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Performance Evaluation of WUPA Wastewater Treatment Plant Idu-Industrial Area, Abuja

ABSTRACT

This paper evaluates the performance efficiency of WUPA waste water treatment plant. Wastewater samples were collected and monitored in the raw influents, primary effluents and final treated effluents at three different locations of WUPA waste water treatment plant using standard methods for physiochemical characteristic analysis. The results revealed that the average concentrations of DO, BOD_5^{20}, COD, TSS, TDS, NH_4^{-N}, NO_3^{-N} and PO_4^{-p} in the final effluent of WUPA WWTP were 6.7, 22, 50, 13.1, 20, 3.8, 2.73, and 2.4 mg/L respectively and that of electrical conductivity, temperature and pH are 271µs (cm), 25.1% and 7.42 respectively which fell within the standard recommended by WHO for effluent discharged into water bodies. Values of TDS and NO_3^{-N} however increase from the raw influent to the final treated effluent instead of decreasing which shows the inefficiencies of the system to effectively reduce the concentration of these parameters. The average removal efficiencies of BOD_5^{20}, COD, TSS and NH_4^{-N} were found to be 87.28%, 85.88%, 91.44% and 38.71% respectively. The effect of the final treated effluent on the water quality of WUPA river was also determined by analyzing the physiochemical characteristic of the surface water sample collected at two sampling locations 30m away upstream from the discharge point before the effluent meets the river water (S_4) and 30m away downstream from the exist point after the effluent meets the river water (S_5). Though there were slight increases in the concentrations of the most parameters downstream after the effluent meets the WUPA River, the study has revealed that there was no adverse effect on the physiochemical characteristics of the receiving water.

Keywords: *Effluent, influent, river water, wastewater, water treatment plant*

1 INTRODUCTION

Fresh accessible water is a scarce and unevenly distributed resource, not matching patterns of human development. Because it plays a vital role in the sustenance of all life, water is a source of economic and political power (Narasimhan, 2008). However, it is not right to discharge contaminated water back into the environment which can be a source of pollution to the water at the downstream (Ado et al., 2015; Proia et al., 2016; Eunice et al., 2017). As water travels through the hydrological system from the upstream to the sea, the activities of human society capture, divert and extract, treat and reuse water to sustain communities and economies throughout the watershed (industrial, agricultural and municipal) (Izah et al., 2016; Oribhabor, 2016; Seiyaboh & Izah. 2017). These activities however, do not return the water they extract in the same condition. Unmanaged waste water can be a source of pollution, a hazard for the health of human populations and the environment like (Fattoruso et al., 2015; Onifade *et al*. 2015; Ogunjuyigbe et al., 2017). Wastewater can be contaminated with a myriad of different compounds pathogens, organic compounds, synthetic chemicals nutrients, organic matter and heavy metals (Naveen et al., 2017). They are either in solution or particulate matter and are carried along in the water from different source and affect water quality. These components can have bio-cumulative and persistence characteristics affecting ecosystem human health and food production. Harder et al. (2019) defined wastewater as a combination of one or more domestic effluent consisting of black water (excreta, urine and fecal sludge) and grey water (kitchen and bathing waste water). Wastewater is also defined as the spent or used water of a community or industry which contains dissolved and suspended matter (Rana et al., 2017). Even though nature has an amazing ability to cope with certain amount of contaminants, there is a necessity to treat the billion gallons of wastewater and sewage generated daily by homes, business establishments and industries before releasing back to the environment.

The effluent discharged into the receiving water bodies which serves as a source of water to some communities downstream is used for variety of purposes. The need to know the quality of the effluent discharged through the appraisal of the waste water treatment plant informed this study. This study therefore, is undertaken to evaluate performance efficiency of a waste water treatment plant located at WUPA, Idu-industrial district, Abuja-Nigeria, operating on biological treatment method (activated sludge process). The objective is to analyze the effluent collected from three sampling locations and compare the final treated effluents with WHO standards. The second objective is to analyze the physiochemical parameters of the water sample collected from upstream and downstream and compare to WHO standards.

2 METHODOLOGY

2.1 DESCRIPTION OF STUDY AREA

The study area is WUPA sewage treatment plant, located in Idu-industrial layout, Abuja-Nigeria it covers an area of 297,960 square meters and is designed to meet the requirements of 700,000 population's equivalent meaning that the plant can accommodate an annual dry weather inflow of 5,500 cubic meters per day. It lies between longitude 7º8'20.33 and latitude 9º2'14.46'' respectively the WUPA sewage treatment plant Abuja is designed for F.C.T to handle waste water generated by 700,000 populations equivalent and expandable to 1,000,000 populations equivalent on an average domestic waste water of 230 l/c/d.

2.2 DATA COLLECTION AND SAMPLING

According to Kumar et al. (2010), there is no truer sign of civilization and culture than good sanitation. The entire treatment process can be divided into mechanical and biological phases. WUPA sewage treatment plant performs its two main operations in the treatment process as follows unit operations; which involves the raw sewage (influent) undergoing physical treatment from the intake structure to the screen and grease chambers. The practically treated sewage then goes to the distribution well for transport to next stage of operation, and unit process; which involves the biological treatment of the pre-treated sewage by ensuring an unlimited supply of oxygen to facilitate aerobic microbial biodegrading activity. This microbial activity takes place in the aeration tank after which the sewage is transported to the clarifiers (sedimentation tank) where the effluent would be ready for disinfection before final discharge to the stream. Sludge formed at the clarifiers is then collected and transported to the dewatering house from where it is concentrated and later sent to the drying beds before it is used as manure. Part of the sludge in the clarifier would be recycled to the aeration tank in order to maintain adequate food to micro organisms

Sampling design and data collections were carried out once in a week from WUPA waste water treatment plant for 4 weeks at the three different sampling points. This involves collection of samples in a well labeled clean plastic container that was rinsed with distilled water prior to collection.

The samples, were analyzed to determine parameters like; pH, BOD5, COD, TDS, TSS, NH4¬¬N, NO3N,¬ and PO4P,¬¬ according to the procedure outlined in standards methods for examination of water and waste water APHA (1998).

The three different sampling locations or units of the treatment plant where waste water samples were collected are as below;

a) influent to the plant S_1
b) effluent to aerobic tank S_2 and
c) final effluent from secondary clarifiers (S_3)

The overall efficiency of the plant was estimated from the formula:

Removal efficiency =

$$\frac{Influent(mg/l) - Effluent(mg/l)}{Influent(mg/l)} x100 \quad (1)$$

Sampling water at WUPA River was conducted to establish short-term relationship between the physiochemical characteristics of the river and the final treated effluent from the WWTP. Samples were collected from WUPA River at two different sampling locations which are as follows;

a) The upstream point (stream before meeting the effluent) S_4
b) and downstream at the point (effluent and stream at the point of use) S_5

2.3 PHYSIOCHEMICAL ANALYSIS

The total suspended solids, total dissolved solids, and biochemical oxygen demand, were calculated thus;

$$TSS = \left(\frac{A-B}{Sample\ volume}\right) x1000 \left(\frac{mg}{l}\right) \quad (2).$$

where
A = weight of filter paper and solids(mg),
B=weight of cooled filter paper(mg), V=volume(ml).

$$TDS = \left(\frac{B-A}{sample\ volume}\right) X1000 \left(\frac{mg}{l}\right) \quad (3).$$

where
A=the weight of the evaporating dish only,
B= the weight of the evaporating dish and solids.

$$BOD(5) = \left(\frac{D1-D2}{P}\right)\left(\frac{mg}{l}\right) \quad (4)$$

where
D_1 = dissolved oxygen of sample immediately after preparation,
D_2 = dissolved oxygen of sample after 5days at 20°C,
P = decimal volumetric fraction of sample used.

The pH was calculated by conducting a test on site using a multi-purpose meter. A calibrated pH meter Probe was submerged in a sample of the effluent and was stirred gently for a few moments and the pH meter gave a stable pH reading. The concentration of the chemical oxygen demand (COD) was measured in a photometer. The determination of phosphate (PO_4^{-P}) was carried out using calorimetric method and was determined using photometer (palintest photometer 7100). This same method was used in the determination of ammonium as nitrogen (NH_4^{-N}) and nitrate (NO_3^{-N}).

3 RESULTS AND DISCUSSION

The results obtained from physiochemical analysis of effluents from three different sampling locations are summarized in Table 1. The pH of the water samples ranged from 6.99 in S_2 to 7.49 in S_1 as shown in Table 1. Both COD and BOD_5 were reduced to meet the WHO Standards as the analysis made on S_3 gave a reduced value compared to the analysis on S_1 and S_2. This showed the efficiency of the treatment plant. Same pattern was recorded on other parameters like Temperature, Total Suspended Solids, TSS, Total Dissolved Solids, TDS, Ammonium ions, Potassium ions, with the exception of Nitrate ions, Dissolved Oxygen, and Electrical Conductivity

TABLE1: AVERAGE PARAMETERS CHARACTERIZED AT DIFFERENT SAMPLING LOCATION COMPARED WITH PERMISSIBLE LIMIT OF WHO

PARAMETERS	SAMPLING LOCATION			
	(S_1)	(S_2)	(S_3)	WHO Value
pH	7.49	6.99	7.42	6.0-9.0
COD (mg/l)	354	317	50	100
BOD_5 (mg/l)	173	158	22	30
TSS (mg/l)	153	141	13.1	30
TDS (mg/l)	193	198	201	500
NH_4 (mg/l)	6.2	5.9	3.8	10
NO_3 (mg/l)	1.69	1.67	2.73	2.0
PO_4 (mg/l)	3.3	3.1	2.4	5
DO	2.0	4.7	7.7	7.0-10.0
EC	263	273	271	1250
TEMP	26.9	25.5	25.1	< 40 ºC

S_1 = RAW INFLUENT; S_2 = PRIMARY INFLUENT; S_3 = FINAL TREATED EFFLUENT

3.1 ASSESSMENT OF WATER SAMPLES FROM WUPA RIVER

The physiochemical parameters (pH, conductivity temperature, total suspended solids total dissolved solids, COD, NO3-N, NH4-N PO4-P, dissolved oxygen (DO) and BOD5) were analyzed. The result indicated that all the parameters at the downstream and upstream point showed conformity with the WHO standards as shown in the Table 2.

TABLE 2: PARAMETERS CHARACTERIZED AT UPSTREAM AND DOWNSTREAM OF THE WUPA RIVER WITH WHO STANDARDS

PARAMETER	UPSTREAM	DOWNSTREAM	W.H.O MAXIMUM PERMISSIBLE LIMIT
TDS (mg/l)	152	155	560
Temperature o	30.7	30.9	Less than 40 ºC.
Conductivity (µs/cm)	227	232	1250
Dissolved Oxygen (mg/l)	6.23	5.70	700-10.0
Suspended Solid (mg/l)	3	6	30
BOD5 (mg/l)	0	1	30
COD (mg/l)	0	3	100
Nitrogen (mg/l)	1.63	1.67	20
Phosphate (mg/l)	0.45	0.68	5
Ammonia as Nitrogen (mg/l)	0.67	0.69	10
pH	7.38	7.41	6.5-8.5

3.2 REMOVAL EFFICIENCY

The performance of WUPA WWTP in terms of removal efficiency (%) in the pollution parameters is given in Table 3. The removal efficiencies of different units in terms of average TSS, COD, BOD5, and NH4-N were determined. The reduction in COD (85.88%), BOD5 (87.28%) and TSS (91.44%) which is within the required range of 85-100% confirms the efficiency of the secondary clarifiers. But the reduction in NH4-N (38.71%) dropped below the normal limit.

TABLE 3: REMOVAL EFFICIENCY OF THE DIFFERENT SAMPLING LOCATION OF WUPA WWTP

	BOD (%)	COD (%)	TSS (%)	NH_4^{-N}
(S_1-S_2)	8.67	10.45	7.84	4.84
(S_2-S_3)	86.08	84.23	90.71	35.59
(S_1-S_3)	87.28	85.88	91.44	38.71

4 CONCLUSION

Performance evaluation of WUPA waste water treatment plant in Idu Industrial area in Abuja, FCT has been studied. That WUPA WWTP achieved higher percentages in terms of removal efficiencies for most parameters and the overall efficiency is in the order NH4-N< COD< BOD5<TSS. The effluent qualities met the acceptable standards outlined by WHO for effluents to be discharged into water bodies which are critical to the provision of clean and safe water. The analysis revealed that parameters such as BOD_5[20], COD, TSS, NH_4-N, PO_4-P, E.C, PH, temperature and DO in the final treated effluent when compared with the standards were found mostly within the limits set by world health organization. TDS and NO_3-N in the final treated effluent also fell within the

standard but their values increase from raw influent to final treated effluent instead of decreasing which shows the inefficiency of the system to effectively reduce the concentration of these parameters. The final treated effluent can be safely discharged in the receiving water bodies.

Downstream concentration of the physiochemical parameters increases slightly when compared with the upstream values after the final treated effluent was discharged into the river from the exits point, but the values are still within the standards recommended by WHO for drinking water. Therefore, it can be concluded that waste water effluents from WUPA WWTP have no much effect on the water qualities of WUPA River.

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