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Treatment of canned fish factory wastewater by upflow anaerobic sludge blanket (uasb) reactors

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Abstract

Application of UASB method for wastewater treatment of canned fish factory reduces the costs of pre-treatments processes such as neutralization, and also reduced the costs of final aeration process. In this study, an UASB reactor which was equipped with a 3-phase separator system has been used. At first, a complex of anaerobic digester sludge and return sludge of activated sludge was added to reactor with ratio of 25 to 15. Then, the wastewater of factory entered into the reactor with inlet Organic Loading Rate (OLR) of 0.5 kg/m3.day which was increased gradually up to 4 kg/m3.day. Then, sampling was done for various tests during 75 days. The results of this study showed that UASB method neutralized and reduced the pH of the inlet wastewater from 10.5 to 7.3; and also reduced the SS of the inlet wastewater from 43 gr/l to 8 gr/l. the COD removal rate of this method was around 87%.

Keywords: canned fish wastewater, anaerobic treatment, UASB, COD, OLR.

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1. Introduction

In under developing societies, around 75 to 80 % of water consumption will became wastewater, which must be rejected from societies. If these wastes are the result of industrial activities, we call it “industrial wastewater”. In addition, there are other kinds of wastewater such as urban and agricultural wastewater that threat the human life. The physical and chemical and biological methods which are divided into two categories of aerobic and anaerobic are among the wastewater treatment methods. Because of ability for treatment of highly contaminated wastewater (such as industrial wastewater) and lower costs, the anaerobic methods are widely applicable for treatment of industrial wastewater. UASB anaerobic systems have a special place among the anaerobic treatment methods.

UASB reactor is a kind of anaerobic biological treatment method that has been invented for the first time by Lettinga in the Netherlands in 1979 and after that, it was widely used for the treatment of different kinds of wastewater, especially industrial one (such as food and paper industries) (Forster, 1999; Patil, Kulkarni & Kore, 2012). The especial design of UASB reactor allowing the separation of three phase of solid, liquid and gas, inside of a reactor, which will increase the capabilities of the system (Gahngrekar, Aslekar & Josh, 2006; Aina, Kpondjo & Adounkpe, 2012).

By considering the mentioned characteristics of the UASB systems, we defined a project to apply this method in a laboratory research for treatment of canned fish factory wastewater. In this study, we investigated the ability of UASB reactor for primary treatment and removal of organic compounds from canned fish factory wastewater.

2. Material and methods

The UASB reactor used in this study was designed and created in accordance to previous studies and integrating of the available information in this field. Total volume of the reactor is about 117 L and it was equipped with a 3-phase (solid-liquid-gas) separator system. The cylindrical reactor was made of P.V.C material and placed on a steel base. The height of the reactor from entrance point to the highest point was equals to 254cm and internal diameter was equals to 24cm. sampling valves placed in 5 proper points on the body of the reactor for monitoring and quality control of sludge inside of the reactor. Also for sampling from inlet wastewater into reactor and outlet swage, some proper places installed on inlet and outlet path toward the reactor. This study was performed on mesophilic conditions (mean temperature between 30-35°C) in order to reach better performance and achieving higher efficiency. The Coarse particles settling on the upper part of the entrance, but remaining suspended because of upward flow of fluid inside of the reactor. On the upper part of this zone, which is under the 3-phase separation zone, settling will occur as a result of collision and sticking of sludge particles together and forming of heavier flocks. Low height of this zone (lower than 1m) cause to the washing of sludge and smaller granules, which itself leads to adverse operation and performance of the system. on the other side, too much height of settlement zone, will cause additional costs of construction and operation (Vierra & Garcia, 2002; Muthusamy, Murugan & Manothi, 2012) so, in this study, the height of this part of the reactor selected around 170 cm. for monitoring of concentration variations and particles size, 5 sampling valves with same distance equals to 50 cm installed in this zone.

The fluid inside of the reactor after passing through a spillway was discharged from reactor. Inside of the reactor, there was a specific part that designed for collecting of bulbs generated inside of the reactor.

For primary inoculation of reactor, 60 L digester sludge of municipal wastewater treatment and 15 kg cow dung and also 20 L sludge of industrial wastewater treatment were mixed together. For adaptation of bacteria with wastewater and fresh food, diluted wastewater discontinuously added into the reactor during a month, in order to reach to the complete mixing, and with it some Nitrate and phosphate fertilizer were added into the reactor to supply nitrogen and phosphorous requirements of bacteria. The specifications of the used sludge are presented in Table 1.

Table 1. Specifications of sludge which were used for inoculation of the reactor.

parameter	values
TSS	9800 mg/L
VSS	6200 mg/L
Temp	34 °C
pH	6.8

Table 2. Characteristics of canned fish factory wastewater.

Wastewater characteristics	Range of measuring (mg/l)	Mean values(mg/l)
COD	1500-3200	2500
BOD	700-1800	1100
TKN	0-0.8	0.3
TP	0.5-2.5	1.2
PH	8.5-13	10.5
Alkalinity(mg/$CaCO_3$)	110-300	230

After achieving the required efficiency of COD removal, second stage has started by switching the operating mode of the system from continuous to batch mode. Nutrients added to the reactor were same as previous stage and the only change was the increase of methanol in inlet flow of the system which must have been considered in the calculation of COD. Methanol was increased to accelerate the growth of methanol bacteria to complete the anaerobic process by consumption of the acid produced by acidic methanol and on the other side, balance the pH of the system (Berrueta & Gutierrez, 1998; Patil, 2012). Converting of operation mode took several steps. At first, the system was operated continuously just 1-3 hours per day for 10 days and at the rest of the time operated in batch mode. At next step, 6-8 hours per day for 10 days, and then 15-20 hours per day for 20 days and finally, 25 days operated in continuous mode. As expected, during these steps duo to the fluid discharge from the system, the washing and leaving of the sludge was a critical issue, and making proper strategies and predictions will be necessary to prevent washing of the sludge and any stopping in operation of the system which is duo to VSS (Volatile Suspended Solids) reduction at inside of the system. So, at the beginning of this step, the velocity of the system kept down as possible and inlet OLR was kept constant at 4 kg COD/m3.day. At the end of the period, hydraulic retention time and inlet concentration was 18 hr and about 300 mg per L, respectively, and this step lasted for 70 days. The criterion for completion of the continuous stage was reaching to more than 70% COD removal rate, which at this study was about 86%.

3. Results and Discussion

For more precise examine of obtained results during two stages of operation at the reactor, we presented tables and graphs as below. 80 L of mixed sludge (aerobic and anaerobic) were added to the reactor. With respect to the change of conditions, some micro-organism that were vulnerable relative to these variations, have been vanished. This issue can be readily concluded by measuring the activity of micro-organism during first 10-15 days of operation and with attention to the VSS reduction from 33.8 to 6.9 g/l and reduction of SS from 43.2 to 8 g/l. Fig. (1) shows the SS reduction in the outlet flow of the system.

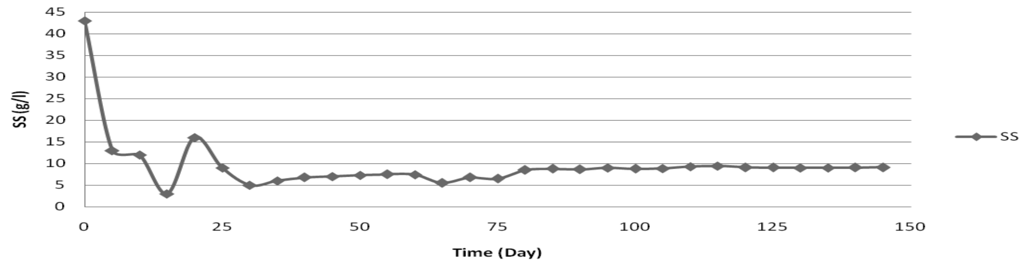

Fig 1. Reduction of SS in the outlet flow of the system

When the growth rate of micro-organism was entered into the new stage and parallel to increase of OLR about 25 days after inoculation of the reactor, the sludge cloud was largely formed and this issue was continued till the complete filling of the reactor by these mass of sludge. During this period of time, pH was permanently monitored in order to prepare optimal conditions for growth of the micro-organism. PH of the system was kept about 7.5 by adding of soda and lime to the system.

For better control of the system during first stage of operation, the sampling was repeated every 5 to 10 days. The main purpose of this stage was successful commissioning of the system and providing suitable conditions for formation of granules. OLR was increased up to 4 kg COD/m3.day during continuous operation stages. Although volatile acids aggregation and increase of their concentration, this value reduced immediately, but after a while the increment rate of OLR took place again.

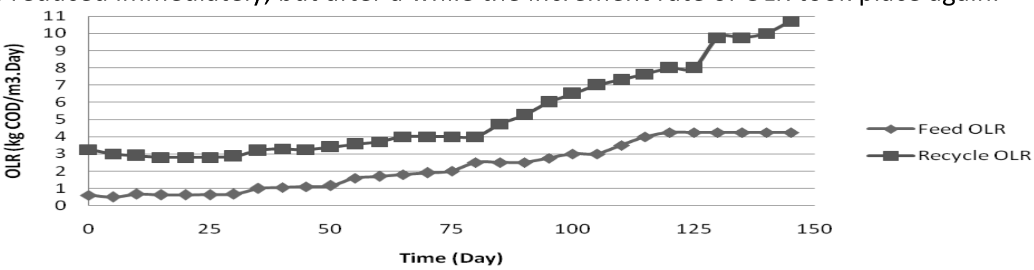

Fig 2. Comparison of inlet and outlet OLR to the system

During operation and at the beginning of study, two granule kinds with relatively distinct differences were in the system. First group were dull reddish granules with a very pungent odor and low pH (about 4) and were more at the lower parts of the reactor. The second group was black granules with less odor than previous groups of granules. Environmental pH of this group of bacteria was higher and about 6-7.5. The first group was acidic granules and second group were methanol bacteria, and this is a suitable method for primary recognition of granules at the UASB reactor (Bitton, 2003; Pascal, Agbangnan, Christine & Tachon, 2012).

As a result of speeding up the velocity in the system, single and lighter micro-organisms which had lighter viscosity washed away from the system. Also, it must be mentioned that after the addition of the sludge into the system and filling it, returning flow path of the sludge changed from outlet of the system at above of the reactor to inlet of the system at bottom of the reactor. This subject is one of critical issues for creation of granules with spherical shape and proper biological activity (Costello & Lee, 2001; Swapnil, 2012; Baroniya, Baroniya Sanjay & Jain, 2012). At the end of this period, it was observed that granular sludge had particles with different sizes.

larger granules remains at the bottom of the reactor or at the sludge bed and by going upward, the diameter and size of the granules decreased which can be confirmed by measuring VSS in various heights of the reactor. Interestingly, the removal efficiency of the organic matter in the fluid is directly related to the diameter of the granules and size of the particles. It is duo to the accumulation of the very active microorganism in the structures of the granules and increasing of its efficiency. It was observed that 70% of the system efficiency occurs at lower one third of the height of the reactor. So it can be claimed that decrease of COD concentration related directly on the size of the granules.

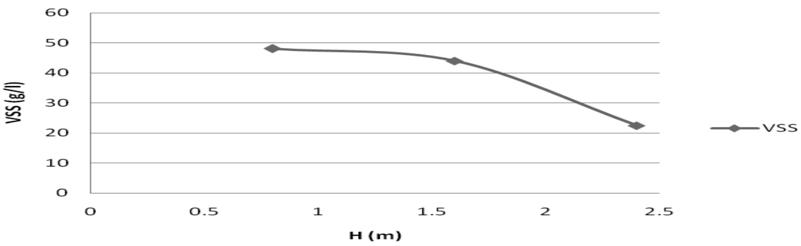

Fig 3. VSS concentration in the height of the reactor

According to COD removal rate measurement at various heights of the reactor, this result is achieved that there is limitations in increase of reactor height and excess increase is not effective on performance. According to conducted sampling, first granules were observed as small round particles with diameter of about 1 mm at 70-75 days. At the end of this period, larger granules with diameter of about 2-3 mm formed and COD removal rate reached to about 86% which is an acceptable value. Fig (4) and (5) shows the variations of inlet and outlet COD and removal rate of COD during the experiments.

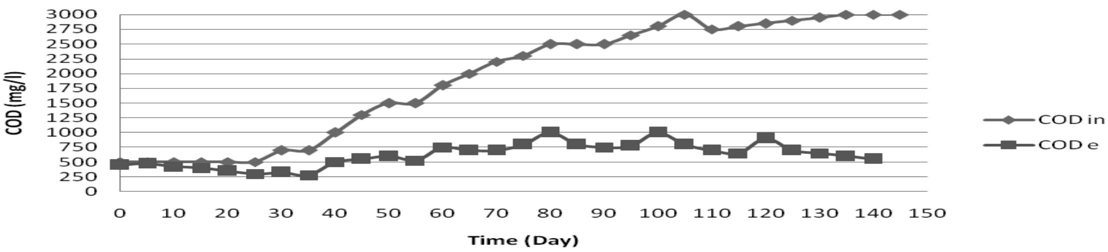

Fig 4. comparison of inlet and outlet COD

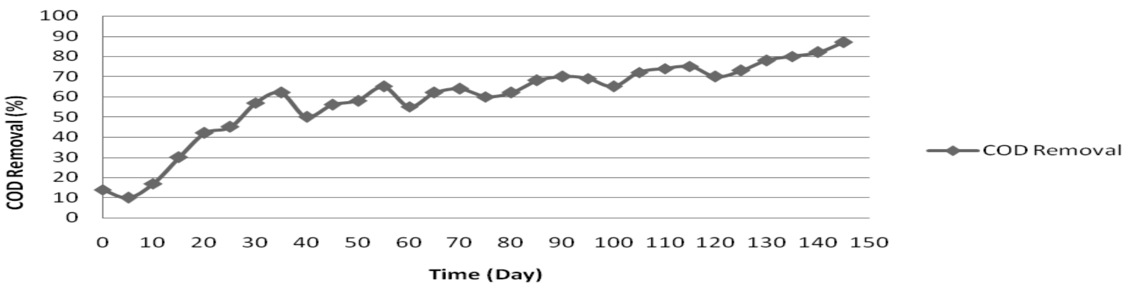

Fig 5. COD removal rate during the experiments

4. Conclusion

Duo to the variety of compounds and high load of certain pollutants, the treatment of canned fish factories wastewater must be all-examined and according to the characteristics of different sections of treatment process, the desirable option is selected and used. It means that for an appropriate treatment in accordance with wastewater treatment regulations, a wastewater treatment plant consist of different sections and various contaminants removal efficiencies is required. Application of UASB process in treatment of food industry wastewater reduced the costs of pre-treatment stages such as neutralization and also, reduced the costs of final aeration process. The organic load resistance of UASB reactors is different for wastewater of various industries. In this study, application of 4.5 kgCOD/m3.day organic load from food industries wastewater had acceptable performance. In this study, COD removal efficiency from food industries wastewater by UASB process was about 86 %. For treatment of cannery industries wastewater, in order to provide sufficient retention time and right up-ward velocity, at least 2.5 m height must be considered for the reactor. On start up of the process with wastewater as a matter of food, two kinds of granules with relatively different characteristics were observed in the reactor. Firs group were dull reddish granules with a very pungent odor and low pH which were more at the lower parts of the reactor. The second group was black granules with fewer odors than previous groups of the granules. Environmental pH of this group of bacteria was higher and about 6-7.5. The first groups were acidic granules and second group were methanol bacteria.

Duo to the sensitivity of the microbial mass of UASB anaerobic system, and severe reduction of removal efficiency during the fall of temperature, application of mesophilic system for treatment of industrial wastewater at temperate and cold regions is not recommended, because a lot of costs will be needed to heat the system which doesn't justify the application of it. So, in regions with warm climates and mean temperature of at least 25 °C, the system performance will be useful and acceptable. By regarding the same operation conditions, partial destruction of weaker granules during adjustment and feeding by wastewater can be attributed to the presence of complex and hard-degradable and even toxic compounds in the wastewater which affect on the microbial tissue of the system. As compounds of the feed becoming more complex and hard-degradable, formation and durability of the granules in the UASB system will be slower and finally, smaller granules will be formed, in comparison to the system onsist of wastewater with easy-degradable compounds. This topic is relateşd to the mass transfer equations. In the case of granules with large diameter, the penetration of complex organic compounds into it will impaired which finally will leads to the death of bacteria in core of granule and happening of scattering of granules phenomena and significant increase in the outlet and drop of removal efficiency of the system.

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