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Assessment of River Benue Water Quality for Irrigation Farming at Ibi Local Government Area, Taraba State, Nigeria.

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ABSTRACT: Water quality influences its suitability for a particular use, i.e. how well the quality fulfills the requirement of the user. Water quality deals with the physical, chemical and biological characteristics of water in relation to all other hydrological properties. The possible contamination in water included organic matter, nutrients, suspended solids, heavy metals, pesticides and industrial chemicals. Water quality is critical for the survival of humans, animals, industry and agriculture. Ibi is the headquarter of Ibi local Government in Taraba State, Nigeria the town is located at the South bank of the River Benue opposite the influx of the much smaller Shemanker river. The results obtained were subjected to descriptive statistics to determine the mean and standard deviation all analyses will be performed by using Statistical Agricultural Science (version 14) software. The Na (mg/l) for upstream has a mean value of 11.04 which is significantly different from midstream and downstream which has a mean value of 8.74 and 8.97 form the sampled location. For TDS, the Midstream and Downstream are not significantly different from each other which have a mean value of 7.99 and 4.39 but is significantly different from upstream with a mean value of 58.73. In conclusion most problems associated with irrigation waters occur in the long run. Yet, poor-quality water will weaken turfgrass and make it more sensitive to environmental stress and diseases. Recommendation, good management practices and proper amendments can make some of the marginal waters usable for irrigation.

KEYWORDS: Water quality, Irrigation, River Benue, Chemical properties, Physical properties

I. INTRODUCTION

Water quality is a term used to describe the physical, chemical and biological parameters of water based its standard for specific usage [12] such as agricultural activities among others. Water is an important component that is supplied by a network of irrigation channels. Rivers, lakes, and spring water are sources of irrigation water that are facing pollution problems. Agricultural water sources may be of poor quality because of natural causes, contamination, or both. Indonesian rivers are polluted due to the discharge of untreated sewage and industrial effluents. The poor water quality of rivers and spring water has an effect on irrigation water quality. In the last century, surface water resources have been polluted to such levels that they could no longer be used for agricultural irrigation [21].

Most of the water sources used in irrigation contain impurities and dissolved mineral salts with changeable concentrations and compositions. Most of these mineral salts are beneficial to crop growth and soil conditioning. Irrigation water quality can affect soil fertility and irrigation system performance as well as crop yields and soil physical condition. Therefore, the knowledge of irrigation quality is critical to understanding of necessary management changes for long-term productivity [3] depending on the water, soil, crop, and environmental factors. This is due to the fact that most of the mineral salts remain in the soil after the water has been used by the crop [16].

The total amount of water on the earth is about 1.35 billion cubic kilometers. About 97.1 percent has been locked into oceans as saltwater. Ice sheets and glaciers have arrested 2.1 percent. Thereby only 0.2 percent is the fresh water present on the earth, which can be used by human for variety of purposes. Remaining 0.6 per cent is in underground form [22]. The qualities of these water bodies vary widely depending on the location and environmental factors [24].

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It is a well-known fact that a polluted environment has a detrimental effect on health of people, animal life and vegetation [23]. The features of irrigation water that define its quality vary with the source of the water [17]. The Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful to crop growth if they exceed certain threshold values [12]. Water is the most important natural resource used in irrigation farming and therefore, there is the need to assess its quality. River Benue is a large body of fresh water with the potential for large scale irrigation scheme particularly in Ibi local government area of Taraba State but studies on the assessment of the water suitability for irrigation farming and other domestic uses in the study area are very scarce or almost nonexistent. Therefore, this study will provide a baseline data on the quality and composition of this water used for small scale irrigation farming as well as to help farmers in the study area to upgrade their irrigation farming.

II. MATERIALS AND METHOD

Study Area

The study was carried along River Benue in Ibi town, Ibi Local Governemnt, Taraba State, Northeast Nigeria. The area lies between Latitude $8^0$10'52.39"N and Longitude $9^0$44'39.52"E of the Greenwich meridian, with its climatic condition conducive for cultivation of a large variety of agricultural products. Due to the richness of the minerals in the parent rock; these soils are generally well suited for rice, maize, guinea corn as well as arable farming and tree crops production [2].

Figure 1: Map of Taraba State showing the study area. Source: [2]

Climate

Ibi is one of the coldest regions in Nigeria with an average daily high temperature of 33^0C. The climate is very warm, but has a very few tropical and humid months. The climate is characterized by seasonal rainfall, high temperatures and high humidity. The environment is noted for two distinct seasons, rainy and dry periods. The dominance of the seasons is primarily controlled by two major air masses or wind currents. It is year-long warm or hot. Due to the lesser rain, the best time for travelling is from November to March. Most precipitation increases from June to October.

Vegetation, Soils and Land Use

The vegetation consists of grassland interspersed with trees and shrubs. The soils are moderately deep to deep, shallow, and well-drained to poorly draining with loamy sand to sandy loam surface over sandy clay loam to sandy clay subsoil. Land use includes the cultivation of Maize (Zea mays), Cowpea (Vigna unguiculata L. Walp), Groundnut (Arachis 1013ubterra), Rice (Oryza sativa), Guinea corn (Sorghum bicolor), Millet, Beniseed (Sesamum indicum), Bambara nut (Voadenzia 1013ubterranean), Yam (Dioscorea spp), Okra (Albemuschus esculentus), as well as Cashew (Anacardium occidentale) and Mango (Mangifera indica) as well as plantations. Grassland areas support animal grazing activities.

Geomorphology

Ibi lies largely within Taraba which is in the middle belt of Nigeria and consist of undulating landscape dotted with few mountainous features, this include the scenic prominent Mambilla plateau. The river Benue at Ibi is one of the main river in the State alongside with Donga, and river Taraba. They rise from Cameroon Mountains, straining

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almost the entire length of the state in the north and south direction to link up with the River Niger. The major occupation of people in Ibi Local Government Area is fish farming.

Sample Collection and Analysis

Water samples were collected from the Ibi segment of the River Benue. The site was visited in the early morning hours for samples collection for analyses. Triplicate water samples were collected from three mapped segments (Upstream, Midstream and Downstream) of the river. In each sampling location, samples were collected from the outer and mid-sections of the river using 1 litre plastic bottles, properly labeled. Samples were transported to the laboratory in ice-packed container for subsequent analysis to prevent chemical and biological transformation.

The water quality indicators that were analyzed were: EC, Ca^{2+}, Mg^{2+}, Na^{+}, Ph, SO_4^{2+}, NO_3^{-}, and TDS. The trace metals include boron (B), arsenic, and lead. The concentrations of Na^{+}, Ca^{2+} and Mg^{2+} were used to quantify the sodium adsorption ratio (SAR). Also faecal coliform was determined according to standard microbiological techniques.

Analysis of Water Samples

Sample analysis of Benue River at Ibi was done for the major and minor ions. These include^{+}, Ca^{2+} and Mg^{2+} and anions (NO_3, and SO_4^{2+}). In addition other chemical parameter such as (SAR) was also determined using standard procedures. Beside this, measurements of Ph, EC, TDS were done.

Ph, TDS and Electrical conductivity (EC) were measured on site using portable Ph/EC/TDS meter H198106. Palin test photometer was used with colorimetric method to determine the following: NO_3^{-}, SO_4, and Na^{+}. Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) were determined by Atomic Adsorption Spectrophotometer (ASS), while potassium was determined by flame photometry. Phosphorus was determined by the method described by [11]. The choice of variables or parameters analyzed was informed by their roles during crop production. Other water quality parameters and indexes necessary for irrigation practice such as Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Soluble Sodium percentage (SSP), Permeability Index (PI) and Kelly ratio (KR) were evaluated.

Statistical Analysis

The results obtained were subjected to descriptive statistics to determine the mean and standard deviation. All analyses were performed using Statistical Agricultural Science (version 14) software.

III. RESULTS AND DISCUSSION

Physical Properties of the Water Sample

The mean values of the variation of the water quality indicators evaluated from the studied area are presented in Table 1 and 2 respectively.

Total Dissolved Solid (TDS)

The mean value of TDS has the ranged values from 46.89 mg/L to 58.73 mg/l. The dispersion around the mean indicated that all the value falls below the mean and within the threshold value for irrigation purpose since the higher concentration is below the permissible limit of the standards 2000mg/l [13], also according to irrigation water quality classification [8]. All the value falls below the mean and within the threshold value for irrigation purpose since the higher concentration is below (< 450mg/l) and they had no restriction to use for irrigation.

TABLE 1: MEAN WATER QUALITY PARAMETERS OF SAMPLED LOCATIONS

Parameter	Sample Description			
	Upstream	Midstream	Downstream	FAO
TDS	58.73	41.17	46.89	<450
Electrical Conductivity (μS/m)	80.82	65.88	64.42	3000

The source of Dissolve solids in the water is natural as minerals in soil and anthrophonic as agrochemicals [7]. The TDS mean result in the upstream is higher than that of the midstream and downstream. Therefore, upstream is significantly different with midstream and downstream Table 2. This may be because of the wide interval among the three collecting points and water dissolved the

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TDS before reaching the midstream and downstream. According to [15] high concentrations of TDS limit the suitability of a water source as a drinking water supply. Water with dissolved solids below 500 mg/L is optimum. Concentration exceeding 1000 mg/L is generally unacceptable for most uses. For animals, concentrations less than 2500 mg/L have proven to be satisfactory in most circumstances. Primary guidelines for drinking water are related to taste and palatability associated with TDS. Industries are sensitive to boiler scaling or to accelerated corrosion. High TDS may interfere with the clarity, color, and taste of manufactured products.

[1] in their work on Assessment of the Suitability of Water quality for irrigation in Ogbomoso, Oyo State obtained a TDS concentration in the water ranged from 33.30 to 34.10 mg/l during the dry season which also agrees with the result of this study.

Electrical Conductivity (EC)

The Electrical conductivity (EC) of the sample collected at the studied area has the mean values ranges from (64.42 – 80.82 µS/m) downstream/midstream in comparison, Electrical Conductivity is high at the upstream than midstream and downstream. This implies that the salt concentration is fairly uniform at the midstream and downstream. This may be attributed to the soil formation that, the soil does not add salt to the water within the sampling point of river Benue at Ibi. However, Electrical conductivity, at the upstream is significantly different from midstream and downstream in Table 2.

TABLE 2: STATISTICAL COMPARISON OF MEAN VALUES OF PARAMETERS OF SAMPLED LOCATIONS

Sample Description	Sample Description							
	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	Ph	TDS (mg/l)	SO_4^{2-}	NO_3^-	Conductivity (µS/m)
Upstream	11.04[a]	19.72[a]	9.58[a]	6.01[a]	58.73[a]	8.09[a]	11.08[a]	80.82[a]
Midstream	8.74[b]	16.78[a]	8.37[a]	6.54[a]	41.17[b]	7.99[a]	7.92[b]	65.88[b]
Downstream	8.97[b]	19.25[a]	6.54[a]	6.54[a]	46.89[b]	4.39[b]	6.67[b]	64.42[b]
SE(P<0.05)	0.59	NS	NS	NS	4.22	0.99	1.07	4.28

In a column, mean followed by the same lower case letter are not significantly different at P<0.05. NS = Non significant

The maximum limit for irrigation water was prescribed as 300 µS/m, this value fall into slightly to moderate in terms of degree of restriction in use. A lower EC value signifies less concentration of the dissolved ions and organic matters while salinity of water is an indication of high EC. [25] in their work on Assessment of the suitability of Water Quality for Irrigation in Minna, Niger State found that the EC found to be 1.02 and 0.60 ds-m/L for mechanic village and Chanchaga River water samples respectively. Higher salinity result in higher ECw and as the salt level increases, the plant must expend more energy to take in nutrient dissolved in the water from fertilizer and soil.

Chemical Properties of the sampled water

The chemical properties of the sampled water are as presented in table 3. This table contains parameters such as the pH, Na^+, SAR, Ca, Mg, SO_4^{2-} and NO_3^-

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TABLE 3: CHEMICAL PARAMETERS OF THE SAMPLED WATER

Parameter	Sample Description			
	Upstream	Midstream	Downstream	FAO
Ph	6.01	6.54	6.54	6.6–8.4
Na (mg/L)	11.04	8.74	8.97	200
SAR(mg/L)	0.48	0.43	0.45	0-20meq/L
Ca (mg/L)	19.72	16.78	19.25	800
Mg (mg/L)	9.58	8.37	6.54	120
SO_4^{2-}	8.09	8.00	4.39	0–20 me/l
NO_3^-	11.08	7.92	6.67	0–10

*WHO
ND = Non Detectable

pH of Water Sample

The pH concentration in the studied area as shown in Table 3 ranged from 6.01 to 6.54. These values are within the permissible limit for irrigated agriculture as reported by [8].

The study further revealed that the pH values of upstream were lower compared to the midstream and downstream though there is no significant difference among them. This condition may be due to the anthropogenic acidity originated by generated organic substance. A comparison of the pH values with the normal range of the standard irrigation water 6.0 – 8.4 show that the sampled are within the range of irrigation use. The mean value of pH indicated that the river across the point of collection did not have alkaline. Moreover, high pH water cause salts to precipitate and can reduce the efficiency of pesticides [19] thereby affecting the suitability for irrigation use. Another study by [6] on water composition and irrigation suitability of various surface water and ground water sources at Matahara Plain in South Africa showed the following results; pH of water sample from Awash River, irrigation Canal Reservoir, factory effluent, and ground water are considered to be within the normal range (6.5 – 8.5) for most crops. The Cl of Na, Ca and Mg are all highly soluble in water, and if absorbed through plant roots or foliage can affect crop yield and quality significantly. Most water samples have a pH greater than 7.0 as acidic water (less than 6.0) could cause corrosion of metal parts in irrigation equipment.

Sodium Content

Sodium (Na^+) concentrations in the studied area had the mean value ranged from 8.97 to 11.04 mg/L. this implies that, the concentration of sodium at the upstream is slightly higher than that of midstream and downstream. Therefore, the upstream is significantly different from midstream and downstream as indicated in Table 2. Thus, irrigation water containing larger amount of sodium (Na) and absorption ratio (SAR) are of special concern due to sodium effects on the crop growth as well as soil physical condition. Their excessively high sodium content has a potential to destroy sol structure and aggregate stability, which can lead to the reduction of soil fertility [19]

Sodium Absorption Ratio (SAR)

The waters having SAR values less than 10 meq/L are considered excellent, 10 meq/l to 18 meq/L as good, 18 meq/l to 26 meq/l as fair, and above 26 meq/l are unsuitable for irrigation use [26]. In this work, the sodium value at the upstream is 0.48, midstream 0.43 and downstream 0.45mg/L. The mean values at the collection point are lesser than 10 meq/l therefore it is graded as excellent for irrigation use (Table 2). SAR is a measure of tendency of sodium (Na) ion to displace Ca ion in the irrigation water soil [4]. [12] opined that continued use of water having high SAR or Sodium damages the soil physical properties due to the fact that the sodium ions replace calcium and magnesium ions absorbed on the soil clay and causes dispersion of soil particles.

Calcium (Ca) Content

Calcium concentration in the studied water showed the mean values with ranged from 16.25 – 19.72 mg/L, these values falls below the maximum contamination limit for irrigation (800mg/l). This shows that the water is suitable for irrigation activities. Though the mean value for upstream 19.72, midstream 16.78 and downstream 19.25 and the upstream is slightly higher than the

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midstream and downstream there is not significantly deferent at 5% as indicated in table 2. This agrees with [17] standard for irrigation.

Magnesium (Mg) Content

Magnesium (Mg) concentration in the studied water has the mean values with the ranged from 6.54 – 9.58Mg/L, these values falls below the maximum contamination limit for irrigation (120mg/l). It means that the water is good for irrigation use. None of the sample exceeded the threshold values in respective of the points of collection. Thus, no threat, High concentration of Ca^{2+} and Mg^{2+} ions in irrigation water will causes increase in soil pH leading to reduction in the availability of phosphorus to plants.

Despite the difference in the mean value of magnesium, there is not significantly difference among the upstream, downstream as showed in table 2.

Sulphur (S) Content

The content of Sulphur in the water samples ranged from 4.39-8.09meag/L. Sulphur content in all water sample were not problematic for irrigating agricultural crops on all soils, were the maximum recommended concentrated of SO_4 was 20mg/l [8].

Nitrate ($N0_3$) Content

Nitrate nitrogen (NO_3^-N) in the studied water has the mean values ranges from 6.67 – 11.08mg/l. the value sat the upstream raised slightly above the limit 10mg/L while midstream and downstream fall below the limit of (10mg/l) therefore, this can be recommended for irrigation [9].

The slightly high level of NO_3-N concentration in the water could be attributed to a high percentage of crop land within the studied area that indicted higher nitrogen based fertilizer was used. This is similar to the finding of [28] and [20] nitrogen is the major nutrient needed by the plants. It abundance is desired in irrigation. Water, though the slightly high concentration of it does not make the water unfit.

The nitrate –nitrogen level in the upstream is 11.08, in the midstream 7.92 and in the downstream is 6.67mg/L. it reduces as it flows to downstream. There is not significant between upstream and midstream but the upstream and midstream has significant difference with the downstream.

Heavy Metals and Microbial Properties

The parameters of the heavy metals and microbial properties are shown in table 4. These parameters include As, Pb, Boron and Faecal coliform unit.

TABLE 4: MEAN VALUES OF HEAVY METAL AND MICROBIAL PROPERTIES OF WATER SAMPLE

Parameter	Sample Description			
	Upstream	Midstream	Downstream	FAO
As (mg/l)	0.007	0.002	0.001	0.10
Pb (mg/l)	0.017	ND	ND	5.00
Boron (mg/l)	0.46	0.33	0.33	0.70
Faecal coliform unit (cfu/ml)	1.5×10^5	1.4×10^5	8.4×10^4	<1000 cfu/100ml*

*WHO
ND = Non Detectable

Arsenic (As) Concentration

The content of arsenic in the water sampled ranged from 0.01 – 0.007 mg/L. the maximum level of arsenic in irrigation recommended by the FAO is 0.10mg/L. the WHO recommended that the maximum level of arsenic in drinking water should not exceed 0.010 mg/L. The reduction of WHO provisional guideline values for Arsenic concentration in drinking water from $50pgL^{-1}$ to a provisional $10pgL^{-1}$ in 1993 [27] and the reduction in 2002 of the USEPA maximum Admissible Concentration (MAC) to $10pgL^{-1}$ has been made in response to growing concern about

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upstream poisons carcinogen and raised awareness of the danger of arsenic in drinking water.

Lead (Pb) Concentration

The mean value of lead is as follows 0.017 for upstream, 0.01for midstream and 0.1 for downstream respectively. This shows that the concentration of lead in the studied water falls below the maximum permissible value of 5.00mg/L in irrigation water quality. [18] ported that lead concentration within the drinking water quality standard in River Benue which differs significantly from the finding of this study. Lead is well known as cumulative poison that has several damaging effects on public and organization. The concentration differs from each other's.

Boron (B) concentration

Boron concentration in the studied water has the mean value with the range from 0.33-0.46mg/L. according to water quality classification after [29] all water was within the safe limit of 0.70mg/L and graded as excellent for irrigation.
This finding confirm the result of [10] content (0.60 -0.82 mg/L) though this was slightly problematic for irrigating agricultural crop in all soils where the maximum recommendation concentration of p was 2.0 mg/L [8].

Fecal Coliform Concentration

The water sample tested were for the present of fecal coliform and Escherichia coli. The medium values per 100ml these indicator in the irrigation water sample were $1.5x10^5$ x 10^5 and $8.4x\ 10^4$cfu/mL respectively. Between $1.5x\ 10^5$ and 1.4 x 105% of irrigation water sample contained acceptable level of fecal coliform or Ecoli, according to Published irrigation water quality guidelines.

The absence of significant difference between the mean value of fecal count in the upstream and downstream is in line with the findings of [6] Show continuous fecal pollution from the point sources such as domestic drain effluent from abattoir mechanic workshop etc. The higher count will be in rainy season as a result of runoff as reported by [5]. The mean vale of the downstream is significantly different with upstream and midstream.

Statistical comparison of mean Value of heavy Metal and microbial Parameters

The statistical comparison of mean value of heavy metals and microbial parameter are as given in table 5. This table shows the upstream, midstream and downstream results for As, Pb, Boron and Faecal coliform respectively.

TABLE 5: STATISTICAL COMPARISON OF MEAN VALUE OF HEAVY METALS AND MICROBIAL PARAMETERS

Sample Description	Sample Description			
	As (mg/l)	Pb mg/l)	Boron (mg/l)	Faecal coliform unit (cfu/ml)
Upstream	0.007	0.017	0.457^a	1.5×10^{5a}
Midstream	0.002	< 0.01	0.327^b	1.4×10^{5b}
Downstream	0.001	< 0.01	0.33^b	8.4×10^{4c}
SE (P<0.05)	NS	NS	0.04	16768
FAO	0.10	5.00	0.70	$<1000_{CFU}$/100ml

In a column, mean followed by the same lower case letter are not significantly different at P<0.05. NS = Non Significant

For As (mg/l) and Pb (mg/l) is not significantly different from upstream, midstream and downstream across parameter. Boron for upstream is significantly different from midstream and downstream. Midstream and downstream has a mean value of (0.327 and 0.33) has not significant different across the parameter. The result of Faecal coliform unit (cfu/ml) the upstream has a mean value of (1.5) which is significantly different, midstream has a mean value of (1.4) is significantly different and downstream is significantly different (p>0.05).

IV. CONCLUSION

The Assessment of River Benue water quality for irrigation farming was studied. The water sampled results revealed that the studied

water are under desirable limit and suitable for irrigation during the dry season as quality index ranged from good to excellent uses. The results shows pH 6.01(mg/L), Sodium 11.04 (mg/L), Calcium 19.72 (mg/L), magnesium 9.58 (mg/L), TDS 58.73 (mg/L), Sulphur 8.90 (mg/L), Nitrate 11.08 (mg/L), Electric Conductivity 80.82 (µS/m), Arsenic 0.007 (mg/L), Lead 0.017 (mg/L), Boron 0.46 (mg/L), Fecal coliform 1.5 $x10^5$(cfu/ml) and SAR 0.48 (meq/L). More so, the water could be used almost on all soil but the water quality should be assessed regularly to assess pollution activities from time to time for taking appropriate management measured to prevent pollution activities.

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