

IMPACTS OF SEASONS ON THE BACTERIOLOGICAL QUALITY OF OMAMBALA RIVER AT OTUOCHA IN ANAMBRA STATE, NIGERIA

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ABSTRACT

Clean and safe water is an important natural resource for the sustainability of life and a healthy economy. Several surface and ground water used as sources of water for domestic activities including drinking have often been associated with faecal contamination. The quality of Omambala River at Otuocha in Anambra-West Local Government Area of Anambra State was therefore studied to determine the impacts of seasons on the bacteriological quality. The wet season samples were collected between July and September, 2023 while the dry season, samples were collected between December, 2023 and February, 2024. There was a change in the total bacterial count, total coliform and faecal coliform counts due to seasonal variations. Total bacterial counts from the water samples in the dry season ranged from 31×10^2 cfu/ml to 57×10^2 cfu/ml, total coliform count, from 12MPN/100ml to 22 MPN/100ml while the faecal coliform count was 0MPN/100ml. Total bacterial counts from the water samples in the wet season ranged from 102×10^2 cfu/ml to 157×10^2 cfu/ml, total coliform count, from 19MPN/100ml to 44MPN/100ml, faecal coliform count, from 6MPN/100ml to 12MPN/100ml while shigellae count ranged from 1 cfu/ml to 2 cfu/ml. The average total bacterial counts for both seasons ranged from 66.5×10^2 cfu/ml to 182.5×10^2 cfu/ml while the average total coliform count were 17MPN/100ml to 32MPN/100ml. The average faecal coliform count for both seasons ranged from 3MPN/ml to 6.5MPN/100ml. The average Shigella counts ranged from 0.5cfu/ml to 1cfu/ml. The average total bacterial counts in all the samples were more than the WHO limit for potable water. The bacteriological analysis of the water samples for both seasons revealed the presence of *Pseudomonas aeruginosa*, *Escherichia coli*, *Bacillus cereus*, *Klebsiella aerogenes* and *Shigella dysenteriae*. This was an indication that Omambala River is not suitable to be used as potable water due to the high bacterial growth from the samples. It is therefore advisable to subject the water to treatments such as boiling, chlorination and filtration before it can be consumed.

Keywords: Bacteriological, potable, Omambala River, Seasons, Otuocha

1. INTRODUCTION

Potable water is water that is suitable for human consumption both for drinking and other purposes. The importance of potable water can never be overestimated because of its benefits of providing a number of useful services for humans and the ecosystem. Water is safe and fit for drinking, cooking and other domestic purposes if its bacteriological, chemical and physical properties are at acceptable levels. Freshwater availability is one of the major problems facing the world and approximately one third of drinking water requirement of the world is obtained from surface sources like rivers, dams, lakes and canals (Jonnalagadda, et.al, 2001). These sources of water also serve as sinks for the discharge of domestic and industrial wastes. The biggest threat to sustainable water supply is the contamination of available water resources through pollution, and this might lead to deaths, due to water-borne diseases such as diarrhea, cholera, typhoid, amoebiasis and hepatitis A (Patel, 2019).

According to WHO (2012), about 1.1 billion people consume unsafe water across the globe contributing to about 1.7 million global deaths annually (approximately 3.1%) with a potential annual disability burden of 54.2 million (~3.7%). Making water safe for drinking is a big challenge in developing countries. Another prevailing challenge to safe drinking water in developing countries is the issue of natural scarcity of fresh water sources in certain areas especially in sub-Saharan Africa. Fast increase in world's population and shifting demography at an alarming rate, whereas the available freshwater resources seldom change but almost remain constant has also contributed to the challenges (Dinka, 2018).

Daniel (2015) reported that the climate of Nigeria is usually characterized by two seasons -the wet and dry seasons. The wet season is characterized by heavy rainfall. It varies across the country as it falls upon the Southern region much earlier than the rest of the country. During this season, the Southern coast of the country alone can receive more than 150 inches of rainfall, whereas the Northern region in the Sahel zone experiences only about 20 inches. The change is due to the climatic conditions of both areas. The wet season (summer) begins around March and lasts to the end of July with a peak in June. This is followed by a short dry break in August known as August break which is a short dry season

lasting for two to three weeks in August. This break is broken by the short rainy season starting around early September and lasting to mid-October with a peak period at the end of September. The ending of the short rainy season in October is followed by long dry season (Daniel, 2015).

The dry season (winter) is from late October and lasts until early March with peak dry conditions between early December and late February. The dry season is accompanied by hot sunny days, in which there is little amount of rainfall. This season has temperatures that average about 100 degrees Fahrenheit during the day but can drop to 54 degrees at night. One of the significant characteristics of the dry season is the wind known as harmattan (Daniel, 2015). Bacteriological quality is one of the important parameters of water potability. It is defined in terms of the absence or presence of indicator organisms such as coliforms, faecal coliforms, faecal Streptococci, Clostridium perfringenes, Salmonella species, Shigella species and Vibrio species in a water sample. The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal feces. Wastewater discharges into fresh waters and coastal seawaters are the major source of fecal microorganisms, including pathogens (Grabow, 1996).

In Nigeria, the origin of water shortage is dated as far back as the pre-colonial time when people had to journey from one part of the country to another in search of water. There are constraints in the provision of bulk supply of potable water to people living near Omambala River despite the intervention of the state government. Some of these constraints are largely due to insufficient allocation of funds and inadequate human resources. In communities where potable water is supplied, it is usually erratic and unreliable, forcing residents to revert to surface water from rivers for their domestic needs. One of the major threats to public health is the presence of high concentration of pathogens in surface water capable of compromising the health of the people that drink the water and use it for recreational and agricultural purposes (Obi, et.al, 2002).

Omambala River which is being studied is at the South-Eastern part of Nigeria. Many communities in Omambala region still rely on untreated or insufficiently treated water from Omambala River for their daily supply, and thus are at a high risk of waterborne diseases. It is therefore necessary to assess the water quality of Omambala River which is used by residents of several communities surrounding it for domestic, recreational and agricultural purposes so as to prevent any episode of water-related diseases.

2. MATERIALS AND METHODS

Study Area

The research was carried out on Omambala River at Otuocha, in Anambra -West Local Government Area of Anambra State. The Omambala River is an alternative source of drinking water supply for the communities living around the river. The geographical coordinates are 6.0299°N and 7.1626°E. The region is characterized by a warm wet season which is associated with high temperatures up to 40°C usually between October and March (with peak precipitation in January and February) and cold dry season (April-September). Upstream land use in the catchment area includes subsistence and commercial agriculture, schools, formal and informal human settlements, hospital, garages, waste stabilization ponds (WSPs), brick making factories, sand and gravel mining. Brick making is usually done at the bank of the river. Abstraction of water from the river for drinking and other domestic purposes without treatment is a common practice. Pipes are usually connected to the river by farmers for irrigation of their crops. Low scale fishing is done downstream of the river. There is limited water infrastructure in the communities surrounding the Omambala River.

Study Design

The design that was used is experimental. Two sampling seasons were employed (wet and dry seasons) and the samples were collected randomly from three points (inflow, middle and outlet) of the river. The wet season samples were collected in July, August and September, 2023 while for the dry season the samples were collected in December, January and February, 2024.

Samples Collection

A total of twelve (12) composite samples were collected from three different points of the river that is the inlet, the middle and outlet of the river using well labeled sterile rubber containers (1 litre) tied with a strong twine. Two samples were collected from each of the three sampling points each month. The containers for the samples were first sterilized by rinsing with 70% ethanol and secondly with distilled water and lastly with the water to be sampled before collection of samples. In order to prevent contamination during the samples collection, laboratory coat, hand gloves and nose masks were worn. The samples were transported to the microbiological laboratory of Nnamdi Azikiwe University Awka, Anambra State in ice-packed containers within one hour of collection after which they were analyzed within six hours.

Total Bacterial Count

This was carried out as described by Cheesbrough (2006). Tenfold serial dilutions of the samples were prepared using sterile water. This was done by filling ten sterilized test tubes with nine milliliters (9ml) of sterile water. One millimeter of the water sample was transferred aseptically using a sterile pipette into the first test tube containing nine-millimeter of sterile water and mixed properly. One millimeter (1ml) was taken from the first tube (10^{-1}) and introduced into the second tube and mixed properly. This was continued until the tenth test tube. All the pipettes that were used for each transfer were sterilized in a hot air oven. The total bacterial count in the water samples were obtained by inoculating 0.1 ml of the diluted sample on to nutrient agar plate using the pour plate method and incubated at 37°C for 24 hours. Petri dishes from dilutions with the range of 30 and 300 discrete colonies were counted and result was expressed as colony forming unit per milliliter. The colonies were sub-cultured by streaking in order to obtain pure cultures. Pure cultures were stored in agar slants in Bijou bottles for identification.

Total Coliform Count

The total coliform counts were determined using the multiple tube fermentation test as described by APHA (2005). This involved three tests namely: the presumptive test, the confirmed test and the completed test.

Presumptive coliform test

Coliform counts were obtained using the three tubes assay of the most probable number technique (MPN). The medium that was used is MacConkey broth which was prepared according to the manufacturer's instruction and five drops of bromocresol purple indicator were added. The first set of the five test tubes had sterile 10ml double strength broth and the second and third sets had 10ml single strength broth. All the tubes contained inverted Durham tubes before sterilization. They were sterilized by autoclaving at 121°C for 15 minutes. These test tubes were allowed to cool before inoculation. The three sets of the tubes were inoculated with 5ml, 1ml and 0.1ml of the water samples from Omambala River using sterile pipettes. The test tubes were labeled properly and incubated for 48 hours at 37°C . The test tubes that showed acid and gas production in the Durham tubes were taken as positive result and recorded. The MPN of the total coliforms was read from the McCrady's Probability Table.

Confirmed coliform test

A loopful of culture from positive tubes from the presumptive test was inoculated into tubes of freshly prepared MacConkey broth containing Durham tubes and five drops of bromocresol purple indicator. The test tubes were incubated at 44°C for 48 hours. Test tubes that showed gas production after incubation were recorded as positive. The most probable number was read from McCrady's probability Table. A loopful of culture from the positive presumptive test was also inoculated on Eosin methylene blue agar. The plates were incubated for 48 hours at 35°C and were examined for metallic sheen colonies.

Completed coliform test

Completed test was carried out by sub-culturing colonies from Eosin methylene blue agar plates into lactose broth fermentation tubes with Durham tubes and on nutrient agar plates and these were incubated for 24 hours at 35°C . The broth was examined for gas production while the colonies on the nutrient agar plates were purified by subculturing for another 24 hours at 35°C . Pure cultures that were obtained after the sub-culturing were further subjected to biochemical tests for identification.

Faecal Coliform Count

The test was carried out as done by Anazoo and Ibe (2005). The test involved three stages namely, the presumptive test, the confirmed test and the completed test.

Presumptive test

The most probable number MPN technique using the three tube test with MacConkey broth was employed. Fermentation tubes were inoculated with 10ml, 1ml and 0.1ml aliquots of the sample. The tubes were incubated at 44.5°C for 48 hours. Positive tubes producing acid and gas were used in estimating the most probable number of faecal coliforms per 100ml of sample.

Confirmed test

Confirmed test was carried out by transferring a loopful of broth from a positive tube into Brilliant green lactose bile (BGLB) broth, followed by incubation at 44.5°C for 48 hours. The tubes were observed for gas production.

Completed test

This was done by plating a loopful of broth from a positive BGLB tube onto an Eosine methylene blue (EMB) agar (oxid) plate. The plates were incubated at 44°C for 48 hours and observed for dark red colonies with metallic green

sheen. Stock cultures of the colonies were prepared on nutrient agar slants and colonies were subjected to gram staining and biochemical tests (IMVIC).

Salmonella and Shigellae Count

The test was carried out as done by Cheesbrough (2006). Salmonella Shigella agar (SSA) was used to screen for the presence of Salmonella and Shigella species. The medium was prepared following the manufacturer's instructions. The examination for the Salmonella and Shigella species was done using membrane filtration method. The membrane filter that was used is Advantech filter with the pore size of 0.45µm. Hundred milliliters (100ml) of the sample was filtered through a membrane filter after which the membrane filter was placed upside down on the surface of an already prepared Salmonella and Shigella agar plates and incubated for 48 hours at 37°C. Presence of colonies after incubation was a positive test and the colonies were sub-cultured and subjected to biochemical tests for identification.

Vibrio Count

The test was carried out as described by Cheesbrough (2006). The medium that was used for the test is Thiosulphate Citrate Bile Salt Sucrose (TCBS) Agar. The medium was prepared according to the manufacturer's instructions and distributed into Petri dishes and allowed to gel. Hundred milliliters (100ml) of the sample was made to pass through the membrane filter (Advantec) after which the membrane filter was placed on the surface of an already prepared Thiosulphate Citrate Bile Salt Sucrose (TCBS) agar plates and incubated for 48 hours at 37°C. Presence of colonies after incubation was a positive test and these colonies were sub-cultured and subjected to biochemical tests for identification.

Characterization and Identification of the Isolates

The isolates were characterized using the cultural, morphological and biochemical characteristics. The tests that were carried out to identify the bacterial isolates were Gram staining, catalase test, coagulase test, oxidase test, motility test, spore staining, indole test, methyl red test, voges proskauer test, citrate utilization test and sugar fermentation test as described by Cheesbrough (2006).

Gram staining

A smear from a 24 hour culture were prepared on a grease-free slide. The smear was air-dried and fixed by gently passing it over a bunsen flame. The smear was flooded with crystal violet and allowed to stand for 1 minute. The stain was rinsed with running water. It was flooded with lugol's iodine solution and allowed to stand for one minute and rinsed with running water. This was followed by decolourization with alcohol for ten seconds. The slide was washed with water. It was then counter - stained with safranin for thirty seconds, washed with water, air-dried and examined under the oil immersion lens (X100) of the microscope.

Catalase test

A drop of 3% hydrogen peroxide was made on a clean and grease free slide. A wire loopful of the test isolate was mixed with the hydrogen peroxide on the slide. The production of gas bubbles from the mixture which occurred almost immediately was an indication of a positive reaction.

Coagulase test

A drop of physiological saline was placed on each end of a slide. With the aid of a wire loop, a colony of the test isolate was picked using the wire loop and emulsified in each drop to make two thick suspensions. A drop of human plasma was added to one of the suspensions and mixed gently. The clumping of the mixture within 10 seconds was a positive reaction. No plasma was added to the second suspension and this served as the control so as to differentiate any granular appearance of the organism from true coagulase clumping.

Oxidase test

The test was carried out using the method described by Cheesbrough⁴. A filter paper was moistened with the substrate (1% tetramethyl-p- phenylenediamine dihydrochloride) and a colony of the isolate was picked using a wire loop and mixed with the reagent on the filter paper. Positive result was indicated by the development of dark purple color (indophenols) within 10 seconds while negative result was indicated by the absence of color.

Motility test

A semi-solid agar medium was prepared in a test tube and a colony of the test organism was inoculated by a single stab made down the center of the tube using a straight wire. This tube was incubated at 37°C and examined at intervals by holding it up to the light and the stab line looked at to determine motility. Non-motile isolates produced growths that were confined to the stab-line, having sharply defined margins and leaving the surrounding medium clearly transparent while motile bacteria diffused and produced hazy growths that spread throughout the medium making it to be slightly opaque.

Spore staining

A smear from the test culture was prepared and flooded with 5% malachite green. A wire loop with cotton wool at the tip was dipped into ethanol and used in heating the slide to steaming for five minutes. The slide was washed and counter stained with 5% safranin for 30 seconds and allowed to dry and examined under the oil immersion lens (X100) of the microscope.

Indole test

A loopful of twenty-four hour pure culture of the isolate was inoculated into a sterilized test tubes containing four milliliter (4 ml) of tryptophan broth and incubated at 37°C for 24 hours. After the 24 hours, 0.5 ml of Kovac's reagent was added. The production of a red ring was an indication of a positive reaction.

Methyl red test

A loopful of the isolate was inoculated into a sterilized test tubes containing four milliliter of glucose phosphate peptone water and incubated at 37°C for 48 hours. After 48 hours, two drops of methyl red indicator was added and shaken with the mixture. A bright red colour was an indication of a positive result.

Voges proskauer test

A twenty-four-hour pure culture of the isolate was inoculated into a test tube containing glucose phosphate peptone water and incubated at 35°C for 48 hours. 0.6 ml of 50% alcoholic naphthol and 0.2 ml of 40% potassium hydroxide was added into the inoculated medium after the 48 hours incubation. The mixture was shaken and left to stand. A red colour production in the test tube was an indication of a positive result while the development of a yellow colour was an indication of a negative result.

Citrate utilization test

Simmon's citrate medium was inoculated with a loopful of peptone water culture of the pure isolate and incubated at 37°C for 4 days. A colour change from green to blue after the 4 days incubation was an indication of a positive result while the absence of any colour change was an indication of a negative result.

Sugar fermentation test

The pure isolates were inoculated into peptone water each containing 1% of the following sugars, glucose, lactose, fructose, galactose and mannitol and an indicator, bromothymol blue. Durham tubes were inserted, followed by sterilization, inoculation and incubation at 37°C for 48 hours. Development of gas in the Durham tubes and a change in the colour of the indicator from blue to yellow was an indication of a positive reaction

Data Analysis The results from this research were analyzed using 2-way ANOVA (Analysis of variance) to determine the level of variation among the parameters during the wet and dry season. The analysis was done using Statistical Package for the Social Sciences (SPSS) version 23.0.

3. RESULTS

The average bacteriological count of the water samples in the dry season is presented in Table 1. The total bacterial count ranged from 30 x 10²cfu/ml to 57x10²cfu/ml while the total coliform count ranged from 12MPN/100ml to 22MPN/100ml. The faecal coliform count was 0MPN/100ml and Salmonellae, Shigellae and Vibrio species were not detected in the dry season.

Table-1: Average bacteriological count of the samples from Omambala River during the dry season

| Samples | Total bacterial count (x10 ² cfu/ml) | Total coliform count (MPN/100ml) | Faecal coliform count (MPN/100ml) | Salmonellae count (cfu/ml) | Shigellae count (cfu/ml) | Vibrio count (cfu/ml) |
|---------------------|-------------------------------------------------|----------------------------------|-----------------------------------|----------------------------|--------------------------|-----------------------|
| S1 | 46 | 12 | 0 | 0 | 0 | 0 |
| S2 | 44 | 15 | 0 | 0 | 0 | 0 |
| S3 | 31 | 20 | 0 | 0 | 0 | 0 |
| S4 | 40 | 21 | 0 | 0 | 0 | 0 |
| S5 | 57 | 20 | 0 | 0 | 0 | 0 |
| S6 | 30 | 22 | 0 | 0 | 0 | 0 |
| WHO Standard (2006) | 100cfu/ml | 10 | Nil | Nil | Nil | Nil |

S1 and S2= samples collected in December

S3 and S4= samples collected in January

S5 and S6= samples collected in February

The average bacteriological count in the wet season is presented in Table 2. The total bacterial count ranged from 102×10^2 cfu/ml to 159×10^2 cfu/ml, while the total coliform count and the faecal coliform counts range from 19MPN/100ml to 44MPN/100ml and 6MPN/100ml to 13MPN/100ml respectively. Shigellae species count ranged from 0cfu/ml to 2cfu/ml, while Salmonella species and Vibrio species were not detected in the samples.

Table-2: Average bacteriological count of the samples from Omambala River during the wet season

| Samples | Total bacterial count (x10 ² cfu/ml) | Total coliform count (MPN/100ml) | Faecal coliform count (MPN/100ml) | Shigellae count (cfu/ml) | Salmonellae count (cfu/ml) | Vibrio count (cfu/ml) |
|---------------------|-------------------------------------------------|----------------------------------|-----------------------------------|--------------------------|----------------------------|-----------------------|
| S1 | 159 | 28 | 13 | 2 | 0 | 0 |
| S2 | 135 | 19 | 9 | 0 | 0 | 0 |
| S3 | 102 | 28 | 6 | 0 | 0 | 0 |
| S4 | 157 | 43 | 12 | 0 | 0 | 0 |
| S5 | 105 | 44 | 8 | 1 | 0 | 0 |
| S6 | 130 | 28 | 9 | 0 | 0 | 0 |
| WHO standard (2006) | 100cfu/ml | 10 | Nil | Nil | Nil | Nil |

Key:

S1 and S2= samples collected in July

S3 and S4= samples collected in August

S5 and S6= samples collected in September

The average bacteriological count in the wet and dry seasons was presented in Table 3. The total bacterial count ranged from 66.5×10^2 cfu/ml to 102.5×10^2 cfu/ml, while the total coliform count ranged from 17MPN/100ml to 32 MPN/100ml and the faecal coliform counts range from 3MPN/100ml to 6.5MPN/100ml. Shigellae count ranged from 0.5×10^2 cfu/ml to 1×10^2 cfu/ml, while Salmonellae and Vibrio species were not detected in the samples.

Table-3: Average bacteriological count of the water samples during the dry and wet seasons

| Samples | Total bacterial count (x10 ² cfu/ml) | Total coliform count (MPN/100ml) | Faecal Coliform Count (MPN/100ml) | Shigellae Count (cfu/ml) | Salmonellae Count (cfu/ml) | Vibro Count (cfu/ml) |
|---------------------|-------------------------------------------------|----------------------------------|-----------------------------------|--------------------------|----------------------------|----------------------|
| S1 | 102.5 | 20 | 6.5 | 1 | 0 | 0 |
| S2 | 89.5 | 17 | 4.5 | 0 | 0 | 0 |
| S3 | 66.5 | 24 | 3 | 0 | 0 | 0 |
| S4 | 98.5 | 32 | 6 | 0 | 0 | 0 |
| S5 | 81 | 32 | 4 | 0.5 | 0 | 0 |
| S6 | 80 | 25 | 4.5 | 0 | 0 | 0 |
| WHO Standard (2006) | 100cfu/ml | 10 | Nil | Nil | Nil | Nil |

Key:

S1=average of S1 in dry season and S1 in wet season

S2=average of S2 in dry season and S2 in wet season

S3=average of S3 in dry season and S3 in wet season

S4=average of S4 in dry season and S4 in wet season

S5=average of S5 in dry season and S5 in wet season

S6=average of S6 in dry season and S6 in wet season

The morphological and biochemical characteristics of the isolates from the water samples during the dry and wet seasons are presented in table 4. The bacteria were identified as Pseudomonas aeruginosa, Escherichia coli, Bacillus cereus, Shigella dysenteriae and Klebsiella aerogenes.

Table 4: Morphological and biochemical characteristics of the isolates from the water samples during the dry and wet seasons.

| Isolates | Morphological characteristics on solid media | Cell morphology | Morphological test | | | | | | | | | | Sugar fermentation test | | | | | |
|----------|-----------------------------------------------------------------------------|-----------------|--------------------|----------|-----------|---------|----------|-------|--------|----|----|---------|-------------------------|---------|----------|-----------|----------|------------------------|
| | | | Gram stain | Catalase | Coagulase | Oxidase | Motility | Spore | Indole | MR | VP | Citrate | Glucose | Lactose | Fructose | Galactose | Mannitol | Identity |
| 1 | Pale blue colonies. The colonies were smooth, transparent, convex and large | Rods | - | + | - | + | + | - | - | - | - | - | + | - | - | - | - | Pseudomonas aeruginosa |
| 2 | Round pinkish colonies | Rods | - | + | - | - | + | - | + | + | - | - | AG | AG | AG | - | AG | Escherichia coli |
| 3 | Grey colonies | Rods | - | - | - | - | - | - | + | - | - | - | + | - | + | - | + | Shigella dysenteriae |
| 4 | Shiny white and spreading colonies | Rods | + | + | - | + | + | + | - | - | - | - | + | - | + | - | + | Bacillus cereus |
| 5 | Milk, round colonies. The colonies are smooth | Rods | - | + | - | - | + | - | - | - | + | + | AG | + | - | + | + | Klebsiella aerogenes |

MR = Methyl Red, VP = VogesProskauer, AG = Acid and Gas, += Positive, - = Negative

The occurrence of the isolates in the water samples during the dry and wet seasons are presented in Table 5. Bacillus cereus and klebsiella aerogenes were detected during the dry season while all the bacterial isolates were detected during the wet season.

Table 5: Occurrence of the isolates in samples during the dry and wet seasons

| Isolates | Dry Season | Wet Season |
|-------------------------------|------------|------------|
| <i>Pseudomonas aeruginosa</i> | - | + |
| <i>Escherichia coli</i> | - | + |
| <i>Shigella dysenteriae</i> | - | + |
| <i>Bacillus cereus</i> | + | + |
| <i>Klebsiella aerogenes</i> | + | + |

Key: += present, - = absent

The frequency of occurrence of the isolates in the samples during the dry is presented in figure 1. The frequency of occurrence of the isolates in the samples during the wet season is presented in figure 2. The frequency of occurrence of the isolates in the samples during the dry and wet seasons are presented in figure 3. The frequency of occurrence of the isolates in percentage are as follow: *Pseudomonas aeruginosa* (25%), *Escherichia coli* (8%), *Shigella dysenteriae* (5%), *Bacillus cereus* (50%) and *Klebsiella aerogenes* (12%).

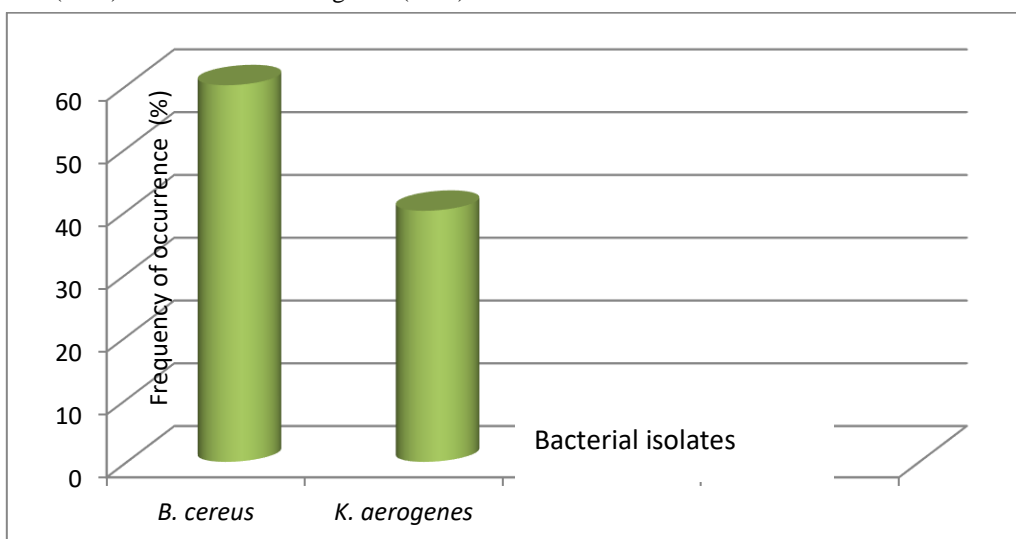


Figure 1: frequency of occurrence of the isolates in the water samples during the dry season

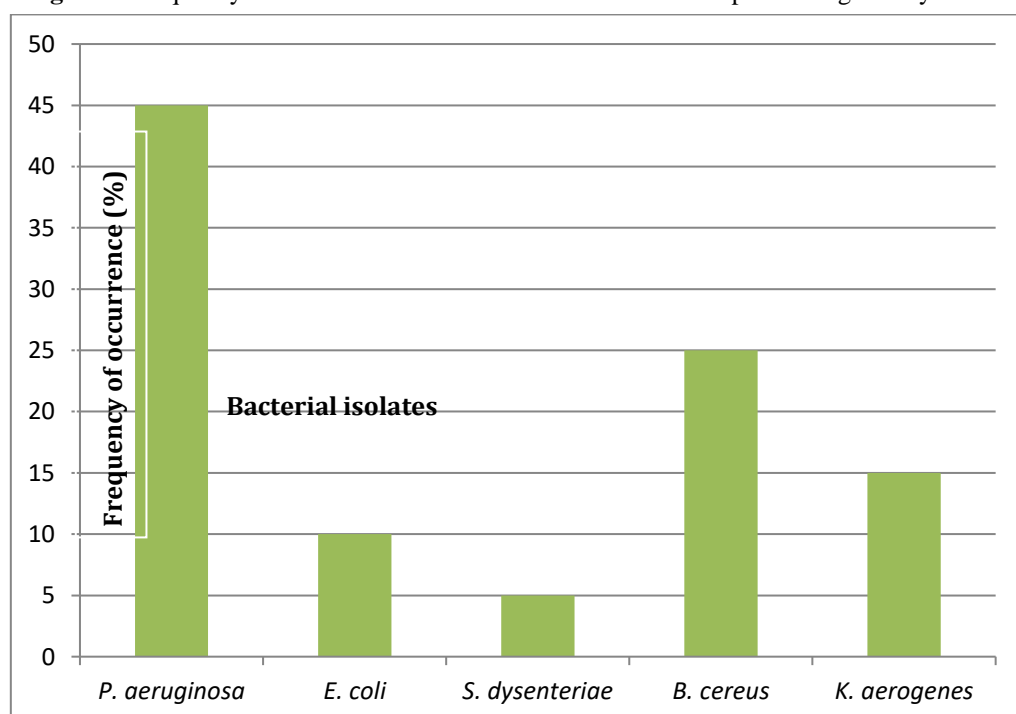


Figure 2: Frequency of occurrence of the isolates in the water samples during the wet season

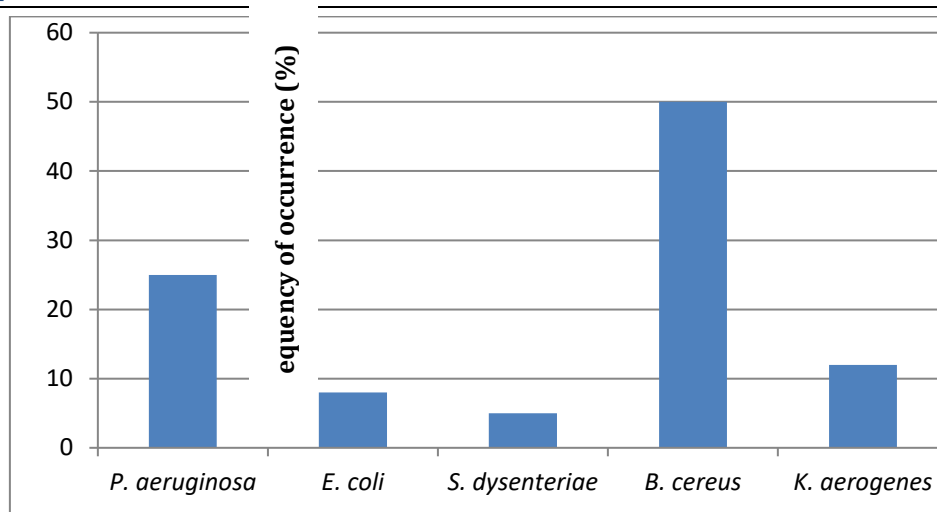


Figure 3: Frequency of occurrence of the isolates in the water samples during the dry and wet seasons

4. DISCUSSION

Results of the analysis showed that the values for the total bacterial count in dry seasons ranged from 31×10^2 cfu/ml to 57×10^2 cfu/ml while the total coliforms count ranged from 15 MPN/100ml to 20 MPN/100ml. Faecal coliforms and shigella species were detected while salmonella species and Vibrio species were not detected during both seasons (Table 1). The results for dry season samples agreed with the report of Elochukwu et al. (2022) who observed that the total bacterial count in wet season ranged from 102×10^2 cfu/ml to 159×10^2 cfu/ml while the total coliforms count ranged from 21MPN/100ml to 42 MPN/100ml. The faecal coliforms ranged from 4 MPN/100ml to 14 MPN/100ml. Shigella species count ranged from 0cfu/ml to 2 cfu/ml (Table 2). The results that were obtained from samples collected during the wet seasons were above the WHO limits for potable water and that was the highest for both seasons. This result agreed with the report of Dami, et al. (2012) who observed a change in the number of coliforms in the water samples collected from Okpai and Beneku, Delta state in the dry and wet seasons. This indicated that Omambala River was highly contaminated in the wet season and this could be as a result of discharged domestic and industrial wastes into the river as well as inflow of water from farms after rainfall events.

This showed that Omambala River was not fit for drinking due to the its high bacterial load (Table 3). These results agreed with Okonko et al. (2008) who observed that all the samples of water collected from tap, well, stream and wastewaters in Abeokuta and Ojota (both in Nigeria) were found to harbor coliforms in numbers greater than the required WHO/FAO standards for drinking water. The total viable counts for all the samples were all high exceeding the recommended limit of 100 cfu/ml. The MPN counts ranged from 9.3 to 44MPN/100ml. The faecal coliform counts ranged between 5 and 48 cells and also exceeding the standard limit for potable water. The results were also in line with Olatunji and Anani (2020) who in their evaluation of bacteriological and physicochemical quality of samples from River Brahmani of Rourkela, observed that all the bacteriological and physicochemical parameters investigated exceeded the WHO standards except sulphate and nitrate.

The bacteriological identification of the isolates from the samples during the dry and wet seasons revealed the bacteria present as Bacillus cereus, Klebsiella aerogenes, Pseudomonas aeruginosa Escherichia coli and Shigella dysenteriae (Table 4). The results indicated that the dry season sample had the presence of Bacillus cereus and Klebsiella aerogenes but free from Pseudomonas aeruginosa, Escherichia coli and Shigella dysenteriae while all the mentioned organisms were present in the samples collected during the wet season. This result agreed with the report of Onuorah and Ndumdi (2021) who observed some changes in the bacteriological analysis of samples from Iyifeyi stream in Ugwobi Abbi due to change in season. B. cereus are periodically associated with bacteremia, infections of wounds, the eyes, ears, respiratory tract, urinary and gastro-intestinal tract. Klebsiella aerogenes has been implicated in sepsis and a severe form of necrotizing meningitis in neonates (Jane, 2015). Pseudomas aeruginosa is an opportunistic pathogen that infects cystic fibrosis patients.

It also invades tissues that have been burned and also causes urinary tract infections (Joanne, et al. 2017). E. coli is an inhabitant of the colon of humans and other warm-blooded animals and as such its presence in the samples suggests faecal contamination and the presence of other enteric pathogens. Some strains of E coli cause gastroenteritis or urinary tract infection. Shigella dysenteriae is a pathogen that causes a disease known as shigellosis, a diarrheal illness resulting from an acute inflammatory reaction of the intestinal tract. The presence of these pathogens in samples from Omambala

River poses a serious risk to the people that are using the river as their source of drinking water. Their presence in Omambala River could be through discharge of human faeces and animal wastes into the river, natural runoff after rainfall events, effluents from wastewater treatment facilities, agricultural and industrial effluents and several other human activities as seen in riverine areas.

There were few isolates in the dry season (Table 5) and this could be as a result of absence of rainfall and flooding during the dry season resulting in the depletion of water and nutrients required for the growth of microorganisms. The isolates occurred more frequently in wet season and this could be as a result of presence of nutrients in abundance due to the inflow of these nutrients during flooding and rainfall events into Omambala River. The frequency of occurrence of the isolates in percentage were as follow: *Pseudomonas aeruginosa* (25%), *Escherichia coli* (8%), *Shigella dysenteriae* (5%), *Bacillus cereus* (50%) and *Klebsiella aerogenes* (12%).

5. CONCLUSION

There were variations in the total bacterial count, total coliform count and total faecal coliform count in the water samples from Omambala river as a result of seasonal variations (the dry and wet season). The bacteriological quality of the water samples from the river for the wet and dry seasons was not acceptable since they all gave moderate to heavy bacterial growth especially the coliforms therefore the water from Omambala River is considered unfit to be used as a potable water if not well treated.

6. RECOMMENDATIONS

Controlling of some activities done in and around Omambala River such as discharge of domestic, agricultural and industrial wastes into the river will go a long way to reduce the level of contaminants in the river. Flood control by building water ways and the dredging of Omambala River will help to reduce the inflow of runoff water after rainfall events into the river.

Government and public-spirited individuals should come to the aid of the people living around the Omambala river by providing pipe-borne water for them. It is also recommended that the water from the river should be boiled, filtered or treated with chlorine before drinking.

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