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Wastewater Treatment from Antibiotics Plant(UASB Reactor)

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ABSTRACT: Upflow anaerobic sludge blanket (UASB) reactors have been widely used for treatment of industrial wastewater. In this study, performance of a lab-scale up-flow anaerobic sludge blanket (UASB) reactor, treating a chemical synthesis-based pharmaceutical wastewater, was evaluated under different operating conditions. A (P.E) pipe with a diameter of 250 mm and total height of 120 cm and effective height of 100 cm with approximate volume of 49 liter was used as a reactor. The loading rates on reactor were increased in steps to assess the maximum loading capacity of the reactor to study the performance of reactor at different loading rates. The COD concentrations used in the present investigation ranges between 1850 mg/L to 15170 mg/L. The performance of the reactor up to 10.81 kg COD/m^3.d was evaluated and the hydraulic retention times were examined. During this study, which lasted for 120 days, the temperature of the wastewater entering the reactor ranged from 30 to 35 ^{o}C and no heat exchanger was used. Finally the removal ratio of COD with hydraulic retention time of 33.7 hours and organic loading rate of 10.81 kg COD/m^3.day were 54 percent respectively.

Key words: Anaerobic Treatment, Synthesis-Based Pharmaceutical, Industrial Wastewater,UASB

INTRODUCTION

Among all the pharmaceutical drugs that cause contamination of the environment, antibiotics occupy an important place due to their high consumption rates in both veterinary and human medicine. In recent years, the incidence of antibiotics resistant bacteria has increased and may people believe the increase is due to the use of antibiotics (Walter and Vennes, 1985). Antibiotics are emerging contaminates in the aquatic environment because of their adverse effects on aquatic life humans. Antibiotics wastewater has high COD and very low BOD and hence is difficult to treat biologically. Most of the antibiotics used today are manufactured through chemical synthesis techniques that involve a series of complex chemical reactions (Oktem *et al.*, 2007). The synthesis-based pharmaceutical wastewater contain a variety of organic and inorganic constituents including spent solvents, catalysts, additives, reactants and small amounts of intermediates and products, and may therefore be high in chemical oxygen demand (Fent *et al.*, 2006; Oktem *et al.*, 2007). It is estimated that approximately half of the pharmaceutical wastewaters produced worldwide are discarded without specific treatment (Lang, 2006 ; Enick and Moore, 2007). Major unit operations in synthesized organic chemical plants generally include chemical reactions in vessels, solvent extraction, crystallization, filtration, and drying. The waste streams generated from these plants typically consist of cooling waters, condensed steam still bottoms, mother liquors, crystal end product washes, and solvents resulting from the process (Sudhir *et al.*,1992). Synthesis-Based pharmaceutical wastewater is not suitable for physical and/or chemical treatment because of their low efficiency for dissolved COD removal and high consumption of chemicals. The high COD concentration in such pharmaceutical wastewaters makes them potential candidates for anaerobic technology (Enright *et al.*, 2005 ; Chelliapan *et al.*, 2006). Anaerobic processes have become a viable option for the treatment of medium-high strength industrial wastewaters. The most important merits of anaerobic treatment are the ability to treat high strength wastes, low energy input, low sludge yield, low nutrient requirement, low operating cost, low space requirement and net benefit of energy generation in the form of biogas (Acharya *et al.*, 2008 ; Mahmoud, 2008). These favorable characteristics of anaerobic processes together with

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suitable environmental conditions have contributed to highlight anaerobic systems for the treatment of synthesis-based pharmaceutical wastewater. Upflow anaerobic sludge blanket (UASB) reactor is a popular anaerobic reactor for both high and low temperature and among the recently developed high-rate processes, has probably attracted most commercial and research interests (Lettinga *et al.*,1980). This reactor has been employed in industrial and municipal wastewater treatment for decades since it was developed by Lettinga and his co-workers in the 1970s (Lettinga *et al.*,1980). The UASB reactor has four major components: 1) sludge bed, 2) sludge blanket, 3) gas–solids separator (GSS) and 4) settlement compartment (Metcalf and Eddy, 2003). Compared with other anaerobic technologies, UASB has some remarkable advantages such as high organic loadings, great efficiency, low energy demand, short hydraulic retention time (HRT) and easy reactor construction. One of the main obstacles for the application of UASB is long start-up time, usually 2–8 months, needed for the formation of granules. Performance and stability of these reactors depend a lot on sludge granulation, but the success of the self-immobilization process is not warranted, since several factors affect this process (Kalyuzhnyi *et al.*,1996). In fact, these reactors are designed to pretreating soluble non-complex wastewater and complex partially soluble wastewater. This research was carried out to study the feasibility of UASB process as a pretreatment for Iran chemical synthesis-based pharmaceutical wastewater treatment. This factory is located in north of Iran. In this factory Amoxicillin and ampicilin produce among synthetic methods and 6-Penny Sylanyk amino acid (6-PAA is intermediate material to produce both of Amoxicillin and Ampicilin) produce in semi-batch method (using enzyme reactors).

MATERIALS & METHODS

The UASB reactor used in this study was made with a pipe of 250 mm inner diameter, a total height of 120 cm, an effective height of 100 cm, and a total volume of 49 liter (Fig.1). An outlet was provided at the top, which is connected to the effluent tank. On the top of the reactor a gas solid separator is provided to separate gas and solid raised due to the upward movement of the feed. This reactor was fed with synthesis-based pharmaceutical wastewater from the Wastewater Treatment Plant of Antibiotics factory that is located in north of Iran. In order to develop the desired organic loading rate, 2 parameter that so called COD and the influent flow rate to the reactor was changed. Following each change in the organic loading rate the reactor was allowed to reach steady state. The wastewater was introduced at the bottom of the reactor though a tube with a 50 mm diameter and distributed over the cross-section by means of a perforated Plexiglas plate, which was placed about 25 cm above the feed tube. Sample ports were placed at 30 and 80 cm intervals throughout the height of column with an additional port at the bottom of the reactor (the port used for solids removal). The performance of the reactor in reduce COD was monitored through 24-hour flow weighted composite samples, taken from inlet and sample ports. It should be mentioned that the average wastewater temperature and pH were monitored daily and all the analyses were carried out according to the Standard Methods (SM, 1998).

About 40 liter sludge from outlet of activated sludge from domestic wastewater plant and 10 liter synthetic wastewater from Iran's antibiotics building and 100gr sawdust mixed in vague plastic and hold in anaerobic condition to produce biogas. Subsequently, 30 liter of this solution added to reactor to productive this reactor. II) Synthetic wastewater with a COD concentration of 1850 mg/L was used as primary substrate. This medium was completed with drinking water and after 88 days concentration raised to 15170 mg/L. III) To provide convenient alkalinity and neutral pH, 3500 mg/L $NaHCO_3$ was added to the UASB reactor.

The inoculums for seeding the reactor were brought from wastage of activated sludge from domestic wastewater plant. 40 liter sludge from this sample that characteristics is shown in Table 1, associated with 10 liter synthetic wastewater from Iran's antibiotics building mixed in vague plastic vessel and hold in anaerobic condition to produce biogas. To prevent transforming wastewater into septic, it was shaked daily and after 15 days was prepared. After that, 30 liter of this solution added to reactor.

Table 1. characteristics of utilized sludge for seeding of reactor

Character / Source	VSS (mg/Lit)	TSS (mg/Lit)	VSS/TSS	pH
Domestic Wastage	6680	10200	0.655	7
Equilibrium Tank of Factory	39	80	0.488	6.9

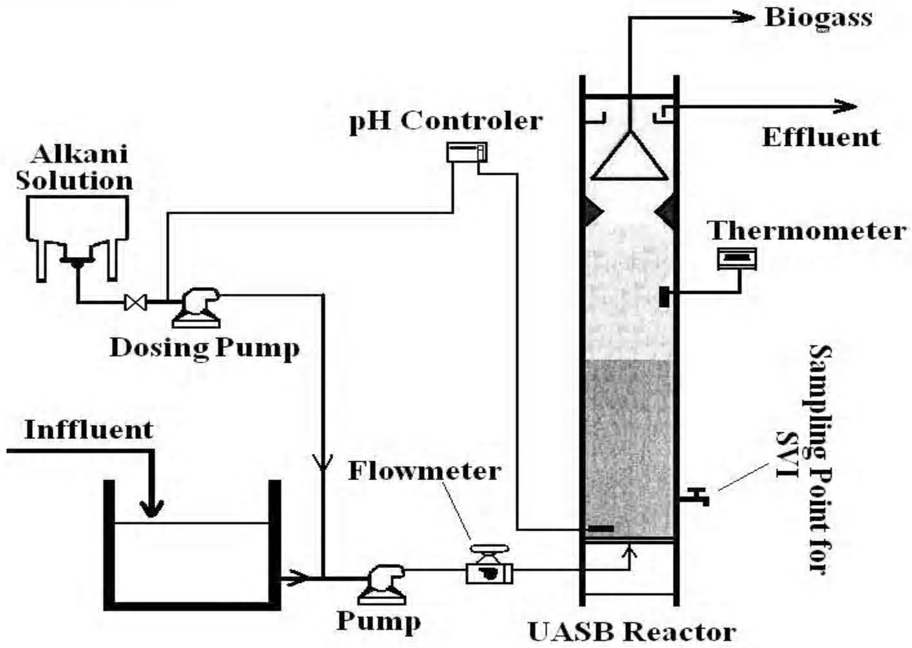

Fig. 1. Sketch map of the UASB reactor

Operations of bioreactors

In the start-up period, the UASB reactor was continuously fed with synthetic wastewater. During the start-up period, the reactor was operated to be fed with increasing of organic loading rate. Increasing organic loading rate from 0.96 kgCOD/m^3.d to 10.81 kgCOD/m^3.d performed in 2 methods: by increasing the flow rate or increasing the COD in 12 steps that can be observed in Table 2. In these changes the concentration of COD in the reactor were increased sequentially from 1850 to 15170 mg/L and the hydraulic retention time (HRT) decreased from 46.2hr to 39.3hr, 35.7 and then 33.7hr. And In the first week of testing, while organic waste at the entrance to the reactor increases, a small decline in output efficiency of the pilot are likely to occur because of the need to accustom with the new conditions of microorganisms.

RESULTS & DISCUSSION

The start up period of an anaerobic UASB reactor is directly proportional to the concentration of the microbial population. Rate of start-up depends on the type of inoculums, the type and strength of waste, level of volatile acids maintained. Temperature was measured daily in UASB reactor inlet and outlet with an electronic temperature meter. The temperature was kept in mesophilic condition (30 to 35°C) by controlling the temperature of room, where the UASB reactor was kept in it. pH was measured daily in reactors inlet and outlet with a pH meter probe and to control alkalinity of inlet, a sensor was located in body of reactor that could realized decreasing the alkalinity and announce to dosing pump and The pH of the reactor feed is always maintained neutral by adding necessary amount of $NaHCO_3$. The outlet pH is found to be in the range of 7–7.5 indicated an active metabolism of the methanogens. The best operation of anaerobic reactors can be expected when the pH is maintained near neutrality (Sudhir *et al.*,1992 ; Lettinga *et al.*,1980). Soluble COD in UASB reactor influent and effluent was measured per day and the reactor was operated in a continuous mode of operation. Also after experimental process analysis of alkalinity, sludge volume index (SVI) and COD were conducted in accordance with Standard Method (SM, 1998). Best utilization of the reactor, respectively in organic loading rate of 10.81 kg COD/m^3.day and hydraulic retention time of 33.7hr. Stable efficiency in this condition is 55.4 percent after 88 days. Summary results of experiments are shown in Table 2 and Figs 2 to 6.

Removal performance of the UASB reactor in terms of COD, HRT and organic loading rate is shown in Table 2. On the basis of the obtained results, the optimum removal of COD is 54% with an organic loading of 10.81 kg COD/m^3.d, occurred at an HRT of 33.7 hr. Increasing the HRT from 46.2 to 33.7 hr resulted in additional removal of COD 10% & 16% respectively at temperature range of 30 to 35° C. In days leading 29-34 the efficiency of pilot dropped due to reduction in the alkalinity of reactor. This problem was resolved by re-setting the dosing pump through increasing salt $NaHCO_3$ to the current input.

Table 2. Summary results of experiments on pilot

Days of Experiment	Q (lit/day)	HRT(hr)	UpflowVelocity (m/hr)	Influent COD (mg/Lit)	Organic Loading Rate $kgCOD/m^3.d$	Maximum Efficiency (%)
1-14	25.5	46.2	0.022	1850	0.96	13.5
15-28	25.5	46.2	0.022	2180	1.13	31
29-38	25.5	46.2	0.022	3650	1.90	31
39-48	30	39.3	0.025	3650	2.23	34.9
49-58	30	39.3	0.025	4860	2.97	40.8
59-68	30	39.3	0.025	7150	4.37	42
69-76	33	35.7	0.028	7150	4.81	46.8
77-86	33	35.7	0.028	9215	6.20	52
87-94	33	35.7	0.028	10630	7.15	56.1
95-100	35	33.7	0.030	10630	7.57	54.6
101-110	35	33.7	0.030	12425	8.85	55.3
111-120	35	33.7	0.030	15170	10.81	54.4

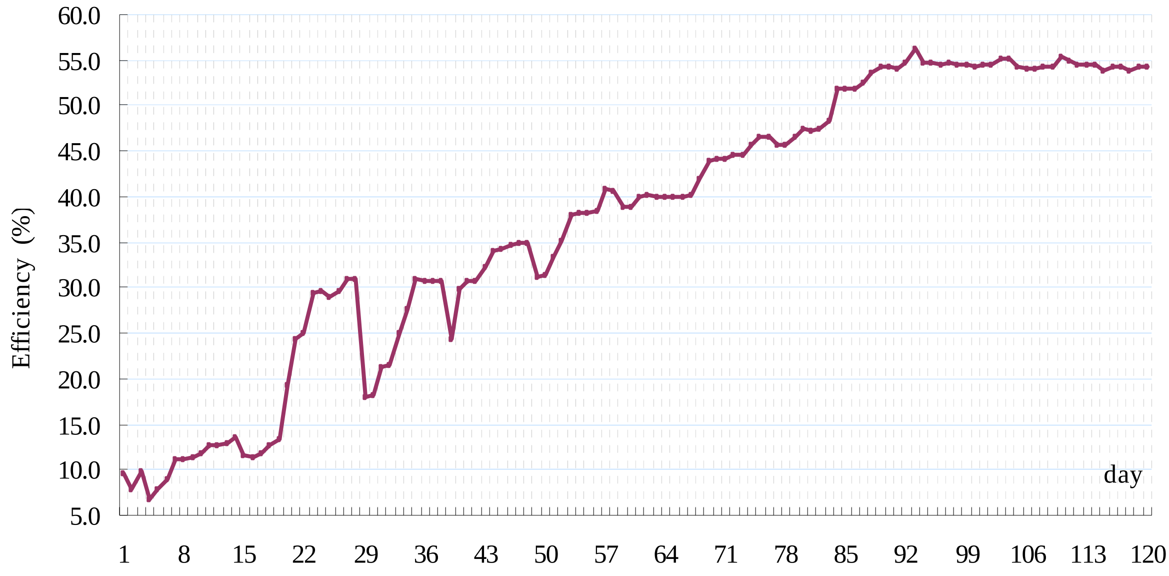

Fig. 2. Efficiency of pilot

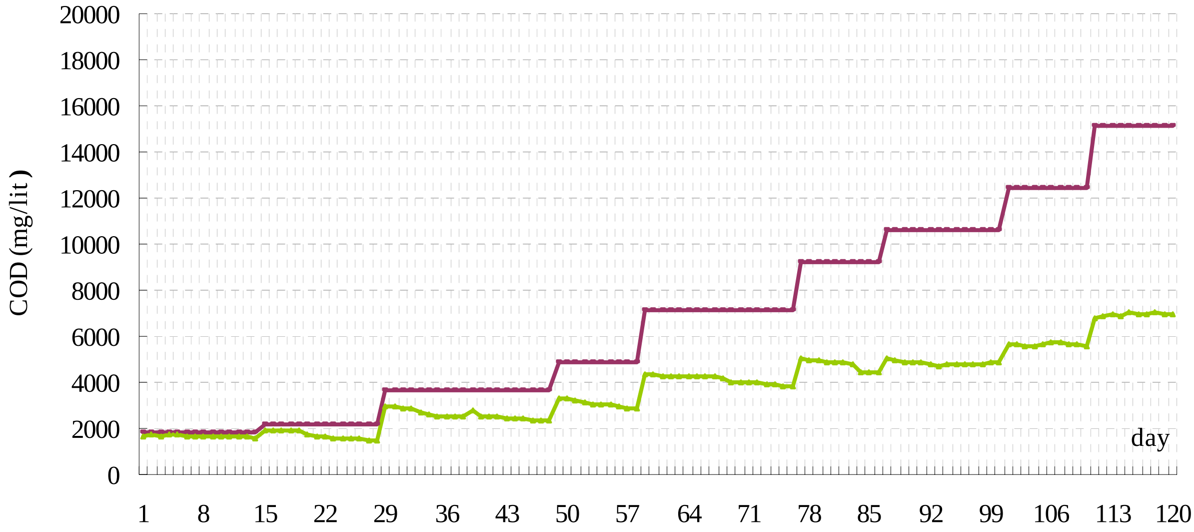

Fig. 3. COD values of input and output of UASB

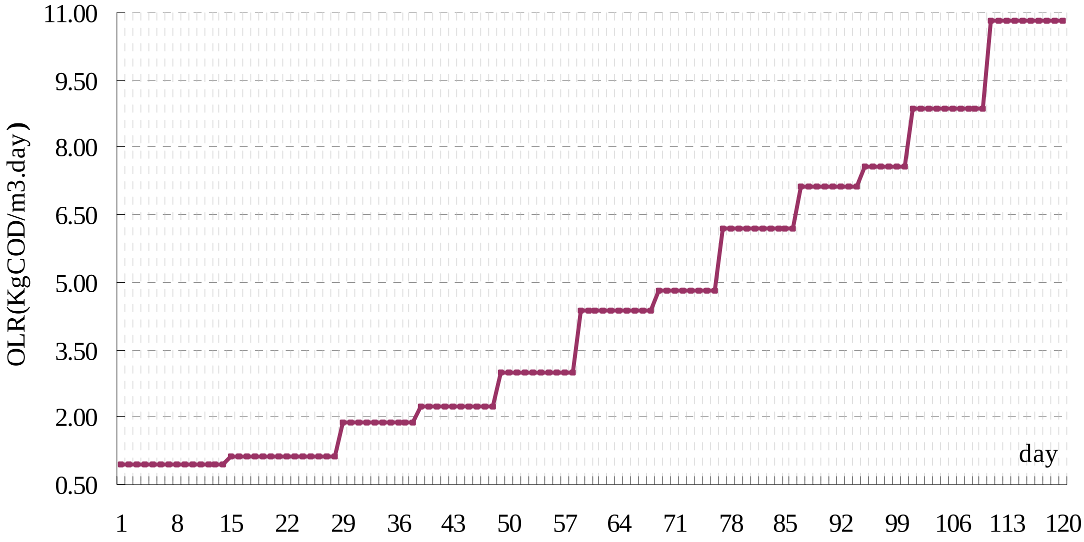

Fig. 4. Organic loading rate (OLR) of UASB

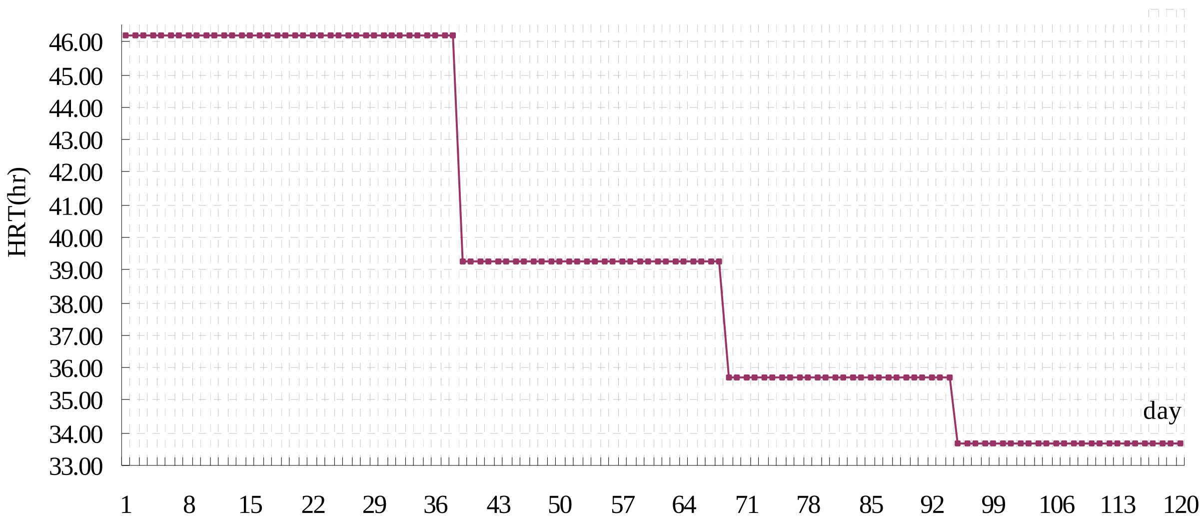

Fig. 5. Hydraulic retention time of UASB

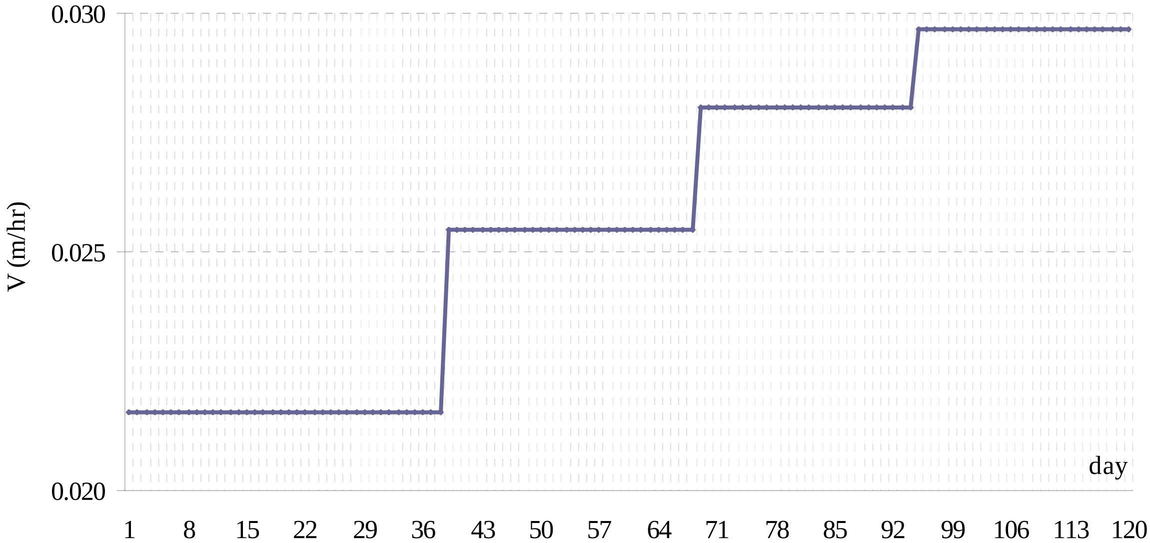

Fig. 6. Speed-up in UASB

CONCLUSION

From the data presented in this experiment the following conclusions can be drawn:

• The UASB reactor could be used as an effective pretreatment alternative for treatment of pharmaceutical wastewater,

• The efficiency of the pilot has been gradually rising through course of time,

• Due to the nature of wastewater, we preferred to add light nutrient such as sugar solution and

• Reduction of alkalinity can lead to lower efficiency of reactor.

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