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Impacts of Physico-chemical parameters of effluent from Wupa Sewage Treatment Plant on Enteropathogens of Surrounding Water Body

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Abstract: This study on the impacts of physico-chemical parameters of effluent from wupa sewage treatment plant on enteropathogens of surrounding water body was conducted, and a total of fifteen (15) water samples were collected from Wupa river, with five (5) each from the upstream, downstream and point of effluent discharge into the river and screened for the presence of enteropathogens and then analysed for physio-chemical parameters using standard laboratory procedures. The isolation of enteropathogens associated with effluent from wupa sewage treatment plant samples was also determined using the spread plate technique. The point of effluent discharge had higher temperature of 24.70±0.71 ^{o}C than the upstream (24.60±1.42 ^{o}C) and downstream (24.20±1.02 ^{o}C) respectively. Similarly, at the point of effluent discharge to the River, the nitrate (1.70±0.28mg/l), phosphate (0.12±0.02mg/l) and chloride (11.10±2.3mg/l), turbidity (29.44±4.60), total dissolved solid (16.00±2.69mg/l), conductivity (125±14.21 µS/cm), chemical oxygen demand (25±1.00mg/l), and biochemical oxygen demand (1.89±0.33mg/l) was lower than that of the upstream and downstream respectively while the pH was the same with that of the upstream pH (7.40±0.03). Results of the total aerobic bacterial loads upstream ranged from 1.06×10^{9}±0.20 Cfu/ml to 1.23×10^{9}±0.21 Cfu/ml while the coliform ranges from 2.65×10^{8}±0.21 Cfu/ml to 2.9×10^{8}±0.28 Cfu/ml. However, the total aerobic bacterial loads at the point of effluent discharge to the River range from 8.20×10^{8}±0.28 Cfu/ml to 9.40×10^{8}±0.22 Cfu/ml while the coliform ranges from 2.10×10^{7}±0.11 Cfu/ml to 2.40×10^{7}±0.14 Cfu/ml. The downstream of wupa river recorded the highest number of enteropathogens with seven (7) bacteria which include *Escherichia coli*, *Salmonella enterica*, *Salmonella typhimurium*, *Proteus mirabilis*, *Klebsiella pneumonia*, *Enterobacter cloacae* and *Oblitimonas alkaliphila*. Maximum of five (5) enteropathogens were isolated from the point of effluent discharge to the river and they include *Escherichia coli*, *Salmonella typhimurium*, *Proteus mirabilis*, *Klebsiella pneumonia*, and *Oblitimonas alkaliphila*. Similarly, the maximum of five (5) enteropathogens were also isolated from the Upstream station of Wupa River before discharge point and they include *Escherichia coli*, *Salmonella enterica*, *Proteus mirabilis*, *Klebsiella pneumoniae* and *Enterobacter cloacae* respectively as represented in Figure 1. *Escherichia coli* was the most frequently isolated bacteria which represented 25.64%, followed by five *Salmonella* species which represented 23.08% of the total isolates. *Proteus mirabilis* was eight (8) (20.51%) while *Klebsiella pneumoniae* recorded 15.38% and *Enterobacter cloacae* isolated was 10.26%, whereas *Oblitimonas alkaliphila* recorded 5.13 % being the least number of isolated bacteria. It can be concluded from this study that, there was positive correlation between the physic-chemical parameters of effluent from wupa sewage treatment plant and the enteropathogens of surrounding water body. Therefore the need for proper treatment, management and monitoring of the effluent before discharged into surrounding water body.
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1.0 INTRODUCTION

It is a well-known fact that man has dominated the planet for decades and with constantly increasing population numbers, hydrological variability and rapid urbanization coupled with the need for greater socio-economic development, man will continue to play an ever increasing dominant role (WHO, 2018). In addition, obtaining a global perspective of surface water quality has become increasingly difficult as different nations struggle with different environmental pressures, more so in developing countries where available resources are limited. One such visible example is the increasing volume and pressure on existing wastewater treatment plants

together with surrounding inefficient hygiene practices and exacerbated nutrient and microbiological loads constantly entering receiving river systems and water supplies. Increased pressure on existing infrastructure coupled with the use of outdated guidelines for treated effluent has further compounded these issues. This has ultimately resulted, not only in an increase in waterborne diseases but also an increase in waterborne-disease-related deaths (Tchobanoglous *et al*., 2012; Coetzee, 2013).

Increasing pressure on existing wastewater treatment plants has led to the discharge of inadequately treated effluent, reinforcing the need to improve and adopt more stringent methods for monitoring discharged effluent and surrounding water sources (Barrell *et al*., 2010). The quality of effluent varies according to the types of influents the WWTFs receive such as domestic wastewater, dry and wet atmospheric deposition, urban runoff containing traffic related pollution, or agricultural runoff (Momba *et al*., 2010; Ratola *et al*., 2012). The contaminants in effluent are removed by physical, chemical and biological treatment processes in municipal treatment plants. Each phase include a range of unit operations and processes that have a certain valuable function. This study therefore evaluates the impacts of physico-chemical parameters of effluent from wupa sewage treatment plant (WSTP) on enteropathogens of surrounding water body.

2.0 Materials and Method

2.1 Study Area

This study was carried out at Wupa Abuja sewage treatment plant and the Microbiology laboratory of University of Abuja, Gwagwalada Federal Capital Territory, Abuja.

2.2 Sample Collection

A total of 15 effluent samples were collected from Wupa Abuja sewage treatment plant with five (5) random samples each from three (3) different points. The samples were collected from the point of discharge into Wupa River, upstream of Wupa River (20 meter from the point of discharge) and downstream of Wupa River (50 meters from the upstream). The samples were collected aseptically, using sterile universal bottles and transported in an ice-cold container to the Microbiology Laboratory of the University of Abuja for the assessment. The samples were analyzed on the day of collection as described by Kulikov *et al*. (2015) with some modifications.

2.3 Determination of Physicochemical Parameters of the Samples

2.3.1 Colour of the Samples

The colour of the samples was measured using a colorimeter as described by APHA (2017) thus; 10 ml of the sample was poured into cuvette and then inserted into the machine and the colour equivalent of the reading was noted.

2.3.2 Odour of the Samples

Odour was carried out according to Muazu *et al.* (2012) thus; about 20 mL volume of each effluent sample was poured into a clean beaker, followed by vigorous shaken and then brought close to the nose to determine the odour.

2.3.3 Turbidity of the Samples

The turbidity was carried out as described by APHA (2017). A 10 ml portion of deionised water was poured into a cuvette which was used to standardize the spectrophotometer and then 10 ml of each sample was poured into other cuvette which was inserted into the spectrophotometer and the reading was noted and recorded at 430 nm on turbidity meter. The average of the readings was recorded in NTU.

Turbidity measurement from UV-Vis data is given as:

Turbidity = (2.3Xa) / L

Where A = the absorbance and

L= the optical path length

2.3.4 Temperature

About 50 ml of each sample was poured into a beaker and the temperature was determined using a thermometer by inserting the thermometer into a depth of about 30 ml in each sample. The temperature was determined at the sample location.

2.3.5 Determination of pH

The pH of each sample was determined by the potentiometric method (APHA, 2017) using a digital pH meter. Thirty milliliter of the sample was transferred to a clean 100 ml beaker\ and the electrode was immersed into the beaker containing the sample and meter reading was recorded. The pH was determined at the sample location.

2.3.6 Determination of Electrical Conductivity (EC)

The electrical conductivity of each sample was determined following the procedure outlined by Joshi and Santani (2012). Electrical conductivity is the measurement of total amount of soluble salts present in the sample and is expressed as millisimens/cm (mS/cm). About 50 ml of each sample was allowed to settle for 8 hrs. The electrode of the conductivity cell was then immersed into the sample solution and the EC was read and expressed in millisimens/cm (mS/cm).

2.3.7 Total hardness of the Samples

Total hardness of the sample was carried out as described by APHA (2017). Twenty-five milliliter of the effluent sample and 25 ml of distilled water were transferred into 250 ml conical flask, and then 2 ml of phosphate buffer solution and 0.1g of Errochrome black dye was added, which was titrated with 0.02 M

ethylenediamine tetra acetic acid (EDTA). The total hardness was calculated as show below.

Total hardness (mg/l) =

$$\frac{\text{Volume of EDTA x N x 50 x 1000}}{\text{Sample volume}}$$

Where N= normality of EDTA

2.3.8 Chloride of the Samples

One hundred milliliter of the effluent sample was transferred into 250 ml conical flask, two to three drops of potassium chromate were added and the content was swirled for a few minutes which was then titrated against 0.0141 N silver nitrate solution until dirty reddish precipitate was obtained (APHA, 2017). Chloride ion concentration was calculated thus:

Chloride Ion Concentration (mg/L) =

$$\frac{(A \times N \times 35450)}{\text{Volume of sample}}$$

Where: A = volume of titrant used

N= normality of silver nitrate

2.3.9 Sulphate of the Sample

Twenty five milliliters of the effluent sample and 25 ml of distilled water was transferred into 250 ml conical flask. One gram of barium chloride ($BaCl_2$) was added, stirred and allowed to stand for 30 minutes. The colour intensity was then measured at 430nm on colorimeter (APHA, 2017).

2.3.10 Nitrate of the Samples

One hundred milliliters of effluent sample was poured into a clean dry crucible and kept in an oven at 100 ^oC till dryness. It was removed and allowed to cool after which 2 ml of phenol disulphoric acid was added and swirled round uniformly, after 10 minutes, 10ml of distilled water was added in which 5ml of ammonia solution was also added and the colour change was read at 430nm on colorimeter (APHA, 2017).

2.3.11 Phosphate of the Samples

One hundred milliliters (100 ml) of the effluent sample was transferred into a 250 ml conical flask, 1ml of ammonium molybdate reagent and 1 drop of stannous chloride was added which was then allowed to react for 12 minutes and the colour change was read at 600 nm (APHA, 2017).

2.3.12 Determination of Biochemical Oxygen Demand

The determination of BOD was done according to the method of Kwak *et al*. (2013). About 300 ml of the effluent sample was taken into BOD bottle and sterile air was blown in for 10 min and then incubated in the dark at 20 ^oC for 5 days prior to test. Two (2) ml of $MnSO_4$ and 2 ml of alkaline iodine-sodium azide solution (dissolve 500 g of sodium hydroxide (NaOH) or 700 g of potassium hydroxide (KOH) and 135 g of sodium iodide (Nai) or 150 g of potassium iodide (KI) in distilled water and dilute to 1 liter. To this solution add 10 g of sodium azide (NaN3) dissolved in 40 mL of distilled water) was added to each BOD bottle. Stoppers were placed and air bubbles expelled by inverting bottle several times. Bottles were left for precipitation and then 2 ml of H_2SO_4 was also added and mixed by inverting the bottles until iodine becomes uniformly distributed. Three drops of starch indicator were added to 2 ml sample and then titrated with 0.025M $Na_2S_2O_3$ until the blue colour disappears. Volume of $Na_2S_2O_3$ was used to calculate BOD (Kwak *et al*., 2013) as follows:

$$BOD = \frac{D_1 - D_2}{P}$$

D_1= Initial dissolvedO_2 concentration

D_2= Final or 5-day dissolved O_2 concentration

P= Volumetric fraction of water sample

2.3.13 Determination of Chemical Oxygen Demand

The determination of COD was done according to Kwak *et al*. (2013). Twenty milliliter of each sample was pipetted into 250 ml of refluxing flask. Approximately 400 mg mercuric sulphate was added and 10 ml of potassium dichromate was also added. About 30 ml of concentrated sulphuric acid was carefully added to the mixing sample. After the colour changed to green, it was then diluted and the procedure was repeated for the diluted sample and then reflux for 2hrs at 150 ^oC in a reflux flask connected to the condenser. About 30 ml of water was added to the condenser to cool the sample to room temperature and then titrated with standard sulphate using 3 drops of ferroin indicator. The end point sharp colour change from blue-green to brick red was observed which later return to blue-green after few minutes. A blank with 20 ml of distilled water was reflux in the same manner and the same procedure was followed (Kwak *et al*., 2013) and the COD was calculated thus:

COD = (B-A) x N x 3000 x V

Where A= Titre value of sample

B= Titre value of blank

N= Normality

V= Volume of sample

2.3.14 Total Dissolved Solid

About 50 ml of effluent sample was transferred to a clean and pre-weighed evaporating dish and evaporated to dryness in an oven at 180 ^oC. The dish was then cools in a desicator to an ambient temperature and re-weighted (APHA, 2017). The TDS was calculated thus:

Total Dissolved Solid (mg/litre)=

$$\frac{\text{Final weight of dish- Inirial weight of dish x } 10^6}{\text{Sample volume}}$$

2.4 Preparation and Sterilization of Media

The sterilization of glass ware such as conical flasks, beaker and test tubes after washing with detergent were carried out in hot air oven at 160 ºC for 2 hours. The media used in this study include: Nutrient agar (Oxoid), MacConkey agar (Oxoid), Salmonella-Shigella agar (Himedia) and Eosin Methylene Blue (EMB) agar (Himedia). The media were prepared according to their manufacturers' instructions.

2.5 Assessment of Enteropathogens in Effluent from WSTP on the Surrounding Water Body

The isolation of enteropathogens associated with effluent from wupa sewage treatment plant samples was determined using the spread plate technique according to Tassadaq *et al*. (2013). One milliliter (1 ml) of the sewage effluent and Wupa river samples were aseptically transferred into separate 10 ml of sterile distilled water as the stock culture. Ten fold serial dilutions of the stock sample were made using sterile water as diluents. Then 1.0 ml of the dilution sample was aseptically pipetted into a sterile test tube containing 9.0 ml of sterile distilled water. The content was mixed thoroughly. Other ten-fold dilutions were similarly made up to 10^{-6}, and some 0.1 ml were inoculated on the Nutrient agar (10^{-6}) and Mac Conkey Agar (10^{-3}) respectively using the spread plate method according to Cheesebrough (2006). The plates were allowed to stand undisturbed for about 15 minutes and then incubated at 37 ^{0}C for 24 hours. The numbers of colony forming units were counted using a colony counter and the colonial density was calculated as the colony forming unit (CFU) multiplied by the dilution factor. The mean total count obtained were recorded and expressed in colony forming units per milliliter (Cfu/ml) of the sample.

2.6 Preparation of Pure Cultures of Isolated Bacteria

Representatives of each colony type (that is discrete colonies) on Mac Conkey Agar were aseptically transferred to freshly prepared sterile Salmonella-Shigella Agar and Eosine Methylene Blue Agar respectively to obtain pure cultures. The pure cultures weree maintained on nutrient agar slants and stored at 4 ºC for biochemical test (Cheesebrough, 2006). Purification was done by repeated subculturing.

2.7 Identification of Bacteria Isolates

Identifications were done on the basis of microscopy, gram-staining, biochemical tests, and morphological characteristics through macroscopic features (Cheesebrough, 2006; Ravea *et al*., 2019). The biochemical characteristics used were catalase test, oxidase test, urease test as well as IMViC test (citrate utilization test, indole test, methyl red and voges-proskauer test).

2.8 Determination of frequencies of occurrence

The frequency of occurrence of isolated bacteria associated with the Wupa Abuja sewage treatment effluent were determined using descriptive statistics. The sum of all the numbers of Cfu/ml of the organisms in each sample and the percentage were calculated thus:

$$\frac{\text{Number of each Isolates}}{\text{Total number of Isolates}} \times 100$$

2.9 Statistical Analysis

Data obtained in this study were analyzed using Analysis of Variance (ANOVA) from Ms Excel Statistics and the test applied were F-test statistic at $p < 0.05$.

3.0 Results

3.1 Physico-chemical Parameters

Table 1 shows the physico-chemical parameters of the Wupa sewage treatment plant. The water quality parameters include temperature, pH, turbidity, conductivity, biochemical oxygen demand, chemical oxygen demand, total dissolved solid, nitrate, phosphate and chloride contents. The point of effluent discharge had higher temperature of 24.70±0.71 ºC than the upstream (24.60±1.42 ºC) and downstream (24.20±1.02 ºC) respectively.

Similarly, at the point of effluent discharge to the River, the nitrate (1.70±0.28mg/l), phosphate (0.12±0.02mg/l) and chloride (11.10±2.3mg/l), turbidity (29.44±4.60), total dissolved solid (16.00±2.69mg/l), conductivity (125±14.21 µS/cm), chemical oxygen demand (25±1.00mg/l), and biochemical oxygen demand (1.89±0.33mg/l) was lower than that of the upstream and downstream respectively while the pH was the same with that of the upstream pH (7.40±0.03).

Table 1: Physico-chemical Parameters of the effluent from Wupa Sewage Treatment Plant and Surrounding Water Body

Water Quality Parameters	UPS	DSS	PED
Temperature (^{0}C)	24.60±1.42^a	24.20±1.02^a	24.70±0.71^a
Conductivity (µS/cm)	170±11.69^b	168±17.23^b	125±14.21^b
BOD (mg/L)	7.0±0.10^a	10.0±1.19^a	1.89±0.33^a
pH	7.40±0.04^b	7.30±0.01^a	7.40 ± 0.03^b
COD (mg/1)	38±1.00^a	31±2.00^a	25±1.00^a
TDS (mg/1)	25.00±2.69^b	27.00±2.36^b	16.00±2.69^b
Turbidity (NUT)	135.10±11.15^a	157.10±31.96^a	29.44 ± 4.60^a
NO_3^- (mg/1)	2.23 ± 0.21^b	2.10 ± 0.18^b	1.70 ± 0.28^b
PO_4^{3-} (mg/1)	0.17 ± 0.02^a	0.14 ± 0.02^a	0.12 ± 0.02^a
Cl^- (mg/1)	29.13 ±3.37^b	28.94±2.40^b	11.10±2.23^b

Values are mean± standard deviation of triplicate determinations.
UPS = Upstream station of Wupa River before discharge point,
DSS = Downstream of Wupa river after effluent discharge point
PED = Point of Effluent discharge to the River.
Means with the same superscript are not significantly different (P>0.05).
Keys: BOD= Biochemical Oxygen demand
COD= Chemical Oxygen Demand
TDS= Total Dissolve Oxygen
NO_3^- = Nitrate
PO_4^{3-} = Phosphate
Cl^- = Chloride
^{a} = superscript
^{b}= superscript.

3.2 Microbial Density of Effluent from Wupa Sewage Treatment Plant on the Surrounding Water Body

Table 2 showed the total aerobic bacteria loads and the coliforms of effluent from Wupa sewage treatment plant on the surrounding water body. The total aerobic bacterial loads in upstream station of Wupa River before discharge point showed that, the resulting colonies range from 1.06×10^9±0.20 Cfu/ml to 1.23×10^9±0.21 Cfu/ml while the coliform ranges from 2.65×10^8±0.21 Cfu/ml to 2.9×10^8±0.28 Cfu/ml as seen in Table 4.2. Similarly, the total aerobic bacterial loads in downstream of Wupa river after effluent discharge point showed that, the resulting colonies range from 1.40×10^9±0.30 Cfu/ml to 1.80×10^9±0.21 Cfu/ml while the coliform ranges from 2.60×10^8±0.22 Cfu/ml to 2.80×10^8±0.28 Cfu/ml. However, the total aerobic bacterial loads at the point of effluent discharge to the River showed that, the resulting colonies range from 8.20×10^8±0.28 Cfu/ml to 9.40×10^8±0.22 Cfu/ml while the coliform ranges from 2.10×10^7±0.11 Cfu/ml to 2.40×10^7±0.14 Cfu/ml as shown in Table 2.

Table 2: Total Aerobic Bacteria Loads and Coliforms of Effluent from Wupa Sewage Treatment Plant on the Surrounding Water Body

Sample locations	Microbial Density (CFu/mL)	
	Total aerobic bioloads	Coliform loads
UPS		
1	$1.06 \times 10^{9} \pm 0.20^{a}$	$2.65 \times 10^{8} \pm 0.21^{a}$
2	$1.15 \times 10^{9} \pm 0.14^{a}$	$2.8 \times 10^{8} \pm 0.14^{a}$
3	$1.23 \times 10^{9} \pm 0.21^{b}$	$2.9 \times 10^{8} \pm 0.28^{a}$
4	$1.10 \times 10^{9} \pm 0.20^{b}$	$2.7 \pm \times 10^{8} 0.14^{b}$
5	$1.11 \times 10^{9} \pm 0.14^{a}$	$2.85 \times 10^{8} \pm 0.07^{b}$
DSS		
1	$1.02 \times 10^{9} \pm 0.28^{b}$	$2.70 \times 10^{8} \pm 0.04^{a}$
2	$1.40 \times 10^{9} \pm 0.30^{b}$	$2.80 \times 10^{8} \pm 0.28^{a}$
3	$1.10 \times 10^{9} \pm 0.14^{a}$	$2.60 \times 10^{8} \pm 0.22^{b}$
4	$1.06 \times 10^{9} \pm 0.22^{b}$	$2.75 \times 10^{8} \pm 0.10^{a}$
5	$1.80 \times 10^{9} \pm 0.21^{a}$	$2.70 \times 10^{8} \pm 0.22^{b}$
PED		
1	$8.30 \times 10^{8} \pm 0.14^{a}$	$2.10 \times 10^{7} \pm 0.11^{a}$
2	$8.60 \times 10^{8} \pm 0.28^{a}$	$2.20 \times 10^{7} \pm 0.16^{b}$
3	$9.40 \times 10^{8} \pm 0.22^{a}$	$2.40 \times 10^{7} \pm 0.14^{b}$
4	$9.10 \times 10^{8} \pm 0.14^{b}$	$2.30 \times 10^{7} \pm 0.00^{a}$
5	$8.20 \times 10^{8} \pm 0.28^{b}$	$2.20 \times 10^{7} \pm 0.21^{a}$

Values are means ± standard deviation of triplicate values.
Keys: UPS= Upstream station of Wupa River before discharge point, DSS=Downstream of Wupa river after effluent discharge point
PED= Point of Effluent discharge to the River
^{a} = superscript
^{b}= superscript. Mean with the same superscript are not significantly different (P>0.05).

3.3 Identification of Isolated Enteropathogens

Table 3 showed the morphological characteristics and biochemical features of the isolated enteropathogens from Wupa sewage treatment plant effluent on the surrounding water body. Isolates obtained were identified on the basis of microscopy, biochemical tests, and morphological characteristics through macroscopic features. Among the characteristics used are: colonial characteristics such as size, surface appearance, texture and colour of the colonies.

Table 3: Biochemical Characteristics of Isolated Enteropathogens from Wupa Sewage Treatment Plant Effluent and the Surrounding Water Body

Isolates	Biochemical Tests										Probable Organisms
	Shape	Surface	GR	IN	CI	OX	CA	UR	MR	VP	
A1	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
A2	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
A3	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
A4	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
A5	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
A6	Rod	Mucoid	-	-	+	-	+	-	-	+	*Klebsiella* spp
B1	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
B2	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
B3	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
C1	Rod	Smooth	-	-	-	+	+	-	-	-	*Oblitimonas* spp
C2	Rod	Smooth	-	-	-	+	+	-	-	-	*Oblitimonas* spp
D1	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
D2	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
D3	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
D4	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
D5	Rod	Smooth	-	-	+	-	+	+	+	-	*Proteus* spp.
E1	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
E2	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
E3	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
E4	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
E5	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
F1	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
F2	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
F3	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
F4	Rod	Smooth	-	-	+	-	+	-	-	-	*Salmonella* spp.
G1	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G2	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G3	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G4	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G5	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G6	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G7	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G8	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G9	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
G10	Rod	Smooth	-	+	-	-	+	-	+	-	*Escherichia coli*
H1	Rod	Smooth	-	-	+	-	+	-	-	+	*Enterobacter* spp
H2	Rod	Smooth	-	-	+	-	+	-	-	+	*Enterobacter* spp
H3	Rod	Smooth	-	-	+	-	+	-	-	+	*Enterobacter* spp
H4	Rod	Smooth	-	-	+	-	+	-	-	+	*Enterobacter* spp

Key: GR=Gram reaction, IN= Indole, CI= Citrate, OX= Oxidase, CA= Catalase test, MR=Methyl red, VP=Voges-Proskauer, A= Isolate A, B= Isolate B, C= Isolate C, D= Isolate D, E= Isolate E, F= Isolate F, G= Isolate G, H= Isolate H.

3.5 Enteropathogens Associated with Effluent and Surrounding Water Body

The results of the frequency of occurrence of the isolated bacteria are shown in Figure 1. The downstream of wupa river recorded the highest number of enteropathogens with seven (7) bacteria which include *Escherichia coli, Salmonella enterica, Salmonella typhimurium, Proteus mirabilis, Klebsiella pneumonia, Enterobacter cloacae* and *Oblitimonas alkaliphila*. Maximum of five (5) enteropathogens were isolated from the point of effluent discharge to the river and they include *Escherichia coli, Salmonella typhimurium, Proteus mirabilis, Klebsiella pneumonia,* and *Oblitimonas alkaliphila*. Similarly, the maximum of five (5) enteropathogens were also isolated from the Upstream station of Wupa River before discharge point and they include *Escherichia coli, Salmonella enterica, Proteus mirabilis, Klebsiella pneumoniae* and *Enterobacter cloacae* respectively as represented in Figure 1. *Escherichia coli* was the most frequently isolated bacteria which represented 25.64%, followed by five *Salmonella* species which represented 23.08% of the total isolates. *Proteus mirabilis* was eight (8) (20.51%) while *Klebsiella pneumoniae* recorded 15.38% and *Enterobacter cloacae* isolated was 10.26%, whereas *Oblitimonas alkaliphila* recorded 5.13 % being the least number of isolated bacteria as seen in Figure 1.

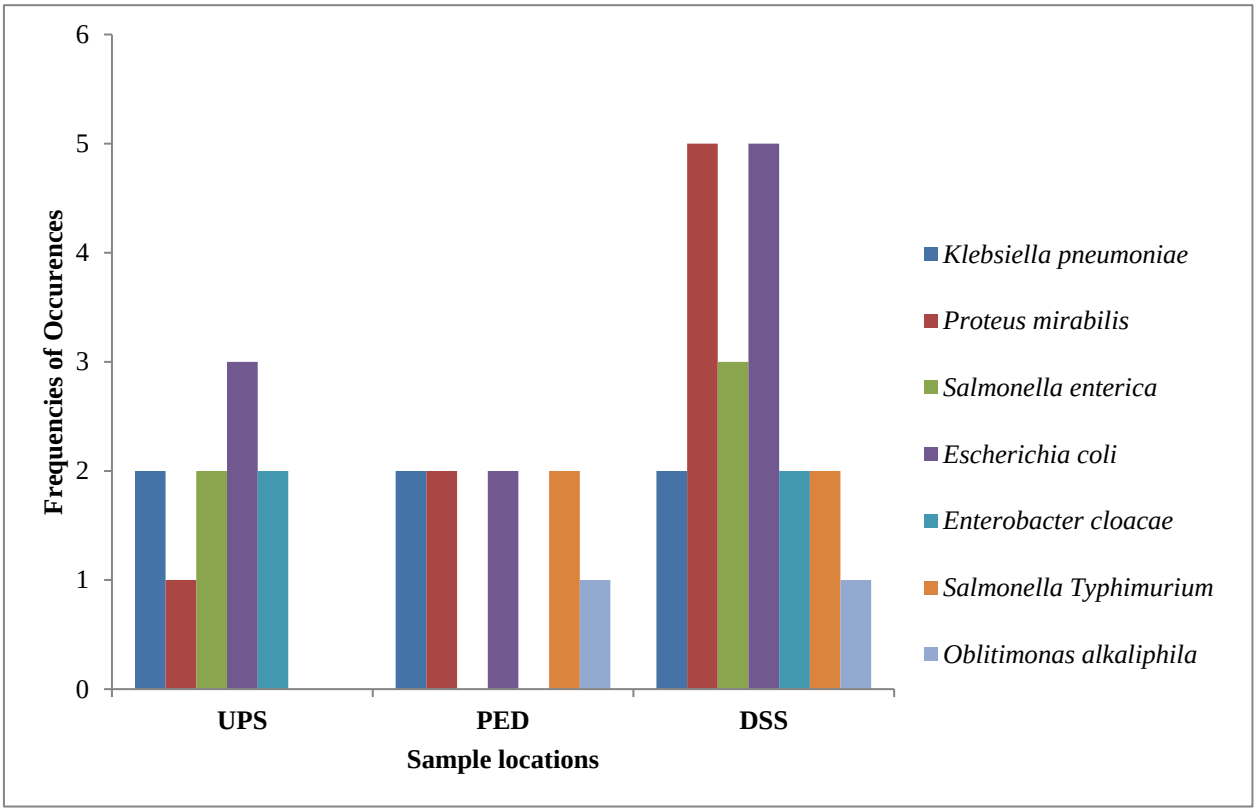

Figure 1: Frequencies of Occurrences of Enteropathogens of Wupa Sewage Treatment Effluent and Surrounding Water Body

Keys: UPS= Upstream station of Wupa River before discharge point,
DSS=Downstream of Wupa river after effluent discharge point
PED= Point of Effluent discharge to the River.

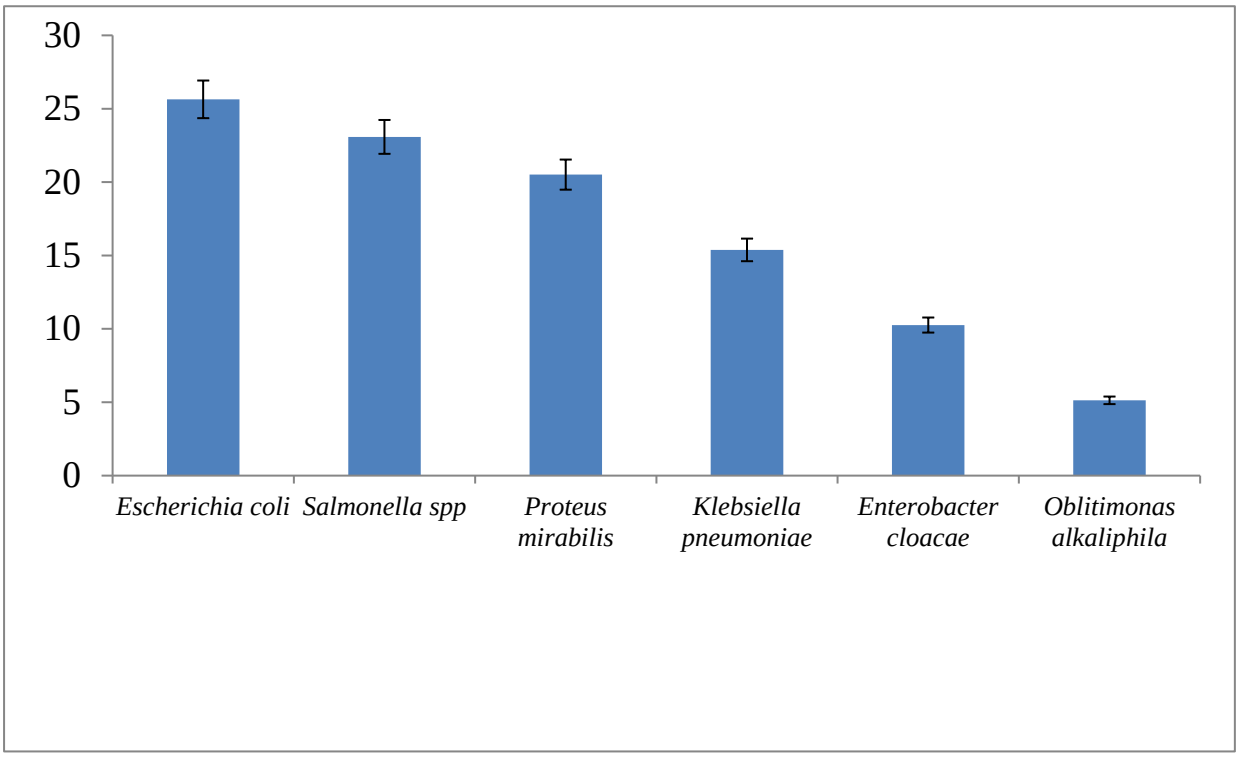

Figure 2: Percentage of Occurrences of Isolated Bacteria Enteropathogens From Wupa Sewage Treatment Plant Effluent and Surrounding Water Body

4.0 Discussion

With the tremendous increase in both human population and activities in Federal Capital Territory, Abuja, the Federal Government have long developed sewage treatment plant for treating sewage water and then redirecting the treated effluents into freshwater body in other to reduce human vulnerability to pathogenic bacteria. This study revealed that the pH for the upstream and discharged effluent was 7.40 while downstream was 7.30 which is in agreement with the WHO (2013) report for the Drinking Water Quality Standard, that pH of drinking water has to be in the range of 6.5-9.0. It is because, for pH more than the range could cause irritation and worsen the skin condition. This is also in agreement with Miskiah *et al*. (2018) report that the pH range of riverbank was between 7.3 - 7.5. It appears from this study that, the conductivity of the effluent was lower than the conductivities of upstream and downstream. High pH increased the ionic concentration of effluent, thus the conductivity of effluent was increased. The mean conductivity of effluent, 125 µS/cm is in agreement with World Health Organization (WHO) limit for conductivity (1250 µS/cm). In this study, the chemical oxygen demand (COD) of upstream and downstream of wupa River were significantly higher than that of the treated sewage effluent throughout the study period. This was probably because the effluent contained small quantities of organic and inorganic contents, thus lower concentration of dissolved oxygen was needed for decomposition of the organic matter. The effluent COD range of 25 ± 1.00 mg/l is within the World Health Organization limit for effluent which is 100 mg/l. There was a significant difference between the COD of upstream and downstream of wupa River and the treated sewage effluent ($P < 0.05$).

The biochemical oxygen demand (BOD) of both the upstream and downstream was significantly different from that of the effluent ($P < 0.05$). This was probably because the effluent contained small quantity of organic content, thus lesser concentration of dissolved oxygen would be needed for the decomposition of organic matter. The effluent, 1.9 ± 0.3 mg/l is within the World Health Organization (WHO) limit for effluent BOD (30 mg/l). The TDS values of the effluent (16.0 ± 2.7 mg/l) agreed with the requirement for TDS values according to the National Guidelines of the Federal Ministry of Environment (2013) which states that TDS value of effluent should not be greater than 2000 mg/l. This showed that the effluent was fairly safe to be

discharged. Turbidity value exceeded Drinking Water Quality Standard which is the permissible limit of 5 NUT. The higher value was recorded during the rainy season due to increasing of river water flow rate and also the runoff from heavy rains because runoff can introduce large amount of solids from land surface into the water. The high turbidity may have interfered with the disinfection process thereby provide a medium for microbial growth.

It appears from this study that a total of thirty-nine (39) enteropathogens belonging to six bacteria genera and six species were isolated from this study. The bacteria isolates from this study belong to the genera of potential pathogenic bacteria and they include *Escherichia coli*, *Salmonella enterica*, *Salmonella typhimurium*, *Proteus mirabilis*, *Klebsiella pneumonia*, *Enterobacter cloacae* and *Oblitimonas alkaliphila*.

The isolation of these organisms is of great health concern because this domestic wastewater effluent was collected at the point of discharge into a nearby river, which may not only serve as a source of drinking water to the immediate community but also as a source of food (that is, through fishing) and its used for other domestic purposes. According to Ugoh *et al*. (2013), *Escherichia coli* and *Salmonella* spp are associated with water borne diseases and reports from available health outposts in the areas in which this study was carried out revealed typhoid fever, dysentery, cholera and hepatitis to be the most prevalent (Ashbolt, 2014).

Physicochemical parameters' values except TDS were within the permissible limits of World Health Organisation (WHO), Federal Environmental Protection Agency (FEPA) and the National Guidelines of Federal Ministry of Environment (FMEnv). The isolation of enteropathogens which include *Escherichia coli*, *Salmonella typhimurium*, *Proteus mirabilis*, *Klebsiella pneumoniae*, and *Oblitimonas alkaliphila* from the effluent discharged point to the river as well as the downstream site of the wupa River in this study is an indication that although, sewage treatment reduced the pathogens, but does not guarantee the complete elimination of pathogenic bacteria.

4.1 Conclusion

Based on the findings of this study, there is an urgent need for appropriate steps to be taken for proper management and sanitation of the effluent such as addition of chlorine before discharging it to the stream, in order to ensure total conformity with the approved standards.

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