Heavy Metal and Microbial Assessment of Rivers in the Niger Delta Basin, Nigeria

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ABSTRACT

The present study assessed the heavy metal and microbial loads of Rivers in the Niger Delta basin. Mixed research design was adopted in this study. Nun River, Sagbama River, Andoni River, New Calabar River and Forcados River were purposively selected for the study. Grab method was used to collect the water samples. In each selected rivers selected, three water samples were collected at three different sampling points. The sampling points were about 500 meters apart from each other. Samples were collected against the flow of the water, where any flow was discernible. Water samples were collected at about 10-20cm depth. Determination of water quality was conducted in the laboratory. Descriptive statistics was used to analyze the assembled data. Laboratory results of water quality analyses indicate that most heavy metals and microbial parameters measured were above the acceptable water quality standard which implies that the sampled Rivers are polluted. Seasonal variations were observed in the concentrations of heavy metals and microbial loads. Based on the results, it becomes expedient for aggressive public enlightenment to discontinue the practice where rivers are used as a receptacle for the dumping of all sorts of waste and also as pier toilet for defecation. There is therefore need for regular surveillance of rivers within the Niger Delta basin.

Keywords: Water Quality; Contamination; Heavy Metals; Microbial Loads

INTRODUCTION

Water is one of the most precious natural resources that exist on our planet. It plays important roles in supporting human life and biodiversity; hence water is essential for the continuation of life. It is a resource of immense importance. The benefits of this vital resource cannot be over emphasized as it is essential for human existence, agriculture, and industry. Despite its importance, water is the most poorly managed resource in the world (Izonfuo & Bareweni, 2001). It is increasingly deteriorating in quality. Rivers are repeatedly used as receptacles for the effluents arising from industrial activities. The river systems have become the primary means for disposal of waste, especially the effluents from industries that are near them.

On a daily basis, it is being polluted by anthropogenic activities which affect not only the physical and chemical characteristics but also the microbiological characteristics of rivers. Thus, the contamination of freshwater with a wide range of pollutants has become a matter of great concern as it has rendered many water bodies unsuitable for usage.

Following the increase in population and industrial activities, large amount of pollutants has been discharged into rivers which have resulted in deterioration of water quality (Anyanwu, 2012). Rivers are increasingly and frequently contaminated through several routes including direct deposition of wastes and indirectly through runoff. The compositing of the wastes and runoff affects the hydrology and aquatic integrity of these rivers. It affects the water quality parameters including microbial diversity and density

(Seiyaboh & Kolawole, 2017). Hence, anthropogenic activities have been so extensive that the rivers have lost their self-purification capacity to a large extent owning to contamination.

The scarcity of potable water and contamination of rivers has led to a situation in which one-fifth of the urban dwellers in third world countries and three quarters of their rural population lack access to potable water supplies (Muhammad, 2014). According to the World Bank Group nearly half of the world population lacks access to potable water supply. This is worse among third world countries (Onyegeme-Okerenta & Ogunka-Nnoka, 2017). Polluted water is a path way for the spread of diseases (Ayobahan, Ezenwa, Orogun, Uriri, & Wemimo, 2014). In other words, poor water quality is responsible for a number of diseases and fatalities.

Creeks, streams and rivers that flow through the cities, towns and villages that lies within the Niger Delta, have witnessed serious pollution resulting from deliberate dumping of waste and improper channelization of drainage discharge. Rivers which serves as the main domestic water supply source for residents of many coastal communities is used as receptacle for sewage disposal. These water bodies are used for open defecation. Several coastal communities use river as pier toilet. Oil exploration and exploitation ongoing in the basin has also contributed to the pollution of Rivers in the basin. This is so as the incessant oil spills in the basin pollute the Rivers. Fears are that should the pollution continue to increase at the present rate, in the near future, inhabitants of the area will be faced with a myriad of health hazards that could be costly and disruptive.

It is against this background that the present study which seeks to assess the heavy metal and microbial load of Rivers in the Niger Delta Basin.

MATERIALS AND METHODS

The present study adopted a mixed research design. This type of research design involves experimental and cross-sectional research designs. As obtainable in all experimental research designs, the study was carried out under controlled conditions. A control was selected outside the Niger Delta basin and region. This was taken from Ogun River which is located in Ogun-Osun River Basin, South western Nigeria.

The data for this research were gathered mainly from two sources, namely: primary and secondary sources. The primary data were gathered through fieldwork and laboratory analysis. Nun River, Sagbama River, Andoni River, New Calabar River and Forcados River shall be purposively selected for the study. The selection of the rivers is based on the fact that they cut across minimum of eight communities within the Niger River Basin. Grab water collection technique were used to collect water samples. This water collection technique is appropriate where river water is well mixed and slow to change, hence the choice of the sampling technique. In each selected river, three water samples were collected at three different sampling points using random sampling technique. The sampling points were about 500meters apart from each other. Samples were collected as near to the middle of the water body as could be reached. Samples were collected against the ?ow of the water, where any ?ow was discernible. Water samples were collected at about 10-20cm depth using sterile screw-capped bottles. The sampling bottles were submerged to a depth of 10-20cm so as to collect the water sample. Water samples were collected in both wet (July- October) and dry season (December-March).

Determination of heavy metal and microbial loads was conducted in the laboratory. A Perkin-Elmer Analyst 100 model atomic absorption spectrometer (AAS) equipped with deuterium background correction and HGA-800 graphite furnace was used for the heavy metals (Fe, Pb, Zn, Cd, Cr, Mn, Cu and Co) determination (Ademoroti, 1996). Total coliform was detected and quantified with the use of Eosin methylene blue (EMB) agar. Faecal coliform and total viable count were detected using standard methods.

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All media, chemicals and reagents were prepared in accordance with manufacturer's specifications. The culture media were used to sterilize while Petri-dishes, pipettes and other glass wares were sterilized in a hot air oven. A serial dilution method was used to determine the total viable count while the total coliform counts were determined through standard plate count technique using MacConkey agar. Faecal coliform was determined through the use of Eosin methylene blue medium using pour plate technique. Descriptive statistics was used in the course of data analysis for the present study.

Study Area

This study was conducted within the Niger Delta Basin. The Basin Basin covers Rivers State, Bayelsa State and part of Edo State drained by Benin, Escravos, Forcadoes and Ramos River creek system. Niger Delta is located between latitudes 4º 00'N and 6º 10'N and longitudes 5º 00'E and 8º 00'E (Fig. 1).

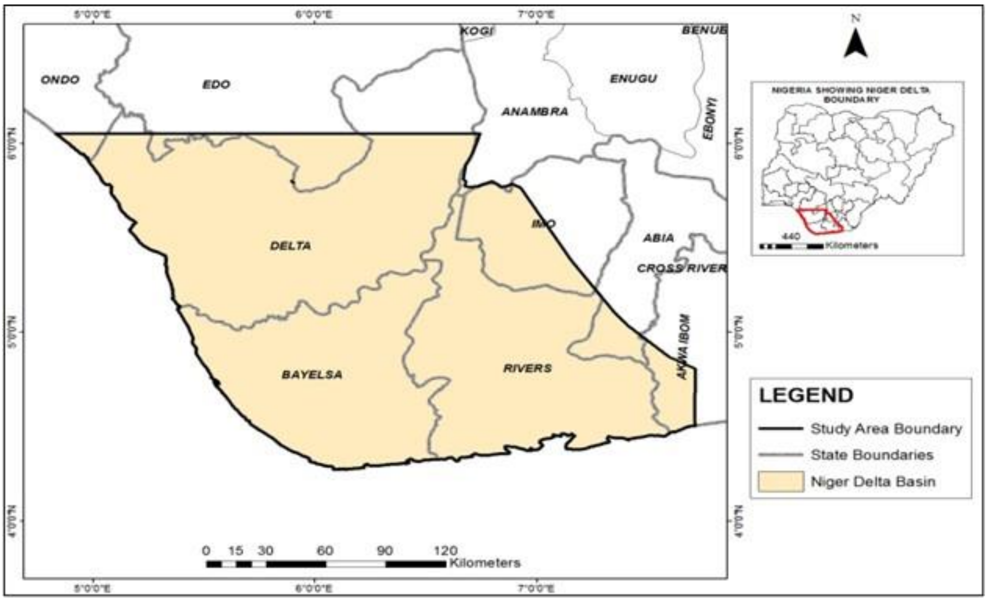

Fig. 1: Niger Delta Basin

The Niger Delta Basin is characterized by low-lying to moderately high plain topography. The topography of the area is essentially flat, sloping gently seawards. However, there exists little physiographic differentiation over the entire area, which is generally uniformly undulating. The topography of the area ranges from about 3m above mean sea level mostly around the coastal areas to about 60m which can be observed from a few deeper valleys (Williams, 2018).

The area is drained by network of distributaries. The study area is criss-crossed by a number of rivers, streams, creeks, rivulets and lakes (Fig. 2) (Amangabara & Obenade, 2015; Williams, 2018). A prominent feature of rivers and creeks in the Niger Delta River Basin is the occurrence of natural levees on both banks, behind which occur vast of backswamps and lagoons where surface flow is negligible (Nwankwoala & Ngah, 2014). Notable rivers in the Niger Delta River Basin includes: Escravos, Forcados, Benin, New Calabar and Bonny River, Santa Barbara River, Andoni River, Nun River, River Orashi, San Bartholomeo River, Sombreiro River, St Nicholas River, Otamiriochie River, Ogochie River, Oloshi River and Opobo Channel River. Some of these rivers are subjected to tidal fluctuations and receptacle to freshwater inflow during the wet season. The drainage of the area can be said to be poor, essentially due to the combination of low relief, high water table and high precipitation. The implication of this is the incessant flooding in the area.

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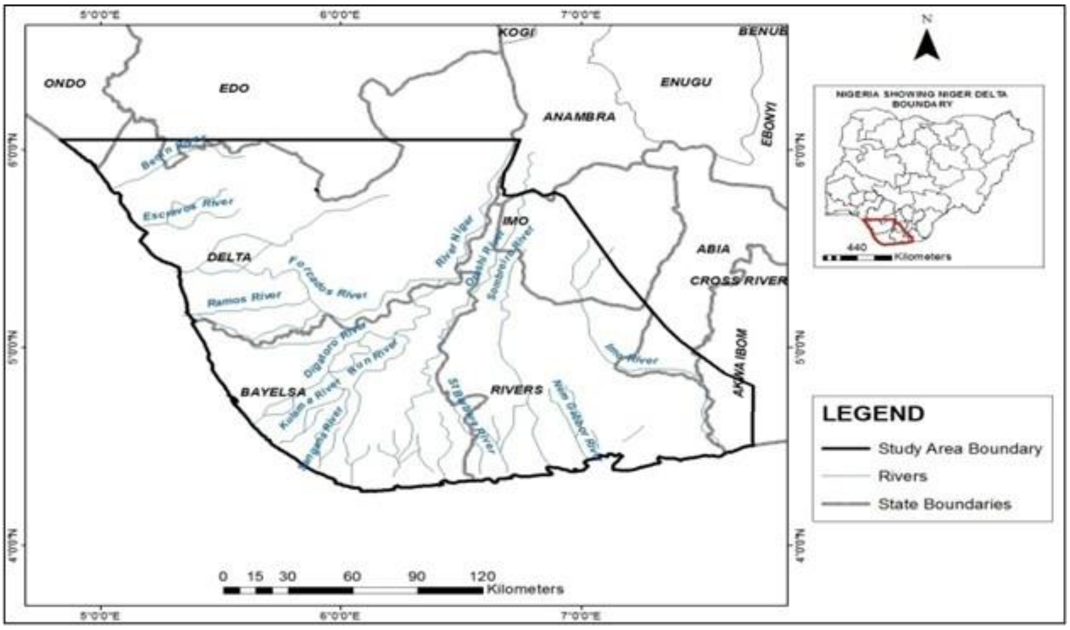

Fig. 2: Drainage of Niger Delta Basin

Climatic condition of the area drain by the Niger Delta Basin can be classified as humid tropical climate with relatively long rainy season. Rainfall in the study area is generally seasonal, variable, as well as heavy. The only dry months are January and February. Rainfall in this area is not only heavy but also more persistent. The area experiences her wet season between March and October through November. Rainfall within the areas drained by the Niger Delta River Basin is at its peak in the month of July and September with slight dry season occurring in the month of August. The wet season peaks in July, lasting more than 290 days. Serious lightning and thunderstorm occur during the months of August and September (Williams, 2018).

Mean annual rainfall ranges from over 4000mm in the coastal towns of Bonny and Brass in Rivers and Bayelsa States respectively, and decreases inland to 3000mm in the mid-delta around Ahoada, Yenagoa and Warri in Rivers, Bayelsa and Delta States, respectively (NDRDMP, 2005). While Nembe has an average monthly rainfall of 3419mm and about 128 rainy days, Ndele has an average monthly rainfall of about 2285mm with 124 rainy days (Williams, 2018).

The annual rain fall in the Niger Delta is high and varies from 500mm per annum at the coast to 300mm at the northern part of the Delta (Etu-Efeotor & Odigi, 1983; Nwankwoala & Ngah, 2014). It is 4698 mm (185 inch) at Bonny along the coast and 1862 mm (73 inch) at Degema. Evapo-transpiration is 1000mm, leaving an effective rainfall of 2000mm. Of this effective rainfall, 750mm is known to recharge the subsurface aquifer while the remaining 1250mm flows directly into the stream (Nwankwoala & Ngah, 2014). High rainfall experienced in the area makes it prone to flooding.

Temperatures are generally high in the region and fairly constant with little variation throughout the year. The warmest months are February, March and early April in most parts of the study area. Temperature during these months ranges from 28 to 33°C. The coolest months are June through to September during the peak of the wet season. Average temperatures are typically between 25-28°C (NDRDMP, 2005). Minimum temperature values are almost consistent throughout the year.

Relative humidity in the study area is normally high with its relative humidity varying from 58.8 to 95.0 percent; depending on the specific time of the year. The cloud cover in the area is usually high (Williams,

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2018). Relative humidity rarely dips below 60 percent and fluctuates between 90 percent and 100 percent for most of the year. The relative humidity is high all through the year and decreases slightly during the dry season with February and May having the lowest relative humidity (Williams, 2018). The area drained by Niger Delta Basin is the economic hub of Nigeria, as the area house several oil multinationals, oil servicing companies, and other industrial concerns. The study area holds over 55% of the oil wells in Nigeria. The Niger Delta Basin produces around 2 million barrels of oil per day. The study area is heavily explored by oil companies. It is one of the largest oil producers in the world.

RESULTS

The result was carried out in line with the objectives which the study was set to achieve. The result is presented as follows:

Wet season analysis of heavy metals and microbial loads of Rivers in the Niger Delta Basin

This section of the study presents data on heavy metals and microbial loads of Rivers within the Niger Delta Basin. Table 1 presents the results.

Table 1: Wet season analysis of heavy metals and microbial loads of Rivers in the Niger Delta Basin

S/N	Parameters	Rivers					
		Andoni	Forcados	New Calabar	Nun	Sangana	Ogun (Control)
Upstream Rivers Section							
Heavy Metal							
1	Pb (mg/L)	0.017	0.018	0.021	0.021	0.018	0.024
2	Cd (mg/L)	0.002	0.003	0.001	0.002	0.001	0.002
3	Cr (mg/L)	0.001	0.001	0.008	0.004	0.005	0.004
4	As (mg/L)	0.003	0.003	0.005	0.003	0.007	0.005
5	Hg (mg/L)	0.004	0.005	0.008	0.004	0.003	0.005
5	Ni (mg/L)	0.017	0.003	0.010	0.013	0.007	0.003
6	Fe (mg/L)	0.013	0.019	0.013	0.018	0.016	0.011
Microbal Loads							
7	Total Heterotrophic count (cfus/ml)	2.5×10^{2}	2.0×10^{2}	7.0×10^{2}	3.5×10 2	3.0×10^{2}	1.5×10^{2}
8	Total coliform count (cfus/ml)	2.0×10	2.0×10	2.2×10	2.2×10	2.0×10	1.0×10
9	Total faecal coliform count(cfus/ml)	2.8×10	2.0×10	3.2×10	2.0×10	7.0×10	1.0×10
10	Total fungal count (cfus/ml)	4.8×10	2.0×10	6.0×10	3.0×10	6.0×10	4.0×10
Midstream Rivers Section							

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue VI June 2023

Heavy Metal							
1	Pb (mg/L)	2.753	2.933	2.612	2.345	2.884	1.682
2	Cd (mg/L)	2.105	1.664	1.344	2.150	1.710	1.106
3	Cr (mg/L)	1.677	1.873	1.468	2.049	1.733	1.107
4	As (mg/L)	1.724	1.515	1.871	1.373	1.589	1.035
5	Hg (mg/L)	1.455	1.886	2.120	1.670	1.484	1.142
6	Ni (mg/L)	2.967	2.328	2.474	2.292	2.772	1.836
7	Fe (mg/L)	2.965	3.386	3.791	2.344	2.629	1.913
Microbal Loads							
8	Total Heterotrophic count (cfus/ml)	3.1 x 10^2	1.1 x 10^2	2.6 x 10^2	1.6 x 10^2	1.8 x 10^2	2.3 x 10^2
9	Total coliform count (cfus/ml)	1.7 x 10^2	1.9 x 10	1.8 x 10	1.2 x 10	1.7 x10	1.6 x 10
9	Total faecal coliform count(cfus/ml)	2.9 x 10	2.0 x 10	1.7 x 10	1.5 x 10	1.4 x 10	2.9 x 10
10	Total fungal count (cfus/ml)	4.2 x 10	2.8 x 10	2.5 x 10	5.3 x 10	2.6 x 10	0.6 x 10
Downstream Rivers Section							
Heavy Metal							
15	Pb (mg/L)	2.913	2. 834	2.715	2.236	2.863	1.662
16	Cd (mg/L)	2.123	1.545	1.367	2.235	1.389	0.764
17	Cr (mg/L)	1.672	1.841	1.325	1.804	1.523	0.747
18	As (mg/L)	1.421	1.215	1.510	1.093	1.173	0.815
19	Hg (mg/L)	1.284	1.543	1.835	1.638	1.358	1.085
20	Ni (mg/L)	2.817	2.923	2.855	2.727	2.625	1.843
21	Fe (mg/L)	3.282	3.356	3.512	2.128	2.238	1.345
Microbal Loads							
22	Total Heterotrophic count (cfus/ml)	2.3 x 10^2	1.7 x 10^2	3.9 x 10	2.4 x 10^2	2.1 x 10^2	1.7 x 10^2
23	Total coliform count (cfus/ml)	2.3 x 10	1.6 x 10	2.1 x 10	3.2 x 10	0.8 x 10^2	2.3 x 10
24	Total faecal coliform count(cfus/ml)	2.3 x 10	2.1 x 10	3.3 x 10	1.8 x10	1.7 x 10	3.2 x 10
25	Total fungal count (cfus/ml)	1.8 x 10	3.7 x 10	4.5 x 10	2.3 x 10	1.7 x 10	1.4 x 10

Source: Researchers Field Report (2021)

Pb value for upstream river section for the selected Rivers ranged from 0.017mg/L to 0.021mg/L, with upstream sections of Andoni River recording the lowest value while upstream sections of New Calabar and Nun Rivers recorded the highest value. Pb value for upstream River section for the control sample was found to be 0.024mg/L. Cd value for upstream river section for the selected Rivers ranged from 0.001mg/L

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to 0.003mg/L, with upstream sections of New Calabar River and Sangana Rivers recording the lowest value while upstream sections of Forcados River recorded the highest value. Cd value for upstream River section for the control sample taken from Ogun River was found to be 0.002mg/L. Cr value for upstream river section for the selected Rivers ranged from 0.001mg/L to 0.008mg/L, with upstream sections of Andoni and Forcados Rivers recording the lowest value while upstream section of New Calabar recorded the highest value. Cr value for upstream River section for the control sample was found to be 0.004mg/L. As value for upstream river section for the selected Rivers ranged from 0.003mg/L to 0.007mg/L, with upstream sections of Andoni, Forcados and Nun Rivers recording the lowest value while upstream section of Sangana River recorded the highest value. As value for upstream River section for the control sample was found to be 0.005mg/L.

Hg value for upstream river section for the selected Rivers ranged from 0.003mg/L to 0.008mg/L, with upstream sections of Sangana River and New Calabar River recording the lowest and highest values respectively. As value for upstream River section for the control sample was found to be 0.005mg/L. Ni value for upstream river section for the selected Rivers ranged from 0.003mg/L to 0.017mg/L, with upstream sections of Forcados and Andoni Rivers recording the lowest and highest values respectively. Ni value for upstream River section for the control sample was found to be 0.003mg/L. Fe value for upstream river section for the selected Rivers ranged from 0.013mg/L to 0.019mg/L, with upstream sections of Andoni and New Calabar Rivers recording the lowest while Forcados River had the highest values. Fe value for upstream River section for the control sample was found to be 0.011mg/L. Mg value for upstream river section for the selected Rivers ranged from 5.30mg/L to 11.30mg/L, with upstream sections of New Calabar and Nun Rivers recording the lowest and highest values respectively. Mg value for upstream River section for the control sample was found to be 9.12mg/L.

Total Heterotrophic count for upstream river section of sampled Rivers ranged from 2.0×10^2 to 7.0×10^2 . The lowest total heterotrophic count (THC) was recorded in upstream section of Forcados River while the highest value was recorded in upstream section of New Calabar River. The value for the control (Ogun River) was 1.5×10^2. Total coliform count for upstream river section of sampled Rivers ranged from 2.0 x 10 to 2.2 x 10. The lowest total coliform count (TCC) was recorded in upstream section of Andoni, Forcados and Sangana Rivers while the highest value was recorded in upstream section of New Calabar and Nun Rivers. Total faecal coliform count (TFCC) for upstream river section of sampled Rivers ranged from 2.0 x 10 to 7.0 x 10. The lowest total faecal coliform count (TFCC) was recorded in upstream section of Forcados and Nun Rivers while the highest value was recorded in upstream section of Sangana River. Total fungal count (TFC) for upstream river section of sampled Rivers ranged from 2.0 x 10 to 6.0 x 10. The lowest total fungal count (TFC) was recorded in upstream section of Forcados Rivers while the highest value was recorded in upstream section of Sangana River.

Wet season midstream Pb value for the selected Rivers ranged from 0.012mg/L to 0.030mg/L, with midstream sections of Forcados River recording the lowest value while midstream section of Nun Rivers recorded the highest value. Wet season midstream Pb value for the control sample was found to be 0.041mg/L. Wet season midstream Cd value for the selected Rivers ranged from 0.001mg/L to 0.004mg/L, with midstream section of Andoni River and Sangana Rivers recording the lowest and highest value respectively. Wet season midstream Cd value for the control sample taken from Ogun River was found to be 0.001mg/L. Wet season midstream Cr value for the selected Rivers ranged from 0.001mg/L to 0.005mg/L, with midstream sections of Forcados and New Calabar Rivers recording the lowest highest values respectively. Wet season midstream Cr value for the control sample was found to be 0.001mg/L. Wet season midstream As value for the selected Rivers ranged from 0.002mg/L to 0.010mg/L, with midstream sections of Forcados and Nun Rivers recording the lowest and highest values respectively. Wet season midstream As value for the control sample was found to be 0.002mg/L.

Wet season midstream Hg value for the selected Rivers ranged from 0.005mg/L to 0.010mg/L, with midstream sections of Andoni, Forcados and Nun Rivers recording the lowest value while Sangana Rivers recorded the highest value. For the control sample (Ogun River) wet season midstream value of Hg was 0.004mg/L. Wet season midstream Ni value for the selected Rivers ranged from 0.006mg/L to 0.014mg/L, with midstream sections of Nun and Andoni Rivers recording the lowest and highest values respectively. For the control sample (Ogun River) wet season midstream value of Ni was 0.001mg/L. Wet season midstream Fe value for the selected Rivers ranged from 0.010mg/L to 0.021mg/L, with midstream sections of Forcados and New Calabar Rivers recording the lowest and highest values respectively. Wet season midstream Fe value for the control sample was 0.014mg/L. Mg value for upstream river section for the selected Rivers ranged from 8.15mg/L to 9.20mg/L, with midstream sections of Sangana River recording the lowest value while Forcados and New Calabar Rivers recording the highest values. Wet season midstream Mg value for the control sample was 12.53mg/L.

Wet season total heterotrophic count for midstream river section of sampled Rivers ranged from 1.5 x 10^2 to 5.0 x 10^2 . The lowest total heterotrophic count (THC) was recorded in midstream section of Forcados River while the highest value was recorded in upstream section of Andoni River. The value for the control (Ogun River) was 3.1 x 10^2. Total coliform count for midstream river section of sampled Rivers ranged from 1.5 x 10 to 2.3 x 10. The lowest total coliform count (TCC) was recorded in midstream section of Nun Rivers while the highest value was recorded in midstream section of Forcados. Total faecal coliform count (TFCC) for midstream river section of sampled Rivers ranged from 2.0 x 10 to 3.5 x 10. The lowest total faecal coliform count (TFCC) was recorded in midstream section of New Calabar and Sangana Rivers while the highest value was recorded in midstream section of Andoni River. Wet season total fungal count (TFC) for midstream river section of sampled Rivers ranged from 3.0 x 10 to 8.0 x 10. The lowest total fungal count (TFC) was recorded in midstream section of New Calabar and Sangana Rivers while the highest value was recorded in midstream section of Nun River.

Wet season downstream Pb value for the selected Rivers ranged from 0.018mg/L to 0.028mg/L, with downstream sections of Andoni River recording the lowest value while downstream section of Forcados Rivers recorded the highest value. Wet season downstream Pb value for the control sample was 0.015mg/L. Wet season downstream Cd value for the selected Rivers ranged from 0.001mg/L to 0.006mg/L. The downstream section of Forcados, New Calabar and Sangana Rivers recording the lowest value of 0.001mg/L each while Nun River has the highest value of 0.006mg/L. Wet season downstream Cd value for the control sample taken from Ogun River was 0.004mg/L. Wet season downstream Cr value for the selected Rivers ranged from 0.001mg/L to 0.006mg/L, with downstream sections of Nun and New Calabar Rivers recording the lowest and highest values respectively. On the contrary, wet season downstream Cr value for the control sample was 0.002mg/L. Wet season downstream value of As for the selected Rivers ranged from 0.002mg/L to 0.05mg/L. The downstream section of Forcados recorded the lowest value while Andoni, New Calabar, Nun, Sangana Rivers recording the highest values respectively. Wet season downstream As value for the control sample was 0.001mg/L.

Wet season downstream Hg value for the selected Rivers ranged from 0.004mg/L to 0.011mg/L, with downstream sections of Sangana and New Calabar Rivers recording the lowest and highest values respectively. For the control sample (Ogun River) wet season downstream value of Hg was 0.001mg/L. Wet season downstream Ni value for the selected Rivers ranged from 0.009mg/L to 0.012mg/L. The downstream sections of Andoni and Sangana Rivers recorded the lowest values while Forcados River recorded the highest value. For the control sample (Ogun River) wet season downstream value of Ni was 0.002mg/L. Wet season downstream Fe value for the selected Rivers ranged from 0.013mg/L to 0.021mg/L, with downstream sections of Nun and Sangana Rivers recording the lowest and highest values respectively. Wet season downstream Fe value for the control sample was 0.012mg/L. Wet season downstream Mg value for

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upstream river section for the selected Rivers ranged from 7.30mg/L to 12.10mg/L, with downstream sections of Andoni and Forcados recording the lowest and highest values. Wet season downstream Mg value for the control sample was 14.51mg/L.

Wet season total heterotrophic count for downstream river section of sampled Rivers ranged from 2.0 x 10^2 to 5.9 x 10^2. The lowest total heterotrophic count (THC) was recorded in downstream section of Forcados River while the highest value was recorded in downstream section of New Calabar River. The wet season total heterotrophic count value for downstream of Ogun River was 2.0 x 10^2. Wet season total coliform count for downstream river section of sampled Rivers ranged from 1.0 x 10 to 4.0 x 10. The lowest total coliform count (TCC) was recorded in downstream section of Sangana Rivers while the highest value was recorded in downstream section of Nun River. Wet season total faecal coliform count (TFCC) for downstream river section of sampled Rivers ranged from 2.0 x 10 to 5.3 x 10. The lowest wet season total faecal coliform count (TFCC) was recorded in downstream section of Nun and Sangana Rivers while the highest value was recorded in downstream section of New Calabar River. Wet season total fungal count (TFC) for downstream river section of sampled Rivers ranged from 2.0 x 10 to 9.7 x 10. The lowest total fungal count (TFC) was recorded in downstream section of Andoni and Sangana Rivers while the highest value was recorded in downstream section of New Calabar River.

Dry season analysis of heavy metals and microbial loads of Rivers in the Niger Delta Basin

This section of the study presents data on heavy metals and microbial loads of Rivers within the Niger Delta Basin. Table 2 presents the results.

Table 2: Dry season analysis of heavy metals and microbial loads of Rivers in the Niger Delta Basin

S/N	Parameters	Rivers					
		Andoni	Forcados	New Calabar	Nun	Sangana	Ogun (Control)
Upstream Rivers Section							
Heavy Metal							
1	Pb (mg/L)	2.631	2.829	2.476	2.174	2.732	1.485
2	Cd (mg/L)	1.907	1.484	1.184	1.830	1.001	0.509
3	Cr (mg/L)	1.468	1.659	1.075	1.804	1.523	0.747
4	As (mg/L)	1.421	1.215	1.510	1.093	1.173	0.815
5	Hg (mg/L)	1.284	1.543	1.832	1.406	1.142	0.925
6	Ni (mg/L)	2.915	2.107	2.257	2.073	2.480	1.453
7	Fe (mg/L)	3.061	3.217	3.415	2.047	2.109	1.064
Biological Parameters							
8	Total Heterotrophic count (cfus/ml)	1.7 x 10^2	2.0 x 10^2	4.2 x 10^2	2.5×10^2	2.2 x 10^2	0.5 x 10^2
9	Total coliform count (cfus/ml)	1.6 x 10	1.4 x 10	1.7 x 10	1.9 x 10	1.5 x 10	0.8 x 10
9	Total faecal coliform count(cfus/ml)	1.8 x 10	1.5 x 10	2.2 x 10	1.6 x 10	3.8 x 10	0.9 x 10

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue VI June 2023

10	Total fungal count (cfus/ml)	2.5 x 10	1.8 x 10	3.2 x 10	2.0 x 10	2.8 x 10	2.1 x 10
Midstream Rivers Section							
Heavy Metal							
1	Pb (mg/L)	2.753	2.933	2.612	2.345	2.884	1.682
2	Cd (mg/L)	2.105	1.664	1.344	2.150	1.710	1.106
3	Cr (mg/L)	1.677	1.873	1.468	2.049	1.733	1.107
4	As (mg/L)	1.724	1.515	1.871	1.373	1.589	1.035
5	Hg (mg/L)	1.455	1.886	2.120	1.670	1.484	1.142
6	Ni (mg/L)	2.967	2.328	2.474	2.292	2.772	1.836
7	Fe (mg/L)	2.965	3.386	3.791	2.344	2.629	1.913
Microbal Loads							
8	Total Heterotrophic count (cfus/ml)	3.1 x 10^2	1.1 x 10^2	2.6 x 10^2	1.6 x 10^2	1.8 x 10^2	2.3 x 10^2
9	Total coliform count (cfus/ml)	1.7 x 10^2	1.9 x 10	1.8 x 10	1.2 x 10	1.7 x10	1.6 x 10
9	Total faecal coliform count(cfus/ml)	2.9 x 10	2.0 x 10	1.7 x 10	1.5 x 10	1.4 x 10	2.9 x 10
10	Total fungal count (cfus/ml)	4.2 x 10	2.8 x 10	2.5 x 10	5.3 x 10	2.6 x 10	0.6 x 10
Downstream Rivers Section							
Heavy Metal							
1	Pb (mg/L)	2.913	2. 834	2.715	2.236	2.863	1.662
2	Cd (mg/L)	2.123	1.545	1.367	2.235	1.389	0.764
3	Cr (mg/L)	1.672	1.841	1.325	1.804	1.523	0.747
4	As (mg/L)	1.421	1.215	1.510	1.093	1.173	0.815
5	Hg (mg/L)	1.284	1.543	1.835	1.638	1.358	1.085
6	Ni (mg/L)	2.817	2.923	2.855	2.727	2.625	1.843
7	Fe (mg/L)	3.282	3.356	3.512	2.128	2.238	1.345
Microbal Loads							
8	Total Heterotrophic count (cfus/ml)	2.3 x 10^2	1.7 x 10^2	3.9 x 10	2.4 x 10^2	2.1 x 10^2	1.7 x 10^2
9	Total coliform count (cfus/ml)	2.3 x 10	1.6 x 10	2.1 x 10	3.2 x 10	0.8 x 10^2	2.3 x 10
9	Total faecal coliform count(cfus/ml)	2.3 x 10	2.1 x 10	3.3 x 10	1.8 x10	1.7 x 10	3.2 x 10
10	Total fungal count (cfus/ml)	1.8 x 10	3.7 x10	4.5 x 10	2.3 x 10	1.7 x 10	1.4 x 10

Source: Researchers Field Report (2021)

Dry season upstream Pb value for the selected Rivers ranged from 2.174mg/L to 2.829mg/L, with upstream sections of Nun and Andoni Rivers recording the lowest and highest values respectively. Dry season upstream Pb value for the control sample was 1.485mg/L. Dry season upstream Cd value for the selected Rivers ranged from 1.001mg/L to 1.907mg/L. The upstream section of Sangana and Andoni Rivers recorded the lowest and highest values respectively. Dry season upstream Cd value for the control sample taken from Ogun River was 0.004mg/L. Dry season upstream Cr value for the selected Rivers ranged from 1.075mg/L to 1.804mg/L, with upstream sections of New Calabar and Nun Rivers recording the lowest and highest values respectively. On the contrary, dry season upstream Cr value for the control sample was 0.747mg/L. Dry season upstream value of As for the selected Rivers ranged from 1.093mg/L to 1.510mg/L. The upstream section of Nun River recorded the lowest value while New Calabar River recorded the highest values. Dry season upstream As value for the control sample was 0.815mg/L.

Dry season upstream Hg value for the selected Rivers ranged from 0.142mg/L to 1.832mg/L, with upstream sections of Sangana and New Calabar Rivers recording the lowest and highest values respectively. For the control sample (Ogun River) dry season upstream value of Hg was 0.925mg/L. Dry season upstream Ni value for the selected Rivers ranged from 2.073mg/L to 2.915mg/L. The upstream sections of Nun and Andoni Rivers recorded the lowest and highest values respectively. For the control sample, dry season upstream value of Ni was 1.453mg/L. Dry season upstream Fe value for the selected Rivers ranged from 2.047mg/L to 3.061mg/L, with upstream sections of Nun and Andoni Rivers recording the lowest and highest values respectively. Dry season upstream Fe value for the control sample was 1.064mg/L. Dry season upstream Mg value for upstream river section for the selected Rivers ranged from 9.05mg/L to 12.70mg/L, with upstream sections of Sangana and Nun Rivers recording the lowest and highest values. Dry season upstream Mg value for the control sample was 10.72mg/L.

Dry season total heterotrophic count for upstream river section of sampled Rivers ranged from 1.7×10^2 to 4.2×10^2. The lowest total heterotrophic count (THC) was recorded in upstream section of Andoni River while the highest value was recorded in upstream section of New Calabar River. The dry season total heterotrophic count value for downstream of Ogun River was 0.5×10^2. Dry season total coliform count for upstream river section of sampled Rivers ranged from 1.4 x 10 to 1.9 x 10. The lowest total coliform count (TCC) was recorded in upstream section of Forcados River while the highest value was recorded in upstream section of Nun River. Dry season total faecal coliform count (TFCC) for upstream river section of sampled Rivers ranged from 1.5 x 10 to 3.8 x 10. The lowest dry season total faecal coliform count (TFCC) was recorded in upstream section of Forcados River while the highest value was recorded in upstream section of Sangana River. Dry season total fungal count (TFC) for upstream river section of sampled Rivers ranged from 1.8 x 10 to 3.2 x 10. The lowest dry season total fungal count (TFC) was recorded in the upstream section of Forcados River while the highest value was recorded in upstream section of New Calabar River.

Dry season midstream Pb value for the selected Rivers ranged from 2.345mg/L to 2.933mg/L, with midstream sections of Nun and Forcados Rivers recording the lowest and highest values respectively. Dry season midstream Pb value for the control sample was 1.682mg/L. Dry season midstream Cd value for the selected Rivers ranged from 1.344mg/L to 2.105mg/L. The midstream section of New Calabar and Andoni Rivers recorded the lowest and highest values respectively while Cd value for the control sample taken from Ogun River was 1.106mg/L. Dry season midstream Cr value for the selected Rivers ranged from 1.468mg/L to 2.049mg/L, with midstream sections of New Calabar and Nun Rivers recording the lowest and highest values respectively. On the contrary, dry season midstream Cr value for the control sample was 1.107mg/L. Dry season midstream value of As for the selected Rivers ranged from 1.373mg/L to 1.871mg/L. The midstream section of Nun River recorded the lowest value while New Calabar River recorded the highest values. Dry season midstream As value for the control sample was 1.035mg/L.

Dry season midstream Hg value for the selected Rivers ranged from 1.455mg/L to 2.120mg/L, with midstream sections of Andoni and New Calabar Rivers recording the lowest and highest values respectively. For the control sample (Ogun River) dry season midstream value of Hg was 1.142mg/L. Dry season midstream Ni value for the selected Rivers ranged from 2.292mg/L to 2.967mg/L. The midstream sections of Nun and Andoni Rivers recorded the lowest and highest values respectively. For the control sample, dry season midstream value of Ni was 1.836mg/L. Dry season midstream Fe value for the selected Rivers ranged from 2.344mg/L to 3.791mg/L, with midstream sections of Nun and New Calabar Rivers recording the lowest and highest values respectively. Dry season midstream Fe value for the control sample was 1.913mg/L. Dry season midstream Mg value for midstream river section for the selected Rivers ranged from 10.14mg/L to 12.76mg/L, with midstream sections of New Calabar and Andoni Rivers recording the lowest and highest values respectively. Dry season midstream Mg value for the control sample was 11.16mg/L.

Dry season total heterotrophic count for midstream river section of sampled Rivers ranged from 1.1 x 10^2 to 3.1 x 10^2. The lowest dry season total heterotrophic count (THC) was recorded in midstream section of Forcados River while the highest value was recorded in midstream section of Andoni River. Dry season total coliform count for midstream river section of sampled Rivers ranged from 1.2 x 10 to 1.9 x 10. The lowest total coliform count (TCC) was recorded in midstream section of New Calabar River while the highest value was recorded in midstream section of Forcados River. Dry season total faecal coliform count (TFCC) for midstream river section of sampled Rivers ranged from 1.5 x 10 to 2.9 x 10. The lowest dry season total faecal coliform count (TFCC) was recorded in midstream section of Nun River while the highest value was recorded in midstream section of Andoni River. Dry season total fungal count (TFC) for midstream river section of sampled Rivers ranged from 2.5 x 10 to 5.3 x 10. The lowest dry season total fungal count (TFC) was recorded in the midstream section of New Calabar River while the highest value was recorded in midstream section of Nun River.

Dry season downstream Pb value for the selected Rivers ranged from 2.236g/L to 2.913mg/L, with midstream sections of Nun and Andoni Rivers recording the lowest and highest values respectively. Dry season midstream Pb value for the control sample was 1.662mg/L. Dry season downstream Cd value for the selected Rivers ranged from 1.367mg/L to 2.235mg/L. The downstream section of New Calabar and Nun Rivers recorded the lowest and highest values respectively while dry season downstream Cd value for the control sample taken from Ogun River was 0.764mg/L. Dry season downstream Cr value for the selected Rivers ranged from 1.325mg/L to 1.841mg/L, with downstream sections of New Calabar and Nun Rivers recording the lowest and highest values respectively. On the contrary, dry season downstream Cr value for the control sample was 0.747mg/L. Dry season downstream value of As for the selected Rivers ranged from 1.093mg/L to 1.510mg/L. The downstream section of Nun River recorded the lowest value while New Calabar River recorded the highest values.

Dry season dstream as value for the control sample was 0.815mg/L.

Dry season downstream Hg value for the selected Rivers ranged from 1.284mg/L to 1.835mg/L, with downstream sections of Andoni and New Calabar Rivers recording the lowest and highest values respectively. For the control sample (Ogun River) dry season downstream value of Hg was 1.085mg/L. Dry season downstream Ni value for the selected Rivers ranged from 2.625mg/L to 2.923mg/L. The downstream sections of Sangana and Forcados Rivers recorded the lowest and highest values respectively. For the control sample, dry season downstream value of Ni was 1.843mg/L. Dry season downstream Fe value for the selected Rivers ranged from 2.238mg/L to 3.512mg/L, with downstream sections of Sangana and New Calabar Rivers recording the lowest and highest values respectively. Dry season midstream Fe value for the control sample was 1.345mg/L. Dry season midstream Mg value for downstream river section for the selected Rivers ranged from 10.25mg/L to 13.15mg/L, with downstream sections of Sangana and Andoni Rivers recording the lowest and highest values respectively.

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Dry season total heterotrophic count for downstream river section of sampled Rivers ranged from 1.7 x 10^2 to 3.9 x 10^2. The lowest dry season total heterotrophic count (THC) was recorded in downstream section of Forcados River while the highest value was recorded in downstream section of New Calabar River. Dry season total coliform count for downstream river section of sampled Rivers ranged from 0.8 x 10 to 3.2 x 10. The lowest total coliform count (TCC) was recorded in downstream section of Sangana River while the highest value was recorded in downstream section of Nun River. Dry season total faecal coliform count (TFCC) for downstream river section of sampled Rivers ranged from 1.7 x 10 to 3.3 x 10. The lowest dry season total faecal coliform count (TFCC) was recorded in downstream section of Sangana River while the highest value was recorded in midstream section of New Calabar River. Dry season total fungal count (TFC) for downstream river section of sampled Rivers ranged from 1.7 x 10 to 4.5 x 10. The lowest dry season total fungal count (TFC) was recorded in the downstream section of Sangana River while the highest value was recorded in midstream section of New Calabar River.

Mean seasonal variation of heavy metals of Rivers in the Niger Delta Basin

This section compares the mean variation of heavy metals and microbial load of Rivers in Niger Delta basin. This is presented as follows.

Table 3: Mean seasonal variation of heavy metals of Rivers in the Niger Delta Basin

S/N	Parameters	Rivers									
		Andoni		Forcados		New Calabar		Nun		Sangana	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Heavy Metal											
1	Pb (mg/L)	0.018	2.77	0.021	2.87	0.024	2.60	0.024	2.25	0.022	2.83
2	Cd (mg/L)	0.003	2.045	0.002	1.564	0.001	1.298	0.004	2.072	0.002	1.367
3	Cr (mg/L)	0.002	1.606	0.002	1.791	0.006	1.289	0.003	1.886	0.003	1.593
4	As (mg/L)	0.004	1.538	0.002	1.463	0.005	1.485	0.003	1.423	0.005	1.428
4	Hg (mg/L)	0.005	1.341	0.006	1.657	0.008	1.929	0.006	1.571	0.006	1.328
5	Ni (mg/L)	0.013	2.900	0.009	2.453	0.009	2.529	0.010	2.364	0.009	2.626
6	Fe (mg/L)	0.015	3.103	0.014	3.320	0.016	3.573	0.014	2.173	0.017	2.325

According to the Table, mean Pb, Cd, Cr and As values for the selected Rivers were higher during dry season when compared to wet season values. The same applies to other heavy metals. The value of Fe in particular was higher in dry season than as was obtained in wet season. As can be seen from the Table, the mean wet season Fe value for Andoni River was 0.015mg/L while its mean dry season value was 3.103mg/L. The mean wet season Fe value for Forcados River was 0.014mg/L while its mean dry season value for the same parameter was 3.320mg/L. The mean wet season Fe value for New Calabar was 0.016mg/L while dry season Fe value was 3.573mg/L.

The mean wet season Fe value for Nun River stood at 0.014mg/L while its mean dry season value for the same parameter was 2.173mg/L. The mean wet season Fe value for Sangana River stood at 0.017mg/L while its mean dry season value for the same parameter was 2.325mg/L.

Seasonal variation of microbial isolated from Rivers in the Niger Delta basin

This section shows the result of micro-organisms isolated from Rivers in the Niger Delta basin at different segments of the sampled Rivers and at different seasons. This is presented in Table 4.8.

Table 4: Microbial isolates from Rivers in the Niger Delta basin

Sampled Rivers	**Microbes**	**Wet season**			**Dry season**		
		Upstream	**Midstream**	**Downstream**	**Upstream**	**Midstream**	**Downstream**
Andoni River	Micrococus spp			*	*		*
	Bacillus spp	*	*		*	*	
	PseudomonesSpp						*
	Flavorbacteriumspp						
	E.coli	*	*	*	*	*	*
	Salmonella spp						
	Aeromonas spp		*				
	Aspergillus spp		*				*
	Rhizopus spp	*		*			*
	Penicillum spp	*	*		*	*	
Forcados River	Micrococus spp		*		*	*	
	Bacillus spp	*		*	*		*
	PseudomonesSpp	*		*		*	*
	Flavorbacteriumspp						
	E.coli	*	*	*	*		*
	Salmonella spp	*	*			*	
	Aeromonas spp						
	Aspergillus spp		*	*		*	*
	Rhizopus spp	*			*		
	Penicillum spp	*	*		*	*	*
New Calabar River	Micrococus spp	*		*	*		
	Bacillus spp		*	*		*	*
	Pseudomonesspp			*			*
	Flavor bacterium spp	*		*	*		
	E.coli	*	*	*	*	*	*
	Salmonella spp		*	*		*	*
	Aeromonas spp	*		*			
	Aspergillus spp		*	*		*	
	Rhizopus spp	*		*			*
	Penicillum spp	*		*	*		*

	Micrococus spp		*			*	
	Bacillus spp	*		*	*		*
	Pseudomones spp						
	Flavorbacterium spp	*					
Nun River	E.coli	*	*	*	*	*	*
	Salmonella spp	*			*		
	Aeromonas spp			*			*
	Aspergillus spp		*			*	
	Rhizopus spp		*			*	
	Penicillum spp	*		*			*
	Micrococus spp		*	*			*
	Bacillus spp	*		*		*	*
	Pseudomones Spp	*			*		
	Flavorbacterium spp						
Sangana River	E.coli	*	*	*	*	*	*
	Salmonella spp	*	*			*	*
	Aeromonas spp		*				
	Aspergillus spp		*	*		*	
	Rhizopus spp	*		*			*
	Penicillum spp	*	*		*	*	*

Source: Researchers Field Report (2021)

According to Table 4.8 above, a number of micro-organisms which included: micrococus spp, bacillus spp, pseudomones spp, flavor bacterium spp, e.coli, salmonella spp, aeromonas spp, aspergillus spp, rhizopus spp and penicillum spp. As can be inferred from the table, these micro-organisms were more during wet season when compared with their presence during dry season. Micro-organisms were detected from the water samples with variation in the dry and wet seasons. On the other hand, downstream section of sampled Rivers has more of these microbial then the midstream and upstream sections. Majority of the micro-organisms isolated are germ-negative micro-organisms as they can cause ailment such as diarrhea, dysentery, urinary tract infection etc. The presence of pathogens renders the water unfit for drinking and domestic use.

DISCUSSIONS

Heavy metals such as: Pb, Cd, Cr, As ad Fe values for the selected Rivers were found to be higher during dry season when compared to wet season values. In other words, the concentrations of heavy metals were higher in dry season. Majority of these heavy metals exceeds the permissible standards of international and national regulatory agencies making the water unfit for drinking and domestic use. Dry season heavy metal concentrations were generally higher compared with the wet season values for all the sampled Rivers within the Niger Delta basin. It was found to be higher in midstream and downstream sections of the sampled Rivers. This could be attributed to the high pH value of recorded during dry season. The result is in agreement with the findings of Onwugbuta-Enyi, Zabbey & Erondu (2008) who observed obvious seasonal fluxes in the water parameters except nitrate concentrations that were not statistically significant. It is also in tandem with the observation of Akinnawo, Abiola & Edward (2016) who observed a seasonal variation in physico-chemical and microbial characterization of sediment and water samples from selected coastal areas in Ondo state.

Microorganisms such as: micrococus spp, bacillus spp, pseudomones spp, flavor bacterium spp, e.coli, salmonella spp, aeromonas spp, aspergillus spp, rhizopus spp and penicillum spp were detected. These micro-organisms were more during the wet season when compared with their presence during dry season. In other words, there was a seasonal variation in the presence of micro-organisms. On the other hand, downstream section of sampled Rivers has more of these microbial then the midstream and upstream sections. Majority of the micro-organisms isolated are germ-negative micro-organisms as they can cause ailment such as diarrhea, dysentery, urinary tract infection etc. The presence of pathogens renders the water unfit for drinking and domestic use.

CONCLUSION AND RECOMMENDATIONS

Water quality in Niger Delta basin is generally poor. This can be seen from the heavy metal and microbial loads from the selected rivers. The heavy metals were above the acceptable water quality standards and therefore indicate the existence of pollution. This poses a serious challenge to the availability of potable drinking water for communities within the study area. Both heavy metals and microbial loads vary according to season. From the results of this study, the following recommendations are put forward:

1. There is need for aggressive public enlightenment to dissuade the abuse of rivers. This will help to discourage the public from using the river as a receptacle for dumping of waste.
2. There should be regular surveillance of rivers within the Niger Delta to safeguard the users of this vital resource.

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