Characterization of Sewage Treatment Plant in an Emerging Territory

P. A. Ozor, C. Mbohwa

ABSTRACT: Effective sewage management demands continuous evaluation of waste water plants to pick out any potential environmental or health challenges as quickly as possible. One of the cardinal objectives of a sewage treatment plant is to reduce biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solid (TSS). The characterization and evaluation of a waste water treatment plant a developing territory is undertaken. Qualitative research design was adopted for the study and the methodological steps used in the work graphically displayed. The plant achieved its lowest BOD, COD and TSS of 7.7mg/l, 18mg/l and 12mg/l respectively at the effluent in June, 2015. A comparative assessment of the characteristic discharge parameters in relation with standard limits given as 30mg/l, 100mg/l and 30mg/l, for BOD, COD and TSS respectively show that the studied case is operating at safe conditions. A further comparison with the subsisting national effluent benchmarks of 30mg/l, 80mg/l and 30mg/l respectively for BOD, COD and TSS indicate that the sewage plant is within the safe operational ranges prescribed by the prevailing environmental benchmarks.

Keywords: Sewage management, treatment plant, characteristic parameters, global standards

I INTRODUCTION

Water use rate has increased in recent times with an attendant increase in the volume of water collected in sewage effluents. The implication of this is a rise in the level of global environmental health challenges posed by contaminated water. It is evident that if wastewater is not appropriately managed, it can cause great threats to the already threatened environment. The question is not whether sewage should be treated, but how to conduct the treatment within the confines of global standards and best practices. Sequel to this, Doherty et al. [1] emphasize the need to develop tools and methodologies that can assist the wastewater sector in measuring resource efficiency and benchmarking performance in a realistic and standardised manner. The call appears to be more needful in developing countries where a major portion of the population lacks access to safe drinking water and sanitation which can have a direct proportional relationship to susceptibility to high incidence of waterborne diseases. Treatment of sewage simply refers to a set of procedures implemented to remove pollutants from domestic used or contaminated water as well as effluents from tanneries, industries and distilleries.

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Various categories of pollutants can be removed by different physical, chemical and biological processes. Barbu et al. [2] evaluates how the control of water quality, greenhouse gas emission and operational cost of a sewage plant can be efficiently achieved for a useful global effect. There are other aspects of performance indicators that are usually considered in addressing waste water treatment, mainly on environmental impact. For instance, Mustapha et al. [3] present a unified performance indicator that can be applied universally in assessment of wastewater treatment with its many processes while other researchers labored on removal of waste water treatment imperfections [4] and possible defense mechanism [5].

Treatment of wastewater strategies [6] and procedure [7] are normally part of the design considerations in many areas. It is noteworthy that majority of the processes suggested for treating waste water to date cannot be suited for all kinds of locations. Effluent characteristics can vary both in time and between different treatment plants [8]. That is the more reason why the presentation of a unified parametric characteristics and benchmarks suggested by previous researchers may not be very efficient in all cases. It is pertinent to constantly but intermittently evaluate or characterize globally tested parameters for sewage plants in specific locations and compare with already established standards to ascertain the status of sewage plants vis-à-vis environmental pollutants. This step will reveal better picture of every necessary parameter in the plant rather than to depend on reports conducted in a location with different climatic conditions. This paper is focused on characterizing the sewage treatment plant located in Wupe, North central Nigeria with the aim of comparing the characteristic parameters and processes with global and national benchmarks and best practices.

II MATERIALS AND METHODS

The research employed a qualitative research design as well as reliance upon secondary sources. As a result, the majority of the data used were obtained from primary sources. The daily values of the characteristic parameters (BOD, COD and TSS) were obtained for a period of six months. Specifically, January to June, 2015. The monthly average of these characteristics were computed and recorded. The choice of the period was informed by the desire to obtain data for both periods of the two prevalent weather in the area. That is; Rainy and Dry season. The composite sampling techniques was used in analyzing the data collected. The average gotten was used to compute the efficiency of the plant for each parameter (BOD, COD, and TSS). The data presented in Table 1 gives the volumetric inflow rates from the city and service units to the Wupa treatment plant for the period January to June, 2015.

The data constitutes the daily inflow to the inflow chamber ready to undergo treatment; they are computed by getting the mean of the daily, weekly, and monthly inflows. The monthly averages as computed were used to get the plant overall efficiency. After wards the efficiency obtained are summed up and divided by the number of months. The table can equally be employed to evaluate the utility of the plant. The results and values of the characteristic parameters were compared with the World health organization (WHO) and National environmental standards and regulations enforcement agency (NESREA) benchmarks.

Table: I Average daily inflow of wastewater

MONTH	INFLOW m^3/day
January 2015	29,627
February 2015	28,626
March 2015	28,126
April 2015	25,941.9
May 2015	25,560
June 2015	30.044.7

Source; [WUPA WWTP ABUJA, 11]

II PLANT CHARACTERISTIC FEATURES

Several parameters can be employed in characterizing the water treatment plant. The most important features that constitutes the influent – effluent quality inter alia include BOD, Coli form, COD, TSS, PH and volumetric flow rate shaft velocity These characteristics can be broadly classified into Mechanical, Biological and Chemical parameters. The mechanical parameters relates to the design of waste treatment systems and processes, including measuring and instrumentation devices. The parameters drive the treatment plant modeling and gives the resultant characteristic of the influent – effluent qualities. The parameters include – power, volumetric flow rate, flow types, SRT, No/capacity of marmot rotors, power of mixer, raking diameters. The volumetric head of flow measures the head of the sewage flow from the inflow station. In particular, head losses through the bar racks can be expressed in terms of the approach (upstream) velocity and the velocity through the bars (downstream) using Bernoulli's equation (1) [9].

$$h_1 + \frac{v^2}{2g} = h_2 + \frac{V^2}{2g} + \Delta h \qquad (1)$$

And

$$h = h_1 - h_2 = \frac{V^2 - v^2}{2gC^2} \qquad (2)$$

Where:

h_2 = downstream depth of water, m or ft
h = headloss, m or ft
V = flow velocity through the bar rack m/s or ft/s
v = approach velocity in upstream channel, m/s or ft/s
g = acceleration due to gravity, 9.81 m/s2 or 32.2 ft/s^2
C = discharge coefficient with a typical value of 0.84

The total head loss through racks can be evaluated from Keschmer's equation (3) [9-10]. It represents the pressure differential in the step screen, otherwise called the fine screen chamber.

$$H = B\left(\frac{w}{b}\right)^{\frac{4}{3}}\left(\frac{v^2}{2g}\right) sin\theta \qquad (3)$$

Where:

H = head loss, m or ft,
B = bar shape factor, typical values are presented in literature [10],
w = maximum width of the bar facing the flow, m,
b = minimum spacing of bars, m, v and g retain their significance in equation (2)
θ = angle of the rack to the horizontal

The procedural steps followed in characterizing the wastewater treatment plant is displayed in figure 1.

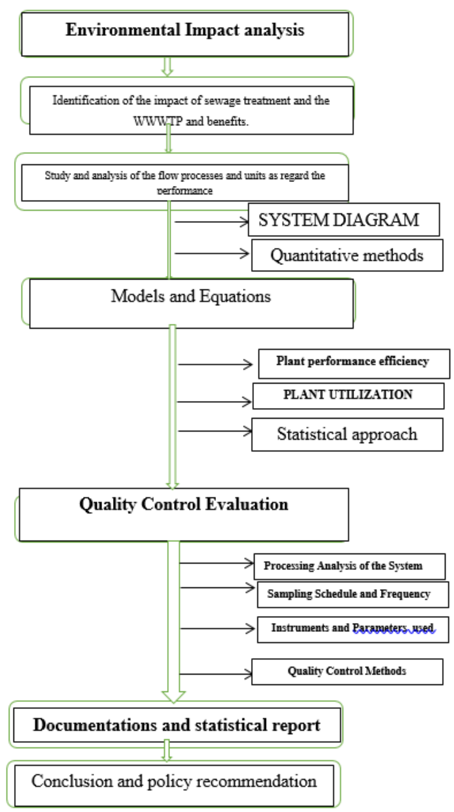

Fig 1: Procedural step for Characterizing the Sewage Treatment Plant

III Analysis

Equation (4) can be utilized in estimating the amount of BOD removal in a wastewater treatment plant [11].

$$L_r = 9.23 + 0.725L_o \qquad (4)$$

Where :
L_r = BOD removal, L_o = BOD loading

The regression equation (4) present a coefficient of 0.995 and a confidence level of 95%. The model have been shown to be inadequate for use in all sewage treatment plant scenario. Accordingly, model (5) through (7) is adopted for this study [11].

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$$E_{BOD5} = \frac{\text{influent } BOD_5 - \text{effluent } BOD_5}{\text{influent } BOD_5} \quad (5)$$

$$E_{COD} = \frac{\text{influent COD} - \text{effluent COD}}{\text{influent COD}} \quad (6)$$

$$E_{TSS} = \frac{\text{influent TSS} - \text{effluent TSS}}{\text{influent TSS}} \quad (7)$$

Where:
E = the plant efficiency
The values of the parameters can be affected by the factors that characterize sewage strengths. The effluent data showed that there are sufficient or elevated dissolved Oxygen by the marmot rotors, mixers and air blowers. The high PH is a factor that allowed lower BOD as achievable. Hence, the proper and simultaneous mixing of the sewage helped to expose the raw sewage to a greater light intensity, so as to improve the action of microbes on the organic wastes. The removal of toxic waste in the primary stage further reduces the BOD in the aeration tank. The same factors induced the low COD as obtained and presented in Table 2 for a period of six months

Table II: Treatment Level (BOD, COD and TSS)

MONTH	PARAMETERS (mg/1)	INFLUENT (avg.)	EFFLUENT (avg.)
Jan 2015	BOD t	141.4	36.3
	COD	302.5	61.7
	TSS	159.8	15.7
Feb 2015	BOD t	167.5	40.5
	COD	390	68.0
	TSS	141.0	15.0
Mar 2015	BOD t	158.9	41.6
	COD	365.0	58
	TSS	174.3	41.5
Apr 2015	BOD t	180.0	41.0
	COD	330	74.5
	TSS	158.9	15.9
May 2015	BOD t	187.1	20
	COD	295.3	71
	TSS	218.3	14.0
Jun 2015	BOD t	167	7.7
	COD	405	18
	TSS	246	12

t = total, avg. = average

The monthly averages were computed and presented in Table 1 to ascertain the average, so as to get the plant overall efficiency. After wards the efficiency obtained are summed up and divided by the number of months evaluated. Table 3 present the average influent and effluent for the period of January to June 2015.

Table III: Parametric Avg. of the characteristics (Jan-Jun, 2015**)**

Parameter (mg/1)	Influent Avg. (mg/l)	Effluent Avg. (mg/l)
BOD	1623.93	20.52
COD	3343.8	41
TSS	2400.3	18.7

Table IV: Overall efficiencies

Parameter (mg/1)	Influent avg(mg/l)	Effluent avg (mg/l)	Efficiency
BOD	1623.93	20.52	0.98
TOD	3343.8	41	0.98
TSS	2400.3	18.7	0.9

The mean of the values of the different parameters were computed to get the average discharge limits. It will be observed that the ranges of the parameters evaluated and presented in Table V are within the ranges of the WHO and NESREA criterion [11].

Table V: Comparison of characteristic parameters with Standard limits

Parameters	Effluent values	W.H.O limits	NESREA limits
Phosphate as P (PO_4-P)	1.25	5	5
Ammonia as N (NH_4-N)	2.08	10	10
$BOD_5$20 (mg/1)	20.52	30	30
CODS (mg/1)	41	100	80
TSS (mg/1)	18.7	30	30
Total Coliform (MPN/100ml)	178.33	400	400

The Wupa sewage treatment plant manages effectively all inflow raw sewage into the plant as it even accommodates the changes encountered in different seasons, from the value obtained in table, it is noted that the plant is underutilized since the peak volume flow rate on June is 30.044.7m^3/day which is a little fraction of the designed volume flow rate.

IV RESULT AND DISCUSSION

From the methods employed in the evaluation and characterization of the waste water treatment plant undertaken in this study, the following results are obtained. The value ranges of the result presented indicates the biochemical oxygen demand (BOD), chemical oxygen demand (COD), and TSS both at the influent and effluent points. The result show that waste water at the Wupa treatment plant can be treated to eliminate pathogenic microorganisms to prevent water born disease transmissions using ultraviolet (UV) radiation. The values of the characteristic parameters and discharges indicate that a seasonal variation has effect on the strength of the influent and effluent. It can be observed that the amount of rainfall is inversely proportional to sewage strength, as illustrated with the data. It further shows that the BOD, COD and TSS at influent is at the peak in May and June with value of 187.1mg/l and 246mg/l respectively. One of the primary objectives of a sewage treatment plant is to reduce BOD, COD and TSS. The plant achieved its lowest BOD, COD and TSS of 7.7mg/l, 18mg/l and 12mg/l respectively at the effluent in June. A comparative assessment of the discharge limits and the Wupa STP discharge parameters with that of WHO with limits as 30mg/l, 100mg/l, 30mg/l for BOD, COD, TSS respectively show that the studied case is operating at safe conditions. A further comparison with NESREA effluent benchmarks of 30mg/l, 80mg/l and 30mg/l respectively for BOD, COD and TSS indicate that the sewage plant is within the safe operational ranges prescribed by the country administration. The PH values are important since it accounts for the acidity and alkalinity of the sewage and the supernatant at the different sampling points. It must be stated that these values are influenced by the intensity of light, the diameter of the points, and the foxiness of the samples. At the influent and effluent points, the PH values averages 6.13 and 7.23 respectively. This result show that the sewage has an acidic concentration at the influent and closely matches WHO recommendation of 7 at the effluent [11]. From the standpoint of equation in equation (3.4), it could be observe that the plant is very efficient, as the low values of the average BOD, COD and TSS at effluent points has confirmed the effectiveness of the plant with respect to sewage treatment.

V CONCLUSION

The Wupa sewage treatment plant located in North central Nigeria has been characterized in this study. The methodology followed in the characterization has been elicited clearly and the results presented in an easy to understand manner. Though, the plant poses no potential health risks at the moment, the efficiency might decrease if approximate measures are not adopted to maintain the status of the characteristic parameters. The efficiency can be maintained through adequate supply of oxygen by adding an equivalent number of rotors, mixers and air blower in the aeration basin. The research reveal that Peak values for all parameters and components are considered in running and installation of the studied plant, to account for seasonal variation. The low utilization factor recorded for the plant can be improved by channeling all drainage facilities in the metropolis into the sewage plant. The Territory administration can enforce queueing into the sewer lines by every part of the area as provided in the original master plan. This presentation recommends that in further development of the remaining phases of the territory and surrounding environs, strict policies should be enacted to ensure full utilization of the plant.

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