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CONTENTS

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Treatment of fishery wastewater using aerobic granules in sequencing batch reactor

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Abstract

Exporting seafood is one of the most important business worldwide, which brings forth a tremendous amount of wastewater at the end of its process. Utilization of sea water as a primary resource for its process make the wastewater rich in salinity, thus leads to performance failure in the treatment of wastewater using activated sludge process. Various researches on aerobic granules reported that it has advantages like quick settlingability, treatability against salinity as well as tolerance to toxic substances. This work particularly focussed on treating the fishery wastewater by forming aerobic granules in Sequencing Batch Reactor (SBR) for improving process performance and achieving good treatability with rifling operational area. This research indicates that effective cultivation of aerobic granules in fishery wastewater can be accelerated by inoculating Chlamydospores of strain HSD. Results reveal that aerobic granules was successfully cultivated and accelerated at 25 days of operation with strain HSD acceleration, in comparison to the process operation without the HSD strain of 32 days. Further aerobic granules reinforce SBR and the BOD removal efficiency of 78%, 76%, and 79% from R1, R2, and R3 respectively was achieved after 8-hours of the treatment process.

Index Terms — Aerobic granules, Chlamydospores, fishery wastewater, SBR.

I. INTRODUCTION

Exporting seafood is an important economic mainstay for many of the nations and among them India is the second largest country in Seafood export. The Seafood processing industry utilizes a vast quantity of water for its processing and most of its water requirements are met by the use of sea water(Adav et al. 2008; Figueroa et al. 2008). This wastewater is rich in nutrients and various pollutants and moreover disposal of the untreated seafood wastewater, lead to eutrophication and significant negative impact to the surrounding environment(Gonzalez 1996). Hence, it is extremely necessary to treat properly to comply the discharge standards set by the regulatory agencies.

Activated Sludge Process is a commonly adopted treatment method, in which activated sludge reacts with substrate to remove pollutants from wastewater and higher salinity leads to performance failure(Figueroa et al. 2008). Granular sludge is one of the recent advancement in the treatment of wastewater and within those aerobic granules poses more advantages over anaerobic based granules. It can be termed as the granules containing active microorganisms with not only limited to microbial origin (Cassidy and Belia 2005; de Kreuk and de Bruin 2004; Ni et al. 2014; Su and Yu 2005; Williams and de los Reyes 2006; Yang et al. 2008).The Recent literature survey shows that aerobic granules exhibit great tolerance against various complicated wastewater (Arne Alphenaar et al. 1993; Schwarzenbeck et al. 2004, 2005) and the use of Sequencing Batch Reactor (SBR) greatly reduces the land requirement. This research work focuses on by combining both technologies, to develop an effective treatment process within minimum space requirement and Chlamydospores of strain HSD was used as an accelerating agent to accelerate up the process of granulation (Hailei et al. 2011).

II. MATERIALS AND METHODS

Fishery wastewater, Chemical and seed activated sludge

Fishery wastewater was collected from nearby seafood industry and directly transported to the lab for storage in preserved condition. All chemicals used were of analytical grade. The seed activated sludge was obtained from the domestic wastewater treatment plant and Superior mixed flora (SMF) and Chlamydospores of Phanerochaete sp. HSD was obtained from the National Collection of Industrial Microorganisms, National Chemical Laboratory, Pune.

A. *Reactor Operation*

The batch experiment was conducted in controlled conditions in the lab scale Sequencing Batch Reactor (SBR), which consist of three SBRs and categorized as R1, R2 and R3.Chlamydospores was prepared based on the method prescribed by

Hailei et al. 2006. Initially the reactor was fed with 1 litre of activated sludge seed for 3 days and later 1 litre of fishery wastewater was added to the reactor. After 6 days of initial operation the reactors R2 and R3 were inoculated with Chlamydospores strain and the reactor R1 was kept as such without inoculation as control. The reactor Operation cycle consists of four phases namely feeding phase, aerobic phase, discharge and idle phase (Li et al. 2014; Wichern et al. 2008). Aeration was provided at the bottom using air bubbles to diffuse. This technique of aeration made uniform of air transfer around the reactor, which leads to a favourable condition for aerobic granules cultivation (Beun et al. 1999; Lee et al. 2010; Liu and Tay 2002; McSwain et al. 2004; Osman et al. 2001). After the successful cultivation of granules, the granules were separated from flocculent sludge using a sieve. This separated granule was considered as aerobic granules and it further reinforced the reactor to carry out wastewater treatment (Benzhai et al. 2014; Ni and Yu 2008). During the entire cognitive process, influent as well as effluent characteristics were tested in order to calculate the treatment efficiency and to observe the extent of treatability (American Public Health Association et al. 1999).

III. ANALYSIS OF AEROBIC GRANULES

The morphology of the granules was observed using a bio-microscope and SEM was used to understand the microorganisms on the surface and the interior of aerobic granule. Integrity coefficient (%)was assessed by using the method of prescribed by Ghangrekar et al. 1996and the Percentage of GR was calculated using the following formula

$$Gr(\%) = \left(\frac{Weight\ of\ Aerobic\ Granules}{Weight\ of\ Sludge}\right) x\ 100$$

IV. RESULTS AND DISCUSSION

a. Cultivation of Aerobic Granules

Aerobic granules cultivation has been carried out in the same Sequencing Batch Reactor, where wastewater treatment also was processed. During the start-up phase, microbes grew up more rapidly in the reactors. The MLSS curves of the reactors shown in the Figure 4.1 reveals that a sharp decline was observed during the start-up phase this phenomena was happening in the reactor due to scattering of sludge with poor settling abilities which were washed out in the effluent during the process.

After day 4, the MLSS concentration in reactors started to rise. The MLSS concentration in R2 and R3 were higher than in R1 throughout the testing period and the SVI in reactors were improved during the operation which is depicted in the Figure 4.2.

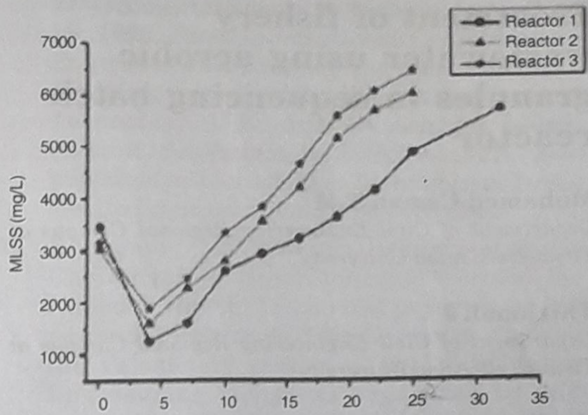

Figure 4.1 MLSS varied with time during Aerobic Granule cultivation

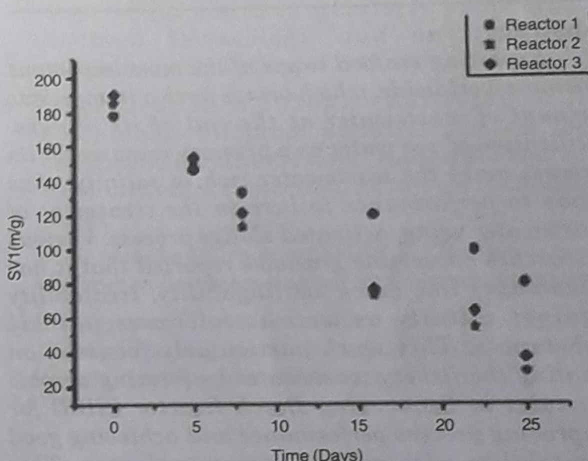

Figure 4.2 Variations of SVI with time during Aerobic Granule cultivation

After day 7, SVI in R2 and R3 was significantly lower than that in R1, Further more Subsequent operation of 15 days in the reactor R1 the flocs started to appear. On the other hand the reactors R2 and R3 only took 9 to 10 days of operation to form mature flocs.The formation of random Granules occured during the 23rd day of operation in R1 and 16, 14 days of operation in the reactors R2 and R3 respectively. The R1 was operated without Chlamydospores of strain HSD, while other two reactors R2 and R3 were incubated with Chlamydospores of strain HSD. In R2 and R3 aerobic granules appeared earlier than R1. This result infers that Chlamydospores of strain HSD accelerate the aerobic granule formation in the sequencing batch reactor (SBR) and the maximum number of granules appeared in the 32nd day of operation in R1 and 25 days in Reactors R2 and R3 respectively

It was observed that the average size of the granules is approximately 2.8 mm and the shape of aerobic Granules was in spherical or spherical with compact appearance. SEM image of cultivated Aerobic Granules (GR) in the Figure 4.3 showed that Aerobic Granules had an uneven appearance, with many spherical and filamentous microorganisms on its surface.

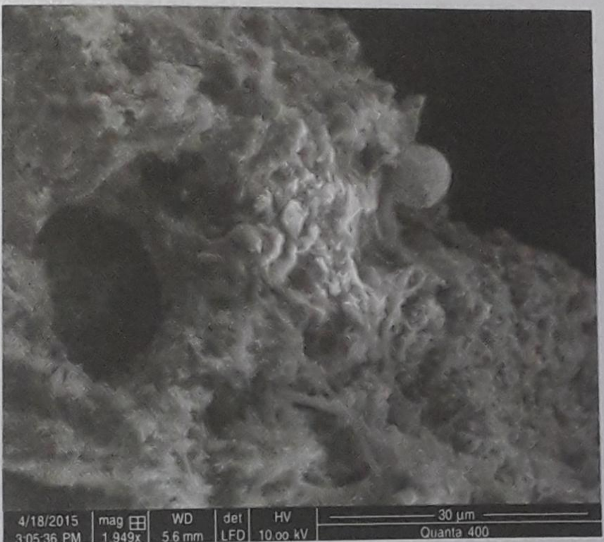

Figure 4.3 SEM images of microbes on the surface of Granule

It was also further observed that Sludge Granules increase with time till the maximum value was reached. In Reactor R1 more than 80% of granules were obtained after 32 days of SBR operation, R2 and R3 produce more than 80% of granules with 25 days of successful SBR operations which is shown in the Figure 4.4.

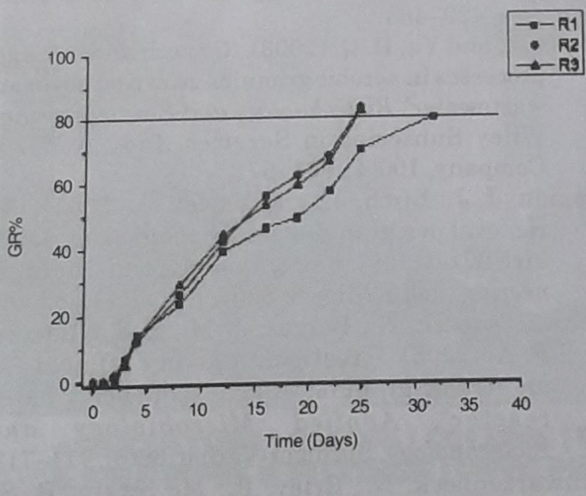

Figure 4.4 Variations of GR with time during Aerobic Granules formation

b. ***Treatment of Wastewater using cultivated Aerobic Granules***

Treatment of fishery wastewater was carried out in a fully aerobic granules reinforced Sequencing Batch Rector (SBR). The same Sequencing Batch Rector (SBR) setup was utilized for the present treatment which was utilized earlier for aerobic granules cultivation. In R1, R2, R3, the BOD removal rate of the wastewater treatment observed was 78%, 76%, and 79%, respectively after 8 hours. The results obtained from our study is shown the figure 4.5 and it was concluded that for the treatment of fishery waste water successful cultivation as well as the higher treatment efficiency using Aerobic Granules can be achieved by Sequencing Batch Reactor.

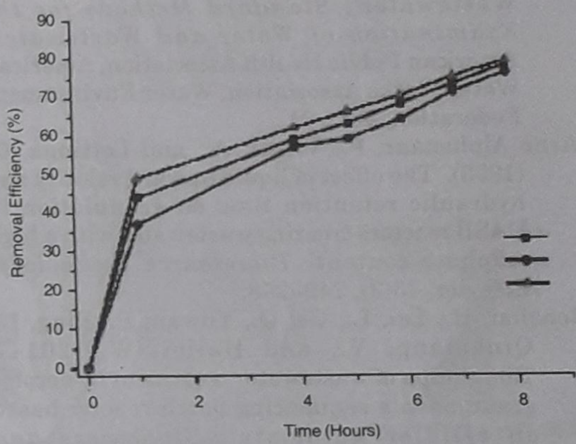

Figure 4.5 Comparison of BOD Removal efficiency in reactors

V. CONCLUSION

The Seafood export involved many processes which require huge quantity of water and its waste water was rich in nutrient pollutants. Most of its traditional treatment technique adopted so will encounter serious performance and occupies large operation area leads to financial over burden to the sector. This limitation makes us to find out newer solution for the effective treatment of fishery wastewater. Sequencing Batch reactor based technology effectively utilizing land by combining all treatment process than can be borne away in a single reactor and process dynamics limitation can be overcome by using Aerobic Granule technology and Studies reveals that a microbial process culture can be accelerated by Superior mixed flora (SMF) or chlamydospores of Phanerochaete sp. HSD. Chlamydospores of Phanerochaete sp. HSD incubated in the reactors R2 and R3 produce aerobic granules within 25 days of operation which is quicker than R1 (32 days of operation. The aerobic granules reinforced rectors achieved BOD removal efficiency of 78%, 76%, and 79% for reactors R1, R2 and R3 respectively. This, study showed that effective treatment can be achieved with help aerobic granules for treating fishery wastewater.

REFERENCES

Adav, S. S., Lee, D. J., Show, K. Y., and Tay, J. H. (2008). 'Aerobic granular sludge: Recent advances'. *Biotechnology Advances,* 26(5), 411–423.

American Public Health Association, American Water Works Association, and Water Environment Federation. (1999). 'Standard Methods for the Examination of Water and Wastewater'. *Standard Methods for the Examination of Water and Wastewater,* American Public Health Association, American Water Works Association, Water Environment Federation, 541.

Arne Alphenaar, P., Visser, A., and Lettinga, G. (1993). 'The effect of liquid upward velocity and hydraulic retention time on granulation in UASB reactors treating wastewater with a high sulphate content'. *Bioresource Technology,* Elsevier, 43(3), 249–258.

Benzhai, H., Lei, L., Ge, Q., Yuwan, P., Ping, L., Qingxiang, Y., and Hailei, W. (2014). 'Simulation of wastewater treatment by aerobic granules in a sequencing batch reactor based on cellular automata'. *Bioprocess and Biosystems Engineering,* 37(10), 2049–2059.

Beun, J. J., Hendriks, A., Van Loosdrecht, M. C. M., Morgenroth, E., Wilderer, P. A., and Heijnen, J. J. (1999). 'Aerobic granulation in a sequencing batch reactor'. *Water Research,* Pergamon, 33(10), 2283–2290.

Cassidy, D. P., and Belia, E. (2005). 'Nitrogen and phosphorus removal from an abattoir wastewater in a SBR with aerobic granular sludge'. *Water Research,* Pergamon, 39(19), 4817–4823.

Figueroa, M., Mosquera-Corral, A., Campos, J. L., and Méndez, R. (2008). 'Treatment of saline wastewater in SBR aerobic granular reactors'. *Water Science and Technology,* 58(2), 479–485.

Ghangrekar, M. M., Asolekar, S. R., Ranganathan, K. R., and Joshi, S. G. (1996). 'Experience with UASB reactor start-up under different operating conditions'. *Water Science and Technology,* No longer published by Elsevier, 421–428.

Gonzalez, J. F. (1996). *Wastewater Treatment in the Fishery Industry.FAO Fisheries Technical Paper (FAO), No. 355/FAO, Rome (Italy), Fisheries Dept.*

Hailei, W., Guangli, Y., Guosheng, L., and Feng, P. (2006). 'A new way to cultivate aerobic granules in the process of papermaking wastewater treatment'. *Biochemical Engineering Journal,* Elsevier, 28(1), 99–103.

Hailei, W., Li, L., Ping, L., Hui, L., Guosheng, L., and Jianming, Y. (2011). 'The acceleration of sludge granulation using the chlamydospores of Phanerochaete sp. HSD'. *Journal of Hazardous Materials,* 192(3), 963–969.

de Kreuk, M. K., and de Bruin, L. M. M. (2004). 'Aerobic Granule Reactor Technology'. *IWA Publishing, STOWA REPORT,* IWA Publishing, 4(0), 9781780402901–9781780402901.

Lee, D. J., Chen, Y. Y., Show, K. Y., Whiteley, C. G., and Tay, J. H. (2010). 'Advances in aerobic granule formation and granule stability in the course of storage and reactor operation'. *Biotechnology Advances,* Elsevier Inc., 28(6), 919–934.

Li, J., Ding, L. Bin, Cai, A., Huang, G. X., and Horn, H. (2014). 'Aerobic sludge granulation in a full-scale sequencing batch reactor'. *BioMed Research International,* 2014, 268789.

Liu, Y., and Tay, J. H. (2002). 'The essential role of hydrodynamic shear force in the formation of biofilm and granular sludge'. *Water Research,* Pergamon.

McSwain, B. S., Irvine, R. L., and Wilderer, P. A. (2004). 'The effect of intermittent feeding on aerobic granule structure'. *Water Science and Technology,* 49(11–12), 19–25.

Ni, B.-J., Yu, H.-Q., and Bing-Jie Ni and Han-Qing Yu. (2014). 'Aerobic Granular Sludge Technology for Wastewater Treatment'. *Biological Sludge Minimization and Biomaterials/Bioenergy Recovery Technologies,* 429–463.

Ni, B. J., and Yu, H. Q. (2008). 'Growth and storage processes in aerobic granules grown on soybean wastewater'. *Biotechnology and Bioengineering,* Wiley Subscription Services, Inc., A Wiley Company, 100(4), 664–672.

Osman, J. J., Birch, J., and Varley, J. (2001). 'N-removal in a granular sludge sequencing batch airlift reactor'. *Biotechnology and Bioengineering,* John Wiley & Sons, Inc., 75(1), 82–92.

Schwarzenbeck, N., Borges, J. M., and Wilderer, P. A. (2005). 'Treatment of dairy effluents in an aerobic granular sludge sequencing batch reactor'. *Applied Microbiology and Biotechnology,* Springer-Verlag, 66(6), 711–718.

Schwarzenbeck, N., Erley, R., Mc Swain, B. S., Wilderer, P. A., and Irvine, R. L. (2004). 'Treatment of malting wastewater in a granular sludge sequencing batch reactor (SBR)'. *Acta Hydrochimica et Hydrobiologica*, WILEY VCH Verlag, 32(1), 16–24.

Su, K.-Z., and Yu, H.-Q. (2005). 'Formation and Characterization of Aerobic Granules in a Sequencing Batch Reactor Treating Soybean-Processing Wastewater'. *Environmental Science & Technology*, American Chemical Society, 39(8), 2818–2827.

Wichern, M., Lübken, M., and Horn, H. (2008). 'Optimizing sequencing batch reactor (SBR) reactor operation for treatment of dairy wastewater with aerobic granular sludge'. *Water Science and Technology*, 58(6), 1199–1206.

Williams, J. C., and de los Reyes, F. L. (2006). 'Microbial community structure of activated sludge during aerobic granulation in an annular gap bioreactor'. *Water Science and Technology*, IWA Publishing, 54(1), 139–146.

Yang, S. F., Li, X. Y., and Yu, H. Q. (2008). 'Formation and characterisation of fungal and bacterial granules under different feeding alkalinity and pH conditions'. *Process Biochemistry*, Elsevier, 43(1), 8–14.

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