Research Journal of Agriculture and Biological Sciences, 2(6): 452-459, 2006

Efficacy of a Biological Treatment Plant at Ahmadu Bello University Zaria

[1]I.A. Oke, [3]J.A. Otun, [3]C.A. Okuofu and [2]N.O. Olarinoye

[1]Department of Civil Engineering, Obafemi Awolowo University, IleIfe, Nigeria.
[2]Department of Chemistry, Adeyemi College of Education, Ondo, Nigeria.
[3]Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria.

Abstract: Efficacy of a biological treatment process in removing pollutants (BOD, suspended solids, faecal coliform, COD and nutrient) from wastewater originated from an institution (Ahmadu Bello University main-campus, Zaria) was studied and presented in this paper. The pond consists of facultative and maturation ponds in series. Influent and effluent wastewater's qualities were monitored from the ponds for a period of a year. Results of the study revealed that the flow rates of both influent and final sewage effluents are 620 m^3/d. The strong raw sewage has a BOD of greater than 400 mg/l and the ponds have a BOD removal efficiency in the range of 93.2-95%, suspended solids removal of 55.0-76.1% and faecal coliform reduction of 99.1-99.6% with average BOD reduction of 93.6% and average faecal coliform removal efficiency is 99.3% and average reduction in suspended solids by the ponds is 66.1%. The ammonia and phosphate concentrations of the raw influent were reduced on an average of 87.58 and 80.8% respectively by the ponds and overall average COD reduction was 96.4%. It was concluded that under tropical conditions the waste stabilization ponds are more suitable and appropriate compared to conventional treatment systems such as trickling filters and activated sludge, because of the ease of operation and maintenance and level of treatment efficiencies the ponds are able to achieve.

Key words: Waste stabilization ponds, institutional wastewater, nutrients removal, faecal coliform removal, BOD reduction, COD

INTRODUCTION

High levels of organic matter and nitrogenous compounds characterized wastewaters from institutions[1]. The organic matter is mainly present as carbohydrates and the nitrogenous compounds as urea. Consequently, biological treatment of these wastewaters requires a combined process of carbon and nitrogen removal. These biological treatment processes (among which is waste stabilization ponds) could be carried out in a pre-denitrification system, which is usually used to treat wastewaters with a high content of organic matter that can be used as carbon source for denitrification. The pre-denitrification system avoids or decreases the need for adding an external carbon source, which is interesting from an environmental and economic point of view. Organic matter removal, hydrolysis of nitrogen compounds and denitrification of nitrate recirculated from the aerobic unit would take place in the anoxic reactor. Nitrification of ammonium provided by the anoxic unit and biodegradation of the organic matter that would not have been removed in the anoxic reactor would take place in the aerobic reactor[2]. Cheng *et al.*[3] studied the treatment of wastewaters from a resin-producing industry using a pre-denitrification system (anoxic-aerobic-aerobic) at laboratory scale. They achieved removal efficiencies of COD and TKN 95.3 and 83.8% respectively, at organic loading rates of between 0.27 and 0.72 kg COD/m^3·d and nitrogen loading rates of between 0.04 and 0.12 kg TKN/m^3·d. Garrido *et al.*,[4] also studied treatment of wastewaters from a resin-producing industry using a pre-denitrification system (anoxic-aerobic) at laboratory scale. They achieved COD removal efficiencies between 70 and 85%, at organic loading rates of between 0.7 and 1.9 kg COD/m^3·d. Hodgson[5] monitored the performance of a typical biological treatment process at Akuse, Ghana and obtained 65% BOD reduction, 99.99% removal faecal count, 46% reduction of suspended solids 92 and 94% of ammonia and phosphate removal respectively. It is well known that the usage of waste stabilisation ponds for treatment of wastewaters can be found in over fifty countries with very different climatic conditions ranging from tropical to temperate climates. A great number of these ponds can be found in Asia, Latin America and Africa[1,5,6]. In Nigeria the common treatment technologies adopted for domestic and institutional sewages treatment are septic tank and soak away, trickling filters, activated sludge and waste stabilization ponds

Corresponding Author: I.A. Oke, Department of Civil Engineering, Obafemi Awolowo University, IleIfe, Nigeria.

Waste stabilization ponds have been installed in some institutions (Ahmadu Bello University, Zaria; University of Ibadan, Ibadan; IITA, Ibadan and Obafemi Awolowo University, Ile-Ife[1]). With increasing population in most of these institutions and with sudden change in climate and wastewater quality there is a need to monitor efficacy of biological treatment processes which depend mainly on nature. The main objective of the study is to evaluate the efficiencies of ponds at Ahmadu Bello University, Zaria, Nigeria.

MATERIALS and METHOD

Physical and engineering properties of the ponds were assessed. Wastewater samples were taken from the influent (raw sewage) and effluent (Pond A, Pond B and Pond C, Fig. 1). The samples were taken on five different days per week for a period of a year. Standard sampling methods specified in APHA[7] were used in the collection of wastewater samples and parameters such as BOD, COD, nutrient and microorganism were examined. The methods and procedures in Standard Methods for the Examination of Water and Wastewater were followed in the examinations of those selected parameters (APHA[7]). The BOD_5 concentrations were determined using respirometric method. Computations of BOD were carried out using expression:

$$BOD_t = \frac{(D_1 - D_2) - (B_1 - B_2) f}{p} \quad (1)$$

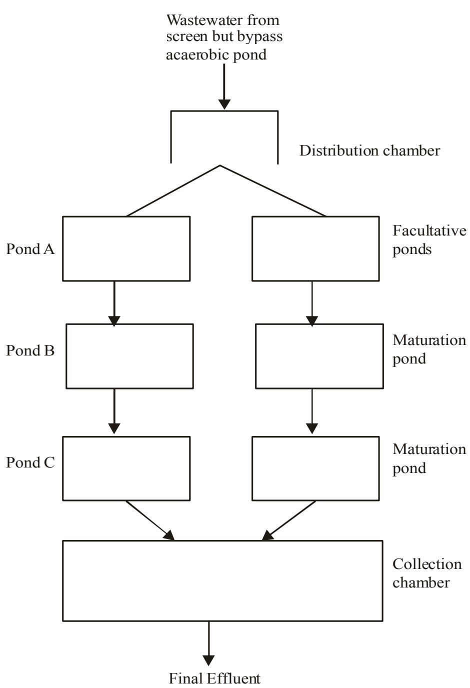

Fig. 1: Plan view of the waste stabilization pond.

For the determination of COD closed reflux method was used. COD concentrations were calculated using expression:

$$COD = \frac{(A_1 - B_2) x\ m\ x\ 8000}{ml\ of\ sample} \quad (2)$$

For phosphorus determination stannous chloride method was used. Phosphorus concentration was calculated using

$$P_s = \frac{M_a\ x\ (1000)}{ml\ of\ sample} \quad (3)$$

Organic-nitrogen concentration was determined using Macro-kjeldahl method while ammonia-nitrogen was determined using titrimetric method and computation was made using expression :

$$NH_3 - N(mg/L) = \frac{(A_a - B_b)\ x280}{ml\ of\ sample} \quad (4)$$

RESULTS AND DISCUSSIONS

The results of physical and engineering properties assessed are as shown in Table 1. The engineering properties assessed are retention time, weir loading, hydraulic loading, which was determined using equation (5) and BOD loading, which was determined using equation (6), COD and TKN loadings were not left out (determined using equations 7 and 8 respectively). Retention time has been defined as the minimum time required by any incoming wastewater to stay in a given wastewater treatment facility.

$$H_y = \frac{Q}{A} \quad (5)$$

$$BOD_L = \frac{10BOD_{av}}{A}Q \quad (6)$$

$$COD_L = \frac{10COD_{av}}{A}Q \quad (7)$$

$$TKN_L = \frac{10TKN_{av}}{A}Q \quad (8)$$

Weir loading has been defined as the ratio of discharge to the length of the collector, which can be expressed mathematically as:

$$W_s = \frac{Q}{L} \quad (9)$$

Retention time in the facultative pond and maturation ponds are 23 and 6 days respectively. These values fall the ranges of 7-30 and 5-20 days specified in literature[8,10-12] indicating that the ponds met international standards in engineering. The BOD loading recommended is less than 15 kg of BOD per hectare. day. The values obtained for both facultative and maturation ponds were less than specified limit. These results indicate that hydraulic loading and BOD loading met the standards too (Table 1). The averages of depth of the liquid in both facultative and maturation ponds were 1.37 and 0.92 meters respectively, indicating that the values fall in the ranges highlighted in literature[13]. A lower depth of liquid (0.92 m) in maturation ponds (Ponds B and C) indicates that there is a need to de-sludge the ponds for higher depth (Actual depth of liquid).

Treatment performance: The treatment performance of the ponds was assessed based on the following considerations, namely: organic matter removal (BOD); COD removal; suspended solids (SS) removal; nutrient removal (ammonia, nitrate, phosphate); and microorganisms removal. The summary of the laboratory results is given in Table 2.

BOD removal: Biological Oxygen demand (BOD) is the measure of the oxygen required by microorganisms whilst breaking down organic matter. It is well reported that wastewaters effluents with h3igh concentrations of BOD_5 can cause depletion of natural oxygen resources, which may lead to the development of septic conditions[5,8]. The BOD_5 of the raw sewage were between 450 and 650 mg/l with a mean of 609 mg/l. Metcalf and Eddy[8] classifies domestic wastewater into three (strong, medium and weak) using BOD_5 concentrations (Table 3). The BOD_5 concentrations of the raw sewage were greater than 400 mg/l the strength of sewage can be considered as strong[5,8,9]. This result is in agreement with documentation on similar wastewater influent (institutional wastewater)[1].The BOD_5 concentration of

Table 1: Summary of engineering properties and physical assessment.

Ponds	Liquid depth (m)	Volume of the pond (m^3)	Surface area (m^2)	Hydraulic loading (m^3/m^2.d)	BOD loading (kg/ha.d)	Retention time (d)	Length: breadth ratio
Pond A	1.37	14400	10500	15.34	0.75	23	3:1
Pond B	0.92	1700	1850	10.2	4.59	6	1.5:1
Pond C	0.92	1700	1850	10.2	4.59	6	1.5:1
Expected physical and engineering properties of similar ponds[8]							
Pond A	1.0- 2.0		10000-40000		15 –80	7 –30	
Pond B	1.0 -1.5		10000-40000		< 15	5 - 20	
Pond C	1.0 -1.5		10000-40000		<15	5 - 20	
Expected physical and engineering properties of similar ponds[10]							
Pond A	1.0 1.5		264000		15- 30	32	
Pond B	1.0 1.5		116000		15- 30	14	
Pond C	1.0 1.5		116000		15- 30	14	

Table 2: Summary of the assessment.

	Raw influent		Facultative pond				Maturation pond				Overall	
	Concentration (mg/l)		Concentration (mg/l)		Efficacies (%)		Concentration (mg/l)		Efficacies (%)		Efficacies (%)	
Parameters	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
BOD (mg/L)	450-650	609	120-150	139.5	68.5-78.6	75.8	25-45	37.5	67.7-82.8	73.14	93.2-95	93.58
COD	880-1850	1120.6	235-430	256.8	73.3-82.4	79.7	60-110	75.8	74.7- 85.6	80.2	93.4-97.8	96.4
Organic_ Nitrogen	12-21	16.5	10-16	12.5	16.7-31.3	23.78	7.9.0	8.1	26.7-43.8	34.56	39.3- 57.5	50.04
Phosphorus	12- 28	22.6	6.-11	7.8	42.3-58.4	48.6	2-8.2	4.6	35.8-41.2	38.2	76.7- 83.3	80.8
Ammonia	38-65	62.4	26.-35	32.5	44.2-51.2	47.4	5-10	6.2	60.3-71.4	67.8	85.6-88.9	87.58
Feacal count	$1.0x 10^5$- $4.0x 10^5$	$3.0x 10^5$	$1.0x 10^4$ - $7.0x 10^4$	$3.0x 10^4$	50.8- 82.5	71.13	$2.0x 10^2$ - $4.0x 10^2$	$3.0x 10^2$	98.1-99.4	98.9	99.1-99.6	99.3
Suspended Solid	300-1600	800	250-600	378.6	49.4-75.0	62.3	100-180	122.2	40.6-55.2	46.8	55-76.1	66.1

Table 3: Classification of wastewaters based on composition.

Parameter	Strong	Medium	Weak
BOD (mg/L)	400	220	110
COD(mg/L)	1000	500	250
SS (mg/L)	350	220	100
Phosphate as phosphorus (mg/L)	15	8	4
Organic- nitrogen (mg/L)	35	15	8
Ammonia (mg/L)	50	25	12

the effluent from facultative ponds ranged from 120 to 150 mg/l with a mean of 139.5 mg/l. The efficacies of facultative ponds ranged from 68.5% with and average of 75.81%. The mean BOD_5 removal efficiency of the facultative ponds is 75.81% which is higher compared to other waste stabilization ponds which give BOD_5 removal efficiencies of 60%[10,5], but lower that 80-95% specified in literature such as Metcalf and Eddy[8]. The BOD concentration of the effluent from maturation ponds (Pond B and Pond C) ranged from 25 to 45 mg/l with a mean of 37.5 mg/l. The efficacies of maturation ponds ranged from 67.7-82.8% with and an average of 73.14%, which is higher compared to other waste stabilization ponds, which give BOD_5 removal efficiencies lower than 60%[8,5,9,10], but falls in the range (60-80%) highlighted in Metcalf and Eddy[8] The overall BOD_5 efficacies were between 93.2-95.0% with an average of 93.58%, which is high compared with ponds specified in literature[5,11]. The high BOD removal may be attributed to the high strength of the raw sewage (rate of BOD removal is of first order kinetic) and high retention time in the facultative ponds. High BOD removal can be attributed to sewered and open channel flow system adopted. The mean overall BOD of the final effluent is low and satisfactory compared to the guideline value of 50-mg/l specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many other standard environmental engineering literature[5,11,12].

COD removal: Chemical Oxygen Demand (COD) has been defined as the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters. It has been well documented that wastewater effluents with high concentrations of COD can cause depletion of natural oxygen resources, which may lead to the development of septic conditions[5,8]. The COD of the raw sewage were between 880 and 1850 mg/l with a mean of 1120.6 mg/l. The BOD_5 to COD ratio ranged from 0.351 to 0.789 (COD : BOD_5 is 1.267 to 2.851) indicating that at most 0.789 mg and at least 0.351 mg out of 1 mg of COD will be degraded biologically within the shortest time of 5 days. Metcalf and Eddy[8]classifies wastewater into three (strong, medium and weak). Using COD concentrations (Table 3). The COD concentrations of the raw sewage were greater than 1000 mg/l the strength of sewage can be considered as strong. High COD concentration can be attributed to combination of both commercial and institutional activities with residential in the community. The COD concentration of the effluent from facultative ponds ranged from 235 to 430 mg/l with a mean of 256.8 mg/l. The efficacies of facultative ponds ranged from 73.3-82.40% with and average of 79.70%. COD concentration of the effluent from maturation ponds ranged from 60 to 110 mg/l with a mean of 75.8 mg/l. Efficacies of maturation ponds ranged from 74.7-85.6% with and an average of 80.20%. Overall COD efficacies were between 93.4-97.8% with an average of 96.40%. The high COD removal may be attributed to the high strength of the raw sewage, availability of sunlight, low COD: BOD and availability of algae. This high COD removal may be attributed to high COD loading on the system. The mean overall COD of the final effluent is low and satisfactory compared to the guideline value of 120-mg/l. specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many otherstandard environmental engineering literature[5,11,12].

Suspended solid removal: Suspended solids (SS) concentration is the measure of amount of floating matter in the wastewater, because of its relationship with sedimentation tank, sludge formation and biological treatment suspended solids in the wastewater must be measured in characterisation of a particular wastewater for proper design. Literature[1,5,8,9,10] stressed that the discharge of effluents with high SS concentrations can cause sludge depositions and anaerobic conditions in the receiving water body. SS of the raw sewage ranged from 300 to 1600 mg/l with a mean value of 800 mg/l. The ratio of suspended solid to COD ranged from 0.341 to 0.866 and suspended solid to BOD was 0.121 to 0.682. High SS can be attributed to commercial activities and lack of anaerobic pond or sedimentation tank, which suppose to give pre-treatment before biological treatment. The SS concentration of the effluent from facultative ponds ranged from 250 to 600 mg/l with a mean of 378.6 mg/l. Efficacies of facultative ponds ranged from 49.4-75.0% with and average of 62.3%. The mean SS removal efficiency of the facultative ponds is 62.3% which is low compared to other waste stabilization ponds which give SS removal efficiencies greater than 70%[5]. The SS concentration of the effluent from maturation ponds ranged from 100 to 180 mg/l with a mean of 122.2 mg/l. The efficacies of maturation ponds ranged from 40.6-55.2% with and average of 46.8%. The mean SS removal efficiency of the maturation ponds is 46.8%, which is low compared to other waste stabilization ponds which give SS removal efficiencies greater than 70%[5]. Also contrary to literature[10] (facultative ponds suppose to increase SS) facultative pond here reduced suspended solid rather than increasing SS. This reduction might be attributed to high retention time and weir collection system used. High-suspended solid removal may be attributed to weir (collection) system used which makes the ponds to behave as sedimentation tanks (solids removal). The overall SS efficacies were between 55.0-76.1% with an average of 66.1%. The mean overall SS of the final effluent is higher and un-satisfactory compared to the guideline value of 30-mg/l specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many other standard environmental engineering literature[5,12,13].

Nutrients removal: It has been documented that wastewater effluents with high concentrations of nutrients (organic nitrogen, phosphorus, ammonia) can cause undesirable phytoplankton growth (Eutrophication) in the receiving water body[5,8,9,10]. The ammonia concentrations of the raw sewage ranged from 38 to 65 mg/l with a mean value of 62.4 mg/l. High ammonia can be attributed to the presence of commercial and recreation activities and lack of anaerobic pond or sedimentation tank, which suppose to give pre-treatment before biological treatment. This result is similar to Hodgson[5] observation made of a biological treatment plant at Akuse (Ghana) in which ammonia concentration was high due to lack of anaerobic pond[5]. Ammonia concentration of the effluent from facultative ponds ranged from 26 to 35 mg/l with a mean of 32.50 mg/l. Efficacies of facultative ponds ranged from 44.2-51.2% with and average of 47.4%. The ammonia concentration of the effluent from maturation ponds ranged from 5.0 to 10. mg/l with a mean of 6.20 mg/l. The efficacies of maturation ponds ranged from 60.3-71.4% with and average of 67.8%. The overall ammonia efficacies were between 85.6-88.9% with an average of 87.58%. The low removal may be attributed to the high strength of the raw sewage, high temperature (discourage solubility of oxygen) couple with high surface area and low removal might be attributed to influx NH_3 from anaerobic reactions for sludge digestion at the bottom of the ponds (equation 1). This result indicates that de-sludge is an urgent event. The mean overall ammonia of the final effluent is high and unsatisfactory compared to the guideline value of 0.2-mg/l. specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many other standard environmental engineering literature[5,11,12,13].

The organic-nitrogen concentrations of the raw sewage ranged from 12 to 21 mg/l with a mean value of 16.5 mg/l. Like ammonia high organic-nitrogen can be attributed to commercial and recreation activities and lack of anaerobic pond or sedimentation tank, which suppose to give pre-treatment before biological treatment. The organic-nitrogen concentration of the effluent from facultative ponds ranged from 10. to 16. mg/l with a mean of 12.50 mg/l. The efficacies of facultative ponds ranged from 16.7-31.3% with and average of 23.78%. Organic-nitrogen concentration of the effluent from maturation ponds ranged from 7.00 to 9.0 mg/l with a mean of 8.10 mg/l. The efficacies of maturation ponds ranged from 26.7-43.8% with and average of 34.56%. The mean organic-nitrogen removal efficiency of the maturation ponds is 34.56%, which is low compared to other waste stabilization ponds which give nitrate-nitrogen removal efficiencies greater than 70%[5]. The overall organic-nitrogen efficacies were between 39.34-57.5% with an average of 50.04%. The low organic-nitrogen removal may be attributed to the high strength of the raw sewage, anaerobic reactions at the bottom of the ponds and probably denitrification process at the bottom of the pond (equation 1) and low strength of algae. The mean overall organic-nitrogen of the final effluent is low and satisfactory compared to the guideline specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many otherstandard environmental engineering literature[5,12,13].

The phosphate (as phosphorus) concentrations of the raw sewage ranged from 12 to 28 mg/l with a mean value of 22.6 mg/l. High phosphate (as phosphorus) can be attributed to washing activities and the use of detergent which are known as the source of phosphate. The phosphate (as phosphorus) concentration of the effluent from facultative ponds ranged from 6.0 to 11.0mg/l with a mean of 7.80 mg/l. The efficacies of facultative ponds ranged from 42.3-58.4% with and average of 48.6%. The mean phosphate (as phosphorus) removal efficiency of the facultative ponds is 48.6% which is low compared to other waste stabilization ponds which give phosphate (as phosphorus) removal efficiencies greater than 70%[5]. The phosphate (as phosphorus) concentration of the effluent from maturation ponds ranged from 2.0 to 8.2 mg/l with a mean of 4.60 mg/l. The efficacies of maturation ponds ranged from 35.8-41.3% with and average of 38.2%. The mean phosphate (as phosphorus) removal efficiency of the maturation ponds is 38.2%, which is low compared to other waste stabilization ponds which give phosphate (as phosphorus) removal efficiencies greater than 90%[5]. The overall phosphate (as phosphorus) efficacies were between 83.3-76.7% with an average of 80.8%. The low phosphate (as phosphorus) removal may be attributed to the high strength of the raw sewage and low strength

Table 4: Characteristics of the major types of ponds (Source: Horan[10]).

Pond type	Depth (m)	Detention time (days)	Major role	Typical removal effluent
Anaerobic	2 – 5	3 – 5	Sedimentation of solid, BOD removal, Stabilization of effluent and removal of helminths.	BOD 40% - 60%, S.S 50% - 70%, Faecal coliforms 1 log and Helminth 70%
Facultative	1 – 2	4 – 6	BOD removal	BOD 50% - 70%, Faecal coliforms 1 log S.S increases due to algae
Maturation	1 – 2	12 – 18	Pathogen and nutrient removal	BOD 30% - 60%, S.S 20% - 40%,Faecal coliforms 4 log, Nitrogen 40% - 60% and Helminth 100%

Table 5: Studies using anaerobic filter process on wastewater.

Wastewater	Scale and temperature	Organic loading (kg/m^3.d)	Efficiency (%)	Retention time (hour)
Food processing (8500mg/l)	28cm x 41cm column, 35°C	1.602-10.353	30-86	13-83
Potato processing (3000mg/l)	12cm x 24 cm column, 19- 22°C	0.530-2.323	41-79	13-59
Wheat and starch (8800mg/l)	61 cm x 91 cm column, 32°C	3.797	64	22
Synthetic organic : Alkanol (alcohols), glycol, phenol, acids, Alkanal (aldehudes), amides (2000 mg/l)	64 cm x 89 cm column, 34°C	0.561-2.083	64-76	17-46
Petrochemical (2000- 8000mg/l)	0.91m x 140 cm column, 35°C	0.641-2.323	39002	72
Brewery press (6000- 24000mg/l)	0.91.83m x 15.2cm column, 35°C	0.801	>90	15-330
Pharmaceutical waste 95 % methanol (1250 - 16000mg/l)	1m x 140 cm column, 37°C	0.224-3.524	94-98	12-48
Sulphite liquor (1300- 5300mg/l)	5.8m x 14.5 cm column 35°C	2.003-6.008	27-58	89-95
Sewage: (60- 220mg/l BOD)	5.5m x 1.5m column 15- 20°C	0.048-0.609	55	2.5-10.5
(44- 573mg/l BOD)		0.048-0.545	76	24
Guar (9140 mg/l)	9.1m x 12.1m Column 36°C	7.529	60	24
Acetate + formate + 2-butanone (5000- 10000mg/l)	-	6.09-8.01	86-94	-
Acetate + aldehyde + glycol (7000-10000mg/l)	-	6.09-8.01	86-94	-
Acetate + formate +methanol + formaldehyde (17000- 24000mg/l)	-	11.054-14.528	72-92	-
Acrylic acid + acrylate esters (79000–85000 mg/l)	-	8.01-9.612	94-97	-
Evaporated milk (24 000mg/l)	-	7.201-8.811	80-90	-
Leachate from solid waste landfill (30000 mg/l)	-	0.785	95	0.7 days
Shellfish process (121-466 mg/l)	1.5m x 15.2 cm column 9.8-26°C	0.032-0.368	46-81	8-74
Effluent from heat treatment of activated sludge (9500mg/l)	1.8m x140 cm column 32°C	4.806	76	48

Source: Kobayashi *et al.*,[15] .

algae. The mean overall phosphate (as phosphorus) of the final effluent is low and satisfactory compared to the guideline value of 5-mg/l. specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14] and many other standard environmental engineering literature[5,12,13].

Micro-organisms removal: The faecal coliform count of the raw sewage ranged between 2.0 x 10^5 and 4.00 x 10^5 MPN/100 ml with a mean value of 3.0 x 10^5 MPN/100 ml. High faecal coliform are expected from such a community (Table 4). The faecal coliform of the effluent from facultative ponds ranged from 1.00 x 10^4 to 7.0 x 10^4

MPN/100 ml with a mean of 3.0 x 10^4 MPN/100 ml. The efficacies of facultative ponds ranged from 50.8-82.5% with and average of 71.13%. The mean faecal coliform removal efficiency of the facultative ponds is 71.13% which is high compared to other waste stabilization ponds which give faecal coliform removal efficiencies greater than 70%[10]. The faecal coliform of the effluent from maturation ponds ranged from 2.00 x 10^2 to 4.0 x 10^2 MPN/100 ml with a mean of 3.0 x 10^2 MPN/100 ml. The efficacies of maturation ponds ranged from 98.1-99.4% with and average of 98.9%. The mean faecal coliform removal efficiency of the maturation ponds is 98.9%, which is low compared to other waste stabilization ponds which give faecal coliform removal efficiencies greater than 99.97%[5]. The overall faecal coliform efficacies were between 99.1-99.6% with an average of 99.3%. The high faecal coliform removal may be attributed to the high strength of the raw sewage and shorter retention time in the maturation ponds. The mean overall faecal coliform of the final effluent is low and satisfactory compared to the guideline value of 400-MPN/100 ml specified in Nigeria Federal Ministry of Environment guideline as stated in FEPA[14]. The faecal coliform level of the final effluent is low and acceptable compared to the recommended guideline value of 400 to 5 000 MPN per 100 ml[5,11].

Comparison with data from literature: Although literature on biological treatment of wastewaters are common but data on efficacies of biological treatment processes on domestic-institutional wastewaters are limited. Hodgson[5] monitored treatment domestic wastewater biologically and the following results were obtained:

The flow rates for both influent and effluent wastewaters are 570 m^3/d.

The wastewater has weak BOD and faecal coliform count per 100 ml (i.e. less than 100mg/L BOD and 5900000 counts per 100ml).

The ponds achieved BOD reduction of 65% suspended solids of 46%, ammonia reduction of 92% and phosphate removal of 94%.

These results are different from the results from this study and it can be attributed to different in the type of wastewaters and the strength of wastewater.

Similarly, Kobayashi *et al.,*[15] reviewed biological treatment of wastewaters and the results were summarized as shown in Table 5. Nkegbe *et al.*,[16] assessed the performance of a biological treatment plant at Glen valley and the result indicates that average reduction of the parameters measured (COD, BOD, TSS, NH_3-N and TKN) are 97.7, 99, 98.2, 95.5 and 93.6%.

Conclusions: The following conclusions were drawn from the study on the sewage treatment ponds at Ahmadu Bello University, Zaria, Nigeria.

- The treated effluent from the waste stabilisation ponds at ABU meets some of the environmental and health criteria set by the FEPA (1991).
- The raw sewage has BOD concentrations of greater than 400 mg/l (its can be classified as strong domestic wastewater)
- The quality of the final effluent would not have any adverse effect on the Lower Kubanni River into which it is discharged.
- The treatment ponds are able to achieve mean SS, BOD, COD, ammonia organic nitrogen and phosphate removal efficiency of 66.1, 93.58, 96.4, 87.58, 50.04 and 80.8% respectively.
- A faecal coliform reduction of 99.3% was achieved.

ACKNOWLEDGEMENTS

The authors acknowledged the following people P.C. Alika, Late Buhari Halilu, Yakubu, Y., Luka M., Geofery H., Ozumi, Mohammed, A. Bello, M.H and Asekhame, O.P of Department Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria (Nigeria) for their role in the collection and the laboratory analysis of the samples.

Abbreviation and Symbols:

BOD: Biochemical Oxygen Demand
COD: Chemical Oxygen Demand
DO: Dissolved Oxygen
mg/l: milligrams per litre
SS: Suspended solids
D_i and D_2: initial and final dissolved oxygen of the sample respectively (mg/l)
f: ratio of seed in the sample to seed in the control
p: decimal volumetric fraction of sample used.
B_i and B_2: initial and final dissolved oxygen of the seeded control respectively (mg/l)
A_1: ml of FAS used for the blank
B_2: ml of FAS used for the sample

M: Molarity of FAS
FAS: Ferrous ammonium sulphate
M_a: equivalent phosphorus from calibrated plot.
A_a: volume H_2SO_4 used for the sample
B_a: volume H_2SO_4 used for the blank

REFERENCES

1. Adewumi, I., I.A. Oke and P.A. Bamgboye, 2005. Determination of the Deoxygenation Rates of a Residential Institution's Wastewater. J. Appl. Sci., 5 : 108-112,
2. Eiroa, M., A. Vilar, C. Kennes and M.C. Veiga, 2006 Biological treatment of industrial wastewater containing formaldehyde and formic acid. Water SA., 32: 115-118.
3. Cheng, S., Y. Lin and S. Chen, 1996. Enhanced biodegradation of organic nitrogenous compounds in resin manufacturing wastewater by anoxic denitrification Technol., 34: 35-41.
4. Garrido, J.M, R. Méndez and J.M. Lema, 2000. Treatment of wastewaters from a formaldehyde-urea adhesives factory. Water Sci. Technol., 42: 293-300.
5. Hodgson, O.A., 2000. Treatment of domestic sewage at Akuse (Ghana), Water SA., 26: 413-416.
6. Ogunfowokan, A.O., E.K. Okoh, A.A. Adenuga and O.I. Asubiojo, 2005. An Assessment of the Impact of Point Source Pollution from a University Sewage Treatment Oxidation Pond on a Receiving Stream-A Preliminary Study. J. Appl. Sci., 5: 36-43. 14
7. APHA, 1998. Standard Method for the Examination of Water and Wastewater, 20th edn, America Water Works Association and Water Pollution Control Federation, Washington DC.
8. Metcalf and Eddy Inc., 1991. Wastewater Engineering Treatment Disposal and Reuse, 3rd edn, McGraw-Hill Book Company, New York.
9. Mara, D.D., 1986. Sewage Treatment in hot climate. 3rd Edn., John Willey and Sons, Interscience, London.
10. Horan, N.J., 1993. Biological Wastewater Treatment System, Theory and Operation, 1st Edn., John Wiley and Sons, New York .
11. MOP8, 1967. Sewage Treatment plant Design, Water Pollution Control Federation and the America Society of Civil Engineers, Washington, D.C.
12. GLUMRBSSE, 1968. Recommended Standards for Sewage Work. 1968 Edn., Health Education Service, New York.
13. Viessman, W.Jr. and M.J. Hammer, 1993. Water Supply and Pollution Control, 5th Edn., Harper Collins College Publishers, New York.
14. FEPA., 1991. Guidelines to Standards for Environmental Pollution Control in Nigeria, Federal Environmental Protection Agency (FEPA), Lagos.
15. Kobayashi, H.A., M.K. Stenstom and Mah, R.A. 1983. Treatment of low strength domestic wastewater using the anaerobic filter. Water Res., 17: 903-909.
16. Nkegbe, E., V, Emongor and Koorapetsi, 2005. Assessement of effluent quality at Glen valley Wastewater treatment plant. J. Appl. Sci., 5: 647-650.