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COMPARISON OF MODERN AND TRADITIONAL PIG WASTEWATER TREATMENT IN SERIAN, SARAWAK

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ABSTRACT

Pig farming is an important industry in Sarawak. Efforts have been made by pig farmers to treat pig wastewater by installation of oxidation ponds. However, little information is available on the effectiveness of the ponds installed. In this study, wastewater quality was investigated in two pig farms in Serian, Sarawak. Farms selected were a farm with 8,000 standing pig population (SPP) uses multiple pond system (TB farm) and another farm with 800 SPP use only one pond system (HB farm). The oxidation ponds of TB farm reduced TSS, BOD_5, COD, and NH_3-N by 54%, 39%, 35% and 56%, respectively, whereas in HB farm reductions were 29%, 15%, 10% and 9%, respectively. DO concentrations for TB farm and HB farm increased 40% and 13%, respectively. Nitrate was reduced at 65% in the water samples of TB farm but there was an increase of 11% in the HB farm effluent. Even though TB farm has ten times more SPP than HB farms, the final discharge from TB farm was of significantly better water quality than that of HB farm. It is recommended that at least three ponds of appropriate size with separator be installed for the treatment of pig farm wastewater before being discharged into the river.

ABSTRAK

Penternakan babi adalah satu industri yang penting di Sarawak. Pelbagai usaha telah dijalankan oleh penternak babi untuk merawat air buangan dari kandang babi ini seperti membina kolam pengoksidaan. Terdapat kurang maklumat tentang keberkesanan kolam-kolam yang dibina. Dalam kajian ini, kualiti air buangan dari dua buah ladang penternakan babi di daerah Serian, Sarawak dibandingkan. Ladang yang dipilih adalah ladang yang mempunyai 8,000 populasi berdiri babi (PBB) yang menggunakan sistem banyak kolam (ladang TB) manakala satu lagi ladang Ladang mempunyai 800 PBB dan menggunakan sistem satu kolam sahaja (ladang HB). Kolam pengoksidaan ladang TB menurunkan kandungan efluen TSS, BOD_5, COD, dan NH_3-N masing-masing sebanyak 54%, 39%, 35% dan 56%, manakala ladang HB menurunkan masing-masing sebanyak 29%, 15%, 10% and 9%. Kepekatan DO dari ladang TB dan HB masing-masing meningkat 40% dan 13%. Nilai nitrat menurun ke 65% pada air sampel daripada ladang TB tetapi meningkat ke 11% di ladang HB. Walaupun ladang TB mempunyai sepuluh kali ganda PBB daripada ladang HB, namun hasil akhir yang dikeluarkan mempunyai kualiti air yang lebih baik daripada ladang HB. Oleh itu dicadangkan sekurang-kurangnya pembinaan tiga buah kolam berasingan dengan saiz yang tertentu digunakan dalam rawatan air buangan dari kandang babi sebelum air dikeluarkan ke sungai.

Key words: pig wastewater, oxidation pond, water quality, Sarawak

INTRODUCTION

During the last 20 years, the livestock industry experienced an exponential growth resulting in integrated large intensive animal farming units that created the need for laws and regulations to control animal waste pollution and minimize the environmental impact of the associated malodors. Pollution from pig, cattle, and poultry farms has become one of the most challenging

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environmental problems. The environmental problems include the generation of nuisance odors, the release of ammonia and other noxious gases to the atmosphere, the under-utilization of excess nitrogen and phosphorus, the improper use of persistent chemicals and the potential of zoonotic diseases. It was estimated that 28% of river basins in Malaysia were polluted with sewage and animal farm wastewater (Rahman, 2001). In Malaysia, being tropical, pigs are hosed with water twice a day to cool the pigs and remove the waste (Choo *et al.,* 1987; Teoh *et al.*, 1988).

In Sarawak pig farming is an important industry generating about RM 60 million a year (Kinson *et al.,* 2001). There are 154 farms in Sarawak with an estimated standing pig population (SPP) of 461,289 (SAD, 2002). Pig wastewater contains highly concentrated pollutants, including suspended solids, organics and nutrients that may deteriorate the quality of aquatic environments into which they are discharged (Lee *at al.,* 2004). There have been significant efforts to reduce surface water pollution by Sarawak Government in terms of licensing of pig farm operations whereby under the Control of Livestock Pollution Rules of the Natural Resources and Environmental Board (NREB), farms with more than 100 animals need to have oxidation ponds installed (NREB, 1996).

Oxidation ponds are widely used in human, industrial and animal waste treatment due to low capital cost and simple operation and maintenance requirements compared to other biological treatment systems. However, information on the performance of the oxidation ponds is lacking. Therefore, in this study, water quality of two farms with different number of oxidation ponds was investigated.

MATERIALS AND METHODS

Sample Collection

The two pig farms, TB and HB farms, selected for studies were located in Serian, Sarawak. Both farms have been in operation for 10 years. TB farm had 8,000 pigs with modern wastewater treatment system of a solid-liquid separator followed by three oxidation ponds whereas HB farm which has 800 pigs with conventional wastewater treatment system of only one pond. The size of the oxidation ponds in TB farm was 12.2 m x 18.3 m x 4.6 m while HB farm was 6.1 m X 9.1 m x 1.5 m.

Water sampling was conducted for three times, each in April, May and June 2003. Each parameter was done in duplicate. Grab samples were taken at 5 sampling points in TB farm: at inflow (S1) and before outflow (S2) in the second pond, inflow (S3) and before outflow (S4) in third pond and final discharge point (S5) (Fig. 1). For the HB farm, grab samples were taken at 3 different locations: at outflow of oxidation pond (S1), 50 m from S1 along the drain (S2) and 50 m from S2 (S3) (Fig. 2). In both farms the first pond was the sedimentation pond. In TB farm, wastewater from pig shed passed through the separator before entering the first pond. Samples collected were stored in polyethylene bottles (1L), placed in an icebox and transported to the laboratory for analysis. All samples were analyzed in triplicates.

Parameters measured

The *in situ* parameters measured were temperature, pH and dissolved oxygen (DO) using YSI 55 and YSI 30 meters. Water quality parameters analyzed were total suspended solids (TSS), biological oxygen demand (BOD_5), chemical oxygen demand (COD), ammonia-nitrogen (NH_3-N) and nitrate-nitrogen (NO_3-N).

TSS analysis was performed according to Standard Methods (Clesceri *et al.,* 1998). A well-mixed sample was filtered through a preweighed glass microfiber filter paper (Whatman GF/C) and the residue on the filter was dried to constant weight at 105ºC.

BOD_5 determination follows that of Standard Methods 5210. Samples were diluted with phosphate buffer. After the initial DO was determined the samples were incubated at 20ºC for five days before final DO was measured (Clesceri *et al*., 1998). DO meter (YSI55) was used for initial and final DO readings.

Closed reflux, colorimetric method was used to determine COD. Potassium dichromate (1.5 mL) and (3.5 ml) sulfuric acid reagent was added to 2.5 ml sample and the resulting solution was refluxed at 150ºC for 2 hours. It was cooled and the measurement of absorbance was taken at wavelength of 620 nm (Clesceri *et al*., 1998).

NH_3-N was analyzed using Nessler USEPA method where the water sample was distilled first before analysis. Then, 25 ml of the distilled sample was added with salicylate reagent followed by cyanurate reagent. Concentration of NH_3-N in the resulting solution was determined using spectrophotometer DR2010 at 425 nm (Hach, 1996).

NO_3-N was analyzed using cadmium reduction method whereby Nitra Ver 6 nitrate reagent and Nitri Ver 3 nitrite reagents were added to a sample. Concentration of NO_3-N in the resulting solution was determined using spectrophotometer DR2010 (Hach, 1996).

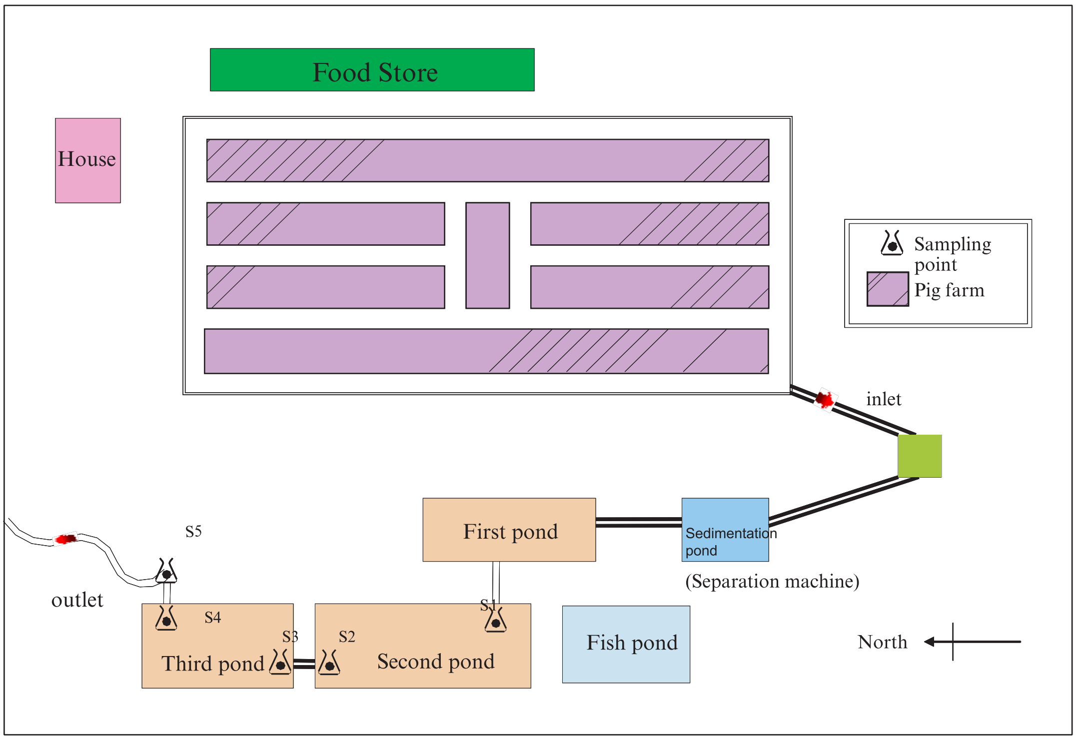

Fig. 1. Location of sampling at TB farm oxidation pond.

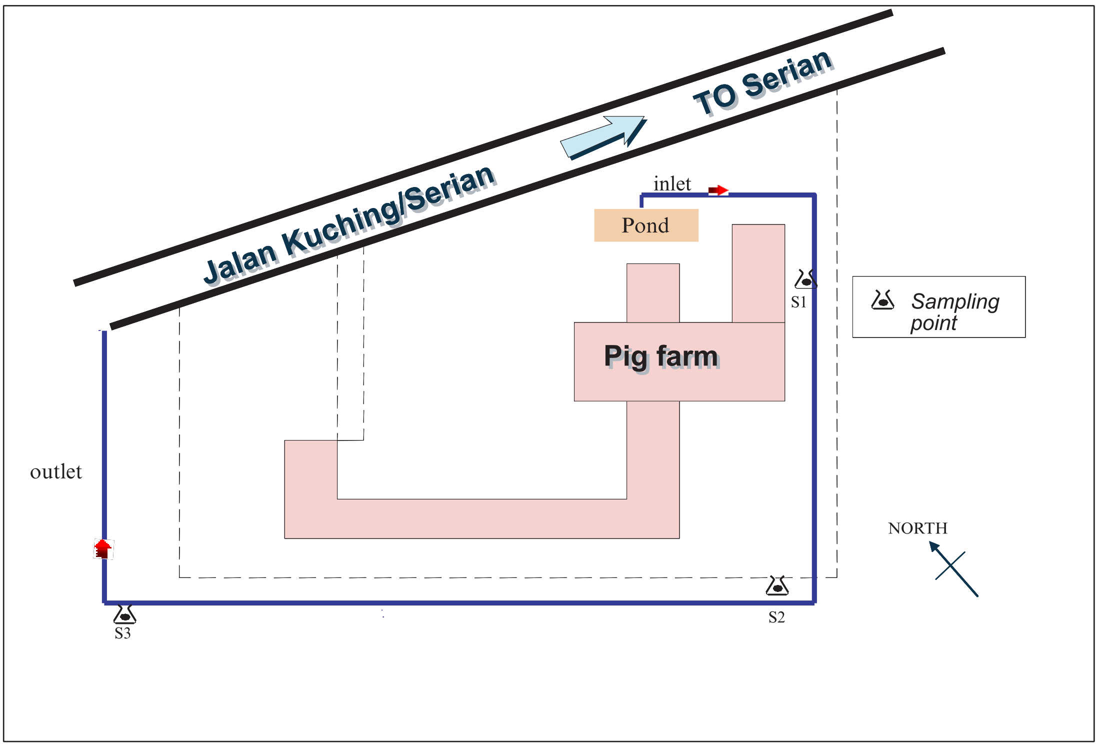

Fig. 2. Location of sampling at HB farm oxidation pond.

Statistical analysis

Paired t-test was used to compare the overall change (%) in concentrations of water quality parameters between the farms. All analysis was performed by using SPSS ver 12.0.

RESULTS AND DISCUSSION

pH and Temperature

The pH values from TB farm ranged from 4-6 whereas those from HB farms were at the value of 4 indicating acidic condition. The acidic condition is probably due to the end products of organic waste stabilization occurring in the ponds such as carbon dioxide and organic acids (Tchobanoglous and Burton, 1991). Temperatures from TB farms are more variable when compared to that of HB farm (Table 1).

TSS

A high reduction of TSS concentration in TB farm (54%) as the wastewater flowed through the three lagoon systems when compared with that of HB farm (28%) (Fig. 2, Table 2). Even though TB farm has 10 times SPP than HB, concentration at S1 was almost the same as that of HB. This could be due to the solids being separated before first pond in TB farm. The final discharged from the TB farm was significantly better in terms of TSS ($p=0.007$). This is most likely due to the presence of two additional oxidation ponds of TB farm that allowed more retention time for solids to settle. However, the final discharge for both farms were still high, TB farm is under class III and HB farm under class IV of the proposed Interim Water Quality Standard (DOE, 1994).

DO

In both farms, the dissolve oxygen (DO) values only ranged from 1.20 to 1.75 mg/L and were the lowest at S1 and highest at discharge (Fig. 4). DO of discharge in TB farm was significantly higher than that of HB farm ($p=0.06$) but the values were very low and unhealthy for aquatic organisms. This result showed that in the wastewater of both farms, the DO was heavily used up in treatment process as microorganisms consume oxygen during degradation of organic matter.

Table 1. Mean temperature and pH of the wastewater from pig farm at the sampling points in TB farm and HB farm

Sampling Points	Temperature (°C)		pH	
	TB farm	HB farm	TB farm	HB farm
S1	28.7±0.6	28.0±0.0	4.0±0.0	4.0±0.0
S2	28.0±0.0	28.0±0.0	4.0±0.0	4.0±0.0
S3	28.0±0.0	28.3±0.6	4.3±0.6	4.0±0.0
S4	28.3±0.6	–	4.7±1.2	–
S5	26.7±0.6	–	5.7±0.6	–

BOD_5

Mean BOD_5 at HB farm was higher than those in TB farm even though TB farm has 10 times more SPP (Fig. 5). A large drop of BOD from S3 to S5 in TB farm indicated large reduction occurred in the third oxidation pond. After treatment process in the three oxidation ponds of TB farm, BOD_5 was reduced by 39% to a final value of 33 mg/L (Table 2). However, at HB farm BOD of the final water was only reduced by 15% to 51 mg/L. The presence of the separator which partly removed the solids materials together with the three ponds systems possibly resulted in lower BOD_5 at S1 in TB farm when compared with that of HB farm. Degradation of organic materials in the wastewater by microorganisms contributes to high consumption of oxygen and therefore high BOD value especially in HB farm discharge. According to INWQS (DOE, 1994), the discharge is in Class V level since the BOD is more than 12 mg/L.

COD

The trend of reduction in COD is similar to that of BOD_5 whereby COD values were higher in HB farm than in TB farm even from the first sampling point S1 (Fig. 6). The COD in the oxidation pond in TB farm was reduced by 35% to 277 mg/L before discharged into the river whereas in HB farm it was only reduced by 10% to 490 mg/L (Table 2). This high COD value

Table 2. Overall change in concentrations of water quality parameters from sedimentation pond outflow point to the discharge point at the two farms studied

Parameter	Change in concentrations (%)	
	TB Farm	HB Farm
TSS (mg/L)	-53.9±0.8[a]	-28.5±2.7[b]
DO (mg/L)	+40.4±6.5[a]	+13.0±15.9[b]
BOD_5 (mg/L)	-39.3±13.4[a]	-14.7±2.3[b]
COD (mg/L)	-35.3±11.4[a]	-10.0±1.2[b]
NH_3-N (mg/L)	-55.6±0.7[a]	-8.9±2.7[b]
NO_3-N (mg/L)	-64.6±6.7[a]	+10.6±0.8[b]

Means in the same row with the same letters are not significantly different at 10% level.

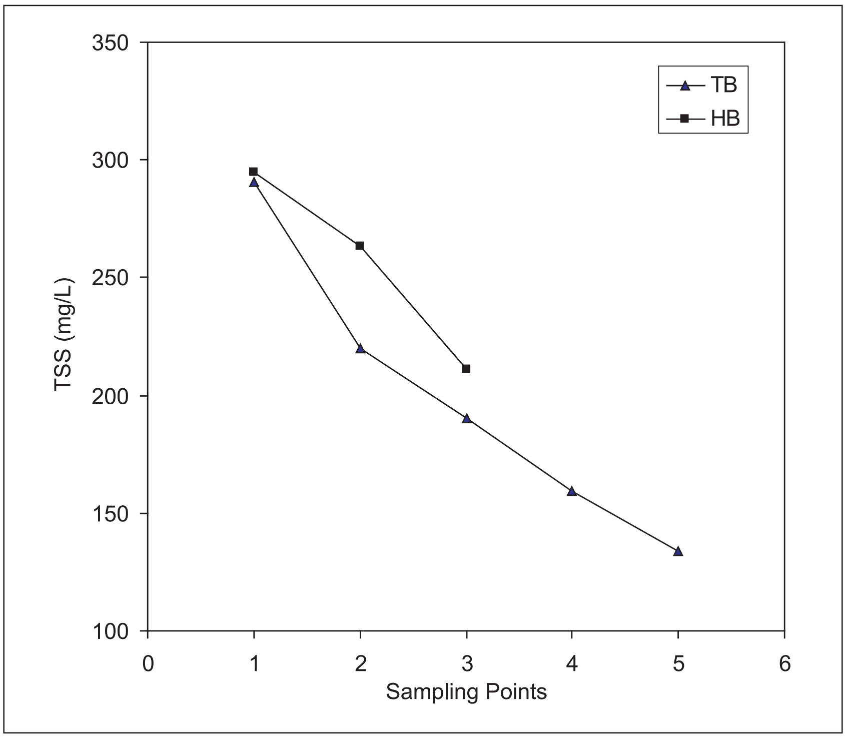

Fig. 3. Total suspended solids (TSS) concentrations at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

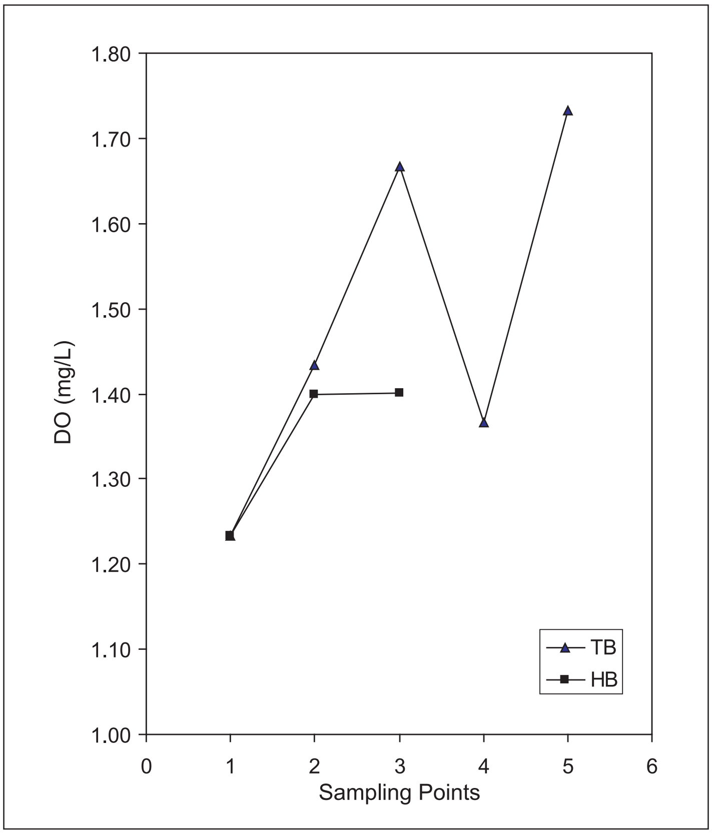

Fig. 4. Dissolved oxygen (DO) concentrations at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

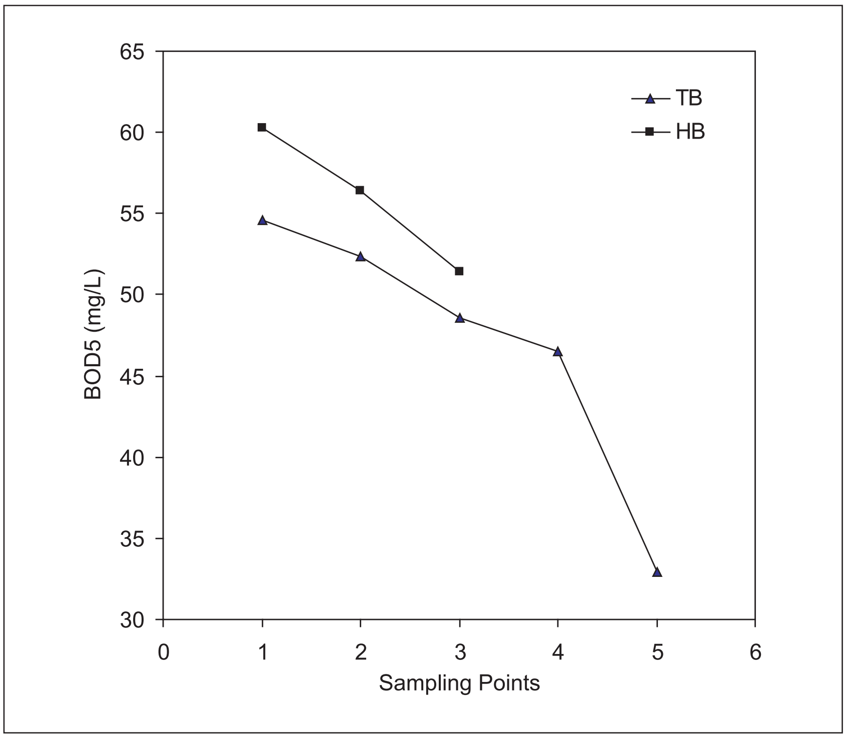

Fig. 5. Biological oxygen demand (BOD_5) at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

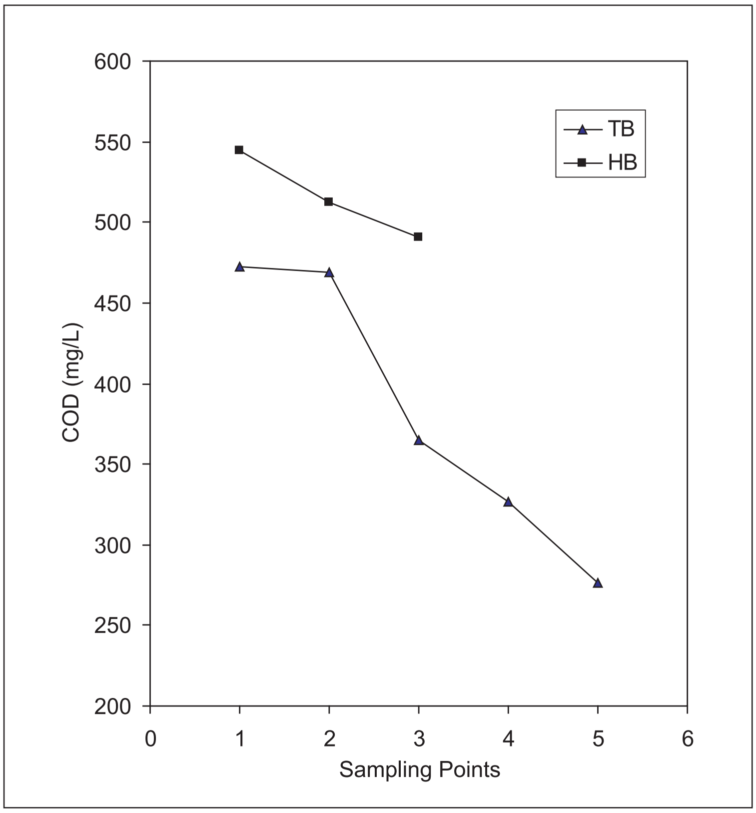

Fig. 6. Chemical oxygen demand (COD) at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

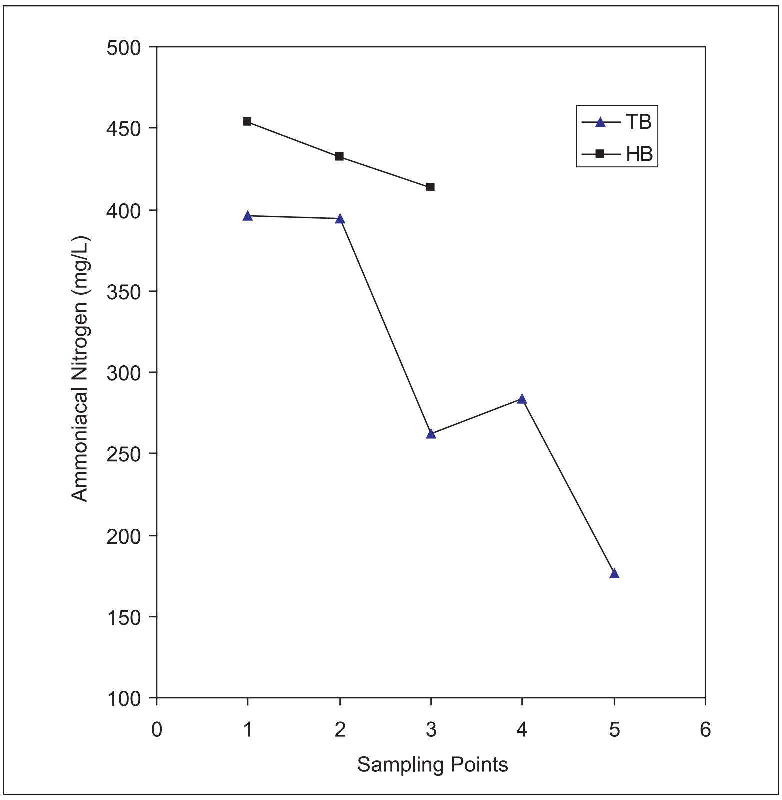

Fig. 7. Ammoniacal nitrogen (NH_3-N) concentrations at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

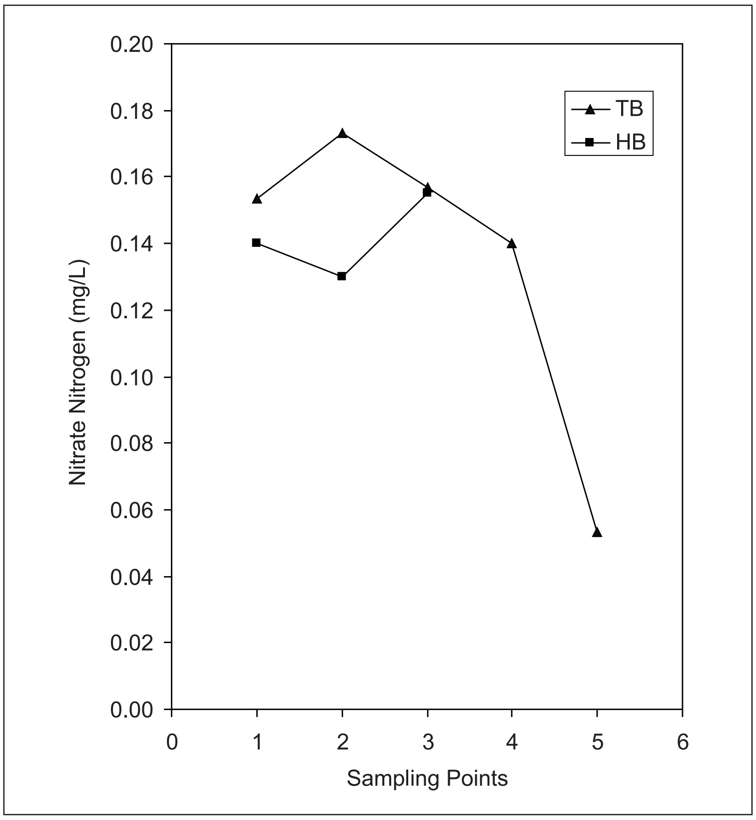

Fig. 8. Nitrate-nitrogen (NO_3-N) concentrations at the five sampling points from sedimentation pond outflow to the discharge point at the two farms studied.

shows the large amount of oxygen required for chemical oxidation of the organic matter in the wastewater. Since the final discharge from both farms exceeded 100 mg/L, they are under class V of the INWQS (DOE, 1994).

NH_3-N

Ammoniacal nitrogen in both farms at the first sampling site, S1, was very high, 396 mg/L and 453 mg/L from HB and TB farm respectively (Fig. 7). However, in TB farms, its concentration was reduced 56% whereas in HB farm, the reduction was only 9% (Table 2). Most of the reduction was achieved at the second and third oxidation pond as indicated by the large drop in the concentration from S2 to S5. Nitrogenous compounds in pig wastes are mainly in organic form that is converted to ammonia by bacteria and subsequently to nitrate (Taiganides, 1986). In HB farm, the amount of NH_3-N did not reduced efficiently since there was only one pond and the retention time is insufficient to hold the water for treatment by bacteria.

NO_3

In TB farm, the nitrate nitrogen concentration was reduced 65% whereas in HB farm there was an increase of 11% (Table 2). This is most likely due to low retention time in HB farm where the bacteria oxidizes ammonia compounds to nitrate but the resulting nitrate was not significantly utilized before discharge. In TB farm, nitrate nitrogen increased in the second pond (S1 to S2) but decreased in the third pond (S3-S5) (Fig. 8). In HB farms there was an increased in nitrate nitrogen in the drain from S1 to S3. This is most likely due to the oxidation of ammonia to nitrate by nitrifying bacteria. The reduction of nitrate was observed to occur in the third pond. This is possibly due to the uptake of nitrate by algae when the water was retained in the third pond. However, in HB farm, no such pond was installed. Therefore, nitrate was not reduced.

CONCLUSION

The farm with three oxidation ponds was showed to treat wastewater from pig farm significantly better when compared with that of only one pond. The installation of solid-liquid separator also showed evidence of improving the water quality. Therefore, traditional one pond system should be replaced with the modern system with three or more ponds and separator in order to reduce environmental pollution resulting from discharge from the pig farms.

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