Treatment of wastewater from slaughterhouse by biodigester and Vetiveria zizanioides L

Published on: 4/15/2014

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Summary

Waste products from a slaughterhouse in Hau Giang province were passed through a biodigester tank followed by an area planted with Vetiver grass (*Vetiveria zizanioides*) before discharging to the environment. Wastewater samples were collected in three positions, at input and output of biodigester and adjacent to the Vetiver grass area with four monthly sampling intervals. Measurements were made of temperature, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), total nitrogen (tot N), phosphorus (tot P) and total Coliforms.

The model was effective and satisfied the National Technical Regulation on Industrial Wastewater (QCVN 24:2009/BTNMT), except for tot P and total Coliforms.

Key words: *animal waste, biological wastewater treatment*

Introduction

Wastewater from a slaughterhouse is very harmful to the environment (Polprasert et al 1992). The main contaminants are organic matter, consisting of manure, gut contents, blood, suspended material, urine, grit and colloidal particles. Full scale conventional wastewater system such as anaerobic lagoon, activated sludge and biological nutrient removal technologies have been used to treat wastewater from slaughterhouse but they are expensive. In Vietnam, slaughterhouses apply some types of primary pre-treatment to minimize the pollutant before going out to the environment such as using settling tank in combination with biodigester tank or a fish pond. At farm level, anaerobic treatment with biodigesters is widely employed for treating pig wastewaters containing high concentrations of organic matter. The advantages of the biodigester are widely reported by many authors (Bui Xuan An et al 1997a,b; Sophin and Preston 2001; Duong Nguyen Khang et al 2002; San Thy 2003).

In Vietnam cities, available land area is limited, thus it is very important to design a treatment system for slaughterhouse to be environmentally friendly, efficientt and able to meet the requirements of the environmental regulations. Vetiver grass (Vetiveria zizanioides) has been introduced as a new phyto-technology for various environmental protection applications (Truong 2001). Vetiver grass is a “super absorbent” plant, mainly used for soil conservation, with a strong root system, which can develop to a depth of 5 m, is able to penetrate compacted soil layers and has minimal lateral growth. According to Truong (2000) and Truong and Hart (2001), Vetiver grass has been used for the disposal of leachate and effluent generated from landfill and wastewater treatment plants in Australia, China and Thailand.

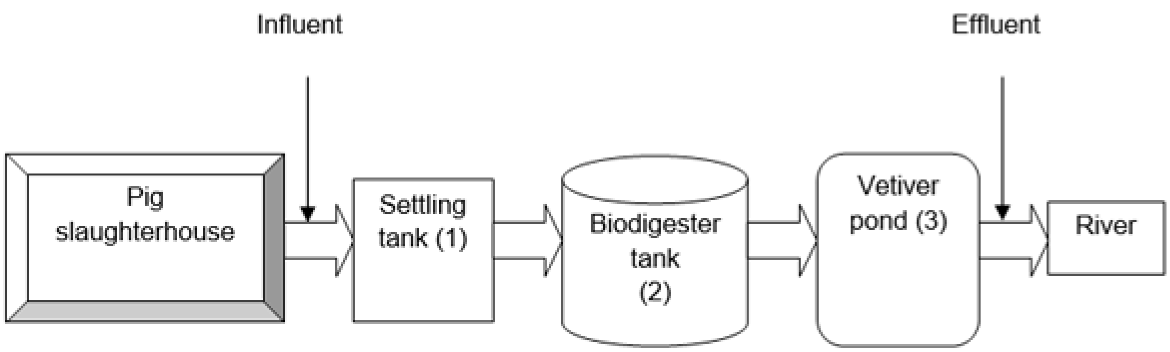
Objectives

The aim of this study was to evaluate the effects of a wastewater treatment model, to process influent from a slaughterhouse passing it through a biodigester followed by *Vetiveria zizanioides*. prior to discharge to the environment. Biochemical parameters were compared against the National Technical Regulations on Industrial Wastewater (QCVN 24:2009/BTNMT).

Materials and Methods

The study was conducted at a slaughterhouse in Hau Giang province. The wastewater treatment system included a settling tank with volume of 3m^3 connected to a biodigester tank of 30m^3 from which it drained directly into a pond of 330m^2 with Vetiver grass (*Vetiveria zizanioides*) surrounding the pond (Figure 1). Some 50 pigs were slaughtered daily producing 30m^3 of wastewater per day.

Figure 1. Sample collection points



Sample collection

Monthly sample of the influent and effluent were taken for analysis. Samples were collected at three positions (Figure 1), settling tank (2.00-3.00 am after cleaning the slaughterhouse), biodigester, and ffrom the planted Vetiver pond (6:00 to 9:00 am) with four replicates. Collected samples were placed in plastic bottles, previously cleaned by washing in non-ionic detergent, rinsed with tap-water and finally with non-ionic water. To determine total Coliforms, samples were stored in sterile bottle. Bottles were labeled, transported to the laboratory and stored at 4°C prior to analysis.

Analytical methods

Temperature and pH were determined by using a pH meter (Hanna instrument). Total nitrogen (tot N) was determined by using Kjeldahl digestion. Total phosphorus (tot P) was determined by using a colorimetric ascorbic-molybdate method after digesting with a H_2SO_4/H_2O_2 mixture (Murphy and Riley 1962). Suspended solids (SS) were determined gravimetrically after oven drying at 105°C (APHA 1995). Chemical oxygen demand (COD) was analyzed by the potassium permanganate method. Five-day biological oxygen demand (BOD_5) samples were stored at 20°C and analyzed by Winker's method (APHA 1995). Total Coliforms were determined using the Most Probable Number method (APHA 1998). Evaluation of the wastewater quality was based on the National Technical Regulation on Industrial Wastewater (QCVN 24:2009/BTNMT).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) available in Minitab 13.2. The Tukey test in the same software was used to detect significant differences among treatment means.

Results and Discussion

Effect of treatment method on wastewater quality

The temperature was lower in the Vetiver pond (25oC) than that in settling tank (26.9oC) and biodigester (26.8oC), while the pH of settling tank (6.9) and biodigester (6.3) was slightly lower than that of Vetiver pond (7.4), because of the fermentation into acids and gases of organic matter in anaerobic digestion

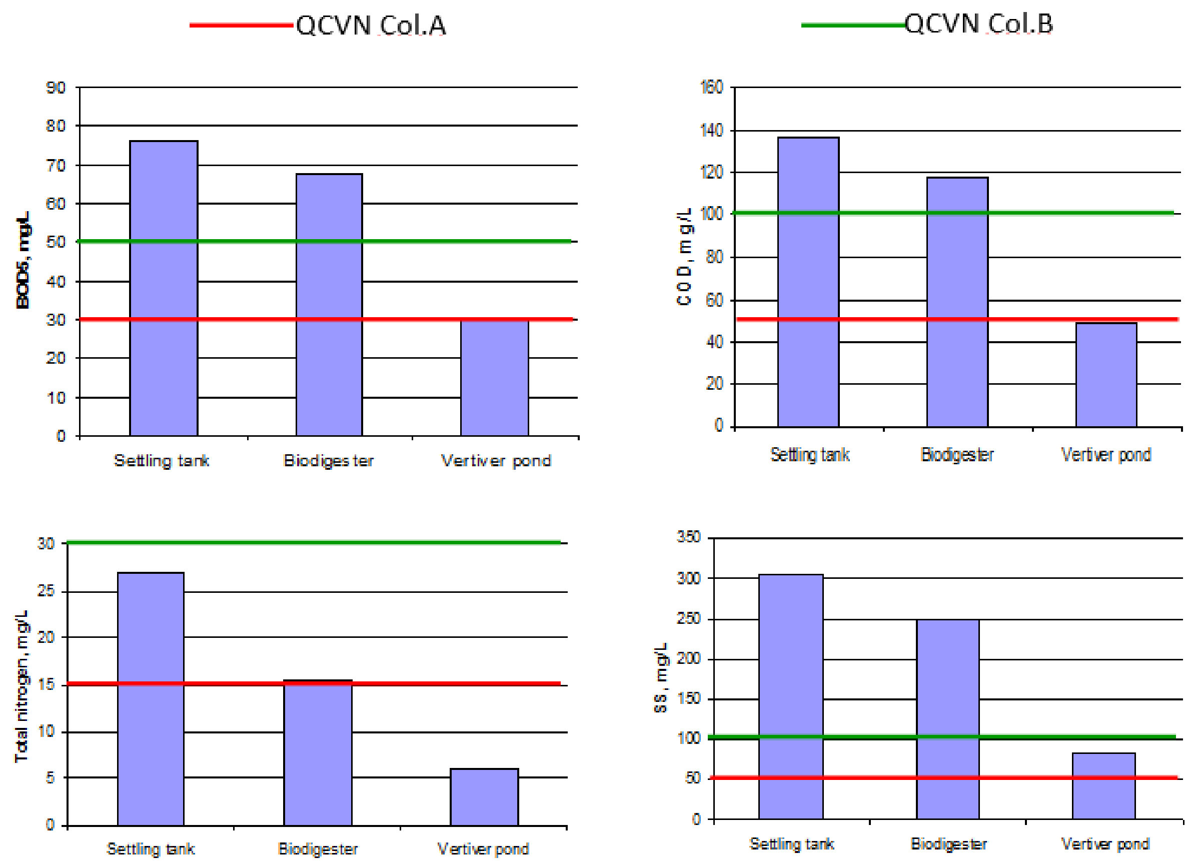
(Table1; Figure 2). The temperature and pH in a three sample collection points reached the column A of National Technical Regulation on Industrial Wastewater (QCVN 24:2009/BTNMT). Table 1: Effect of wastewater treatment on biochemical parameters and compared against the National Technical

Regulation on Industrial Wastewater QCVN 24 :2009/BTNMT

Parameters	**Collection points of samples**			***P***	**Compared to QCVN 24:2009/BTNMT**	
	Settling tank	**Biodigester**	**Vetiver pond**		**Column A**	**Column B**
Temperature (°C)	26.9	26.8	25.0	-	40	40
pH	6.97	6.30	7.43	-	6 - 9	5.5 - 9
BOD_5 (mg/l)	76.2^a	67.6^a	30.1^b	<0.01	30	50
COD (mg/l)	137^a	118^a	49.1^b	<0.01	50	100
N_{tot} (mg/l)	26.9	15.5	6.10	0.11	15	30
P_{tot} (mg/l)	94.8^a	84.4^{ab}	51.1^c	<0.01	4	6
SS (mg/l)	306^a	247^{ab}	82.9^c	<0.01	50	100
Total *Coliforms* (MPN/100ml)	370 x10^6	315 x10^6	634,500	0.29	3,000	5,000

[abc] Data in a row within collection points without common superscript differ at $P < 0.01$

Figure 2. Effect of wastewater treatment model by biodigester and vetiver grass on BOD_5, COD, SS and total nitrogen compared against the Technical Regulation on Industrial Wastewater QCVN 24:2009/BTNMT



The rates of removal of BOD_5 and COD from the settling tank through the biodigester were 11.3% and 13.9%. The BOD_5 and COD concentrations of the effluent from the biodigester exceeded the QCVN 24:2009/BTNMT. After the vertivia pond, the concentrations of BOD_5 and COD were reduced by 59.8% and 60%, respectively ($P<0.01$). These parameters were close to the QCVN 24:2009/BTNMT standard. In principle, COD reflects the amount of organic matter oxygenated by chemical factors and BOD_5 is the amount of organic matter oxygenated by biological factors. Bwire et al (2011) reported that Vetiver grass tolerated leachate with high loading of COD up 14,000 mg/liter. Vetiver is very effective in removing COD. According to Tran Van Nhan et al (2002) wastewater is considered well treated by biologically effectively methods if the ratio of BOD_5 to COD is equal or more than 0.05. In this study, the ratio of BOD_5 to COD was 0.56 and thus should be subjected to further application of biological treatment methods.

The suspended solids (SS) were high in the settling tank (306 mg/l) and was reduced slightly in the biodigester (247 mg/l), but still exceeded the QCVN 24:2009/BTNMT standard), while in the vetiver pond, SS were reduced to 82.4 mg/l). The removal of SS from biodigester to the Vetiver pond was 73%. The SS is an important factor that affects development of aquatic organisms. The high concentration of SS was also caused by high fecal Coliform counts in the slaughterhouse as mentioned below.

Nitrogen and phosphorus are necessary for aquatic organisms, but their high concentration causes eutrophication and this can be toxic for aquatic animals (Meybeck et al 1996). From the settling tank through biodigester, total nitrogen (tot N) was reduced 42.3% and by 77.2% at the Vetiver pond. Total phosphorus (tot P) was reduced by 11 and 46% at these points. However, in the Vetiver pond, the wastewater still contained a high level of tot P. This could be explained that the removal of P and N by Vetiver grass increases with time, while the Vetiver pond continued to receive waste water from the slaughterhouse with very high amount of nitrogen and phosphorus from animal waste products. Vetiver grass has been shown to have a very high capacity of absorbing nitrogen (up to 10,000 kg N/ha/year) and phosphorus (up to 1,000 kg/ha/year); the capacity to use phosphorus was found to exceed that of other tropical and subtropical grasses (Wagner et al 2003).

Total Coliform bacteria in the settling tank and biodigester were very high ($370x10^6$, $315x10^6$ MPN/100ml, respectively) as compared to that in the Vetiver pond (634,500 MPN/100ml). The removal efficiency for total coliforms was 100%, but their amount was still very high (634,500 MPN/100ml) and far exceeded the QCVN 24:2009/BTNMT standard. The high level of Coliforms in the Vetiver pond reflected the high load received from the biodigester. These levels contrast with the report of Truong and Hart (2001) in which fecal coliforms declined with Vetiver treatment by 95% (from 500 to 23 MPN/100 ml). As far as we are aware our results are the first to demonstrate the use of Vetiver for treating wastewater from a slaughterhouse. It is possible that the area dedicated to the Vetiver was too small ($330m^2$) to permit greater reduction in the Coliform load. This aspect requires further research. The results of this study nevertheless are in agreement with the report of Boonsong and Chansiri (2008) that Vetiver has a good potential to treat wastewaters.

Conclusions

The model of a biodigester tank followed by *Vetiveria zizanioides L*. was suitable for treating wastewater from a slaughterhouse, reaching the standards of the Technical Regulation on Industrial Wastewater (QCVN 24:2009/BTNMT), in all criteria other than total P and total Coliforms.

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