PERFORMANCE OF ASOKWA WASTE STABILIZATION PONDS AND THE CONDITION OF OTHER SEWAGE TREATMENT PLANTS IN GHANA

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ABSTRACT

The performance of a functional waste stabilization pond among a series of three neglected ones, was evaluated during a two month period for its operational efficiency. The relevant parameters measured were flow rates, pH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids, total bacterial, coliform counts, nitrate nitrogen, ammonia nitrogen and phosphorus in samples of both the influent and effluent. The influent flow rate of 290 m^3 per day was higher than the design value of 270 m^3 per day. The effluent flow rate was 230 m^3 per day. The detention period of 8.31 days was markedly different from the design value of 53.76 days. The pond's efficiency as determined by the measurements of ***BOD***, ***COD***, *suspended solids and total bacteria plate count, indicated that the pond can still handle more wastes without failing. Its organic (i.e.* ***BOD****) loading was 256 kg ha/day compared to maximum capacity of 635 kg ha/day obtained by using the empirical formula $(11.2)(1.054)^T$. The pond was, however, inefficient in the removal of ammonia nitrogen and coliforms. The condition of other Sewage Treatment Plants inspected between 1988-1991 showed that most of these plants have been neglected and need rehabilitation and properly trained personnel to operate and maintain them.*

KEY WORDS: *Influent, Effluent, Trickling filter, Waste stabilisation ponds, Detention period, Sewage.*

INTRODUCTION

Sewage treatment is essential for the removal of pathogenic micro-organisms and oxygen-consuming organic matter normally found in excreta. It consists of a series of processes in which undesirable materials in the sewage are removed or rendered harmless before they are discharged into the environment. To improve upon the environmental sanitation in Ghana, a number of these Sewage Treatment Plants were constructed in the 1960's. Many of these plants have broken down but, inspite of this, they still receive wastewater for treatment. A series of three waste stabilisation ponds in Asokwa, Kumasi designed in 1962 to have an operational life of 5 years falls into this category. Besides being the largest of all the ponds examined, it also receives sewage from the nation's second largest hospital, the Komfo Anokye Teaching Hospital. The evaluation of the performance of this treatment plant was thus considered necessary. In addition to this plant, a number of Waste Treatment Plants in the country, mainly in southern Ghana, were inspected to determine their condition and their performance also assessed.

DESCRIPTION OF THE ASOKWA PONDS

The Asokwa waste stabilisation ponds consist of three ponds, a large pond (Pond 1) 8030.16 m^2 in area and two smaller ponds (Ponds 2 and 3) each 1474.9 m^2 in area, designed to operate either in series or in parallel (fig. 1). The total surface area of the ponds was 1098.00 m^2. The depth of Pond 1 was 1.37m whilst that of Ponds 2 and 3 was 1.22 m for each pond. Flow from one pond to the other was through concrete weir chambers and an 0.3 m diameter connecting pipe. Provision had also been made for the draining and desludging of the ponds. At the time of study from May to July 1988, Ponds 2 and 3 were covered with sediments and weeds and consequently had been cut off from the treatment process. Pond 1 had about two-thirds of its area covered with weeds; the effective estimated area of handling the waste water was about 3000 m^3. The depth was then estimated to be 0.7 m by allowing a sludge cover of 0.67 m due to inaccessibility. The effluent flowed uninterrupted into the nearby Nsuben stream. The area reserved for future duplication of the ponds had been used for charcoal production, and the Forestry Reservation area for farming.

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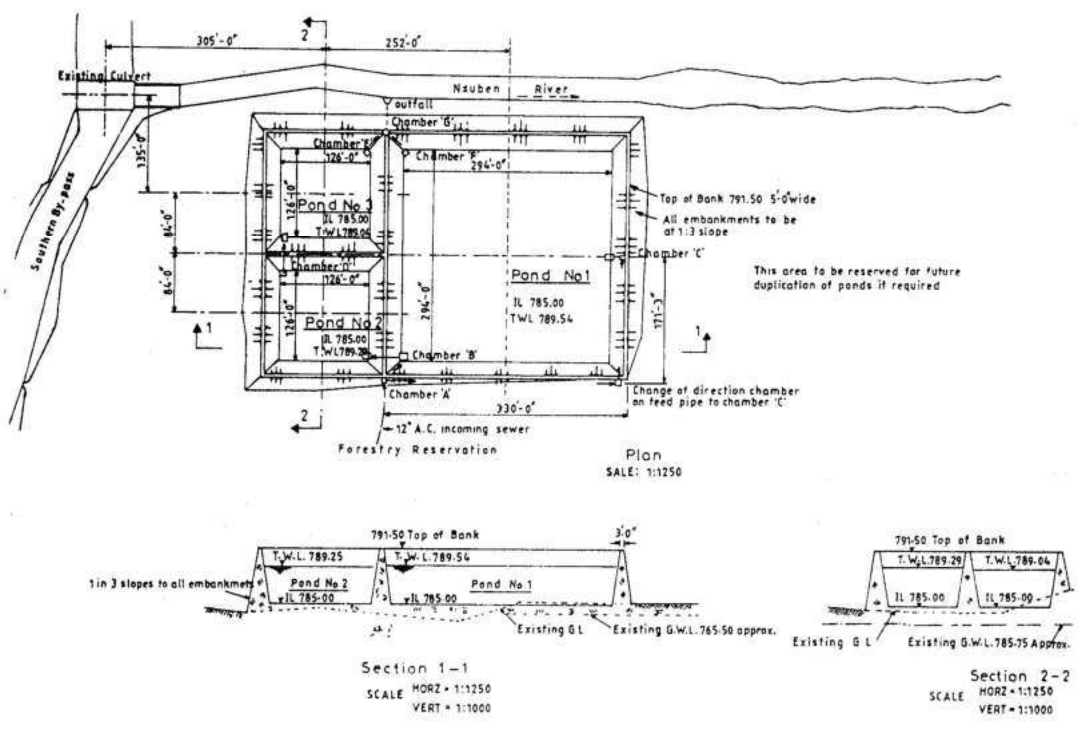

Fig. 1: Asokwa Waste Stabilization Ponds as Designed

MATERIALS AND METHODS

Flow Rate

The influent flow rate was measured at hourly intervals for 24 hours (5 a.m. to the following morning 5 a.m.) by installing a V-Notch, designed according to British Standards 3680 part 4A [2], in the influent receiving chamber. The instrument was calibrated in the laboratory prior to installation. The effluent flowrate was measured hourly with a calibrated bucket at the point of discharge into the Nsuben stream for 13 hours (6 a.m. -6 p.m.). Measurements were made over a period of two months.

Sampling

Sampling was done manually and at hourly intervals over a 24 hours period for the influent and for 13 hours period (6 a.m. - 6 p.m.) for the effluent. Individual samples were collected at regular intervals such that at the end of the two months study period, at least 3 samples had been obtained and analysed for each hour for the influent and 2 samples for the effluent. At least 4 samples were collected on 4 consecutive hours on any sampling day and stored in an ice chest prior to laboratory testing. Composite samples representing specified periods were obtained by mixing together portions of the samples relative to flowrates at sampling time. At each sampling time the ambient temperature, pH and temperatures for both influent and effluent were measured.

Laboratory Tests

Analyses were made on flow-weighted composite samples of both influent and effluent for the following parameters; BOD, COD, total solids, suspended solids, nitrogen, phosphorous, coliforms and total bacteria plate count. The procedures

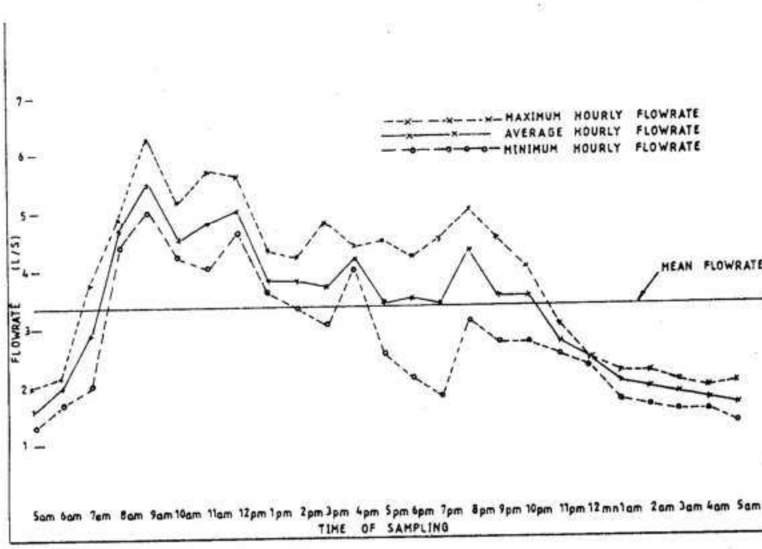

Fig. 2: Hourly Variation of Influent Flowrate

for analysing samples were according to the methods described in the Standard Methods for the Examination of Water and Waste by the American Public Health Association [1].

INSPECTION OF OTHER WASTE TREATMENT PLANTS

The trickling filter treatment plants at Achimota Secondary School, Accra, University of Science and Technology, Kumasi, University of Ghana, Legon and Burma Camp, Accra were inspected at least twice between 1988 and 1991. The waste stabilization ponds inspected during the same period were at Burma Camp, Accra Pantang Mental Hospital and Ashaiman estate. The night soil stabilization ponds at Teshie Nungua were inspected once in January 1989 and the Ankaful Mental Hospital waste stabilization ponds were also inspected once in July, 1990. Waste water samples were collected from the ponds at Pantang Mental Hospital, and effluent from the trickling filters and the stabilization pond at Burma Camp and analysed. The BOD of the raw sewage from the University of Science Technology treatment plant was also determined.

RESULTS AND DISCUSSIONS

Flow Rate of Asokwa Waste Stabilization ponds

Variations in the influent flow were observed with high flows occurring between 8 a.m. - 12 p.m. and low flows from 12 midnight to 6 a.m. (Fig. 2). An average influent flow rate of 290m^3 per day was obtained. Even though this was not remarkedly different from the design value of 270 m^3 per day, it was very different from the value obtained on the ponds by Krakue Mercer *et al* [5] i.e. 558 m^3/ day, (Table 1). The sewer lines should be checked for possible leakage and diversions, if any, to prevent the contamination of the environment. The effluent flow rate was fairly constant with an average of 230m^3 per day (fig. 3).

TABLE 1: Comparison between design parameters and loading obtained in 1974 study and present study.

Parameter	Design Value	1974 Value	1988 Value
Average influent flow (m^3/day)	270	558	290
Detention Period (Days)	53.76	19.5 (assumed 0.3m of sludge accumulation)	8.31 (First order reaction kinetics)
Raw Sewage BOD (mg/*l*)	660 (based on 54 gm BOD per person and 90 *l*/day)	200	210
BOD pplied to pond (kg.day)	163	112.5	60.8
Overall BOD Loading kg/ha/day	122	84	256

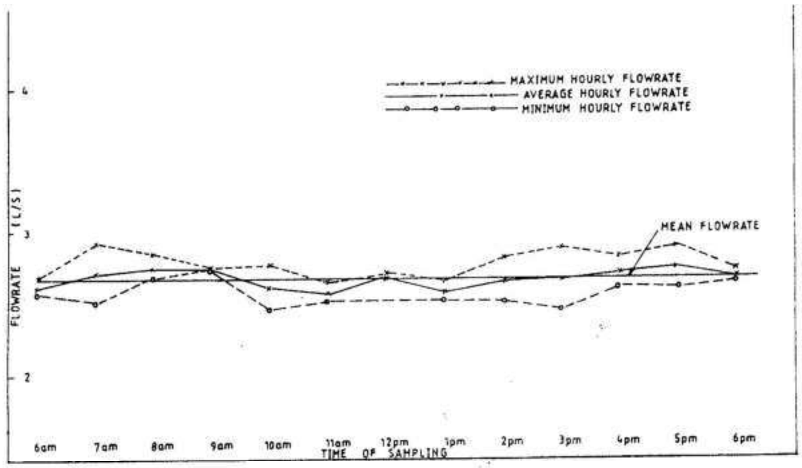

Fig. 3: Hourly Variation of Effluent Flowrate

Detention Period

A detention of 8.31 days was obtained by using the first order Kinetic reaction of BOD's removal formula;

$$\frac{Le}{L_l} = \frac{1}{K_l R_l + 1}$$

where,

Le	=	effluent BOD_5
L_l	=	Influent BOD_5
K_t	=	$K_{20}\phi^{(T-20)}$
K_{20}	=	0.8 [3]
	=	1.054 [7]
R_t	=	Detention Period

Asokwa Pond Performance

There had not been any significant change in the flow of wastewater to the pond with respect to design flow (Table 1). An average BOD concentration of 210 mg/l of influent wastewater was found to be consistent with BOD concentration of 200 mg/l of influent obtained during the 1974 study on the ponds. It was however lower than the design BOD concentration of 600 mg/l which was based on contribution of 0.54 kg BOD per person per day and 90 litres of water per person per day. There was a potential overloading of the remaining section of the pond; BOD surface loading 256 kg/ha day obtained was more than the design value of 122 kg/ha day. In addition to this, the effluent did not have any dissolved oxygen in it (Table 2), an indication of the onset of anaerobic conditions. However, by applying McGary and Pescod's [4] empirical formula: (maximum BOD_5 surface loading = $(11.2)\ (1.054)^T$, which is an expression for obtaining maximum BOD_5 surface loading that could be applied by the pond before it fails, the value obtained 635 kg/ha/day is within appreciable limit for adequate treatment in the pond.

Inspite of the lack of maintenance of this pond, with respect to the study conducted, the efficiency of the pond in BOD removal was 90% and the quality of effluent 21.5 mg/l BOD was within acceptable level (Table 2). The COD removal and that of suspended solids and bacteria plate count was over 70% efficient (Table 2). The average pH of both influent and effluent of 6.5, the average ambient temperature of 27.3°C and the ratio of suspended solids to BOD of 1:1, offer favourable conditions for effective working of waste stabilization ponds. Ironically the BOD of Nsuben, the receiving stream, was 46 mg/l. There was virtually no removal of ammonia nitrogen. This could cause eutrophiation in the receiving stream. The performance of the pond in reference to reduction of coliforms was inconclusive. The concentration in the effluent was more than 2400/l and that is not within accepted levels.

The ponds were visited in June 1989, March 1990 and July 1991. In June 1989, the sewage was flowing into the pond with no change in the surface area. In March, 1990 the sewage was no longer seen entering the pond.

TABLE 2: Overall Pond Performance

Parameters	Influent	Effluent	Efficiency of Removal
BOD	210 mg/l	21.5 ml/l	90%
COD	558 "	135 "	76%
Suspended Solids	254 "	58 "	77%
Total Solids	752 "	480 "	36%
Volatile Solids	930 "	433 "	18%
Ammonia Nitrogen	46.4 "	46.8 "	-
Nitrite Nitrogen	0.2 "	Trace	-
Nitrate Nitrogen	10.5 "	4.8 "	54%
Phosphate	4.0 "	2.1 "	47.5%
Coliforms	>2400/100 ml	>2400/100 ml	-
Total Bacteria	$170x10^4$/100 ml	$27x10^4$/100 ml	84%
Ambient Temperature	27.3°C	-	-
Flow rate m^3/day	290 m^3	230 m^3	-
Temperature	28°C	27.5°C	-
pH	6.5	6.5	-
Dissolved Oxygen	3 mg/l	0 mg/l	-

*Average Value from composite samples.

There was a blockage along the pipe leading into the pond line and the raw sewage had found its own path into the Nsuben stream. There were birds on the pond, an indication of the presence of fish and low organic loading. In July, 1991 the pond water was very turbid and no birds were seen. The whole site was inaccessible due to the presence of weeds.

The State of Other Sewage Treatment Plants in the Country

The state of other waste treatment plants in the country showed a gloss negligence of maintenance (Table 3). With the exception of the ponds at Pantang Mental Hospital and Burma Camp, the rest had been woefully neglected. There is no proper documentation on the construction and operational dates of these treatment works. The maintenance departments are generally responsible for the operation and maintenance of the treatment works in institutions. However, the public ones seem to be no man's concern. It seems that once they are put to use they are left at the mercy of nature. There were no attendants at some of these facilities. The educational background of the attendants on site shows lack of the necessary skills and training required to maintain such facilities. Operation of a trickling filter plant for example, requires some knowledge in electrical, mechanical and sanitary engineering. It is not surprising that these plant have all broken down. It is important to rehabilitate all the broken down trickling filters and waste stabilization ponds. If it is impossible to do so for the trickling filters, waste stabilization or oxidation ponds should be constructed in their stead since there is enough room for expansion on all the sites inspected. These alternate treatment ponds are inexpensive to maintain and have good performance if properly maintained. The careless handling of sewage in our environment can lead to serious outbreaks of enteric diseases in the country. It is important to have a reliable organization to supervise the management of these facilities.

CONCLUSIONS

It is clear from the results that the standards of sanitation in the country had gone down. All waste treatment plants should be properly maintained and their performance evaluated using the minimum guidelines recommended by Pearsons, Mara and Bartone [6].

The Kumasi Waste Stabilization ponds need urgent rehabilitation to prevent any health hazards. A new concept of approach should be established towards the improvement of environmental sanitation in the country including the maintenance and upgrading of all the existing sewage treatment plants. A new body could be formed to administer the sanitation problem in the Country.

OBSERVATION

At the time of going to press in 1996 there had not been any appreciable improvement in the conditions of all the treatment plants visited. The Pantang Waste Stabilization ponds however had been fenced to protect mental patients from accidental drowning. The source of leakage of the waste treatment plant at Asokwa had also been identified as a broken part of the sewer line from Okomfo Anokye Teaching Hospital behind the Volta River Authority Substation in Kumasi. It was estimated that about 75% of the sewage from the sewer line is going into a wetland which is unfortunately been used by some farmers for sugar cane and taro cultivation.

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TABLE 3: The Condition of other S[illegible]age Treatment Plants in Ghana

Site	University of Science and Technology, Kumasi	University of Ghana, Legon	Achimota Secondary School, Achimota	Burma Camp Trickling filters, Accra.	Ankaful Mental Hospital, Cape Coast.
General Description	Operate by the means of Trickling filters, dosing chamber and a sand filter.	Operate using Trickling filters, dosing chamber and a humus tank.	Operate with the combination of an Imhoff tank and trickling filters.	Operate on trickling filters; Imhoff tank does not function.	2 small ponds designed to operate in series
Inspection dates	June 1988, June 1990, July 1991	January 1988	June 1988 and January 1989	June 1988 and January 1989	July 1990
Area or volume	-	-	-	-	-
Analyses	BOD of raw sewage at 9 a.m. on 10th June 1990 240 mg/l	-	-	Effluent BOD and COD values from trickling filters are 18mg/l and 79.2 mg/l respectively	-
Performance	Performance is good when plant is in operation. Inconsistency in operation. In June 1988 the plant was out of order. In June 1990 the plant was working. In July 1991 the plant was out of order.	The plant was out of order and according to the attendant it has been out of order for several years.	Out of the 3 trickling filters only one was working at the time of inspection.	The performance is good.	Does not function anymore.
Problems	The sewage was flowing on the streets in July 1991 and down into the Wiwi valley of Taro Farms	Rusty pumps and machines	Odour	The whole area is very bushy. The Imhoff tanks hold waters.	The site is filled with silt and weeds.
Recommendations	Authorities concerned should give this treatment a priority in their maintenance schedule.	The plant should be rehabilitated. A series of stabilization ponds should be constructed in their stead.	The filters should be repaired and put to use.	The area should be cleared and the Imhoff tank which is no longer in use should be dismantled to prevent the breeding of mosquitoes.	The ponds should be desilted and put into use instead of constructing several septic tanks

Site	Ashiaman Estate Ponds	Burma Camp, Accra Ponds	Pantang Mental Hospital	Teshie Nungua Night Soil Ponds
General Description	Pair of small ponds designed to work in series for a low cost housing estate.	1 big pond - concrete lined - waste water is from a trickling filter.	2 pairs of ponds designed to work on parallel treatment basis, level of water is still below the overflow pipes in both ponds	Three small ponds designed to work on parallel basis. The night soil is obtained from public and domestic bucket latrines.
Inspection dates	June 1988 and January 1989	June 1988, January 1989	June 1988, January 1989	January 1989
Area or volume	-	4600 m^3	3000 m^2	1800 m^2 per pond
Analyses	-	Effluent from the pond showed a BOD of 16 mg/l and COD of 57.6 mg/l.	First pond had BOD and COD values of 15 mg/l and 259.2 mg/l respectively, and the second pond had BOD and COD values of 11mg/l and 136.8 mg/l respectively	Suspected to have high salt concentrations as seen deposited on the banks of the ponds
Performance	The area is covered with weeds and the raw sewage has been diverted to nearby rice farms.	Performance is good. The effluent is used by nearby rice farmers for irrigation.	Performance is very good and the ponds are well maintained.	Performance is very poor.
Problems	Odour and gross faecal contamination of the rice farms.	Weeds were growing at one corner of the pond.	COD values are rather high and shows that a high content of some of the carbonaceous substances remain undegraded; this will increase the rate of sludge cover.	Odour is a big problem.
Recommendations	New ponds should be constructed. The effluent can then be used by the farmers. A well trained personnel should be selected to supervise the maintenance of the ponds.	Weeds should be removed and the pond desludged.	The good maintenance practices should continue. The types of wastes entering the ponds should be investigated for maximum efficiency.	The surface area of the ponds should be increased and diluted with septic tank contents and other domestic waste water for the rapid degradation of organic matter and stabilization of the ponds.