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Microbial Contaminant Effects of Pre-Treated Sewerage Wastewater on Receiving Surface Water in Ibadan, Nigeria

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Abstract: Microbial content of sewage wastewater and the impact on microbial population of receiving surface water was studied in university of Ibadan, Oyo State, Nigeria. Sewage wastewater samples were collected over 3 months period and examined for microbial content at the University of Ibadan surface water receiving pre-treated wastewaters from staff residential quarters, academic departments and students hostels. Surface water samples that were contaminated as a result of the sewage discharge were collected and analyzed for microbial content as compared to samples without sewage contamination 10 m upstream section from the point of discharge (control). Some physico-chemical parameters of the water samples were also examined. The sewage wastewater samples were highly contaminated; sewage wastewater showed mean faecal coliform count of 2.4×10^3 cfu/100 mL, mean total coliform count of 7.5×10^5 cfu/100 mL and mean total aerobic count of 6.7×10^7 cfu/100 mL. In the contaminated surface water sample, mean faecal coliform count (2.2×10^2 cfu/100 mL), total coliform count (3.1×10^5 cfu/100 mL) and total aerobic count (8.2×10^6 cfu/100 mL) are high compared to their respective values (1.1×10^2, 1.2×10^5 and 6.3×10^6 cfu/100 mL) for the control samples. These results were higher than Federal Environmental Protection Agency (FEPA) permissible limit of (500 cfu/100 mL). In this study, high microbial load in sewage wastewater with negative effects on microbial population in the receiving stream, further confirmed the need to pre-treat wastewater rather than discharging directly it to the environment.

Key words: Sewage, wastewater, microbial load, stream flow, Nigeria

INTRODUCTION

Irrespective of the efforts geared towards curbing the menace of pollution around the world, the disposal of sewage in natural waters has remained a common practice among many nations, especially the developing countries. Large inputs of organic loads and nutrients from raw sewage to a weak hydrodynamic environment poses serious environmental and health problems from deterioration of water quality (Ribeiro and Araujo, 2002; Cimino *et al*., 2002; Rajagopalan, 2005; Al-Dahmi, 2009). Inadequate or faulty sewerage and/or sewage treatment system are major causes of pollution in natural waters. The exponential growth in urbanization through migration of people from rural and semi-urban areas to cities in search of livelihood has contributed to the deploring sewerage situations in most major cities of the world especially developing countries (Longe *et al*., 2010).

Raw sewage contains urine and faeces from toilet flushing as well as other types of human waste; it may also contain such things as toilet tissue and wipes. These may as well include tampons and other feminine sanitary products (Longe *et al*., 2010). The pathogens in raw sewage can contaminate ecological systems as well as causing sickness to humans and animals. Also, raw sewage contains a variety of other constituents including oxygen-demanding organisms which can deplete dissolved oxygen in receiving waters; pathogenic microorganisms which can spread disease (*E. coli* and hepatitis A; cholera) and nutrients which can stimulate growth of aquatic plants (Theodorou, 1997; Akoachere *et al*., 2008). Sewage may also contain potentially toxic, mutagenic or carcinogenic compounds (Al-Muzaini *et al*., 1999). Besides being exposed to bacteria and viruses, a person exposed to raw sewage may develop a range of illnesses including gastroenteritis which is marked by diarrhea, vomiting and abdominal pain.

Excessive deposition of chemical nutrients in water bodies such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Solids (TS), pH and conductivity impairs the quality of the water bodies and as well endanger aquatic life (Mallin *et al*., 2007).

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Eutrophication from organic load on water bodies is one of the numerous problems created by sewage pollution (Diaz *et al*., 2005; Garg, 2006). Even though, water bodies in their natural form contain chemical compounds such as the bicarbonates, nitrates, chlorides, sulphates, various problems however arise with the increase in the amount of these compounds within the water bodies. The buildup of salts from sewage can interfere with water re-use as salts like sodium chloride, potassium sulphate pass through conventional water and wastewater treatment plants without change. High salt concentrations in wastewater effluents can increase the salinity of the receiving water which may result in adverse ecological effects on aquatic life (Chapman, 1996).

Water which contains salts is not useful for irrigation either as utilization of such water leads to the salinization of the soil which in turn leads to soil erosion. The toxins released into the rivers through sewage water are consumed by fishes and other organisms thus increasing the possibility of these toxins entering the food chain (Gomez-Couso *et al*., 2006). However, different methods of wastewater treatment have been developed for reasons of public health and conservation which results in the destruction of pathogens and the mineralization of the organic components of sewage prior to discharge (Adesemoye *et al*., 2006). Such methods include anaerobic wastewater treatment using granular sludge reactor, aerobic lagoon, facultative ponds, etc. (Liu *et al*., 2002; Boadi and Kuitunen, 2003; USAID, 2006). However, in Nigeria, like many developing countries, the discharge of untreated wastewater into the environment is still a problem, despite the establishment of Federal Environmental Protection Agency (FEPA) since 1998 (Adeyemo, 2003).

MATERIALS AND METHODS

Study site: This study was carried out on Awba stream, University of Ibadan, Ibadan which is located in South-Western Nigeria between longitude 3°58'E and latitude 7°22'N. The altitude generally ranges from 15-21 m above mean sea level (Alawode, 2000). The stream flows from Sango through the institution and empties in Awba dam at the university. The dam provides an aesthetic value within the university and water is abstracted from the dam by the university water treatment plant for distribution of treated water to the residents on campus.

Sampling design: Water samples were collected at three different points along the stream using random grab sampling. Also, raw sewage samples were collected just before it joins the stream. Sampling was done three times from each of the points and all samples were collected in triplicate to improve reliability. Water samples were collected from the mid-width of the stream using 1 L plastic bottles that had previously been cleaned, soaked in 10% nitric acid and rinsed thrice with distilled water. Three 1 L samples were collected at each of the four sampling points designated A-D. The full description of sampling locations is shown in Table 1.

Analyses of wastewater samples for physico-chemical properties: Samples were analysed for the following physico-chemical parameters: hydrogen ion concentration, temperature, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and electrical conductivity. The samples pH were determined with a pH meter (Unicam, 9450, Orion Model No. 91-02). Temperature was measured with mercury thermometer immediately after sample collection. Gravimetric Method involving filtration and evaporation were used to measure the TSS. Methods recommended by APHA (1998) were followed for the measurement of BOD and COD. The electrical conductivity was determined using a conductivity meter (Metrohm 640, Switzerland).

Determination of bacteriological analysis: The indicator organisms rather than the viruses and pathogens were analysed. The total coliform group of bacterial was analysed using isolation of organisms in a sample and the media used for isolation was prepared from Nutrient Agar medium (NA) and Petatres Dextrose Agar (PDA) was used. The determination of minimum inhibitory concentration (m/c) as well as the Bactericidal/Bacteriostatic extraction effect was also included (Ademoroti, 2006).

Statistics: Laboratory analysis results were subjected to data analysis using SPSS, Version 12.0 to analyse changes in the levels of BOD, COD, TSS, pH and EC that might be attributed to sewage discharge into River Zik, One-way Analysis of Variance (ANOVA) at $p = 0.05$ was employed.

Table 1: Sampling location description

Designation	Characteristics
A	Sampling point for sewage just before it joins the stream
B	Sampling point located 10 m upstream with respect to sewage discharge point. It served as reference point
C	Sampling point at sewage discharge point
D	Sampling point located 10 m downstream from sewage discharge point

RESULTS AND DISCUSSION

Summary of the physico-chemical properties of analysed wastewater: The physico-chemical analyses results were presented in Table 2. All physico-chemical parameters analysed were statistically different for the stream before and after the impact at sampling points B and D, respectively except for the mean temperature (26±0.8°C at B and 26±0.2°C at D) and pH (6.04±0.2 at B and 6.05±0.1 at D).

Microbial population of the water samples: Mean values of faecal coliform counts, total coliform count and total aerobic count from the stream were statistically different at $p \leq 0.05$. The mean faecal coliform count (Fig. 1) for sampling point D (after the impact) was 2.2×10^2 cfu/100 mL and is statistically greater than that from sampling point B (before the impact) which was 1.1×10^2 cfu/100 mL. Similarly, the mean values of the total coliform counts (Fig. 2) were 1.2×10^5 and 3.1×10^5 cfu/100 mL, before and after the impact, respectively. Also, the mean values of the total aerobic counts (Fig. 3) were 6.3×10^6 and 8.2×10^6 cfu/100 mL before and after the sewage discharge, respectively. All these are indications of human feacal contamination which could be harmful to consumers or user of such water down stream if the microbial contaminants are not treated before usage. The mean values of faecal coliform count, total coliform count and total aerobic count (Fig. 1-3) were higher after the impact of sewage discharge on the stream. Also, the result showed that the values of these microbial parameters were high at point B, before the impact (1.1×10^2, 1.2×10^5 and 6.3×10^6 cfu/100 mL). This indicates that the stream may have been contaminated upstream by non-point pollution sources such as domestic wastewater and agricultural wastes. This was however, aggravated by the sewage wastewater. Going by international standard, any water contaminated to this level is neither good for domestic use nor is it supposed to be discharged directly into the environment without treatment (Adesemoye *et al*., 2006).

The presence of fecal coliform in a stream may indicate recent contamination of the surface water by human sewage or animal droppings which could contain other bacteria, viruses or disease causing organisms. The organisms isolated include *Bacillus*, *Micrococcus*, *Proteus*, *Flavobacterium*, *Pseudomonas* sp. and *E. coli* (Table 3). Their presence warns of the potential presence of human pathogenic organisms and should alert the person responsible for the water to take precautionary action. For example, *E. coli* may contain other harmful bacteria, viruses or parasites such as Giardia, the cause of beaver fever.

Table 2: Physico-chemical properties of sewage and water samples

	Sampling points			
Parameters	A	B	C	D
Colour	Pale brown	Pale brown	Pale amber	Colorless
Appearance	Turbid	Turbid	Turbid	Clear
Temperature	27±0.7	26±0.8	27±1.1	26±0.2
pH	6.05±0.2	6.04±0.2	6.04±0.2	6.05±0.1
Conductivity (µS/cm)	1934±15.9	435.5±3.2	1905.25±9.5	741.13±5.1
Turbidity (NTU)	193±2.3	158±2.0	134±1.9	93±1.2
TSS	1417.5±21.4	1510.63±217.2	2476.88±21.2	1838.75±81.5
BOD	1150±32.5	36±1.8	954.5±16.7	733±35.2
COD	2153.25±43.0	66±1.9	1839±34.3	1150±39.2

All parameters are in mg/L except where stated. Values are means of three repeated sampling of three replicates each

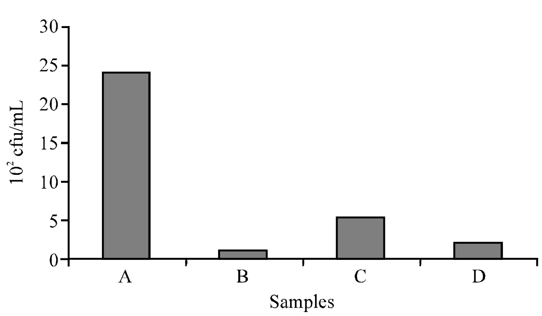

Fig. 1: Mean of faecal coliform count at the sampling points

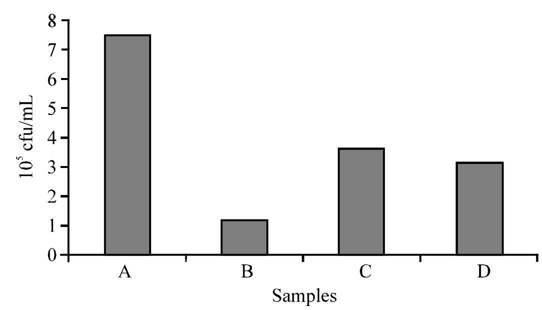

Fig. 2: Mean of total coliform count at the sampling points

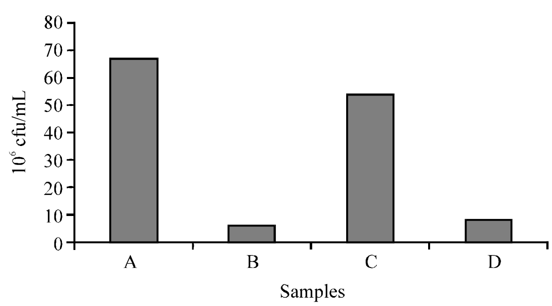

Fig. 3: Mean of total aerobic count at the sampling points

Table 3: Microbial isolates from the samples

	Organisms isolated from the samples			
Microbes	A	B	C	D
Faecal coliform count	*Enterobacter* sp.	*Enterobacter* sp.	*Enterobacter* sp.	*Enterobacter* sp.
Total aerobic count	*Bacillus*, *Micrococcus*, *Proteus*, *Flavobacterium* and *Pseudomonas* sp.	*Bacillus*, *Micrococcus*, *Pseudomonas*, *Proteus* and *Flavobacterium* sp.	*Bacillus*, *Micrococcus*, *Proteus* and *Flavobacterium* sp.	*Bacillus*, *Micrococcus*, *Pseudomonas* and *Proteus* sp.
Total coliform count	*Aeromonas*, *Enterobacter*, *Proteus* sp. and *E. coli*	*Aeromonas*, *Enterobacter*, *Proteus* and *Klebsiella* sp.	*Aeromonas*, *Enterobacter*, *Proteus* sp. and *E. coli*	*Aeromonas*, *Enterobacter*, *Proteus* sp. and *E. coli*

Drinking and recreational waters contaminated with these organisms can cause stomach and intestinal illness including dysentery, gastroenteritis, hepatitis A, diarrhea and nausea and even lead to death (Metcalf and Eddy, 2003). These effects may be more severe and possibly life threatening for babies, children, the elderly or people with immune deficiencies or other illnesses.

The pH of the water samples was slightly acidic, ranging from 5.8-6.2. However, a pH near 7.0 (neutral) plays a part in determining both the qualitative and quantitative abundance of microbes (Fedorov *et al*., 1993; Edwards, 1990). It could be inferred then that more hydrogen ion became available; lowering the pH value of contaminated water and affecting the pattern of microbial population. This can be corroborated by the report of Nazina *et al*. (2002) that abundance and activity of microorganisms are controlled by the availability of water, nutrients, pH, concentration of metal ions, etc.

Total coliform bacterial population obtained from the contaminated water was more than that in the water without sewage wastewater contamination. This could be regarded as destabilization of the aquatic ecological balance arising from contamination. Environmental stresses brought about by the contamination could be adduced for the reduction in microbial species diversity but increasing the population of few surviving species. A possible explanation on what transpired leading to the change in population pattern is that the organisms in the wastewater and organisms autochthonous to the stream engaged in competition and other negative microbial interactions such as antibiosis after the sewage was discharged into the stream. Guided by the law of survival of the fittest (Madigan *et al*., 2003) those that were not able to survive the new conditions were probably excluded. Similar to a earlier study (Adesemoye *et al*., 2006), less diversity of bacteria but increase in population of surviving species was observed in this study. Higher population of aerobic bacteria observed in the contaminated stream (Fig. 3) possibly had more of bacteria that were able to withstand acidic conditions. Changes in the aquatic ecosystem have been observed by different researchers but one germane question is how long such changes can persist. Researchers believe the duration depends on many factors but the type, quantity or concentration of the contaminant and the level of toxicity are very important.

High level of contamination of the sewage wastewater as revealed in this study, further confirmed the dangers associated with discharging untreated wastewater to the environment, thus the need for adequate treatment to ensure decontamination.

CONCLUSION

This study examined the extent of contamination in untreated sewage wastewater and the impact on the ecology of microorganisms in the receiving surface water with the aim of re-awakening concerned authorities and other stakeholders involved in standards and regulations.

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