Evaluation of the Effectiveness of Aerated Lagoon Treatment Methods on Flushed Poultry Waste

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Abstract

A commercial poultry wastewater management system was evaluated for solids separation and degradation. The characteristics of the flushed water and collected manure were determined. The performance of solid-liquid separator and the impact of low rate aeration in the lagoons on solid degradation and odour reduction were also evaluated.. Solid removal efficiency of the stationary screen separator was 26.9%, 33.9%, 36.8% and 41.5% for TS, VS, SS, and VSS respectively. The aerated cells shows higher solid removal efficiency than unaerated cell and the low rate aeration of the lagoons did result in less solid build-up and reduced the odour threshold by 20-40%, but it had an insignificant impact on the existing sludge in the lagoons. More intense aeration is needed in order to cause significant degradation of solid in the lagoons.

Keywords: *Evaluation, poultry waste, solid-liquid separation and aerated lagoon.*

Introduction

Liquid manure handling systems are commonly used on Nigeria poultry production farms that house several numbers of birds in a battery cage system. In such systems, Manure is collected by flushing the cage two to three times a day with water. The collected manure is normally stored in aerobic lagoons until it is needed for irrigation onto nearby agricultural fields. Solid-liquid separators are used on most poultry farms to remove solids from the flushed manure before the lagoon storage for the purpose of reducing solids build-up in the lagoon (Olayinka 1990). Stationery screens and earthen or concrete settling basins are the most common types of separators. Flushing and solid-liquid separation are two processes that contribute the most to energy use for manure management in poultries. The efficiencies of solid-liquid separators and the daily energy demand associated with manure collection and treatment are important aspects of manure management for poultry product producers and engineers to consider in planning intensive system of poultry management (Sekela and Rudell 2003).

Due to limited solids removal efficiency of the separators, solids build-up and odours are major concerns with the lagoons. Recently, small aerators that are capable of aerating the surface layers of lagoons as well as providing mixing have been marketed to poultries for the purpose of reducing solid and odours in the lagoons. However, there is a lack of scientific evaluation of the performance of these aerators in terms of their aeration efficiencies and effectiveness in treating the poultry lagoons. This project is then conducted to evaluate the performance of such aerators with regard to their impact on the solid levels and odour threshold of poultry wastewater lagoon with an aim of developing guidelines for the proper applications of these aerators. The objectives of this work are to characterize the wastewater on a commercial poultry and evaluate the performance of a stationary screen separator for solids removal and to evaluate the effectiveness of a low aeration system for solids removal and odour control in poultry lagoons.

Materials and Methods

The study site is a commercial poultry farm in Ibadan, Oyo state, south-western Nigeria. The farm contains about 15,000 birds (layers, broilers and cockerels) housed in a battery cage system. The birds' droppings are flushed two times a day for manure collection. The flush pump ran for 3.5 hour each day. The flush water is recycled wastewater out of a storage pond. The flushing and wastewater collection system is designed such that water is pumped out of the storage pond with a 35 hp centrifugal pump (flush pump), released through the free stall barns, collected in a concrete pit, and then lifted with another 35 hp pump (separator pump) to a stationary screen separator. In addition, two other 18 hp pumps are used to transport the flush water and manure around the collection system. After the separator, the wastewater flows through an earthen solids settling basin, then into two lagoons connected in series and finally into a storage pond.

Evaluation of aerobic treatment in lagoons

Two stage lagoons already existing on the farm were used for this study. The first lagoon was 50 x 25 x 5 m and the second stage lagoon was 65 x 27 x 6 m .To evaluate the effectiveness of aeration, the two lagoons were divided into halves by installing polyethylene sheets in the middle of each lagoon so that two cells of equal volume were created in each lagoon. The cells on the same side of each of the two lagoons were then connected to make a two-stage lagoon system, thus creating two testing lagoon systems to operate side by side. The dimensions of the cells in each testing system were 25x25x5 m for the first stage and 32.5x27x6 m for the second stage. One system was used as a control without aeration, and the other system was used as a treatment with aeration. Thus, water flowed from the solids settling basin was divided equally into the aerated and the control cell of the first stage lagoon, and then from each of those cells into an aerated and a control cell of the second stage lagoon .Tests were conducted for a total of four months. In the first two months, two aerators were used in the first stage and three aerators in the second stage. The aerators were placed in the center of the lagoon at 12.5m spacing along the entire length. After two months, the number of aerators in each stage was doubled due to the findings that the effectiveness of the treatment was not significant. The aerators tested were electrically driven aerators that floated on the lagoon surface.

To evaluate the impact of treatment on sludge levels in the lagoons, the sludge depth in the aerated and unaerated lagoon cells were measured at five different times over the four months period. The sludge depth in each lagoon cell was measured initially before the aerators were turned on and later at 1, 3 and 4 months. At each measurement, the surface of the lagoon cell was divided into a number of grids of equal area and the sludge depth was measured at the center of each square.

The characteristics of wastewater flowing in and out of each lagoon cell were also measured on the same day of the sludge measurement. Samples of 500 ml each were taken from each flow hourly over a 24 hour period and then all the samples were well mixed in a container. Then a 500 ml sample was taken and used as the sample to give the average solids concentrations for that flow. The samples were placed on ice and transported for analysis of TS, VS, SS, and VSS. Then the difference in solids concentrations between the influent and effluent of each lagoon cell was calculated.

Results and Discussions

The solids separation efficiency of the separator is shown in Table 1. The mean removals for TS, VS, SS, and VSS are 24.0%, 30.7%, 32.9% and 37.8%, respectively. The efficiency of this separator was higher than the efficiencies (2.07-20.34% TS removal) reported by McNeillie and Anderson (2001) for similar separators on California poultries. The flow rate over the separator was measured to be 1913 m^3/day or 0.64 m^3/100birds/day.

Table 1. Solid separation efficiency (%) of the separator.

Date	Total Solids	Volatile Solids	Suspended solids	Volatile Suspended solids
17 May	26.6	34.4	34.8	38.6
20 May	22.3	29.7	30.8	35.6
20June	20.5	24.7	27.5	34.7
24 June	38.6	45.9	47.7	51.6
19 July	20.6	26.6	32.4	36.6
20 July	14.6	20.1	25.4	28.8
25 Aug	20.9	29.3	30.4	36.1
26 Aug	27.9	35.1	34.4	40.3
Average	24.0	30.7	32.9	37.8

Table 2. Total and sludge depths (m) in aerated and unaerated lagoons.

	First Stage				Second Stage			
	Aerated		Unaerated		Aerated		Unaerated	
Date	Sludge depth	Total depth	Sludge depth	Total depth	Sludge depth	Total depth	Sludge depth	Total depth
May	3.90	4.26	3.61	4.27	3.46	4.92	4.06	5.02
June	4.37	4.33	4.27	4.43	3.54	4.74	4.40	4.68
July	3.92	4.35	4.12	4.48	3.59	4.63	4.56	5.09
August	3.66	4.41	4.13	4.43	3.70	4.64	4.60	5.01

Average sludge depths in aerated and unaerated lagoon cells are shown in Table 2.

It was found that initially 75%-85% of lagoon depths were filled with sludge due to the solids build-up over a three- year period. Over a five-month period, the sludge depth in all the lagoon cells increased due to solids settling. However, the increase in aerated cells was less than in the unaerated cells. The sludge depth increases in unaerated cells were 0.49-0.52 m more than the aerated cells. This indicates that the aeration did result in less solids build-up in the lagoons, but due to the low rate of aeration, the impact on the existing sludge was insignificant. This is still in agreement but a little higher than what was reported by Sumpter and Siegrist (2001). The TS and VS removals from the liquid effluent by the aerated and unaerated lagoons are shown in Table 3.

Table 3. Reduction of solids concentrations (%) in aerated and unaerated lagoons.

	First stage				Second stage			
	Aerated		Unaerated		Aerated		Unaerated	
Date	TS	VS	TS	VS	TS	VS	TS	VS
29 May	7.3	18.2	6.6	17.5	3.3	7.7	3.4	11.2
30 May	6.0	14.3	6.7	15.2	4.6	11.1	5.5	14.5
24 June	17.3	27.5	13.0	21.4	1.1	8.5	6.1	16.3
25 June	19.8	34.8	9.1	18.3	2.6	3.0	10.1	15.9
22 July	13.3	29.0	25.5	45.6	20.5	45.9	10.6	1.5
23 July	26.4	45.5	23.9	38.9	7.1	13.9	11.5	25.9
25 Aug	13.2	22.0	7.0	13.7	4.4	4.5	2.2	13.3
26 Aug	5.9	18.2	5.2	15.2	5.6	8.4	8.9	19.6

All values are in mg/l.

Comparing first stage aerated and unaerated lagoon cells, the aerated cell showed slightly higher solids removal than the unaerated cell. Overall, there were large variations among different samplings, making it difficult to draw any conclusions but more intense aeration will increase the solid removal efficiency (Hagedorn and McCoy 1981).

Conclusion

The following conclusions can be drawn from this study. The characteristics of recycled wastewater for flushing were quite consistent over a four-month period. The ratios of VS/TS and SS/TS of the fresh manure were 79.7% and 92.2%, respectively. Solids removals of the stationery screen separator were 26.9%, 33.9%, 36.8% and 41.5%, for TS, VS, SS, and VSS, respectively. The low rate aeration of the lagoons did result in less solids build-up but it had insignificant impact on the existing sludge in the lagoons. More intense aeration is needed in order to cause significant degradation of solids in the lagoons.

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