

Pig Shed Wastewater Recycling Model for Smallholder Pig Production System of Northeast Himalayan Region

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Abstract

Pig farming requires large amount of water for effective management. Most of the water requirement is for cleaning of sheds and washing the animals. Therefore, effective recycling of this wastewater will lead to proper utilization of water and help mitigation of water scarcity. Present study was made to develop a model for effective recycling of wastewater for smallholder pig production system especially for the northeast Himalayan region. The recycling model unit consisted of five stages viz., physical screening, sedimentation unit and alum treatment, filtration tanks 1 and 2, followed by chlorination in the final storage tank. The water quality before and after the treatment were analysed to find out the efficacy of filtration process. Parameters analysed were pH, total dissolved solids (TDS), colour, turbidity, total plate count (TPC), coliform, faecal streptococci, 5-day Biological Oxygen Demand (BOD5) and dissolved oxygen (DO). Results from the present study indicated that the recycled water is fit for reuse in agriculture as well as cleaning of the pig sheds. The model was found to be an effective method for recycling of wastewater and preventing the environmental population from the pig sheds in the northeastern hill region.

Keywords: Northeast Himalaya, Pig Shed Wastewater, Small Holder Pig Production, Water Recycling

Introduction

Water is an essential part of the nutrition, thermoregulation and welfare requirements of animals and is used in livestock farms for consumption as well as cleaning of the shed (Tavares *et al.*, 2014). Pig farms require large amounts of water for effective management. The amount of water required for production of 1 kg of pork is approximately 6000 L/day (Freelancer, 2016). About 3 to 5 L is used for consumption and more than 90% accounts for cleaning purpose, both the animals and pig sheds. Therefore, recycling of this wastewater derived from washing will lead to proper utilization of water and help mitigation of water scarcity. Further, there is a growing concern about the environmental hazards from livestock enterprises, especially swine production systems (Zhang *et al.*, 2017). In many developing countries, majority of small holder pig farms directly release the pig shed wastes without any treatment which causes serious environmental concerns (Zhou *et al.*, 2013). Piggery wastewater contains high concentrations of nitrogen, phosphorus, and organic matter; thus, direct discharge can cause eutrophication of water bodies or soil contamination due to nitrate infiltration (Flotats *et al.*, 2009). The excessive accumulation of these minerals in nearby croplands can also affect the vegetation as well as the water source causing harmful effects to the human health. Thus, lack of proper treatment facilities together with mismanagement of pig wastes pose a threat to the environment (Zhang *et al.*, 2017).

North-eastern Himalayan region receives heavy rainfall during monsoon, however, there is water scarcity during winter season. People have to cover a long distance for fetching of water. In this scenario, recycling of wastewater from the pig farms can provide an important source of water for cleaning of the sheds and at the same time act as an effective wastewater management system before releasing it the environment. Therefore, the study was carried with an objective to develop a low-cost recycling model for wastewater from the pig farms.

Materials and Methods

Study Location

The study was carried out in Pig Breeding farm of the Institute. It is located at 24.58°N to 26.07°N latitude and 89.48°E to 92.51°E longitude with an altitude of 1010 meter above mean sea level. The annual rainfall varies from 17.50 mm to 409.74 mm with an average of 170.83 mm. The annual minimum, maximum and mean temperatures recorded were 13.06°C, 25.46°C and 19.26°C, respectively. The relative humidity varies from 65.00% to 81.70% with an average of 72.24%.

Management Practices of the Experimental Sheds

The wastewater treatment model was developed at ICAR-Research Complex for NEH region. The pigs were fed commercial mash *ad-libitum* as per standard recommendation, *i.e.*, pig starter feed containing 22% crude protein and 3300 ME/kg and 18% crude protein and 3200 ME/kg for growers. Drinking water was provided in a trough of 5 litres capacity. Two sheds were chosen for the present study; one shed consists of 9 pens and the other consists of 12 pens, and each pen housed 4-6 grower pigs. The floor was concrete and partially slotted above the drain. The feed waste as well as dung and other solid wastes was first removed using a shovel before flushing the shed. After this, the pig shed was flushed using a hose pipe using water force down the drain from the shed. Animals were washed and sty was cleaned daily from 8.30 am to 10 am in the morning. Around 2000L of water was utilised for washing the sheds and animals per day. The wastewater was collected and allowed to flow to the recycling model unit.

Pig Shed Wastewater Recycling Model Unit

The hilly terrains near the pig shed were selected for constructing the wastewater recycling unit and was established adjacent to the drainage of the shed. The recycling model unit consists of five stages as discussed below.

Physical Screening

The first stage of filtration involved physical straining of solid wastes from the pig shed wastewater by screens installed in the drain. Screens were installed at three places, two along the drain having pore size of 1.3 mm and 0.5 mm, respectively, followed by a third screen having a pore size of 0.3 mm in the intake pipe of the wastewater

recycling unit. The effluent after screening flowed to the sedimentation tank due to gravity facilitated by the terrain.

Sedimentation Unit

This stage aims to reduce any settle-able solids as well as sand and grit within the wastewater via settling and sedimentation processes. Wastewater after screening in the drain was allowed to flow to a three-chamber masonry tank/sedimentation tank, where the water flow rate gradually slows down, enabling the wastewater to sit in these settling tanks. During this time, most of the heavy solids fall to the bottom of the tank forming primary sludge thereby reducing the suspended solid content of the wastewater. The sedimentation tank was designed with an overflow so as to allow the movement of water with least impurities. The effluent was then collected in a storage tank of 3000L capacity, where it was subjected to alum (hydrated potassium aluminium sulphate) treatment. Two hundred gram of alum dissolved in one litre of tap water was added and stirred for fifteen minutes for uniform mixing.

Filtration Tank 1

The supernatant from the storage tank was subjected to slow sand filtration in the first filtration tank. The wastewater flowed to this tank through a pipe connected from the storage tank as it was placed at a lower terrain. The slow filtration tank was constructed with concrete walls and provided with a bed of dried gravel (20mm size) up to 0.5m height at the bottom followed by activated charcoal of 0.5m height. It was followed by 0.5m layers each of coarse sand and fine sand. A wire mesh (0.3mm) covered by a layer of gunny bags was provided at the top of this filtration tank. There was a continuous flow of water through this filtration tank. A pipe was connected to the bottom of this tank that allowed the flow of water to next tank.

Filtration Tank 2

The filtered water from the first filtration tank allowed flowing to the second filtration tank via a pipe facilitated by gravity. Initially, a bed of dried gravel (20mm size) was provided at the bottom followed by fine sand and covered with jute gunny bags at the top. Water was allowed to pass through this tank and the filtrate was allowed to flow and collected in the final storage tank.

Storage Tank

The filtrate from the second filtration tank was collected in the final storage tank. A tank of 3000L capacity was used for disinfection of treated wastewater. 100 ml of twelve per cent sodium hypochlorite was used in 500 litres of treated wastewater for disinfection. The level of chlorine in the treated wastewater was maintained at 0.2 ppm (parts per million) of residual chlorine for the proper chlorination.

The recycled water from the final storage tank was utilised for cleaning of the sheds and agricultural use. Water was pumped to the shed using an electric motor that was connected to four pig sheds where it was used for cleaning purpose.

Analysis of Water Quality

The water quality before and after the treatment were analysed to find out the efficacy of filtration process. One litre each of the raw wastewater before any treatment and final treated water after chlorination (reclaimed water) was collected in a sterile container for the estimation of physical and chemical parameters. Samples were kept under refrigeration at 4°C until analysis. The usual feeding and management practices prevailing in the farm were followed throughout the treatment period. The quality of water was assessed as per standards (IS 3025) prescribed by the Central Pollution Control Board, for reusing in the pig sty. The parameters analysed were pH, total dissolved solids (TDS), colour, turbidity, total plate count (TPC), coliform, faecal streptococci, 5-day Biological Oxygen Demand (BOD₅) and dissolved oxygen (DO). The water samples were sent to Erec India Research Laboratory (NABL certified lab), Guwahati, Assam for testing and results were plotted.

Results and Discussion

Setting up of wastewater treatment units have been very costly which made the farmers prefer getting new water for use rather than setting up a recycling unit, but this current model unit is very simple and it is also cost effective enough for a small farm to afford it for recycling the water for reuse. The current recycling model unit consisted of five stages *viz.*, physical screening, sedimentation unit and alum treatment, filtration tanks 1 and 2, followed by chlorination in the final storage tank. This model is also cost effective since there was no involvement of energy source except in the final step where electric motor was used for pumping the water from the final storage tank to the pig shed for cleaning purpose. Radhakrishnan *et al.* (2019) have reported similar type of filtration model in their study, however, their model consisted of only one filtration unit unlike the present model where two filtration units have been included. They have also reported more use of electric motor than the present study, thus, the present filtration model was found to be more cost effective in terms of energy utilisation. Various other researchers have also reported other methods of wastewater treatment. Olanrewaju and Olowoyeye (2018) have also described a design for wastewater treatment plant for piggery farms from locally available plastic materials which consist of bio-filters such as coarse, fine sand and activated carbon. Their model consisted of three components, i.e., storage tank/facultative lagoon, filtration tank and a multi-media filter. Velho *et al.* (2012) also reported the treatment of piggery wastewater by using stabilization reservoirs which were fed with treated piggery wastewater taken from the maturation pond of the tertiary stabilization ponds unlike the present day, where no pre-treatment has been applied. The water quality at the initial and final points of the treatment were analysed to find out the efficacy of the recycling unit. The results of the water quality analysis in different treatments are depicted in Table 1.

Table 1: Water quality at different treatment points

S. No.	Test parameters	Requirement/ Maximum desirable limit (As per CPCB guidelines)	Before treatment (pig shed wastewater)	After treatment (Reclaimed water)
1.	pH	5.5- 9.0	7.77	7.01
2.	TDS, mg/l	500	400	115
3.	Colour, Hazen	5	5	1
4.	Turbidity (NTU)	1	0.05	0.05
5.	TPC (37°C)	----	28.5	3.25
6.	Coliform	----	present	present
7.	Faecal streptococci	----	absent	absent
8.	BOD ₅ , mg/l	30	509.09	218.18
9.	DO, mg/l	3.0-9.0	0	1.6

In the present study, the pH of the effluent was found to be 7.77 before treatment which reduced to 7.01 after treatment. The pH of the recycled water in the present study was found to be within the range reported by Tokhun *et al.* (2010) and Radhakrishnan *et al.* (2019) for treated water from pig shed wastewater. The total dissolved solids (TDS) was found to be 400 mg/l for raw wastewater and 115 mg/l after treatment which was similar to the report of Tokhun *et al.* (2010) for release to the environment after treatment and he reported that it was safe for agricultural use. On the contrary, Radhakrishnan *et al.* (2019) reported much higher TDS in wastewater after treatment than the present finding. The mean colour value in Hazen unit was found to be within the limit specified by Indian standards which corroborates with the report of Radhakrishnan *et al.* (2019). The total plate count (TPC) reduced from 28.5 in raw wastewater to 3.25 in the reclaimed water. In addition, the reclaimed water was found to contain coliform but no faecal streptococci. The turbidity of the recycled wastewater was found to be 0.05 NTU and BOD₅ was 218.18 mg/l after filtration. The present finding of Biological Oxygen Demand was found to be higher than the reports of Tokhun *et al.* (2010) and Radhakrishnan *et al.* (2019). Dissolved Oxygen of the pig shed wastewater was found to increase to 1.6 mg/l after treatment which was similar with the findings of Velho *et al.* (2012) for treated piggery wastes in their study. With respect to all the parameters studied, the recycled water was found to be within permissible limits as per Indian standards for water quality for cleaning and effluents and can be recommended for reuse in the pig farms.

In the present study, two thousand litres of wastewater could be reclaimed from three thousand litres of pig farm wastewater after different treatments for reuse in the shed as well as agricultural irrigation. Radhakrishnan *et al.* (2019) also reported that four hundred litres of wastewater could be reclaimed from five hundred litres of pig farm wastewater and was supported by Zhang and Lei (1998) who found that 44 per cent of the water can be reclaimed

from the original wastewater.

Conclusion

Evaluation of the reclaimed water from the pig farm wastewater in the present study indicated that it was fit for reuse in agriculture as well as cleaning of the pig sheds. The recycling model was found to be an effective method for rendering the reuse of wastewater whilst preventing the pollution of the environment from piggery wastes. Hence, development of this low-cost water treatment system for small holder pig production systems would be a solution for water scarcity areas as a water conservation practice.

Conflict of Interests

There is no conflict of interest.

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