly of dolomites. The rocks are rich in dolomite and also feldspar. The superficial deposits are clay, dolomites and fine sand (SiO2). The clay is believed to have be formed from the weathering of dolomites mineral present in sedimentary rocks due to alteration of sedimentary by hydrothermal process and the dolomitic marbles due to high degree of cyclic weathering.

### 2.2 Experimental Procedures

The required water samples were collected at selected locations (upstream, downstream and Iworoko bridge as control) with 1000 ml plastic bottle each and field filtration was carried out through filter papers to remove suspended solids. Samples were taken at 50 cm depth of water in the morning (10 a.m) analyses were performed next day. Measured physicochemical water quality parameters were pH, EC, TDS, Ca2+, Mg2+, Na+, K+, Cl-, C03-, HC03-, B, S042-, NO3-N and PO4-P). Measurements replicated three times.

### 2.3 Measurements Of Water Quality Parameters

The pH and EC were taken in-situ using a multi parameter EC-D 1152 model and 215 model pH meters respectively. Ca2+, Mg2+, Na+, K+ were measured using Atomic Absorption Spectrophotometer (AAS). Titrimetric method was used to measure for chloride, boron, nitrate, phosphate, sulphates, carbonate and bicarbonate. All the measurement was done in accordance with the American Public Health Association (APHA, 2005).

### 2.4 Data Analysis

SPSS program version 17.0 was used for statistical analysis. Mean values of each parameter measured was compared using Duncan`s multiple range test. The statistical inference was at 0.05 (5%) level of significance. Equations used for irrigation indices as follows:

(1) The Sodium Adsorption ratio (SAR)

$$SAR = \frac{Na^+}{\frac{(Ca^{2+}+Mg^{2+})^{\frac{1}{2}}}{2}}$$

Richards (1954) (1)

(2) The Residual Sodium Carbonate (RSC)

$$RSC = (CO_3{}^{2-} + HCO_3{}^{-}) - (Ca^{2+} + Mg^{+2})$$

Easton (1950) (2)

(3) The Magnesium Adsorption ratio (MAR)

$$MAR = \frac{Mg^{2+}}{(Ca^{2+}+Mg^{2+})} \; x \; 100$$

Raghunath (1987) (3)

(4) The Kelly ratio (KR)

$$KR = \frac{Na^+ \; x \; 100}{(Ca^{2+}+Mg^{2+})}$$

Kelly (1963) (4)

(5) The Potential Salinity (PS)

$$PS = Cl^- \; x \; 0.5 \; x \; SO_4^+$$

Palacious and Aceves (1970) (5)

(6) Sodium Percentage (Na %)

$$Na\% = \frac{Na^+ + K^+}{Ca^{2+}+Mg^{2+}+Na^+ + K^+} \; x \; 100$$

Wilcox (1955) (6)

(7) The Soluble sodium percentage (SSP)

$$SSP = \frac{Na^+}{Ca^{2+}+Mg^{2+}+Na^+} \; X \; 100$$

Todd and Mays (2005) (7)

(8) The Permeability Index (PI)

$$PI = \frac{Na^+ + (HCO_3^- \; x \; 100)^{1/2}}{Ca^{2+}+Mg^{2+}+Na^+}$$

Doneen (1964) (8)

(All the ions are expressed in meg/L)

## 3.0 RESULTS AND DISCUSSION

### 3.1. pH

The mean of pH ranges from 7.1 - 7.4 (Table 11). The pH of water samples at the selected locations were within the specified standard limits of 6.5 - 8.5 (FAO, 2013). The pH of the water sampled ranged from neutral to basic (alkaline). pH higher than 7, carbonate becomes an issue and it may nutrients less available. The concentrations of pH in the study area were suitable for some crops except acid-loving plants such vegetables (sweet corn, cucumbers, and onions) and fruits (blue berries).

### 3.2 TDS and EC

They are indicators of salt concentration in water. The TDS concentration measured in the study area ranged (30 - 50) mg/L, while EC ranged (0.04 - 0.05) ds/m (Table 11). The measured values of TDS and EC were within standard limits recommended for irrigation (FAO, 2013). There is no degree of restriction of using water for irrigation (Table 1). The EC is indicated to be excellent and classified as C1 (Table 2). Concentrations of EC were suitable for all crops that grown in the study area.

### 3.3 Sodium, Calcium, Magnesium, Sulphate, Bicarbonate, Carbonate, Chloride, and Boron (Cations and Anions)

The concentrations of Na+, Ca2+, Mg2+, S042- , HC03-, C03-, Cl- , and (B) range from (2.9 – 3.5) mg/L, (3.12 – 4.60) mg/L, (20.7 – 35.8) mg/L, (0.15 – 0.18) mg/L, (65.4 – 82.6) mg/L, (0.60 – 0.81) mg/L, (6.2 – 7.7), and (0.87 – 1.12) mg/L respectively (Table 11). The values were within standard limits recommended for irrigation (FAO, 2013). There is no degree of restriction especially in the concentrations of chloride and nitrate, but concentrations of boron and bicarbonate proved to be slightly moderate degree of restriction on use (Table 3). The concentration of boron is classified as good and suitable for semi-tolerant plants (Table 4). Irrigation water that contains ample calcium is most desirable, but it fall below desirable range of 40 – 120 mgL-1 despite it within standard limits. Sodium, calcium and magnesium were used to establish the relationship to total salinity and to estimate the sodium hazard (SAR, Na%, KR, SSP, and PI). HC03- levels is indicates low value and it reflects pH level. Both bicarbonate and carbonate concentrations are used to assess sodium permeability hazard especially if their levels are greater than 120 and 15 mg/L respectively. While Cl- is used to estimate potential salinity which indicates salinity hazard

### 3.4 Potassium, Phosphate and Nitrate (Nutrients)

The concentrations of K+, PO4-P, and NO3-N range from (2.6 – 3.5) mg/L, (0.37 – 0.89), and (0.78 – 1.02) mg/L respectively (Table 11). The values were within standard limits recommended for irrigation except potassium (FAO, 2013). High concentration of potassium may be attributed to metamorphic rock and also present of feldspar which riches of potassium. Hence, it depends on the inherent property of the soil in the study area. Research conducted by U.S. Salinity Laboratory Staff (1954) proved that potassium can be expressed in term of potassium adsorption ratio (PAR) by replaced sodium with potassium concentration as what is obtained in SAR, but there are no guidelines based on standard reference related to irrigation water quality assessment (Ayers and Westcot, 1985, Wallender and Tanji, 2012). Researchers such as Arienzo et al (2009) and Rengasamy and Murchuk (2011) proved that accumulation of potassium reduces in standard hydraulic conductivity of water in soil.

**Table 11** Average concentration of physicochemical parameters of the study area at selected locations

| S/N | Parameters | Upstream | Downstream | Iworoko first bridge | FAO (2013) |
|---|---|---|---|---|---|
| 1 | pH | 7.4a | 7.1a | 7.2a | 6.5 – 8.5 |
| 2 | Electricity conductivity (dS/m) | 0.05a | 0.04a | 0.05a | 0 - 3.0 |
| 3 | Total dissolved solid (mg/L) | 50a | 30a | 40a | 0 - 2000 |
| 4 | Chloride (mg/L) | 6.1a | 7.7a | 7.6a | 0 – 500 |
| 5 | Phosphate (mg/L) | 0.37a | 0.41a | 0.89a | 0 - 2 |
| 6 | Sulphate (mg/L) | 0.19a | 0.18a | 0.15a | 0 - 960 |
| 7 | Bicarbonate (mg/L) | 65.4a | 76.3b | 82.6b | 0 - 300 |
| 8 | Carbonate (mg/L) | 0.81a | 0.71a | 0.60a | 0 - 30 |
| 9 | Nitrate (mg/L) | 0.96a | 1.02a | 0.78a | 0 - 10 |
| 10 | Boron (mg/L) | 0.87a | 1.01a | 1.12a | 0 - 2 |
| 11 | Sodium (mg/L) | 2.9a | 3.3a | 3.5a | 0 - 440 |
| 12 | Potassium (mg/L) | 2.6a | 3.4a | 3.5a | 0 - 2 |
| 13 | Calcium (mg/L) | 3.12a | 4.60a | 4.41a | 0 - 400 |
| 14 | Calcium hardness (mg/L) | 5.71a | 8.40a | 8.45a | 0 - 150 |
| 15 | Magnesium (mg/L) | 35.8a | 29.5a | 20.7b | 0 - 60 |
| 16 | Magnesium hardness (mg/L) | 10.4a | 5.60b | 1.90c | 0 - 50 |

Means with similar letters do not differ ($P \geq 0.05$) significantly (horizontal comparisons only)

### 3.5 Irrigation Water Quality Analysis Parameters

#### *3.5.1 Sodium Adsorption Ratio (SAR)*

Sodium is generally expressed as sodium adsorption ratio, which indicates it hazard and also relationship with concentrations of calcium and magnesium. The concentration of sodium to that of calcium and magnesium is the primary factor determining the hydraulic conductivity of water in soil. It ranges from 0.210 to 0.323 (Table 12) indicates low values which reveals that the surface water of Ero Dam is free from sodium hazard. Significant relationship between SAR values of irrigation water reflects to which Na+ is absorbed by the soil. All the SAR in the study area is indicated to be excellent and classified as S1 (Table 5).

#### *3.5.2 Residual Sodium Carbonate (RSC).*

It serves as alternative means of measuring the sodium hazard. It ranges from-1.103 megL-1 to 0.740 megL-1 (Table 12). The negative RSC Value indicates that dissolved calcium and magnesium ions greater than that of carbonate and bicarbonate contents vice versa. All the RSC indicated to be safe water quality for irrigation purpose (Table 6). It serves as indicators of soil permeability. Hence, water samples were safe according to water class set by Ayers and Westcot (1985).

#### *3.5.3 Sodium Percentage (Na %)*

It is also used for evaluation of sodium hazard. It ranges from 11.2 to 15.5 (Table 12). It indicates low level. The entire Na% indicated to be excellent water quality for irrigation purpose (Table 7). The value depends on Na+, K+, Ca2+ and Mg2+levels in water samples.

#### *3.5.4 Potential Salinity (PS)*

It is another way of expressing electrical conductivity and it is used to evaluate salinity hazard (total soluble salt concentration) of water. It ranges from 0.359megL-1 to 0.455megL-1 (Table 12). It indicates low level. The entire PS indicated to be excellent water quality for irrigation purpose (Table 8). It value depends on Cl- and SO42- levels in water samples.

#### *3.5.5 Soluble Sodium Percentage (SSP)*

The value of SSP ranges from 7.73% to 10.14% (Table12). The entire SSP values for water surface of study area are less than 60 % and indicate good quality water for irrigation purpose (Table 9). It indicates low level and depends on Na+, Ca2+ and Mg2+levels in water samples. It is used to evaluate sodium hazard.

#### *3.5.6 Kelly Ratio (KR)*

The value of KR ranges from 0.084 to 0.164 (Table12). The entire KR values for water surface of study area are less than 1 and indicate suitable water quality for irrigation purpose (Table 9). It indicates low level and depends on Na+, Ca2+ and Mg2+levels in water samples. It is used to evaluate sodium hazard

#### *3.5.7 Magnesium Adsorption Ratio (MAR)*

The value of MAR ranges from 88.7% to 95.1% (Table 12). It is used to evaluate magnesium hazard in water quality for irrigation. The entire MAR values for water surface of study area are above acceptance limits of 50% indicating unsuitable for irrigation purpose (Table 9). The above result indicated magnesium hazard and adversely affects crop growth. It value is influenced by Ca2+ and Mg2+ levels in water samples. The high values of observed magnesium content are due to the influence of dolomite in the area.

#### *3.5.8 Permeability Index (PI)*

PI is one of criteria of assessing irrigation water quality. The value of PI ranges from 50.4 % to 86.3% (Table 12). The above result indicated that water samples fall within water class 1 and 11 and can be categorized as good irrigation water (Doneen, 1964). It is based on long term application of water to the soil and influenced by HCO3-, Na+, Ca2+ and Mg2+ levels. Majority, (67%), of the study area (upstream and downstream) indicate good water for irrigation purpose, while the control indicates excellent water for irrigation purpose (Table 10).

**Table 12** Summary of different indices of water parameters of study area at selected locations

| Parameters | Upstream | Downstream | Iworoko Bridge (Control) |
|---|---|---|---|
| SAR (meg/L) | 0.210 | 0.260 | 0.323 |
| RSC (meg/L) | -1.103 | -0.125 | 0.74 |
| Na (%) | 11.2 | 15.2 | 13.5 |
| PS (meg/L) | 0.359 | 0.455 | 0.447 |
| SSP (%) | 7.73 | 10.14 | 9.03 |
| KR | 0.084 | 0.113 | 0.164 |
| MAR (%) | 95.08 | 92.48 | 88.67 |
| PI (%) | 50.403 | 63.176 | 86.262 |

Summarily, majority (94 %) of the physicochemical parameters of water samples indicating suitable water quality for irrigation purposes. Similarly, majority, (87.5%) irrigation indexes indicated that water samples in the study area were fall under suitable/safe/excellent for irrigation purposes. Summary of water classification based irrigation indices and its occurrence is presented in Table 13

**Table13:** Summary of water classification based irrigation indexes and its occurrence in the study area

| Irrigation Indices | WATER CLASSIFICATION | | | Occurrence (%) |
|---|---|---|---|---|
| | Upstream | Downstream | Control | |
| SAR | Excellent | Excellent | Excellent | 100 |
| RSC | Safe | Safe | Safe | 100 |
| Na (%) | Excellent | Excellent | Excellent | 100 |
| PS | Excellent | Excellent | Excellent | 100 |
| SSP | Suitable | Suitable | Suitable | 100 |
| KR | Suitable | Suitable | Suitable | 100 |
| MAR | Unsuitable | Unsuitable | Unsuitable | 100 |
| PI | Good | Good | Excellent | 67or 33 |

## 3.0 CONCLUSION

Water qualities of Ero Dam were assessed. The concentrations of the Ca2+, Mg2+, Na+, K+, Cl-), C03-, HC03-, B, S042-, NO3-N and PO4-P were within the acceptance limits for irrigation purposes except potassium that above the specified limit. Evaluation of surface water quality of Ero dam were carried out using different indexes methods such as SAR, RSC, Na %, PS, SSP, KR, MAR and PI; among these, majority of indices results fall under excellent to safe and classified CISI. Therefore, the results were concluded, that the majority of surface water qualities in the study area were suitable for irrigation purpose.

## References


[1] Adedeji, O. J. 1993.The Socio-Economic Characteristics of River Dam Development on Non-Metropolitan Communities. A case Study of Ero Dam at Ikun Ekiti. B.Sc. Thesis, University of Ado-Ekiti, Ekiti State. 67

[2] Al-Omran, A. M., Al-Harbi, A. R., Wahb-Allah, M. A., Nadeem, M. and Al-Eter, A. 2010. Impact of Irrigation Water Quality, Irrigation Systems, Irrigation Rates And Soil Amendments On Tomato Production In Sandy Calcareous Soil. *Turkish Journal of Agriculture.* 34:59–73

[3] American Public Health Association, APHA. 2005. Standard Methods for the Examination of Water and Wastewater, 16th and 17th Eds. Washington, DC; American Water Works Association, Water Control Federation

[4] Arienzo, M., Christen, E. W., Quayle, W. C. and Kumar, A. 2009. A Review Of The Fate For Potassium In The Soil Plant System After Land Application Of Wastewaters. *Journal of Hazard Master*. 164: 415 – 422

[5] Ayers, R. S. and Westcot, D. W. 1985. Water Quality for Agriculture. *FAO Irrigation and Drainage*. 29 (1): 1-109.

[6] Ayers, R. S. and Westcot, D. W. 1994. Water Quality For Agriculture: FAO Irrigation and Drainage Paper 29. *Revision*. 1: 1-130.

[7] Bauder, T. A., Cardon, G. E., Waskam, R. M. and Davis, J. G. 2004. Irrigation Water Quality Cooperative Extension Agriculture 506. Colorado State University, Colorado

[8] Doneen, L. D. 1964. Notes on Water Quality in Agriculture, Department of Water Science and Engineering, University of California, Water Science and Engineering. 400.

[9] Easton, F.M. 1950. Significance of Carbonate In Irrigation Waters. *Soil Science*. 67(3): 128-1

[10] Food and Agriculture Organization of the United Nations (FAO). 2011. Fast facts: The state of world's land and water resources. Retrieved Mar. 24, 2013 from http://www.fao.org/fileadmin/user_upload/newsroom/docs/en-solaw-facts_1.pdf

[11] Jaji, M. O., Bamgbose, O., Odukoya, O. O. and Arowolo, T. A. 2007. Water quality assessment of Ogun River, South West Nigeria. *Environmental Monitoring Assessment*. 33(1-3): 473-482.

[12] Joshi, D. M. Kumar, A. and Agrawal, N. 2009. Assessment of the Irrigation Water Quality of River Ganga in Haridwar District India *Journal of Chemistry.* 2(2):285-292.

[13] Kankal, N., Indurkar, M., Gudadhe, S. and Wate, S. 2012. Water Quality Index of Surface Water Bodies of Gujarat, India. *Asian Journal of Experimental Science*. 26(1): 39-48

[14] Kelly, W. P, 1963. Use of Saline Irrigation Water. *Soil Science*. 95(4): 355-391.

[15] Nishanthiny, S. C., Thusshanthy, M., Barathithasan, T. and Saravanan, S. 2010. Irrigation water quality based on hydrochemical analysis, Jaffna, Sri Lanka. *American-Eurasian Journal Of Agriculture And Environmental Science*. 7(1): 100-102.

[16] Palacios, O. and Aceves, E. 1970. Instructivo para el registro, muestreo e interpretación de datos de calidad del agua para riego. Colegio de Posgraduados. Serie de Apuntes No. 15. Chapingo, México

[17] Prasad, A., Kumar, D. and Singh, D.V. 2001. Effect of Residual Sodium Carbonate In Irrigation Water On The Soil Sodification And Yields of Palmarosa and Lemongrass. *Agricultural Water Management*. 50: 161–172.

[18] Raghunath, H. M. 1987. Groundwater, 2nd Ed. Wiley Eastern Ltd. New Delhi, India. 344-369.

[19] Rengasamy, P. and Marchuk, V. 2011. Cation Ratio Of Soils Structural Stability (CROSS). *Soil Resources.* 49: 280 – 285

[20] Richards, L. A. 1954. Diagnosis and Improvement Of Saline And Alkaline Soils. Agriculture Handbook 60, U.S. Department of Agriculture, Washington, D.C. 69-82.

[21] Seilsepour, M., Rashidi, M. and Khabaz, B.G. 2009. Prediction of Soil Exchangeable Sodium Percentage Based On Soil Sodium Adsorption Ratio. *American-Eurasian Journal of Agricultural and Environment Science.* 5 (1): 1–4.

[22] Talukder, M. S. U., Shirazi, S. M., Niazuddin, M. and Ghosh, A. K. 1999. Groundwater Quality And Its Impact On Soil And Crop, Bangladesh. *Journal of Agricultural Science*. 26(3): 153–160

[23] Todd, K. D and Mays, L. W. 2005. Ground water Hydrology 3rd, ed. John Wiley and Sons, New York, 636.

[24] UCCC. 1974. Guidelines for Interpretations Of Water Quality For Irrigation. University of California Committee of Consultants, California

[25] U.S. Salinity Laboratory staff. 1954. Diagnosis and Improvement of Saline and Alkaline Soils. Handbook No. 60, US Department of Agriculture, Washington, DC.

[26] Van de Graff, R. and Patterson, R. A. 2001. Explaining the Mysteries of Salinity, Sodicity, SAR and ESP in On-Site Practice. http://www.lanfaxlabs.com.au/papers/P47-mysteries.pdf

[27] Wallender, W. W. and Tanji, K. K. 2012. Agricultural Salinity Assessment and Management. ASCE Manuals and Reports on Engineering Practice No. 71. ASCE, Reston, VA..

[28] Wilcox, L. V. 1955. Classification and Use Of Irrigation Water. US Department of Agriculture, Washington, DC.

.