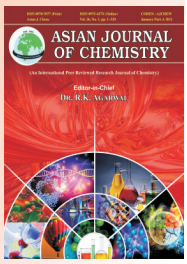
Asian Journal of Chemistry; Vol. 26, No. 11 (2014), 3261-3264

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2014.17505



Biological Treatment of Mustard Tuber Wastewater and Urban Sewage by Cyclic Activated Sludge System

HONGXIANG CHAI[1,2,*], ZHIWEN WEI[1,2], WEI KANG[1,2], YINGHUA WEI[1,2], JUN DU[1,2], JIAN ZHOU[1,2] and QIANG HE[1,2]

[1]Key Laboratory of Three Gorges Reservoir Region's Eco-Environment, Ministry of Education, Chongqing University, Chongqing 400045, P.R. China
[2]National Centre for International Research of Low-Carbon and Green-Buildings, Chongqing University, Chongqing 400045, P.R. China

*Corresponding author: Tel/Fax: +86 23 65120980; E-mail: chaihx@cqu.edu.cn

Received: 5 February 2014; *Accepted*: 10 April 2014; *Published online*: 25 May 2014; AJC-15228

Treatment of high salt,high nitrogen and high phosphorous organic wastewater has been proved to be a difficult task due to the toxic effects of high salinity on microorganisms. In order to find an effective, economical and environmentally friendly approach, a cyclic activated sludge system (CASS) was used at the pilot scale for the treatment of nitrogen, phosphorus, COD and suspended solid in mixed wastewater of mustard factory effluent and urban sewage. The treatment performance of CASS pool under the several conditions of mustard wastewater mixing ratios were investigated. Effectiveness was measured periodically in terms of influent and effluent COD, total nitrogem, total phosphorus and suspended solid. The oxido-reduction potential (ORP) in anoxic phase in the reactor was also considered. Results showed that the highest mixing ratio that met the discharge standard was obtained, thus the highest salinity, COD, total nitrogem, total phosphorus and suspended solid of influent wastewater were determined. Therefore, an alternative for high salinity wastewater treatment *via* CASS is provided.

Keywords: Salinity, Cyclic activated sludge system, Mustard wastewater, Oxido-reduction potential, Urban sewage.

INTRODUCTION

Salinity wastewater is generated in many industries over the world[1]. Yan *et al.*[2] used catalytic vacuum distillation to treat salinity petroleum refinery wastewater and COD removal rate reached 99 %. Calheiros *et al.*[3] found that the constructed wetlands were efficient to treat salinity wastewater. Vemura *et al.*[4] hold that average COD and NH_4^+-N removal rate was 99.6 and 96.8 %, respectively when treat salinity wastewater by a DHS reactor.

Compared to physical and chemical methods, biological wastewater treatment technology has a series of advantages[5]. However, salinity organic wastewater was poorly degraded in conventional treatment plants due to the adverse effects of saline on microbes[6]. High salinity leads to sharp changes on metabolism of microbial and dramatic rise in osmotic pressure, which causes cell plasmolysis[7,8]. Besides, salt causes changes on sludge flocs and biofilms architecture and sludge settle ability characteristics[7]. High salinity also puts negative impacts on the removal efficiency of N, P, BOD and COD[9,10]. Biological treatment of saline wastewater has not been universal[11].

However, many scholars indicate that bacteria living in hypersaline environments have a great potential in degrading pollutants and treat high salinity wastewater[12,13]. Salt-tolerant halophilic organisms may be used for effective biological treatment of salinity wastewater[14]. Biological treatment of hypersaline wastewater by pure halophilic bacteria has been studied in biofilms, sequencing batch reactors[15,16] and in rotating biological contactor[17]. Various types of microbial cultures were tested for the treatment of salinity wastewater in an aerated percolator unit. Salt-tolerant, halobacter supplemented mixture by an activated sludge culture was found to be the best of the cultures tested in terms of COD removal efficiency. Nearly 80 % was obtained at a 5 % salt concentration[18].

Bio-treatment of high-salt wastewater has made great achievements, but most are still limited to laboratory scale. The purpose of this work is to provide a helpful reference for high-salt wastewater reduction by cyclic activated sludge system (CASS) process.

EXPERIMENTAL

Experimental set-up: The structure of CASS pool with handling capacity 2500 m^3/d is shown in Fig. 1. The pool consists of biological selection pool and main reaction pool. Wastewater flows into the former pool along with backflow sludge from the latter one.

TABLE-1
COMPOSITION OF MUSTARD WASTEWATER AND URBAN SEWAGE

	Salinity (%)	COD (mg/L)	NH_4^+-N (mg/L)	TN (mg/L)	TP (mg/L)	SS (mg/L)
Mustard wastewater	1.5-2	380-422	57.5-71.4	188.5-237.1	21.22-27.09	263-315
Urban sewage	–	186-235	15.1-19.7	20.5-27.1	1.13-3.90	143-188

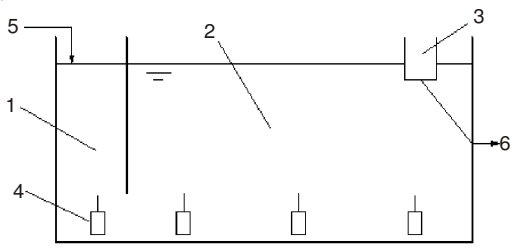


Fig. 1. Structure of CASS pool. 1-Pre-reaction zone 2-main reaction zone 3-decanter4-aerator 5-influent 6-effluent

In the bottom of the biological selection pool a duplex aeration agitation dual-use machine is installed. The designed flow, available depth and hydraulic retention time are 57.87 L/s, 4.5 m and 2.23 h, respectively. The size is 6.45 m × 8.00 m (L × B).

Three duplex aeration agitation dual-use machines with oxygenation ability 13 kg O_2/h and mixing diameter 12 m are installed in the bottom of the main react pool with size 36.55 m × 8.00 m (L × B). The designed flow, available depth, hydraulic retention time, sludge loading, suspended sediment concentration and sludge yield of the pool are 57.87 L/s, 4.5 m and 12.65 h, 0.1 kg BOD_5/kg MLSS d, 4000 mg/L, 0.45 kg D_5/kg BOD, respectively.

Water composition: The influent is mixture of urban sewage and pretreated industrial mustard wastewater (Table-1). The mixed water looped through coarse grid, fine grid, adjusting pool and grit chamber orderly before flowing into CASS pool. CASS pool ran in accordance with the design conditions.

Experiment procedure: In the collaborative process, the effluent water equality under circumstance of different influent mustard wastewater mixing ratios was investigated.The mixing ratio was increased until the effluent could not meet the emission standards[19]. Influent and effluent COD, TN, TP and SS were measured periodically and the ORP in anoxic phase was also tested. The experimentation lasted 135 days, during which mixing ratio was increased from 8 ± 1 % to 35 ± 1 % gently (Table-2). The collaborative treatment was stabilized by modifying the drainage ratio, run time and sludge concentration.

TABLE-2
WATER QUALITY IN EACH PERIOD

Period (days)	Mixing ratio (%)	Organic load (kg COD/m^3 d)	Salinity (%)
1-30	8 ± 1	0.45-0.50	0.21 ± 1
31-60	15 ± 1	0.51-0.55	0.29 ± 1
61-90	20 ± 1	0.56-0.60	0.44 ± 1
91-105	25 ± 1	0.61-0.64	0.54 ± 1
106-120	30 ± 1	0.65-0.70	0.64 ± 1
121-135	35 ± 1	0.71-0.75	0.74 ± 1

Analysis methods: All water quality objectives were tested according to standard methods for the examination of water and wastewater[20].

RESULTS AND DISCUSSION

Removal of COD: Increase of salinity, led to a reduction in microbial activity[21]. Although the increase in salinity and influent COD would result in a short period of substandard of effluent COD (66-88 mg/L), effluent COD would maintain 50 mg/L or less afterwards (Fig. 2). Microbial activity recovered over time and then effluent COD met the requirements. Meanwhile, with the increase of mixing ratio, microbial activity suppression by salinity intensified and microbial activity recovery time lengthened[22]. The total flow was lower than designed (2500 m^3/d). Organic load changed little after mixing of the two wastewaters, so salinity was a major factor affecting the run. The HRT should be extended appropriately, or the drainage ratio should be reduced to ensure the compliance of effluent COD.

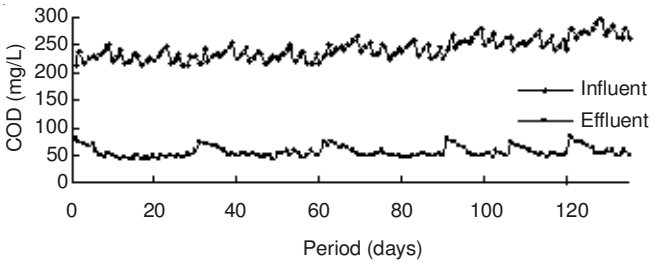


Fig. 2. Influent and effluent COD in different mixing ratios and organic load

Removal of total nitrogen: Influent total nitrogen increased dramatically (Fig. 3), which resulted from rise of mixing ratio. When incorporation ratio rose from 8 ± 1 % to 35 ± 1 %, influent TN rose from 40 to 88 mg/L. Effluent TN was mixing ratio depended and increase in salinity inhibited nitrifying and denitrifying bacteria activities. In the initial, effluent TN were 20-40.48 mg/L generally. As time increase, microbial activity gradually recovered and effluent TN reached the mark. When mixing ratio was 30 ± 1-35 ± 1 %, influent TN was 83.2-88.3 mg/L and effluent TN was 25.3-32.9 mg/L. High TN and lack of carbon source led to damage of nitrification and denitrification system, making it difficult to achieve a TN discharge standard. Aslan and Simsek[23] indicated that the nitrification rate was negatively affected from the salinity.

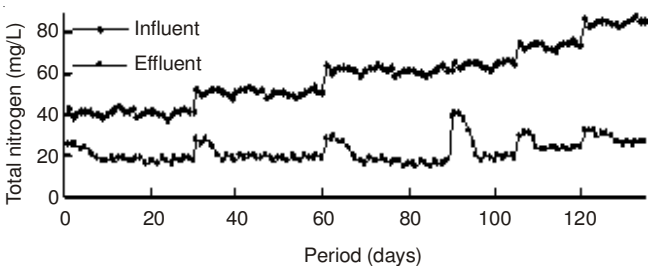


Fig. 3. Influent and effluent total nitrogen in different mixing ratios and organic load

Besides, it took more time than the other bacteria for nitrification and denitrification system to recover, which meant that nitrifying bacteria and denitrifying bacteria had a worse adaptability to high salinity than normal zoogloea. Therefore, only when the mixing ratio was less than 30 ± 1 %, namely, salinity and organic load were less than 0.65 % and 0.55 kg COD/(m^3 d), effluent TN could reach the mark.

Removal of total phosphorus: With the increase of mixing ratio from 8 ± 1 % to 35 ± 1 %, influent TP increased sharply from 4.2-9.78 mg/L (Fig. 4). When mixing ratio was 8 ± 1 % to 30 ± 1 %, effluent TP was 0.66-3.28 mg/L. In each stage, effluent is 1.03-1.55 mg/L after phase of adjustment. Although inhibited, phosphorus removal bacteria restored over time and effluent TP could reach the mark. When the mixing ratio was 30 ± 1 % to 35 ± 1 %, influent TP was 8.04-9.78 mg/L and effluent was 1.67-3.88 mg/L and effluent was 1.67-1.99 mg/L even after adjustment. This showed that phosphorus removal bacteria had a limited capability of phosphorus removal.

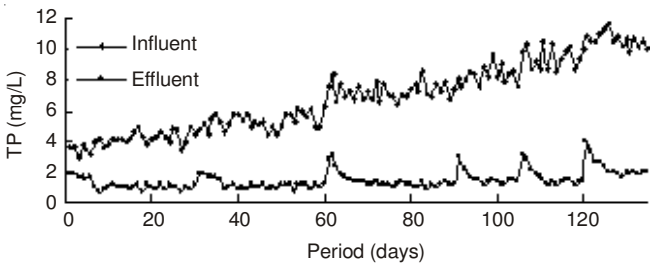


Fig. 4. Influent and effluent TP in different mixing ratios and organic load

Removal of suspended solid: Influent SS hardly changed as mixing ratio increased (Fig. 5) which meant there was no definite correlation between SS and salinity. However, the zoogloea bacteria activity was depressed by increase of salinity. So the degradation of microbial flocculation and sedimentation performance resulted in substandard effluent SS temporarily and effluent SS were 20-38 mg/L generally. After a few days of adjustment, microbial activity gradually restored and effluent is 12-19 mg/L and up to standard. Although influent SS fluctuated, effluent SS was stable and adjustment period were similar in each stage, which meant there was little effect of SS fluctuation on zoogloea bacteria.

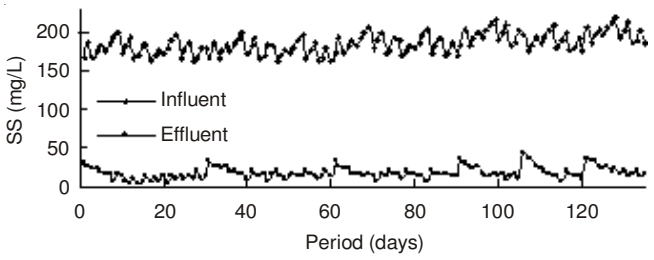


Fig. 5. Influent and effluent SS in different mixing ratios and organic loads

Oxidation-reduction potential in anoxic phase: For activated sludge process, ORP measurement appeared to be helpful for aeration management[24]. In the case of the mixing ratio 8 ± 1 % to 35 ± 1 %, the ORP of the hypoxia pool was -128 to -98 mV, just as shown in Fig. 6. However, ORP of anoxic phase in conventional wastewater treatment processes, such as A^2O, is higher as -105 to -90 mV, generally. That is, denitrification potential of CASS is better than other normal treatment plants, which can be demonstrated by removal efficiency of TN in this work.With the increase of incorporation ratio, ORP increased slowly in this work, indicating a strong adaptability of salinity. Under circumstance of above 30 ± 1 % mixing ratio, ORP of hypoxia pool was above -100 mV, leading to a bad nitrogen removal rate.

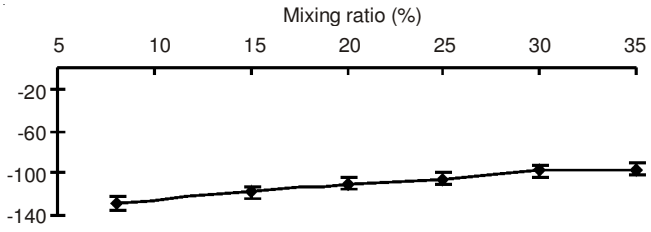


Fig. 6. ORP in different mixing ratios

Conclusion

Total nitrogen and total phosphorus were restriction indicators affecting the co-processing performance. When the influent salinity, COD, TN, TP and SS were up to 0.62-0.65 %, 241-274, 71.68-76.46, 6.90-8.72 and 177-210 mg/L, respectively, CASS pool was capable of disposing the mixed wastewater. When mixing ratio was above 35 ± 1 %, other nitrogen and phosphorus removal methods were necessary. In order to reduce the negative impact of increase in total organic load, TN and salinity on treatment performance, drainage ratio, running time, aeration intensity and sludge concentration were modified. Therefore, when mixing ratio was less than 30 ± 1 %, all the indicators are stable to achieve a B standard, level I of urban sewage treatment plant pollutant discharge standards (GB18918-2002).

ACKNOWLEDGEMENTS

The work reported here was supported by China National Science Foundation Program (Grant No. 51008318) and the 111 Project, No. B13041.

REFERENCES

1. V.N. Anupama, P.N. Amrutha, G.S. Chitra and B. Krishnakumar, *Water Res.*, **42**, 2796 (2008).
2. L. Yan, H.Z. Ma, B. Wang, W. Mao and Y.S. Chen, *J. Hazard. Mater.*, **178**, 1120 (2010).
3. C.S.C. Calheiros, P.V.B. Quitério, G. Silva, L.F.C. Crispim, H. Brix, S.C. Moura and P.M.L. Castro, *J. Environ. Manage.*, **95**, 66 (2012).
4. S. Uemura, S. Suzuki, K. Abe, K. Kubota, T. Yamaguchi, A. Ohashi, Y. Takemura and H. Harada, *Bioresour. Technol.*, **101**, 5180 (2010).
5. A.R. Pendashteh, L.C. Abdullah, A. Fakhru'l-Razi, S.S. Madaeni, Z. Zainal Abidin and D.R. Awang Biak, *Process Saf. Environ.*, **90**, 45 (2012).
6. F.J.Ludzack and D.K.Noran, *J. Water Pollut. Control Fed.*, **37**, 1404 (1965).
7. J.P. Bassin, M. Dezotti and G.L. Sant'Anna Jr., *J. Hazard. Mater.*, **185**, 242 (2011).
8. I. Vyrides and D.C. Stuckey, *Enzyme Microb. Technol.*, **44**, 46 (2009).
9. F. Kargi and A.R. Dincer, *Bioprocess Eng.*, **15**, 51 (1996).
10. Q. Fontenot, C. Bonvillain, M. Kilgen and R. Boopathy, *Bioresour. Technol.*, **98**, 1700 (2007).
11. S.H. Lin, C.T. Shyu and M.C. Sun, *Water Res.*, **32**, 1059 (1998).

12. C.A. Nicholson and B.Z. Fathepure, *FEMS Microbiol. Lett*., **245**, 257 (2005).
13. F. Kargi, *Biotechnol. Lett*., **24**, 1569 (2002).
14. M.T. Garcia and E. Mellado, *Int. J. Syst. Evol. Microbiol*., **54**, 1723 (2004).
15. C.R. Woolard and R.L. Irvine, *Water Environ. Res*., **66**, 230 (1994).
16. C.R. Woolard and R.L. Irvine, *Water Res*., **29**, 1159 (1995).
17. F. Kargi and A.R. Dinçer, *Enzyme Microb. Technol*., **22**, 427 (1998).
18. F. Kargi and A. Uygur, *Environ. Technol*., **17**, 325 (1996).
19. Ministry of Environmental Protection of People's Republic of China, General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB 18918-2002) (2002).
20. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, Washington DC, USA, edn 21 (2005).
21. C. Ma, R.C. Jin, G.F. Yang, J.J. Yu, B.S. Xing and Q.Q. Zhang, *Bioresour. Technol*., **112**, 124 (2012).
22. X.L. Zhuang, Z. Han, Z.H. Bai, G.Q. Zhuang and H. Shim, *Environ. Pollut*., **158**, 1119 (2010).
23. S. Aslan and E. Simsek, *Bioresour. Technol*., **118**, 24 (2012).
24. E. Paul, S. Plisson-Saune, M. Mauret and J. Cantet, *Water Sci. Technol*., **38**, 299 (1998).