Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 11(X), 2023:
http://dx.doi.org/10.7770/safer-V11N1-art604

An appraisal of the pollution status for drinking and irrigation purposes: Case study Anya River, Ikwuano, Abia State in South-eastern, Nigeria.

Una evaluación del estado de contaminación para consumo humano y riego: estudio de caso Río Anya, Ikwuano, estado de Abia en el sureste de Nigeria.

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ABSTRACT

Sixteen physico-chemical parameters of were investigated and used to estimate water pollution status. The River was sampled for seven months (February –August, 2019) and analysed following standard procedures and protocols. There were no significant differences (P > 0.05) among all the investigated physico-chemical parameters across stations. Mean values of all the investigated physico-chemical parameters were within the Federal ministry of environment FMEnv.) set standard except, dissolved oxygen and pH and chemical oxygen demand. Most of the investigated parameters were higher during rainy season with exception of water temperature, pH, dissolve oxygen (DO), biological oxygen demand (BOD) were higher during dry season months. The values of each phyisco-chemical parameters were used for estimation of water pollution index. All the water quality indices both for drinking and irrigation were also favourable and within their respective acceptable limits; except comprehensive pollution indices for drinking water.

Key words: pollution index, physico-chemical, irrigation, drinking water, surface water,

INTRODUCTION

Activities aimed at sustaining human population such as intensive farming and industrialization, activities, and waste discharge into surface water bodies have been a threat to the availability of good drinking water and water for agricultural purposes. Surface water bodies have been the major sources of drinking water for numerous rural communities in Nigeria; and the quality of the water has been greatly affected by upsurge in the indiscriminate use of agro-chemical, dumping and disposal of wastes into land and water bodies (Enitan et al*.2018)*

These anthropogenic activities can also alters physic-chemical characteristics of any receiving surface water body. The water quality of Anya river is suspected to be deteriorating day by day due to numerous anthropogenic such as washing of motorcycles, kitchen utensils, application of fertilizers, pesticides, and other unsustainable agricultural practices within and along floodplain of the river (Field Observation 2019). Surface water bodies Pollution as a result of anthropogenic activities, is a growing concern globally (Hillel et al. 2015; Amah-Jerry et al. 2017)

Quality evaluation of the surface water quality can be complex process involving numerous parameters which contribute with different pressures on water quality (Dogru et al. 2019).Considering spatio-temporal variations in physic-chemical parameters of surface water bodies, regular monitoring programs and rapid interpretation of the surface water bodies' status are necessary since river is a dynamic ecosystem, influenced by various activities in the river bank (Effendi and Wardiatno 2015; Anyanwu and Umeham 2020). Although, It is difficult to interpret the results of a large number of physic-chemical parameters and as well describe the status of the river, especially when different anthropogenic stressors influence individual parameters and could reflect in water quality of diverse categories (Popovic et al. 2016) The use of one or few metrics, on the other hand will reduce the credibility of the assessment method.

Recently, a number of indices, Water Quality Index (WQI) and Nemerow's Pollution Index (NPI) have been developed for the assessment of water quality and employed in this study (Adimalla 2019; Adimalla and Taloor 2020). These index are assessment methods that greatly reduces the data volume and expresses water quality status in a simple form (Effendi 2016; Anyanwu and Umeham 2020) In addition, percentage sodium (Na %) is useful too in estimation of surface water body's status for irrigation purpose and it has been for evaluation of river suitability for irrigation (Al-Othman 2015)

Despite all the anthropogenic activities that are capable of altering physic-chemicals characteristics of Anya River and their associated adverse effects on its suitability for different use, no work has been carried out to investigate the status of Anya River for different uses to the best of our knowledge. Thus, this study focuses on the evaluation of surface water for its suitability for a range of purposes; the evaluation being based on, Nemerow's pollution index, Na% and WQI.

MATERIALS AND METHODS

Study Area (Fig. 1): Station 1: Upper stream located at Abia State University (ABSU), Umudike Campus extension. The substrata are sand clay, leaves of trees and remains of dead macrophytes. Floating macrophytes present are *Pistia stratiotes, Nymphaea lotus* and *Eichhornia crassipes*. The trees shade a large portion of the stream. Human activities carried out here include washing of motorcycle, manual dredging, and cultivation of crops around along the banks.

Station 2: Station 2 is located mid-stream at NRCRI reservoir. Human activities carried out here include washing of vehicles, watering of cattle and irrigation activities takes place during the dry season. Vegetation are subjected to chemical input from application of fertilizers, herbicides and pesticides.

Station 3: This is downstream, located in Michael Okpara University of Agriculture Umudike, along the road leading to Goodluck hostels. Activities impacting the River are flash flood and wastewater from a greater part of University environment, occasional bathing and fishing.

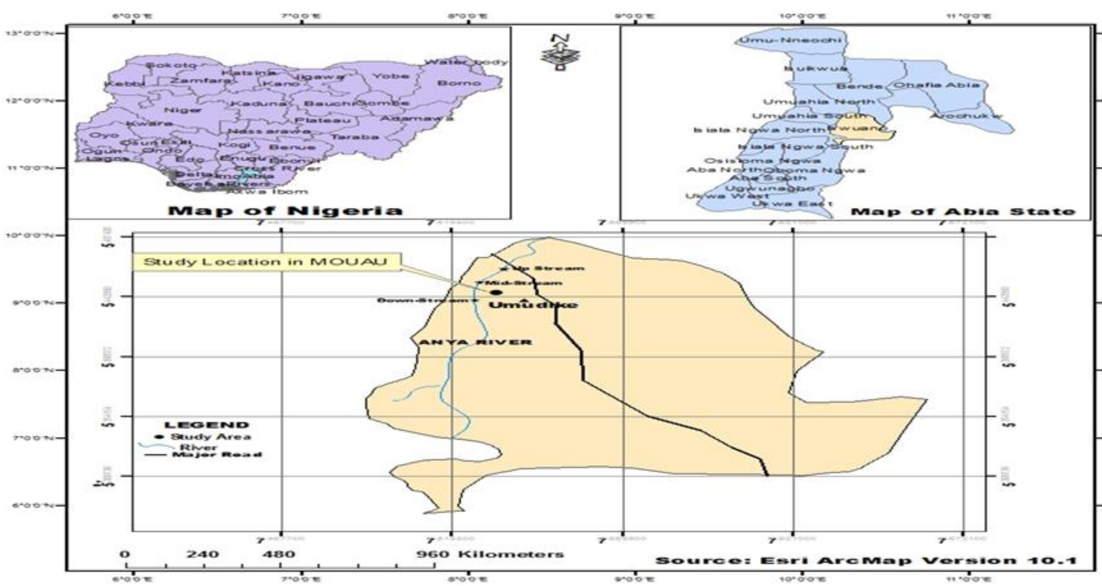

Figure 1. Map of Study Area with Sampling Points.

Samples collection and analyses: Water samples were collected from Anya River monthly from February to September, 2019. Water samples were collected with 1 L water sampler and stored in sterilized 1 L plastic bottles and then taken to the laboratory for analysis. The physico-chemical parameters were analysed using standard methods: pH (Jenway 550 Portable pH meter),turbidity (Jenway 6035 Portable Turbidimeter), dissolved oxygen and biochemical oxygen demand (Winkler method with azide modification method), Chemical oxygen demand (Open Reflux Method), nitrate (UV Spectrophotometric Method), phosphate (Stannous Chloride Method), sulphate (Turbidi- metric Method), chloride (Argentometric Method), potassium (Flame Photometric Method), calcium, sodium and magnesium (Atomic Emission Spectrophotometry Method) (Mallick, 2017).

Calculation of Water Quality Assessment Indices

Water pollution index

Pollution index of Anya River was evaluated using:

Nemerow pollution index (NPI) = $\sqrt{\frac{\left(\frac{C_i}{L_1}\right)_M^2 + \left(\frac{C_i}{L_i}\right)_R^2}{2}}$ (Anyanwu and Umeham 2020) (1)

Where, NPI is the pollution index for a specified water quality purpose, C_i is measured water quality parameters, L_i is the standard water quality parameter for each parameter at specified water quality purpose, (C_i/L_i) M is C_i/L_i maximum, (C_i/L_i) R is C_i/L_i average

Water Quality Index: The Weighted arithmetic water quality index (WAWQI) method is used in the classification of the water quality based on the level of purity; using the most commonly measured water quality parameters - pH, Total Dissolved Solids, Electrical Conductivity, Turbidity, Nitrate, Chloride, Sulphate, Magnesium, Sodium. The method has been widely used by the various scientists (Chandra et al. 2017; Anyanwu and Ukaegbu 2019; Anyanwu and Emeka 2019; Agarwal et al. 2020) and the calculation of WQI was made as described by Brown et al. (1972) using the equation:

WQI = $\frac{\sum Q_i w_i}{\sum w_i}$ (2)

The quality rating scale (Q_i) for each parameter is calculated by using this expression:

Qi = $\frac{C_i}{S_i} x\ 100$ (3)

Where,

Ci is estimated concentration of ith parameter in the analyzed water; S*i* is recommended standard value of ith parameter by Nigerian Standard for Drinking Water Quality (SON 2015).

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

Wi = 1/S*i* (4)

Comprehensive pollution index (CPI): The CPI gives useful information for management and control of the pollution in a watershed (Imneisi and Aydin 2018; Matta et al. 2018; Son et al. 2020). The formula for computing CPI is presented as:

CPI = $\frac{1}{n}\sum_{i=o}^{n} PI_i$ (5)

Where, CPI = Comprehensive Polluted Index; *n* = number of monitoring parameters; PI_i = the pollution index number *i*.

PI_i is calculated according to the following equation:

$$PI_i = \frac{C_i}{S_i} \qquad (6)$$

Where, *Ci* = measured concentration of parameter in water; *Si* = permitted standard of parameter according to environmental standard (FMEnv. 2011).

The CPI was calculated using 12 water parameters: pH, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Nitrate, Phosphate, Chloride, Sulphate, Magnesium, Sodium, Potassium and Calcium.

Irrigation Indices: The characteristics of irrigation water indicates its mineral content and also determines its effectiveness in supporting plants and the soil (Adimalla et al. 2020); thus making it necessary to assess surface water for irrigation purpose. Irrigation water properties were estimated using a number of indices – sodium percentage (%Na), soluble sodium percentage (SSP), sodium adsorption ratio (SAR), Kelly's ratio (KR), and magnesium hazard (MHR). These indices are important for evaluating water quality of surface water for crops irrigation uses

Percentage Sodium (% Na) = $\frac{Na}{Na \; x \; K \; X \; Ca \; x \; Mg} \; x \; \frac{100}{1}$ (Al-Othman 2015) (7)

Sodium adsorption ratio (SAR): Sodium adsorption ratio (SAR) reveals the sodium hazard and signifies the suitability of surface water for irrigation purposes (Ara 2019). It is calculated using the following formula:

$$SAR = \frac{Na^+}{\sqrt{\frac{Mg^{2+} + Ca^{2+}}{2}}} \qquad (8)$$

The concentrations of ions are measured in meq/L.

Soluble Percentage Sodium (SSP): Soluble Sodium percentage is another important parameter used in evaluating sodium hazard and water quality for agricultural purposes (Udom et al. 2019). It is calculated using the following formula:

$$\%Na = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \; x \; 100 \qquad (9)$$

The concentrations of ions are measured in meq/L.

Magnesium hazard Ratio (MHR) measures the adverse influence of magnesium in irrigated water (Davoudi et al. 2021) It is calculated using the following formula (Shil et al. 2019).

$$MHR = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \; x \; 100 \qquad (10)$$

Kelly's Ratio (KR)

It is also used in the determination the appropriateness surface water for irrigation purposes. Sodium is measured in respect to magnesium and calcium and estimated using the following formula (Shil et al. 2019; Meena and Bisht, 2020).

$$KR = \frac{Na^{2+}}{Ca^{2+} + Mg^{2+}} \ x\, 100 \qquad (11)$$

The concentrations of ions are measured in meq/L.

Statistical Analysis: All the results were statistically analyzed using ANOVA and Turkey pairwise test was performed to determine the location of significant difference.

RESULTS AND DISCUSSION

The physico-chemical characteristics of Anya River are presented in Table 1

The pH values were acidic ranging from 5.4 to 6.6 and lower than the acceptable limit (6.5–8.5); attributable to both geogenic (Anyanwu and Ihediwah 2015; Akankali, 2017) and anthropogenic influences. Akankali et al. (2017) and Anyanwu and Ukaegbu (2019 recorded pH values within the ranges recorded in this study.

The turbidity values ranged from 0.19 to 2.6 NTU; the lowest mean value (0.69 NTU) was recorded in station 1. All the turbidity values were within the limit (5 NTU) set by FMEnv. (2011) and the values were within the results obtained by Anyanwu and Umeham (2020) However, Anyanwu and Ukaegbu (2019) recorded a higher range turbidity (1.3–14.7 NTU) in Ossah River, Umuahia, Abia State than this present study and Akankali et al (2017) also recorded a higher range of 20.1–24.4 NTU in Okoro Nsit stream in Akwa Ibom state in Nigeria.

The electrical conductivity (EC) values ranged from 11.8 to 94.3 mg/L; all the EC values were below. High EC in surface water lead to psychological drought and it makes water less availability to plants although irrigated soil seems wet (Meena and Bisht, 2020). This Psychological drought reduces plant growth and yield (Richard, USDA,1954). The results of this study disagreed with Meena and Bisht, (2020) who reported high EC in most of his investigated station. The dissolved oxygen (DO) values ranged from 3.1 to 6.7 mg/L; all the DO mean values were below the acceptable limit) (> 6 mg/L)set by FMEnv. (2011) and could be attributed human activities. Rao et al. (2013) observed that addition of nutrients, alteration in the flow of water, high water temperature and the addition of chemicals can cause oxygen depletion in water.

Biochemical oxygen demand values ranged from 0.09 to 2.40 mg/L. All BOD values were below the acceptable limit (3 mg/L).The results of this study were in line with some studies of rivers in southeast Nigeria (Akankali et al., 2017; Anyanwu and Ukaegbu 2019; Anyanwu and Umeham 2020). The total dissolved solid (TDS) ranged from 9.8 mg/L to 65.0 mg/L, all the values were below the acceptable limit (500 mg/L). The suspended dissolved solid (TSS) ranged from 0.68 mg/L to 4.3 mg/L, all the values were below the acceptable limit (100 mg/L). The chemical oxygen demand (COD) ranged from 21.7 mg/L to 491.0 mg/L; majority of COD values exceeded the acceptable limit (30 mg/L). This could be ascribed human activities such sand mining which introduction of unusual volumes of organic material, nutrients and reintroduction of toxic substances contribute to oxygen demands (Anyanwu and Emeka 2019). The results of this study were in line with the results obtained by Anyanwu and Umeham (2020) in Eme River.

Table 1. Chemical parameters of studied site.

Parameters	Min.	Max.	Station 1	Station 2	Station 3	P-value	FM-Env. (2011)	SON (2015)
pH	5.40	6.60	5.97±0.25	5.90±0.38	5.91±0.18	P > 0.05	6.5 - 8.5	6.5- 8.5
TurbidityNTU)	0.19	2.60	0.69±0.13	0.82±0.19	0.75±0.21	P > 0.05	5	5
EC(µS /cm)	11.80	94.30	41.49±9.20	49.9±11.70	49.83±10.93	P > 0.05	1000	1000
DO (mg/L)	3.10	6.70	5.14±0.51	5.61±0.46	5.69±0.34	P > 0.05	6	5
BOD (mg/L)	0.09	2.40	1.34±0.08	1.89±0.17	1.67±0.20	P > 0.05	3	-
TDS (mg/L)	9.80	65.0	25.06±7.33	27.21±6.11	28.32±7.31	P > 0.05	500	-
TSS (mg/L)	0.68	4.30	1.94±0.35	2.2±0.48	2.3±0.41	P > 0.05	100	-
COD (mg/L)	21.70	491.0	156.87±65.4	158.03±63.15	171.38±65.45	P > 0.05	30	-
Sulphate (mg/L)	0.09	0.75	0.30±0.09	0.34±0.10	0.30±0.13	P > 0.05	100	100
Nitrate (mg/L)	0.27	2.35	0.67±0.21	0.77±0.27	0.76±0.31	P > 0.05	9.1	50
PO_4 (mg/L)	0.49	1.31	0.80±0.11	0.82±0.08	0.89±0.08	P > 0.05	3.5	
Chloride (Cl)	44.2	101.4	75.51	80.63	70.59	P > 0.05	--	250
Sodium (mg/L)	0.28	1.91	0.71±0.21	0.80±0.20	0.83±0.19	P > 0.05	120	200
Potassium(mg/L)	0.11	0.89	0.36±0.10	0.38±0.07	0.43±0.10	P > 0.05	50	-
Calcium(mg/L)	0.89	3.9	1.99±0.44	2.66±0.21	2.98±0.07	P > 0.05	180	-
Magnesium(mg/L)	0.58	2.64	1.22±0.67	2.2±0.20	1.34±0.31	P >0.05	40	20

The SO_4 values ranged between 0.09 and 0.75 mg/L (Table 2) and the values were in line with Anyanwu and Emeka (2019) who recorded values between 0.28 and 1.27mg/L in Ikwu River Umuahia Abia State and Anynwu and Ukaegbu (2019)recorded 0.31mg/L and 0.88mg/L in Ossah River Umuahia, Southeast while Akankali et al. (2017) recorded a relatively higher range of 15.0–15.5 mg/L in Okoro Nsit stream in Akwa Ibom state, all in southeast Nigeria. All the values obtained throughout the study period were below the acceptable limit of 100mg/L set by FMEnv. (2011)for environments. The mean values recorded in all stations showed that there were no significant differences ($P > 0.05$) in the SO_4 across all the stations in all the stations.

The PO_4 values ranged from 0.49 to 1.31 mg/L, all values were within the acceptable limit (3.5 mg/L) set standard by FMEnv. (2011) (table 1). Anyanwu and Ukaegbu (2019), Anyanwu and Umeham (2020) and Anyanwu et al. (2022) recorded a similar results in station 1 of Ossah River, Eme River, and Ikwu river all in Umuahia while Akankali et al. (2017) recorded a higher values (2.5–3.6 mg/L) in Okoro Nsit stream in Akwa Ibom state in Nigeria.

Nitrated values ranged from 0.27 mg/L to 2.35 mg/L; all values were within the acceptable limit (9.1 mg/L) (table 1). Chloride ranged between 35.50 and 141.80 mg/L; the lowest and highest values were recorded in station 1 in January and June 2019 respectively.

Table 2: Assessment drinking water Quality Indices and Water Quality Criteria.

Irrigation water Indices	Station 1	Station 2	Station 3	Status of water for irrigation
Sodium percentage (% Na)	16.59	13.24	14.82	Excellent (<20%), Good (20–40%), Permissible (40–60%), Doubtful (60–80%) and Unsuitable (>80%) (Al-Othman 2015)
Soluble Sodium Percentage (%)	20.97	29.98	25.00	< 20% (Excellent), 20 – 40 % (Good), 40 – 60 % (Permissible), 60 – 80 % (Doubtful), > 80 % (Unsuitable) (Anyanwu et al. (2022)
Sodium Adsorption Ratio	0.231	1.859	0.483	< 10 (excellent), 10–18 (good), 19–26 (doubtful/fair poor), > 26 (unsuitable) (Tomaz et al. 2020)
Kerry's Ratio	0.412	0.292	0.221	< 1 (Suitable), > 1(Unsuitable)
Magnesium Hazard Ratio (%)	39.46	40.37	38.01	< 50 (Suitable), > 50 (Unsuitable)

Sodium values were also within acceptable limit and ranged from 0.28 mg/L to 1.91 mg/L. Potassium values were ranged from 0.11 mg/L to 0.89 mg/L. Calcium values were all ranged from 0.89 mg/L (Station to 3.9 mg/L. Magnesium values were ranging from 0.58 mg/L to 2.64 mg/L. All the cat-ions (sodium, potassium, calcium and magnesium and sodium) values were within the acceptable limits set by FMEnv (2011) and SON (2015). Generally, there was no significant difference ($p > 0.05$) across the stations in all the investigated cat-ions across stations. The major cations were generally low and were within results obtained in River (Anyanwu and Emeka, 2019) in Ossah and Em Rivers, Umuahia..

Water quality indices: The results of the water quality assessment indices and respective acceptable limits/criteria are presented in Table 2. The NPI results varied from 0.57 to 0.67; reflecting the effects of the anthropogenic activities. The results indicated that the all the station had values less than one, one indicating good water quality and suitable to support aquatic biodiversity based on the NPI standards (Table 2). Anyanwu and Ukaegbu (2020) reported same range (0.58 – 0.81) but fall under good water quality in Ossah River and Anwyanwu and Umeham (2022)0.54 to 0.91

The WQI values for drinking water ranged between 49.78 and 66.83. The WQI values in stion 2 and 3 were 500 -100, indicating good water quality while water from station1 is < 50 (classified as excellent water quality) for drinking based on WQI standards (Tyagi *et al* 2013). The WQI reflected the level of anthropogenic activities along the watershed and extraction drinking water points. The high WQI in station 2 and 3 may be attributed to heavy farming and recreation activities within the stations although the activities have not adversely impact on Anya River.

Anyanwu and Emeka (2019) reported similar values (56.49 - 79.70) indicating poor water in upstream and downstream while mid-stream fall under very poor water quality in Ikwu River and Anyanwu and Ukaegbu (2019) also reported same range (49.2 – 77. 7) indicating good water quality in down-stream, poor water quality in mid-stream and very poor water quality in up-stream in Ossah River. However, Anyanwu et al. (2022) reported slightly lower values (37. 73 – 38.13) indicating good water quality in all the stations in Ikwu Rivers and Matta et al. (2022)

also reported lower values (41.03 - 52.25) in in Upper Ganga basin. The variation WQI among the rivers and across the stations with a river may be attributed to anthropogenic activities and location.

The CPI values ranged between 8.738 and 9.383 for sustenance of aquatic life all the stations. The recorded CPI values were within the range of >0.21 (heavily polluted) based on classification in Anyanwu et al. (2022), Imneisi and Aydin (2018) and Matta et al. (2018). This shows that the anthropogenic activities observed in the river had adversely impacted the water quality and as such not suitable to support aquatic life. The results of this study were quite higher than Anyanwu et al. (2022) that recorded 0.23 (sub clean) in Ikwu River Imneisi and Aydin (2018) recorded slightly higher values (0.60 – 0.88) indicating slight pollution in the Elmali and Karacomak streams, Turkey while Matta et al. (2018) recorded values (0.54 – 2.47) in Ganga River at Rishikesh, India .

Excess sodium concentration in surface water for irrigation affect the soil absorptivity infiltration of water and total salinity thus may result an increase to soil alkalinity, which negatively affect some sensitive crops (Megahed 2020). Soluble sodium percentage (SSP) is another useful tool employed in assessing sodium hazard and water quality for irrigation activities (Udom et al. 2019). High soluble sodium percentage in surface water may cause stunted growth, poor crop yield and reduced soil nutrients absorptivity (Anyanwu et al. 2022).

The sodium percentage (% Na) values for crop irrigation ranged from 13.24 - 16.59%. All the values were below 20 indicating excellent that Anya River has water for irrigating crops (Al-Othman, 2015). The variation observed across stations may be ascribed to different human activities along each station watershed.

The soluble sodium percentage (SSP) ranged from 20.97- 29.98%. The values were within the good irrigation category (20 - 40%). Wilcox (1950) classified SSP as <20% (excellent). 20 – 40% (good), 40 – 80% (fair) and >80% (poor/unsuitable). Udom et al. (2019) reported values (28.16-34.69%) in Abak River were within the good irrigation water quality while Anyanwu et al. (2022) and Omofunmi et al. (2019) recorded values that were also within the excellent category in Ikwu River Umuahia and Ero dam, Ikun –Ekiti, Nigeria. However Eruola et al. (2020) recorded higher values (51.8 – 54.0%) that was within the permissible category in Owiwi River, Abeokuta, Ogun state, Nigeria. The variations across regions and within region and rivers may be attributed to different human activities along the watershed.

Sodium Adsorption Ratio (SAR) is a tool to assess sodium hazard (Anyanwu et al. 2022; Adimalla et al. 2020) and is used to estimatd the relative proportion of sodium ions in relation to the magnesium and calcium ions in irrigation water sample (Davoudi et al. 2021; Anyanwu et al.2022). The SAR ranged from 0.231– 1.859. All the values recorded were < 10 indicating excellent irrigation quality (table 3).Some studies in Nigerian Rivers reported relative higher values (Ogunfowokan et al. (2013) in streams of Amuta (1.32–8.28), Agbogbo (1.41–9.07) and Abagbooro (1.04–8.46) in Ile-Ife, and Eruola et al. (2020) recorded higher values (2.34 – 4.28) in Owiwi River, Abeokuta, Ogun State, Nigeria.)Nigeria. However, Anyanwu et al. (2022) and Udom et al. (2019) recorded values with the range of this study in Ikwu River and in Abak River, Abak both the same south=eastern Nigeria. Kelly's ratio (KR) is employed in the estimating the contents of sodium ion in relation to calcium ion and magnesium ion for evaluation of water quality for irrigation of crops (Elsayed et al. 2020; Anyanwu 2022). KR ranged from 0. 221-0. 412, all the KR values were < 1 indicating suitability (table 3). High value of KR (> 1) point out indica excess sodium in the water and as such makes it unsuitable for crop production (Kelly 1940; Sundaray et al. 2009). Most studies in Nigerian rivers reported slight lower KR, Omofunmi et al. (2019) in Ero dam, Ikun –Ekiti, Ekiti State, Udom et al. (2019) in Abak River, Abak and Anyanwu et al. (2022) in. Ikwu River Umuahia , Abia State.

Table 3: Summary of Irrigation water quality of Anya River, Ikwuano Abia State Nigeria.

Indices	Station 1	Station 2	Station3	Water Quality Criteria
NPI	0.57	0.59	0.67	0 < NPI < 1.0: meeting standard quality (good condition), 1.0 < NPIavg < 5.0: slight polluted, 5.0 < NPIavg < 10: medium pollution and NPIavg > 10: heavily polluted
WQI	49.78	55.81	66.83	0 – 25 (Excellent), 26 – 50 (Good), 51 – 75 (Poor), 76 – 100 (Very Poor), >100 (Unsuitable) (Tyagi et al. 2013)
CPI	8.738	9.022	9.383	0 - 0.20 (clean), 0.21 - 0.40 (sub clean), 0.41 - 1.00 (slightly polluted), 1.01–2.00 (medium polluted), >2.01 (heavily polluted).

Level of magnesium in surface water especially for agriculture purpose is very useful parameter used in the estimated quality of the water body (Anyanwu et al. (2022). Excess magnesium contents in surface water body will severely affect crop yields if water from such surface water body are used to irrigate crops due to increase in salinity of the soils resulting from irrigated water (Davoudi et al. 2021). Magnesium Hazard Ratio ranged from 38.01-40.37%, all the Magnesium Hazard Ratio were <50% indicating that water from Anya River is suitable for crop production (table 3). Anyanwu et al. (200) reported close values (45.60 – 48.10%) reported close to values in Ikwu River Umuahia Abia State, which was considered suitable While Eruola et al. (2020) reported values (55.2 – 55.9%) slightly above the limit in Owiwi River, Abeokuta, Ogun state, and Udom et al. (2019) obtaine values (77.78 - 87.59%) that exceeded limit in Abak River, Abak, , and Omofunmi et al. (2019) recorded very high values (88.7 - 95.1%) in Ero dam, Ikun –Ekiti, Ekiti State, all in Nigeria which were considered unsuitable for irrigation of crops.

As conclusion, this study showed that all the physic-chemical parameters evaluated were within acceptable limits except pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand. Variations in physico-chemical parameters were majorly influenced anthropogenic activities as well as season. All the water quality index both for drinking and irrigation were also favourable and within their respective acceptable limits; except comprehensive pollution indices for drinking water but all reflecting the anthropogenic influence especially in station 2 and 3. The indices used effectively displayed the potential of Anya River for multiple eco-services and showed that the water from Anya River is suitable for human consumption and irrigating crops.

ACKNOWLEDGMENT

Authors acknowledged Ndukwe, John for his support during the samples collection.

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Received: 06th November 2023; Accepted: 18th January 2023; First distribution: 18th September 2023