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Performance Evaluation of Wupa Waste Water Treatment Plant Abuja, Federal Capital Territory, Nigeria

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ABSTRCT: *This study assessed the performance of Wupa wastewater treatment plant at Abuja, Nigeria.This treatment plant was built with a view of treating The Municipal wastewater which was otherwise polluting the receiving stream, a source of drinking and irrigation activities for the villagers in the area . Wastewater samples were collected at the influent point (IP) and effluent point (EP) of the treatment plant. The samples were analyzed for physicochemical parameters, viz. Total solids (TS), Total suspended solids (TSS) ,Total dissolved solids (TDS),and the values of 329.53 mg/l, 62.03 mg/l and 266.30 mg/l, for the effluent were obtained respectively, which shows a significant reduction compared with the results obtained for the influent. Also the Biochemical Oxygen Demand (BOD), Chemical and Oxygen Demand (COD) were obtained. Standard methods specified by the American Public Health Association (APHA) were followed. The results showed a reduction of 51.9% in COD, 43.3% in BOD but yet did not meet the required effluent standards. Other parameters such as pH, temperature, phosphate, nitrate and total Chloride which reduced from 270.0mg/l to 110.0 mg/l all were within the permissible limits set by National Guidelines FEPA. Finally, the downstream water is therefore not 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, and there is need for urgent steps to be taken for proper management and sanitation of the wastewater treatment plant*.

Keywords: Effluent, wastewater, BOD, treatment plant

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I. 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 resources in the world (Omole and Longe, 2008). Like all scarce resources which have global regulations guiding their exploitation, ownership, preservation, and sustenance, water in Nigeria is protected by a body of laws, policies, and regulations in order to prevent abuse (FGN, 2000).

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*., 2004). Wastewater comprises many substances such as human waste, food scraps, oil, soaps and chemicals. It includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers from domestic activities. Businesses and industries also contribute to the generation of wastewater. Wastewater also includes storm runoff generated from floods. Although some people assume that the rain that runs down the street during storm is fairly clean, it is not. Harmful substances that washes off roads, parking lots and rooftops can harm our rivers and lakes (Long *et al*., 2010). Domestic wastewater also contains countless numbers of living organisms - bacteria and other microorganisms whose life activities cause the process of decomposition. When decay proceeds under anaerobic conditions, that is, in the absence of dissolved oxygen in the wastewater, offensive conditions result and odors and unsightly appearances are produced. When decay proceeds under aerobic conditions, that is, in the presence of dissolved oxygen, offensive conditions are avoided and the treatment process is greatly accelerated. In many developing countries impounded water bodies are grossly polluted by surface runoffs and untreated wastewater. Some of these water sources are used for domestic water needs and they pose public health problems if care is not taken for the effluent quality. The treated waste water from the plant is being discharged into the stream that is being used for the villages in the area for both consumption and irrigation activities,

Treatment of wastewater is a relatively modern practice. It was not until the late 19th century that large cities realized that they had to reduce the amount of pollutants they were discharging into the environment (CORETECH, 2003). In 1885, the City of Birziet began its first municipal sewer service, which was only along the lower portion of Fifth and Sixth avenues in downtown with the raw effluent discharged directly into San Diego Bay. As the City grew, raw sewage was not only discharged into the bay, but also directly into the Pacific Ocean through 22 sewage outfalls (CORETECH, 2003).

In 1943, a 14 million-gallon-per-day treatment plant went into operation on East Harbor Drive just south of 32nd Street. The U.S. Navy built the treatment plant to reduce the health risks to sailors on ships in San Diego Bay (CORETECH, 2003). Although the plant was enlarged in 1950 to handle 40 million gallons of wastewater per day, San Diego's growing population soon overwhelmed the plant's capabilities (EMWATER Project, 2006).

The potential of effluent water to transport microbial pathogens to great number of people, causing subsequent illness, is well documented (Belmont Marco etal, 2004, Moe and Reingans 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).

Biochemical oxygen demand (BOD), chemical oxygen demand (COD), total oxygen demand and dissolved oxygen (DO) are the common parameters used in assessing the assimilative capacity of a river. The BOD measures the amount of oxygen utilized by micro-organisms during the oxidation of organic materials (Rao, 2006). It gives an indication of water pollution potential of a given organic waste. The test has its widest application in measuring waste loading to treatment plants and in evaluating the efficiency of such treatment systems.

Water quality of various rivers and streams receiving effluent discharges from variouswaste

Water treatment plants and industries have been studied and monitored.(Akpen and Eze, 2006) conducted water quality assessment of River Benue at Makurdi with the aim of using the water quality parameters to develop a model for prediction. (Apeh and Ekenta, 2012) conducted a study on the surface water quality of Benue River within the reach of the Makurdibrewery. In the study, water quality monitoringwas carried out over a period of six months for point and non-point source discharges. The study concluded that pollution in River Benue is influenced by natural regimes such as rainfall and discharges of effluents. Physical and chemical pollutions increased with rainfall while microbial pollution is inversely proportional

to rainfall. Similarly,(Ogbaji *et al*. 2013) worked on the same river and applied a mathematical model to describe the self-purification of the River Benue, and concluded that selfpurification of the polluted river is possible .(Ogedengbe and Akinbile, 2010) carried out a comparative assessment of industrial and agricultural effluents on the surface water of Ona stream in Ibadan, Nigeria with the aim of identifying major pollutants, their effects on water

Qualities and to ascertain the potential of using the polluted surface water for irrigation pur poses. The result showed that the surface water from the Ona stream was unsuitable for irrigation due to the attendant health hazards associated with the negative effects of pathogens and

toxic chemicals in the discharged wastewater.

(Adedokun and Agunwamba, 2013) modeled the effect of industrial effluents on water quality of River Challawa in Nigeria. The study investigated the physicochemical characteristics associated with industrial effluents from the Challawa and Sharada Industrial Estate in Kano State, Nigeria and the effect on water quality downstream of River Challawa for a period covering wet and dry seasons. The findings identified high BOD load and low dissolved oxygen level, as contributing to a polluted stream with poor assimilatory capacity.

(Paul ,2011) studied the impact of industrial effluents on water quality of receiving streams in Nakawa-Ntinda, Uganda with the aim of developing preventive measures. Water quality parameters were assessed and the investigation found that a high degree of pollution in the stream exists and made recommendations on reduction of pollution in the stream. Sharma *et al*. (2003) monitored the water quality of Hathli stream in lower Himalayan Region for parameters of BOD and DO beside others, and established that those parameters were mainly critical during very low discharges

The quality of effluent consumable water is a concern to consumers (Wupa dwellers), water suppliers (Wupa Wastewater Treatment Plant), regulatory and public health authorities (E.g. Abuja Environmental Protection

Board). Because of the associated dangers of wastewater, this paper aimed at evaluating the performance of the plant by assessing some physico-chemical parameters from Wupa Wastewater Treatment Plant, Abuja..

II. MATERIALS AND METHODS

This analysis of physico-chemical parameters was carried out at Water Quality Laboratory at Department of Civil Engineering, Nigerian Defence Academy Kaduna, Nigeria.

2.1 Study Location

The study area is the Wupa waste water treatment plant Abuja, Nigeria it lies between latitude 7^0 20^1 and 9^0 20^1 N and longitude 6^0 45^1 and 7^0 39^1E (figure 2.1) . The plant was designed to treat waste generated from Abuja city. It has three operating units with one -unit being under operation while the remaining two units are standby in the event of failure of one unit. The plants were designed for a full capacity operation of 131,250 m^3 of waste per day, though at the moment, it is operating below designed capacity. The administrative map of the Federal Capital Territory (FCT) is also depicting the location of the Wupa River, this River is part of the Jabi River watershed in Abuja which served as receiving end of the treated waste water from the plant.

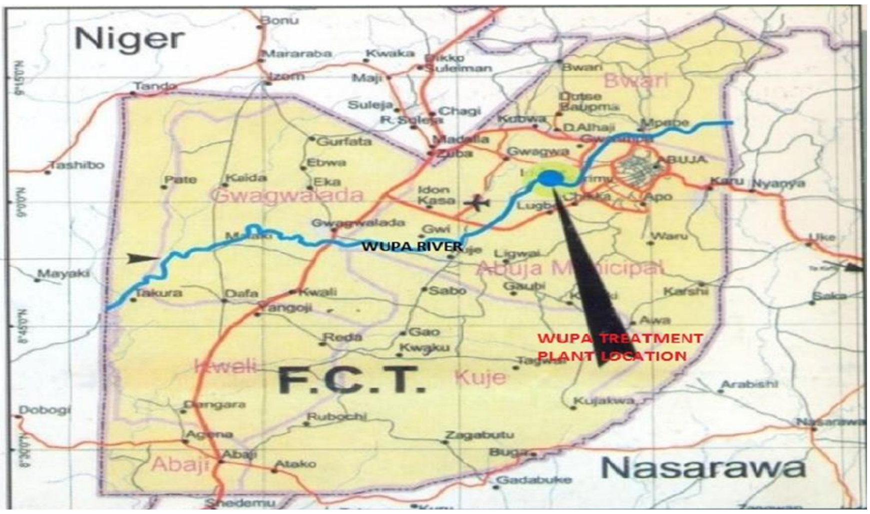

Fig 2.1 Administrative map of Abuja showing the location of Wupa waste water treatment plant and Wupa

River

The FCT has two seasons, the rainy seasons begins from April to October while the dry season lasts from November to March (GEO – LENESCO 2011). The average temperature ranges from 29^0 to 37^{0c} in the dry season month of August and dry season month of March respectively (GEHS, 2014) Nigeria which lies between latitude 3°53'E and 7°26'N. The mean daily air temperature is 24.6°C.Rainy season between April and October while the dry season is between November and March.

Figure 2.2: Shows first part of Wupa Wastewater Treatment Plant

Figure 2.3: Shows the second part of Wupa Wastewater Treatment Plant

2.2: Sampling Area

Two (2) 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 (after ultra violet rays)-just as it passes through the ultra violet ray channel, before it was discharged into the Wupa River;

2.3: Collection of Wastewater Samples

Two respective samples were collected: 'Influent' at the point of entry into the first unit of the tank just after the grit chamber and Effluent from the fourth unit (last chamber) in the series at the point of exit into the receiving water body, the Wupa River. At the time of collection of the samples, the Influent was yellowish brown and effluent was colourless, these samples were collected 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 Method

The chemical analysis was enhanced by carrying out experiment on the samples that have been collected to relate its properties and characteristics with basic parameters used in defining the quality of the waste water.

The temperature of the samples was determined using a calibrated thermometer and it was recorded as 26 0^C and 26.3 0^C for the influent and effuluent samples. Examination of the influent and effluent samples was carried out as prescribed by the (Americal Public Health Association, APHA (1998) to ascertain the levels of the physicochemical parameters and to evaluate the purification efficiency of the treatment plant. The parameters determined include pH, which was determined using a pH meter (Model Metrohm Herisau E520), amounts of total phosphate, ammonia and nitrates were determined using the auto-analyzer. BOD and DO were determined using the iodometric (azide modification) method. The total dissolved solids was determined using a portable TDS meter, while the total suspended solids were obtained in the laboratory using gravimetric method after filtration through a standard filter paper and drying.

III. RESULTS AND DISCUSSION

Table 3.1 present the data obtained from the descriptive statistics of the results obtained from the determination of the performance of the wupa waste water treatment plant.

Table3. 1: Characteristics of the Influent and Effluent from Wupa Wastewater Treatment Plant

S/N	Parameters	Experimental Results of Influent and Effluent		National Guidelines FMEnv (2013)
		Influent	Effluent	
1	Temperature, 0C	26	26.3	< 40
2	pH	7.40	7.01	6.0-9.0
3	Conductivity, µs/cm	287.00	93.00	50-125
4	Turbidity, FTU	25.00	7.00	-
	Total suspended solid, mg/l	450.00	62.03	30
5	Total Dissolved Solids, mg/l	902.5	266.30	2000

6	Total Solid, mg/l	1318.50	329.53	-
7	Biochemical Oxygen Demand, mg/l	676.10	378.60	50
8	Chemical Oxygen Demand, mg/l	2150.00	1030.00	-
9	Alkalinity	0.00	110	-
10	Total Hardness	310	180	-
11	Ammonia, NH_3, mg/l	158.00	95.00	-
12	Nitrates, mg/l	7.30	4.2	20
13	Phosphate, mg/l	0.34	0.045	5
14	Total Chloride, mg/l	270.00	110.00	600

The table shows that the waste water treatment plant is effective in the sense that the levels of alkalinity in the influent were reduced in the outcome or effluent.

The results show that the level of pH in both the influent and effluent were within the range of 6.0 to 9.0 allowed by Federal Ministry of the Environment (FMENV). Conductivity which measures thje concentration of dissolved salts and ions were expectedly found to be higher in the influent (287.00 µs/cm) than the effluent (93.00 µs/cm) which was within the limits of the regulatory body. The temperatures of both the influent and effluent were almost similar and were within the requirement. Temperatures >50^{0c} or < 2^{0c} impede aerobic digestion (Purcele, 2003).

Turbidity which is a measure of clarity of water showed massive reduction from 25.00 NTU in the influent to 9.00 in the effluent indicating the plant is effective in reducing the turbidity of waste water.

The level of total solids which include both suspended and dissolved species have also been reduced in the effluent compared with the levels in the influent. However, the level of suspended solids in the influent were higher than the limit of the regulatory agency (30.00mg/l). Regarding the dissolved solids even the influent rendered lower than the limit (2000.00mg/l) despite reduction in the effluent.

Biochemical oxygen demand (BOD5) and Chemical oxygen demand (COD) Measures the biodegradability of organic fraction of water or waste water (Purcell 2003). The former is measured after 5 days while the latter is a more rapid through the oxidation of waste by potassium dichromate. The values of both BOD_5 and COD were higher in influent than in effluent and indicate the biodegradable action in the effluent. Higher level of COD than BOD_5 in both influent and effluent agree with standard measurements (Purcell, 2003).

Alkalinity is closely related with pH which is the measure in acid neutralizing capacity. It showed remarkable increase from 0.00 in influent to 110.00mg/l in effluent, this is rather unusual because adequate alkalinity in wastewater is necessary in wastewater treatment (Purcell, 2003).

Alkalinity is also related with hardness caused by the presence of Ca or Mg which may be associated with carbonates responsible for alkalinity.

The level of hardness cause scale formation in hot water and reduce the efficiency of soap, decreased from 310 to 180 mg/l $CaCo_3$ in influent and effluent respectively the implication of the above is that waste water treatment plant has the capacity to remove hardness substances especially with adequate alkalinity.

The level of ammonia, nitrate, phosphate and total chloride were found to be insignificant. It may be most of the influent is not from agricultural practices. Level of NH_3 was reduced by about 60% after treatment. Level of nitrates, phosphate and chloride were found to be lower than the limit of the regulatory body even in the influent which were further reduced in the treated effluent.

IV. CONCLUSION

This paper evaluated the performance of Wupa waste water treatment plant in Wupa, Abuja Nigeria, samples were collected before treatment (influent) and after treatment (effluent). Results showed that the treatment plant is effective in in reducing the levels of the investigated parameters reducing except alkalinity to mostly within the limits of FMEnv. The paper concludes that the effluents can safely be released to water courses even though not fit for consumption.

V. RECOMMENDATION

In view of the success of the Wupa waste water treatment plant, Abuja, FCT, in remediating polluted water mostly from municipal activities it is recommended that similar facilities should be provided in cities and State Capitals in Nigeria. This is with a view to reduce the negative impacts in the environments

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