Up-flow Anaerobic Sludge Blanket Reactor Effluent and Electrochemical Treatments: An Overview

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Abstract: ***Anaerobic processes present a high potential in most developing countries for municipal wastewater treatment, and thus is a suitable and economical solution. The anaerobic process can serve as a viable alternative, compared to conventional aerobic processes. Within the spectrum of anaerobic sewage treatment technologies, the upflow anaerobic sludge blanket (UASB) reactor offers great promise, especially in developing countries that usually have hot climates. Effluent from UASB reactors, however, rarely meets disposal standards/guidelines especially in relation to organic content, suspended solids, nutrients and pathogen content.. Hence, this reports is a small attempt to review the applicability of electrochemical treatments as a possible post-treatment for UASB reactor effluent treating various wastewaters.***

Keywords: Upflow anaerobic sludge blanket, electrochemical treatment, FPU

1. Introduction

Municipal wastewater treatment using anaerobic technology found highly potential in most developing countries (Foresti, 2002, Makwana and Mansoor, 2016). Among the different anaerobic treatment technologies, the upflow anaerobic sludge blanket (UASB) process offers great promise, especially in developing countries due to its various advantages (Foresti, 2002; Makwana and Mansoor, 2016). UASB technology has been recognized as the most cost effective and suitable sewage treatment process considering the environmental requirements in India (Makwana and Mansoor, 2016). Effluent from UASB reactors, however, rarely meets disposal standards/guidelines especially in relation to organic content, suspended solids,nutrients and pathogen content. (Khan et al., 2011). The nutrients generally remain unaltered and the residual pathogen concentrations are high. This necessitates post treatment of UASB reactor effluent before its reuse in irrigation or discharge into natural water bodies.

2. The UASB Technology

Application of anaerobic technology for the treatment of domestic sewage has been reported in the literature listing advantages like elevated organic matter removal, shorter reaction time, energy recover
y in the form of biogas, simple operation, no energy requirement during operation, less production of sludge and over all low operational cost (Khan et al., 2011). In late 1970s, Lettinga and his colleagues had proposed upflow anaerobic sludge blanket reactor (UASBR) as a possible type of anaerobic treatment technique with suspended growth process (Letinga et al., 1980). Underdeveloped tropical countries like India has identified UASB as the most feasible treatment for sewage to withstand energy and financial crisis too (Khan et al., 2011). Since 1980s, several researchers had worked on the applicability of UASB process for the treatment of sewage and found around 70% chemical oxygen demand (COD) removal under tropical climate (Khan et al., 2011;). A well-operated UASB process shows the formation of a well-developed dense granulated sludge blanket which can take higher volumetric COD loadings than any other anaerobic processes (Lettinga et al., 1980). Despite of having unique advantages, certain limitation of this technology limits its use in sewage treatment. It requires longer start-up time compared to aerobic treatment. Requirements of active microbial population, consistent higher temperature and wastewater being treated affect the initial start-up time (Chong et al., 2012). Further, the temperature directly affects the treatment efficiency (Chong et al. 2012). Effluent from UASB reactors, however, rarely meets disposal standards/guidelines set by most governing agencies for discharge into surface water and re-use for agriculture purposes especially in relation to organic content, suspended solids, nutrients and pathogen content. (Khan et al., 2011). UASBR-treated effluent, without post-treatment reports 60-150 mg/L of biochemical oxygen demand (BOD) (Khan et al., 2011). The COD ranges from 100-200 mg/L with 50-100 mg/L of total suspended solids (TSS) (Khan et al., 2011). Literature reports little nutrient alteration in UASBR treating domestic wastewater (Khan et al., 2011; Lettinga et al., 1981;). 7–20 mg/L sulphide concentration was observed in the UASB effluent treating sewage which increases the effluent oxygen demand (Khan et al., 2011). UASB promises only 1 log unit removal of faecal coliforms with 60-90% helminth eggs removal (Khan et al., 2011). These limitations demand high rate UASB treatment in combination with innovative post-treatment system to make UASB technology sustainable.

2.1 Post-treatment options for UASBR effluent

The selection of an appropriate, reliable and efficient post-treatment technique for the UASBR-treated sewage which has to be easy in operation and maintenance, cost-effective, technically feasible is a challenging task. Literature reports use of several physico-chemical and biological processes for post-treatment of UASBR-treated sewage (Chong et al., 2012; Khan et al., 2011). Several researchers have studied various processes as post-treatment option for UASB effluent and the analysis was mostly based on space requirement and only a few had evaluated based on total cost, total annual expenditure and energy requirements (Khan et al., 2011).

Penetra et al. (1999) and Reali et al. (2001) in Brazil reported dissolved air floatation (DAF) as efficient in organic matter removal with limitation of higher chemical cost (Khan et al., 2011). Rotating biological contactor (RBC) and down hanging sponge (DHS) methods can meet disposal standards but shortfall due to high energy need and expensive growth media (Khan et al., 2011). Coagulation and flocculation method as post-treatment was reported to be feasible with 20 mg/L effluent BOD and 50 mg/L effluent TSS with residual chlorine dose of 3 mg/L (Prakash et al., 2007) but also produces large sludge volume with higher chemical dose and cost. Khan et al. (2011) reported aeration as an effective post-treatment for COD, BOD and TSS removals and also reported significant feacal coliform and nutrient removals. Tawfik et al. (2010) found moving bed biofilm reactor (MBBR) a feasible process but also documented sludge development with poor settleability. Thus, post-treatments like DAF, RBC, DHS, coagulation-flocculation, ASP, MBBR produce an effluent which complies with the disposal standards for COD, BOD and TSS. However, these options are not sustainable due to higher chemical cost, high energy need, large sludge generation, poor microbial removal, and poor settling characteristics of sludge. Further Chong et al. (2012) reported their non applicability due to high automation level, high initial and operation costs with large energy and land requirements.

In India final polishing pond (FPU) is a common unit provided to post-treat UASB effluent with 1d HRT (Khan et al., 2011). However, it is reported that the efficiency of FPU was low with only 50 % BOD and TSS removals due to limited algal activity. Further, limited algal growth in FPU has lead to 1-2 log removal of coliforms too (Khan et al., 2011), rendering effluent unfit for inland surface disposal and for agricultural use. Slower algal growth is due to presence of sulphide concentration in the UASB effluent, which necessitates 2.2-2.5 days HRT for complete growth. Von Sperling et al. (2001) reported activated sludge process (ASP) efficiency of 85-93% overall COD removal but ASP was found to be quite energy intensive. Overall energy requirement of UASB with aerobic system (ASP) was 74.25 KWh/MLD (Khan et al., 2011) which is relatively less compared to energy requirements of aerobic process as the sole wastewater treatment process, including initial pumping (Khan et al., 2011). Khan et al. (2011) concluded provision of ASP after UASB was considered good at low organic loading but may not be most sustainable for concentrated sewage due to linear increase in energy consumption with increase in organic load. Further, DHS, SBR type aerobic system are reported promising due to their low cost, low space requirements and low solid production (Khan et al., 2011).

3. Use of electrochemical treatment for post-treatment of UASBR effluent

A few studies have been reported in the literature on the use of EC for treating anaerobically-treated wastewaters. Fernandes et al. (2004) reported preliminary test results of electrochemical degradation of UASB reactor effluent feeding with a basal medium in which glucose was used as carbon source and supplemented with Acid Orange 7 dye (60 mg/L). Electrooxidation using BDD anode with 6.7 mA/cm^2 current for 10 h gave 77% and 98% COD and colour removal respectively. Buzzini et al. (2007) reported preliminary evaluation of the electrocoagulation processes in the post-treatment of effluent from an UASB reactor treating unbleached kraft pulp mill wastewater. The EC removed up to 67% (with Al electrodes) and 82% (with SS electrodes) of the remaining COD and 84% (SS) and 98% (Al) of the colour in the wastewater. These efficiencies were achieved with an energy consumption ranging from 14 to 20 Wh/L. Performance of electrocoagulation technique for decolorization and COD reduction of anaerobically pretreated poultry manure wastewater was investigated in a laboratory batch study (Yetilmezsoy et al., 2009). Preliminary tests conducted with two types of sacrificial electrodes (Al and Fe) showed that Al electrodes were more effective for both COD and colour removals than Fe electrodes. The subsequent EC tests performed with Al electrodes showed about 90% of COD and 92% of residual colour removal from the UASB effluent at initial pH of 5.0 and a current density of 15mA/cm^2. Katsoni et al. (2014) studied the applicability of electrochemical oxidation as an advanced post-treatment for the complete removal of COD from the anaerobically treated cheese whey using BDD at 9 and 18 A current. Complete removal of COD was reported after 3-4 h reaction.

4. Conclusion

Study of domestic sewage treatment with UASB followed by different post treatments contains certain limitations. Further it is also observed that UASB along with electrochemical or advanced oxidation process as post treatment, works well on various industrial effluent. Similarly literature on domestic waste treatment with EC alone is also available. This review shows that electrochemical treatment processes, are all found to be effective on various industrial effluents when taken as post treatment for UASB effluent. AS UASB plus convention post treatments as well EC alone are not found satisfactory for domestic waste. Then there is one more treatment option possible for domestic wastewater, according to which UASB should be core treatment followed by EC as post treatment. Both the treatments are having their own advantages and can give best result one had ever achieved.

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