ISSN: 2456-8643

ASSESSMENT OF IRRIGATION AND WATER QUALITY INDICES OF INDUSTRIAL EFFLUENT AND SURFACE WATER IN ALETO ELEME, RIVERS STATE

[1]Ideriah, T.J.K., [2]Dollah, O.C. and [2]Dabo, P.E

[1]Institute of Pollution Studies, Rivers State University Port Harcourt, Nigeria.

[2]Institute of Geosciences and Environmental Management, Rivers State University, Port Harcourt, Nigeria.

https://doi.org/10.35410/IJAEB.2023.5824

ABSTRACT

The study assessed the irrigation water quality indices of industrial surface water in Aleto Eleme, Rivers State, Nigeria. A total of 9 samples of water effluents and surface water were collected and taken to laboratory to test for the level of concentrations of the physico-chemical parameters using standard laboratory analyses as recommended by the American Society for Testing and Materials for physico-chemical properties and descriptive statistics were employed for the data analysis. Findings revealed that Sodium Absorption Ration (SAR) values ranged from 0.32 to 12.39; Soluble Sodium Percentage (SSP) values ranged from 23.39 to 80.62; PI values ranged from 24.79 to 889.8; KR values ranged from 0.39 to 4.16, Residual Sodium Carbonate(RSC) values ranged from -585.3 to 9.9. Also, the different classes of salinity hazard in the USSL diagram include low, C1 (EC < 250 µS/cm); medium, C2 Electrical Conductivity (EC 250–750 µS/cm); high, C3 (EC 750 -2250 µS/cm); and very high, C4 (EC > 2250 µS/cm), as shown in figure 4. Also, the sodium hazard classes include: low, S1 Sodium Absorption Ratio (SAR < 10); medium, S2 Sodium Absorption Ratio (SAR 10 -18); high, S3 (SAR 18–26); and very high, S4 (SAR > 26). Thus, the quality of river water in the area had WQI values (WQI > 300), rating the water as unsuitable for drinking. The study recommended that the water quality should be improved for domestic purposes by making sure that regulatory bodies monitor the level of water pollution everywhere in Rivers State. More studies on water quality should also be conducted periodically.

Keywords: Water quality, Surface water, Irrigation, Effluent, Eleme.

1. INTRODUCTION

Water is a fundamental normal asset for supporting life and climate yet throughout the course of recent many years it is disintegrating because of its over double-dealing. Water quality is fundamental boundary to be examined when the general center is manageable improvement keeping humankind at point of convergence (Saxena and Saxena, 2015). The nature of water is depicted by its physical, compound and microbial attributes. Notwithstanding, in the event that a few relationships are conceivable among this boundary, the huger ones would be valuable to demonstrate genuinely the nature of water (Dhembare and Pondhe, 1997).

Water is a characteristic asset of principal significance; upholds all types of life and makes occupations and riches, the travel industry, diversion and fisheries (Ntengwe, 2015). Without water life as it exists on our planet is incomprehensible (Asthana and Asthana, 2001). Freshwater is an inexhaustible asset, yet the world's stock of spotless, new water is consistently diminishing. Water request as of now surpasses supply in many regions of the planet, and as total populace keeps on expanding at an extraordinary rate, a lot more regions are supposed to encounter this irregularity sooner rather than later (Ayoade, 2018). The interest for new water has expanded with the consistently expanding populace on the planet. About portion of individuals that live in emerging nations don't approach safe drinking water and 73% have no disinfection and a portion of their squanders at last defile their drinking water supply prompting an elevated degree of torment (Vivian *et. al.,* 2012).

Water quality alludes to the compound, physical, organic and radiological attributes of water. It is a proportion of the state of water comparative with the necessities of at least one biotic animal types as well as to human need or reason. Consumable water is significant for the appropriate working of man and his endurance relies upon its accessibility. Accessibility of value water to rustic and metropolitan populace is significant to hinder wellbeing challenges (Dong *et al,* 2007). Sadly, most Countries all over the planet, including Nigeria, consumable water supplies have become contaminated for certain poisons that have influenced adversely on the wellbeing and financial fortune of the populaces (Egboka *et al.*, 1989). In this manner surface and groundwater have turned into the fundamental wellspring of savoring water most human populaces of the world and it is being contaminated by human exercises because of different kinds of squanders released to the climate. The byproducts of modern exercises and metropolitan run-off track down their direction into groundwater, in this manner debasing it for certain harmful metals. It is essential to break down water to decide its reasonableness for homegrown and modern use (Ocheri, 2010).

One of the most difficult issues in Nigeria today is the availability of water for home and other purposes in both rural and urban areas. The inappropriate handling of the enormous amounts of trash produced by diverse human activities is another of the most serious issues facing emerging countries. The issue of waste disposal has always been a challenge. The most damaged aquatic bodies are freshwater reservoirs in particular. Due to this, these natural resources are frequently no longer suited for both main and secondary uses (Nsiah-Gyabaah, 2013).

Nigeria's effluent discharge practices are still relatively primitive, endangering society overall but especially in the industrialized regions. Pollution control in our cities has not been much improved by the National Environmental Standard and Regulatory Enforcement Agency (NESREA, 2017), which was intended to stop these environmental violations. Numerous water resources have become unwholesome and dangerous for people and other living things as a result of population boom, uncontrolled quick urbanisation, industrial and technical advancement, energy use, and waste creation from home and industrial sources (Ezeronye and Amogu, 2018).

Indorama petrochemicals make up the petrochemical sector, and as a result, numerous environmentally hazardous substances are produced. Before being dumped into the environment, these pollutants (effluents) are meant to decompose into non-toxic forms (land, air and water). Because rivers have a limited ability to absorb pollution, the water quality may alter when waste is discharged into them or when agricultural land drains into them (UNESCO and WHO, 2017; Austin, 2018).

According to researchers, the majority of Nigeria's popular fresh water sources are contaminated, which contributes to a significant epidemic of illnesses. Numerous research on various elements of water quality and pollution in various regions of Nigeria (Umeh *et al.*, 2014; Jaji et al., 2015; Olaoye and Onilude, 2016; Yusuf and Shuaibu, 2017; Garba et al., 2018) have shown varying degrees of adverse effects of anthropogenic activities on the environment. For instance, a

Vol. 08, No. 02; 2023

ISSN: 2456-8643

research by Umeh *et al.* (2014) found that a rise in the water pollution index caused urinary schistosomiasis to infect 48% of the population in the Katsina-Ala Local Government region of Benue state. According to some earlier studies, urinary schistosomiasis affects 19% of the whole Nigerian population, with incidence rates as high as 50% in particular areas. The World Health Organization has expressed grave worries about this in an effort to increase cultural and socioeconomic standards of people in the tropical area (Umeh *et al*., 2014). Jaji et al. (2017) investigated the Ogun River's water quality, which receives industrial wastewater from Lagos and Abeokuta. It was stated that all of the sample locations had extremely high levels of turbidity, oil and grease, faecal coliform, and iron. Olaoye and Onilude's (2016) investigation found that drinking water from western portions of the country had variable degrees of microbial contamination. Between 2.86-4.45 and 1.62 cfu/ml of total bacteria and coliforms were discovered, respectively. Heavy metal toxicity by drinking water has also been observed, in addition to microbiological diseases. (2018) Yusuf and Shuaibu (2014) investigated how garbage discharge affected the Samaru stream in Zaria's quality. A few of the previous studies had been unable to effectively quantify the water index especially around the industrial area in which the present study is focusing at. Thus, the study intended to spatially analyse the water quality index of surface water in Aleto Industrial Area, Eleme LGA, Rivers State, Nigeria.

2.MATERIALS AND METHODS

The study was carried out in Aleto Community, Eleme, Rivers State, Nigeria. In this study, the designs adopted were experimental; involving physical, chemical and biological analysis of water samples collected at varying locations along the river. Eleme LGA is one of the ethnic Nationalities in Nigeria located in the south- south region and is geographically located between longitudes 7.064952ºE and 7.267800ºE and latitudes 4.709200N and 4.851040 (Fig. 1) with abundance of crude oil. The population of Eleme is over one hundred and ninety thousand with fishing and farming as their main occupation (Ngofa, 2006).

The procedure for sample collection began with a survey of the area before sample collection; all plastic bottles were washed thrice with the sample water. In total in 1-liter plastic bottles, water sample collection took place. Samples from the river were taken every month during the dry and wet seasons for a year, when there is the least activity. After sampling, the containers were properly labelled, carefully covered, and transferred to the laboratory, where the samples underwent routine laboratory analysis utilising standard procedures. The samples collected were analyzed for the parameters below using standard laboratory methods for the Sodium Absorption Ratio (SAR), Soluable Sodium Percentage (SSP), Kelly Ratio (KR), Permeability Index (PI) and Residual Carbonate (RSC).The WQI is computed in four steps, calculated using the following Equations 3.13 – 3.16 adopted from Sener (2017).

Assign a weight (w_i) to each parameter according to its importance in drinking water purposes

Step 1: Compute the Relative Weight (W_i) for each parameter using equation (Equ.1)

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad \text{(Equ. 1)}$$

Step 2: Assign a quality rating scale (q_i) for each parameter by dividing its determined concentration (c_i) in each sample by its respective guideline value (s_i); multiplied by 100

ISSN: 2456-8643

$$q_i = \left(\frac{C_i}{S_i}\right) \times 100 \qquad \text{(Equ. 2)}$$

Step 3: Determine the sub index (SI_i) for each parameter using equation (3.15)

$$SI_i = W_i \times q_i \qquad \text{(Equ 3)}$$

Step 4: Sum all sub-indices to get the WQI

$$WQI = \sum_{i=1}^{n} SI_i \qquad \text{(Equ. 4)}$$

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Where qi is the quality rating for each chemical indicator, wi is the weight of each element, SIi is the sub-index of the ith indicator, and Wi is the relative weight. Excellent (WQI 50), Good (WQI = 50–100), Poor (WQI = 100–200), Very Poor (WQI = 200–300), and Unsatisfactory for Drinking (WQI > 300) are the WQI's classifications for water quality (Batabyal and Chakraborty, 2015; Ramakrishnaiah *et al*., 2009).Descriptive statistics such as mean and standard deviations were employed for the data analysis and graphs tables and charts were used for data presentation.

Irrigation Indices:

Methods for calculating the different irrigation parameters are as follows:

Sodium Adsorption Ratio (SAR): The SAR was calculated using the formula by Richards (1954).

$$SAR = \frac{Na^+}{\sqrt{\frac{\{Ca^{2+} + Mg^{2+}\}}{2}}} \qquad (5)$$

Where, Ca^{2+}, Mg^{2+} and Na^+ are concentrations in mili-eqivalent per litre (meq/L)

Soluble Sodium Percentage (SPP): The SPP was calculated using a modified formula by Todd (1980).

$$SPP = \frac{Na^+}{Ca^{2+} + Mg^{2+} + Na^{2+}} \times 100 \qquad (6)$$

Where, Ca^{2+}, Mg^{2+} and Na^+ are concentrations in mili-eqivalent per litre (meq/L)

Permeability Index (PI): The PI was calculated using a modified formula by Doneen (1964).

$$PI = \frac{Na^+ + HCO_3^-}{Ca^{2+} + Mg^{2+} + Na^+} \times 100 \qquad (7)$$

Where, Ca^{2+}, Mg^{2+}, Na^+ and HCO_3 are concentrations in mili-eqivalent per litre (meq/L)

Kelly Ratio (KR): The KR was calculated using a formula by Kelly (1940)

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

Where, Ca^{2+}, Mg^{2+} and Na^+ concentrations in mili-eqivalent per litre (meq/L)

Residual Sodium Carbonate (RSC): The RSC was calculated using a formula by Richards (1954)

$$RSC = [(HCO_3^-) - (Ca^{2+} + Mg^{2+})] \qquad (9)$$

Where, Ca^{2+}, Mg^{2+} and HCO_3^- are concentrations in mili-eqivalent per litre (meq/L).

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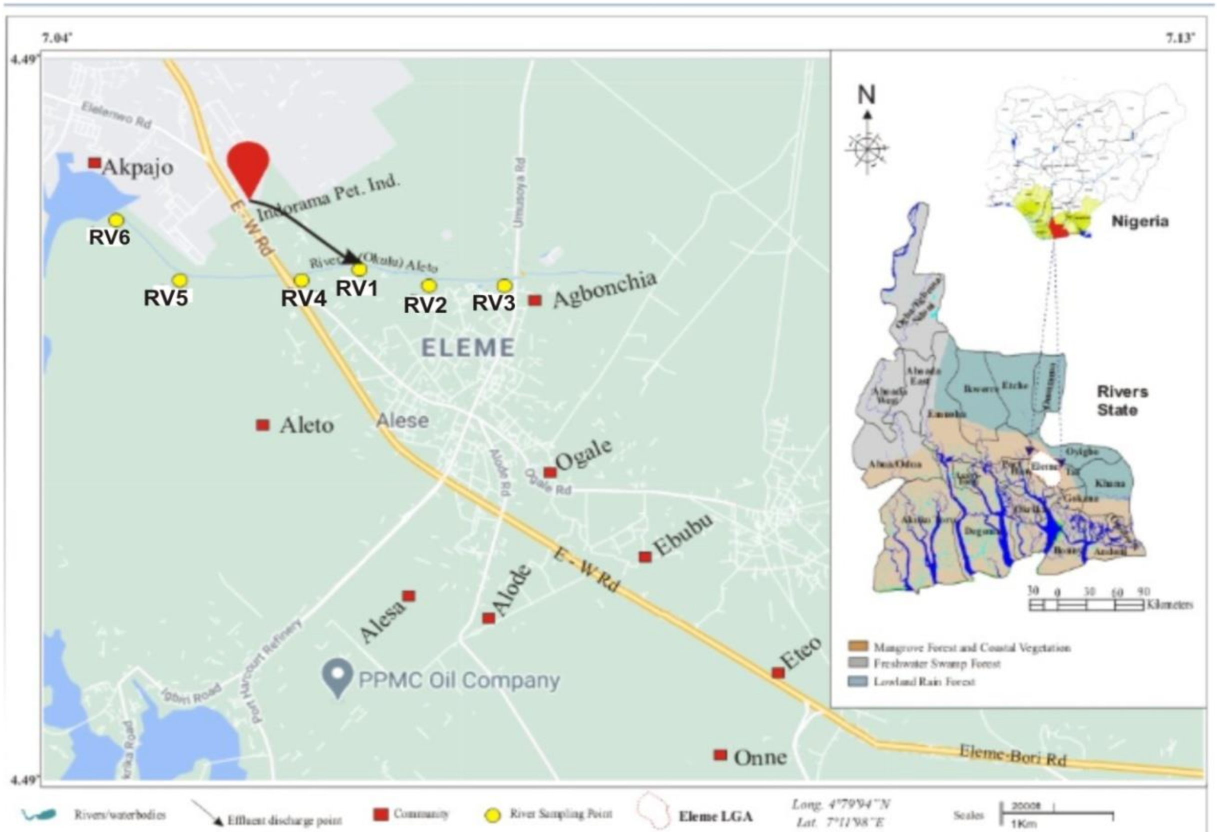

Figure 1. Study area showing sampled locations

3. RESULTS AND DISCUSSIONS

Water Quality Values

Fig. 2 shows a graphical representation of the water quality index obtained from the study area. The WQI values ranged from 210 – 1487.

Vol. 08, No. 02; 2023

ISSN: 2456-8643

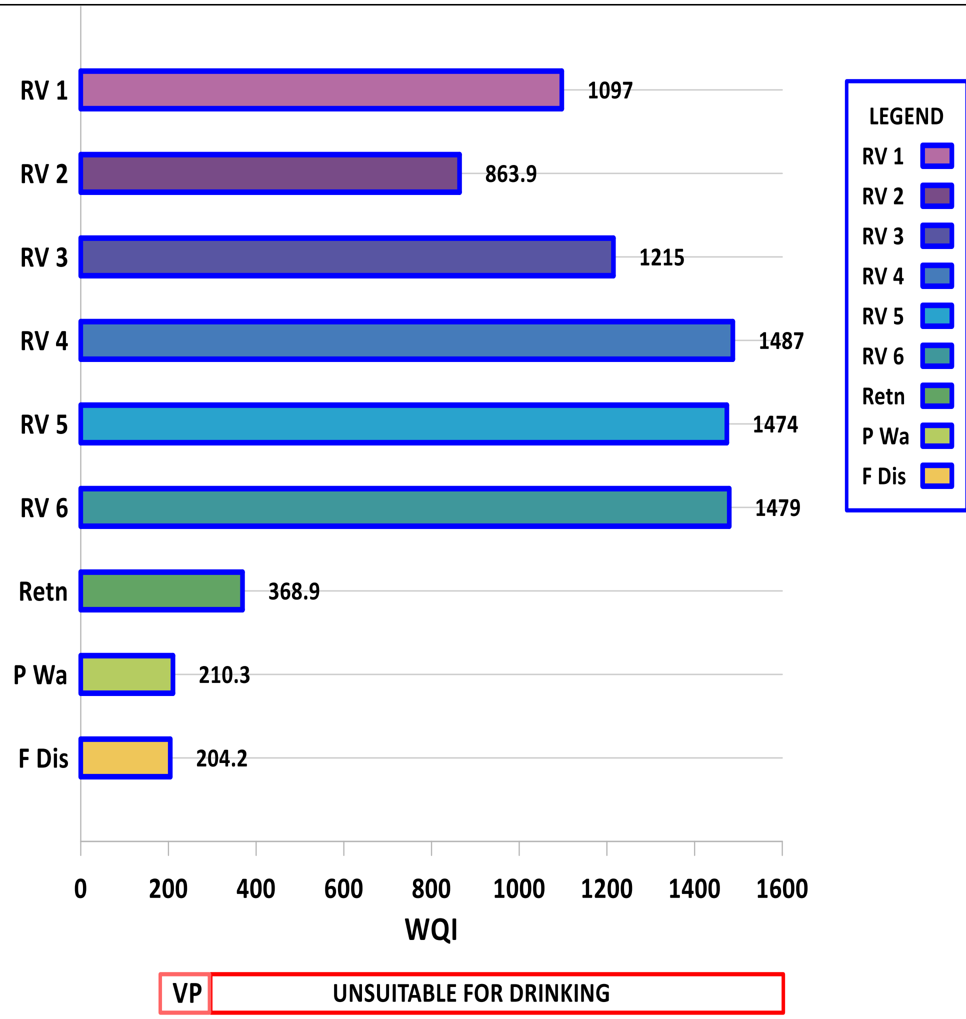

Fig. 2: Water Quality Index Ratings of the River and Effluent Water in the Study Areas Calculated for the Period of Study

Water Classification

Plotting of samples on the Piper Trilinear Diagram (Figure 3) reveals the composition of the water in the different sampling stations, indicating the water type (Piper, 1944).

ISSN: 2456-8643

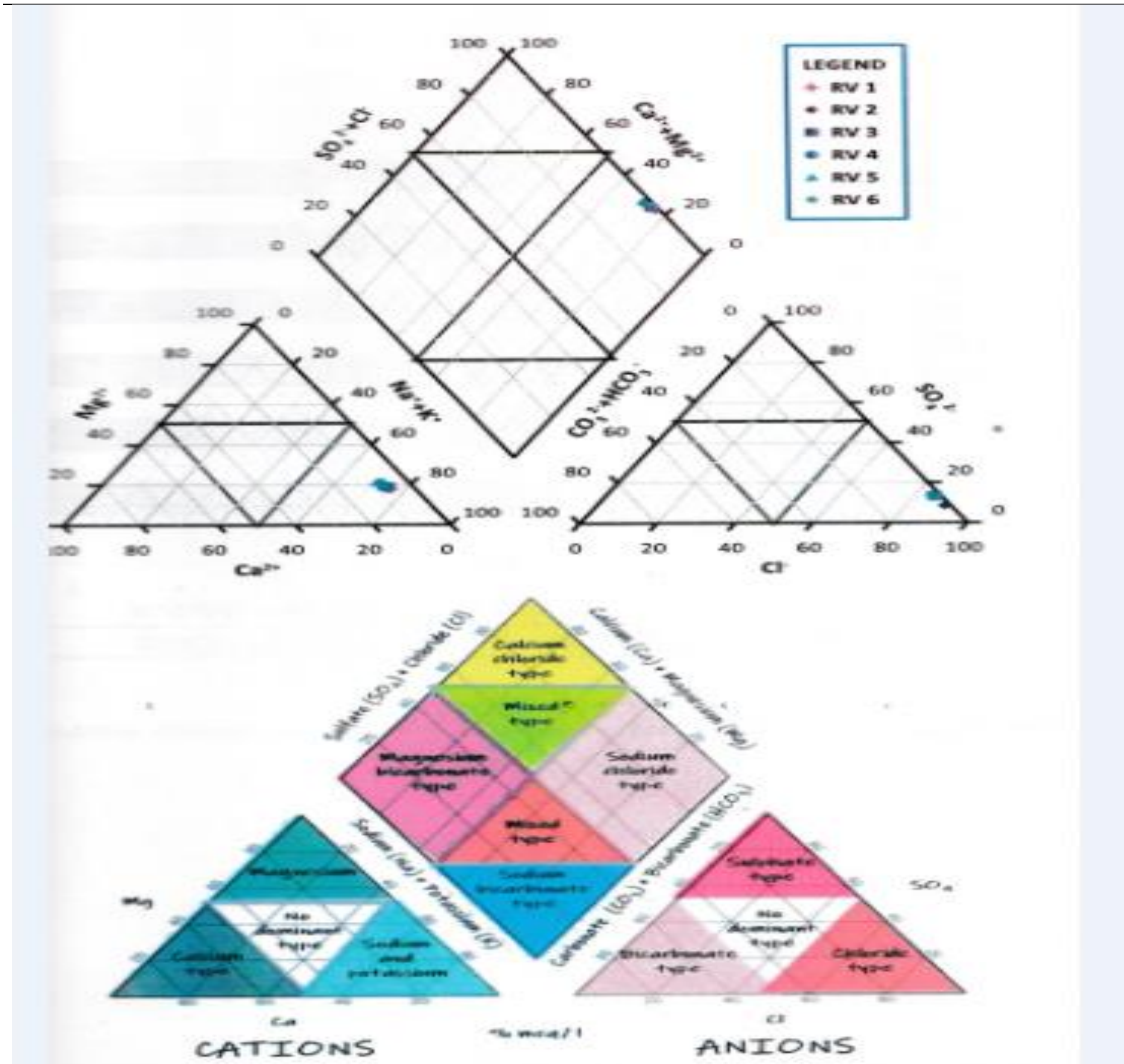

Fig. 3: Piper Trilinear Diagram Showing the Classification of Water in the Hydrological Facies

Irrigation Parameters

Irrigation is an agricultural practice used to mitigate the lack of adequate soil moisture resulting from insufficient rainfall (George, 2004). Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP), Kelly Ratio (KR), Permeability Index (PI), and Residual Sodium Carbonate are the irrigation indices employed in this study (RSC). Figures 4 to 8 provide ratings of the research area's based on these indicators.

All of the effluent/discharge water and river water RV2 in the research region were evaluated as "excellent" for irrigation purposes (SAR10) based on the Sodium Adsorption Ratio (SAR) assessment (Fig. 4). For irrigation reasons, the other river water tests were deemed "good" or "safe." SAR measures the appropriateness of water for irrigation in relation to the salinity or sodium danger and represents the relative activity of sodium ions in exchange interactions with soil (Sundaray *et al*., 2009).

The Soluble Sodium Percentage (SSP) values (Fig. 5) show that all the river water samples had water rated as “good” for irrigation purposes (SPP = 20 - 40). One of the effluent/discharge water, F-Dis, had its water rated as “good” for irrigation purposes (SPP= 23.9) while P-Wa and Retn were rated as “doubtful” (SSP= 73.38) and ‘unsuitable’ (SSP= 80.62) respectively, for irrigation purposes. High Na+ contents in water, in comparison to Ca2+ and Mg2+ concentrations, react with soil and reduce its permeability, which contributes to a degradation of the soil structure resulting in stunted plants, according to Purushothman et al. (2012).

According to the Kelly Ratio (KR) results (Fig. 6), all river water samples in the study region are deemed "unsuitable" for irrigation (KR1). F-Dis was evaluated as "unsuitable" for the effluent/discharge water samples, whereas P-Wa and Retn were classified as "good" for irrigation purposes (KR>1). Because of the high salt content, KR values larger than one (KR > 1) are inappropriate for irrigation whereas those less than one (KR 1) (Sundaray, 2009).

Residual Sodium Carbonate (RSC) values (Fig. 7) show that all the river water samples in the study area had their water rated as “good” for irrigation purposes (RSC < 1.25). For effluent/discharge water samples, F-Dis was rated as good for irrigation (RSC < 1.25) while Retn and P-Wa were rated as unsuitable for irrigation (RSC > 2.5). High RSC water has high pH and if lands been irrigated with this, might cause serious infertility including accumulation of sodium carbonate which turns soil black colored (Eaton, 1950).

Permeability Index (PI) values in this study are shown in Fig. 8., Doneen (1964) classified the water for irrigation purposes in Class I, Class II, and Class III, based on a permeability index (P.I.) where Class I and Class II waters are categorized as “good” for irrigation with permeability range of 50% - 75% or more; Class III is marked as “unsuitable” with 25% of maximum permeability. The results show that, of the river water samples, RV5 and RV6 were rated as “unsuitable” (PI < 25), while RV1, RV2 and RV3 were rated as ‘good (class 2)’ (PI= 25% – 75%). The effluent/discharge water had F-Dis rated as ‘good (class 2)’ (PI= 25% – 75%), while Retn and P-Wa were rated as ‘good (class 1)’ (PI> 75%). The PI assesses the suitability of irrigation water, which is influenced by high concentrations of Na^+, Ca^{2+}, Mg^{2+} and alkalinity ions (Ravikumar *et al*, 2011).

The USSL diagram (Fig. 9) indicated that all the river water samples fell in the C4-S4 group indicating Very Poor water quality; having high salinity and high sodium. F-Dis, which indicates "Very Good" water quality and has low salinity and low sodium, was plotted in the C1-S1 group for the effluent/discharge water samples. P-Wa, which has moderate salinity and low sodium, was plotted in the C2-S1 group, and Retn, which has high salinity and low sodium, was plotted in the C3-S1 group. Classes C1-S1 are ideal for irrigation. With low risk of a salt issue, C2-S1 classes can be used for irrigation on practically all soil types. Irrigation is often not a good fit for C4-S4 courses. Classes C2-S4, C3-S2, and C3-S4 are borderline or uncertain for irrigation. The Wilcox (Sodium Percent vs Electrical Conductivity) diagram (Fig. 10) also showed that all the river water samples in the study area were classified as ‘unsuitable’ for irrigation purposes. Two of the discharge water samples (P-Wa and F-Dis) were classified as ‘Excellent to Good’ while the Retn sample was classified as ‘permissible to doubtful’ for irrigation purposes.

Vol. 08, No. 02; 2023

ISSN: 2456-8643

Fig. 4: Sodium Adsorption Ratio (SAR) Values for Water in the Study Area

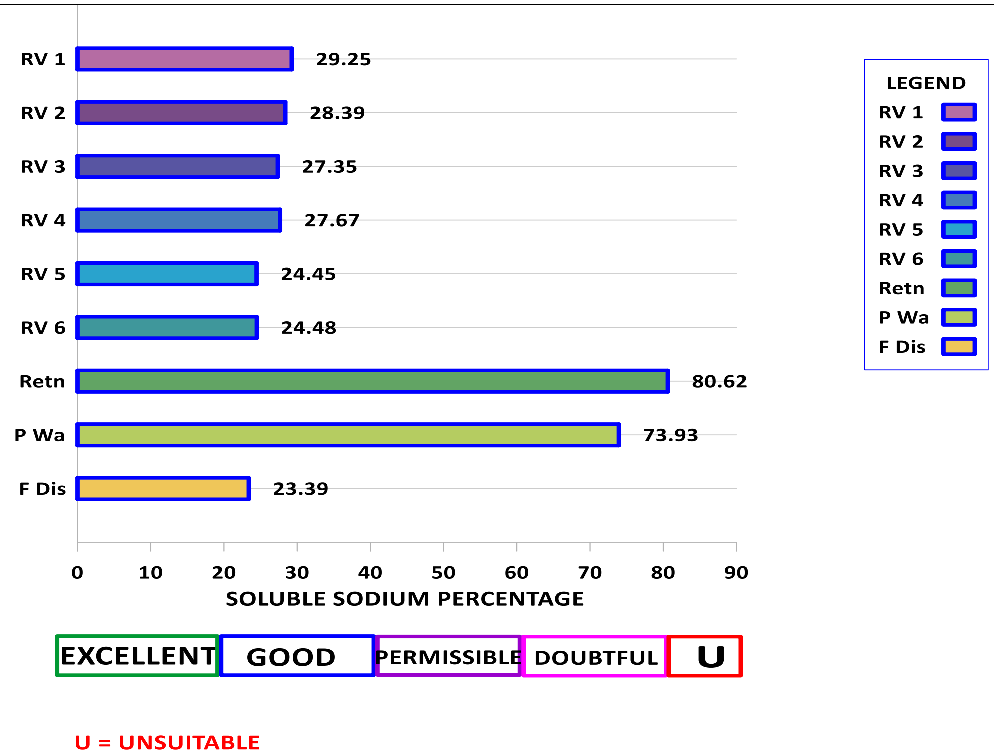

Fig. 5: Soluble Sodium Percentage (SSP) Values for Water in the Study Area

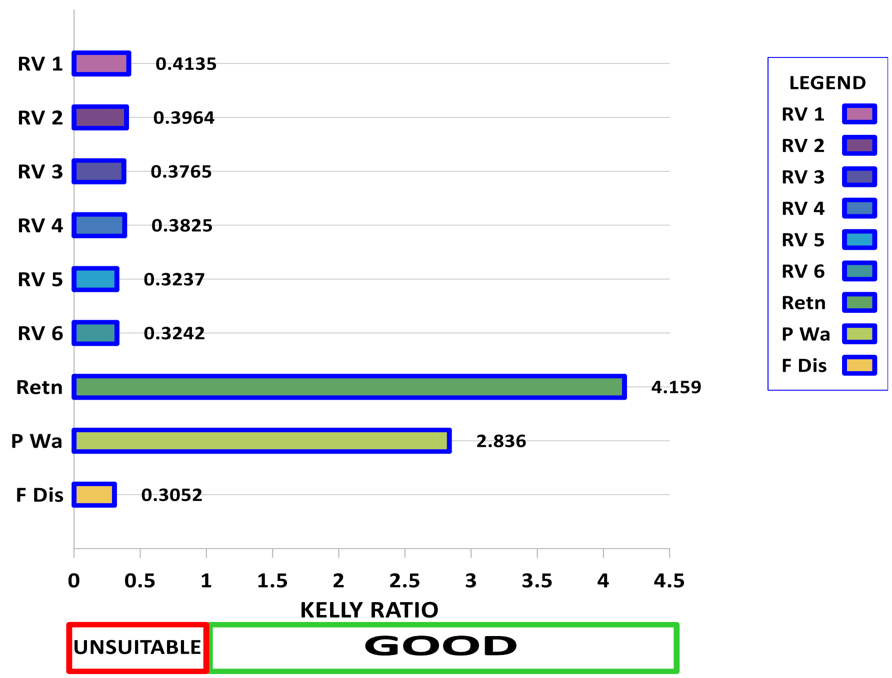

Fig. 6: Kelly Ratio (KR) Values for Water in the Study Area

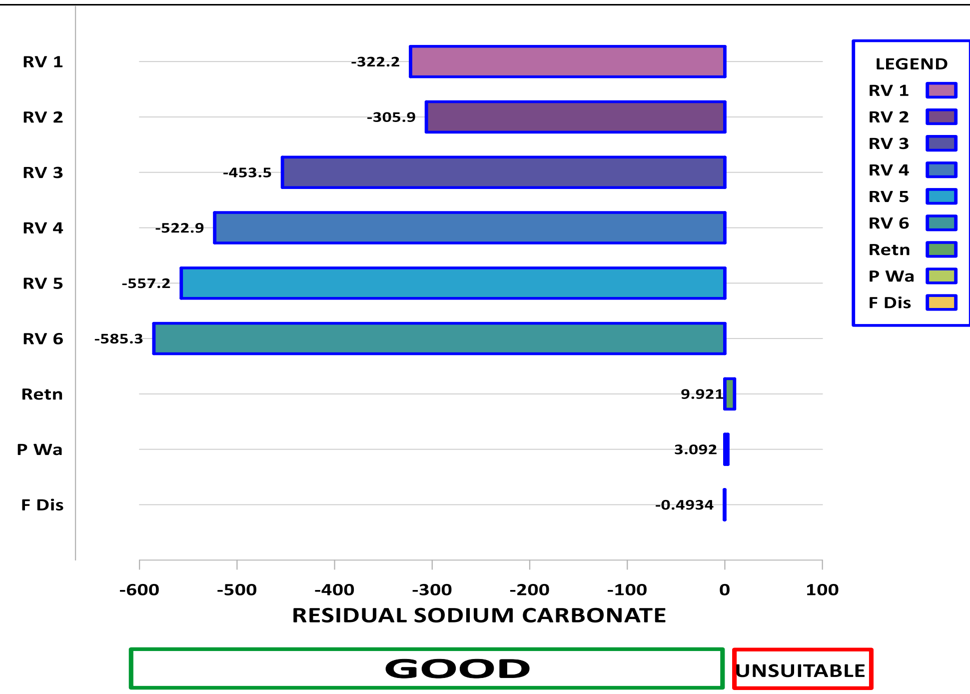

Fig. 7: Residual Sodium Carbonate (RSC) Values for Water in the Study Areas

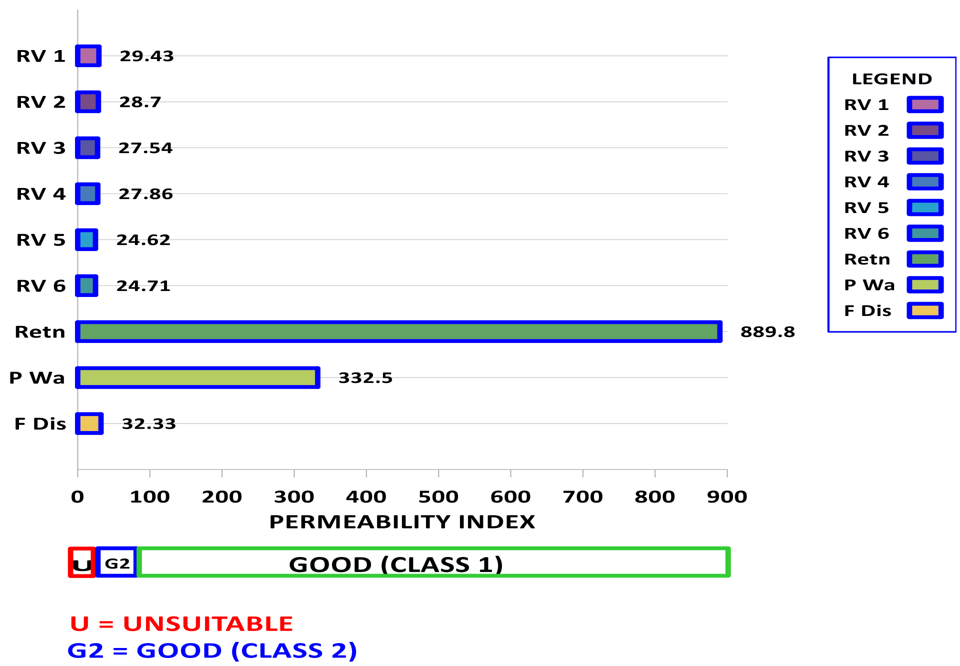

Fig. 8: Permeability Index (PI) Values for Water in the Study Area

ISSN: 2456-8643

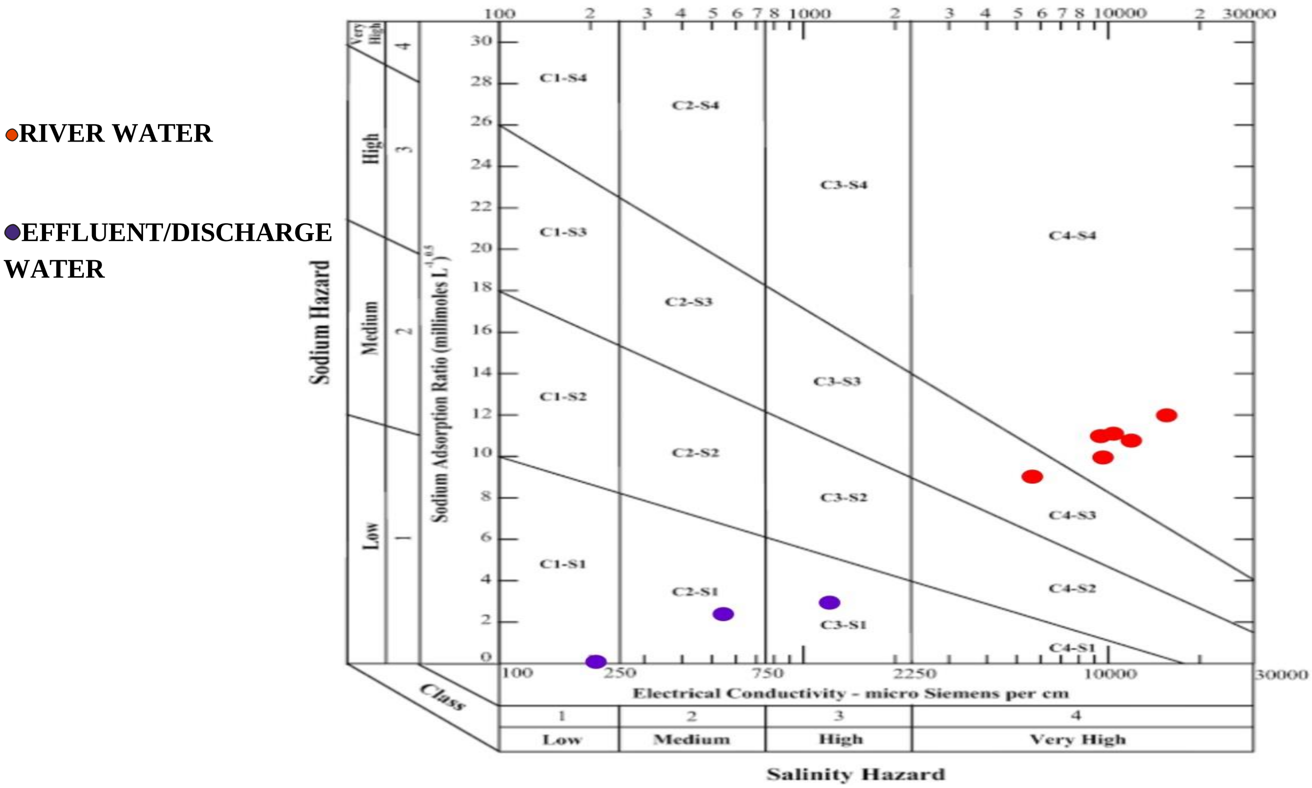

Fig. 9: USSL Diagram for Classification of Water in the Study Area for Irrigation Suitability

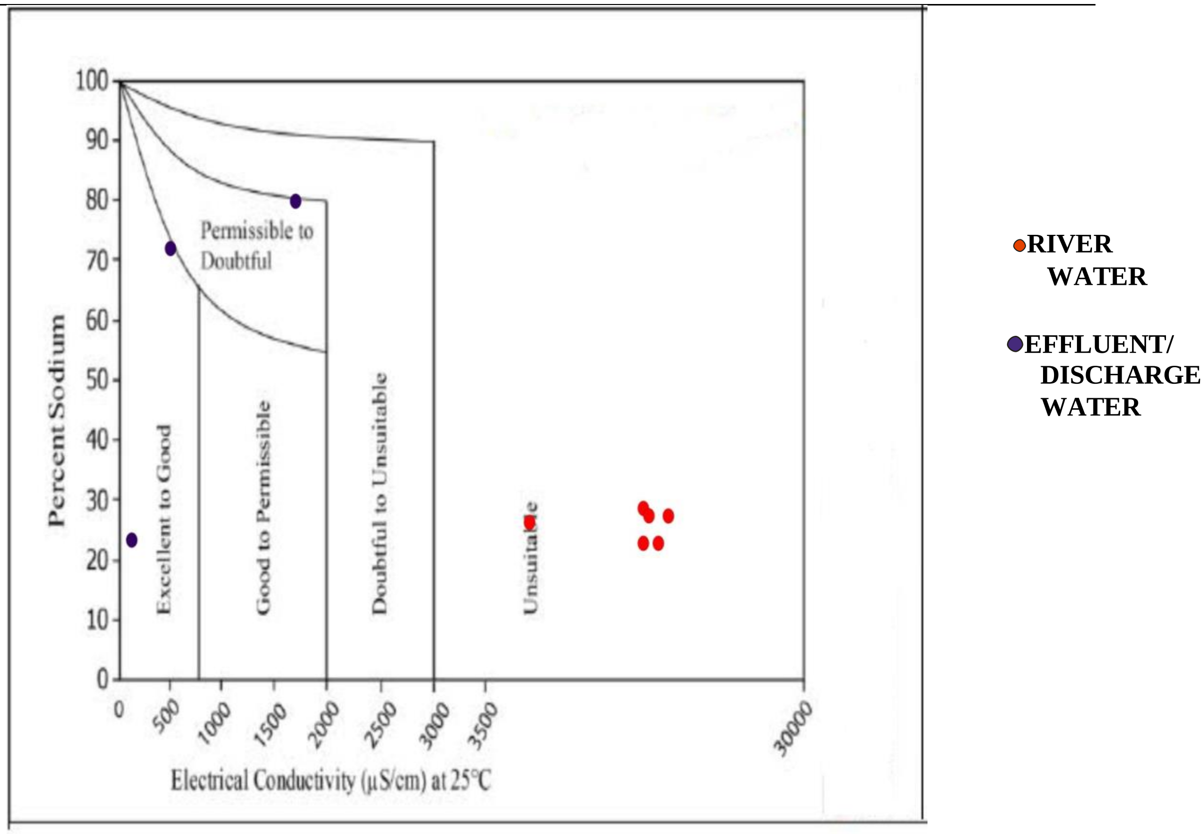

Fig. 10: Wilcox (Sodium Percent vs Conductivity) Diagram for Classification of Water in the Study Area for Irrigation Suitability

4.CONCLUSION

The, study had revealed that the quality of river water in the area had WQI values > 300, rating the water as unsuitable for drinking. For the effluent/discharge waters, Retn had WQI > 300, and thus rated as 'unsuitable' for drinking, while P-Wa and F-Dis had WQI = 200 – 300, rating them as 'very poor' for drinking. The irrigation indices in the study area also showed that the water is very poor, making it unsuitable for irrigation purposes or activities according to the various classifications and rating used for the irrigation induces.

REFERENCES

Asthana, D.K. and Asthana, W. (2001). Environmental Problems and Solutions, second revised edition. New Delhi: Chand and Company Limited.

Austin, B. (2018). Kaduna Petrochemical Company Annual Environmental Audit report by Midlands Consultancy Services Kaduna.

Ayoade, J.O. (2018). *Tropical Hydrology and Water Resources.* London: Macmillan publisher 's ltd, pp 275.

Doneen, L. D. (1964). Notes on water quality in agriculture. Department of Water Science and Engineering, University of California, Davis.

Eaton, F. M. (1950). Significance of carbonates in irrigation waters. *Soil Science*, 69, 123-134.

Egboka, B. C. E., Nwankwor, G. P. Orajaka, G.I. and Ejiofor, A. 0. (1989). Principles and Problems of Environmental Pollution of Groundwater Resources with Case Examples from Developing Countries. *Environmental Health Perspectives* Vol. 83, pp. 39-68

Ezeronye, O.U. and Amogu, N. (2018). Microbiological Studies of Effluents from the Nigerian Fertilizer and Paper Mill Plants. *International Journal of Environmental Studies*, 54, 213-221.

Garba, Z.N. Hamza, S.A. and Galadima, A. (2018). Arsenic Level Speciation in Fresh Water from Karaye Local Government Area, Kano State, Nigeria. *International Journal of Chemistry, India*. 20(2), 113-117.

Jaji, M.O. Bamgbose, O. Odukoya, O.O. and Arowolo, T.A. (2015). Water Quality Assessment of Ogun River, South West Nigeria. Department of environmental management and toxicology, University of Agriculture, Abeokuta, Ogun State, Nigeria. *Environmental Monitoring and Assessment*. 133(1-3), 473-482.

National environmental standards and regulations enforcement agency (NESREA) (2017). Establishment ACT, 2017, No. 25

Nsiah-Gyabaah, K. (2013). Urbanization, Environmental Degradation and Food Security in Nigeria National Petroleum Corporation (NNPC) (2002). The Petroleum Industry and the Nigeria Environment. Seminar NNPC, Warri 9-12 November.

Ntengwe, F.W. (2015). Designing a Domestic Water Supply System. The Engineer 's Perspective and Considerations as a Challenge to Consumers. *Physics Chem. Earth* 30(11-16), 850-858.

Ocheri, M. I. (2010). Distribution of iron in rural groundwater of Benue State, Nigeria. *Journal of research in forestry, wildlife and environment*, 2(2).

Olaoye, O.A. and Onulide, A.A. (2016). Assessment of Microbial Quality of Sachet-Packaged Drinking Water in Western Nigeria and its Public Health Significance. *Public Health*, 123: 729-734.

Purushothman, P., Rao, M.S., Kumar, B., Rawat, Y.S., Krishan, G., Gupta, S., Marwah, S., Bhatia, A.K., Kaushik, Y.B., Angurala, M.P. (2012). Drinking and irrigation water quality in Jalandhar and Kapurthala Districts, Punjab, India: using hydrochemistry. *International Journal of Earth Science and Engineering*. 5, 1599–1608.

Ravikumar, P., Somashekar, R. K. and Angami, M. (2011). Hydrochemistry and evaluation of groundwater suitability for irrigation and drinking purposes in the Markandeya River Basin, Belgaum District, Karnataka State, India. *Environmental Monitoring and Assessment*, 173, 459–487.

Saxena, U. and Saxena, S. (2015). Correlation Study On Physico-Chemical Parameters And Quality Assessment Of Ground Water Of Bassi Tehsil Of District Jaipur, Rajasthan, India. International Journal of Environment, Science and Technology 1, (1),.78-91.

Sener, S., Sener, E. and Davraz, A. (2017). Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). *Science of the Total Environment*, 584, 131–144.

Sundaray, S.K., Nayak, B.B., Bhatta, D. (2009). Environmental studies on river water quality with reference to suitability for agricultural purposes: Mahanadi River estuarine system, India- A case study. *Environ. Monit. Assess*., 155, 227–243.

Umeh, J.C.,Amali, O. and Umeh, E.U (2014).The Socio-Economic Effects of Tropical Diseases in Nigeria. *Economics and Human Biology*, 245-263.

UNESCO and WHO (2017). Water Quality Survey. A Guide for the Collection and Interpretation of Water Quality Data. IHD-WHO Working Group. Pp. 32 – 785.

Vivian, E.L.,Bashiru. D. and Adamu, C.I. (2012). An Appraisal of Water Supply and Sanitation Situation in Some Selected Areas of Kaduna Metropolis. Published in GURARA Journal of Vocational Technology, School of Agricultural Technology Nuhu Bamalli Polytechnic, Zaria.

Yusuf, R. O. and Sonibare, J. A. (2014). Characterization of textile industries effluent in Kaduna, Nigeria and pollution implications. Global Nest:The Int J. 6: 212-221.