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Research Paper

Water Quality Assessment of Joinkrama Community, Rivers State, Nigeria

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Abstract: *This study presents an assessment of the water quality in Joinkrama, Ahoada West Local Government Area, Rivers State, Nigeria. Six surface water samples were collected from selected water bodies, and their physicochemical parameters were analyzed using standard laboratory procedures. ArcGIS 10.5 was employed for data processing. The study evaluated pH, conductivity, total dissolved solids, nitrate, chloride, sulfate, total hardness, phosphate, iron, and manganese levels. The World Health Organization (WHO) standards for 2011 were used as benchmarks for assessing the water's suitability for human consumption. Results indicated that Joinkrama's water quality largely complies with WHO standards. pH values fell within the acceptable range, and electrical conductivity and total dissolved solids were below WHO limits for drinking water. Nitrate and chloride concentrations were significantly below the maximum permissible levels, ensuring the water's safety. Sulfate, total hardness, and manganese levels met WHO standards. However, phosphate and iron concentrations exceeded recommended limits, necessitating attention and intervention. The Water Quality Index (WQI) was calculated to provide an overall assessment of water quality. WQI values ranged from 241.79 to 417.33, leading to the classification of water into categories such as excellent, good, poor, very poor, and unsuitable. The study identified specific sampling points as having "unsuitable water" due to elevated contamination levels, potentially attributed to industrial discharges, agricultural runoff. Immediate measures are recommended to prevent further deterioration of water quality.This study provides crucial information on Joinkrama water quality, stressing the need for ongoing monitoring and intervention to protect community health.*
Keywords: *Water Quality Index (WQI), ArcGIS 10., Contamination levels; Joinkrama*

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I. INTRODUCTION

Water covers approximately 70% of the Earth's surface, with fresh water constituting a mere 2.53% while salt water dominates the remainder [1]. However, the disposal of household wastes, sewage, agricultural runoff, and industrial effluents into these water bodies has become a prevalent issue, leading to contamination of both surface and groundwater in various regions globally [2]. This contamination poses significant threats to human health, agricultural productivity, and ecological balance. The increasing demand for freshwater and fertile soil for agricultural purposes is inextricably linked to the expanding global population. Unfortunately, water contamination arises from a myriad of sources, spanning nearly all significant human activities. Moreover, the advent of modern technology has facilitated industrial expansion, introducing numerous synthetic compounds into the environment, some of which may pose hazards or carcinogenic risks [3]. Furthermore, alterations in land use and soil cover resulting from human interventions profoundly impact the water balance, often shifting the relative significance of processes regulating water quality [4]. The provision of high-quality water is imperative for maintaining public health, ensuring food security, and fostering sustainable development [5]. However, the alarming level of water body contamination, particularly in emerging nations like Nigeria, raises serious concerns [6]. As highlighted by [6], the quality of a water body is determined by a combination of physicochemical and biological factors, whose interactions significantly influence water quality characteristics. Unfortunately, rivers, in particular, are subjected to indiscriminate discharge of sewage, industrial waste, and various human activities, leading to alterations in their physicochemical and microbiological properties [7]. Hydrology, physicochemical parameters, and biological communities are identified as the three fundamental components in the investigation of water quality by [8]. Their research underscores the reciprocal relationship between sediment and interstitial water environmental quality and the dynamics within the water column. This relationship, influenced by ecological exchanges between the components, is critical for the sustainability of aquatic ecosystems. Consequently, assessing water quality for physical, biological, and chemical attributes, including trace element levels, holds paramount importance for public health research [9]. [10] further elucidate the deteriorating state of water bodies due to pollution stemming from residential, industrial, agricultural, and transportation activities. Particularly concerning is the increasing environmental damage associated with transportation operations, with rivers being exploited for inland transport at the expense of aquatic ecosystems. Such activities can have profound and lasting impacts on water bodies and their inhabitants.

In Nigeria, especially within the Ahoada West Local Government Area (LGA) of Rivers State, localities like Joinkrama confront issues in guaranteeing water quality adequate for residential consumption. [11] Focused on the Orashi River, a freshwater source in the region, indicating increased levels of several parameters surpassing national and international permitted limits. These results raise concerns about the possible vulnerability of Joinkrama's water supplies, prompting a specialized evaluation to understand the unique dangers faced by its population. Hence, this research dives into the present status of Joinkrama's water resources, attempting to give a full evaluation of their potability via the perspective of recognized scientific techniques and relevant literature.

The research employs established water quality index (WQI) methodologies to evaluate the suitability of the water resources in Joinkrama for various uses based on their physical, chemical, and biological parameters by drawing upon established water quality guidelines set by the World Health Organization [12]. WQI is a tool for assessing and conveying the general quality of water in a specific area. It is a composite metric that includes numerous water quality parameters such as dissolved oxygen, pH, temperature, turbidity, and the occurrence of contaminants into an individual value. The WQI is an important environmental management tool because it allows policymakers and water managers to track changes in water quality over time and locate likely pollution sources. This research will thus contribute to a better knowledge of the existing condition of water quality in the study region and give significant insights for guiding measures to enhance water security and public health in the community.

II. LOCATION AND GEOLOGY OF THE STUDY AREA

The research area is in Ahoada West, Rivers State, Nigeria, on the eastern side of the Orashi River. Joinkrama is located at 4.8265° N, 6.0665° E. The land is mostly flat, ranging from below sea level to 39 meters high. Roads and footpaths make the area accessible, and oil companies like Shell and NAOC have flow stations nearby. Geologically, the area belongs to the Niger Delta's South-Western flank, formed millions of years ago. The underlying Akata Formation, rich in shales and sands, is invisible at the shoreline. Above it lies the Agbada and Benin Formations.

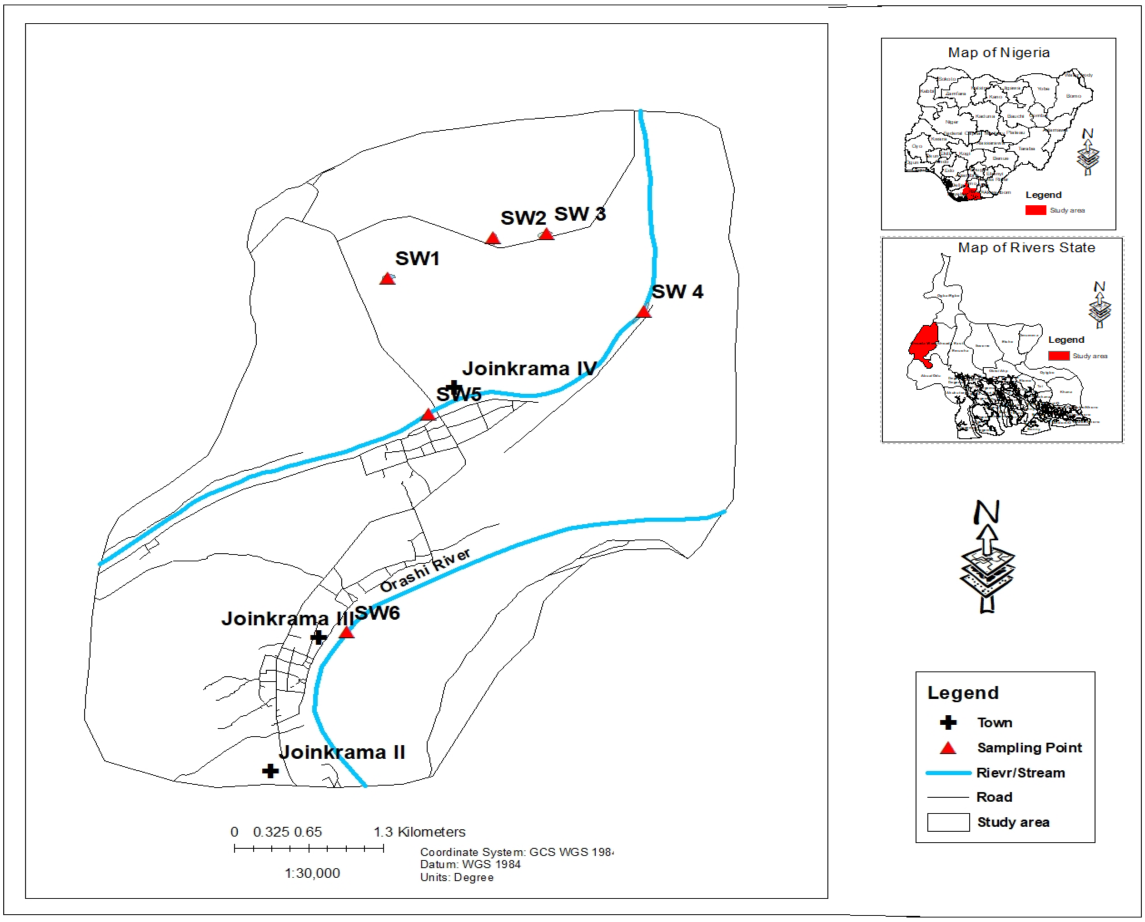

Figure 1: Map of Study area

The Benin Formation is the main aquiferous formation in this research area. At the center of the basin, it is around 2100 meters thick 13. The quaternary layers, which make up the top part of the Benin Formation, are 40–120 meters thick and are composed mostly of silt and sand, with the latter becoming more noticeable as one moves seaward. The Niger Delta's most widely used aquifer is the Benin Formation, which is very prolific, productive, and permeable. The sediments of the Benin Formation are lacustrine and fluvial, with varying thicknesses. The region now has a multi-aquifer system as a result of the clayey intercalations. When yearly rainfall reaches up to 3000 mm, direct precipitation serves as the primary source of recharge [14]. To replenish the aquifers, water seeps through the Benin Formation's very porous sands. The very discontinuous structure of the shales in the continental and transitional facies, which typically occur between 0 and 1220 meters, indicates, according to [15], that this interval is made up of a complex, non-uniform, discontinuous, and heterogeneous system. Few industrial and municipal groundwater supply wells draw from the lower aquifers (between 180 and 300 meters deep), while the bulk of groundwater supply wells draw from the first and second aquifers (less than 150 meters deep).

III. MATERIAL AND METHODS

Data Collection and Analysis:

Six surface water samples were systematically collected from various water bodies, including rivers, lakes, and creeks in strategically chosen locations within Ahoada West LGA, Rivers State. The selection aimed to ensure comprehensive coverage of the study area. Georeferencing of the sampling locations was carried out using a Global Positioning System (GPS) device. Standard analytical procedures were employed in the laboratory to determine the levels of pH, conductivity (COND), total dissolved solids (TDS), nitrate (NO_3), chloride (Cl^-), sulphate (SO_4^{2-}), total hardness (TH), phosphate (PO_4), iron (Fe), and manganese (Mn) in the surface water.

Data Processing:

ArcGIS 10.5 software was utilized for the processing of the collected data. This involved determining the graphical distribution of various parameters, including pH, conductivity (COND), total dissolved solids (TDS), nitrate (NO_3^-), chloride (Cl), sulphate (SO_4^{2-}), total hardness (TH), phosphate (PO_4), iron (Fe), and manganese (Mn), on maps. Additionally, the water quality index (WQI) was calculated using a specific approach involving Excel.

Water Quality Index Determination:
The Water Quality Index serves as a valuable tool for policymakers, scientists, and environmentalists in comprehensively evaluating water quality. By condensing complex data into a single numerical value, WQI facilitates easy interpretation and comparison across different water bodies and over time. This simplicity enables stakeholders to identify trends, prioritize interventions, and communicate findings to the public effectively.

Parameters Included in WQI Calculation:
The parameters considered in WQI calculation typically encompass physical, chemical, and biological aspects of water quality. These include pH, conductivity (COND), total dissolved solids (TDS), nitrate (NO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}), total hardness (TH), phosphate (PO_4), iron (Fe), and manganese (Mn). Each parameter reflects specific aspects of water quality, such as its acidity, oxygen content, nutrient levels, and contamination by pollutants.

Calculation of Water Quality Index (WQI):
Several methods exist for calculating WQI, with variations in the formulae and weighting factors assigned to different parameters [16]. One commonly used formula is the weighted arithmetic index, which involves assigning weights based on the relative importance of each parameter. The formula for this method can be represented as:

$$WQI = \sum_{i=1}^{n} (Wi \times Ii) \qquad 1$$

Where:
WQI = Water Quality Index
Wi = Weight assigned to the i^{th} parameter
Ii = Sub-index value for the i^{th} parameter
n = Total number of parameters considered
The sub-index value for each parameter can be calculated using appropriate conversion functions or lookup tables, transforming raw data into a standardized scale typically ranging from 0 to 100. The weights assigned to parameters reflect their relative importance in determining overall water quality, which may vary based on regional conditions, environmental objectives, and stakeholder preferences. The computed WQI values were classified into five types, excellent water, good water, poor water, very poor water and water unsuitable for drinking, according to [17 and 18].

IV. RESULTS AND DISCUSSION

The physicochemical study findings for Joinkrama surface water in the Akinima Local Government Area (LGA) of Rivers State are shown in Table 1. pH, conductivity (COND), total dissolved solids (TDS), nitrate (NO_3), chloride (Cl), sulphate (SO_4^{2-}), total hardness (TH), phosphate (PO_4), iron (Fe), and manganese (Mn) are among the characteristics that are examined. Below are the coordinates for latitude (Lat) and longitude (Long), along with a code for each sample location (SW1 to SW6):

Table 1: Result of Physicochemical analysis of surface water in Joinkrama

Code	PH	COND	TDS (mg/L)	NO_3 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	TH (mg/L)	PO_4 (mg/L)	Fe (mg/L)	Mn (mg/L)
SW1	5.66	176.5	88.25	0.36	36	1.38	31	1.4	1.84	0.03
SW2	5.86	87.54	43.77	0.28	13	1.04	37	0.82	1.32	0.04
SW 3	6.89	162.5	81.25	0.22	16	2.31	40	1.56	1.53	0.03
SW 4	6.94	84.4	42.2	0.17	20	1.36	30	1.28	1.53	0.03
SW5	6.8	75.6	37.8	0.27	28	0.74	23	1.78	0.45	0.02
SW6	6.77	52.17	26.09	0.35	31.33	0.56	40	1.2	0.66	0.02
WHO (2011)	6.5- 8.5	1000	500	50	200	250	150	0.05	0.03	0.1

Distribution of Physicochemical Results in Surface Water

As shown in the many Figures and Tables, the investigation of the water quality in Joinkrama offers important insights into the various factors influencing the potability of the water in this area. The analysis of Figure 2 indicates that the pH values obtained from all sample locations are within the 5.66 to 6.94 range. When these readings are compared to the pH in drinking water standards set by the World Health Organization [13], which range from 6.5 to 8.5, it is comforting to know that the water in Joinkrama meets this requirement, guaranteeing that it is safe for human consumption.

Figure 2 shows how the electrical conductivity varies from 52.17 to 176.5 µS/cm. The WHO has established a criterion of 2000 µS/cm for conductivity in drinking water. Table 1 shows that Joinkrama's water clearly satisfies this requirement. Figure 3's distribution map provides further information on the Total Dissolved Solids (TDS) values, which range from 26.09 to 88.25 mg/L. Once again, Joinkrama's water quality satisfies the requirements for safe consumption since it complies with the WHO norm for TDS in drinking water, which is 500 mg/L.

Figure 3 illustrates nitrate concentrations that fall significantly short of the 50 mg/L WHO limit for nitrate in drinking water, ranging from 0.17 to 0.36 mg/L. This guarantees that there is no risk to human health and that the water in Joinkrama is both far below the maximum limit and within an acceptable range. Let's move on to the chloride concentrations, which are shown in Table 1 and Figure 4 and vary in value from 13 to 36 mg/L. The WHO threshold for chloride in drinking water is 250 mg/L, meaning that the water is well within permissible bounds and won't have any negative health consequences.

Figure 4's sulfate values, which range from 16 to 40 mg/L, are in line with the WHO's 200 mg/L threshold for sulfate in drinking water. The water at Joinkrama is safe to drink since it complies with set criteria. Figure 5 shows Total Hardness levels between 23 and 40 mg/L, which are under the 150 mg/L WHO limit for total hardness in drinking water. Concerns are raised, nevertheless, by the distribution of phosphate concentrations in Figure 5, which range from 0.82 to 1.78 mg/L and exceed the 2011 WHO limit for phosphate in drinking water, which is set at 0.1 mg/L, as shown in Table 1.

The distribution of iron concentrations in Figure 6 and Table 1 varies from 1.32 to 1.84 mg/L, considerably above the 0.3 mg/L WHO limit for iron in drinking water. Comparably, Figure 6's manganese contents fall between 0.02 and 0.04 mg/L, which is within the WHO's recommended limit of 0.1 mg/L for manganese in drinking water. In summary, although though Joinkrama's water quality metrics mostly meet WHO guidelines, the high phosphate and iron levels need attention and action to maintain the community's safety and wellbeing.

Tables 1 and 2 detail the physical and chemical properties of the water samples. Table 4 summarizes the water quality index (WQI) calculated for the study. Finally, Table 3 categorizes the water quality based on the WQI value, using classifications from [17 and 18].

Unsuitable Water: According to the geological evaluation, water samples collected from SW1, SW3, SW4, and SW5 have been categorized as "Unsuitable Water" based on their respective Water Quality Index (WQI) values, as shown in Tables 3 and 4. This classification denotes a significant amount of contamination or the presence of pollutants above permitted standards. Figure 7 depicts the various sources of this contamination, which could include industrial discharges, agricultural runoff, or poor waste disposal practices in the surrounding area.

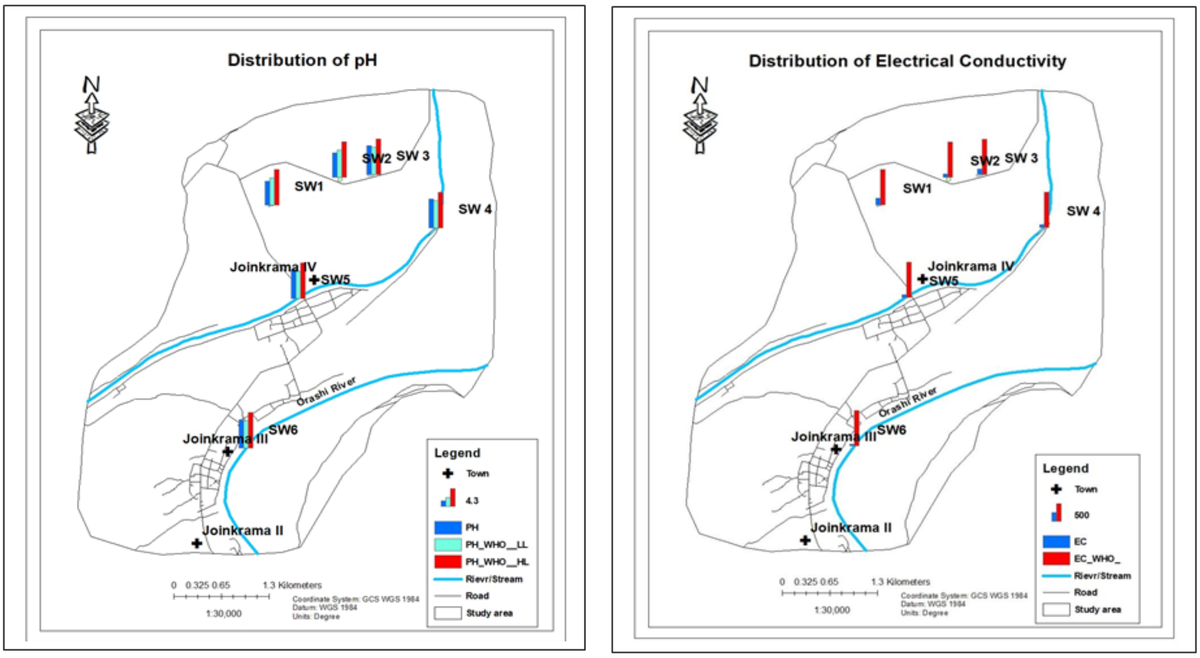

Figure 2: pH and Electrical Conductivity Concentration in Joinkrama

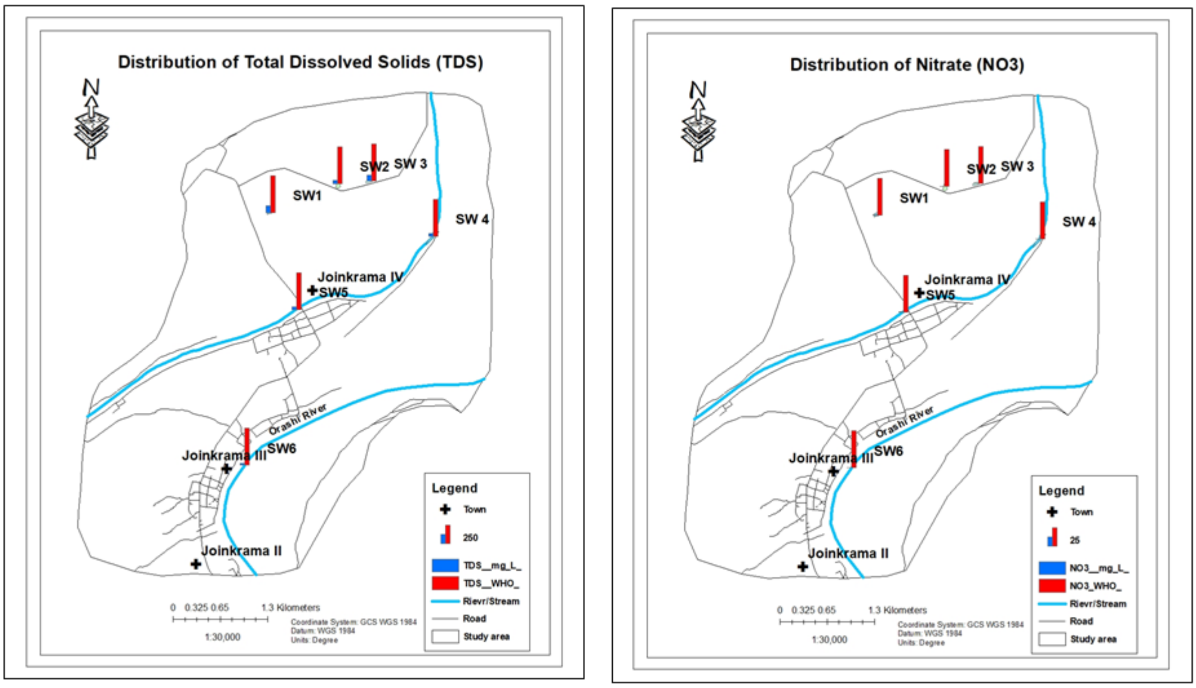

Figure 3: Total dissolved solids (TDS), Nitrate (NO_3), Concentration in Joinkrama

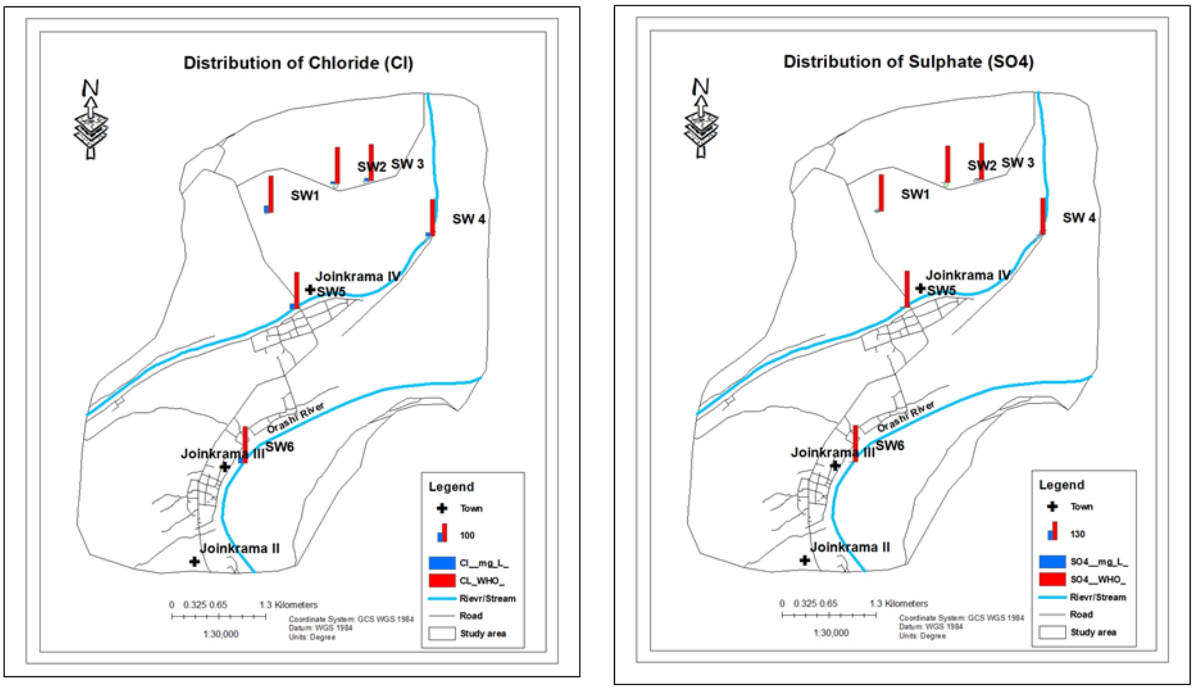

Figure 4: Chloride (Cl^-), Sulphate (SO_4^{2-}) Concentration in Joinkrama

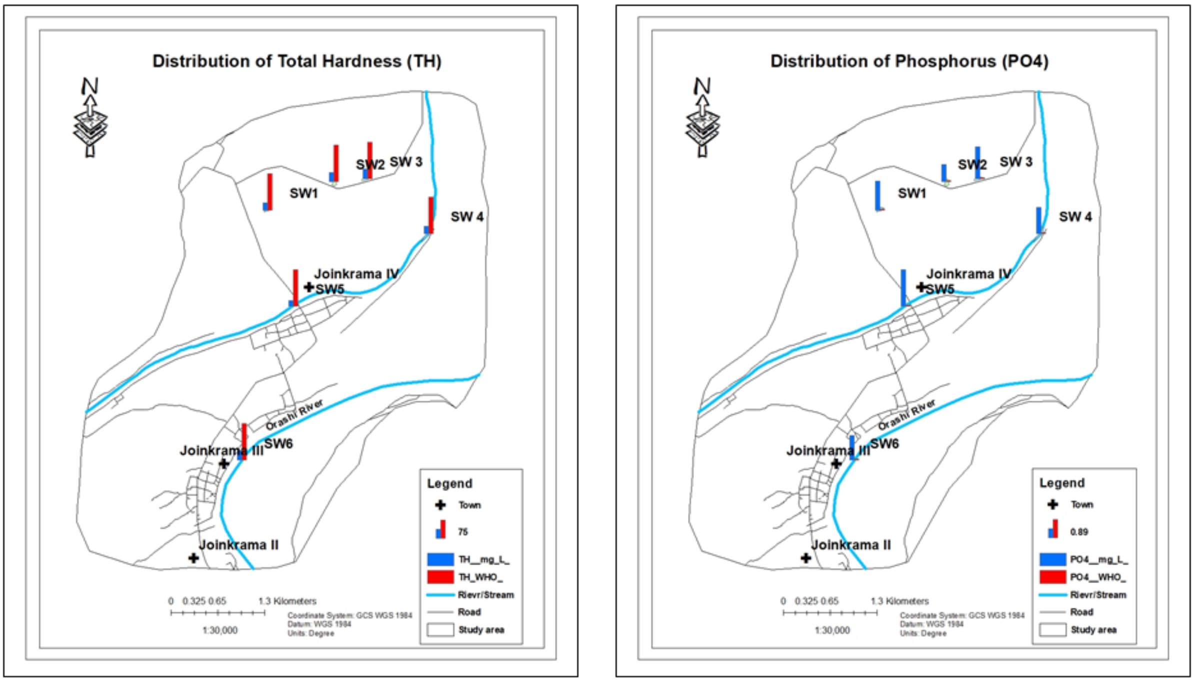

Figure 5: Total hardness (TH) and phosphate (PO_4) Concentration in Joinkrama

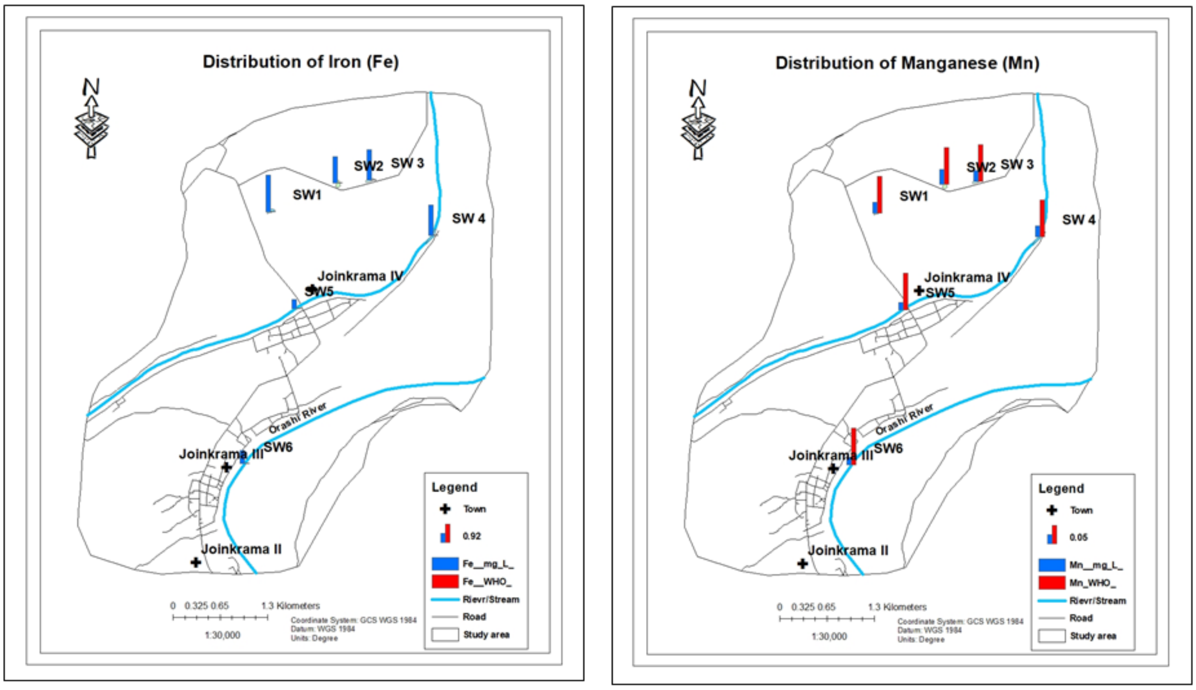

Figure 6: Iron (Fe), and Manganese (Mn) **Concentration in Joinkrama**

Water Quality Index

The assessment of water quality is paramount, and this is often accomplished through the determination of Water Quality Index (WQI) values. These values serve as indicators of the overall quality of water in a particular area, with variations pointing towards differing degrees of water quality. The WQI values obtained from six distinct sampling sites in the study area range from 241.79 to 417.33, signifying diverse conditions of water quality. The classification of water quality is typically contingent on the WQI value, with distinct classes representing varying levels of suitability for different applications, as outlined in Tables 1 and 2.

Table 2: Calculation of relative weight of each parameter

s/n	Chemical Parameters	Desirable limit	Weight(wi)	Relative weight (Wi)
1	pH	7.5	4	0.09
2	Conductivity	1000	4	0.09
3	Total dissolved solids	500	4	0.09
4	Total Hardness	150	4	0.09
5	Sulphate	100	5	0.11
6	Manganese	0.1	5	0.11
7	Chloride	250	5	0.11
8	Iron	0.3	5	0.11
9	Nitrate	50	5	0.11
10	Phosphate	0.05	5	0.11
			Σwi=46	ΣWi = 1

Table 3: Using the Water Quality Index (WQI) value as a basis for classification, [17 and 18]

Water quality index value (WQI)	Class	Water quality status
<50	I	Excellent Water
50-I00	II	Good Water
I00-200	III	Poor Water
200-300	Iv	Very Poor Water
>300	V	Unsuitable Water

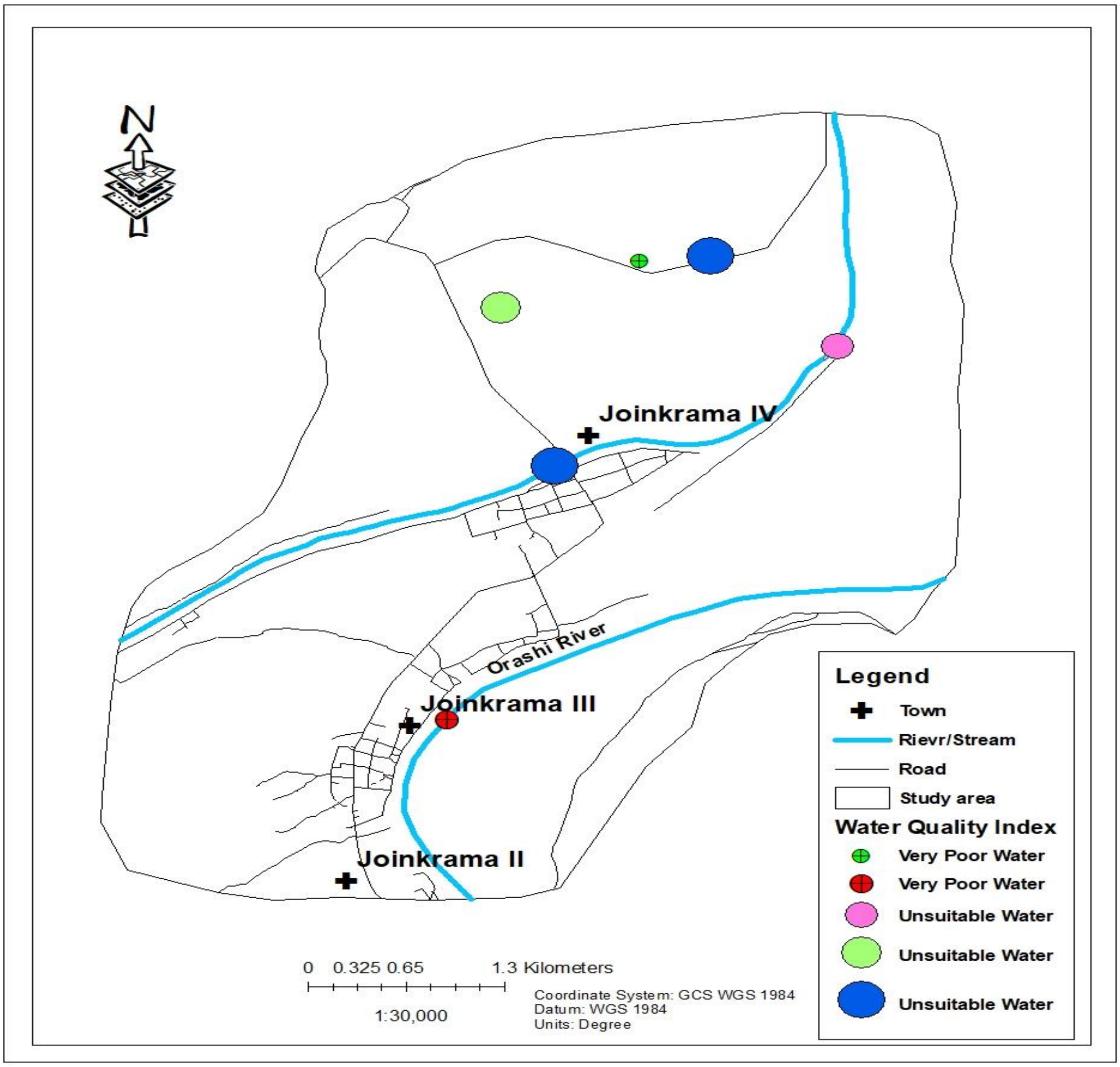

Figure 7: Water quality index in surface water

Very Poor Water Quality: Another significant observation pertains to SW2 and SW6, which are designated as "Very Poor Water" in terms of quality. Despite SW6 exhibiting a relatively lower WQI compared to other sampling points, it still falls within the "Very Poor" category, as depicted in Table 3 and Table 4. This classification implies a moderate level of contamination, highlighting the urgency of implementing immediate measures to prevent further deterioration of water quality, as illustrated in Figure 7.

Table 4: Summary of Water Quality of the Study Area for surface water

Lat	Long	Code	Water Quality Index (WQI) Value	Class of Water
5.193866	6.498092	SW1	387.48	Unsuitable Water
5.202038	6.51603	SW2	241.79	Very Poor Water
5.19933	6.514558	SW 3	411.87	Unsuitable Water
5.197602	6.512788	SW 4	349.22	Unsuitable Water
5.181572	6.501128	SW5	417.33	Unsuitable Water
5.087546	6.469853	SW6	299.49	Very Poor Water

V. CONCLUSION

The study of the water quality in Joinkrama, Ahoada West LGA, Rivers State, Nigeria, demonstrated a thorough comprehension of the physicochemical factors influencing the region's surface water's potability. The distribution of many water quality indicators, such as pH, conductivity, total dissolved solids, nitrate, chloride, sulfate, total hardness, phosphate, iron, and manganese, was revealed by the methodical collecting and analysis of six surface water samples. The findings show that, for the most part, the water in Joinkrama complies with World Health Organization (WHO) standards, meaning that it is safe for human consumption. Notably, quantities of nitrate, chloride, sulfate, total dissolved solids, electrical conductivity, and pH are all within allowable bounds. On the other hand, excessive levels of iron and phosphate surpass WHO guidelines, raising concerns and highlighting the need of action to preserve community safety and wellbeing. The water quality is further classified into groups by the Water Quality Index (WQI) values, which range from "unsuitable water" to "very poor water." Four of the six sample locations were deemed to be "unsuitable water," a designation that denotes a high degree of pollution or the presence of contaminants exceeding allowed limits. Two more sample locations were classified as having "very poor water," indicating a moderate degree of pollution and highlighting the urgent need to take action to stop the water quality from continuing to decline. As a result, the Water Quality Index computation and the integration of GIS technology provide useful instruments for determining and disseminating the state of the water quality in the area. For the community's welfare, ongoing efforts should concentrate on putting the right policies in place to reduce the sources of pollution and enhance the quality of the water.

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