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Study on removal of organic pollutants using the Expanded Granular Sludge Bed Reactor

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ABSTRACT

Slaughterhouse wastewater includes various and large concentrations of organic matter, which contributes paunch, feces, oil, fat, and lard, undigested foods, blood, suspended content, urine, loose meat, soluble proteins, excrement, compost, grit and colloidal particles. The aim of this analysis is to look at the viability of using EGSBR to treat slaughterhouse wastewater, as well as the effect of HRT on the organic removal yield. The experimental model was run with six average COD ranges of 1752, 1744, 1820, 2264, 2768, and 3176 mg/l in the influent. With a HRT of 4 days and an OLR of 0.081Kg COD/m3.day, the maximum effective organic removal was 90.17 percent. The experiment was carried out at a mesophilic temperature range to ensure that the organism grew efficiently. Scanning microscopy was used to examine the slaughterhouse wastewater at varying magnifications.

Key words : *Chemical oxidation demand, Expanded granular sludge bed reactor, Hydraulic retention time, Organic loading rate, Slaughter house wastewater*

Introduction

The wastewater from the slaughterhouse is a combination of production water from both the slaughtering line and the gut cleaning, resulting in a wide range of organic matter concentrations. Organic matter is the largest pollutant of slaughterhouse effluents. Paunch, vomit, fat and lard, oil, undigested beef, blood, suspended content, urine, loose meat, soluble proteins, excrement, compost, grit, and colloidal particles all contribute to the organic load in these effluents Asselin *et al.* (2008); Tezcan *et al.* (2009). In India, there are approximately 4,000 licensed slaughterhouses with local authorities and over 25,000 unregistered premises where animals are slaughtered to meet domestic market demands. About 45-50 percent of the animals can be transformed into food (MEAT). Leather, soaps, candles (tallow), and adhesives are made from about 15 percent waste and the remaining 40-45 percent of the animal. Paunch, vomit, oil, butter, and lard, undigested meats, blood, suspended waste, urine, loose meat, soluble proteins, excrement, compost, grit, and colloidal particles all contribute to the biological load in these effluents (Bazrafshan *et al.*, 2007). Because of the different contaminants loads derived from the form and amount of animals slaughtered, which fluctuate in the meat industry, slaughter house wastewater is usually measured using bulk criteria (Bustillo-Lecompte and Mehrvar, 2015). Various processes, such as aerobic and anaerobic biological systems, are used to treat slaughterhouse wastewater (Masse and Masse (2005); Torkian *et al.*, (2003); Manjunath *et al.*, (2000); Palatsi *et al.*, (2011)) and hybrid systems (Tezcan *et al.* (2009)) have been intensively studied. Sugito *et al.*, (2016) determined

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the effect of BOD concentrate influent to remove pollutant load in wastewater of a chicken slaughterhouse. Stets *et al.* (2016) studied that Microbial community and performance of slaughterhouse wastewater treatment filters. Dipti Giri *et al.* (2015) studied that Anaerobic fixed film fixed bed reactor with special media is used to process slaughterhouse wastewater. The efficiency of the upflow flat film fixed bed reactor was assessed at two separate HRTs of one and two days at various organic loading rates ranging from 0.8 to 3.2 kg COD/m^3/day. At one day HRT, COD and BOD declines ranged from 85.4 to 91.8 percent and 87.4 to 93.2 percent, respectively, while at two days HRT, they ranged from 87.0 to 93.5 percent and 89.2 to 95.8%, respectively. Gajender *et al.* (2013) determined that Anaerobic Hybrid Reactor Packed with Special Floating Media for Efficient Treatment of Slaughter House Wastewater The high energy consumption required for aeration, as well as the high sludge output, restrict aerobic treatment methods. Organics such as Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Nitrogen and Phosphorus, filtered blood, fat, grease, fats, and a considerable number of suspended solids are all present in slaughterhouse wastewater. Abattoirs use a lot of water in their manufacturing processes, which results in a lot of pollution. Masse and Masse, (2000) determined that Characterization of Wastewater from Eastern Canadian Hog Slaughterhouses and Evaluation of In-Plant Wastewater Treatment Systems Because of the growing environmental crisis, adequate management of this wastewater is needed prior to discharge. Ameen Sarairah and Almad Jamrah (2008) studied Characterization and Assessment of Treatability of Wastewater Generated in Amman Slaughterhouse. Ping F. Wu and Gauri (2011) examined that Characterization of provincial inspected slaughterhouse wastewater.

Furthermore, the anaerobic treatment of slaughterhouse wastewater is often slowed or hampered by the deposition of suspended solids and floating fats in the reactor, resulting in reduced methanogenic operation and biomass wash-out. Furthermore, anaerobic therapy is said to be vulnerable to elevated organic loading temperatures, which is a significant drawback (Cuetos *et al.,* 2008, Torkian *et al.,* 2003). Even though biological processes are efficient and cost-effective, they both require a long hydraulic retention period and significant reactor volumes, as well as a high biomass concentration and sludge loss control to prevent sludge wash-out. Complete suspended solids (TSS), colloids, and fats are commonly removed from slaughterhouse wastewaters using physico-chemical processes such as dissolved air flotation (DAF) and coagulation–flocculation units (Asselin *et al.,* 2008). It is important to keep the SRT above the doubling time of methanogens in order to hold a sufficient amount of methanogens in the biofilm. As a result, granular sludge with a proper amount of methanogenic bacteria forms. To ensure stable activity, SRT should be held 2 to 3 times longer than the bacterial doubling time. Sludge retention time in anaerobic bioreactors has been studied in the literature (Syutsubo *et al.*, 1997; de la Rubia *et al.*, 2006). However, there are almost no reported data on SRT in the EGSB reactor system for low-strength wastewater treatment. Inoculation of granular sludge was found to be successful in reducing the reactor start-up time needed to sustain a proper SRT (Syutsubo *et al.*, 1997; Syutsubo *et al.*, 1998; Syutsubo *et al.,* 2008). A lab-scale EGSB reactor was fed with low-strength wastewater (0.6-0.8 g COD/l) at 20 °C to gather basic information on granulation in this system, and examined the changes in physical and microbial properties of the retained sludge. It is difficult to apply the preservation of granular sludge in EGSB reactor for low intensity wastewater treatment at 20°C in this method, so effluent recirculation was used to improve substrate-biofilm interaction. An effort has been made in this study to investigate the production efficiency of EGSBR technologies for the removal of soluble organic matter from slaughterhouse wastewater.

Materials and Methods

The aim of this study was to assess the efficiency of an anaerobic extended granular sludge bed reactor for removing organics from slaughter wastewater. Figure 1 shows a schematic diagram of an EGSB reactor. Plexiglass was used to construct the experimental laboratory model. A column portion of 9.54 liters and a gas-solid separators (GSS) portion of 4.93 liters make up the reactor. The inside diameter and height of the cylinder column section are 121.5 cm and 10 cm, respectively. The reactor's operating volume, including GSS, is 14.47 liters. The flow rate was regulated with a variable speed peristaltic pump (PP-10). The physical characteristics of the experimental setup are shown in the Table 1.

Table 1. Physical features and process parameters of experimental model

Specification	Dimensions
Total height of the reactor	152.5cm
Column portion	121.5cm
Diameter of the cylinder column	10cm
Triangle portion	9cm
Total liquid volume	14.47l
Peristaltic pump	PP – 10 model
Free board	11cm

Results and Discussion

The start-up cycle is described as the time it takes to achieve stable activity. This is a critical step in ensuring that the AEGSB and other anaerobic reactors operate at the intended organic loading rate (OLR). From 55 to 60 days, the reactor reached a stable state, with a COD removal efficiency of 76 percent.

During the experimental study cycle, real-time slaughterhouse wastewater was used. Using a peristaltic pump, the AEGSB reactor was continuously pumped with six sets of average COD loading of 1752, 1744, 1820, 2264, 2768, and 3176 mg/l at flow rates of 0.930, 0.744, 0.558, 0.372, and 0.186 Kg COD/m^3.day. During the start-up stage, the reactor reached a steady state with a maximum COD removal efficiency of 91.14 percent and a biogas conversion of 0.0034 m^3 of biogas per kg COD removed. The bacterial degradation kinetics is affected by the mesophilic range temperature, allowing for an increase in the percentage of organic matter removed.

Figure 2 shows the output characteristics of HRT in terms of percentage COD elimination efficiency over time. At room temperature, the EGSB reactor

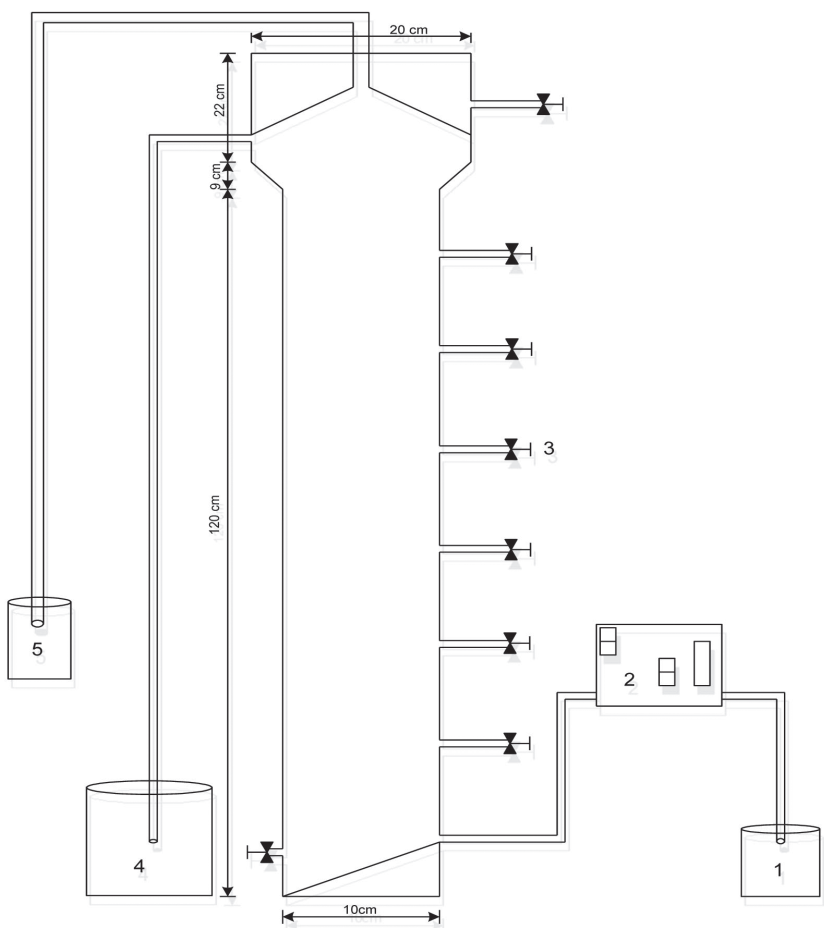

Fig. 1. Schematic of Anaerobic Expanded Granular sludge bed reactor

1. Influent tank
2. Peristaltic Pump
3. Sampling Ports
4. Effluent tank
5. Bio gas collecting jar

performed well between 240 and 370 degrees Celsius. Three sets of analyses were performed in a real-time slaughterhouse wastewater with an average influent COD of 1752, 1744, and 1820 mg/l without the inclusion of a co-substrate. For a HRT of 8 days, the overall COD elimination was 84.32 percent without the inclusion of co-substrate. Since the removal quality was not up to par, it was decided to add Potato Dextrose Aga as a co-substrate for another three sets of experiments. With a HRT of 4 days and an influent COD of 3176 mg/l, the maximum COD elimination was 90.17 percent. The maximal conversion was obtained 905 ml/minute at an OLR of 0.040Kg COD/m^3.day with a HRT of 8 days, as seen in Figure 2. The conversion fluctuated at first due to the organisms' malnutrition as well as the pH and environmental conditions inside the reactor. During the experimental study cycle, real-time slaughterhouse wastewater was used. Using a peristaltic pump, the EGSB reactor was continuously pumped with three sets of average COD loading of 1752, 1744, and 1820 mg/l and flow rates of 15.120, 12.240, 9.360, 6.480, and 3.600 l/day. With HRT of 2.00, 3.00, 4.00, 6.00, and 8.00 days, the influent COD of the slaughterhouse wastewater ranged from 1520 to 2080 mg/l. The overall performance of the EGSB reactor was tested between the retention time and COD removal efficiency at room temperature (240 to 370C). With an influent COD of 1850 mg/l and a HRT of 8.00 days, the maximum COD elimination was reached at 84.32 percent. After the addition of glucose as a co-substrate the maximum removal efficiency was attained at 90.17 with a HRT of 8 days. The higher efficiency of oxidation in the reactor is supported by the high proportion of organics in suspended state. The conversion was not gradual because it was fluctuating, and it happened as a result of the organisms' malnutrition as well as the pH and environmental conditions within the reactor.

SEM Image of the slaughter effluent

In a scanning Electron Microscopy experiment, the sample was examined at different magnifications (Figure 6). The majority of the research centered on microbial population distribution in the ABR, and the findings revealed certain disparities in microbial population distribution under various experimental conditions (Sallis and Uyanik, 2003). The sludge was taken for SEM analysis in this report. Figure 3 shows an example of the SEM review.

Conclusion

The slaughterhouse wastewater was treated with high efficiency in a mesophilic range using an expanded granular sludge bed reactor. With the addition of co-substrate, the highest COD removal efficiency was reached at 90.17 percent with a HRT of 4 days and an influent COD of 3176 mg/l at an OLR of 0.081Kg COD/ m^3.days. The most common technology was the extended granular sludge bed bioreactor, which uses a fluidized bed to allow for increased organic load and cell retention times, resulting in higher treatment efficiencies and renewable energy. Finally, the AEGSB reactor seeded with granular sludge exhibits good process efficiency for the treatment of slaughter house wastewater in the mesophilic range, according to the findings of this report. The most important element in achieving high productivity was the temperature. Bacillus haikouensis was identified as the microorganism responsible for decomposition of organic matter.

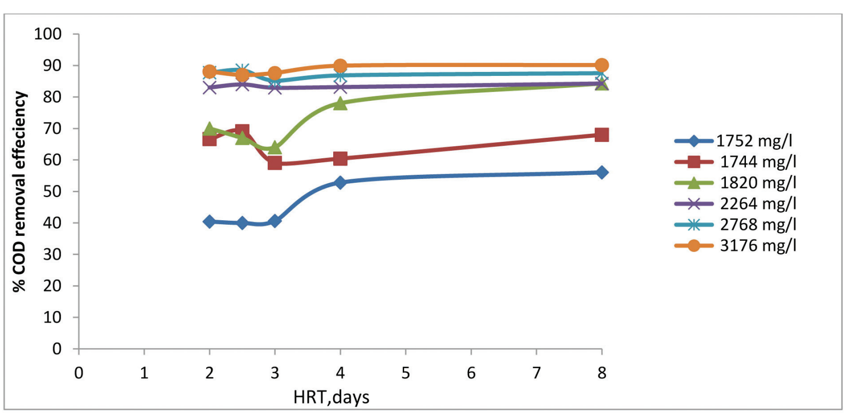

Fig. 2. Profile of % COD reduction in EGSBR for treating Slaughterhouse wastewater

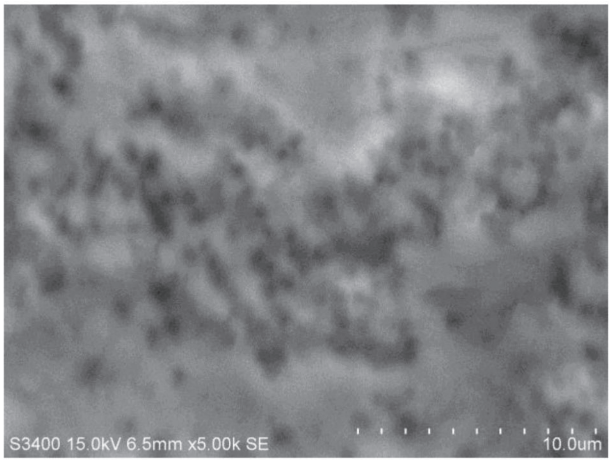

Fig. 3. SEM Image of the slaughter effluent

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