International Journal of
Civil Engineering (IJCE)
ISSN(P): 2278-9987; ISSN(E): 2278-9995
Vol. 4, Issue 5, Aug - Sep 2015, 11-16

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

START UP AND ENHANCEMENT GRANULATION IN AN ANAEROBIC BAFFLED REACTOR FOR THE TREATMENT OF TEXTILE WASTEWATER

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ABSTRACT

A laboratory scale anaerobic baffled reactor with working volume of 36 litres for treating textile wastewater at 26°C was started-up and loaded to an organic loading rate of 0.252kg COD/m^3.d. Operational parameters such as influent COD concentration and pH were identified that was modified to improve the reactor's performance without the need for external pH control. Moreover, this experiment was found that the reactor could reach a steady state from 75 to 78 days, respectively. This paper envisaged that the startup performance of ABR in treating textile wastewater at continuous phase was investigated.

KEYWORDS: Anaerobic Baffled Reactor, Chemical Oxidation Demand, Flow rate, Organic Loading Rate, pH, Startup performance.

INTRODUCTION

With the increasing deterioration of world water resources, configuring a technical and economic viable wastewater treatment and recycle technology to satisfy the increasing complexity of wastewater and stringent environmental regulation has been a great challenge over the past decades. Developing reliable technologies for wastewater treatment is of urgent importance. In recent years, anaerobic baffled reactor (ABR) treating wastewater effectively have received considerable attention in the literature. It was indicated that ABR had become a promising alternative for wastewater treatment with great further development potential.

Now a days, many researchers have focused on anaerobic reactors for the treatment of wastewater Barber W.P. and Stuckey D.C. (1999), She Z. L et.al., (2006), Uyanik. S, et.al, (2002a), and Krishna GVT et.al., (2008).As one of the high-rate anaerobic reactors, the ABR was extensively used in treating wastewater. The ABR was initially developed at Stanford University and it was described as a series of up-flow anaerobic sludge blanket reactors. As the name suggests, it consists of a series of vertical baffles to force the wastewater to flow under and over them as it passes from the inlet to the outlet. The wastewater can then come into intimate contact with a large amount of active biomass, while the effluent remains relatively free of biological solids (Wang. J.L., et al., 2004; Krishna. GVT et al., 2007).

The anaerobic baffled reactor (ABR) is one of the high-rate anaerobic designs developed by Mc Carty and co-workers at Stanford University (Bachmann A., Beard V. L., and Mc Carty P.L. 1985). It is suggested by several researchers as a promising system for industrial wastewater treatment (Bachmann A., Beard V. L., and Mc Carty P. L., 1985; Boopathy R., Larsen V. F., and Senior E. 1988; Grobicki A., and Stuckey D. C. 1991; Setiadi T., Husaini, and Djajadiningrat A., 1996).

Anaerobic digestion has proven to be a stable process for the treatment of many organic wastes. It has several advantages over the aerobic and physico-chemical process such as design simplicity, low capital and operating cost, less energy requirement, use of non-sophisticated equipment and applicability in small and large scales. Several recent studies have been reported about the performance, characteristics and applications of ABR(Barber, W.P and Stuckey, D.C. 1999; Uyanik. S. et al., 2002a).

Prompt start-up is essential for the highly efficient operation of ABR, due to slow growth rate of anaerobic microorganisms, especially methane producing bacteria (Liu. R.R et al., 2010). During anaerobic reactor start-up, the biomass is acclimatized to new environmental conditions, such as substrate, operating strategies, temperature and reactor configuration (Alkarimia. R et. al., 2011).The main objective of this work was to look into the start up process performance of a laboratory scale ABR inoculated with digested slurry, which was collected from an active anaerobic wastewater treatment plant at Annamalai Nagar.

EXPERIMENTAL METHODOLOGY

Reactor Configuration

The experimental laboratory model was made up of Plexiglass. The size of the anaerobic baffled reactor was: length 50cm, width 24cm, depth 30cm and working volume of the reactor was 36 liters. A proper construction of the baffles allowed wastewater to flow through the sludge bed from bottom up. The model have five compartments and the distance of the upper edge of baffles between the ascending and descending compartments from the water level was 3cm above the reactor's base at a 45° angle to direct the flow evenly through the up-corner. The physical feature of the experimental set up was shown in **Table 1**. The liquid flow is alternatively upwards and downwards between compartment partitions. This produced effective mixing and contact between the wastewater and biosolids at the base of each up-corners. Sampling ports were located in the middle of the top of each compartment allowing drawing biological sludge and liquid samples. A variable speed peristaltic pump (PP -30) was used to control feed rate. The schematic of the laboratory scale experimental set up was shown in **Figure 1.1.**

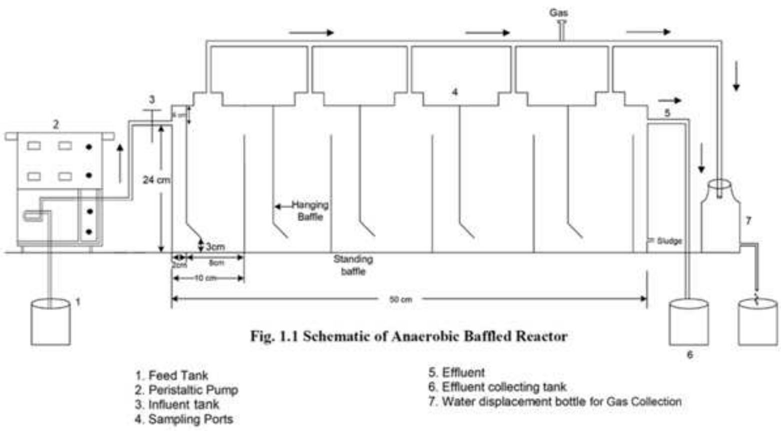

Figure 1.1

Table 1: Physical Features of Experimental Setup

Reactor Configuration	Dimensions
Length	50cm
Depth	30cm
Width	24cm
Compartment free board	6cm top, 3cm bottom
The sample port from the Top of the reactor	6cm
The sample port from the bottom of the reactor	3cm
Working volume	36 liters
Number of compartment	5
Each compartment length	2 to 8cm
Peristaltic pump	PP-30

Analytical Method

The influent and effluent samples were collected on once in three days basis and were analyzed immediately as per the procedure given in Standard Methods (APHA 2005).

RESULT AND DISCUSSIONS

Acclimation and Process Stability

During anaerobic reactor start-up, the biomass is acclimatized to new environmental conditions, such as substrate, operating strategies, temperature and reactor configuration (Alkarimia R., Mahat S. B., Yuzir A., Fadhil M., and Chelliapan S., 2011). The inoculums source was granular sludge taken from the active biomass plant located at Faculty of Agriculture, Annamalai University, Annamalai Nagar. The granules were passed through a screening to remove debris. Establishment of the most suitable microbial population is the overall objective of the start-up of ABR.

Performance of the Reactor

The influent and effluent samples from the reactor were collected on three days once basis and were analyzed immediately. Initially the influent feed of municipal wastewater to the reactor was 440mg/l with an OLR of 0.252Kg COD/m^3.d. The low initial loading rate was recommended for the successful start-up of ABR. A low initial organic loading rate was beneficial for the growth of anaerobic active sludge, due to low COD organic loading resulting in low production of gas rate and low wastewater up- flow velocity. The start-up of ABR and its affecting factors have been well presented in the literature (Barber W.P, and Stuckey D.C, 1999). Prompt start-up is essential for the highly efficient operation of ABR, due to slow growth rates of anaerobic microorganisms, especially methane producing bacteria (Liu R. R. Q., Tian B, Yang and Chen J.H., 2010).

The start-up period is considered as the period taken for stable operation to be achieved. This is a crucial step for the stable operation of the ABR and other anaerobic reactors, at a designed organic loading rate (OLR). One of the main points stressed is the inoculation with high quality methanogenic sludge. In addition, operating temperature is prominent during start-up. In this work, the ABR reactor after seeding was operated at a temperature between 24°C and 37°C (mesophilic range). The COD removal rate during first 36th day was low in the range of 10-20%. The low efficiency in removal at the beginning of the process is due to the biomass adaptation in the new environment. The low removal efficiency during start-up phase can possibly be attributed to the presence of unadapted seed sludge. During the period of 36 to 60 days moderate removal of COD was achieved. It is difficult to maintain the effective number of useful microorganisms in the system (Bal, A. S. and Dhagat, N.N.2001). The reactor attained a steady state from 75 to 78 days with a COD removal efficiency of 78% was achieved. **(Figure 1.2)**

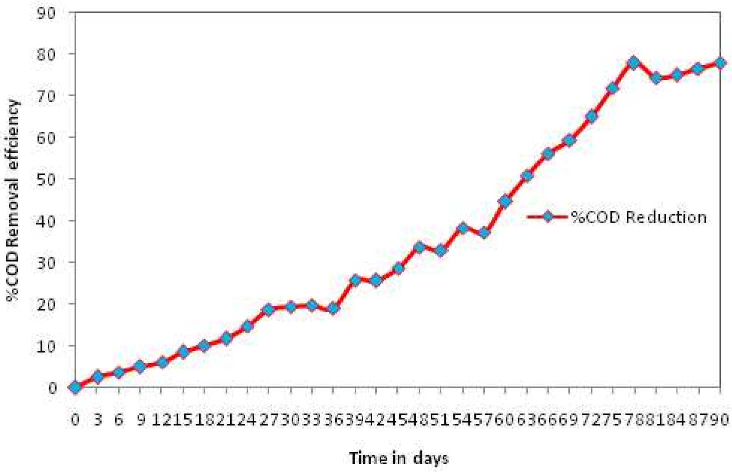

Figure 1.2: Time in Days with Respect to % COD of Removal Efficiency

The pH is an essential factor to control during anaerobic digestion. The methane producing microorganisms have optimum growth in the pH range between 6.6 and 7.6 (Rittmann and Mc Cardy P.L, 2001), although stability may be achieved in the formation of methane over a wider pH range (6.0 – 8.0). pH values below 6.0 and above 8.3 should be avoided, as they can inhibit the methane – forming microorganisms (Chernicharo C.A.L, 2007). The influent and effluent pH during the start up period is shown in **Figure 1.3**. The effluent pH value was little variation throughout the experiment. After 60th day, the variation on pH value was slight and remaining over 7.68.These results indicated that good system buffering and non inhibition of methanogenic organism at the beginning of the adaptation process.

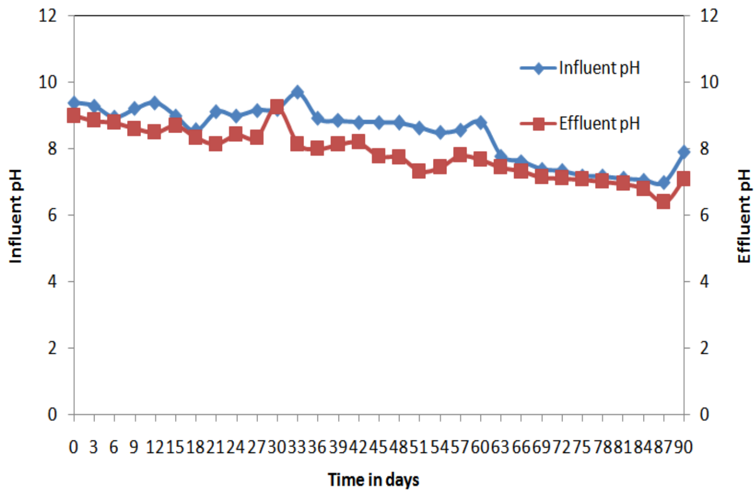

Figure 1.3: Time in Days with Respect to Influent and Effluent pH

After achieving a steady state the real time textile wastewater was fed gradually such as 20%, 40%, 60%,80% and 100% to the reactor. After allowing 100% concentration of textile wastewater, the COD removal is monitored to achieve a stabilized removal of COD.

CONCLUSIONS

The results of the study in this paper lead to the following conclusions:

- The reactor was attained a steady state for 75 to 78 days during startup.
- The COD removal efficiency was achieved around 78% during startup.
- The reactor was started up with an OLR of 0.252kg COD/m^3.day.
- Maintaining a suitable and stable pH within the reactor should be a major priority for ensuring efficient methanogenic digestion.
- Proper pH and alkalinity are of key importance for the prompt startup of ABR, when the reactor was operated efficiently, effluent pH was relatively stable.
- Further investigation should be carried out for a longer duration by varying OLR and HRTs to study the performance of the reactor.

REFERENCES

1. Alkarimia R, Mahat S.B., Yuzir A., Fadhil M., and Chelliapan S. 2011. Performance of an innovative multi stage anaerobic reactor during start-up period, African Journal of Biotechnology, Vol. 10, no. 54, pp. 11294-11302.
2. APHA. 2005. Standards for Water and Wastewater Testing APHA. New York. U.S.A.
3. Bachmann. A. BeardV. L., and McCarty P. L. 1985. Performance characteristics of the anaerobic baffled reactor, War. Res, Vol. 19, pp. 99-106.
4. Bal, A. S. and Dhagat, N.N 2001. Upflow anaerobic sludge blanket reactor- A review, Indian, J. Environ. Health. 43(2), 1-82.
5. Barber, W.P. and Stuckey. D.C. 1999. The Use of the Anaerobic Baffled Reactor (ABR) for Wastewater Treatment: A Review. Water Research. 33(7) pp. 1559-1578.
6. Boopathy R. LarsenV. F. and Senior E. 1988. Performance of Anaerobic Baffled Reactor. (ABR) in treating distillery wastewater from a Scotch Whisky factory, Biomass, Vol. 16, pp. 133-143,
7. Chernicharo, C.A.L., 2007. Anaerobic reactors biological waste water treatment series.V.4, IWA Publication, London.
8. Grobicki, and Stuckey D. C. 1991. Performance of the anaerobic baffled reactor under steady-state and shock loading conditions, Biotechnol. Bioengg., Vol. 37, pp. 344-355.
9. Krishna GVT, Kumar P, Kumar P. 2008. Treatment of low strength complex wastewater using an anaerobic baffled reactor (ABR). Bioresour. Technol. 99: 8193-8200.
10. Krishna GVT, Kumar P. Kumar P. 2007.Treatment of low- strength soluble wastewater using an anaerobic baffled reactor (ABR). J. Environ. Manage. 90: 1-11.

11. Liu, R. R. Q. Tian, B. Yang, and Chen J. H. 2010. Hybrid anaerobic baffled reactor for treatment of desizing, wastewater. Int. J. Environ. Sci. Tech., vol. 7, no. 1, pp. 111-118.
12. Rittmann, B.E., Mc Carty, P.L., 2001. Environmental biotechnology; Principles and applications. Mc Graw – Hill International Edition, New York.
13. Setiadi T, Husaini, and Djajadiningrat A..1996. Palm oil mill effluent treatment by anaerobic baffled reactors: Recycle effects and biokinetic parameters," Water Science Technology, Vol.34,pp. 59-66.
14. She Z.L, Zheng X.L, Yang B.R, Jin C.J, Gao MC. 2006. Granule development and / performance in sucrose fed anaerobic baffled reactors. J. Biotechnol. 122: 198-208.
15. Uyanik S. Salls PJ, Anderson GK. 2002a. The effect of polymer addition on granulation in an anaerobic baffled reactor (ABR). Part 1: process performance. Water Res. 36: 933-943.
16. Wang JL. Huang YH, Zhao X., 2004. Performance and Characteristics of an anaerobic baffled reactor. Bioresour. Technol. 93: 205-208.