Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.7, No.6, 2015

Suspended Growth Bioreactor and Their Potential Application for Slaughterhouse Wastewater Treatment

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Abstract
Wastewater of slaughterhouse process and removal performance for biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) have studied in a suspended growth reactor (SGR) and arranged with activated sludge plus biofringe (BF + AS) and with only activated sludge (AS) reactor. The volumetric capacity of laboratory reactor is 10 liter (L), maintains the pH level at 7.0 ± 0.5 and placed at room temperature (27±3 oC). Wastewater of slaughterhouse commonly contains a large amount of blood and organic pollution, which causes contaminant loading. Therefore, the biological treatment might be effective option with success. Thus, the percentage removal of AS with BF is higher than AS treatment due to aerobic and anaerobic circumstance under AS with BF which occurred with parallel treatment while the aerobic condition is occurred with AS treatment. Bio-reactor is arranged with AS + BF significantly removal BOD, and COD.
Keywords: Biochemical oxygen demand (BOD_5), Chemical oxygen demand (COD), Suspended growth, Biological treatment, Biofringe, Slaughterhouse wastewater.

1. Introduction

Disposal of slaughterhouse wastewater is an important issue for many countries in the world, including Iraq. Due to continuous market demand, a slaughterhouse processing is increasingly growing continuously as well, generating a large amount of pollutant in the ecosystem (Porntip *et al*., 2006; Tay *et al*., 2006). Slaughterhouse wastewater contents high concentrations of organic pollutant loading like BOD_5, COD nutrients due to a large amount of blood and residual waste which is easily biodegradable (Wang *et al.,* 2005). If such wastewater is not treated proper a potentially contaminated many natural sources like soil, surface and ground water.

Chemically, treated wastewater generates a high contamination and sludge, in addition to a complex compound effluents. Activated sludge process is the most common method of biological treatment. The strict regulations of effluent discharge, conventional activated sludge alone are unable to remove the pollutants of wastewater in desirable limits (Aziz *et al*., 2011).

Biological process involves a removal of non-settleable colloidal solids, toxic organic compounds and reducing the concentration of inorganic compounds. Therefore, such process is one of the most important parts of the slaughterhouse wastewater treatment system (Rosso *et al*., 2011).

Attached growth, has a significant impact on the stability of the process. Therefore, it has been tested with a variety of different materials in order to choose the best material. However, the biofilm mechanism for wastewater treatments is well established. The growth of bacteria in the biofilm systems provides several advantages compared with conventional systems. Such advantages are convenient sludge retention time, prevention of biomass washout from the system, and better process stability in terms of withstanding shock loading or short-term inhibitory effects (Bathe *et al*., 2010).

2. Methods

2.1. Slaughterhouse wastewater sampling and characterization

Wastewater samples were collected from the small settling tank. Slaughterhouse wastewater is filled in the plastic container which volumetric size 25 L, and it was then transported to the laboratory and stored in the cooling laboratory storage place at $4C^o$ prior to use in experiments to minimize biological and chemical reactions (APHA, 2005). After storing the sample, get out from the refrigerator for analysis and experimentation purpose, it was kept in a room temperature at (24 – 26) C^o around 2 hours for conditioning before analysis was carried out. The samples were thoroughly agitated for re–suspended of possible settling solid before any test was conducted.

2.2. Activated sludge (AS) sampling and characterization

The activated sludge (AS) used in this experiment was taken before entering the aeration tank from clarified. When analyses AS sample and before using it in experimentation, the sample was aerated. Then sample was analysed for pH, COD and mixed liquor suspended solid (MLSS), and obtained pH range between 7.02-7.27, COD=7820 mg/L and mixed liquor suspended solid (MLSS)=34794 mg/L.

2.3. Design of Experiment

As shown in Fig. 1 the experimental arrangement of AS+BF and only AS reactors, this system contains two rectangle reactor size 0.17m x 0.1m x 0.7m. It was made from Plexiglas material, and the capacity was 10 L liquid volume.

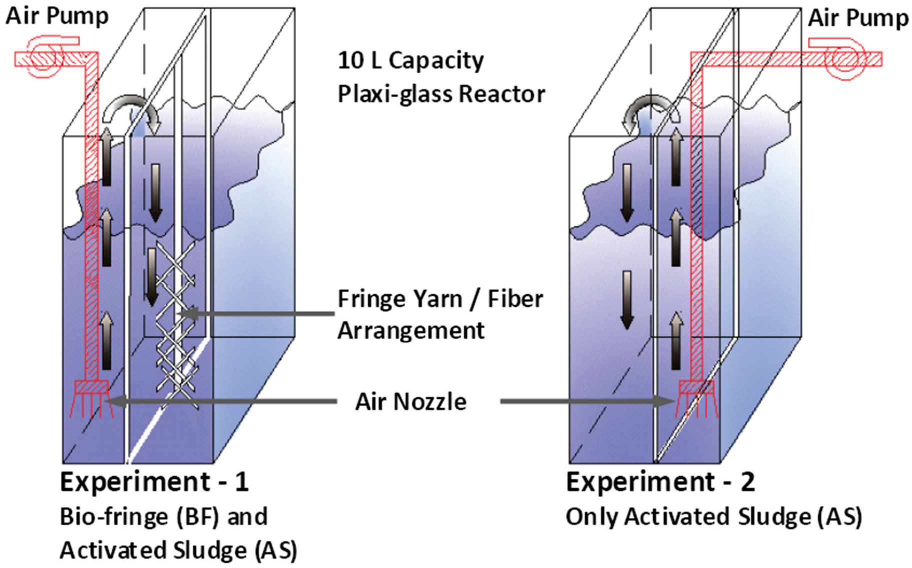

Figure 1. Schematic Diagram of Experiments Arrangement

Principle of operation of sequencing batch reactor (SBR) has been used in this study. The SBR principle has arranged as follows: first seeded with activated sludge, secondly the reactor has fed with the collected slaughterhouse wastewater to maintain MLSS in the range of 1000-1200 mg/L and pH adjusts between 6.5-7.5. The design experiment was showed below:

Table 1: Experiment Design for Treated Slaughterhouse Wastewater

Parameters	**Dimension / unit**
pH	6.5-7.5
Aerator process	21 hours
Pumping rate	20 L/min
MLSS	1200mg/L
F/M	0.21
BOD_5	610 mg/L
Feeding volume	4 L

The feeding volume was calculated:

$$\frac{F}{M} = \frac{\text{BOD X Feeding Volume}}{\text{MLSS X V}}$$

$$0.21 = \frac{\text{610 X Feeding Volume}}{\text{1200 X 10}}$$

Feeding volume = 3.95 L ≈ 4 L

2.4. Analytical methods

Wastewater of slaughterhouse analyses were carried out according to the Standard Method for the Examination of the Water and Wastewater (APHA, 2005) like the Method 5210B for BOD_5 and reactor digestion method (Method 8000) by using a HACH DR/2500 spectrometer. The removal efficiency of the pollutant was calculated by using the following equation:

$$\text{Removal Percentage (\%)} = \frac{(C_i - C_e)}{C_i} \times 100\ \%$$

Where: Ci is the influent concentration of pollutant wastewater,

Ce is the effluent concentration of the pollutant wastewater.

3. Result and Discussion

3.1. The characterization of slaughterhouse wastewater

As shown in Table 2 the parameters of slaughterhouse wastewater has taken during the month of March 2012.

Table 2: Slaughterhouse wastewater parameters

Parameter	Unit	Range (Max - Min)	Mean ± St.Dev[1]	Standard B[2]
pH	N/A	7.10 - 6.82	6.93±0.054	5.5 – 9.0
COD	mg/L	963 - 833	914.33±43.81	100
BOD_5	mg/L	653 - 486.1	609.42±56.83	50

[1] Mean ± Standard Deviation

[2] Source: Department of Environment, Ministry of Science, Technology and Environment, Environmental Quality Report, 1997, Malaysia.

As a presented in Table 2 the pH is ranging between 7.10 and 6.82, which refers to slightly acidic to neutral. The results of pH value are due to small amount of total suspended solid (TSS) and colloidal material (Manahan, 2005; Porntip et al., 2006). The high BOD_5/COD ratio was detected 66%. Which indicates a high degree of biodegradation from wastewater. For wastewater of slaughterhouse has presented between 15% and 82%, which depend on the amount of dissolved materials (Rubio *et al*., 2002).

High BOD_5/COD ratio (66%) which caused many problems, like eutrophication and oxygen depletion in water body (Porntip *et al.,* 2006). Besides, it has noted that the average was around 66%, which is a very important indicator for applied technology in this current research, though the rising of this index indicates better performance of the reactor (Rubio *et al*., 2002). Ammonia nitrogen has affected on BOD_5 in wastewater during transformation NH_3 into NO_3- due to its biologic oxidation process by nitrifying bacteria, which might have a significant dissolved oxygen requirement (Wang et al., 2005). Such results have agreed with Aizz, 2011 and Roye *et al*. ,1980.

3.2. Activated sludge (AS) reactor

The percentage removal during the AS reactor experiment, from an initial concentration of COD and BOD_5 are 84.3%, 98.8 % respectively (Fig 2).

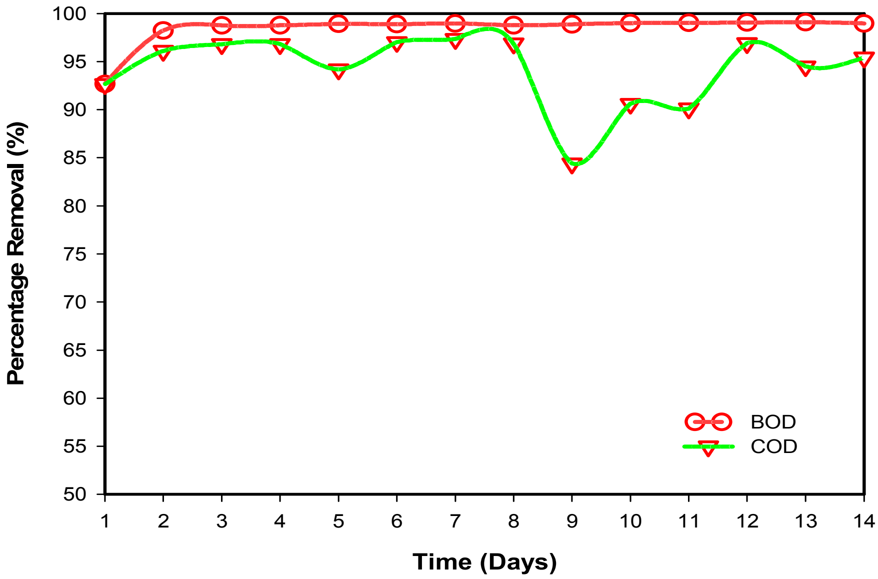

Figure 2 Removal Percentage of COD and BOD_5

The BOD_5 has shown the highest percentage of removal followed by, COD. The COD concentration has reduced from 610mg/L to 6.4mg/L the decreasing of concentration is due to long aeration time in the reactor (Manahan, 2005).

3.3. Activated Sludge Including Biofringe (BF+AS) Reactor Performance

The percentage removal during the BF+AS reactor experiment, from initial concentration of COD, BOD_5, were 97.5%, 99.1% respectively (Fig 3).

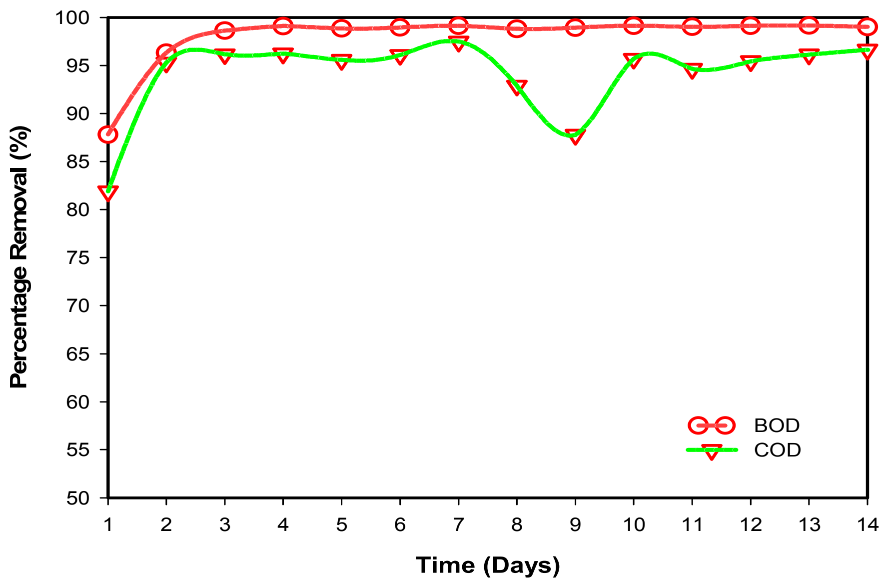

Figure 3 Removal Percentage of BOD_5 and COD

Figure 3 shows the highest removal efficiency for BOD_5 followed by COD. The organic matter was utilized by microbes through the biosynthesis of new microorganisms and oxidation process (Fontenot et al., 2007). BOD_5 removal was 99%. At the same time, COD has decreased. According to Bathe et al., (2010), slaughterhouse wastewater was containing high amounts of carbonaceous compounds. Removal processes were designed for aerobic carbon removal (Fontenot et al., 2007). Nitrification and denitrification process affected on BOD_5 due to biologic oxidation process. Since this process occurred in a good condition due to the aerobic and anaerobic zone in the same system. Therefore, the react his shown a higher removal for BOD (Hasar *et al.,* 2009).

3.4. Performance Between Two Treatment Systems

The comparison between two reactor performance or removing selected pollutants from seafood wastewater presented. Besides, The AS with BF systems show higher performance in less time compare to the AS reactor for the percentage removal of BOD and COD.

Table 3 Summary of comparison between AS with BF and only AS treatment.

Parameter	Mix. Percent removal AS + BF	Day On achievement	Mix. Percent removal AS	Day On achievement
COD (mg/L)	97.5 %	(7 th day)	97.3 %	(7 th day)
BOD (mg/L)	99.1 %	(4 th day)	98 %	(12 th day)

4. Conclusion

Slaughterhouse wastewater pollutant level dependes on many parameters, such as type of operations (like cleaning and butchering), type of the slaughterhouse, and amount of the slaughterhouse. Slaughterhouse wastewater consists of a higher organic pollution loading as well as a large part of food waste, which is easily biodegradable. The influence of fiber biomass carrier BF with activated sludge AS has compared with conventional activated sludge systems by using suspended growth bioreactors. The performance of AS with BF reactor efficiently removed BOD,COD removal due to supply both attach and suspended growth which support aerobic and anaerobic conditions in the AS with BF systems.

Acknowledgement

The authors gratefully acknowledge the supports provided by University of Kufa, Kufa, Najaf, Iraq, and Universiti Sains Malaysia, Malaysia. Sincere thanks is also the Earthcare Environment Technology Sdn, Bhd. (629331-K), Malaysia for their technical support.

Reference

Aziz, H. A., Ling, T. J., Haque, A. A. M., Umar, M. and Adlan M. N. (2011). Leachate Treatment by Swim-Bed Bio Fringe Technology, Desalination, 276 (2011): 278 - 286, doi:10.1016/j.desal.2011.03.063

APHA - American Public Health Association, American water works, water environment federation. (2005). Standard Methods for the Examination of Water and Wastewater, 21st ed., Washington, DC, USA.

Bathe, S., Sudarno, U., Winter J. and Gallert, C. (2010). Nitrification in fixed-bed reactors treating saline wastewater, Appl Microbial Biotechnology, 85(6):2301–2304. doi:10.1007/s00253-009-2301-4.

Banashri S. and Annachhatre, A. P. (2007). Partial nitrification-operational parameters and microorganisms involved, Reviews in Environmental Science and Biotechnology, 6(4):285-313,doi:10.1007/s11157-006-9116-x

Demirer, G. N. and Chen, S. (2005). Two-phase anaerobic digestion of unscreened dairy manure, Journal of Process Biochemistry, 11(40):3542-3549, doi:10.1016/j.procbio.2005.03.062

Fontenot, Q., Bonvillain, C, Kilgen, M, and Boopathy, R. (2007). Effects of temperature, salinity, and carbon nitrogen ratio on sequencing batch reactor treating shrimp aquaculture wastewater. Journal of Bioresource Technology, 9(98):1700–1703.

Hasar, H., Unsal, S. A., Ipek, U., Karatas, S., Cinar, O., Yaman, C., and Kinac, C. (2009). Stripping, flocculation, membrane, bioreactor, reverse osmosis treatment of municipal landfill, Journal of Hazardous Materials, (1-3)171:309-317, doi: 10.1016/j.jhazmat.2009.06.003

Manahan, S. E. (2005). Environmental chemistry, Edition 8, CRC Press LLC, United States of America.

Porntip Ch., Jansongkod K, Anthony P, Christelle W. (2006). Benefits of MBR in seafood wastewater treatment and water reuse: study case in Southern part of Thailand, Desalination, 3(200):712-714, doi: 10.1016/j.desal.2006.03.509

Rosso, D., Lothman, S. E., Jeung, M. K., Pitt, P., Gellner, W. J., Stone, A. L. and Howard, D. (2011).

Oxygen transfer and uptake, nutrient removal, and energy footprint of parallel full-scale IFAS and activated sludge processes, Water Research, 45(18): 5987-5996, doi: 10.1016/j.watres.2011.08.060

Roy, K. H. and Raj, B. (2010). Effect of carbon to nitrogen (C:N) ratio on nitrogen removal from shrimp production water using sequencing batch reactor, Ind. Microbial Biotechnology, 10(37):1105–1110, PubMed: 20835881

Rubio, J; Souza, M. L., and Smith, R. W. (2002). Overview of Flotation as a Wastewater Treatment Technique. Minerals Eng., 3(15):139-155, doi: 10.1016/S0892-6875(01)00216-3

Tay, J. H., Show, K-Y., Hung, Y-T. (2006). Seafood Processing Wastewater Treatment in Waste Treatment in the Food Processing Industry, In: Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo, Constantine Yapijakis (eds.)., Waste treatment in the food processing industry, Taylor &Francis, Boca Raton, Florida, pp.29-66.

Wang, D., Huang, X., and Yuan, Q. (2005). Nitrogen and carbon removals from processing wastewater by an anoxic /aerobic membrane bioreactor, Process Biochemistry, 5(40):1733–1739.

Wu, G, Guan, Y, Zhan, X. (2008). Effect of salinity on the activity, settling and microbial community of activated sludge in sequencing reactors treating synthetic saline wastewater, Water Sci Technol, 58(2):351–358.

BIOGRAP

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