ELSEVIER

Desalination 222 (2008) 146–150

DESALINATION

www.elsevier.com/locate/desal

# High effective to remove nitrogen process in abattoir wastewater treatment

Ye Shengquan[a,b]*, Guo Siyuan[a], Wu Hui[a]

[a]*College of Light Industry and Food, South China University of Technology, Guangzhou 510640, China*
[b]*College of Food Science and Technology, Guangdong Ocean University, P.O. Box 302, Hai Ning Road, No. 67, Xiashan, Zhanjiang, Guangdong 524005, China*
*Tel. +86 759 2669688; Fax +86 759 2106816; email: yeshengq@163.com, yesq@gdou.edu.cn*

Received 10 December 2006; accepted 3 January 2007

**Abstract**

A new method of membrane sequencing batch reactor (MSBR) process in abattoir wastewater treatment is given. With nitrification and denitrification bacterium, it is effective to remove nitrogen. At the same time, the whole system can be autocontrolled and do not add any drugs or bacteriums again after it runs.

The experimental results show that the quality of abattoir wastewater can attain to the national requirements of the first grade of integrated wastewater discharge standard (GB 8978 - 1996). About 45–65% of the solids or approximately 30–40% of the biological oxygen demand (BOD) load can be separated by pre-treatment screening and sedimentation. MSBR systems are lagoon, membrane sequencing batch reactor (MSBR), biological treatment and membrane filter (MF) processes. Abattoir wastewater is well suited to MSBR treatment because it is high in organic compounds. Typical reductions of up to 98% BOD, 93% SS, 98% COD, 95% $NH_3$-N and 95% lipin are approved. Wastewater in abattoirs can be reduced by membrane filtration which can produce recyclable water. Total COD can be reduced below 100 mg/L.

The performances of both sequencing batch reactor (SBR) process and membrane sequencing batch reactor (MSBR) process operating simultaneously under the same condition to treat abattoir wastewater were examined. Conventional SBR treatment average COD removal efficiencies are of 85–90%. MSBR average COD removal efficiencies are of 98%. The result show that MSBR process has better treatment effect and is easier to operate and manage compared with SBR process. MSBR is a new method of abattoir wastewater treatment and has a broad prospects.

*Keywords:* Abattoir; Wastewater; Treatment; Membrane sequencing batch reactor

*Corresponding author.

*Presented at the conference on Desalination and the Environment. Sponsored by the European Desalination Society and Center for Research and Technology Hellas (CERTH), Sani Resort, Halkidiki, Greece, April 22–25, 2007.*

0011-9164/06/$– See front matter 
doi:10.1016/j.desal.0000.00.000

## 1. Introduction

The common methods for disposal of blood by meat processors are rendering, land application, composting and transfer to a wastewater treatment plant. In the United States (US), the federal government provides guidance while state governments regulate composting and land application. Rendering is defined as the process of breaking, through heat application, blood, meat pieces and other animal byproducts to useful components. Rendering plants are closing due to the reduction of feedstock supply and user demand. Rendering plants are now starting charging a disposal fee for blood. Due to this, rendering is now less attractive and less economical. Composting and land application are alternatives for rendering [1].

Composting is a biological decomposition of organic matter (blood or other animal or vegetable products) and can be accelerated by providing correct temperature, moisture content, density and feedstock mixture. The resulting product is a nutrient-rich material that can be used as fertilizer or soil conditioner. Composting methods are: open-air plies and windrows, to self-contained drums, vessels, and anaerobic digesters. Only a few commercial composting units are accepting blood. The composting of animal products (except manure) requires higher level permit and rigorous standards than composting of municipal yard waste. McGill composting (Harrells, North Carolina, USA) estimated a cost of US$25/ton for disposal and an additional charge of US$ 4–10/ton for transportation if the processor is within 160 km of the composting facility. For the disposal of rumen and stomach contents and screenings containing fat and flotation trailings, composting is a suitable method [2]. On-site composting is an alternative for meat processors who are unable to find someone who is willing to accept blood and is cost effective. On-site composting requires know-how, capital investment, sufficient space and regular maintenance. Any type of method specified above can be used. Windrow composting requires less capital investment but large space and maintenance. In-vessel composter requires lesser amount of space and man-power. But for small processors, the initial cost might be prohibitive.

In land application, the biological material is directly put into the land either by injection or by other mechanical means. The materials are biodegradable and provide nutrients to soils. In Canada, land application is not feasible throughout year due to subfreezing temperatures. Thus, in most parts of Canada, considerable amount of wastewater would require to be stored during the winter months. Advantages of land application are [3]: (i) recovery of wastes, (ii) replacement of chemical fertilizers (N, P, K), and (iii) soil structure improvements. The limitations are: (i) public visual nuisance and odour, (ii) surface and groundwater pollution, (iii) soil, contamination due to toxic, heavy metals and organic compounds, and (iv) health hazards to human and animals due to pathogens. Other environmental effects are: (i) acid and greenhouse gases emissions, and (ii) net primary energy consumption associated with treatment, storage and transportation.

Abattoirs in Guangdong provinces of China generally discharge their wastewater in municipal sewers after some degree of primary or chemical pre-treatment at the plant. Abattoirs are therefore required to pay a surcharge to dispose their wastewater for further treatment at the municipal treatment plants [4]. Conventional SBR treatment average COD removal efficiencies are of 85–90%. MSBR is a suitable process for the treatment of abattoir wastewater, due to its ability to maintain a sufficient amount of viable sludge. MSBR average COD removal efficiencies are of 98%.

In this paper, using multi-nitration, anti-nitration bacterium and MSBR, a new method of continuance high effect biology removal nitrogen is given.

## 2. Preliminary treatments

Pretreatments are screening, catch basins, flotation, equalization, and settlers for recovering proteins and fats. Screens or filters can be used to remove suspended solids in wastewater. After filtering, the water may be reused. Solid particles may include fat, bone, hair and meat lost during the slaughtering process. The strainers are made of metal wire and can intercept particles of various sizes depending on strainer mesh size. Most strainers rely on gravity to separate out the coarser particles. Coarse strainers have openings more than 6 mm; fine screens have openings less than 6 mm. Manure can be separated from the wastewater and can be treated as a solid waste. Similarly, separated fat from wastewater can also be considered a solid waste or by-product.

Catch basins or settling tanks also remove grease and finely suspended solids by gravity. Solids heavier than water sink to the bottom and grease and fine solids rise to the surface. A skimmer is used to remove grease and scum off the top and a scraper to remove sludge from the bottom. Typical biological oxygen demand (BOD) removal is from 25% to 40% and soluble solids (SS) removal is 50–70%. Due to very high BOD of blood, it is desirable to collect the maximum amount of blood so that wastewater BOD load can be reduced.

## 3. MSBR treatments

MSBR treatments involve the degradation of organics by microorganisms in the presence of oxygen. The systems require daily maintenance by a trained technician and daily drainage of accumulated sludge. Microorganisms require free dissolved oxygen to reduce the biomass in the wastewater. The biological sludge must be treated before disposal. Aerobic treatments are very effective at reducing odours and pathogens. These include modulation lagoon, aerobic lagoon, activated sludge processes, extended aeration, complete mix, oxidation ditches, sequencing batch reactors (SBRs). Aerobic treatment can directly follow preliminary treatment. Anaerobic treatment with aerobic treatment to further reduce BOD, SS and ammonia concentrations. Aerobic systems require small space, maintenance, management, and energy requirement for artificial oxygenation.

Modulation lagoon is small (about 50 $m^2$) earthen basins that use algae in combination with other microorganisms for wastewater treatment. Oxygen is supplied naturally by the wind, through photosynthesis and by mechanical means. Biological oxygen demands reductions are up to 95%, but effluent SS concentrations are often elevated because of poor sludge settling. Intermittent mixing is necessary. Oxygen requirements and treatment time increase steeply with wastewater strength.

Table 1
Distribution of wastewater treatment units

| Treatment category | Treatment unit | Percent of direct/indirect discharging facilities having the treatment unit in place | |
|---|---|---|---|
| | | Direct discharger | Indirect discharger |
| Preliminary treatment | Screen | 99 | 63 |
| | Dissolved air floatation | 80 | 47 |
| MSBR treatment | Biological treatment | 100 | 12 |
| | Oil and grease removal | 84 | 79 |
| | Filtration | 25 | 0 |

Table 2
Pathogen removals by various wastewater treatment processes

| Process | Percent removed | | | |
|---|---|---|---|---|
| | Bacteria (%) | Enteric viruses (%) | Protozoan cysts (%) | Helminth eggs (%) |
| Sedimentation | 50–90 | 0–3 | 10–90 | 30–90 |
| Trickling filter | 90–95 | 90–95 | 50–90 | 50–95 |
| Activated sludge | 90–99 | 90–99 | 50 | 50–99 |
| Oxidation ditch | 90–99 | 90–99 | 50 | 50–99 |

Activated sludge processes include conventional, complete mix, extended aeration, oxidation ditch and sequencing batch reactor. The sludge is maintained by continually recycling a fraction of the settleable solids separated after aeration back to the aeration basin. These settled solids contain an active microbial population, which aggregate to form flocs. The remaining sludge is removed from the system and may be stabilized using aerobic or anaerobic digestion or lime stabilization. This is capable of 95% reductions in BODs.

The degradation and removal of pollutant in wastewater are completed in the same reaction pool. The dimension of reaction pool reduction is up to 50%. The project investment reduction is up to 45%. Distribution of wastewater treatment units listed in Table 1.

## 4. High effective to remove nitrogen treatments

Abattoir wastewater is well suited to MSBR treatment because it is high in organic compounds. A new method of continuance high effect biology removal nitrogen is given with using multi-nitration, anti-nitration bacterium and MSBR. Nutrients like nitrogen and phosphorus can be removed by biological treatment. Typical reductions of up to 98% BOD, 93% SS, 98% COD, 95% $NH_3$-N and 95% lipin are approved. Pathogen removals by various wastewater treatment processes is shown in Table 2.

## 5. Cost of treatments

Nutrients like nitrogen and phosphorus can be removed by biological treatment, within existing treatment plants. Due to high cost involved, their use in treating abattoir wastewater is limited. In this paper, total cost to the abattoir wastewater industry reduction is up to 45% with using a new method. The results exhibited in Table 3.

## 6. Conclusion

The experimental results show that the quality of abattoir wastewater can attain to the national

Table 3
Performance of MSBR in treating abattoir wastewater

| Parameter | Original wastewater | Effluent | Removal (%) | Cost energy (kw/m$^3$) | Project investment ($/m$^3$) |
|---|---|---|---|---|---|
| $COD_{cr}$ (mg/L) | 5890.8–8950.4 | 8.5 | 98.8 | 0.6 | 2000 |
| $BOD_5$ (mg/L) | 2890.3–3685.5 | 8.2 | 99.7 | | |
| $NH_3$-N (mg/L) | 93.8–150.5 | 5.6 | 95.4 | | |
| Fat and grease (mg/L) | 24.5–32.4 | 0.7 | 97.5 | | |

requirements of the first grade of integrated wastewater discharge standard (GB 8978 - 1996). Typical reductions of up to 98% BOD, 93% SS, 98% COD, 95% $NH_3$-N, 98% phosphorus and 95% lipin are approved. Wastewater in abattoirs can be reduced by membrane filtration which can produce recyclable water. Total COD can be reduced below 100 mg/L.

This wastewater treatment method is easy to operate and manage. The project investment reduction is up to 45%. The effluent is stabilization. This technology has been used in Guangning abattoir plant for three years. It is much of benefit and has a broad prospects.

## Acknowledgements

This work was financially supported by the Guangdong Province Science and Technology Plan Item Foundation of China, Guangdong Ocean University Science Foundation and Zhanjiang City Science Foundation (2003C70220, 200510001, 2006C10007). The authors are grateful to Lecture Shaobo Hou (also a doctor student in Northwestern Polytechnical University, China) for his support.

## References

[1] US-EPA, Environmental assessment of proposed effluent limitations guidelines and standards for the meat and poultry products industry point source, EPA-821-B-01008, Office of Water, US Environmental Protection Agency, Washington, DC, 2002.

[2] W.P. Tritt and F. Schuchardt, Materials flow and possibilities of treating liquid and solid wastes from abattoirs in Germany—a review, Biores. Technol., 41 (1992) 235–245.

[3] D.I. Massé and L. Massé, Characterization of wastewater from hog slaughterhouses in eastern Canada and evaluation of their in-plant wastewater treatment systems, Can. Agric. Eng. 42 (2000) (3) 139–146.

[4] Shengquan Ye and Fu Huang, Separation of carcinogenic aromatic amines in the dyestuff plant wastewater treatment, Desalination, 206 (2007) 78–85.