

Bacteriological And Physico-Chemical Assessment Of Wastewater From Wupa Wastewater Treatment Plant, Abuja

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ABSTRACT: The bacteriological and physico-chemical assessment of wastewater from Wupa Wastewater Treatment Plant, Abuja was carried out. Sixty wastewater samples were collected from four different locations of the wastewater treatment plant. These water samples were also analyzed for the presence of bacterial organisms. The physico-chemical parameters (temperature, pH, conductivity, total dissolved solids and dissolved oxygen) were evaluated. The findings of the result showed that, all samples collected from the entrance points were contaminated with bacteria (100.0%), whereas, in exit points a percentage of 60% was found, but at the downstream (30m from the exit point), the rate of bacterial contamination reduced to 13.30%. Four bacterial species were isolated namely *Escherichia coli*, *Salmonella* spp., *Shigella* spp. and *Streptococcus* spp. The result of the study indicated that the temperature, pH, conductivity, total dissolved solids and dissolved oxygen of the wastewater from exit points showed a slight conformity to the WHO and FEPA standards, but there is still need for urgent steps to be taken for proper management and sanitation of the wastewater before discharging it to the stream, so as to ensure total conformity with the approved standards.

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1.0 INTRODUCTION

Water is a universal resource which, because of its free occurrence in nature, it is often taken for granted and abused, especially in third world nations where information is neither readily accessible, nor disseminated to society (Anyata and Nwaiwu, 2000). Abundant as it may seem, water, in its clean state, is one of the rarest elements in the world (Omole and Longe, 2008). Like all scarce resources which have regulations guiding their exploitation, ownership, preservation, and sustenance, water is protected by a body of laws, policies, and regulations in order to prevent abuse (FGN, 2000). It is the use to which the water is to be put that determines the quality standard that must be imposed (Anyata and Nwaiwu, 2000). For instance, water meant for consumption, food, and pharmaceutical industrial purposes would, for obvious reasons, have higher standards than water for fish production.

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises of liquid waste discharged by domestic residences, commercial properties, and industrial and/or agricultural, and can encompass a wide range of potential contaminants and concentrations (Nielsen *et al.*, 2006). Wastewater is used water that includes substances such as human waste, food scraps, oil, soaps and chemicals. In homes this includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers. Businesses

and industries also contribute their share of used water that must be cleaned. Wastewater also includes storm runoff. Although some people assume that the rain that runs down the street during storm is fairly clean, it is not. Harmful substance that washes off roads, parking lots and rooftops can harm our rivers and lakes (Long *et al.*, 2010).

The microbiological quality of effluent consumable water is a concern to consumers (Wupa dwellers), water suppliers (Wupa Wastewater Treatment Plant), and regulatory and public health authorities alike (E.g. Abuja Environmental Protection Board). The potential of effluent water to transport microbial pathogens to great number of people, causing subsequent illness, is well documented (Moe and Rheingans, 2006). The practice of unintentional indirect reuse in developing countries is largely responsible for the approximately 4 billion cases of diarrhea daily that cause 2.2 million deaths a year, mainly in children under five years of age (Global Water Supply and Sanitation Assessment, 2000). Most recent gastrointestinal outbreaks that have been reported throughout the world demonstrate that transmission of pathogens by effluent consumable water remains a significant cause of illness (Hunter and Syed, 2001).

Because of the associated dangers of wastewater, this study was carried out to assess the bacteriological quality and the physico-chemical

parameters of wastewater from Wupa Wastewater Treatment Plant, Abuja.

2.0 MATERIALS AND METHODS

This research work carried out in Microbiology Laboratory of Department of Biological Sciences, University of Abuja, Nigeria.

2.1 Sampling Area

Four (4) different sites of Wupa Wastewater Treatment Plant were selected for study namely: (A) Raw sewage (influent)-just as it was discharged into the sewage treatment plant; (B) Effluent (before ultra violet rays)-just before it passes through the most important stage of the waste water treatment the UV; (C) Effluent (after ultra violet rays)-just as it passes through the ultra violet ray channel, before it was discharged into the Wupa River; and (D) Downstream-about 30m away from the mixing point of the effluent and the river.

2.2 Method of Sample Collection

A total of sixty samples were examined. Fifteen samples were collected from each of the four different sites of Wupa Treatment Plant. According to the method described by Benethen (2003), 250ml sterile sample bottle was dipped into the wastewater in a depth of 30cm, and placed in the direction of the flow of water. The cork was removed and the sample was taken, leaving space for agitation. The samples were properly labeled, then stored in a cooler and transferred to the laboratory for analysis

2.3 Media Used and their Preparation

Nutrient agar (NA), *Salmonella-Shigella* agar, MacConkey agar and Eosin Methylene Blue (EMB) agar were used. The media were prepared according to manufacturer's instruction.

2.4 Bacteriological Analysis of the Water Samples

Serial dilution of the samples was done according to the method described by Willey *et al.* (2008). Using the pour plate method, 1ml each of the 10^{-6} serial diluents was aseptically transferred into the sterile petri-dishes. Then, a freshly prepared MacConkey agar was poured aseptically into each of the petri-dish and mixed by swirling the plate on the work bench (Uzoigwe and Agwa, 2012). This was also carried out using a Nutrient agar media. The plates were then incubated at 37°C for 24hours. After incubation, the resultant colonies were sub cultured on freshly prepared nutrient agar media to obtain pure cultures of the isolates. The pure cultures were further identified using biochemical characterization described by Chessbrough (2004)

2.5 Faecal Coliform Test

Presumptive, confirmatory and completed test for detection of the presence of coliforms was

carried out according to the methods described by Chessbrough (2004).

2.5.1 Presumptive Test

Inverted Durham tubes were inserted into the McCartney bottles. 10ml of already prepared Lauryl sulphate broth was added to the McCartney bottle containing inverted Durham tubes, which was then inoculated with 10ml, 1ml and 0.1ml dilution factors. The McCartney bottles were then incubated by placing in an oven at 37°C for 24hours. This was done to determine the presence of coliform bacteria in the water samples and also to obtain some index as to the possible number of organism present in the samples under analysis. The bottles were examined for the production of both gas and acid, which indicates positive bottles.

2.5.2 Confirmatory Test

After the incubation of the cultures, a positive tube from the presumptive test of the analysis was then inoculated on the EMB agar plate for confirmatory analysis. The plates were then streaked with the positive 24hours old Lactose culture obtained from the presumptive test. The same culture was also inoculated on the *Salmonella-Shigella* (SS) agar. The plates were then incubated in an inverted position for 24hours at 37°C and were checked for Green, metallic sheen for *E. coli*, and Colorless, Translucent for *Shigella* and Translucent with a black centre for *Salmonella*. All these were done to confirm the presence of coliform bacteria in the water samples showing a positive presumptive test. The positive 24hours old Lactose culture obtained from the presumptive test was also inoculated on an EC medium (broth) and incubated for 24hours at 37°C , for the confirmation of the presence of faecal coliform.

2.5.3 Completion Test

The completed test was carried out in order to confirm the presence of coliform bacteria in the water samples. It is necessary to confirm a suspicious but doubtful result of the previous test. One 24hour old coliform positive EMB culture from each of the three series of dilutions of the confirmed test, that is, 10ml, 1ml and 0.1ml were inoculated on a Lactose broth, EMB agar and also on Nutrient agar slant and all were incubated for 24hours at 37°C .

2.6 Determination of Physico-Chemical Parameters of the Water Samples

The physical parameters which include conductivity, temperature, pH, Total Dissolved Oxygen and Total Dissolved Solids (TDS) were determined according to the methods described by APHA (2005).

2.7 Statistical analysis

Analysis of variance (ANOVA) and Post Hoc Tests (multiple comparison tests) at $P=0.05$ were used to compare the values of the bacteriological analysis

and physiochemical parameters between water samples from different locations in Wupa wastewater Treatment Plant.

3.0 RESULTS

Table 1 shows the frequency of bacterial contamination of water samples collected from

different locations in Wupa wastewater treatment plant, Abuja. Out of 15 samples collected from Site A and B, all the samples examined (100%) were contaminated with >1,600MPN/100ml. Out of 15 samples collected from Site C, 6 (40%) were contaminated with 280MPN/100ml. Out of 15 samples from Site D, 2 (13.30%) were contaminated.

Table 1: Frequency of Bacterial Contamination of Water Samples Collected from Different Locations in Wupa Wastewater Treatment Plant, Abuja

Site	Location	Total Number of Samples Examined	Total Number of Positive Samples	MPN Index/ 100ml
A	Influent	15	15 (100%)	>1600
B	Effluent Before UV	15	15 (100%)	>1600
C	Effluent After UV	15	6 (40%)	280
D	Downstream	15	2 (13.3%)	33
Total		60	38 (63.30)	

Note: Most Probable Number of Bacteria (MPN Index per 100ml) was adapted from APHA (2005).

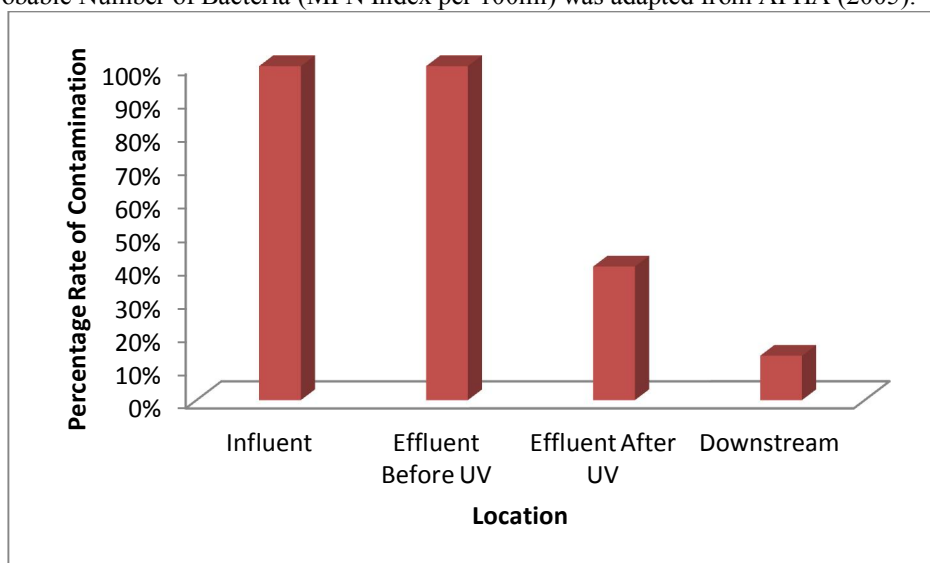


Figure 1: Percentage Rate of Bacterial Contamination of Water Samples Collected from Different Locations in Wupa Wastewater Treatment Plant, Abuja

Table 2 shows the bacteriological analysis of the water samples collected from different locations in Wupa Wastewater Treatment Plant, Abuja. The TVC, TCC, TSSA and TEC of samples collected from Site A were $4.8 \times 10^5 \pm 415$ cfu/ml, $3.7 \times 10^5 \pm 322$ cfu/ml, $1.9 \times 10^5 \pm 305$ cfu/ml and $1.7 \times 10^5 \pm 290$ cfu/ml respectively. The TVC, TCC, TSSA and TEC of samples collected from Site B were $3.2 \times 10^5 \pm 307$ cfu/ml, $3.0 \times 10^5 \pm 217$ cfu/ml, $1.3 \times 10^5 \pm 194$ cfu/ml and $1.2 \times 10^5 \pm 185$ cfu/ml respectively. Furthermore, the TVC, TCC, TSSA and TEC of samples collected from Site C were $3.0 \times 10^1 \pm 7$ cfu/ml, $2.7 \times 10^1 \pm 6$ cfu/ml, $1.2 \times 10^1 \pm 4$ cfu/ml and $1.1 \times 10^1 \pm 4$ cfu/ml respectively. However, the TVC of samples collected from Site D was $2.2 \times 10^1 \pm 8$ cfu/ml.

Table 2: Bacteriological Analysis of Water Samples Collected from Different Locations in Wupa Wastewater Treatment Plant, Abuja

Site	Location	TVC (cfu/ml)	TCC (cfu/ml)	TSSA (cfu/ml)	TEC (cfu/ml)
A	Influent	$4.8 \times 10^5 \pm 415$	$3.7 \times 10^5 \pm 322$	$1.9 \times 10^5 \pm 305$	$1.7 \times 10^5 \pm 290$
B	Effluent Before UV	$3.2 \times 10^5 \pm 307$	$3.0 \times 10^5 \pm 217$	$1.3 \times 10^5 \pm 194$	$1.2 \times 10^5 \pm 185$
C	Effluent After UV	$3.0 \times 10^1 \pm 7$	$2.7 \times 10^1 \pm 6$	$1.2 \times 10^1 \pm 4$	$1.1 \times 10^1 \pm 4$
D	Downstream	$2.2 \times 10^1 \pm 8$	-	-	-

*Results are expressed as Mean of the triplicates \pm Standard Deviation

Note: TCC= Total Coliform Count, TVC= Total Viable Count, TSSA= Total *Salmonella – Shigella* Count, TEC= Total *E. coli* Count

Table 3 shows the morphological and biochemical characterization of the isolates from water samples collected from different locations in Wupa Wastewater Treatment Plant, Abuja. Four bacterial species were isolated from water samples from different locations of the Wupa Wastewater Treatment Plant, Abuja and they include *Streptococcus* spp., *Escherichia coli*, *Salmonella* spp. and *Shigella* spp.

Table 3: Morphological and Biochemical Characterization of the Isolates

Characterization	1	2	3	4
Colony Arrangement	Cocci	Bacilli	Bacilli	Bacilli
Gram Reaction	+	-	-	-
Catalase Test	-	-	+	+
Motility Test	-	+	+	-
Oxidase Test	-	-	-	-
Indole Test	-	+	-	-
Probable Organism	<i>Streptococcus</i> spp	<i>Escherichia coli</i>	<i>Salmonella</i> spp	<i>Shigella</i> spp

Note: - = Negative; + = Positive

Table 4 shows the physico-chemical parameters of water samples collected from different locations of Wupa Wastewater Treatment Plant, Abuja. The temperature, pH, Conductivity, TDS, DO of wastewater from Site A was $29.8 \pm 2.4^{\circ}\text{C}$, 7.6 ± 1.1 , $287 \pm 25 \mu\text{S/cm}$, $205 \pm 21 \text{mg/ml}$ and $4.2 \pm 0.4 \text{mg/ml}$ respectively. For Site B, the temperature, pH, Conductivity, TDS, DO of wastewater was $29.3 \pm 2.7^{\circ}\text{C}$, 7.9 ± 1.3 , $253 \pm 17 \mu\text{S/cm}$, $148 \pm 14 \text{mg/ml}$ and $3.4 \pm 0.2 \text{mg/ml}$ respectively. The temperature, pH, Conductivity, TDS, DO of wastewater from Site C was $39.6 \pm 1.8^{\circ}\text{C}$, 8.1 ± 1.4 , $93 \pm 17 \mu\text{S/cm}$, $456 \pm 22 \text{mg/ml}$ and $7.1 \pm 0.2 \text{mg/ml}$ respectively. Furthermore, the temperature, pH, Conductivity, TDS, DO of wastewater from Site D was $41.6 \pm 2.0^{\circ}\text{C}$, 8.4 ± 1.4 , $78 \pm 12 \mu\text{S/cm}$, $503 \pm 29 \text{mg/ml}$ and $7.4 \pm 0.1 \text{mg/ml}$ respectively.

Table 4: Physico-chemical Parameters of Water Samples Collected from Different Locations of Wupa Wastewater Treatment Plant, Abuja

Parameters	LOCATIONS				FEPA Limit
	Site A (Influent)	Site B (Effluent Before UV)	Site C (Effluent After UV)	Site D (Downstream)	
Temperature($^{\circ}\text{C}$)	29.8 ± 2.4	29.3 ± 2.7	39.6 ± 1.8	41.6 ± 2.0	40
pH	7.6 ± 1.1	7.9 ± 1.3	8.1 ± 1.3	8.4 ± 1.4	6-9
Conductivity($\mu\text{S/cm}$)	287 ± 25	253 ± 17	93 ± 17	78 ± 12	50-125
Total Dissolved Solid (mg/ml)	205 ± 21	148 ± 14	456 ± 22	503 ± 29	500
Dissolved Oxygen (mg/ml)	4.2 ± 0.4	3.4 ± 0.2	7.1 ± 0.2	7.4 ± 0.1	7.5

*Results are expressed as Mean of the triplicates \pm Standard Deviation

4.0 DISCUSSION

The result of this research showed that wastewaters are treated to eliminate pathogenic microorganisms and prevent waterborne transmission using UV radiation. Our research found that, in entrance points, all samples were contaminated with bacteria (100.0%), whereas, in exit points, a percentage of 40% was found. Therefore, wastewater treatment reduces but does not guarantee the complete elimination of a putative contamination with bacteria. This was in accordance with the finding of Salem *et al.* (2011). Downstream samples had lower percentage rate of contamination (13.30%) because of the self-recovery activity of the stream, although this does not guarantee complete absence of bacterial contamination.

The effluent water from the entrance points of sewage treatment plant has considerably high heterotrophic bacteria counts and high total coliform counts and could be concluded to be of bad quality for domestic use. But at the exit point, the high heterotrophic bacteria counts and high total coliform counts were below 100cfu/ml. However, at the downstream, there were no coliform in the water samples. World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) standard for faecal coliform in domestic water is zero (0) faecal coliform per 100ml (WHO, 2009; FEPA, 2005). Regarding the faecal coliform counts, even though the effluent water before Ultra Violet light treatment had much higher value of $>1,600$ MPN per 100ml compared to counts of 280 to 33 MPN per 100ml for effluent after Ultra Violet treatment and

downstream respectively. The presence of no faecal coliform in the water samples from the downstream could be attributed to the proximity of the downstream point which is 30m to the effluent discharge point, reasons being traced back to proper treatment process at the treatment plant using the Ultra Violet light channel. Hence, the downstream water is considered safe for drinking, although may require further chemical purification.

The bacteria isolates from the water belong to the genera of potential pathogenic bacteria, and the microorganisms isolated were *Escherichia coli*, *Streptococcus* spp., *Salmonella* spp. and *Shigella* spp. The isolation of these organisms is of great health concern because this domestic wastewater 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 (i.e through fishing). *Escherichia coli*, *Salmonella* spp. and *Shigella* 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 (Doughari *et al.*, 2007).

The physico-chemical properties of the wastewater samples collected from different locations of the Wupa Wastewater Treatment Plant, Abuja (as in entrance points and in exit points) were shown in Table 4. Physico-chemical parameters such as temperature, pH, conductivity, total dissolved solids (TSS) and dissolved oxygen (DO) have a major influence on bacterial population growth (Amxaka *et al.*, 2004). Also, as wastewaters often have high nutrient loads, high numbers of pathogens can be present, increasing the risk of infections occurring from them.

From these results, the temperature varied between $29.8 \pm 2.4^{\circ}\text{C}$ at the point of entry of the wastewater to $39.6 \pm 1.8^{\circ}\text{C}$ after the treatment of the wastewater. The mean temperature of the treated wastewater was at the recommended FEPA temperature limit for wastewater. Furthermore, the levels of pH varied between 7.6 ± 1.1 in the entrance points of each station and 8.1 ± 1.4 for the exit points. Generally, exit points show the highest concentration which is within the recommended FEPA safe limit. This was in accordance with the findings of Salem *et al.* (2011). The mean pH values recorded for exit sampling points were within the FEPA pH tolerance limit of between 6.00 and 9.00 for wastewater to be discharged into sea or environment. But, pH values ranging from 3 to 10.5 could favor both indicator and pathogenic microorganism growth (Amxaka *et al.*, 2004). Thus, indicated pH levels seem to support bacterial growth.

The Total Dissolved Solids (TDS) concentrations varied between $205 \pm 21\text{mg/L}$ in entrance points and $123 \pm 17\text{mg/L}$ in exit points (Table 4). Literature classified wastewater TDS as follows: TDS less than 100 mg/L as weak, TDS greater than 100 mg/L but less than 220 mg/L as medium and TDS greater than 220 mg/L as strong wastewater. Results of this study show that in entrance points, wastewater can be classified as medium and so cannot be discharged into sea or used for any task. But at the exit point, the TDS value was less than 100 mg/L which reflects the efficiency of wastewater treatment and may be considered safe to be discharged.

An indication of the organic oxygen demand content of wastewater can be obtained by measuring the dissolved oxygen content of the wastewater. The DO in entrance sampling point was lower than the FEPA limit values of 7.2 mg/L. Low DO observed in the wastewater might be due to the use of chemicals, which are organic or inorganic caused by the inflow of domestic, livestock and industrial waste that contain elevated levels of organic pollutants (Ayati, 2003). At the exit point, the DO was $7.1 \pm 0.2\text{mg/ml}$ which can be considered relatively safe to be discharged.

5.1 Conclusion

Results of this study revealed a slight conformation of the bacteriological quality and physiochemical parameters of the wastewater to the World Health Organization and FEPA standards for wastewater. The downstream water is therefore relatively fit for human consumption, but should be further purified for health purposes. It can be concluded that water from the entire source is not fit for domestic usage without further processing. There is, therefore the need for urgent steps to be taken for proper management and sanitation of the wastewater treatment plant because input of sewage or other organic rich wastewaters into the stream results in the increase in organotropic bacteria, algae and cyanobacteria which not only bring about health implications but further complications for aquatic life.

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