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PERFORMANCE OF THE AKOSOMBO WASTE STABILIZATION PONDS IN GHANA

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Abstract

A study was conducted to determine the treatment performance of the Akosombo waste stabilization ponds and the effect of seasonal changes on the final effluent quality. The waste water quality parameters adopted to determine the treatment performance were suspended solids (SS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia, faecal coliform and trace metals. The ponds achieve SS, BOD and COD removals of about 84, 77 and 71 per cent, respectively. The ammonia removal was as high as 93 per cent whilst the faecal coliform removal was 99.99 per cent. The trace metal levels (Pb, Zn, Cd and Cr) of the final effluent were all low and insignificant (below the detection limit of < 0.01 mg l^{-1}). The study revealed that the seasonal changes influenced the quality of the final effluent. The final effluents in the rainy season were less polluted than those of the dry season which may be due to the dilution of the effluent by rain water. The study showed that the quality of the final effluent would not have any adverse effect on the lower Volta river that it is discharged into. The large volume of water available in the lower Volta river is adequate to dilute the final effluent entering it from Akosombo waste stabilization ponds. The mosquito nuisance usually associated with pond systems was absent because of the high fish proliferation in the ponds. A statistical model developed to predict the BOD of the raw sewage was significant at both confidence intervals of 95 and 99 per cent Under Ghanaian conditions, the waste stabilization ponds system has been found to be more reliable than the other conventional systems, i.e., activated sludge and trickling filter system. The trend now is to adopt the waste stabilization ponds system as an appropriate sewage treatment system in areas where land is available in the country.

Résumé

HODGSON, I. O. A.: *Résultats de bassins de stabilisation du déchet d' Akosombo du Ghana.* Une étude était entreprise pour déterminer le résultat de traitement de bassins de stabilisation du déchet d' Akosombo et l' effet de changement saisonnier sur la qualité d' effluent final. Les paramètres de la qualité des eaux usées adoptés pour déterminer les résultats de traitement étaient les flottants (SF), la demande pour l'oxygène biochimique (DOB), la demande pour l'oxygène chimique (DOC) l' ammoniaque, le coliforme fécal, et les oligoéléments. Les bassins atteignent les enlèvements de SF, DOB et DOC respectivement d' environ 84, 77 et 71%. L' enlèvement d' amoniaque était aussi élevé qu'environ 93% alors que l'enlèvement de coliforme fécal était 99.99 %. Les niveaux d' oligoéléments (Pb, Zn, Cd et Cr) de l'effluent final étaient tous faibles et non significatif (au-dessous de la limite et recherche de < 0.01 mg 1^{-1}). L' étude révélait que les changements saisonniers influençaient la qualité d' effluent final. Les effluents finals pendant la saison des pluies étaient moins pollués que ceux de la saison sèche qui pourrait être à cause de la dilution de l' effluent par l'eau de pluie. L' étude montrait que la qualité de l' effluent final n' aurait pas d' influence défavorable sur la Basse Rivière de Volta dans laquelle elle se déverse. Le volume énorme d' eau disponible dans la Basse Rivière de Volta est adéquat à diluer d' effluent final entrant la rivière à partir de bassins stabilisation du déchet d'Akosombo. Le fleau de moustique généralement associé avec le système de bassins était absent à cause de la prolifération élevée de poisson dans les bassins. Un modèle statistique développé pour la DOB des eaux usées non traitées est présentées ci-dessous: DOB = -77.0831 + 0.4513 *ss + 0.3866* Conductivité. Le modèle est significatif a deux intervalles de confiance de 95 et 99% (R carré = 0.8428, F calculé = 37.5, p (F >3.74) = 0.05 et p (F > 6.51) = 0.01) et ainsi le modèle développé n'est pas par hasard. Dans les conditions ghanéennes, le système de bassins de stabilisation du déchet est constaté d' être plus fiable que les autres systèmes conventionnels, c'est-à-dire vidanges activées et le système de filtration dégoulinante. La tendance à présent est d'adopter le système de bassins de stabilisation du déchet comme un système de traitement approprié des eaux usées dans les régions du pays où la terre est disponible.

Introduction

Highly polluted waste water negatively impact on receiving water bodies. Some of the possible adverse effects of wastewater on receiving water bodies include loss of fish life, high levels of sludge deposition, creation of septic conditions and odours produced from anaerobic reactions that may occur at the bottom of the receiving water body, increased water treatment cost, eutrophication and eventual loss of water resources (Mara, 1981). Wastewaters with high levels of faecal coliforms have the potential of causing health problems to the people who come in direct contact with the receiving water body.

In developing countries, the most preferred wastewater treatment system is that which is able to treat the wastewater to meet the recommended physical, chemical and microbiological guidelines at a low cost with minimum operational and maintenance requirements. Waste stabilization ponds are becoming popular for treating wastewater in tropical and subtropical regions because of the abundant sunlight and high ambient temperatures. In Europe waste stabilization ponds are very widely used for small communities (Boutin *et al*., 1987; Bucksteeg, 1987). In the United States one third of all wastewater treatment plants that usually serve populations up to 5000 are waste stabilization ponds (EPA, 1983).

Waste stabilization ponds are basically shallow man-made basins comprising a single or several series of anaerobic, facultative or maturation ponds. The primary treatment usually takes place in the anaerobic pond which is mainly designed for removal of suspended solids, and some of the soluble organic matter. Most of the remaining BOD is removed through the coordinated activity of algae and heterotrophic bacteria in the facultative ponds. The main function of the maturation pond is the removal of pathogens and nutrients (especially nitrogen). Since the waste stabilization ponds are exposed to the atmosphere all year round, the changes in the seasons or weather conditions could influence the quality of the treated effluent and as such the performance. The diurnal variation has been shown to influence the quality of the final effluent (Hodgson, 2003). The objective of the study was to determine the treatment performance of the Akosombo waste stabilization ponds, the effect of seasonal changes on the quality of the final effluent and develop a statistical model for prediction of the raw sewage BOD levels.

Experimental

Study area

Akosombo is located in the Eastern Region of Ghana. It has a population of about 16,000 people. The mean ambient temperature rainfall and humidity for March were 29.4 ^{o}C, 90.2 mm and 72.4 per cent, respectively, whilst for June they were 26.8 ^{o}C, 188.3 mm and 83.8 % respectively. The months of March and June, during which the samples for seasonal changes were taken, fell within the dry and rainy season, respectively. The dry seasons at Akosombo are usually sharp and pronounced.

The Volta River Authority (VRA) was established under the Volta River Development Act (Act 46 of 1961) as a corporate body, and it constructed the Akosombo township to provide accommodation for its employees working on the Hydro-electric dam plants at Akosombo and Kpong. The waste stabilization ponds were constructed to help in the storage, treatment and disposal of liquid waste generated in the township and to ensure good environmental health. The ponds were constructed and commissioned in April, 1993 to replace a trickling filter plant.

Akosombo waste stabilization ponds

Akosombo waste stabilization ponds consist of two ponds, namely primary facultative and maturation ponds as shown in Fig.1. The ponds consist of two serially connected basins with concrete embarkments (WRRI, 1994). There are three inlet points to the first pond. These represent influents from three different parts of the township. The sewage enters a retention chamber and then flows by gravity into the pond at two of the inlet points. The third flows by gravity. The rags, tissues, etc. are removed from the raw sewage by a screen in the retention chamber before it enters the ponds. The dimensions of the ponds are given in Table 1. The discharge rate of the treated effluent is about 1000 m^3/day.

For the evaluation of the treatment performance of the waste stabilization ponds, grab samples of raw sewage, facultative pond effluent and maturation pond effluent (final effluent) were taken on a weekly basis for a period of 6 weeks before 10:00 a.m. For the effect of seasonal changes on the final effluent, grab samples of both the raw sewage and the final sewage were taken on a 2 – hourly basis for a period of 8 h, between 0800 and 1700 h on a particular day in March (dry season) and a particular day in June (rainy season), respectively.

The temperature, *p*H and conductivity were

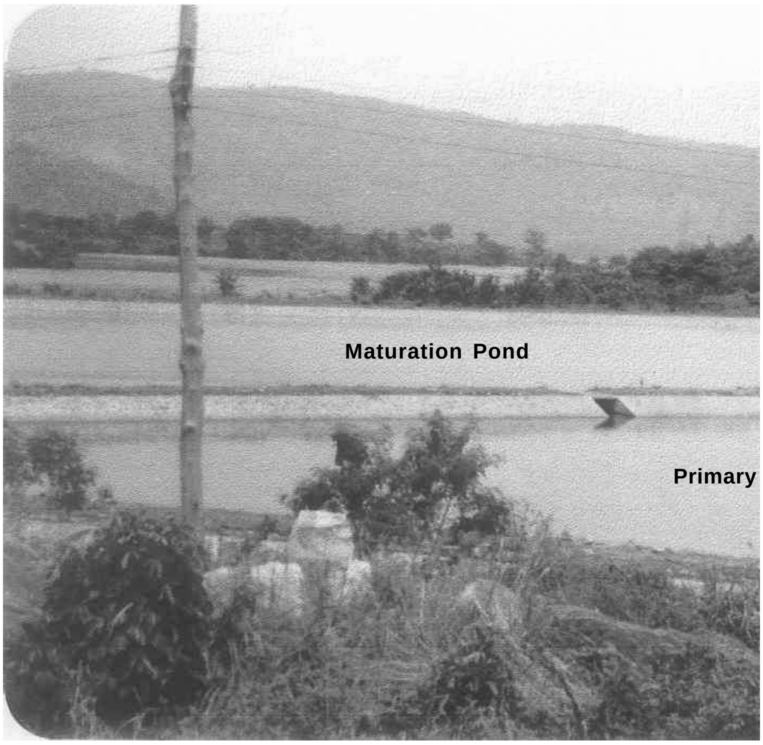

Fig. 1. Akosombo waste stabilization ponds.

TABLE 1

Dimensions of the waste stabilization ponds

Pond	*Area (ha)*	*Depth (m)*	*Retention (day)*
Primary facultative pond	9.6	1.7	24
Maturation pond	2.5	0.8	3

measured *in-situ*. Standard methods for the examination of water and wastewater (APHA, 1998) were adopted for the laboratory analyses. All the equipment for the bacteriological sampling was sterilized. The samples were immediately stored in an ice-chest and transported to the CSIR-WRI laboratories for analysis. Table 2 shows the wastewater quality parameters and the various analytical methods employed for the analysis.

Results and discussion

Evaluation of the treatment performance of the sewage ponds

The treatment performance of the ponds was assessed based on the following wastewater quality parameters:

- suspended solids (SS) removal
- organic matter removal (BOD, COD)
- ammonia removal
- micro-organisms removal; and
- metal ion removal

SS removal

The discharging of effluents with high levels of SS can cause sludge deposition and create anaerobic conditions in the receiving water body. The SS concentration of the raw sewage ranged from 46.0 to 204.0 mg l^{-1} with a mean value of 86.3 mg l^{-1} (Table 3). The SS of the treated effluent ranged from 12.0 to 16.0 mg l^{-1} with a mean value of 14.2 mg l^{-1}. The mean overall SS removal efficiency of the pond system was 83.5 per cent which is significantly high. All the SS concentrations of the final effluent were satisfactory compared to the Ghana Environmental Protection Agency (EPA) guideline value of 50 mg l^{-1}. About 80 per cent of the SS present in the raw sewage was removed in the primary facultative pond, and the rest in the maturation pond.

Organic matter removal

BOD removal. Effluents with high concentration of BOD can cause depletion of natural oxygen resources which may lead to the development of septic conditions in the receiving water body. The BOD removal and the consequent quality of the effluent depend on the amount of oxygen present, retention time and temperature of the ponds. The BOD levels of the raw sewage ranged from 40.0 and 90.0 mg l^{-1} with a mean value of 55.8 mg l^{-1}

TABLE 2

Wastewater parameters and the analytical methods employed for determination

Parameter	*Method employed and detection limit*
Temperature	Mercury in glass thermometer, > 0.5 °C
*p*H	Gallenkamp *p*H meter, >1 unit
Conductivity	Jenway model 4020 conductivity meter, >1 µS/cm
Suspended solids	Gravimetric method, > 1 mg l^{-1}
Ammonia-Nitrogen	Ion Chromatograph, > 0.005 mg l^{-1}
Nitrate- Nitrogen	Ion Chromatograph, > 0.005 mg l^{-1}
Phosphate – Phosphorus	Ion Chromatograph, > 0.005 mg l^{-1}
BOD	Dilution/dissolved oxygen after 5 days incubation at 20 °C, > 0.1 mg l^{-1}
COD	Potassium dichromate reflux method, >5 mg l^{-1}
Total coliform	Membrane filtration method, > 0 counts/100 ml
Faecal coliform	Membrane filtration method, > 0 counts/100 ml
Heavy metals (Cu, Cd, Ni, Zn, Cr)	Atomic absorption spectrophotometry, Cu > 0.020 mg l^{-1}, Cd > 0.002 mg l^{-1}, Ni > 0.010 mg l^{-1}, Zn > 0.005 mg l^{-1}, Cr > 0.010 mg l^{-1}

TABLE 3

Mean overall percentage removal

Parameter	*Raw sewage*		*Pond 1 effluent*		*Pond 2 effluent (Final effluent)*		*% Mean overall removal*
	Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	
Temperature oC	27.1 – 30.6	28.5	28.8 – 30.1	29.4	27.1 – 29.5	28.6	-
*p*H units	6.6 - 7.2	-	7.1 – 8.5	-	7.7 – 9.1	-	-
SS	46.0 – 204	86.3	8 – 30	17.3	12 – 16	14.2	83.5
BOD	28.0 – 90.0	55.8	7.50 – 38.5	20.2	8.0 – 14.5	12.8	77.1
COD	89.8 – 317	176	16.3 – 87.0	54.2	32.6 – 79.0	51.9	70.6
Ammonia	4.8 – 18.3	9.02	0.30 – 7.0	2.39	0.15 – 1.51	0.61	93.2
Total Coliform counts/100 ml	229,000 - 38,000,000	7,700,000	31,000 – 132,000	70,000	290 – 179,000	44000	99.43
Faecal Coliform counts/100 ml	19,000 – 17,400,000	3,450,000	600 – 25,000	9,260	40 – 900	350	99.99

All the units are in mg l^{-1} except otherwise stated.

whilst that of the treated effluent ranged from 8.0 to 14.5 mg l^{-1} with a mean value of 12.8 mg l^{-1}. The strength of the raw sewage could be considered as weak (Mara, 1976). The mean overall BOD removal efficiency was 77 per cent which is high and comparable to other waste stabilization ponds which give BOD removal efficiencies greater than 70 per cent (Arceivala, 1981). The mean overall BOD removal included the algal BOD. About 64% of the BOD is removed in the primary facultative pond.

Abis (2002) reported BOD removal range between 67.5 and 98.6 per cent with a mean of 91 per cent for pilot scale facultative ponds in the United Kingdom. Generally, high proportion of the BOD that does not leave the facultative pond as methane ends up as algal cells. With the removal of algal and other solids from the effluent, the BOD removal range was found to be 89.7 to 99.7 per cent with a mean of 97.3 per cent (Abis, 2002). All the measured BOD levels were low and acceptable compared to the EPA guideline values of 50 mg l^{-1}. The mean BOD to ammonia to phosphate ratio, for the raw sewage, was 150:24:1. The suitable ratio of BOD to ammonia to phosphate for microbial growth is about 100:3:1 (Hammer & Hammer Jnr, 2001) indicating that the ammonia concentration required by the organisms for the biological breakdown of the sewage was about five times in excess.

COD removal. The COD levels for the raw sewage were between 91.0 and 317 mg l^{-1} with a mean of 176 mg l^{-1}, whilst the final effluent COD level ranged from 32.6 to 79.0 mg l^{-1} with a mean of 51.9 mg l^{-1}. The mean overall COD removal was calculated to be 70.6 per cent which is appreciable. The primary facultative pond achieved a mean COD removal of 69 per cent. The ratio of the mean BOD to COD for the raw sewage was 0.32, which indicates a medium level of biodegradability. All the measured COD levels for the final effluent satisfied the EPA guideline values.

Nutrient removal

Wastewaters with high nutrient levels can cause undesirable phytoplankton growth in the receiving water body. The ammonia concentration of the raw sewage ranged from 4.8 to 18.3 mg –l^{-1}

with a mean value of 9.0 mg l^{-1}. The ammonia concentrations of the final effluent were between 0.15 and 1.51 mg l^{-1} with a mean value of 0.61 mg l^{-1}. The mean ammonia removal efficiency was 93.1 per cent which is appreciably high (Hodgson, 2000). Total nitrogen removal in waste stabilization system could be as high as 95 per cent. The facultative pond achieved a mean ammonia removal of about 74 per cent. The mean ammonia concentration of the final effluent was found to be satisfactory compared to the EPA guideline value of 1 mg l^{-1}.

Micro-organism removal

The factors that influence coliform removal in both primary facultative and maturation ponds include retention time, temperature, *p*H and light intensity. The total coliform levels of the raw sewage were between 229,000 to 38,000,000 counts/ 100ml with a mean of 7,700,000 counts/ 100 ml. The total coliform levels of the final effluent ranged from 290 to 179,000 counts / 100 ml with a mean value of 44,000. The total coliform removal efficiency was 99.43 per cent. The faecal coliform level of the raw sewage ranged from 19,000 to 17,400,000 counts/100 ml with a mean of 3,450,000 counts/100 ml, whilst the faecal coliform level of the final effluent ranged from 40 to 900 counts/ 100 ml with a mean value of 350 count/100 ml.

The mean faecal colifom removal efficiency was 99.99 per cent which is significantly high. Most of the total coliform (98.8%) and faecal coliform (98.4%) were removed in the primary facultative pond. Waste stabilization ponds usually give such high micro-organism removal efficiencies. Arceivala (1981) reported that the die-off rate of the micro-organisms was accelerated when the *p*H of the pond water was greater than 9.3 units. Hodgson & Larmee (1998) showed that there was no coliforms present in final effluent from a maturation pond with *p*H above 10.7 units. Compared to the EPA guideline value of 0 counts/ 100 ml, the faecal coliform levels of the final effluent were unsatisfactory.

Metal ion removal

Moshe (1972) reported that high concentrations of metal ions (Cd, Cu, Ni, Zn and Cr) adversely affect pond efficiency. However, *p*H levels higher than 8 cause metal ions to precipitate and allow pond purification process to occur normally. The *p*H range for the final effluent was between 7.7 and 9.1 units. Polpraseret & Charnpratheep (1989) showed that adsorption of metals was increased in attached growth stabilization pond as compared to stabilization ponds without attached growth. The metal ion concentration of the raw sewage for Cd (< 0.002-0.008 mg l^{-1}), Zn (0.010-0.021 mg l^{-1}), Pb (< 0.005 mg l^{-1}) and Cr (< 0.01 mg l^{-1}) were generally low. Also, the Cd (< 0.002 mg l^{-1}), Zn (< 0.005 mg l^{-1}), Pb (< 0.005 mg l^{-1}) and Cr (< 0.01 mg l^{-1}) concentrations in the final effluent were below the detection limit and, thus, satisfactory when compared to the EPA guideline values.

Effect of seasonal changes on the final effluent

The temperature of the final effluent for March ranged from 29.9 °C to 31.7 °C with a mean of 30.9 °C (Table 4), whilst the range for the rainy season (June) ranged from 28.4 to 30.3 °C with a mean of 29.6 °C, indicating a slightly higher mean temperature for March compared to that of June. This was expected since the ambient mean air temperature for March (29.4 °C) was higher than that of June (26.8 °C). However, the temperatures of the final effluent were both higher than their corresponding ambient temperatures.

The temperature variation for both the rainy and dry seasons was minimal. The *p*H of the final effluent, for both the dry and rainy seasons, were between 7.25 and 9.01, and 7.69 and 9.06, respectively. The conductivity gives an indication of the amount of dissolved minerals present in the solution. The conductivity of the final effluent for March ranged from 157-290 µS cm^{-1} with a mean of 224 µS cm^{-1}, indicating low amount of dissolved mineral salts in the raw sewage. The conductivity of the final effluent for June was

TABLE 4

Quality of final effluent for both dry (March) and rainy season (June)

Parameter	*Final effluent dry season (March)*		*Final effluent in rainy season (June)*	
	Range	*Mean*	*Range*	*Mean*
Temperature °C	29.9 – 31.7	30.9	28.4 – 30.3	29.6
*p*H, units	7.25 – 9.01	-	7.69 – 9.06	-
Cond. µS cm^{-1}	157 – 290	224	195 – 210	204
SS	13 – 20	15.8	6 - 38	22
Ammonia	0.63 – 1.11	0.87	0.4 – 0.8	0.60
Nitrate	0.41 – 0.99	0.73	0.59 – 0.97	0.74
Phosphate	1.39 – 1.51	1.43	0.15 – 0.54	0.26
BOD	10.2 – 15.0	11.9	5.5 – 9.5	7.7
COD	57 – 73	66.9	24 – 49	38.6
Total coliform counts/100ml	128,00 – 1,780,000	708,400	32,000 – 58,000	42000
Faecal coliform counts/100 ml	1,240 – 1,940	1,760	180 – 800	580

All the units are in mg l^{-1} except otherwise stated.

between 195 to 210 µS cm^{-1} with a mean of 204 µS cm^{-1}. The conductivity of the final effluent in March varied more than that of June. The suspended solids concentration for both March and June ranged from 13.0 to 20.0 mg l^{-1} and from 6 to 38 mg l^{-1}, respectively. Their corresponding means were 15.8 and 22 mg l^{-1}. The means of the suspended solids for June were far higher than that of March. The increase in suspended solids may be due to erosion of soils nearby into the ponds caused by the rains.

Organic matter

The BOD levels in March ranged from 10.2 to 15.0 mg l^{-1} with a mean of 11.9 mg l^{-1}, whilst the BOD levels in June ranged from 5.5 to 9.5 mg l^{-1} with a mean of 7.7 mg l^{-1}. The BOD levels in June were lower than those in March which may be due the diluting of the final effluent by the rains. The mean rainfall for June (188.3 mm) was higher than that of March (90.2 mm).

Nutrients

The ammonia, nitrate and phosphate levels provide an indication of the nutrient content of the final effluent. The ammonia level for March was between 0.63 and 1.11 mg l^{-1} with a mean of 0.87 mg l^{-1}, whilst the ammonia level for June ranged from 0.4 to 0.8 mg l^{-1} with a mean of 0.6 mg l^{-1}. The nitrate concentration for both March and June ranged from 0.41 to 0.99 mg l^{-1} and 0.59 to 0.97 mg l^{-1}, respectively. Their respective means were 0.73 and 0.74 mg l^{-1} which are close. The phosphate level for March ranged from 1.39 to 1.51 mg l^{-1} with a mean of 1.43 mg l^{-1}, whilst the phosphate level in June ranged from 0.15 to 0.54 mg l^{-1} with a mean of 0.26 mg l^{-1}.

Micro-organisms

The total coliform range in March (128,000-1,780,000 counts/100 ml) was higher than that in June (32,000-58,000 counts/100 ml). The mean total coliform for March (708,400 counts/100 ml) was also higher than that of June (42,000 counts/100 ml). The faecal coliform range for both March and June were 1,240-1,940 counts/100 ml and 180-800 counts/100 ml, respectively. Their respective means were 1,760 and 580 counts/100 ml, indicating lower faecal coliform counts in the rainy season compared to that in the dry season.

Regression model for predicting the BOD of the raw sewage

Regression analysis has been developed to predict the BOD of the raw sewage using the BOD, SS and conductivity data of the raw sewage obtained from the both the rainy and dry seasons in 2004, and in March and December 1999 (Hodgson, 2003). The BOD, SS and conductivity measured values used are given in Table 5. Though, the data set used for this model is small (17 observations), it covers the range of values of BOD levels expected for raw sewage for the Akosombo waste stabilization ponds system. Since it takes about 5 days to obtain the results of the laboratory analysis for BOD measurements the model could assist in obtaining a fair idea of the raw BOD levels using simple measurable wastewater parameters like SS and conductivity whose determination could be carried in hours and not days.

$$BOD = -77.0831 + 0.4513 * TSS + 0.3866 * \text{conductivity}$$

The regression model given above is significant at 95 and 99 per cent confidence interval (R square = 0.8438, F calculated = 40.1, $p(F > 3.74) = 0.05$ and $p(F > 6.51) = 0.01$) and, thus, the regression model developed is not due to chance. The model could assist in getting a 'quick' first hand information of a rough estimate of the BOD levels in the raw sewage and also the average amount of BOD that could be removed from the sewage by the waste stabilization pond, i.e. by multiplying the predicted BOD by the mean BOD percentage removal of 77 per cent. Fig. 2 shows the correlation between the measured BOD and the predicted BOD which gives a good fit.

TABLE 5

BOD, SS and conductivity results used for the regression model

BOD, mg l^{-1}	*SS, mg l^{-1}*	*Conductivity µS cm^{-1}*
160	116	427
81	34	326
78	134	283
88	64	193
20	20	190
22	36	200
38	56	220
52	110	232
34	76	174
10	30	237
16	31	284
42	82	216
50	80	226
34	48	230
26	38	243
70	96	310
74	92	250

Conclusion

The following conclusions were made from the study conducted to determine the performance of the Akosombo waste stabilization ponds system and the effect of seasonal changes on the quality of the final effluent:

- The ponds achieved mean overall SS, BOD and COD removals of about 84, 77, and 71 per cent, respectively. The mean overall ammonia reduction was as high as about 93 per cent whilst the faecal coliform removal was 99.99 per cent. The trace metal levels (Pb, Zn, Cd and Cr) of the final effluent were all low and insignificant (< 0.01 mg l^{-1}). Most of the SS (80%), BOD (64%), COD (69%), ammonia (74%) and faecal coliform (98.4%) present in the raw sewage were removed in the primary facultative pond (pond 1). Further polishing of the effluent from the facultative pond was obtained in the maturation pond.
- The quality of the final effluent was found to be satisfactory and would not have serious potential health hazard and any

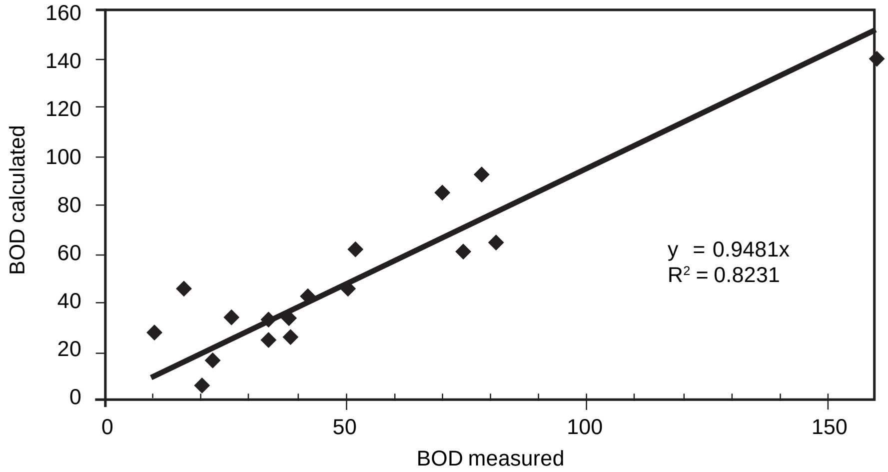

Fig. 2. A graph of calculated BOD versus measured BOD

adverse effect on the lower Volta river into which effluent is discharged.

- The mosquito nuisance usually associated with ponds system was absent because of the high fish proliferation in the ponds.
- The results showed that seasonal changes influenced the quality of the final effluent. The final effluent in the rainy season was less polluted than that of the dry season which may be due to the dilution of the effluent by the rains. However, the final effluent met the required EPA guideline values with the exception of the total and faecal coliforms.
- The developed regression model for predicting BOD levels of the raw sewage is:

$$BOD = -77.0831 + 0.4513 * SS + 0.3866 * conductivity$$

The model is significant at both 95 and 99 per cent confidence intervals (R square = 0.8428, F calculated = 37.5, $p(F > 3.74) = 0.05$ and $p(F > 6.51) = 0.01$) and, thus, the model developed is not due to chance.

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