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An Insight into Research and Studies on UASB Reactor for Wastewater Treatment

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ABSTRACT

Domestic and industrial wastewater treatment can be carried out by using physical, chemical and biological treatment methods. Biological treatment facilities are important treatment step in wastewater treatment. Aerobic and anaerobic treatments can be carried out to minimize chemical and biological oxygen demand. Anaerobic treatments are effective treatment methods with high treatment efficiencies. Upflow anaerobic sludge blanket (UASB) reactors are gaining importance because of high conversions and cost effectiveness. The high percentage of methane in the generated gas is advantage as it can be used as a fuel. The present review summarizes research and studies on UASB reactors for wastewater and sludge treatment.

Key words: Anaerobic treatment, COD, sludge, HRT, methanogenesis, efficiency.

INTRODUCTION

The treatment of industrial and domestic wastewater is generally carried out in treatment plants comprising of primary, secondary and tertiary treatment. Primary treatment step is physical treatment step, in which coarser solids are removed by bar screens and primary settling. In secondary treatment, biological processes such as activated sludge process or rotating biological contactors are used. Tertiary treatment steps contain chemical and advanced treatments. Investigations for biological treatments are reported for studying operation and affecting parameters. [1-3]

Also chemical treatments for wastewater treatment have shown great promise. [4,5] The treatment of wastewater by different membrane techniques can be employed to have refined water. [6,7] The wastewater treatment by adsorption is also widely studied treatment method. [8-10] Anaerobic treatment methods have advantage over aerobic treatments. They need very less oxygen and also generate less amount of sludge. In tropical climate upflow anaerobic sludge blanket (UASB) reactors show a great promise. At higher temperatures the hydrolysis rate and decrease in the degradable organic matter fraction are high. The current review provides an insight into research and studies on UASB reactor for wastewater treatment.

RESEARCH AND STUDIES ON UASB REACTOR FOR WASTEWATER TREATMENT

Lew et.al. carried out studies on UASB reactor and compared between a classical UASB and hybrid UASB-filter reactor. [11] They conducted experiments at different operational temperatures (28, 20, 14 and 10°C) and loading rates. In hybrid UASB filter reactor, they used 4.0 cm diameter plastic filter rings (100 m^2/m^3 specific surface area) filling the top half of the reactor instead of the standard UASB gas/solid separator. This helped to prevent biomass washout. They observed that both the reactors operated efficiently during startup. They reduced hydraulic retention time from 24 hours to 1 hour. They observed a stable effluent COD concentration in both reactors, even with high fluctuation in influent COD concentration (200-1,300 mg COD/l), for HRTs from 24 to 3 hours (0.04–0.35 m/h up flow velocity). They also found that the

effluent quality deteriorated for both reactor types For HRTs shorter than 3 hours. At lower temperature bacterial activity is less. According to the authors, at lower temperatures (10^0C) solids accumulation in the reactor is more pronounced with better solids retention in the classical UASB.

Davila et.al. used UASB reactor for wastewater treatment and its reuse in small agglomerations. [12] They used a treatment system containing UASB followed by rotating biological contactor. They found that denitrification started immediately after feeding the UASB with nitrate. They also observed that the methanogenesis was negatively affected for two days after starting nitrate addition to the feed and cached up to normal later. They obtained very high nitrite and COD removal rates, nitrate (97.5%) and COD (91%).

Shirule et.al. used UASB reactor treatment for dairy waste water and energy generation. [13] They observed that the degree of removal of organic matter is in direct proportion to the amount of methane produced. The gas generated had 75-80 % methane content. They concluded that the UASB process was one of the most cost effective and efficient anaerobic treatment. García et.al. carried out an investigation on an anaerobic biological reactor in university of pamplona, Colombia. [14] Bhatti et.al. carried out detailed studies aimed at shortening the start up period for UASB reactors. [15] They used two different nutrients during startup period. They tried to decrease the hydraulic retention time from 48 to 24 and 12 to 6 hrs at average temperatures of 25-34 ºC. Initially they fed glucose for 15 days and then macro and micronutrients for 30 days. One more reactor was fed with glucose for 45 days. The COD removal efficiencies were 80 ad 90 % on 8^{th} and 32^{nd} day of first and second stage. The treatment was shifted to municipal wastewater (MWW) mixed with industrial wastewater. Then it was treated the UASB effluent with hydrogen peroxide. The overall removal of 99 percent was observed during the complete treatment. Kasaudhan et.al. carried out optimization of municipal wastewater treatment. [16] Their study involved the wastewater treatment in UASB reactor and polishing pond. They emphasized that effectiveness, low cost, and low energy requirements are advantages of anaerobic treatment. They studied and analyzed operation of 345 MLD capacity plant installed and commissioned in Bharwara, Lucknow. They observed that the hydraulic loading rates were frequently going beyond the designed capacity. According to them it was necessary to pay proper attention towards reduction of algal cell. Algaecide could solve the problem of algal cell reduction.

Aiyuk et.al. analyzed technical problems arising due to treatment of domestic wastewater without pretreatment. [17] They assessed the performance and stability of a domestic sewage treatment system consisting of an upflow anaerobic sludge blanket (UASB) reactor. They obtained 80 percent COD removal in the treatment. The high production of sludge necessitated frequent discharge of solids. Perturbations were observed due to sludge discharge. Vieira et.al. studied the application of UASB for sewage treatment. [18] According to them, for new small communities of low income population UASB can solve sewage treatment problem. They observed that average removal rates of BOD, COD and TSS were 80%, 74% and 87%. UASB reactor was used for milk wastewater by Barampouti et.al. [19] They developed dynamic models for prediction of the efficiency of a UASB reactor. They examined parameters like % COD removal efficiency, influent COD, COD reduction, biomass produced, biogas production rate, % methane in biogas, alkalinity, reactor's temperature and RedOx, recirculation vessel's temperature and pH. According to these studies, the methodology of regression analysis by residuals for the construction of a dynamic model was very satisfactory.

Yasar and Tabinda integrated a UASB reactor with UV and AOPs (advanced oxidation processes) (Ozone, H2O2/UV, Fenton, and photo-Fenton) for industrial wastewater treatment. [20] Highly effecive treatment can be achieved with proper control over the parameters like temperature, sludge age, pH, hydraulic retention time. AOP effectively accomplish pathogen elimination. According to them AOPs with anaerobic treatment minimizes the chances of regrowth. Sousa et.al used UASB reactor for anaerobic digestion and denitrification. [21] They carried out anaerobic digestion and denitrification in the same reactor. They obtained COD removal efficiency of 71 percent and denitrification efficiency of 90 percent. They concluded that denitrification in UASB reactor was a viable option. Moe and Aung constructed laboratory scale upflow anaerobic sludge blanket (UASB) reactor for distillery wastewater from Mandalay Winery and Distillery Plant. [22] Due to lowering of temperature during night, removal efficiency was low during night time. Maalim et.al. carried out an investigation on effect of effective microorganisms(EM) on biogas production in UASB reactor. [23] They treated domestic wastewater under tropical conditions. They observed higher average biogas production and yield in the UASB-EM reactor than the UASB control reactor. They found that EM consortium enhances biogas production and quality. EM consortium produced biogas containing 78 percent methane and UASB control reactor produced biogas containing 72 percent methane. Hampannavar and Shivayogimath treated sugar industry waste in UASB reactor. [24] They seeded the reactor with nongranular anaerobicallly digested sewage sludge. They achieved successful reactor startup with granulation within 95 days of operation. They observed that during startup HRT reduced considerably. They increased organic loading by increasing the COD concentration of the feed at constant HRT of 6 h. They concluded that sugar industry wastewater can be treated at maximum loading of 16 g COD/L at low HRT of 6 at ambient temperature.

Low-strength effluents were treated by UASB reactor by Ganesh et.al. [25] They highlighted the importance of research in treatment of low strength effluents. They treated low-strength dairy industry wash waters with chemical oxygen demand of (COD) 1200-2000 mg/l by the successful operation of UASB. They were able to achieve treatment efficiency of the order of 75-85%. Also they observed that the treatment system could withstand shock-loads without adversely affecting the treatment efficiency. Importance of sludge granules in biodegradation anaerobic process has been established in many investigations. Habeeb et.al. explained the concept of up-flow anaerobic sludge bed UASB reactor operation. [26] According to them, the extracellular polymer (ECP) was reason for bacterial cell correlations and the formation of bacterial communities in the form of granules. They also studied the factors such as temperature, organic loading rate, pH, and alkalinity, nutrients, and cations and heavy metals. Methanogenic activities are practically found in the core of granules.Takahashi et.al. treated municipal sewage in UASB reactor at ambient temperature. [27] Their study indicated that the biodegradation increased due to higher water temperature(>20^0C). Powar et.al. reviewed UASB technology for wastewater treatment. [28] According to these studies, UASB reactor is feasible for treating variety of wastewater. They emphasized that proper HRT should be provided to give sufficient contact time between wastewater and bacteria. Neena et.al. treated coconut husk leachate using UASB-reactor. [29] They analyzed the parameters like VFA, pH, COD and polyphenols. They observed that the polyphenol, VFA and COD were diminished gradually with time. The reactor was able to convert about 82% of the total COD/kg husk to biogas. According to them,

detailed study is required in the direction of phenolic toxicity to anaerobic organisms.

Mirsepasi et.al. carried out an investigation on stillage wastewater treatment by using UASB. [30] In both the reactors, they investigated parameters like pH, temperature and efficiency of COD, BOD, and TOC removal. Also design parameters like upflow velocity, organic loading rate (OLR) and hydraulic retention time were investigated by them. According to them, it is necessary to prevent sudden changes in environmental conditions and wastewater characteristics. They found that, with expansion of granules in the bed of the reactor, it is possible to increase the removal efficiency above 80 percent.

Lomte and Bobade carried out studies on sustainability of UASB in tropical climate like India. [31] In recent years UASB is most widely adopted method. In their studies, they reviewed designs of UASB reactors and their suitability for application in tropical and subtropical regions. According to them there is need to develop efficient method to recover essential nutrients like nitrogen, phosphorous, etc. from the treated effluent. Graaff et.al. described treatment of concentrated black (toilet) water. [32] They carried out this treatment in UASB reactor at a short HRT. They observed that 53% of the suspended solids were hydrolyzed to methane. Ruiz et.al. carried out an investigation on performance and biomass characterization in a UASB reactor. [33] They treated domestic waste water in a laboratory-scale upflow anaerobic sludge blanket (UASB) digester. They kept retention time less than 24 hours. They observed that there was decrease in COD removal due to decrease in HRT. The COD removal efficiencies increased by 5 percent when the UASB digester was used in combination with a completely mixed sludge digester (CMSD) system for the external digestion and stabilization.

CONCLUSION

UASB process is of the most cost effective & efficient anaerobic treatment. Proper HRT should be provided to give sufficient contact time between wastewater and bacteria. For new small communities of low income population UASB can solve sewage treatment problem. In UASB reactor the degree of removal of organic matter is in direct proportion to the amount of methane produced. For smooth operation, it is necessary to prevent sudden changes in environmental conditions and wastewater characteristics. The high percentage of methane in the generated gas is advantage as it can be used as a fuel. The present review summarized research and studies on UASB reactors for wastewater and sludge treatment.

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