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Microbiological Analysis of Sewage Systems for Pathogenic Species of Bacteria Within the Federal Polytechnic, Idah, Kogi State, Nigeria

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Abstract: It has been established that sewage harbours various pathogens and allergens that are harmful to human health. A total of 200 sewage samples were obtained from ten sites of the Federal Polytechnic, Idah and examined for bacterial contamination between the months of August and October 2010. Of this total, 180 (90.0%) were positive for bacilli (Rods) while 20 (10.0%) were positive cocci contamination. The *bacilli* species of bacteria isolaled include: *Escherichia coli*, *Salmonella* sp. and *Shigella* sp. while *Staphylococcus aureus* was the only cocci bacterium isolated. The mean total count recorded for the four species of bacteria ranged from 1.2×10^4 to 9.8×10^4 mL^{-1} and this range falls within the high to extremely high total count of coliform bacteria. The distribution of mean total count of pathogenic bacteria in the ten sites surveyed was not significantly different ($p>0.05$). However, the prevalence (%) or occurrence of the four species of the pathogens in the ten sites differed significantly ($p<0.05$) with 100% cases of *S. aureus* recorded in FPI-Nnamdi Azikiwe, Amina, Bello and FPI-Omaidoko Hostel, respectively. The overall prevalence of *Salmonella typhi* (48.7%) active infection, revealed from clinical records, among students and staff of the polytechnic was not only relatively high but spanned through the three months of the study with prevalence of *S. typhi* ranging from 27.9-61.1% and closely corroborated with the occurrence of *S. typhi*, 55 (30.6%) in the sewage examined. The findings have no doubt provided baseline information about high prevalence of bacterial infections among students and staff of the polytechnic, especially with respect to rampant cases of typhoid fever caused by *Salmonella typhi.* With these data, the stakeholders could put in place the necessary measures against the infections by pathogenic bacteria. Contaminated water and food contribute to high morbidity and mortality rates from diarrhoea disease, typhoid fever and gastrointestinal illness and sometimes can lead to epidemics.

Key words: *Escherichia coli*, prevalence, *Salmonella* sp., sewage, *Shigella* sp., *Staphylococcus aureus*

INTRODUCTION

Sewage is an accumulation of human waste such as faeces, urine, used water and other waste substances that are carried away from houses, industries and farm land through a special pipe or run off (Nov, 2009). Sewage contains a relatively defined suspended matter, colour, taste, odour, dissolved chemicals, bacterial indicative of faecal presence and ethically offensive objects or properties (Chukwura, 2001). Nwachukwu and Otokunefor (2003) pointed out that in areas where there are many pit or open latrines there is always the risk of microbial contamination of water sources.

Various studies by researchers who carried out their research works independently have established the fact that sewage usually carries substances which may be of chemical origin (e.g., pesticides, inorganic fertilizers, phenols, polychlorinated bi-phenols-PCBs, benzene, ethers, phosphorus, nitrogen, etc.) or of biological origin (pathogens and allergens) that can be very harmful to people's health (Mark, 1977; Okafor, 1985; Thomas and Bailliere, 1988; WHO, 1996; Cheesbrough, 2000; Schiffman *et al*., 2000; Reilly, 2001; Jones, 2001). The research of Nwachukwu and Otokunefor (2003) on sanitary bacterial quality of surface water in a rural community of Rivers State, Nigeria, revealed that the overall prevalence of Salmonella was 43.1% and was generally higher during the raining months of the year. The researchers recorded zero (0) prevalence of *Salmonella* in the months of January, February and November and the peak prevalence (100.0%) of the genus occurred in July and August respectively; 66.7 and 33.3% were recorded for the months of September and October, respectively.

Diseases caused by bacteria which constitute high public health importance include cholera (*Vibrio*

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cholerae), kidney and bladder infection (*Escherichia coli*), typhoid fever or gastroenteritis (*Salmonella typhi*), *Shigella* sp. (Paul *et al*., 1995), etc. and they cause serious pathological effects in the victims which are symptomized by sudden diarrhoea, profuse watery stool, vomiting and fever. *Staphylococcus aureus* is a ubiquitous pathogen of man so much that its elimination from among human reservoir hosts appears virtually impossible (Duguid *et al*., 1976; Gerald *et al*., 1979; Schaechter *et al*., 1998; Brooks *et al*., 1998). It is the most common cause of pyogenic infection in man, causing diseases such as boils, furuncles, caruncles, styles, impetigo, etc., especially on the skin (Gerald *et al*., 1979; Thomas and Bailliere, 1988). Uaboi-Egbenni (2003) reported the incidence (87.5%) of Gram-positive cocci, *Staphylococcus aureus*, pathogenic bacterium among healthy different age groups in Lagos. Apart from bacterial infections, other infectious diseases could be of parasitic origin such *Giardia* sp. which causes chronic intestinal illness in adult and children or could be of viral origin like rotavirus which causes severe diarrhoea (Cheesbrough, 2000).

Improper sewage disposal and transportation from hospital, industrial companies, house and launch; application of sewage, agricultural run-off and sewage sludge pose high risk to public health.

From the available literature, no data on multiple pathogenic, bacterial infections associated with sewage from various drainage systems in Federal Polytechnic, Idah-community exists; hence, the main aim of this study is to analyze sewage from drainage systems within the community of Federal Polytechnic Idah with a view to determining the risk of bacterial infection. During the pilot study in the month of July, before the commencement of the research in August 2010, clinical records on prevalence of pathogenic bacteria were obtained from the Senior Medical Laboratory Scientist (Mr. Drisu, Itanyi Uteno-personal communication). These records showed that of the 297 patients in attendance of Federal Polytechnic, Idah Medical Centre in July, 146 individuals were infected with *Salmonella* sp., giving overall prevalence of 48.7%. The clinical records (n = 473, 289 (61.1%); n = 348, 161 (46.3%); n = 247, 69 (27.9%)) were also obtained from the medical centre along side with the raw data gathered from the sewage in the months of August to October. There were however no clinical records for other pathogenic bacteria during the study period. The data obtained would form the baseline information with which control measures can be put in place.

MATERIALS AND METHODS

The study was carried out in Federal Polytechnic Idah, community. Sewage from various drainage systems were obtained at different sampling sites and analyzed for multiple pathogenic, bacterial infections between August and October 2010.

Two hundred samples of sewage were obtained from the following sampling sites: Federal Polytechnic Idah (FPI) student official lodge (AsoRock); FPI Nnamdi Azikiwe (Zik) Hostel; FPI Canteen; FPI Amina Hostel; FPI Market Square; FPI Inikpi Hostel; FPI Bello Hostel; FPI Omaidoko Hostel; FPI Bread Ventures and FPI Pure Water Ventures.

Sample collection and analysis

Location: The description of the sampling areas/sites was given by Ejima and Ajogun (2011) as listed earlier. According to these researchers, faeces were indiscriminately deposited out of toilets onto the soil around human habitations within the students' hostels in the Federal Polytechnic, Idah, Kogi State, Nigeria. In some of the hostels, pit latrines are still in use. The sewage system where it exists was poorly constructed or dilapidated with outlets in so many points from where the samples for the present research were obtained. Twenty samples were collected from each site using clean sterile bottle with each properly labelled to indicate the site of collection. Isolation of Gram-negative rods (*Salmonella* sp. and *Shigella* sp.) and *Escherichia coli* was carried out, using *Salmonella-Shigella* Agar (SSA) and MacConkey agar, respectively while selective medium for isolation of *Staphylococcus aureus* (Gram-positive cocci), Cystine Lactose Electrolyte Deficient Agar (CLEDA) was employed. Each sample was inoculated aseptically and separately by spreading the swab on the appropriate medium-plate (s) to obtain discrete colonies. The plates were thereafter incubated aerobically at 37°C for 48 h. A smear of each sample was prepared, using appropriate staining technique and various biochemical tests (catalase, coagulase, indole, oxidase, citrate and urease) were conducted in accordance with the method adopted by Uaboi-Egbenni (2003) to enable identification of bacteria isolates from the sewage obtained from the ten sites surveyed. The total amount of bacteria in the sewage per mL was enumerated by Direct Microscopic Count Method (Chukwura, 2001).

Statistical analysis: The total mean count of the four pathogenic bacteria isolated was subjected to one-way Analysis of Variance (ANOVA) using Duncan (1955)'s multiple range test to separate difference in variables; whereas Chi-square (χ^2) statistic was employed to analyze difference in prevalence/occurrence of the four species of bacteria in different sites.

RESULTS AND DISCUSSION

The four pathogenic organisms namely: *Escherichia coli*, *Salmonella* and *Shigella* sp. (Gram-negative rods) and *Staphlococcus aureus* (Gram-positive cocci) were isolated from sewage in ten different localities of Federal Polytechnic Idah community. A total of 200 sewage samples were analyzed and 180 (90.0%) of bacilli (rods) group of bacteria including *E. coli*, *Salmonella* sp. *Shigella* sp. were isolated from the ten sites and 20 (10.0%) of cocci group, *Staphylococcus aureus* was isolated from four sites namely: Nnamdi Azikiwe Hostel, Amina Hostel, Bello Hostel and Omaidoko Hostel of the Federal Polytechnic Idah community (Table 1).

Table 1 also shows the prevalence and mean total count of the four species of bacteria isolated from the ten sites. The study showed that the peak total count of (82,800 mL^{-1}) of *E. coli* occurred in AsoRock of FPI while the least mean total count *E. coli* recorded in canteen of FPI. The highest (97,533 mL^{-1}) and the least (25,950 mL^{-1}) mean total count of *Salmonella* sp. occurred in Omaidoko Hostel and Inikpi Hostel, respectively. Again the highest (95,933 mL^{-1}) and least (12,368 mL^{-1}) mean total of *Shigella* sp. were recorded for Amina Hostel and Canteen, respectively. The mean total count of *Staphylococcus aureus* peaked (60,933 mL^{-1}) in Omaidoko Hostel while the least (53,375 mL^{-1}) was recorded for Bello Hostel of FPI.

A total of 200 sewage samples were obtained from ten sites of the Federal polytechnic, Idah and examined for bacterial contamination between the months of August and October 2010. Of this total, 180 (90.0%) were positive for bacilli (Rods) while 20 (10.0%) were positive for cocci contamination. The bacilli species of bacteria isolated include: *Escherichia coli*, *Salmonella* sp. and *Shigella* sp. while *Staphylococcus aureus* was the only cocci bacterium isolated. Although, the overall prevalence of *S. aureus* (10.0%) was relatively low when compared to bacilli group of bacteria, it has been established that the species was the most ubiquitous bacterium in the individual sites surveyed with 100.0% prevalence recorded for FPI-Nnamdi Azikiwe, FPI-Amina, FPI-Bello and Omaidoko Hostel, respectively (Table 1). This observation correlates strongly with those of several other researchers (Duguid *et al*., 1976; Gerald *et al*., 1979; Paul *et al*., 1995; Schaechter *et al*., 1998; Brooks *et al*., 1998). It was generally observed that the prevalence/ occurrence of the pathogenic bacteria was rare in areas where modern sewage facilities exist and the inhabitants maintain high standard of personal and

Table 1: Prevalence and mean (Arithmetic Mean, AM) total count of the four species of bacteria isolated from ten sites of federal polytechnic, Idah, Kogi State, Nigeria

1st S/No.	2nd sites	*3rd NSE	4th BR (%)	5th No+ve *E. coli*	6th Prev (%) *E. coli*	7th MCT/mL *E. coli*	8th No+ve *Salm.* sp.	9th Prev (%) *Salm.* sp.	10th MCT/mL *Salm.* sp.
1	Federal Polytechnic Idah (FPI) AsoRock	20	20	9	45.0	82,800.0	5	25.0	46,500
2	FPI Nnamdi Azikiwe Hostel	20	15	4	27.0	50,467.0	6	40.0	74,667
3	FPI Canteen	20	19	9	47.0	36,316.0	8	42.0	36,947
4	FPI Amina Hostel	20	15	4	27.0	47,333.0	3	20.0	37,333
5	FPI Market Square	20	20	9	45.0	80,450.0	5	25.0	44,850
6	FPI Inikpi Hostel	20	20	9	45.0	78,800.0	3	15.0	25,950
7	Bello Hostel	20	16	4	27.0	45,438.0	6	38.0	68,750
8	Omaidoko Hostel	20	15	4	27.0	47,333.0	8	53.0	97,533
9	FPI Bread Venture	20	20	9	45.0	59,300.0	5	25.0	31,550
10	FPI-Pure Water Venture	20	20	9	45.0	53,050.0	6	30.0	36,950
	Total	200	180 (90.0%)	70	38.9	58,128.7	55	30.6	51,103

1st S/No.	2nd sites	11th No+ve *Shig.* sp.	12th Prev (%) *Shig.* sp.	13th MTC/mL *Shig.* sp.	14th NCI (%)	15th No+ve *Staph.* sp.	16th Prev (%) *Staph.* sp.	17th MCT/mL *Staph.* sp.
1	Federal Polytechnic Idah (FPI) AsoRock	6	30.0	53,750.0	-	-	-	-
2	FPI Nnamdi Azikiwe Hostel	5	33.0	73,200.0	5	5	100.0	60,000
3	FPI Canteen	3	16.0	12,368.0	-	-	-	-
4	FPI Amina Hostel	8	53.0	95,933.0	5	5	100.0	59,333
5	FPI Market Square	6	30.0	56,600.0	-	-	-	-
6	FPI Inikpi Hostel	8	40.0	71,100.0	-	-	-	-
7	Bello Hostel	5	31.0	55,250.0	5	5	100.0	53,375
8	Omaidoko Hostel	3	20.0	36,400.0	5	5	100.0	60,933
9	FPI Bread Venture	6	30.0	38,600.0	-	-	-	-
10	FPI-Pure Water Venture	5	25.0	28,850.0	-	-	-	-
	Total	55	30.6	52,005.1	20 (10.0)	20	100.0	58410.3

*3rd NSE: No. of samples examined; 4th B/R (%): Bacilli/Rods (%); 5th No+ve; 6th Prevalence (%); 7th MTC mL^{-1}: Mean total count (*E. coli*); 8th No+ve; 9th Prevalence (%); 10th MTC mL^{-1}: Mean total count (*Salmonella* sp.); 11th No+ve; 12th Prevalence (%); 13th MTC mL^{-1}: Mean total count (*Shigella* sp.); 14th NCI: No. of Cocci Isolated; 15th No+ve; 16th Prevalence (%); 17th MTC mL^{-1}: Mean total count (*Staphylococcus aureus*). No significant difference in total mean count of the pathogens in the ten sites surveyed ($p>0.05$: $F_{cal.} = 1.00$; $F_{tab.\ 0.05,\ df = 3/30} = 2.92$). There was significant difference in prevalence of the pathogens in the sewage systems of the ten sites surveyed ($p<0.05$: $\chi^2_{cal.} = 340.392$; $\chi^2_{tab.\ 0.05,\ df = 27} = 40.113$)

environmental hygiene. This may account for absence of even the most ubiquitous bacterium (*S. aureus*) in FPI-AsoRock, FPI-Canteen, FPI-Market Square, FPI-Inikpi Hostel, FPI-Bread Venture and FPI-water venture where modern facilities exist and sewage systems hardly open to the exterior environment (Table 1).

The peak mean total count (97,533 mL^{-1} and the least (25,950 mL^{-1}) of *Salmonella* sp. occurred in Omaidoko Hostel and Inikpi Hostel, respectively. Although, these two female hostels were recently constructed in the same location within the campus with modern facilities including sewage systems, pronounced difference in occurrence and intensity of *Salmonella* sp. was recorded. This observation may be due to differences in population densities and contaminatory behaviours of the inhabitants (Ejima and Ajogun, 2011). The overall prevalence of *Salmonella typhi* (48.7%) active infection, revealed from clinical records, among students and staff of the polytechnic was not only relatively high but spanned through the 3 months of the study with prevalence of *S. typhi* ranging from 27.9-61.1%. The rampant cases of typhoid fever among the staff and students of FPI-community as revealed by clinical records (FPI-Medical Centre) and findings in the present research with the prevalence of *Salmonella* sp. ranging from 15.0-53.0% in the ten sites surveyed was in agreement with that of Nwachukwu and Otokunefor (2003) who reported an overall prevalence of the genus (*Salmonella*) in Rivers State, Nigeria and observed that the prevalence was higher in the raining months of the year. The high prevalence of Salmonella recorded in the present research may partly be due to the fact that the research was carried out in the raining months (August to October) and partly due to sanitary conditions of the environment and/or habit of the community. In Kogi State, there are two seasons: dry and rainy seasons. Meteorological records have shown that rainfall starts as late as April and peaks between August and September.

The study revealed that the highest (82,800 mL^{-1}) and the least mean total count (36,316 mL^{-1}) of *E. coli* was recorded for AsoRock and Canteen of FPI, respectively. For *Shigella* sp. the highest mean count (95,933 mL^{-1}) and the least (12,368 mL^{-1}) was recorded in Amina hostel and canteen, respectively. The mean total count of *S. aureus* attained the peak (60,933 mL^{-1}) and the least (53,375 mL^{-1}) in Omaidoko Hostel and Bello Hostel, respectively.

The prevalence of the four species of bacteria within the polytechnic community has serious public health implication. More so, the mean total count of pathogenic bacteria contaminated sewage ranging from about 1.2×10^4 to 9.8×10^4 mL^{-1} (Table 1) recorded in this research calls for concern and urgent measures for prevention and control.

This research has provided baseline information about high prevalence of bacterial infection among students and staff, especially rampant cases of typhoid fever caused by *S. typhi* and *paratyphi* also revealed by clinical reports of the Medical Centre of the Federal Polytechnic Idah. The total 180 (90.0%) for positive bacilli (rods) and 20 (10.0%) for positive cocci recorded for this work were relatively high when compared to 49.9% prevalence of coliphage reported by Reilly (2001) in Ottawa US. Also, 50% of coli bacteria were recorded in Ontario, Toronto (Cheesbrough, 2000). The high prevalence in this research work could be due to poor sanitation and indiscriminate sewage disposal in the community of Federal Polytechnic Idah.

The pathogenic bacilli (rods) and cocci isolated in the community of FPI are of great significance and require serious control measures. The public health implication associated with these organisms is: kidney and bladder infection caused by *Escherichia coli*, typhoid fever caused by *Salmonella typhi*, Shigellosis caused by Shigella and skin disease caused by *Staphylococcus aureus*.

The occurrence of *S. typhi* (30.6%) in the sewage examined which corroborated closely with active infection (48.7%) among the polytechnic community, suggests that active transmission of the disease was ongoing. The bacterial contamination of food and water has profound health risk. Contamination of water and food contributes to high morbidity and mortality rates from diarrhoea diseases, typhoid fever, gastrointestinal illness and sometimes can lead to epidemics.

CONCLUSION

The study showed high occurrence of four species of pathogenic bacteria, namely Escherichia, Salmonella, Shigella and Staphylococcus in the sewage samples examined within the Federal Polytechnic, Idah community which corroborated with rampant cases of active typhoid fever infection as gathered from clinical records.

RECOMMENDATIONS

These are following recommendations:

- It is highly recommended that the school management should provide septic tanks for proper sewage collection and disposal
- The institution should also address the sewers short fall which allow untreated sewage (excreta) to be released directly into the environment so that the sewage can be properly disposed

- It is also recommended that persuasive health education through mass media, on the health risk associated with improper sewage disposal and the need to ensure proper sanitation should be embarked upon

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