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Impact of Effluent Discharge and Seasonal Variations on the Quality of Ekemazu Stream in Delta State, Nigeria

Hilda. A. Emmanuel-Akerele[1*]

[1]Department of Biological Sciences, Anchor University Lagos
Email: akatahhilda@gmail.com

Abstract - *The impact of effluent discharge and seasonal variations on the quality of Ekemazu was determined. Total heterotrophic bacterial counts and most probable number was determined using standard microbiological procedures. The total heterotrophic bacteria counts in the upstream samples analyzed across the seasons varied between 4.8 ± 0.4 x 10^2 cfu/ml and 8.7 ± 0.1 x 10^2 cfu/ml, 36.0 ± 1.0 x 10^2 cfu/ml and 98.0 ± 1.0 x 10^2 cfu/ml in the effluent discharge point, 53.0 ± 6.0 x 10^2 cfu/ml and 85.0 ± 3.0 x 10^2 cfu/ml in the domestic activities point and 46.0 ± 4.0 x 10^2 cfu/ml and 78.0 ± 2.0 x 10^2 cfu/ml in the downstream. The total coliform counts ranged between 11.3 ± 0.9 MPN/100 ml and 19.0 ± 1.0 MPN/100 ml in the upstream, 20.0 ± 0 MPN/100 ml and 37.5 ± 2.5 MPN/100 ml in the effluent discharge point, 18.0 ± 0 MPN/100 ml and 35.0 ± 0 MPN/100 ml in the domestic activities point and 17.0 ± 0 MPN/100 ml and 22.5 ± 2.5 MPN/100 ml in the downstream. The faecal coliform counts in the upstream ranged between 6.0 ± 0 MPN/100 ml and 8.0 ± 1.0 MPN/100 ml, 9.0 ± 1.0 MPN/100 ml and 13.0 ± 1.0 MPN/100 ml in the effluent discharge point, 9.0 ± 0 MPN/100 ml and 11.5 ± 0.5 MPN/100 ml in the domestic activities point, 8.0 ± 0 MPN/100 ml and 10.0 ± 0.8 MPN/100 ml in the downstream. Organisms identified were Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Proteus mirabilis, Aeromonas hydrophilia, Klebsiella pneumoniae and Enterococcus faecalis. Antimicrobial susceptibility test of isolates showed that the organisms were 14% sensitive to Meropenem, Levofloxacin, Amoxicillin, Tetracycline, Ciprofloxacin, Erythromycin and Gentamicin, 29% sensitive to Septrin and Chloramphenicol 43% sensitive to Amikacin, Ampicillin, and Gentamicin, This research clearly showed that bacterial load of the stream is higher than the WHO acceptable limit and the isolates are multidrug resistant.*

Keywords *– Antibiotics, Effluent, Microbiological, Stream, Pollution*
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1. Introduction

Water is one of the most fundamental elements which make man and the entire ecosystem exist on this planet earth (Duru, 2014). Water is a vital component of the development of an area and as such, human settlement is to a large extent dependent on the availability of reliable sources of water preferably in close proximity to the settled localities (Edet *et al.,* 2012). The availability of drinking water is an indispensable feature for preventing epidemic diseases and improving the quality of life (Musyoki *et al.,* 2013).

Water also plays very important role in many industries such as power plant, food and cosmetics industries, as well as Pharmaceutical industries, hence, its quality is very crucial (Owa, 2014). However, these industries and some human activities heighten surface water's exposure to various kinds of pollution with deleterious chemicals and pathogenic microorganisms (Adeyinka *et al*., 2014). As such, most rural villages in developing countries have poor access to safe clean water supply. Chemicals which cause stream pollution from industries are ammonia, phosphate, hydrocarbon compounds, herbicides and pesticides (Asuquo & Etim, 2012). Micro-organisms which cause stream pollution from domestic and industrial activities are mostly coliform bacteria such as *Escherichia coli, Shigella* and *Salmonella species;* Viruses such as *Hepatitis* A *virus;* Protozoans such as *Entamoeba hystolytica,* and helminthes such as *Ascaris lumbricoides* etc (Owa, 2014).

Polluted water bodies pose a very great health risk to people using such water for drinking, bathing, irrigation of crops which are eaten raw, fishing and recreational activities (Adeyinka *et al.,* 2014). A study by Akubuenyi *et al.,*(2013) on microbiological and physicochemical assessment of major sources of water for domestic uses in Calabar metropolis, showed that the genera of *Bacillus, Pseudomonas, Proteus, Enterobacter, Shigella, Vibrio, Streptococcus, Salmonella, Staphylococcus aureus and*

Escherichia coli were isolated from Uwanse stream, Anatigha stream, Idim-Ita stream, Edibe-Edibe stream and Atimbo river. Another study by Musyoki *et al.,* (2013) *on* water-borne bacterial pathogens in surface waters of Nairobi river and health implication to communities downstream Athi River showed that *Escherichia coli, Klebsiella aerogenes, Enterococus faecalis, Salmonella typhi, Salmonella paratyphi, Pseudomonas aeruginosa, Vibrio cholerae, Vibrio parahaemolyticus, Proteus mirabilis and Shigella flexneri* were isolated.

Treatment of infectious diseases is challenging when drug – resistant isolates are involved. The worldwide escalation in both community and hospital-acquired antimicrobial resistant bacteria is threatening the ability to effectively treat patients, emphasizing the need for continued surveillance, more appropriate antimicrobial prescription, prudent infection control, and new treatment alternatives (Olaolu *et al.,* 2004). Epidemiologic surveillance of antimicrobial resistance is indispensable for empirically treating infections, implementing resistance control measures and preventing the spread of antimicrobial-resistant microorganisms (Olaolu *et al.,* 2004).

Ekemazu stream located precisely in Independent Power Plant camp in Okpai Oluchi, Ndokwa East local government area of Delta state in this research serves as the major source of water for domestic purposes, fishing and recreational activities for the residents in the area is heavily polluted by the Power Plant located along the course of the stream with domestic wastes from the power plant residential lodge and from the local community residents, living near the stream. Water for different purposes has its own requirements of composition and purity hence each body of water has to be analysed regularly in order to monitor its quality and ascertain if it is safe to use for domestic and/or industrial purposes (Duru, 2014). The aim of this study was to assess the effects of effluent discharge on the quality of the stream during the different seasons of the year and to determine the susceptibility of the microbial isolates from the water body to antibiotics.

2. Materials and Methods

2.1 Period of Study

This research was conducted between the months of September, 2014 and June, 2015. The choice of the months of the year is to examine the effect of the peak of the flood season, setting in of the dry season, peak of the dry season, and the raining season on the bacteriological and physicochemical properties of the stream.

2.2 Study Area

The study area was a section of Ekemazu stream located in Independent Power Plant Camp near Okpai Oluchi, Delta State Nigeria. The Ekemazu stream is the source of water for domestic purposes, for the residents as well as fishing. It receives effluent from Power Plant which contains compounds of ammonia, phosphate, sodium hypochlorite, hydrazine, and dissolved salts from the water and steam treatment process. The polluted water body also contains domestic wastes from the power plant residential lodge and from the local community residents, living near the stream.

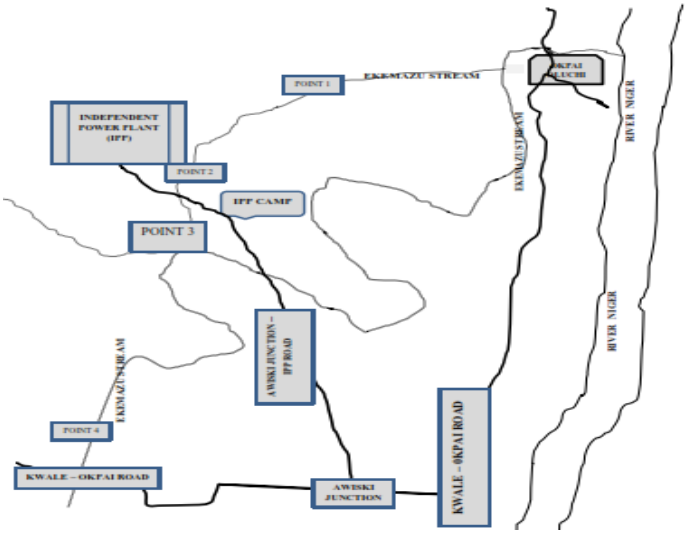


Figure 1. Map showing the various sampling points

2.3 Sample Collection, Transportation and Storage

The water samples were collected from four sampling points along the stream in duplicates with sterile containers and designated with numbers 1 to 4. A retort stand clamp mounted on a stick was used to hold the neck of the sampling container tight and the cover of the container aseptically removed with the mouth of the bottle faced upstream. Then, the neck was dipped downwards about 30cm below the water surface till the container was completely filled and the cover carefully replaced (Ashraf *et al.,* 2010). The samples were collected once in each month of the study period.

Sampling point 1: Upstream (before effluent discharge and human activities point)

Sampling point 2: Midstream A (Effluent discharge point)

Sampling point 3: Midstream B (About 1500metres from effluent discharge point): Bathing and domestic activities point

Sampling point 4: Downstream (about 1000metres away from sampling point 3)

The samples were transported to the laboratory in ice bag for microbiological analysis.

2.4 Bacteriological Analysis

2.4.1 Total heterotrophic bacterial counts

Total heterotrophic bacterial counts were determined using nutrient agar by pour plate method. Aliquot of 1ml of 10^{-1} and 10^{-2} dilutions of the samples were used to inoculate the plates in duplicates, and incubated at 37^{0}C for 48 hours. The mean counts of bacterial colonies were determined and recorded as cfu/ml. The distinct colonies

formed were inoculated on macConkey agar then on nutrient agar for purity and finally on nutrient agar slants and stored for Gram stain and biochemical tests (Cheesbrough, 2006)

2.4.2 Total and faecal coliform counts

The most probable number (MPN) techniques using 50 ml (1 tube), 10 ml (5 tubes) and 1 ml (5 tubes) of sample and MacConkey broth was employed. The water samples were thoroughly mixed by inverting the bottles several times and 50 ml, 10 ml and 1 ml of each of the samples were added with sterile pipette into sterile MacConkey broth containing 50 ml (1tube), 10 ml (5 tubes), and 1 ml (5 tubes) respectively and inverted Durham tube for collection of gas. The tubes were incubated at 35^{O}C for 24 hours. Positive tubes producing acid and gas were used in estimating the presumptive MPN/100 ml (APHA, 1999, and Cheesbrough, 2006).

Confirmed test for total coliform was carried out by plating a loopful of positive MacConkey broth on Eosine Methylene blue (EMB) agar and incubated at 35^{O}C for 24 hours, while faecal coliform test was carried out by transferring a loopful of broth from a positive tube to EC broth followed by incubation at 44.5^{O}C for 48 hours. The tubes were observed for gas formation.

Completed test for faecal coliform was performed by plating a loopful of broth from a positive tube into an Eosine Methylene Blue (EMB) agar plate, and incubated at 44^{O}C for 48 hours.

The distinct colonies formed were inoculated on nutrient agar slants and stored for Gram stain and biochemical tests (Cheesbrough, 2006).

2.4.3 Characterization and identification of the isolates.

The isolates were identified using colonial and morphological appearance by Gram stain. They were further identified using catalase, oxidase, indole production, citrate utilization, motility, urea degradation and lactose fermentation tests (Cheesbrough, 2006).

2.5 Antimicrobial Susceptibility Testing

Susceptibility tests were performed by Bauer-Kirby disc diffusion by using Nutrient Agar. The results were expressed as susceptible or resistant according to criteria of Clinical Laboratory Standards Institute (CLSI, 2018). The discs used were Amikacin (30 µg), Meropenem (10 µg), Levoflovacin (5 µg), Amoxicillin (25 µg), Septrin (25 µg), Tetracycline (25 µg), Ampicillin (25 µg), Ampiclox (10 µg), Chloramphenicol (25 µg), Ciprofloxacin (10 µg), Erythromycin (10 µg) and Gentamicin (10 µg).

2.6. Statistical Analysis

Independent sample t test was used to find the difference between the bacteriological parameters of the upstream samples and the values obtained in the effluent discharge point, domestic activities point and the downstream samples in all the seasons.

3. Results

3.1 Bacteriological Parameters

The total heterotrophic bacteria counts in the upstream samples analyzed across the seasons varied between 4.8 ± 0.4 x 10^2 cfu/ml and 8.7 ± 0.1 x 10^2 cfu/ml, 36.0 ± 1.0 x 10^2 cfu/ml and 98.0 ± 1.0 x 10^2 cfu/ml in the effluent discharge point, 53.0 ± 6.0 x 10^2 cfu/ml and 85.0 ± 3.0 x 10^2 cfu/ml in the domestic activities point and 46.0 ± 4.0 x 10^2 cfu/ml and 78.0 ± 2.0 x 10^2 cfu/ml in the downstream (Table 1). From the results, it is deduced that heterotrophic bacteria counts obtained in effluent discharge point is higher than the value obtained in the upstream by 1026.4% at the peak of the flood season, 1153.5% at the setting in of flood season, 754.2% at the peak of dry season, 918.2% at the setting in of raining season and 592.3% at the peak of raining season (Fig 2). Also the heterotrophic bacteria counts obtained in domestic activities point is higher than the value obtained in the upstream by 877.0% at the peak of the flood season, 956.3% at the setting in of flood season, 1004.2% at the peak of dry season, 1009.1% at the setting in of raining season and 1007.7% at the peak of raining season (Fig 2). At the downstream, the heterotrophic bacteria counts obtained is higher than the value obtained in the upstream by 796.6% at the peak of the flood season, 857.8% at the setting in of flood season, 858.3% at the peak of dry season, 936.4% at the setting in of raining season and 869.2% at the peak of raining season (Fig 2).

The total coliform counts in the upstream ranged between 11.3 ± 0.9 MPN/100 ml and 19.0 ± 1.0 MPN/100 ml, 20.0 ± 0 MPN/100 ml and 37.5 ± 2.5 MPN/100 ml in the effluent discharge point, 18.0 ± 1 MPN/100 ml and 35.0 ± 0 MPN/100 ml in the domestic activities point and 17.0 ± 0 MPN/100 ml and 22.5 ± 2.5 MPN/100 ml in the downstream (Table 2). The faecal coliform counts in the upstream ranged between 6.0 ± 0 MPN/100 ml and 8.0 ± 1.0 MPN/100 ml, 9.0 ± 1.0 MPN/100 ml and 13.0 ± 1.0 MPN/100 ml in the effluent discharge point, 9.0 ± 0 MPN/100 ml and 11.5 ± 0.5 MPN/100 ml in the domestic activities point, 8.0 ± 0 MPN/100 ml and 10.0 ± 0.8 MPN/100 ml in the downstream (Table 3). The total coliform counts obtained in effluent discharge point is higher than the value obtained in the upstream by 97.4% at the peak of the flood season, 114.3% at the setting in of flood season, 136.3% at the peak of dry season, 53.8% at the setting in of raining season and 52.8% at the peak of raining season (Fig. 3).

The total coliform counts obtained in domestic activities point is higher than the value obtained in the upstream by 84.2% at the peak of the flood season, 78.6% at the setting in of flood season, 92% at the peak of dry season, 38.5% at the setting in of raining season and 25% at the peak of raining season (Fig. 3). The total coliform counts obtained in downstream point is higher than the value obtained in the upstream by 18.4% at the peak of the flood season, 42.9% at the setting in of flood season, 62% at the peak of dry season, 30.8% at the setting in of raining season

and 5.6% at the peak of raining season (Fig. 3). The faecal coliform counts obtained in effluent discharge point is higher than the value obtained in the upstream by 18.8% at the peak of the flood season, 66.7% at the setting in of flood season, 74.6% at the peak of dry season, 12.5% at the setting in of raining season and 62.5% at the peak of raining season (Fig. 3). The faecal coliform counts obtained in domestic activities point is higher than the value obtained in the upstream by 12.5% at the peak of the flood season, 50% at the setting in of flood season, 64.2% at the peak of dry season, 12.5% at the setting in of raining season and 43.8% at the peak of raining season (Fig. 3). The faecal coliform counts obtained in downstream point is higher than the value obtained in the upstream by 12.5% at the peak of the flood season, 33.3% at the setting in of flood season, 49.3% at the peak of dry season, 25% at the setting in of raining season and 12.5% at the peak of raining season (Fig. 3).

Seven bacteria species were identified namely; *Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Proteus mirabilis, Aeromonas hydrophilia, Klebsiella pneumoniae and Enterococcus faecalis* (Fig. 4). *Escherichia coli* occurred 100% in all the samples during the period of the research (Table 2). *Pseudomonas aeruginosa* occurred about 90% in upstream and effluent discharge point samples and occurred 100% in bathing/domestic activities sampling point and downstream sampling point in all the seasons (Fig. 4). *Bacillus subtilis* occurred about 90% in upstream and downstream samples, while at the effluent discharge point and bathing /domestic activities sampling points, it occurred 100% (Fig 4). *Proteus mirabilis* and *Aeromonas hydrophilia* had equal occurrence of about 90% in upstream, effluent discharge point and downstream sampling points while in bathing/domestic activities sampling point they occurred 100% in all the seasons during the research (Fig. 4). *Enterococcus faecalis* occurred 90% in the upstream sample and 100% in other three samples throughout the seasons during the period of the research (Fig. 4).

The results of the antimicrobial susceptibility test of isolates from the upstream samples showed that these organisms were 0% sensitivity to Ampiclox, 14% sensitive to Meropenem, Levoflovacin, Amoxicillin, Tetracycline, Ciprofloxacin, Erythromycin and Gentamicin, 29% sensitive to Septrin and Chloramphenicol, 43% sensitive to Amikacin, Ampicillin, and Gentamicin. (Fig. 5). While that from the polluted samples showed that the isolates were 0% sensitive to Amikacin, Ampicillin and Ciprofloxacin, 14% sensitive to Levoflovacin, Amoxicillin, Tetracycline, Ampiclox, Chloramphenicol, and Gentamicin, 29% sensitive to Meropenem, Septrin and Erythromycin (Fig. 6).

The statistical analysis of the difference between the heterotrophic bacteria counts of the upstream samples and the values obtained in effluent discharge point, domestic activities point and the downstream using independent sample t – test showed that the results were all very highly significant ($P<0.05$). The coliform counts also showed similar trend, however the faecal coliform counts was just significant ($P<0.05$) at the downstream.

Table 1. Mean values of heterotrophic bacteria counts at the various sampling points during the different seasons (cfu/ml × 10^2)

Seasons	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Peak of flood season	8.7 ± 0.1	98.0 ± 1.0	85.0 ± 3.0	78.0 ± 2.0	0
Setting in of dry season	7.1 ± 0	89.0 ± 0	75.0 ± 0	68.0 ± 0	0
Peak of dry season	4.8 ± 0.4	41.0 ± 8.0	53.0 ± 6.0	46.0 ± 4.0	0
Setting - in of raining season	5.5 ± 0.3	36.0 ± 1.0	61.0 ± 1.0	57.0 ± 4.0	0
Peak of raining season	6.5 ± 0.3	45.0 ± 7.0	72.0 ± 6.0	63.0 ± 3.0	0

Key: Peak of flood season = September and October; Setting - in of raining season = March and April; Setting in of dry season = November; Peak of raining season = May and June; Peak of dry season = December to February.

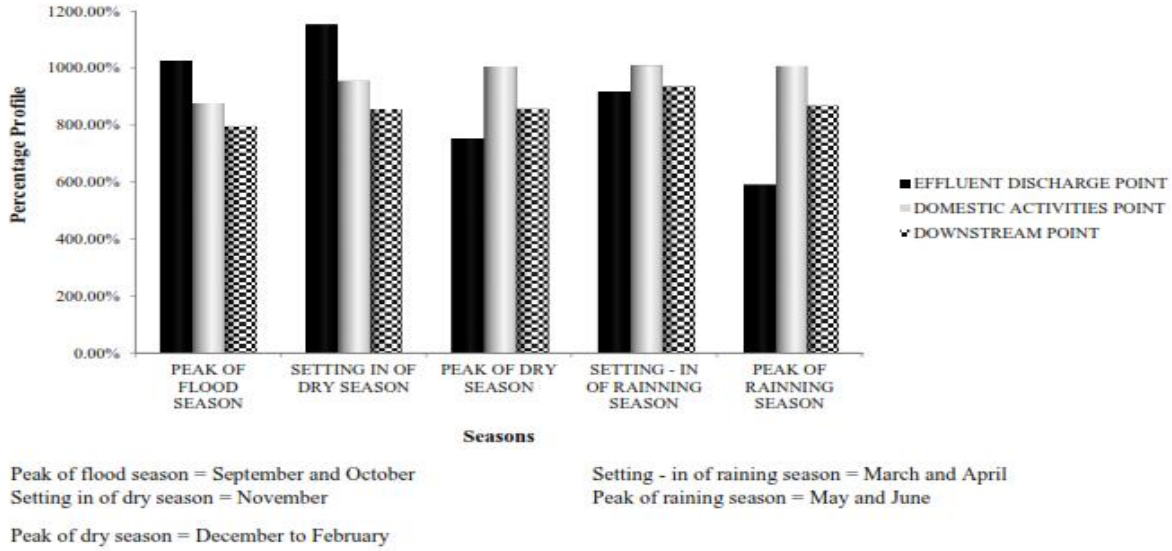


Figure 2. Percentage increase of heterotrophic bacteria counts obtained in effluent discharge point, domestic activities point and downstream point from the count in upstream during the different seasons

Table 2. Mean values of total coliform counts at the various sampling points during the different seasons (MPN/100ml)

Seasons	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Peak of flood season	19.0 ± 1.0	37.5 ± 2.5	35.0 ± 0	22.5 ± 2.5	0
Setting in of dry season	14.0 ± 0	30.0 ± 0	25.0 ± 0	20.0 ± 1.0	0
Peak of dry season	11.3 ± 0.9	26.7 ± 2.4	21.7 ± 2.4	18.3 ± 1.3	0
Setting - in of raining season	13.0 ± 1.0	20.0 ± 0	18.0 ± 0	17.0 ± 0	0
Peak of raining season	18.0 ± 0.3	27.5 ± 2.5	22.5 ±2.5	19.0 ± 1.0	0

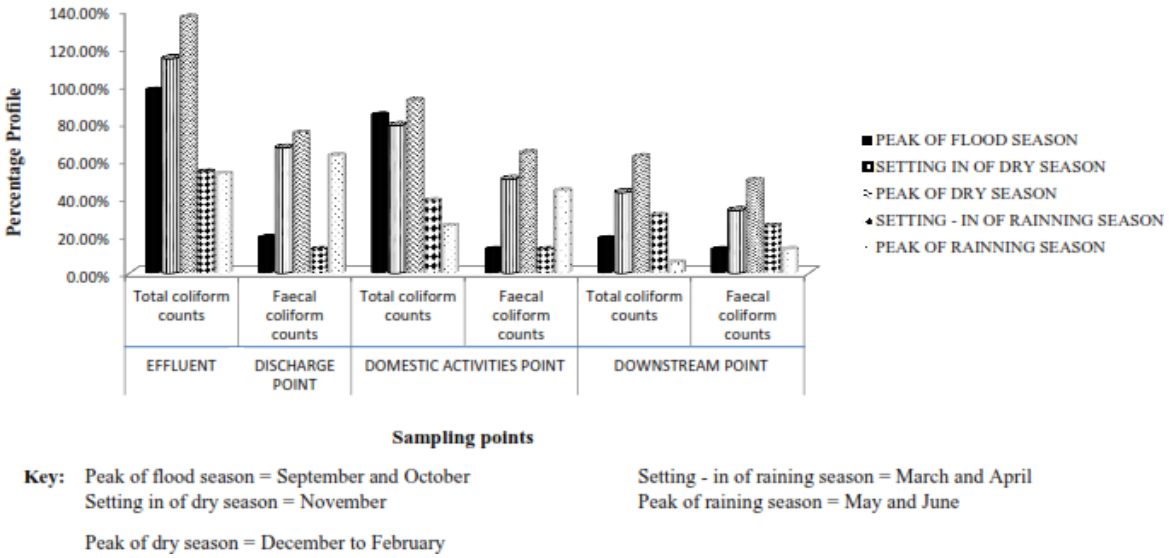
Key: Peak of flood season = September and October; Setting - in of raining season = March and April; Setting in of dry season = November; Peak of raining season = May and June; Peak of dry season = December to February.

Table 3. Mean values of faecal coliform counts at the various sampling points during the different seasons (MPN/100ml**)**

Seasons	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Peak of flood season	8.0 ± 0	9.5 ± 0.5	9.0 ± 0	9.0 ± 0	0
Setting in of dry season	6.0 ± 0	10.0 ± 0	9.0 ± 0	8.0 ± 0	0
Peak of dry season	6.7 ± 1.3	11.7 ± 0.5	11.0 ± 0.8	10.0 ± 0.8	0
Setting - in of raining season	8.0 ± 1.0	9.0 ± 1.0	9.0 ± 1.0	10.0 ± 1.0	0
Peak of raining season	8.0 ± 0	13.0 ± 1.0	11.5 ± 0.5	9.0 ± 0	0

Results are given as mean ± standard deviation

Key: Peak of flood season = September and October; Setting - in of raining season = March and April; Setting in of dry season = November; Peak of raining season = May and June; Peak of dry season = December to February.



Key: Peak of flood season = September and October
Setting in of dry season = November
Peak of dry season = December to February
Setting - in of raining season = March and April
Peak of raining season = May and June

Figure 3. Percentage increase of coliform counts obtained in effluent discharge point, domestic activities point and downstream point from the count in upstream during the different seasons

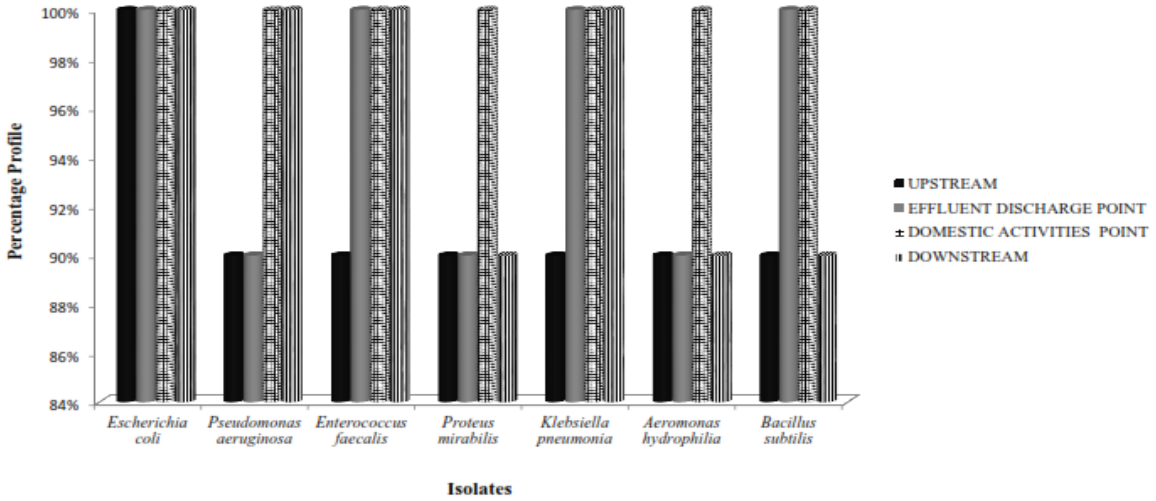


Figure 4: Percentage of occurrence of bacteria isolates from the different sampling points during the research period. (Number of occurrence = 10(September to June))

3.2. Antimicrobial Susceptibility Test

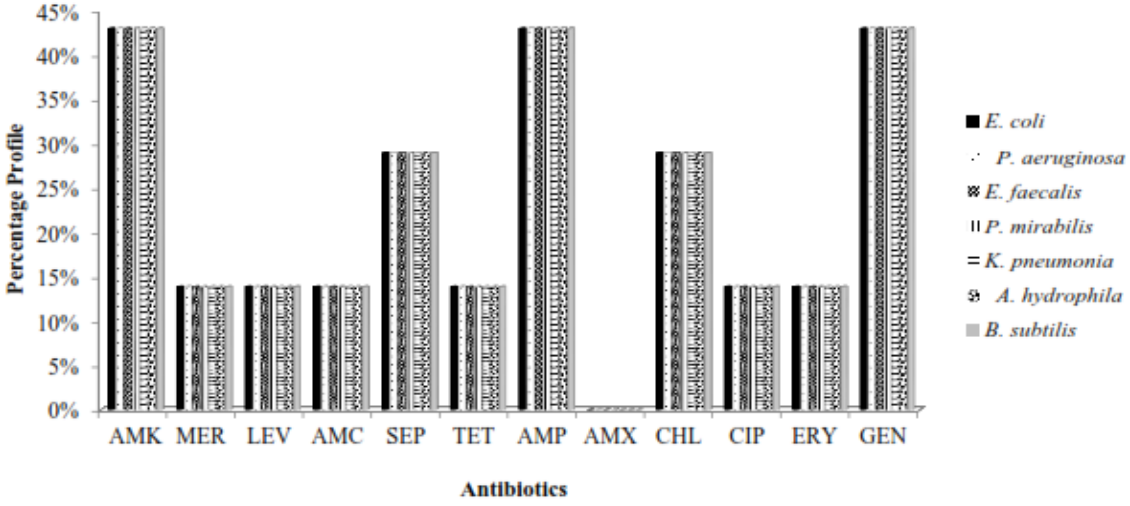


Figure 5: Antibiotics susceptibility profile of the isolates from the upstream samples

Key: Amikacin (AMK), Meropenem (MER), Levoflovacin (LEV), Amoxicillin (AMC), Septrin (SEP), Tetracycline (TET), Ampicillin (AMP), Ampiclox (AMX), Chloramphenicol (CHL), Ciprofloxacin (CIP), Erythromycin (ERY) and Gentamicin (GEN).

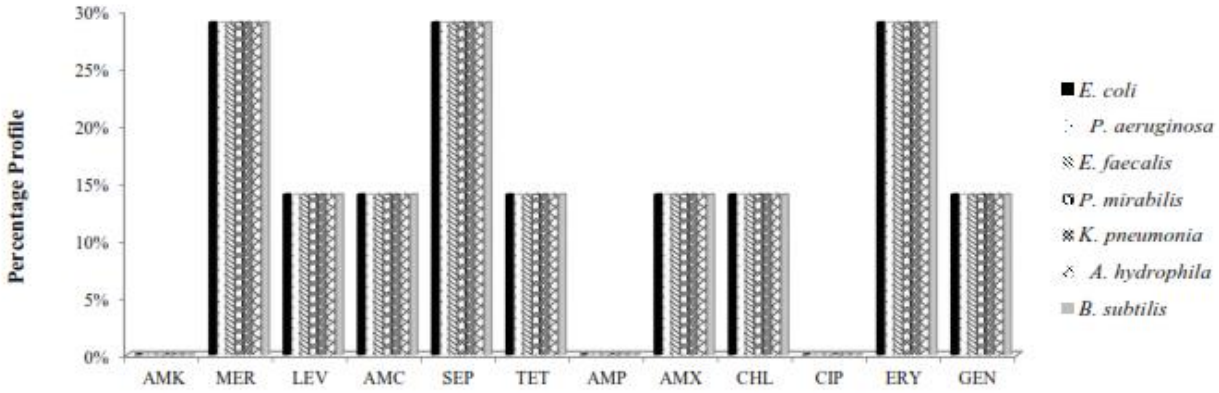


Figure 6. Antibiotics susceptibility profile of the isolates from effluent polluted samples

Key: Amikacin (AMK), Meropenem (MER), Levoflovacin (LEV), Amoxicillin (AMC), Septrin (SEP), Tetracycline (TET), Ampicillin (AMP), Ampiclox (AMX), Chloramphenicol (CHL), Ciprofloxacin (CIP), Erythromycin (ERY) and Gentamicin (GEN).

Table 4. Antibiotics susceptibility profile of isolates from the upstream samples

ANTIBIOTICS	*E. coli*	*P. aeruginosa*	*E. faecalis*	*P. mirabilis*	*K. pneumonia*	*A. hydrophila*	*B. subtili*
Amikacin (30µg)	S	R	S	R	S	R	R
Meropenem (10µg)	R	R	R	S	R	R	R
Levoflovacin (5µg)	R	S	R	R	R	R	R
Amoxicillin (25µg)	R	R	R	S	R	R	R
Septrin (25µg)	S	R	R	R	R	R	S
Tetracycline (25 µg)	R	R	R	R	S	R	R
Ampicillin (25µg)	S	R	R	R	S	S	R
Ampiclox (10µg)	R	R	R	R	R	R	R
Chloramphenicol (25µg)	R	R	S	R	S	R	R
Ciprofloxacin (10µg)	R	R	R	R	R	S	R
Erythromycin (10µg)	R	R	S	R	R	R	R
Gentamicin (10µg)	R	S	R	S	R	S	R

Key: R- Resistant; S-Susceptible.

Table 5. Antibiotics susceptibility profile of isolates from the effluent polluted samples

Antibiotics	*E. coli*	*P. aeruginosa*	*E. faecalis*	*P. mirabilis*	*K. pneumonia*	*A. hydrophila*	*B. subtilis*
Amikacin (30µg)	R	R	R	R	R	R	R
Meropenem (10µg)	S	R	R	R	S	R	R
Levoflovacin (5µg)	R	S	R	R	R	R	R
Amoxicillin (25µg)	S	R	R	R	R	R	R
Septrin (25µg)	R	S	R	R	S	S	R
Tetracycline (25 µg)	R	R	R	R	S	R	R
Ampicillin (25µg)	R	R	R	R	R	R	R
Ampiclox (10µg)	R	R	R	R	S	R	R
Chloramphenicol (25µg)	R	R	R	R	S	R	R
Ciprofloxacin (10µg)	R	R	R	R	R	R	R
Erythromycin (10µg)	R	R	S	S	R	R	R
Gentamicin (10µg)	R	R	R	R	S	R	R

Key: R- Resistant; S-Susceptible.

4. Discussion

The bacteriological quality of Ekemazu stream in Delta state, Nigeria was investigated in order to determine the impact of effluent discharge and seasonal variations on the stream. The result obtained here is similar to that of Asuquo & Etim (2012) on their study of physicochemical study of river water who recorded high value in effluent discharge point, followed by domestic activities point, then the downstream point, upstream sample had the lowest value.

The total heterotrophic bacteria counts of 4.8 x 10^2 cfu/ml obtained in the upstream sampling point and 98 x 10^2 cfu/ml in the effluent discharge point is higher than the acceptable total heterotrophic bacteria counts of zero cfu/ml for drinking and recreational water (WHO, 2011). This observation is however lower than that observed by Ekhaise and Anyasi (2005) and Akatah *et al*., (2018) who recorded 1.3 x 10^7 cfu/ml and 6.7 x 10^3 cfu/ml respectively in their study of influence of effluent discharge on Ikpoba River. This is probably due to the fact that other human centres of activities such as abattoirs, storm water reception points are also located close to the sampling stations of Ikpoba River. The total coliform counts of 10-35 MPN/100 ml and faecal coliform counts of 5-12 MPN/100 ml is an indication of faecal pollution of the stream. This result is higher than the WHO acceptable limit of zero coliform per 100 ml of drinking water (WHO, 2011). The presence of coliform, particularly *Escherichia coli* is a clear indication of faecal pollution of the stream (CDC, 2011). The presence of these microorganisms poses a serious threat to

human health and life (Amazoo & Ibe, 2005). This result is also lower than that recorded by Akatah *et al.,* (2018) who recorded 434 to 819 MPN/100 ml. Presence of coliform in the stream can be attributed to poor sanitary practice, rain flush (water run off) and discharge of large volume of faecal material from human and animal into the stream, which result in release of microorganisms, nutrients and organic matter (Owa, 2014). Similarly, Akatah *et al.,* (2018) observed that a high count of bacteria load in an aquatic system is a reflection of the input of microorganisms from extraneous source and availability of growth supporting organic matters.

Bacteria isolated from the samples are *Escherichia coli Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumonia, Proteus, mirabilis, Aeromonas hydrophilia* and *Enterococcus faecalis.* These isolates are similar to bacteria isolates recorded by Akatah *et al*., (2018) on their study of microbiological analysis of drinking water in Lagos. The antimicrobial susceptibility test showed that isolates from the upstream samples were more susceptible to antibiotics while those of the effluent discharge point were more resistant. This can be as a result of adaptation of isolates from the polluted stations to harsh environmental conditions (Ashraf *et al.,* 2010; Toroglu *et al.,* 2005).

There was observed fluctuation in the bacteria load and physicochemical parameters analysed during the research period. Apart from human activities in the stream and effluent discharge by the Power Plant, seasonal variation also influenced the water quality. This observation is similar to that of Ogbonna, (2010). This was observed in the heterotrophic bacteria count which was highest on October, the peak of the flood season in the area. This could be attributed to many run off into the stream during flooding which carry along it, high microbial load. The bacteria load declined from setting – in of dry season till the peak of dry season. This could be attributed to lack of rainfall at this season. At the setting – in of the raining season there was observed gradual increase. This could be attributed to flushing into the stream as the rain begins. This observation is similar to that of Ekhaise and Anyasi, (2005). The total and faecal coliforms were observed to be highest in the month of December to March (the peak of dry season/setting – in of the raining season). This can be attributed to poor hygiene practice by the local community users as water becomes scarce due to low volume of water regime in the stream during this season.

6. Conclusion

This research clearly showed that the bacteriological quality of Ekemazu stream in Okpai-Oluchi, Delta state, Nigeria is higher than the WHO acceptable limit. This is due to release of heavily polluted effluent by the Power Plant into the stream as well as some human activities in the water body. The high bacteriological load can be used to classify Ekemazu stream as a polluted water body and as such unfit for any human or domestic use/consumption in accordance to World Health Organisation water use guidelines standard. This is a gross violation of effluent discharge permit limits employed by the power plant. It is therefore recommended that the power plant should unlike their present method of only primary treatment of their wastewater, adequately treat their effluent to tertiary stage of waste treatment before discharging into the stream. It is also required that the environmental monitoring body, Federal Environmental Protection Agency, FEPA, regularly inspect and certify the company's effluent before their release into the water body in order to ascertain compliance by the company. Also proper control of human activities to prevent sewage or faecal materials from entering into the stream is highly recommended to prevent faecal contamination of the stream. This can be employed through enacting of rules and regulations that can guide against improper sanitary and hygiene practice, education of the masses on the implications of polluted water body and the need to live a healthy life.

Indiscriminate use of antibiotics in chemotherapy should be avoided to prevent the development of multidrug resistant strains of *Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumonia, Proteus, mirabilis, Aeromonas hydrophilia* and *Enterococcus faecalis.* Since water is most needed in human society, any effort directed towards improving its quality will not be too expensive. This can be enhanced by the government and/or the Power Plant by providing adequate source of purified water for the residents of the area. All these principles and programmes will go a long way in reducing or possibly eradicating water-borne diseases or its public health implications in the polluted Ekemazu stream and our society in general.

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