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ASSESSING THE WATER QUALITY OF FRESH AND MARINE WATERS IN COASTAL AREAS OF RIVERS STATE, NIGERIA

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ABSTRACT

The coastal area of Rivers State is located in the Niger Delta of Nigeria and is criss-crossed by different rivers, streams, creeks and rivulets and they are exposed to uncontrolled, untreated non-point source pollution as they receive run-offs, sediments and sewage directly into them. The aim of this study is to compare the water quality of a fresh and marine water in the coastal area. The water samples were collected in sterile containers for physicochemical and bacteriological estimations using standard methods. The physicochemical parameters were determined by using the Hatchi (2000) instrument that analysed the pH, temperature, conductivity and turbidity *in situ*, while the spectrophotometric techniques were used for the nitrate, phosphate and other parameters as chloride and alkalinity were determined by titration methods. The standard conventional culturing technique of isolation, identification and biochemical tests were used for the bacteriological analysis of water. The results of the physicochemical parameters are pH 5.44 ± 0.37 to 7.42 ± 0.28, temperature 27.5^{o}C ± 1.10 to 28.9 ± 1.13 ^{o}C, conductivity 13.75 ± 0.35 to 32750 ± 353.55µs/cm. Dissolved oxygen 2.94 ± 0.01 to 7.57 ± 0.05 mg/l, chloride 1.00 ± 0.00 to 10397.40 ± 32.81 mg/l and the others. The identified bacteria in the water samples were *Staphylococcus spp, Bacillus spp, Klebsiella spp, Vibrio spp, Pseudomonas spp, Escherichia coli and Chromobacteria violaceum.* It can be inferred that the presence of the isolated bacteria could result to outbreak of epidemics and knowledge of the strains of the bacteria would help in managing their presence in public water.

KEYWORDS: Water quality, freshwater, marine water, physicochemical, bacteriological.

INTRODUCTION

The coastal area of Rivers State has boundary with the Atlantic Ocean and is criss-crossed by marine, streams, rivers and rivulets. Even with the presence of these water types safe drinking water availability is scarce. The World Health Organisation (WHO) (2006) has stated that there is increase in global and local water scarcity and this has led to increase use of sources as recovered or recycled waters, harvested rainwater and desalinated waters. The Nigeria Water Policy of the Federal Republic of Nigeria (2004) has said that a large percentage of the country's population which it estimated to be in the neighbourhood of 120 million does not have access to potable waters. It estimated that 52% of the urban, 48% of the pre-urban and 39% of the rural dwellers are all included.

Water is an essential substance needed for existence of life (WHO, 2006; Osunkiyesi, 2012; Adeyemi *et al.*, 2015). It is used in the day to day activities of man which are cooking, washing, drinking, cooling and industrial activities (Akpoborie *et al.*, 2008).

The surface water in the coastal areas of Rivers State have suffered from debilitating environmental degradation and pollution from human activities such as industrial operations, manufacturing and municipal discharges (Onojake and Frank, 2013). The natural water contains different types of impurities that are introduce into it in different ways such as leaching of soils dissolution of aerosol particles from the atmosphere including mining, processing and the use of metal base materials (Adeyeye, 1994). Run-off by rain brings in fertilizer and pesticides from agricultural products. The lack of potable water in most rural and coastal areas of Rivers State has made the people to turn and depend on stream and river water for domestic use and other activities (Shittu *et al.*, 2008) as their contamination comes from different sources such industries, abattoir activities, pesticides and from faecal discharges into surface and ground waters due to washing by rain fall (Oko, 2008; Iornumbe and Onah, 2008).

Several workers have carried out lots of work on the water systems in different parts of Nigeria such as on

boreholes, groundwater and surface water determining their physico-chemical parameters and microbiological contents and also comparing the different types of water but there have been assessment but no comparison of the fresh and marine water to determine which could be a better source of water for use especially in the rural areas.

The water quality assessment of a fresh and marine water will be determine because water plays vital role in the existence of life and various sectors of the economy such as fishery, livestock production and other creative activities (Tyagi *et al.,* 2013).

The coastal areas of Rivers State have been exposed to increase in population as a result on migration and industrial activities and this has led to increase in generation of waste from sewage domestic, industrial and agricultural activities as they find their way into the surface waters causing pollution and has therefore reduced the potability of the water found in the coastal areas. It has been established from some workers that worked in Niger Delta that pipe borne and boreholes waters are safe for human consumption and domestic purposes but the stream waters are not safe (Etim *et al.,* 2013).

The monitoring of water quality is now a subject of concern in marine, stream, river and rivulet waters due to the uncontrolled disposal of wastes such as, urban effluents, runoffs from rain, atmospheric deposition, municipal and industrial effluents into the water bodies (Droup *et al.,* 2011). It is as a result of these factors that the marine and the fresh waters of coastal area of Rivers State will be compared as a healthy water environment prevents the occurrence of disease. The low quality of drinking water in coastal areas of Rivers State, Nigeria will result in contacting water borne illness as the pollutants find their way into the drinking water sources that are not eliminated by treatment processes thus making people sick since there is uncoordinated efforts by both the local, state and federal agencies.

The aim of this research work is to determine and compare the physiochemical parameters and bacterial levels of marine and fresh waters in coastal area of Rivers State.

MATERIALS AND METHOD

Study area: The study areas are two rivers Amariaria Bonny River and the Agbonchia River in two different Local Government Areas of Rivers State. The Amariaria water sample represents the marine water whereas the Agbonchia river represents the fresh water. The Amariaria Bonny River is located at $N04^{0}\ 24^{1}\ 32.8^{1}$ and $E0070\ 08^{1}09.7^{11}$ while the Agbonchia point is $N04^{0}481\ 24.5^{11}$ and $E007^{0}05^{1}\ 58.7^{11}$ (Yusuff *et al.,* 2014).

Sample Collection: The water samples from the two rivers were collected during the dry season at the designated Global Positioning System (GPS) points. The samples were collected at midstream in sterile universal containers of 25ml capacity for microbiological analysis and in brown bottle of 500ml capacity and were proper labeled and transported to the laboratory in cold chain. The first station Amariaria Bonny River (marine) will be station 1 while the Agbonchia River (fresh) will be station 2.

Sample analysis: The standard analytical methods used for the physicochemical parameters of the water were the American Public Health Association Series of Standard methods of Examination of water and Effluent (2005).

The pH conductivity salinity and turbidity were determined by using the Horiba Water Checker (Model 11 – 10) after calibrating the instrument with the standard Horiba solution and total dissolved solids with a Lovibond CM-21 Tintometer while the temperature was determined with a mercury thermometer.

The bacteria analysis was carried out by using the standard plate count technique where the water samples were cultured and enumerated of culture media as Nutrient agar, Mac Conkey agar, Salmonella-Shigella agar and Thioglycholate citrate bile salt sucrose agar media. These were incubated at 37^{0}C in an incubator for 24 hours after which bacterial counts were made and were subcultured and used for Gram staining and other biochemical tests.

Gram Staining

On different clean grease free slide a smear for each sample was made using a wire loop which was sterilized in a bunsen flame and heat fixed and air dried. The dried slide was placed on as a staining rack and crystal violet was poured and allowed to stay for about 1 minute and was rinsed with water. It was then flooded with Lugol iodine and was allowed on for 1 minute. The mixture was decolourised with 95% Ethanol the slide and allowed to stand for 1minute. The slide was washed air dried, blot dried and observed under microscope using the oil immersion objective and the results were recorded (Singleton, 1999, Benson, 2002, Chakraborty and Pal, 2011).

Motility Test

The Motility agar stab technique was used. Into a soft motility agar test tube which is not a slanted surface was a stab inoculum made with a straight sterile wire with picked bacteria colony from cultured plate. The top surface was not inoculated. The test was set for the isolated bacteria after gram staining. The test tubes were incubated at 37^{0}C for 48hours and it was observed for the motility of the bacteria. The readings were recorded (Barrow and Feltham, 2003).

Catalase Test: The Test Tube Method
Into a 5ml capacity test tube was placed 1.0ml volume of hydrogen peroxide solution. A tiny glass rod was used to pick some colonies of a 24 hour culture of the isolated bacteria and immersed into the hydrogen peroxide. This was observed for bubbles. The positive ones showed bubbles while the negative ones showed no reaction. The results were recorded accordingly (Singleton, 1999, Benson, 2002, Barrow and Feltham, 2003).

Coagulase Test: The Tube Test method
A zero point five (0.5ml) millilitre of a 24 hour broth culture of the isolated bacteria was pipette into a 5.0ml capacity test tube and to this was added 1.0ml of plasma. The mixture in the test tube was then incubated at 37^0C and examined at intervals of one hour for the presence of clotting. The results were recorded during the observation period (Barrow and Feltham, 2003, Forbes *et al*., 2007).

Oxidase Test: Filter Paper Method
A Whatman's No 1 filter paper was torn into 10.0cm long strip and soaked in a freshly prepared 1% solution of tetramethyl-*p*-phenylenediamine dihydrochloride. The soaked papers were allowed to drain and were dried and stored in a dark bottle tightly sealed with a screwed cap. To use the paper strip the colony to be tested was picked with a sterile wire loop and a smear was made on it. A positive reaction was indicated by the appearance of an intense deep-purple colour within 5-10 seconds and a negative reaction was observed to be absence of colouration (Chakraborty and Pal, 2011).

Citrate Utilization
The bacteria were streaked over the surface of a slope Simmon's citrate medium and incubated at room temperature and examining daily for up to 7 days for blue colour change as positive and no colour change as negative and the results were recorded (Barrow and Feltham, 2003, Forbes *et al*., 2007 Chakraborty and Pal, 2011).

Methyl red reaction
The isolated bacteria were inoculated into a methyl red medium of glucose phosphate and were incubated at 37^0C for 2 days and allowed to grow after which two drops of methyl red solution was added to each mixed well shaken and examined for the appearance of red colour at the surface whereas an orange or yellow colour signifies negative (Barrow and Feltham, 2003, Forbes *et al*., 2007 Chakraborty and Pal, 2011).

Voges Proskauer test
The medium used for methyl red reaction were used for the Voges Proskauer test by adding 0.6ml 5% α-naphthol solution and 0.2ml 40% potassium hydroxide (KOH) aqueous into the tubes which were well mixed and shaken very well. The tubes were then sloped to increase the surface area for more reaction to take place after which they were examined after 15minutes to 1 hour for a strong red colour (Barrow and Feltham, 2003, Forbes *et al*., 2007 Chakraborty and Pal, 2011).

Indole test
The sub-cultured bacteria isolates were inoculated into nutrient broth and incubated at 37^0C for 48 hours in incubator. Into these broth cultures were added 0.5ml of Kovács reagent for indole production. The resultant production of red colour in the reagent layer indicates positive for indole (Barrow and Feltham, 2003, Forbes *et al*., 2007, Chakraborty and Pal, 2011).

Spore Staining
A bacteria smear was made on a clean grease slide using a sterile wire loop. The smear was air dried and heat fixed and was covered with small filter paper saturated with malachite green which was steamed for 5 minutes while keeping the paper moist to prevent it from drying up. The slide was washed with distilled and counter stained with safranin for 30 seconds. It was washed with tap water and blot dry. The slide was examined under the microscope and the results were recorded (Barrow and Feltham, 2003, Chakraborty and Pal, 2011).

RESULTS

The Mean and SD values of physicohemical parameters of two water samples Amariaria Bonny River (marine) and Agbonchia River (freshwater).

Table 1: Showing the Physicochemical Parameters of Marine and Fresh water.

Parameters	Station 1 Amariaria Bonny River (Marine)	Station 2 Agbonchia River (Freshwater)	Who Limit
pH	7.40 ± 0.28	5.4 ± 0.37	6.5-8.5
Temperature ^{0}C	28.9 ± 1.13	27.5 ± 1.10	25
Conductivity (µS/cm)	32,750 ± 353.55	13.75 ± 0.35	5.0
Turbidity (NTU)	11.45 ± 0.14	0.00 ± 0.00	5
Salinity ‰	19.50 ± 0.14	0.00 ± 0.00	5
Total Dissolved Solids (ml/l)	22,875.0 ± 176.78	8.23 ± 0.02	500
Chloride (mg/l)	10,397.4 ± 32.81	1.00 ±0.00	0.05
Total Alkalinity (mg/l)	8.40 ± 0.57	4.5 ± 0.71	50
Total Hardness (mg/l)	3,866.0 ± 48.08	3.7 ± 0.14	5.0
Calcium (mg/l)	1,230.30 ± 5.52	0.85 ± 0.01	7.5
Magnesium (mg/l)	186.90 ± 0.42	0.50 ± 0.00	30
Dissolved oxygen (mg/l)	7.52 ± 0.05	2.94 ± 0.01	14
Sulphate (mg/l)	465.2 ± 6.22	< 1.0 ± 00	150

Table 2: Showing the Total Heterotrophic Bacteria Count, Total Coliform, and Most Probable Number.

Parameters	Station 1 Amariaria Bonny River (Marine)	Station 2 Agbonchia River (Freshwater)
Total Heterotrophic Bacteria Count (cfu/µl)	1.90×10^2	0.89×10^2
Total coliform (cfu/ul)	8.0×10^1	3.60×10^1
Most Probable Number (MPN)	5.8×10^2	3.0×10^2

Table 3: Showing the Identified Bacteria in Marine and Freshwater.

Station 1 Amariaria Bonny River (Marine water)	Station 2 Agbonchia River (Freshwater)
Staphylococcus spp.	Chromobacterium violaceum
Bacillus spp	Pseudomonas spp.
Klebsiella spp	Escherichia coli
Vibrio spp	Staphylococcus spp. Bacillus spp.

DISCUSSION

The results for the physicochemical parameters, total heterotrophic bacteria count, total coliform count, Most Probable Number and identified bacteria in the marine and freshwater samples are as shown in tables 1, 2 and 3.

The water qualities of the two water samples marine and fresh water will be confirmed by their physicochemical and bacteriological analyses determining their status. Some of the physicochemical parameters of the marine water are above the recommended World Health Organization (WHO) standards while the freshwater values fall below the recommended standard except the pH value. The result of the bacteriological analysis have shown that there are presence of bacteria in the both the marine and fresh water. The bacteriological results indicate that they are above the recommended WHO standard. There are some common bacteria found in both the marine and fresh water samples and these are *Bacillus spp. and Staphylococcus spp* but *Klebsiella spp and Vibrio* spp are occurring in marine water while *Chrombacterium violaceum, Escherichia coli* and *Pseudomonas* spp occur in the freshwater.

The pH of the water sample is an important parameter that helps to determine the suitability of water for different purpose as it measures the free hydrogen and hydroxyl ions in water. The pH of the marine water in this work agrees with the earlier pH value of other researchers on marine water (Ajao and Fagude, 2002; Etim *et al.*, 2013; Onojake *et al.*, 2015). The value obtained from this work which is 7.40 ± 0.28 falls within the permissible range of 6.5 – 8.5 as prescribed by WHO standard for water quality and the water is suitable to support aquatic life (Zhou *et al.*, 1999). The pH of the fresh water analyzed was 5.44 and it falls out of the range of pH for water which is 6.5 to 8.5 as recommended by the WHO. This pH level is undesirable because it may impact a bitter taste to the water and it might not support the growth of some organisms. The pH of the marine is in agreement with that done for dry and wet season (Onojake *et al.*, 2015).
The temperature of the two water samples marine and fresh water falls within the recommended standard temperature and this will support growth of organisms. The temperature agreed with earlier work carried out in the dry season in the same water (Sikoki and Zabbey, 2006). The reason may be as a result of the openness of

the marine water to daily sunshine that heats up the water during the dry season.

The electrical conductivity is a measure of the ability of an aqueous solution to convey an electric current. Its conductance ability depends upon the presence of minerals, ions, their concentration, temperature valence to carry electric charge. The high value of the electrical condctivity with earlier work indicates that the area receives large volume of materials from the sea and other rivers emptying into it. The fresh water has low level of conductivity because it is not exposed to materials that could conduct electricity and it could also be the materials are transported fast from the water since it is a fast moving river and not stationary.

The salinity of the marine water is high because it has access to the sea and also as a result of depositions it is also receiving from other rivers bringing in materials that could contain salts. The freshwater records no salt because it is not receiving any very materials from other streams or rivers as the marine.

Total dissolved solids and substances composed of the salts mainly carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates, calcium, magnesium, sodium, potassium, iron and manganese in water (Chandra *et al.,* 2012). The high values observed were higher than the recommended value for marine water (McNeely *et al.,* 1979, WHO, 2006) and also an indication that the marine water receives organic and inorganic materials from human activities, domestic industrial waste, sewage and agricultural activities (Saad *et al.,* 1994). The World Health Organization has recommended that high levels of dissolved substances may affect the taste of water (WHO, 2006). The freshwater level of dissolved solids falls within the recommended standard.

The chloride level of the marine water is higher than the recommended level by the WHO. The excess of chloride in water is usually an indication of pollution from sodium, potassium and calcium salts present in water, which contributes to increase in chlorides in water. Chandra *et al.,* (2014) have suggested that large content of chloride in water is an indicator of pollution. The source through which these chlorides enter into the water are through sewage water, industrial effluent rich in chloride, which are discharged as waste into the water and this increases the chloride level. When the level of chloride is above the recommended level it makes the taste of the water to become objectionable to the consumer. It may also contribute to deterioration of some working materials. The marine water has high level of chloride than the freshwater and it is also pointing to the fact that the marine water may be polluted as it receives different materials from other rivers and the sea. In addition, this work shows that the fresh water does not have chloride as a result of not receiving materials from other sources.

The total hardness analysis is to determine the ability of the marine and fresh water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acids from soap solution. The principal ions that cause hardness are calcium, magnesium, bicarbonate, carbonate, chloride and sulphate (Asuquo *et al.,* 2012a). The total hardness value for this work on marine water is 2366 ± 48.08mg/l, which is above the WHO recommended standard receives polluting materials from different sources as against the freshwater that does not receive such substances.

Calcium presence in water depends on the type of rock and availability of limestone and other chemicals containing calcium. The level of calcium in the marine water shows that it is exposed to those substances as the level is higher than the recommenced value. It has been observed that the presence of magnesium in water is often associated with calcium in all kinds of water. The presence of magnesium in water has been seen as being useful and essential for generation of chlorophyll allowing for growth but acts as a limiting factor for the growth of phytoplankton. Its depletion reduces the number of phytoplankton's population in the water (Chandra *et al.,* 2012). Magnesium hardness in particularly associated with sulphate ion and has laxative effect on persons unaccustomed to it. According to the WHO recommended value, the level of magnesium in the marine water was higher while in the fresh water it was low.

Dissolved oxygen in water may be as a result of direct diffusion from the air and photosynthetic activity of aquatic plants. The measurement of dissolved oxygen in water determines the amount of gaseous oxygen (O_2) dissolved in aqueous solution. It is an important parameter that is essential for the metabolism of all aquatic organisms that undergo aerobic respiration (Shanthi *et al.,* 2002). The presence of oxygen in the water can be easily and rapidly removed when there are discharged wastes into the water that demands oxygen (Chandaluri *et al.,* 2010). The marine water values in coastal area of Rivers State fall within the WHO recommended values while the freshwater values fall below the recommended value.

The sulphate level of the marine water as analysed was higher than the recommended value whereas the level of the freshwater was low. It has been said that the high level of sulphate in drinking water is difficult to be removed from water except by expensive techniques as distillation, reverse osmosis or electrodialysis (Etim *et al.,* 2013). The presence of high level of sulphate in water can induce diarrhea especially levels greater than 500mg/l and typically when it is near 750 mg/l. The presence of high sulphate level might also impact slight taste to drinking water than chloride as no significant taste effects are detected at levels below 300mg/l.

CONCLUSION

The obtained data on the water quality of Amariaria Bonny River (marine water) and Agbonchia River (fresh water) have shown that the marine water has higher values for electrical conductivity, total dissolved solids, chloride, total hardness, calcium, magnesium and sulphate and these agree with some earlier studies on other coastal area waters in Niger Delta (Onojake *et al.*, 2015) especially during the dry season where values are high. However, the values for the freshwater are within and below the recommended standard by the WHO recommended values. The increase in these parameters could result from the increase in population, industrial activities, agricultural activities and development of the area.

The bacteria isolated from the marine and fresh water samples give indication that the source of pollution of these rivers as observed includes human activities such as defaecation and dumping of untreated sewage from both domestic and municipal tanks into them. The presence of these bacteria *Eschrichia coli, Klebsiella spp, Pseudomonas spp, Vibrio spp* shows that the water is not good for domestic use as some of them are associated with diarrhoea disease and dysentery. The water quality of the marine and freshwater should be monitored regularly to avoid health risks that result from polluted water and measures should be put in place to discourage those who use the water as dumpsites should stop to avoid possible health hazards associated unhealthy environments. More so, there should be strict implementation of environmental laws and policies to avert the dangers associated with poor sanitation and poor water systems.

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