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Research Article

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Environmental Pollution of Oshin River, Gbugudu, Nigeria; Trace Metal Monitoring and Geo-Chemistry

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ABSTRACT
Oshin river is located around the end of Gbugudu forming a meandering curve across notable areas. It is a tributary of river Niger located within Moro local government area, Kwara state and it meanders across different areas of Beri, Onikoko, Ilaga, Gbugudu, Osin-gada and many more communities.

It was scientifically studied to reveal the importance for its potential for township water supply. The study included evaluation of the physico-chemical characteristics, hydrometerlogical and soluble salts assessment. The assessment was conducted by field work that involved sampling of the river water for salient laboratory studies to reveal basic properties. It entailed the utilization of Atomic Absorption Spectroscopic for heavy metals analysis and Ultra-Violet Light study for the soluble salts analyses.

With an average of 8.36 pH value, the acidity of studied samples could be traced to massive application of fertilizer to crops that gets washed into the Oshin River water, thereby polluting the water and making it unsuitable for public consumption. There was obvious decreasing trend of the total hardness across the area that represent source to the downstream of the flow area. The dissolved oxygen of the area has reflected an anomalous trend of gradual reduction and increase from sample 1 to sample 4 that represent the source of the Oshin River to the downstream of the flow in the area. Electrical conductivity value of 1000-10,000 Us/cm recorded falls within the saline condition. The water samples revealed TDS that varied between 905, 860, 865 and 1715 mg/L. The water samples have a fair TDS value as most falls within the limit of 600-900 mg/L Measured temperature pattern of Oshin River water varied between 23.4, 22.8, 23.1 and 23.00 °C for investigated samples of the area, recorded 54.40, 81.60, 83.20 and 84.80 mg/L. The chemical compositional study of the river water has shown that lead varied between 0.054, 0.032, 0.027 and 0.056 mg/L across the investigated area. The measured cadmium concentration varied between 0.001, 0.160, 0.051 and 0.095 mg/L. In essence, the study concluded that the Oshin River is good for irrigation of farmland, but unfit and moderately toxic for public consumption except if treated for such purpose.

Keywords: Hydrometeriological, Biochemical Oxygen Demand, Electrical Conductivity, Downstream and Total Dissolved Solids

Introduction

The importance of water for sustenance of life cannot be overemphasized. Whether it is in the use of running water in our homes, recreation, rearing cattle, growing crops or the increased use in industries remain immeasurable [1]. It is important therefore, to note that unregularized production ie wasteful use of this commodity either through contamination, shortage or careless use results in serious consequences for human race. Also, it was equally noted that water of adequate quantity and quality is essential for sustainable development of man on earth [2]. This is just as elaborated opinion was made

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on shortage of pipe borne water that has necessitated man finds solace in surface water [3]. Indeed, a world without potable water is unsustainable for human race! Heavy metals are not biodegradable and tend to accumulate in the sediments of water ways in association with organic and inorganic matter in the sediment. Moreso, contribution was made that heavy metals accumulate in sediments of waterways [4]. Excessive nutrients can lead to water eutrophication, causing a hypoxia environment with the reductions of species diversity and microbial growth, mortality of benthic organisms and stress in fishery resources was clearly stated [5]. Human activities are a major factor determining the quality of surface and ground water through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use [6].

Climatic Condition of the Study Area

The climatic condition of the area is closely linked with that of Ilorin metropolis as it belongs to one of the closest communities to the Ilorin town with about 7-15 km of distance apart. The climate of the area is humid tropical under the influence of the two trade winds prevailing over the country and characterized with high temperature throughout the year [7]. Gbugudu enjoys wet and dry seasons. The daily average temperatures are in January with 25ºC, May 27.5ºC and September 22.5ºC. The wet season is between May and October with two peak periods in June and September while the dry season spans between November and April. The mean annual rainfall is 1,200 mm [8]. The mean annual total rainfall is 1,200 mm [7]. The temperature in the area is uniformly high throughout the year.

Temperature

Over the course of the year, the temperature typically varies from 64°F to 95°F and is rarely below 57°F or above 100°F. The hot season lasts for 2.6 months, from January 23 to April 10, with an average daily high temperature above 92°F. The hottest month of the year in Gbugudu is March, with an average high of 94°F and low of 73°F (Figure 1). The cool season lasts for 3.6 months, from June 22 to October 10, with an average daily high temperature below 85°F. The coldest month of the year in Gbugudu is August, with an average low of 70°F and high of 83°F.

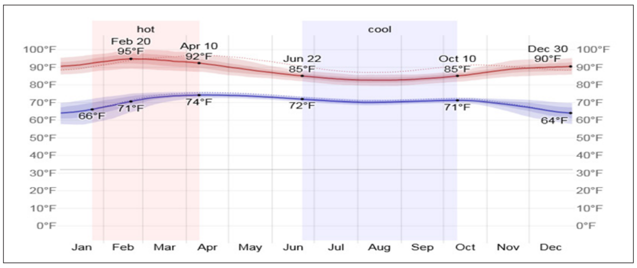

Figure 1: The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

Source: NASA [9].

Precipitation

A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Gbugudu varies very significantly throughout the year. The wetter season lasts 6 months, from April 15 to around October 21, with a greater than 41% chance of a day being a wet day. The month with the most wet day in Gbugudu is September (Figure 2), with an average of 23.6 days with at least 0.04 inches of precipitation. The drier season lasts 5.8 months, from October 21 to around April 15. The month with the fewest wet days in Gbugudu is January, with an average of 0.5 days with at least 0.04 inches of precipitation (Figure 2). Among wet days, we distinguish between those that experience rain alone, snow alone or a mixture of the two. The month with the most day of rain alone in Gbugudu is September to October (Figure 2). Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 80% in September to October.

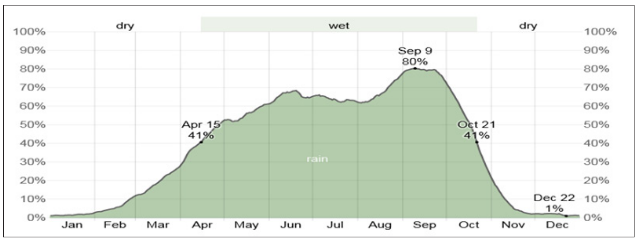

Figure 2: The percentage of days in which various types of precipitation are observed, excluding trace quantities: rain alone, snow alone, and mixed (both rain and snow fell in the same day).

Source: NASA [9].

Humidity

Humidity of Gbugudu area is based on the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so, while the temperature may drop at night, a muggy day is typically followed by a muggy night. Gbugudu experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 10 months, from around February 6 to December 6 (Figure 3), during which time the comfort level is muggy, oppressive, or miserable at least 34% of the time. The month with the fewest muggy days in Gbugudu is January, with 6.4 days that are muggy or worse (Figure 3).

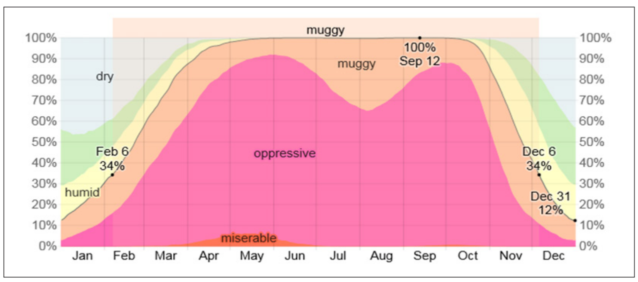

Figure 3: The percentage of time spent at various humidity comfort levels, categorized by dew point.

Source: NASA [9].

Location

Oshin river being a tributary of river Niger is located around Gbugudu area of Moro local government, Kwara state and it meanders across different areas of Beri, Onikoko, Ilaga, Gbugudu, Osin-gada and many more communities. Its worthy of note that this river is currently of great importance and current research to Lower Niger River Basin Development Authority to harness the river potential for the purpose of creating a reservoir dam that can utilize surface water to be impounded for dry season agricultural and irrigation of farmland. Description of the study area revealed the area in question is a tributary of river Niger with vast potential of the Oshin river water in the construction of a dam for irrigation purpose [10]. This study will be conducted on the river. Its course enters the western end and runs northwards around the Oshin-gada area where large amount of fishing activity is going on with extensive agricultural activities for food production coupled with massive deforestation and urbanization with different houses springing up around it (Figure 4 and 5).

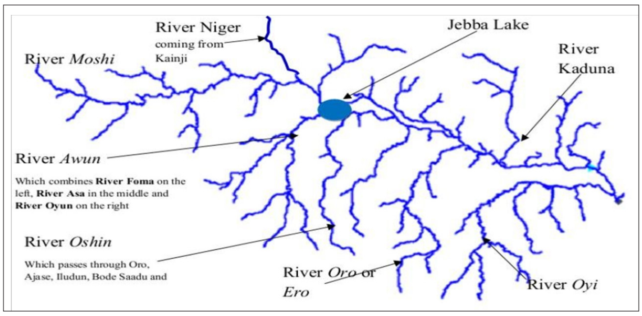

Figure 4: Sketch view of Gbugudu area showing meandering Oshin River

Source: [11].

The Gbugudu axis of the river channel has its geographical locations as Latitude N080° 39’ 38.5’’, longitude E040° 46’ 28.6’’ and latitude N080° 39’ 26.9’’, longitude E04° 46’ 33.3’’. The aerial view map imagery of project location (Figures 4 and 5) has revealed the area in question is quite very promising and suitable for agricultural activity, fishing and industrial hub location. Gbugudu is one of the prominent gateway axis to the northern part of the country. Ecological impacts of constructing a dam in the area using Oshin River tributary ranges from sedimentation in the reservoir area, accumulation of bye-products of anaerobic decomposition, losss of terrestrial habitat etc with adequate mitigations already suggested [11].

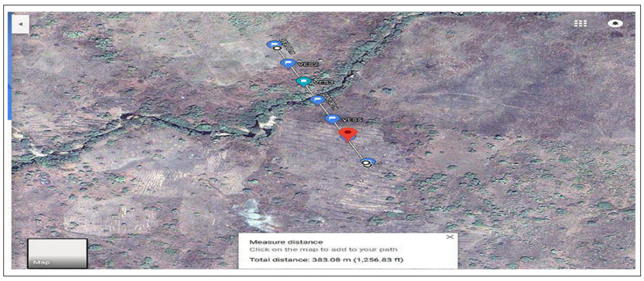

Figure 5: Satellite image of Gbugudu study area

The satellite imagery of the study location has revealed a gentle slope with green vegetation and high farming activities. The river channels are constantly active during the rainy season (Figure 5).

Methodology of Study

Oshin river water samples were aspirated into a flame then sample element changed into atomic vapour of that element. Furthermore, some atoms were thermally excited by flame whereas most of them remain in ground state. The ground state atoms then absorbed the radiation of specific wavelength produced by source i.e. graphite furnance of that specific metal investigated for in the samples. The wavelength of radiation given off by the source or lamp is similar as that of absorbed by the atoms of elements of interest in the flame. In essence, the AAS uses the absorption of light to measure the concentration of gas-phase atoms in the study water samples. Moreso, since the analyte atoms or ions must be in this vapour form for the AAS to absorb and evaluate its chemical constituents, the collected Oshin water samples were vapourise in the graphite furnance for this laboratory analysis [12].

Test for temperature was done on field with portable mercury glass thermometer (accurate to 0.1 °c). the thermometer was gently submerged in to the water, ensuring it is fully immersed and not touching the river bed. The readings were taken after the thermometer is stabilized and a constant temperature reading was displayed. Multiple readings were taken to obtain a representative average temperature [13]. The temperature was recorded in degrees Celsius (°c). The pH was measured using a calibrated pH meter (water quality parameter tester) was used to determine the pH of the samples. Small amount of the water sample was poured into the beaker, the pH meter probe was immersed into the water sample, the readings were taken after the pH meter became stabilized and a constant pH reading was displayed. Multiple readings were taken to obtain a representative pH reading [13]. The TDS of the water samples was determined using a calibrated water quality parameter tester. Small quantity of the water samples was poured into the beaker, the tester was rinsed with distilled water to be free of contaminants, the probe of the tester was carefully immersed into the water samples, ensuring that the probe is fully submerged and not touching the bottom or sides of the beaker. The readings were taken after the tester became stabilized. The TDS was recorded in milligrams per liter (mg/L) [14].

The electrical conductivity of the water samples was measured using a calibrated water quality parameter tester. Small quantity of the water sample was poured into the beaker, the tester was rinsed with distilled water to remove any contaminants, the probe of the tester was carefully immersed into the water samples, ensuring that the probe is fully submerged and not touching the bottom or sides of the beaker. The readings were taken after the tester became stabilized. The electrical conductivity was recorded in micro-Siemens per centimeter (µS/cm) [14]. The total hardness was done with 100ml of Oshin River water sample was measured into a conical flask, 2.00ml of ammonia buffer solution was added and two drops Erio T indicator was also added, the solution turned pink. The initial burette reading was taken, the sample was titrated with the standard EDTA solution until the colour of the mixture turns from pink, through purple, to blue. The volume of the EDTA used was recorded and the titration was repeated twice.

Results Presentation and Discussions

The Physico-chemical properties of the water samples from the study locations (Osingada, Onikoko, Beri and Ilaga) were investigated in the laboratory with the results of findings hereby presented. The measured parameters included pH, Total Hardness, Dissolved Oxygen, Electrical Conductivity, Total Dissolved Solid, Turbidity, Temperature and Biochemical Oxygen Demand. Temperature varies with location, season and depth and affects the solubility of gases and rate of chemical and biological processes, hardness reflects the concentration of calcium and magnesium ions influencing water quality and scale formation. Dissolved oxygen is essential for aquatic life and its concentration can be influenced by temperature, flow rate and organic matter decomposition. The Electrical conductivity measures the water ability to conduct electricity which correlates with the concentration of dissolved salts and minerals. All these physical properties of Oshin River water were thus evaluated in the collected water samples to elaborate on the utilization potential of the river water for different activities.

Table 1: Physico-chemical Properties of water samples from the study Oshin locations

S/N	Physical Properties	Sample 1	Sample 2	Sample 3	Sample 4	Average
1	pH. Value	7.89	7.81	9.94	7.81	8.36
2	Total Hardness (mg/L)	71.40	58.80	46.20	42.00	54.6
3	Dissolved oxygen(mg/L)	145.60	177.60	161.60	160.00	161.2
4	Electrical Conductivity(Us/cm)	1790	1690	1765	1087	1583
5	Total Dissolved Solid (mg/L)	905	860	865	715	836.25
6	Turbidity (NTU)	2.365	2.004	2.052	2.864	2.321
7	Temperature (°C)	23.4	22.8	23.1	23.00	23.07
8	Biochemical Oxygen Demand (mg/L)	54.40	81.60	83.20	84.80	76

Sample 3 recorded the highest pH value of 9.94 (Table 1) with sample 2 recording the lowest value of 7.81 signifying acidic nature of the samples from the location. With an average of 8.36 pH value, the acidity of studied samples could be traced to massive application of fertilizer to crops that gets washed into the Oshin River water, thereby polluting the water and making it unsuitable for public consumption. The anomalous variation of the pH value across the investigated river water samples point towards variation of farming activities in each of the settlements of the area with public health effects of such water bodies on respiratory and cardiovascular impacts. The corrosivity of the sampled water from Oshin River is slightly acidic therefore the Oshin River sampled water cannot leach metal iron, manganese, copper, lead and zinc, in essence, the hydrogen ion activity is slightly acidic in most evaluated samples of the Oshin River water samples.

Total Hardness (mg/L)

The total hardness of collected samples was done as part of the physical characterization of the Oshin river. This facilitated a broad view of the sampled investigation exercise with the concentration of calcium and magnesium ions in the sampled water. Sample 1 recorded a total hardness of 71.40, samples 2, 3 and 4 recorded total hardness of 58.80, 46.20 and 42.00 respectively. All sampled water can be categorized as soft water with a value that ranges from 71.40-42.00 mg/L. There was obvious decreasing trend of the parameter ie total hardness across the area as dictated from sample 1 to sample 4 that represent source of the Oshin river to the downstream of the flow area (Figure 4).1 represent the pattern of total hardness of the studied Oshin River samples of the area. The investigated Oshin River water samples all have the tendency of deposition of little calcium and magnesium salts being soft water on surfaces forming scales that reduces efficiency in appliances like kettles and washing machines in homes that use the water (Table 1).

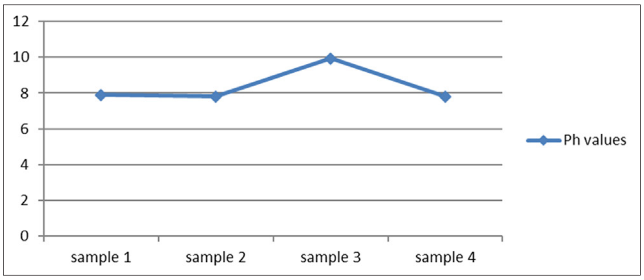

Figure 6: PH value variation across the Oshin river water samples

Dissolved Oxygen (mg/L)

The dissolved oxygen of the area has reflected an anomalous trend of gradual reduction and increase from sample 1 to sample 4 that represent the source of the Oshin River to the downstream of the flow in the area. In essence, sample 1 showed 145.60 mg/L down to sample 4 that revealed 160.00 mg/L This dissolved oxygen is crucial for the survival of aquatic life and as such the aeration rate is fundamental to the introduction of dissolved oxygen into the evaluated water of Oshin area (Table 1).

Electrical Conductivity (Us/cm)

Measured Electrical conductivity of collected water samples of the Oshin River channel revealed the total dissolved salts which gave the potential impacts on the aquatic life of the area. In Oshin River area, human activities like industrial discharges, agricultural runoff and wastewater effluents have all impacted the EC of the collected water samples. Sample 1 measured to be 1790 Us/cm down to sample 2 with 1690 Us/cm and samples 3 and 4 were measured to be 1765 and 1772 Us/cm respectively (Table 1). The Oshin River sampled water with a range value of 1000-10,000 Us/cm falls within the saline condition as dictated by United State Environmental Protection Agency.

Total Dissolved Solid (mg/L)

This is the residual mass of inorganic and organic substances in water that passes through a standard glass fiber filter paper after evaporation at 180 °C. The Oshin River investigated water samples have all revealed TDS that varied between 905, 860, 865 and 1715 mg/L for samples 1, 2, 3 and 4 respectively. The water samples have a fair TDS value as most falls within the limit of 600-900 mg/L with only sample 4 giving a poor TDS value of 1715 mg/L (Table 1).

Turbidity (NTU)
This is the measure of water clarity and it describes the amount of light scattered or block by particles floating in the water and this particle makes the water to look murky or cloudy. The Oshin River water Turbidity was measured with values ranging from 2.365, 2.004, 2.052 and 2.864 NTU for samples 1,2,3 and 4 respectively. This indicated that the turbidity levels of Oshin River water are generally low and suitable for irrigation of farmlands but not for drinking and will allow efficient water flow and nutrient delivery to crops of the Oshin farmland areas.

Temperature (°C)
Temperature is an important factor to consider when assessing water quality in addition to its own effect. Temperature influences several other parameters and can alter the physical and chemical properties of water. Measured temperature pattern of Oshin River water varied between 23.4, 22.8, 23.1 and 23.00 °C for investigated samples 1, 2, 3 and 4 respectively. The climatic condition of the area has been a greater influence on the recorded temperature values of the Oshin River water. Seasonal changes has been identified as a factor that influenced the values recorded in the Oshin river water. The higher identified temperature pattern of Oshin River can be vividly traced to runoff and rainfall pattern of the area (Table 1).

Biochemical Oxygen Demand (mg/L)
This is the amount of oxygen that micro-organisms consume in a river water sample over a specific period of time. The Oshin River water was largely investigated for Biochemical oxygen demand because, rivers naturally contain organic matter from decaying plants, animal waste and industrial discharges. The Oshin River water samples recorded 54.40, 81.60, 83.20 and 84.80 mg/L for samples 1,2,3 and 4 respectively. The studied Oshin River water samples for Biochemical oxygen demand has shown moderate values just as it was advanced that when the BOD is above 8mg/L such river water is said to be severely polluted with significant risk to aquatic life and human health (Table 1) [15].

Chemical Properties of Oshin River Water:
Salient chemical characteristics of the Oshin River water was assessed during the study and entailed lead, cadmium, zinc, copper and Iron. The major influence on the measured salient parameters evaluated included the climatic condition of the area including industrial effluent and agricultural activities with application of fertilizers to crops which are commonly washed into the Oshin River distribution channels (Figure 7).

Lead
This is commonly a serious concern especially around the study area due to its toxicity because of many sources of suspected entrant into the river course notably, industrial discharge, mining activities, urban water runoff, agricultural runoff common around the study area. Samples 1,2,3 and 4 of sampled Oshin River water recorded 0.054, 0.032, 0.027 and 0.056 mg/L respectively. WHO guideline has recommended concentration of Lead in drinking water should not exceed 0.01 mg/L (Figure 7).

Cadmium
This is a heavy metal possessing a significant risk to both aquatic life and human health. Though a naturally occurring elements in the soil, but the activities like mining, industrial and agricultural activities around the study area (Oshin area) have led to its increase in the river leading to its contamination of the river water. The measured cadmium concentration in Oshin River water varied between 0.001, 0.160, 0.051 and 0.095 mg/L for samples 1,2,3 and 4 respectively. WHO guideline has recommended concentration of cadmium in drinking water should not exceed 0.003 mg/L. (Figure 7).

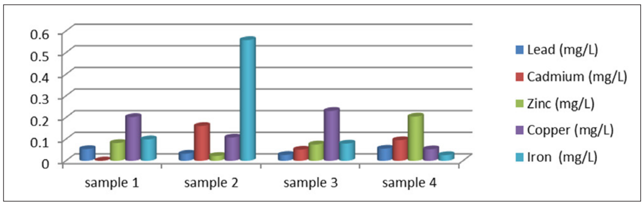

Figure 7: Concentration of heavy metals of studied samples

Zinc
Since elevated zinc concentration level can be detrimental to man and excessive can disrupt the delicate balance of aquatic life, leading to reduced biodiversity, impaired growth and reproduction. The Oshin River water was thus measured for zinc concentration in the collected water samples and the results obtained ranges from 0.082, 0.022, 0.075 and 0.204 mg/L for the river water samples 1,2,3 and 4 respectively. WHO has recommended maximum of 5mg/L in drinking water. In essence all investigated samples of the Oshin River water are within the tolerant level dictated by World Health Organization (Figure 7).

Copper
Due to their complex role in river ecosystems, acting as both an essential nutrient and potential pollutants the Oshin River water samples were evaluated in the laboratory for this purpose. The recorded results emanated from the investigation and included sample 1 with 0.202mg/L, sample 2 with 0.107mg/L, sample 3 with 0.230mg/L and sample 4 with 0.053mg/L. The Environmental Protection Agency of America has set the maximum contaminant level of copper at 1.3mg/L. WHO has its guideline set at 2.0 mg/L in drinking water. All evaluated samples of Oshin River do not exceed the stated benchmarks.

Iron
Due to its common occurrence in most rivers, the iron content of Oshin River water was assessed using collected samples of the river course. Sample 1 gave 0.099mg/L, sample 2 recorded 0.558mg/L, sample 3 showed 0.079mg/L and sample 4 revealed 0.026mg/L. The US Environmental Protection Agency sets maximum level for iron at 0.3mg/L. WHO has set a similar guideline value of 0.3mg/L in water. All evaluated samples of Oshin River water clearly showed a lower value compared to these benchmarks given by these international agencies. The source of the iron concentration can be traced to land use, Geology of the area, pollution sources from agricultural activities

and effluent discharges (Figure 7). The US Environmental Protection Agency sets maximum level for iron at 0.3mg/L. The chemical composition of Oshin River water has displayed high level of toxicity that can be remediated for clean-up for public consumption.

Hydrometerological Assessment

The investigated area was evaluated for the weather variability particularly on the rainfall pattern of the study area as it affects the concentration of the heavy metals in the water samples. Across the river recharge and flow regime at the critical peak condition of rainy season, surface water elemental composition varies greatly. The impacts of climate change is obvious at world and regional scale along the area with massive yearly flooding signature [16]. The result of the study is hereby presented for closer interpretation of the available data of the area to explain the impacts it has on the Oshin River water runoff and concentration of the metals in the river. Collected data covered 20 years of 2001-2010 and 2011-202. (Tables 2 and 3). Rainfall is the greatest environmental factor that impacts the surface water flow regime globally and it's a veritable and highly valuable source of recharge for continues production of potable freshwater and even groundwater. The rainfall precipitation varied between highest 1860.4mm in 2010 to 1352 mm in 2006 (Table 2). The peak of rainfall in this decade falls within April and October (Table 2). This is 7 months in the total 12 months of the year. From November, the rainfall trend started dropping. Predictable rainfall pattern in this decade has contributed to the excellent recharge of surface and underground borehole water and has improved crop yield and socio-economic activities of the people in the area [16].

Table 2: Rainfall pattern of the study area (mm) (2001-2010)

Year	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC.	TOTAL
2001	0	0	18	45	139	121.8	138.7	44.5	176.4	60.8	0	0	744.2
2002	0	0	59.4	163.2	57.2	97.8	180.8	182.7	144.5	116.7	6.5	0	1018.8
2003	0	14	12.4	93.9	124.5	360.7	123.2	130.9	176.2	133.4	46.7	0	1215.9
2004	0	33.1	4.6	260.5	159.2	211.4	145.4	243.5	98.1	31.6	0	0	1187.4
2005	0	5.5	25.5	75.5	187.6	171	130.2	93.6	282.6	109.8	10.5	0	1091.8
2006	0	16.1	27.5	106.6	163.7	259.6	224.1	88.2	276.2	190	0	0	1352
2007	0	29.3	37.6	115.2	150.3	235	198.1	124.7	203.6	137.9	23.8	0	1255.5
2008	0	39.4	47.3	87.6	106.7	131.5	151.4	193.2	199	186.7	41.7	0	1184.5
2009	0	13	17.5	123.4	98	127.3	126.7	139.3	162.4	92	0	0	899.6
2010	0	9 21	115	74	91.6	132.3	186.2	201	117.3	22	0	0	1860.4
TOTAL	0	159.6	364.8	1144.9	1277.8	1848.4	1604.8	1441.6	1836.3	1080.9	129.2	0	

On the other hand, the climatic episode of the 2011 to 2020 has dramatically changed from the 7 months of rainfall recorded in 2001-2010 to just 6 months ie May (1113.2 mm) to October (1257.8mm) (Table 2). Year 2011 recorded the highest amount of rainfall precipitation of 1159.7mm, while the year 2020 with 755.3mm rainfall recorded the least (Table 3). This trend continued till date as rainfall precipitation reduces across the decade. Rainfall in this decade is quite heavy within the months of August, September and October and leads to extensive flooding of coastal areas with attendant rivers including Oshin overflowing banks as urbanization has made people build along water ways with increase in population, generation of more solid waste.

Table 3: Rainfall pattern of the study area (mm) (2011-2020)

Year	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC.	TOTAL
2011	0	0	13	74	124	179.6	146	260.3	178.5	155.3	29	0	1159.7
2012	0	0	43	35.3	134.7	77.6	144.7	228	179.1	134.5	23	0	999.9
2013	0	0	0	29.5	35.7	67.3	163.9	172.8	189.1	98.7	2	0	759
2014	0	0	37	45	66.4	124.3	173.6	193.8	207	79.6	45	0	971.7
2015	0	0	23	63.2	121.7	148.7	154.6	224.2	181.7	127.3	31.3	0	1075.7
2016	0	0	17	28	132.2	167.1	122.2	221.1	198.2	119.3	28	0	1033.1
2017	0	0	19	25	122.2	157.1	102.2	201.1	178.2	132.3	22	0	959.1
2018	0	0	19	23	127.1	158.6	123.9	217.1	179.2	138.3	0	0	986.2
2019	0	0	19	0	162.2	138.8	133.2	211.7	169.2	123.3	0	0	957.4
2020	0	0	16	0	87	98.2	102.2	133.8	168.9	149.2	0	0	755.3
TOTAL	0	0	206	323	1113.2	1317.3	1366.5	2063.9	1829.1	1257.8	180.3	0	

Olubanjo also corroborated this finding of a gradual reduction in rainfall precipitation in Ilorin and environs traced to climate change variability similarly worked on the weather variability on groundwater production with a rainfall signature having the greatest impact on the production capacities of selected wells [16].

Concentration of Soluble Salts

The amount of solute present in the given volume of collected Gbugudu water sample solutions gave the concentration of the salts, as such, these concentrations were measured in the water samples collected from the Gbugudu water samples for the selected heavy metals measured [17,18]. It is worthy of note that the concentration of soluble salts in the solution of these metals varied based on the specific heavy metals, the type of salts, the solubility of the salts in water and the conditions of the solution (such as pH, temperature and presence of other ions) [19]. Different metal salts have different solubilities in water, the collected water samples from Gbugudu area were measured for Cu, Pb, Cd, Fe and Zn. (Figures 8, 9 and 10).

Concentration of Pb

Pb $(NO_3)_2$ of collected salt samples was dissolved in 100 ml of distilled water and subjected to ultraviolet/visible analytical technique. The presence of lead ions was detected through the interation with UV light. The absorbance of the salt varied during the investigation and hereby presented for further interpretation.

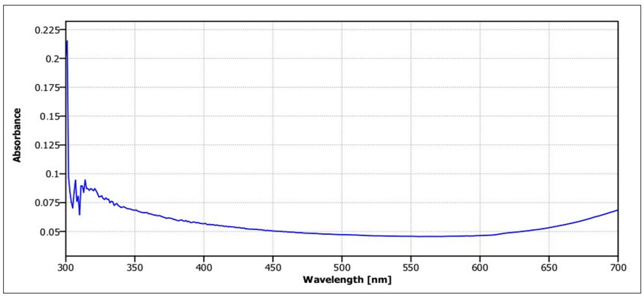

Figure 8: Absorbance against wavelength of soluble salts of copper salt

The spectrum covers a wavelength range from 300 to 700 nm. The highest absorbance appears at the lower wavelength around 300-350 nm with a peak absorbance slightly above 0.2, as the wavelength increases, the absorbance decreases with minimal absorbance (slightly below 0.05) observed at higher wavelength (around 700 nm) [20]. The peak at the lower wavelength indicates that the sample absorbs UV light most strongly in this region. The decrease in absorbance as the wavelength increases suggests that the sample absorbs less visible light indicating that it may be more transparent in the visible range. The UV-VIS spectrum shows an absorbance peak in the lower wavelength range (around 300-350 nm) with absorbance values ranging from approximately 0.225 to 0.075. the peak absorbance in the spectrum (approximately 0.225 at approximately 300-350 nm) suggests that the sample has a higher concentration of Cu which align with the absorbance values of AAS readings (0.202, 0.155 mg/L) which shows the highest UV-VIS absorbance at 300-350 nm (Figure 8) [21]. The lowest absorbance in the spectrum (approximately 0.05 at approximately 500-600 nm) suggests that the sample has lower concentration of Cu which align with the absorbance value of AAS readings (0.053, 0.053 mg/L) which shows the lowest UV-VIS absorbance at 500-600 nm.

Concentration of Fe

The spectrum covers a wavelength range from 300 to 700 nm. The highest absorbance appears at the lower wavelengths around 300-350 nm with a peak absorbance of slightly above 0.1, as the wavelength increases, the absorbance decreases steadily with minimal absorbance (close to 0.025) observed at higher wavelength (around 700 nm). The peak at the lower wavelengths indicates that the sample absorbs UV light most strongly in this region [22]. The decrease in absorbance as the wavelength increases suggests that the sample absorbs less visible light indicating that it may be more transparent in the visible range. The UV-VIS spectrum shows an absorbance peak in the lower wavelength range (around 300-350 nm) with absorbance values ranging from approximately 0.025 to 0.1 (Figure 9). The peak absorbance in the spectrum (approximately 0.1 at approximately 300-350 nm) suggests that the sample has a higher concentration of Fe which align with the absorbance value of the AAS readings (0.558, 0.550 mg/L) which shows the highest UV-VIS absorbance at 300-350 nm. The lowest absorbance in the spectrum (approximately 0.025 at approximately 600-700 nm) suggests that the sample has a lower concentration of Fe which align with the absorbance values of AAS readings (0.026, 0.026 mg/L) which shows the lowest UUV-VIS absorbance at 600-700 nm.

Concentration of Lead

The spectrum covers a wavelength range from 300 to 700 nm. The highest absorbance appears at the lower wavelength around 300-350 nm with a peak absorbance slightly above 0.1, as the wavelength increases the absorbance decreases steadily with minimal absorbance (close to 0.025) observed at higher wavelength around 700 nm. The peak at the lower wavelength indicates that the sample absorbs UV light most strongly in this region. The decrease in absorbance as the wavelength increases suggests that the sample absorbs less visible light indicating that it may be more transparent in the visible range. The peak absorbance in the spectrum (approximately 0.1 at approximately 300-350 nm) suggest that the sample has a higher concentration of Pb which align with the absorbance value of AAS readings (0.056, 0.073 mg/L) shows the highest UV absorbance at 300-350 nm. The lowest absorbance in the spectrum (approximately 0.025 at approximately 600-700 nm) suggests that the sample has a lower concentration of Pb which align with the absorbance value of AAS readings (0.027, 0.031 mg/L) shows the lowest UV absorbance at 600-700 nm (Figure 10).

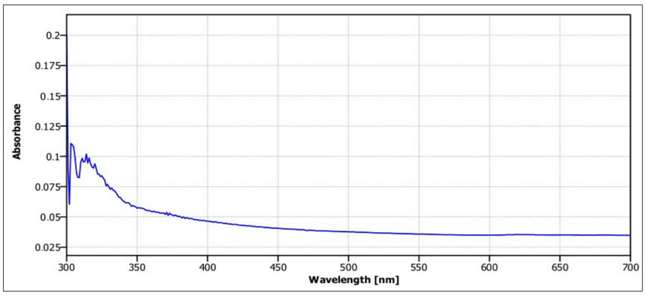

Figure 10: Absorbance against wavelength for soluble salts of Lead

Conclusions

The study of Heavy Metals Pollution of Oshin River, Gbugudu, Nigeria; trace metal monitoring and Geo-chemistry was done to reveal the potential of the river water for different environmental activities. In essence, the study concluded that the physical properties range from the highest Ph value of 9.94 to the lowest value of 7.81 signifying acidic nature of the samples from the location. With an average of 8.36 pH value, the acidity of studied samples could be traced to massive application of fertilizer to crops that gets washed into the Oshin River water, thereby polluting the water and making it unsuitable for public consumption. There was obvious decreasing trend of the total hardness across the area as dictated from sample 1 to sample 4 that represent source of the Oshin River to the downstream of the flow area. The dissolved oxygen of the area has reflected an anomalous trend of gradual reduction and increase from sample 1 to sample 4 that represent the source of the Oshin River to the downstream of the flow in the area. The Oshin River sampled water with a range value of 1000-10,000 Us/cm of Electrical conductivity falls within the saline condition. The Total Dissolved Solids ie TDS varied between 905, 860, 865 and 1715 mg/L for samples 1, 2, 3 and 4 respectively. The water samples have a fair TDS value as most falls within the limit of 600-900 mg/L Measured temperature pattern of Oshin River water varied between 23.4, 22.8, 23.1 and 23.00 °C for investigated samples of the area. Biochemical oxygen demand of Oshin River water was moderate.

The chemical compositional study of Oshin River water has shown that lead varied between 0.054, 0.032, 0.027 and 0.056 mg/L across the investigated area. The measured cadmium concentration in Oshin River water varied between 0.001, 0.160, 0.051 and 0.095 mg/L. The Oshin River water was thus measured for zinc concentration in the collected water samples and the results obtained ranges from 0.082, 0.022, 0.075 and 0.204 mg/L for the river water samples. Copper content in the river water recorded 0.202, 0.107, 0.230 and 0.053 mg/L across the area. Iron varied between 0.099, 0.558, 0.079 and 0.026 mg/L.

Hydro metrological assessment of the area has shown that rainfall is the greatest factor that impacts the surface water flow regime globally including the Oshin River water flow and it's a veritable and highly valuable source of recharge for continues production of potable freshwater. Available data of the area revealed the rainfall precipitation varied between highest 1860.4 mm in 2010 to 1352 mm in 2006. The peak of rainfall in this decade falls within April and October. This is 7 months in the total 12 months of the year and has contributed immensely to the flow regime of the Oshin River flow pattern. In essence, the study concluded that the Oshin River is good for irrigation of farmland, but unfit and moderately toxic for public consumption except if treated for such purpose. The highest absorbance appears at the lower wavelength around 300-350 nm with a peak absorbance slightly above 0.2 for copper salt while for Iron salt, the highest absorbance appears at the lower wavelengths around 300-350 nm with a peak absorbance of slightly above 0.1.

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