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Evaluation of the Potability of Water Sources in Yakurr Local Government Area of Cross River State, Nigeria

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Evaluation of the Potability of Water Sources in Yakurr Local Government Area of Cross River State, Nigeria

Bassey E. Agbo, Francisca Adie, Atoyebi B. Abdulraheem, Daniel O. Etim & Grace O. Daniel

ABSTRACT

Studies on the bacteriological and physico-chemical characteristics of different water sources in Yakurr, Cross River State, Nigeria was carried out using American Public Health Association standard procedures for physico-chemical analyses of water and standard biochemical and microbiological protocol for the analysis of water for faecal and total coliform enumeration. Average temperature, pH, turbidity and conductivity of the samples ranged from 26.90±0.02°C-27.88±0.02°C; 5.00±0.02-6.38±0.03; 3.05±0.01NTU-30.41±0.01NTU and 29.01±0.01µs/cm-72.76±0.01µs/cm respectively. BOD_5, TDS and iron concentration ranged from 6.00±0.02mg/l-10.69±0.01mg/l; 18.24±0.01mg/l-43.63±0.03mg/l and 0.32±0.01mg/l-1.51±0.01mg/l respectively. Total coliform count of the sample from Kesekpang-Ekori had the highest value of 78.00±3.61cfu/100ml, followed by Sokol-Ugep and Mgbeke-Mkpani samples with values of 62.00±3.00cfu/100ml and 38.33±2.52cfu/100ml respectively. The sample from Nkinforna had the least coliform count of 10.00±2.00cfu/100ml. Sample from Ekori River had the highest THBC value of $2.13\pm0.31x10^6$cfu/ml, Kesekpang-Ekori and Sokol-Ugep samples had $1.10\pm0.17x10^6$cfu/ml and $1.03\pm0.06x10^6$cfu/ml respectively. Mgbeke-Mkpani sample had the least valve of $7.00\pm1.00x10^5$cfu/ml. A total of nine bacterial species were isolated, they were *Pseudomonas aeroginosa, Escherichia coli, Bacillus subtilis, Proteus vulgaris, Serratia maecesen, Staphylococcus aureus, Salmonella spp., Enterobacter cloacae* and *Micrococcus leteus*. The study had revealed a high level of poor quality sources of water in Yakurr and makes need for urgent health intervention by relevant body.

Keywords: Potability, water quality, bacteriological quality, physico-chemical characteristics and total coliform count

1. INTRODUCTION

All organisms requires water for life sustenance. Water is one of the most abundant commodities since it occupies about 70% of the earth's surface[1]. Water is the most essential product that is taken by humans which must be prevented from deterioration in quality. It is also essentials for life and life has evolved in water due to its unique chemical and physical properties[2]. Okorafor *et al,*[1] highlighted his point of view when they declared that "water functions in a variety of ways within a cell" can't be debated. Life originated from water, it is the matrix of life and it's also a solvent and medium. Water is also the medium by which diseases such as typhoid fever, dysentery and cholera can be spread from one human to another"[2, 3]. Treatment are performed to remove pathogenic micro-organism and also decrease turbidity, eliminate taste, odour, remove nuisance chemicals, such as manganese or iron and soften the water to make it more useful for consumption, laundry and other industrial processes[4]. Water is that unique substance that is made-up of hydrogen and oxygen elements, it exist in gaseous, liquid and solid states.

Water is the most abundant and essential of compounds. It's a liquid at room temperature, odourless and tasteless, it can dissolve many other substances, the versatility of water as a solvent is of great importance to living organisms[1, 5]. Good water quality for human consumption must therefore be potable or whole some which must be free from odour, colours and turbidity[1]. These physical characteristic of water are easily noticed by a consumer. A part from these physical qualities, chemical quality of the water also calls to mind since chemical analysis is indispensable for eliminating such dangers as the presence of poisonous metals, bad solvency, radioactive elements and other harmful substances. Therefore, all potable water must be free from harmful micro-organisms and must neither deteriorate in distributing system nor storage tanks. It must not also attack or corrode the distribution system[1, 2, 6].

The presence of excrete in water sheds can lead to contamination of both impounded and shallow ground waters-supplies. Water may also be contaminated directly by dumping of untreated or inadequately treated waste and effluent[7]. A variety of pathogenic microorganism may be locally shed and find their water into water supplies in sufficient numbers. Among the most commonly encountered are enteric bacilli such as *Salmonella* and *Shigella*, cholera *Vibrio*s, animal parasites, including *Ascaris, Entamoeba* and *Glardia* also Enteroviruses such as *Polio* viruses, *Consackle* viruses and *Eacho* viruses[1, 2].

There are several micro-organisms commonly found in human and other animal intestinal tracts that can be used as indicators of faecal pollution. Their presence in water supplies in sufficient numbers signals contamination of an intestinal source. The most of these indicator organisms are the coliforms[1, 8]. The fact is that contamination of water is hazardous to life cells whether it's for drinking, recreational, agricultural or industrial purpose. The suitability of water supply is determined by physical, chemical, biological that offers the most delicate test for detection of faecal pollution[1, 2, 9].

Water quality analysis is the standard procedure that aimed at the detection of specific pathogens in contaminated water. This is a possible task, however, it is often impracticable because of certain reasons. The researcher stands the risk of being infected by the pathogen, the number of pathogens present is generally so small in comparison with the normal intestinal bacteria that may be excreted into water sporadically. Therefore, the isolation of pathogens will involve examination of large volume of water may need the application of selective media and their identification may require varied and complex biochemical and serological test. In order to avoid the problems of delayed processes, it is significant that modern sanitary practices including bacteriological assessment of water quality, chlorination of potable water supplies, and adequate treatment and disposal of sewage have virtually eliminated large scale epidemic of enteric infections in developed nations[1, 2, 9, 10].

Water is an essential product that is consumed by humans, animals and plants alike, as such it must be kept safe and prevented from deterioration in quality. The potability of drinking water sources becomes even more important as water borne diseases spread through it. This research will evaluate the potability of drinking water sources in Yakurr Local Government Area of Cross River State, Nigeria having in mind the physical, chemical and microbiological parameters that plays a significant role in determining the potability of drinking water.

2. MATERIALS AND METHODS

2.1 Study Area

The water samples for the research work were collected from different sources in Yakurr local government area, Cross River State, Nigeria. Yakurr is located at the central senatorial district of Cross River State, Nigeria. Yakurr is made up of seven (7) villages which consists of a number of people. The main occupation of the people is farming, civil servant and a few are traders. The sampling sites are all located at various village settlements within Yakurr local government area. They make use of this water though not minding whether the water is potable for consumption or not. The five (5) water samples collected in Yakurr LGA, Cross River State, Nigeria were from Sokol Ugep stream, Nkinforna Assiga stream, Mgbeke Mkpani stream, Ekori River and Kesepang Ekori spring among others provide water for drinking and domestic use to members of the local communities. The water samples are not treated and hence may not meet up the WHO standard.

2.2 Sample Collection

i. **Sokol Ugep stream**: The water is owned by Ugep community and is located between Ugep and Ekori community of Yakurr LGA, Cross River State, Nigeria. The samples were collected at a point where the community take their bath, washing of clothes is done by the villagers and also use for domestic use by the villagers. In that cases the water is exposed to all kinds of contamination.

ii. **Mgbeke Mkpani stream:** The water is located between Ekori and Mkpani community and it is owned by Mkpani community. The samples were collected at a point where the villagers used to fetch their water for domestic use taking their bath and washing of clothes by the members of the community. The water is exposed and it is open in that reason it can readily be contaminated by their dirty hands, clothes or organisms from their body etc.

iii) **Nkinforna Assiga stream:** The water samples were collected at a point where the villagers normally fetch their water for domestic use. Also the point is used for washing of clothes and taking of bath by members of the local community with this, it is expected that the water can be contaminated by the dirty clothes or organisms from the body of those people who take their bath in the stream.

iv) **Ekori River:** This River is owned by Ekori community, it is located at a point where washing of clothes is done by villagers. The villagers do take their bath there, few cases of faecal contamination had been reported by the villagers .

v) **Kesepang Ekori:** This water is lined by bricks to obtain water from underground water. It is owned by Ekori village and is the main source of water for both drinking and domestic use for the village. The water is exposed to all source of contamination from the rope used to fetch the water by the villagers.

2.3 Physicochemical Analysis of Water Samples

2.3.1 Temperature

This was measured with the aid of a thermometer. The thermometer was inserted into the water sample in a beaker and the temperature reading was taken down[2, 11, 12, 13, 14].

2.3.2 pH

The pH values of the water samples were measured with a pH meter with model number: Mettler Toledo MP 220. The pH meter probe was inserted into the water sample in a beaker, the READ key was pressed and the pH reading was noted[2, 11, 12, 13, 14].

2.3.3 Turbidity
A turbidity meter of the model number: HANNA INSTRUMENT H193703 was used for this analysis. The water sample was placed in the turbidimeter bottle and the bottle wiped clean with a cloth to erase finger prints on the sample bottle that may affect the reading. The bottle was then placed on the turbidimeter and the READ key pressed, the turbidity reading was then displayed[2, 11, 12, 13].

2.3.4 Conductivity
Conductivity meter of the model number: HANNA INSTRUMENT H18733 was used for this analysis. The conductivity meter probe was first rinsed with distilled water and inserted into the water sample in a beaker, the conductivity reading was displayed [2, 11, 12, 13, 14].

2.3.5 Aluminium
Five millilitres (5ml) of the water sample was placed in a test tube and 1 micro-spoonful of Al-1A reagent was added and shaken to dissolve. 1.20ml of aluminium reagent Al-2A and 0.6ml of reagent Al-4A was added and mixed. The mixture was allowed for 2 minutes before reading out the aluminium concentration using the spectrophotometer [2, 11, 12, 13].

2.3.6 Ammonia
This was carried out using the colorimetric method. Ten millilitres (10ml) of the water sample was placed in a calibrated plastic cup, 2 drops of ammonia reagent 1 and 8 drops of ammonia reagent 2 (Nessler solution) were each added to the water sample and mixed well. After 5 minutes, the solution was poured into the colorimetry tube and the nearest colour match was used to determine ammonia concentration in the water sample [1, 2, 11, 13].

2.3.7 Calcium
Spectrophotometry method was used, 0.10ml of the sample was placed in a test tube using pipette and 0.50ml of calcium reagent Ca-1 was added and mixed properly. 0.40ml each of calcium reagent Ca-2 and Ca-3 were also added to the test tube and mixed well. The mixture was allowed for eight minutes to give full colour development and then filled into a reaction cell placed in the spectrophotometer where the calcium concentration was displayed [1, 2, 7, 11, 12, 13].

2.3.8 Ammonium
Spectrophotometry method was used for this analysis in which five millilitres (5ml) of the water sample was placed in a pre-labelled test tube and 0.60ml of ammonium reagent NH_4-1 was added using a syringe. 1 level micro-spoonful of ammonium reagent NH_4-2 was also added, shaken and allowed for 5 minutes. Ammonium concentration was determined at a wavelength of 520nm in the spectrophotometer [2, 15].

2.3.9 Copper
Five millilitres (5ml) of the water sample was placed in a reaction cell and 0.50ml of copper reagent Cu-1k was added to the water sample and mixed. Five minutes was allowed to elapse before copper concentration was read from the mixture [2, 7, 11, 13].

2.3.10 BOD
BOD meter (Model: HACH HQ40D) was used to determine this parameter. The meter probe was first of all rinsed with distilled water before it was inserted into the water sample. BOD reading was displayed on activation of the read key [2, 11, 12, 13, 14].

2.3.11 Chloride
Spectrophotometry method was also used for this analysis in which five millilitres (5ml) of the water sample was placed in a pre-labelled test tube and 2.50ml of chloride reagent Cl-1 was added to the water sample and mixed well. Chloride reagent Cl-2 was equally added, shaken and allowed for 1 minute before reading out the chloride concentration from the spectrophotometer at a wavelength of 460nm [2, 11, 12, 13].

2.3.12 Iron
Spectrophotometry method was used for this analysis: five millilitres (5ml) of the water sample was placed in a pre-labelled test tube and 0.30ml of iron reagent Fe-1 was added to the sample, shaken and allowed for 3 minutes. The iron concentration in the water sample was there after read at a wavelength of 420nm in the spectrophotometer [2, 7, 11, 12, 13].

2.3.13 Fluoride
Spectrophotometry method was also used for this analysis: five millilitres (5ml) of the water sample was placed in a reaction cell and 1 dose of fluoride reagent F-1K powder was added to it, shaken and the fluoride concentration read at a wavelength of 620nm using a spectrophotometer [2, 11, 12, 13].

2.3.14 Nitrogen
Spectrophotometry method was used, 5ml of the water sample was placed in test tube and 1 micro-spoonful of nitrite reagent NO_2-AN was added to it and shaken well to dissolve. Ten minutes was allowed to elapse before noting the nitrite concentration in the water sample. This reading gives nitrite value and to get the nitrogen value, the nitrite value is multiplied by a constant 0.3045. Therefore nitrogen is NO_2 x 0.3045 [2, 7, 12, 14].

2.3.15 Sulphate
Spectrophotometry method was used for the analysis in which two and a half millilitres (2.50ml) of the water sample was placed in a pre-labelled test tube and 0.20ml of sulphate reagent SO_4-1A added to it and mixed properly. One level spoonful of sulphate reagent SO_4-2A powder was also added and mixed well. The solution was kept in a water bath at 40^oC for five minutes, after which 2.50ml of sulphate reagent SO_4-3A was added, mixed well again and the solution filtered using Whatman No. 1 filter paper.

The filtrate was then mixed with 0.40ml of sulphate reagent SO_4-4A. The solution was again kept in a water bath for seven minutes at 40^oC. This was transferred to a round cell and placed in the spectrophotometer to read off the concentration of sulphate in the water sample at a wavelength of 520nm [2, 11, 12, 13].

2.3.16 Manganese
Multi-cell adapter with I-inch square cell holder was inserted in the electronic device after the “manganese” test was selected from a button. Then a square sample cell was filled with 10ml of the sample. Contents of one buffer powder pillow, citrate type of manganese stopper was added. Then contents of one sodium periodate powder pillow was added to the sample cell stopper and inverted to mix. The development of violet colour indicated the presence of manganese [2, 13, 16].

2.3.17 Phosphorus
A square sample cell was filled with 10ml of the water sample. The blank was inserted into the cell holder. The ZERO mark was pressed on the button, with the display showing 0.00 mg/l PO_4^{3-} The prepared sample was wiped and inserted into the cell holder with the fill line facing the user. Then results were taken in mg/l PO_4^{3-} [13, 14].

2.3.18 Zinc
Ten millilitres of the sample solution was poured into a square sample cell. With the use of a plastic dropper, 0.50ml of cyclohexanone was added to the solution in the graduated cylinder. Then OK was pressed on the timer. A thirty (30) second reaction period began, during the period the prepared sample in the cylinder was shaken vigorously. A colour change was observed, which depending on the zinc concentration could be reddish orange, brown or blue [2, 13, 16].

2.3.19 Sodium
Spectrophotometry method was used, 0.50ml of sodium reagent Na-1K was placed in a reaction cell and 0.50ml of the water sample added to it and mixed properly. One minute reaction time was allowed to elapse before reading the concentration of sodium from the spectrophotometer [2, 12, 13, 16].

2.3.20 Magnesium
Spectrophotometry method was used, 1ml of Magnesium reagent (Mg-1K) was mixed with 1ml of water sample and the mixture was placed in a reaction cell. The mixture was allowed to stand for 3 minutes and there after 0.30ml of Magnesium reagent (Mg-2K) was added, mixed and placed in the spectrophotometer. Magnesium concentration in the water sample was read at a wave length of 568 nm [2, 14].

2.4 Bacteriological Analysis of Water Samples
The media used for this analysis were all prepared according to manufacturer's direction and were sterilized in the autoclave at 121°C for fifteen minutes. Prepared media were then transferred into sterile Petri dishes (20 ml each) and allowed to cool before inoculation with the water samples. The stainless steel filtration unit and the glass wares used for the analyses were equally sterilized in the hot air oven at 150°C for one hour [2].

2.4.1 Inoculation Technique
The water samples were shaken very well to mix and 100ml measured out of it and filtered through membrane filter (0.45µm pore size). This filter allowed water to pass through but bacteria cells were retained on it. After filtration, the membrane filter was carefully removed with the aid of a sterile forceps and placed on the prepared molten agar. The plates were incubated for 24 hours at 37°C, emerging colonies after the period of incubation were enumerated using a colony counter [1, 2].

2.4.2 Serial Dilution
One millilitres (1ml) of the water samples were pipetted into nine (9ml) of sterile distilled water in a separate test tube. Logarithms dilution ranging from 10^{-1} to 10^{-3} was there after made for each of the water samples. 1ml of the desired aliquot was transferred into a sterile petri dishes and viable plate count determined using pour plate method. Faecal and total coliform counts were performed for each sample and were inoculated in the appropriate media (i.e. MF-C agar

and MacConkey agar). The plates were incubated at 37°C for 24 hours, and was observed for growth, the colony counter was used in counting the colonies, and those with 2-22 *cfu/ml* (colony forming unit) were counted [2, 17].

2.4.3 Maintenance of Pure Culture

The growth from the inoculated plates especially those from the MacConkey agar plates had mixed colonies (culture), this mix cultures were then isolated in their pure form. The bacterial representatives (i.e. from each colony) was picked and sub-cultured onto a fresh sterile nutrient agar medium. Purity of isolates was enhanced and obtained through repeated streaking on fresh plate. The colonies that was obtained now provides the pure culture of that isolates and they were maintained on nutrient agar slants as stock culture for further bacteriological analysis [2, 17].

2.4.4 Characterization of Bacterial Isolates

The pure bacterial isolates were characterized based on their cultural morphology and biochemical tests as reported by [a]Agbo *et al,*[2]; [b]Agbo *et al,*[7] and Cheesbrough[18]. The identification was carried out using the manual for identification of medical bacteria [2, 19]. The biochemical test parameters used for characterization and identification of bacterial isolates included; Grams reaction, oxidase test, coagulase test, catalase test, Voges Proskaurer test, sugar fermentation test, motility test, and methyl-red test.

2.5 Statistical Analysis

Replicate readings were managed using Microsoft Excel 2010. All the replicates readings for the various analyses were subjected to one way factor analysis of variance (ANOVA). Mean values with probability values less than 0.05 ($P<0.05$) were considered significant at 95% level of significance while those greater than 0.05 were not significant ($P>0.05$)[20]. Confidence interval was set as described previously by Uusippaikka [21], while analysis of variance was calculated as reported by Edet *et al.,* [20] and Nelson [22].

3. RESULTS

3.1 Total Heterotrophic Bacterial Load in Water Samples

The extent of the microbiological quality or contaminations were expressed in colony forming unit per millilitres. The results of the total heterotrophic loads in water samples from Yakurr LGA, Nigeria showed that the water sample from Ekori River had the highest total heterotrophic bacteria counts of $2.13\pm0.31x10^6 cfuml^{-1}$. Sample A from Sokol and sample E from Kesekpang Ekori had total heterotrophic bacterial loads of $1.03\pm0.06x10^6 cfuml^{-1}$ and $1.10\pm0.17x10^6 cfuml^{-1}$ respectively.

The results also revealed that sample C from Nkinforma had total heterotrophic bacterial load of $1.27\pm0.25x10^6 cfuml^{-1}$ while sample B from Mgbeke Mkpani had the least total heterotrophic bacteria counts of $7.00\pm1.00x10^5 cfuml^{-1}$. The results of the total heterotrophic bacterial loads are presented in table 1. Superscript represents significant analysis of variance of replicate readings for each sample across the rows ($p< 0.05$).

Table 1: Total Heterotrophic Bacteria Loads in Water Samples from Yakurr Local Government Area, Cross River State, Nigeria (x10^{5}cfuml^{-1})

Sample Code	Mean± SD
SA	10.33 ± 0.58^a
SB	7.00 ± 1.00
SC	12.67 ± 2.52
SD	21. 33± 3.06
SE	11.00±1.73

Superscript represents significant analysis of variance of replicate readings for each sample across the rows ($p < 0.05$)

Key: SA – Sokol water sample SB – Mgbeke Mkpani water sample
SC – Nkinforma water sample SD – Ekori River water sample
SE – Kesekpang Ekori water sample

3.2 Total Fungal Load in various Water Samples

Water sample A from Sokol Ugep had the highest total fungal load of 1.30±0.26x10^{5}cfuml^{-1} while sample E from Kesekpang Ekori had the least total fungal load of 4.67±2.52x10^{4}cfuml^{-1}. Sample C from Nkinforna and sample D from Ekori River had total fungal load of 6.67±2.08x10^{4}cfuml^{-1} and 6.33±1.53x10^{4}cfuml^{-1} respectively, while sample B from Mgbeke Mkpani had total fungal load of 5.33±1.53x10^{4}cfuml^{-1}. The results for the total fungal loads in various water samples from Yakurr LGA are presented in table 2. Superscript represents significant analysis of variance of replicate readings for each sample across the rows ($p < 0.05$).

Table 2: Total fungal loads on water samples from Yakurr Local Government Area, Cross River State, Nigeria (x10^{4}cfuml^{-1})

Sample Code	Mean± SD
SA	13.00 ± 2.65^a
SB	5.33 ± 1.53
SC	6.67 ± 2.08
SD	6. 33± 1.53
SE	4.67±2.52

Superscript represents significant analysis of variance of replicate readings for each sample across the rows ($p < 0.05$)

Key: SA – Sokol SB – MgbekeMkpani SC - Nkinforna
SD – Ekori River SE – Kesekpang Ekori

3.3 Total Coliform Counts in various Water Samples

Sample E from Kesekpang Ekori had the highest total coliform counts of 78.00±3.61cfu100ml^{-1}which was closely followed by that from Sokol ugep (sample A) with total coliform count of 62.00±3.00cfu100ml^{-1}, while sample C from Nkinforna had the least total coliform counts of 10.00±2.00cfu per 100ml. Sample B from Mgbeke Mkpani and sample D from Ekori River had a total coliform counts of 38.33±2.52cfu per 100ml and 17.00±2.00cfu per 100ml respectively. The results for the total coliform counts in water samples from Yakurr LGA are presented in table 3. There was a significance difference across the rows ($p<0.05$).

Table 3: Total coliform counts in water sample from Yakurr Local Government Area, Cross River State, Nigeria (Per 100ml)

Sample Code	Mean± SD
SA	62.00 ± 3.00[a]
SB	38.33 ± 2.52
SC	10.00 ± 2.00
SD	17. 00+ 2.00
SE	78.00±3.61

Superscript represents significant analysis of variance of replicate readings for each sample across the rows ($P < 0.05$).

Key: SA-Sokol Ugep SB – Mgbeke Mkpani SC - Nkinforma
SD – Ekori River SE – Kesekpang Ekori

3.4 Biochemical Characteristics of Isolates

The biochemical characteristics of bacterial isolates in water samples from Yakurr Local Government Area, Cross River State, Nigeria showed that a total of nine (9) bacterial isolates contaminated their water sources. These isolates were *Pseudomonas aeroginosa, Escherichia coli, Bacillus subtilis, Proteus vulgaris, Serratia maecesen, Staphylococcus aureus, Salmonella spp., Enterobacter cloacae* and *Micrococcus leteus*. The results for the biochemical characteristics of bacterial isolates in water samples from Yakurr Local Government Area are presented in table 4.

3.5 Cultural and Morphological Characteristics of Fungal Isolates in Water Samples from Yakurr, Nigeria

Wet mount techniques was employed in the identification of fungal isolates, having carefully compared the macroscopic and microscopic features with a mycology standard Manuel for identification of fungal isolates as shown in table 5. The fungal isolates encountered in the course of the research were: *Penicillium* sp., *Mucor* sp., *Aspergillus* sp., *Rhizopus* sp. and *Fusarium* sp.

Table 4: Biochemical Characteristics of Bacterial Isolates in Water Samples from Yakurr LGA, Cross River State, Nigeria

Sample code	Isolate No	Cultural Characteristics	Shape	Gram	Motility	Indole	Citrate	Catalase	Oxidase	Coagulase	Urease	Methyl red	Vogues	Lactose	Sucrose	Glucose	Gas	Hydrogen	Probable organism
SA	1	Raised, smooth, circular and greenish pigmented	Curved rod	-	+	-	+	+	+	-	-	+	-	-	-	-	-	-	*Pseudomonas aeroginosa*
	2	Mucoid, opaque, circular, convex and smooth colony	Short rod	-	+	+	-	+	-	-	-	+	-	+	+	+	+	-	*Escherichia coli*
	3	Large, irregular, dry flat colony	Bacilli rod	+	+	-	+	+	+	-	-	-	+	-	-	+	-	+	*Bacillus subtilis*
SB	1	Swarming, flat, smooth and moist	Small tiny rod	+	+	-	+	+	-	-	+	+	-	+	+	+	-	+	*Proteus vulgaris*
	2	Circular, spreading, raised and red pigmented colony	Rod, some in chain	-	+	-	+	-	-	-	-	-	+	-	-	+	-	-	*Seratiamarcesen*
	3	Mucoid, circular, convex and smooth colony	Short rod	-	+	+	-	+	-	-	-	+	-	+	+	+	+	-	*Escherichia coli*
SC	1	Translucent, smooth, raised circular colony	Cocci in cluster	+	-	-	-	+	-	+	-	-	+	-	-	+	-	-	*Staphylococcus aureus*
	2	Raised, pink with black centre	Capsulated rod	-	+	-	+	+	-	-	+	+	-	-	-	+	-	+	*Salmonella spp*
	3	Smooth, grey pigmented and moist colony	Single rod	-	+	-	+	+	-	-	-	-	+	+	+	+	+	-	*Enterobactercloacae*
SD	1	Mucoid, opaque, circular, smooth colony	Short rod	-	+	+	-	+	-	-	-	+	-	+	+	+	+	-	*Escherichia coli*
	2	Rod, circular spreading colony	Rod	-	+	-	+	-	-	-	-	-	+	-	-	+	-	-	*Seratiamarcesen*
	3	Raised, smooth, circular, greenish colony	Curved rod	-	+	-	+	+	+	-	-	+	-	-	-	-	-	-	*Pseudomonas aeroginosa*
	4	Bright yellow, moist and smooth colony	Cocci in pairs	+	-	-	+	+	+	-	-	+	-	-	-	+	-	-	*Micrococcus leutus*

Table 5: Cultural and morphological characteristics of fungal isolates

Sample Code	Isolate Number	Colour of Aerialhyphae	Colour of Substrate Hyphae	Nature of Hyphae	Spore Shape	Probable Organisms
SA	1	Green	Brown	Senate	Round Sporangium	*Penicillin*
	2	Dark	White	Aseptate	Round Sporangium	*gabrium*
						Mucor indicus
SB	1	Green	Brown	Senate	Round Sporangium	*Penicillin*
	2	Yellow	Dark	Sepate	Oval Conidia	*sporangium*
	3	Dark	Brown	Aseplate	RomdSporagium	
			White			*Asporgillus niger*
						Mucor indicus
SC	1	Dark	White	Aseplate	Romd Sporangium	*Muco*
	2	Shades of White	Dark	Non-seplate	Romd Sporangium	*rindicus*
						Rlizonus spp
SD	1	Yellow	Dark	Seplate	Oval Conidia	*Asporgillus*
	2	Green	Brown	Seplate	Round Sporangium	*niger*

	3	White	Brown Dark	Non-seplate	Round Sporangium	*Penicillium indicus Rlizopus spp*
SE	1	Pink	Dark	Sentate	Concave	*Fusarium spp*
	2	Green	Brown Brown	Sentate	Round Sporangium	*Aspergillus niger*

Key: SA - SokolUgep SB - MgbekeMkpani SC - Nkinforma SD - Ekori River SE - KesekpangEkori spp – Species

3.6 Physico-chemical Properties of Various Water Samples

The physico-chemical properties of the different water samples from Yakurr Local government Area, Cross River State, Nigeria are as shown in table 6. The result revealed that the water sample from Kesekpong Ekori had the lowest pH and turbidity value of 5.00±0.02 and 3.05±0.01NTU. Sample A from Solok Ugep had the highest electrical conductivity value of 72.76±0.01µs/cm while sample D from Ekori River had the least electrical conductivity value of 29.01±0.01µs/cm.

Of all the water samples collected, sample A from Solok Ugep had the highest BOD_5 value of 10.00±0.01mg/l while sample E from Kesekpong Ekori had the least BOD_5 value of 6.59±0.03mg/l. Sample A also had the highest magnesium content with value of 18.08±0.02mg/l while sample C had the least magnesium content with value of 9.91±0.03. The full results of the Physico-chemical properties of water samples from Yakurr Local Government Area, Cross River State, Nigeria are presented in table 6. Similar superscript represents significant analysis of variance of replicate readings for each sample across the columns for each sampling station ($p < 0.05$).

Table 6: Physicochemical Properties of Water Samples from Yakurr Local Government Area of Cross River State, Nigeria

S/No	Parameters	Units	NIS Guidelines	Solok Ugep (A)	Mgbeke Mkpani (B)	Nkin Fornaassi (C)	Ekori River (D)	Kesekpong El (E)
1	Temperature	°C	Ambient	27.88±0.02[a]	27.00±0.02[a]	26.90±0.02[a]	27.01±0.01[a]	27.11±0.01
2	pH		6.5-8.5	6.38±0.03	6.01±0.01	5.69±0.02	5.50±0.01	5.00±0.02
3	Turbidity	NTU	5.0	10.18±0.03	5.54±0.02	4.51±0.02	30.41±0.01	3.05±0.01
4	Electrical conductivity	µS/cm	500	72.76±0.01	38.84±0.02	35.87±0.03	29.01±0.01	39.45±0.0
5	Total dissolved solids (TDS)	mg/l	1000	43.63±0.03	23.29±0.04	21.51±0.01	18.24±0.01	21.86±0.0
6	Aluminium	mg/l	0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
7	Ammonia NH_3-N	mg/l	0.05	0.25±0.02	0.21±0.01	0.24±0.01	0.34±0.01	0.20±0.01
8	Nickel	mg/l	0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.24±0.01	0.00±0.00
9	Calcium Ca	mg/l	50	10.08±0.03	7.00±0.03	7.20±0.02	6.01±0.02	6.59±0.03
10	Zinc	mg/l	5.0	0.19±0.02	0.30±0.02	0.10±0.01	0.24±0.01	0.14±0.01
11	Salinity	Ppm	4000	30.04±0.01	19.66±0.02	17.25±0.01	13.94±0.02	19.01±0.0
12	Chromium	mg/l	0.01	0.06±0.01	0.01±0.01	0.03±0.01	0.02±0.01	0.01±0.01
13	Ammonium NH_4-N	mg/l	-	0.29±0.01	0.21±0.01	0.26±0.01	0.35±0.01	0.21±0.01
14	Copper	mg/l	1.0	0.06±0.01	0.00±0.00	0.11±0.01	0.00±0.00	0.00±0.00
15	BOD	mg/l	14	10.00±0.01	7.99±0.04	8.60±0.02	10.69±0.01	6.00±0.02
16	Total Chlorine	mg/l	0.5	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
17	Free Chlorine	mg/l	0.2	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
18	Total Hardness	mg/l	100	34.19±0.03	17.05±0.05	17.11±0.01	17.11±0.01	17.10±0.0
19	Iron Fe	mg/l	0.3	1.51±0.01	1.00±0.01	0.55±0.01	0.67±0.01	0.32±0.01
20	Phosphorus P	mg/l	-	5.39±0.03	3.20±0.02	3.10±0.02	5.00±0.02	3.51±0.01
21	Phosphate PO_4	mg/l	250	13.69±0.02	7.47±0.03	7.01±0.02	15.70±0.02	7.90±0.02
22	Manganese	mg/l	0.5	0.11±0.01	0.08±0.01	0.09±0.01	0.15±0.01	0.09±0.01
23	Magnesium-Mg	mg/l	20	18.08±0.02	10.07±0.02	9.91±0.03	11.06±0.06	11.50±0.0
24	Nitrogen – N	mg/l	0.5	0.21±0.01	0.16±0.01	0.20±0.01	0.27±0.01	0.18±0.01
25	Sulfide	mg/l	0.1	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

4. DISCUSSION

Water sources used for drinking and domestic use in Yakurr Local Government Area in Cross River State, Nigeria was found to be surface water which are the river and streams and underground source such as borehole. Out of five (5) water sources sampled in the LGA, three were fit for consumption and that was Mgbeke Mkpani, Kesekpang Ekori and Nkinforna Assiga. The other two sources of water were found to be bacteriological unfit for human consumption because they contain indicator organisms. The indicator organisms are made up of coliforms in which *Escherichia coli* was found in large numbers per 100ml of the water sample analyzed. Okorafor *et al,*[1] and [a]Agbo *et al,*[2] in a similar research in Calabar, detected no coliform in the drinking water sources they sampled.The levels of indicator bacteria per 100ml of water were more than the established standards[23]. From the coliform count there was evidence of faecal contamination. The total viable count for sample A Sokol Ugep was$1.03\pm0.06x10^6 cfuml^{-1}$ this can be attributed to the villagers constant washing of their clothes and bedding in the stream.

The physical and environmental condition of this quality of water contributed to their non-sanitary conditions. Out of the entire organisms isolated from these sources, *Escherichia coli* and *Bacillus sp* were predominant. Isolates from this research were similar to that isolated by Okorafor *et al,*[1] and [a]Agbo *et al,*[2]. Bacteria are found everywhere in nature except within the

tissues of healthy animals and plants and in the deep layers of the earth. The total coliform count for sample B which was Mgbeke Mkpani was 38.33±2.52cfu/100ml of water. This is to shows that fetching of water by many people is accomplished by introduction of coliforms. The total viable count of coliform for sample C which was Nkinforna was 10.00±2.00cfu per 100ml. This could be attributed to the activities of the villagers while fetching water from the stream. During the study it was noticed that some of them used dirty buckers to fetch the water. These contributed to high number of microbial loads.

The total viable coliform count for sample D which was Ekori River was 17.00 ± 2.00cfu per 100ml. This could be attributed to the activities of the communities while fetching water with their dirty hand etc. The presence and high number of faecal coliforms in most of the water samples analysed showed that there were faecally contaminated, this agreed with the findings of Okorafor *et al*,[1]. Total viable count for coliform for sample E which was Kesekpang Ekori was 78.00 ± 3.36/100ml. This have the highest total coliform count because the community members used to wash their clothes and fetch water with their dirty vessels, the coliform count for this particular stream shows that a correlation with of the total viable count against the recovering of coliforms including *Escherichia coli* shown that the contamination was due to a recent factor.

It was very clear that the degree of microbiological contamination of Sokol Ugep, Ekori River are higher than that recommended by World Health Organization standard [8]. The correlation between the general microbial count and the total coliform count shows that the same factors control both parameters. This report was consistent with the finding of Antai & Anozie[24]. The transmission through contaminated water supply is by far most serious of infection and was responsible for the more serious enteric disease particularly cholera and typhoid fever. From this research study, drinking water obtained from Sokol Ugep and Ekori River are unfit for drinking due to non-sanitary conditions, and incidence of disease can be evidence of the water contamination.

The pH of the water samples showed that the pH of Nkin Fornaassi stream water sample and Ekori River water sample was below that of the WHO standard. This findings is in variance with that of [a]Agbo *et al*,[2] but agrees with the findings of Okorafor *et al*,[1]. The turbidity of Ekori River water sample was far above the WHO standard and NIS guideline, this result is contrary to that of Okorafor *et al*,[1] and [a]Agbo *et al*,[2] while Aluminium was not detected in all the water samples. The Manganese concentration of all the water samples was far below that of the NIS standard which was a good one while the Magnesium concentration of Sokol Ugep was slightly close to that of the NIS standard.

For all the five sources analyzed, none have received any treatment. It is surprising that none of the water sources analyzed met the chemical standard recommended by World Health Organization for drinking purposes[23]. Biochemical characteristics of isolate from the research study revealed that there were ten (10) Gram-negative rods and five (5) Gram-positive rods. Most of the physico-chemical parameters had values which conform to the WHO standard for drinking water [9, 23]. However, the high concentration of some parameters such as manganese, iron, lead and turbidity depict possible pollution.

6. RECOMMENDATIONS

- To drastically reduce health problems associated with water pollution by waste and fecal materials in Yakurr Local Government Area, Cross River State, Nigeria. It is necessary to educate the villagers about the desirable quality of potable water and faecal matter into the river and streams.
- The villagers should be prevented from turning the water ways into toilet.
- Water fetched from these contaminated sources, should be treated by boiling and filter it before being use for domestic consumption.
- Government should help and make pipe borne water available which is practically treated before distributions and use.
- Routine assessment and bacteriological examination of water sources show be carried out to ascertain the extent of contamination with the aim of eliminating the contaminants.

6. CONCLUSION

The evaluation of drinking water quality in Yakurr, Cross River State, Nigeria has enable one to estimate the poor quality of water present in the communities found in the local government area. However, some of the water samples are bacteriological fit for drinking and other domestic use. The use of bacterial indicators of faecal pollution are the coliforms groups as a whole and particularly *E. coli*. The result clearly showed that samples from three (3) sources were of W.H.O standards while other sources were unsuitable for human consumption as well as for domestic use.

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