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TOWARDS THE MILLENNIUM DEVELOPMENT GOALS

Industrial wastewater treatment in Port Harcourt City

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WASTEWATER TREATMENT TECHNOLOGY has played a very important role in the **water and sanitation sectors**, it has contributed significantly to the improvement and protection of the environment and also importantly, to the protection of public health by safe guarding water supplies and preventing the spread of water-borne diseases [Spanjers, 2002] The estimated **annual pollution load** input to the coastal and marine environment from industrial sources in Rivers State was put at **260,000 metric tons/years.** [Pollutect, 1998] The implication of this is that large quantities of wastewater are constantly discharged into the environment of Port Harcourt metropolis. This study was carried out between the period of **February 2001 and December 2002.** This paper is centered on the study of two-wastewater treatment plants namely: The **Pure stream Sewage Treatment Plant based on the Extended Aeration Method** belonging to an Oil Servicing/Contracting Company, represented here as **SWTP** and The wastewater treatment plant based on the Principle of **Sequencing Batch Reactor Process** owned by a Vegetable Oil Company, represented here as **RWTP**. The **objectives of this study** were to: [1] Determine effluent qualities discharge by these two plants. [2] Determine the effluent treatment efficiencies of the plants and [3] Identify factors, which militate against the performance of the treatment plants.

Description of the wastewater treatment plants

[1] SWTP Wastewater Treatment Plant This wastewater treatment plant was commissioned in 1999. The wastewater treatment plant is **PURESTREAM MODEL:** which treat about **81,900 L/day** of wastewater. Design to treat wastewater from the residential and industrial areas of the company. The Pure stream Sewage Treatment Plant is based on the Extended Aeration Method of Wastewater System. This method of treatment consists basically of four operations (Purestream 1999): Screening, Aeration, Settling and Chlorination **Screening:** when the sewage first enters the plant it passes through a screening device, also fitted with a grinder. The screen devise is a series of bars welded to a frame with approximately one inch spacing between bars. The communitor a mechanical grinder or cutter designed to cut or shred large solids. **Aeration:** from the screening devices the wastewater passes into the aeration tank. In this tank wastewater is decomposed by aerobic bacteria and other organism in the presence of air (aerobic conditions). In a properly operating plant, these micro organisms (that's a rather technical term, we call them "bugs") will form a dark brown mass called activated sludge, which is mixed with the incoming wastewater. This is done by introducing air along one side of the tank near the bottom air diffusers, thereby settling up mixing current. Within the liquid and maintaining an adequate air supply to allow the organisms to decompose the waste into carbon dioxide and water and other minor constituents. The air is provided by a rotary blower housed in a metal structured mounted a top the settling tank, the air is piped through air header pipes to the diffusers at the bottom of the aeration tank. A second blower for stand by service may be provided. **Settling:** From the aeration tank, the treated wastewater mixed with the activated sludge passes through a port in the wall into the settling tank or clarifier. In the settling tank heavy activated sludge mass settles to the bottom and the clear treated liquid flows over a vertical metal plate or wire into the discharge line. Adequate volume is usually provided in this tank to retain the wastewater for a four-hour period. The settling sludge or bacteria is then returned back to the aeration tank by the air left sludge return system to decompose more incoming wastewater. ***Chlorination:*** - The treated liquid (the effluent) discharged form the settling tank than passes through chlorination facilities; this is done to kill the disease – carrying [Pathogenic] bacteria which might be in the effluent. The treated effluent passes into the chlorine contact tank. **[2] RWTP Waste Water Treatment Plant.** This organisation wastewater treatment plant was commissioned in 1994, when the company diversified into the production of soaps, which makes use of a lot of caustic soda as its raw materials. The wastewater treatment plant work on the Principle of Sequencing Batch Reactor Process. The treatment plant treats an average of **191,100 L/day** of wastewater. This method of treatment consist basically of: Screening, Primary Clarifier/Sedimentation Tank, Reaction Pit (Aeration Pit), Fertilizers And Other Additives Dozing Tanks, Secondary Clarifier/Settler, Sand Bed Filter and Sludge Bed. **Screening:** The wastewater first enters the plants it passes through simple and a every fine screen. This screen is used to relieve overload of the primary clarifier and sedimentation tank by removing some of the potentially settleable solids, and may reduce the biological load of the plant. **Primary Clarifier/Sedimentation Tank:** Sedimentation is the first primary treatment stage of the RWTP. This is an overhead steel tank; with the aid of a pump the inffluents is pump automatically from the screening chamber into this tank. Alum is also added into this tank to enhance coagulation of the sludge. At the bottom of this tank is a pipe with a valve connected to the sludge bed. This valve is open at interval of between 8 and 24 hours, which allows some consolidation to occur and produces a thicker sludge whilst avoiding septic and anaerobic condition, which might cause odour problems and rising sludge. When the inffluents reach a certain levels in the primary clarifier, it is automatically pump to the reactor pit. **Reactor Pit:** The main activity in this pit is the aeration mixing system, the decant system, and the control system. The aeration/mixing system is mechanical turbine aerators. The wastewater in the chamber is automatically pumped into the next tank at certain level. **Fertilizers And Other Additives Dosing Tank:** In this tank fertilizers is added to enable the micro-organism to multiple in large numbers and also provide enough food to the bacteria to digest the organic and inorganic substances in the wastewater. The fertilizers added are Nitrogen, Potassium and Phosphorus types of about 0.28kg in quantity and Urea of 0.230kg about 40kg of Calcium Hydroxide is also added for P^H adjustment. Then the wastewater is transfer by way of automatic pump to the secondary clarifiers. **Secondary Clarifiers:** This performs the initial function of separating oxidized humus or activated sludge to provide an effluent low in solids. The Bottom of this tank is also fitted with pipes and value connected to the sludge bed. **Sand Bed Filter:** This consist of one or more beds of granular materials, typically graded sand, 60 to 90 cm, (2 to 3ft) deep, underline with collection drains imbedded in gravel. The wastewater from the secondary clarifiers is intermittently applied to the surface of the sand bed and allowed to percolate through the bed where it receives treatment. The percolates usually collected by the under drains for disposal. The wastewater is not chlorinated. **Sludge Bed:** The sludge bed removes moisture by drainage and by evaporation. Under drainage is collected and returned back to the reactor pit.

Sampling and analysis methods

Wastewater samples were collected at the plants in-take as well as at the plant outfall. Effluent samples were collected with sterile containers and analyzed for the following parameters: P^H, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Dissolved-Solids. Ammonia-Nitrogen (NH_3-N), Oil and grease, Iron, Total Heterotrophic Bacteria Count {HTBC} and Bacteria of Feacal Pollution- Total Coliform Bacteria {TCB} and Feacal Coliform. The conventional methods described in Standard Methods For The Examinations Of Water And Wastewater, (A.P.H.A., A.W.W.A, W.P.C.F., 1985) were applied.

Result

Physico–Chemical/ Microbiological Characteristics Of SWTP and RWTP Inffluents: SWTP Inffluents had the following characteristics: P^H 5.5, Total Dissolved Solid (TDS) 235mg/l, Oil and Grease 96mg/l, Dissolved Oxygen (DO) 5mg/l, Chemical Oxygen Demand (COD) 65mg/l, Biochemical Oxygen Demand (BOD) 45mg/l, temperature 30^{0c}, Nitrate 1.0mg/l, and Ammonia 2.5 mg/l. **RWTP** inffluent's quality were as follows: pH 7, Total Dissolved Solids (TDS) 484 mg/l Oil and Grease 215 mg/l, Dissolved Oxygen (DO) 2mg/l, Chemical Oxygen Demand 69 mg/l, Biochemical Oxygen Demand 68.5mg/l, Temperature 45^{oc} Nitrite 2.5 mg/l and Ammonia 3.8mg\l. The inffluents of **SWTP** had a Total Heterotrophic Bacteria Count [THBC] of 9.2 x 10^6 cfu/ml, Total Coliform Count [TC] of 1.2 x 10^3. The population of Total Heterotrophic Bacteria in **RWTP** was 8.2 x 10^5 cfu/ml, Total Coliform of 6.1x 10^3 cfu/ml and Feacal Coliform of 1.1 x 10^3 cfu/ml. **Physico – Chemical/ Microbiological Characteristics Of The Effluents: SWTP** had the following characteristics; P^H 7.80 mg/l Total Dissolved Solids [TDS] 100 mg/l Oil and Grease 68.97 mg/l, Dissolved Oxygen (DO) 10.882 mg/l, Chemical Oxygen Demand (COD) 61.86 mg/l, Biochemical Oxygen Demand (BOD) 25 mg/l, Residuals Chlorine at effluent outfall 0.3 mg/l, Nitrite 0.167 mg/l, Nitrate 0.08 mg/l, Ammonia 1.44 mg/l. and temperature $27^{0c.}$ **RWTP** effluent were as follows: P^H 8.0mg/l, Total Dissolved Solids (TDS) 440mg/l Oil and Grease 85mg/l, Dissolved Oxygen (DO) 12.556 mg/l, Chemical Oxygen Demand (COD) 65.0mg/l, Biochemical Oxygen Demand (BOD_5) 45 mg\l, Temperature 30^{oc}, Residual Chlorine was not detected at the effluent outfall, Nitrate 1.0mg/l, Nitrite 1.0 mg/l and Ammonia 1.45mg/l. The **SWTP** effluent had a lower population of Heterotrophic Bacteria 2.2 x10 cfu/ml, Total Coliform and Feacal Coliform was not detected in the effluent. **RWTP** effluent had 8.2-x105 cfm/ml of Heterotrophic Bacteria, 6.1 x 10^3cfu/ml of Total Coliform and 1.1 x 10^3cfu/ml of Feacal Coliform. **Wastewater Treatment Efficiency of SWTP and RWTP: SWTP** had the following Treatment Efficiency: Total Dissolvent Solids 57.44%, Oil and Grease 23.11%, Chemical Oxygen Demand (COD) 4.83%, Biochemical Oxygen Demand (BOD) 44.4%, Nitrate 88.86%, Nitrite 92%, Ammonia 42.4%, Total Heterotrophic Bacteria, 99.9% while both Total Coliform and Feacal Coliform had 100% removal efficiency (see table 20). **RWTP's** Treatment Efficiency was as follows: Total Dissolved Solids 9.09%, Oil and Grease 11.45%, Chemical Oxygen Demand 5.79%, Biochemical Oxygen Demand 33.82 %, Nitrate 60.7%, Ammonia 61.84%, Total Heterotrophic Bacteria 99.43%, Total Coliform 78.68% and Feacal Coliform 47.61%. (See table 1) **Performance Audit Report of SWTP and RWTP:** We discovered that the staff operating the plant were not adequately trained for the operation of the plant hence cannot carry out effective maintenance programme for the plant. Adequate funds were not also made available for routine maintenance and for ease of replacement of spare parts and chemicals.

Discussion and conclusion

The value obtained of BOD_5 in the inffluents and effluents in the study were similar to those of Yagoubi et al (2000) who conducted studies to asses the performance of the Wastewater Stabilization Pond of Boujaad, Morocco. The BOD_5 of SWTP inffluents and effluent was well below the FEPA Effluent Limitation Guidelines. Yagoubi et al (2000) recoded a BOD_5 well below expected design concentration of 150mg/l in Boujaad, Wastewater Stabilization Ponds. Low BOD_5 Removal Efficiency means that less oxygen will remain after decomposition of the organic matter for the survival of bacteria's that aid the degradation of the waste load in the treatment plant. The Hynes (1974) noted that efficient wastewater treatment system could reduce a 5-day BOD of about 300- 600 ppm to something like 20 ppm in a matter of hour. According to him part of this reduction is due to the actual physical removal of organic matter by sedimentation but much of it is due to the biological processes in the filter or activated sludge tank. The **Total Dissolved Solids** of both inffluents and effluents of RWTP were higher than that of SWTP. The treatment or removal efficiency of his parameter was higher in SWTP than in RWTP. Arundel (2000) stated that good quality effluents would have a TDS of less than 15 mg/l; while crude sewage or wastewater is 250- 400mg/l. TDS Removal Efficiency of 9.09% for RWTP was very poor and require very urgent attention. Furthermore, the **chemical Oxygen Demand** (COD) of both effluents is well above the FEPA's Effluent Limitations Guidelines and standards. Grimes et al [1984] recorded a very high COD from the Barceloneta Treatment Plant Effluents. This means that the concentration of the non biodegradable or non easily biodegradable portion (represented by the COD) concentration remain more or less constant, in the inffluents and effluent. Chemical Oxygen Demand is a measure of the oxygen equivalent of that portion of organic matter in effluents that is susceptible to oxidation by strong chemical oxidant. It is an important rapidly measured parameter for industrial waste studies and control of wastewater treatment plant (APHA 1985). The **nitrate and nitrite** concentration in both effluents were below the FEPA Effluent Limitation Standards. The Percentage Removal Efficiency for the two parameters was high in SWTP than RWTP. Nitrate indicates the degree of oxidation being achieved during treatment. This result was expected in nitrate and nitrite level because the wastewater treatment plants of this study performed more of carbonaceous oxidation, which is supposed to contain little nitrate. The **ammonia** levels in both effluents were above the FEPA Effluent Limitation Standards. Their removal efficiency was higher in SWTP and 61.74% for RWTP; the removal efficiency is higher in RWTP than SWTP. This agreed with Arundel [2000]. Ammonia arises in wastewater from breakdown of amines, proteins and nitrogen compounds and the hydrolysis of urea. It is always present in sewage within a typical range of 20-50mg/l. the stronger the sewage the higher the ammonia. Thus an overloaded or poorly- maintained plant will only achieve partial nitrification or only carbonaceous removal and the ammonia test provides a fundamental assessment of the efficiency of oxidization: 60%-95% removal are common in conventional sewage treatment. Thus a good quality's effluent, contain less than 5mg/l Ammonia – Nitrogen. (Arundel 2000) The higher ammonia value in effluent of RWTP was

Table 1. Shows The Physico – Chemical/Microbiological Characteristic Of Inffluents, Effluents and Treatment Efficiency Of SWTP And RWTP

Parameters	INFFLUENT		EFFLUENT		TREATMENT EFFICIENCY		FEPA Limit
	SWTP (mg/l)	RWTP (mg/l)	SWTP (mg/l)	RWTP (mg/l)	SWTP %	RWTP %	(mg/l)
PH	5.5	4	7.80	8			
TDS	235	434	100	440	57.44	9.09	2000
O & G	96	215	68.97	85	23.11	11.45	10
DO	5	2	10.882	12.556			
BOD	45	68	25	45	44.4	33.82	500
COD	65	69	61.86	65.0	4.83	5.79	
Temp.	30 ^{oc}	48^{oc}	27 ^{oc}	30 ^{oc}			40 ^{oc}
Residue Chlorine			0.5	NIL			
Nitrate	1.5	2.8	0.167	1.0	88.8	60	20
Nitrite	1.0	2.5	0.08	1.0	92	60.7	
Ammonia	2.5	3.8	1.44	1.45	42.4	61.84	
THB	$9.2x10^6$ cfu/ml	$8.2x10^5$ cfu/ml	$2.2x10^6$	$4.6x10^3$	99.99	99.43	
TC	$7.2x10^3$ cfu/ml	$6.1x10^3$ cfu/ml	0 cfu/ml	$1.3x10^3$ cfu/ml	100	78.68	500 cfu/ml
FC	$1.2x10^3$ cfu/ml	$1.1x10^3$ cfu/ml	0 cfu/ml	$1.1x10^2$ cfu/ml	100	47.61	

expected because of the additional of urea and NPR fertilizers into the treatment process of the plant. SWTP Inffluent recorded a very high total **Heterotrophic Bacteria Counts** (table 1) than that of RWTP. This was the case in the **Total Coliform and Feacal Coliform Counts**. The reserved was the case in the treated effluent of RWTP effluent which recorded a higher total Heterotrophic Bacteria Counts, Total Coliform and Feacal Coliform Count respectively. The removal efficiency of bacteria load from the SWTP was higher. This result agreed with Southgate, (1951), who confirmed that untreated sewage already contains large numbers of bacteria, some of which are of feacal origin such as the well known *Escherichia coli* and many disease organism. This was also expected because the RWTP do not have chlorination chamber for disinfections of the wastewater.

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