Effluent generated in sugar mills when disposed directly causes pollution of surface or ground water. If this effluent is directly released for irrigation, it affects the soil fertility, plant growth and seed germination. It also affects soil micro flora (Deshmane et al., 2015). Hence treatment of sugar industry effluent attains a high significance.

Sugar industry effluents have high organic concentration hence they are very suitable to be used as a substrate in UASB reactor (Farhadian et al., 2007). High concentration of carbohydrates corresponds to readily fermentative sugars. It also contains nitrogen and phosphorous essential for cultivation of microorganisms. Diluted sugar wastewater acts as a substrate for acidogenic process after it is made available for methanogenesis. Two separate reactors for acidogenesis and methanogenesis can be used is series to optimize the gas production where hydrogen can be collected at first reactor and methane at second (Wang et al., 2013). After several operations it was concluded that UASB design can treat sugar industry wastewater efficiently up to an OLR of 16000 mg COD/L. d. with COD removal efficiency of 89% at HRT as low as 6 hours where biogas containing more than 75% methane can be produced at the rate of 4.66 L/L. d. (Hampannavar et al., 2010).

3. Dairy Wastewater Treatment

Dairy industry is the most important industry in day to day life in India. After the white revolution majorly contributed by Amul, there has been a substantial increase in production as well as consumption of dairy products all over India. However dairy wastewater is the most polluting in nature among the food industry. It contains liquid waste from dairy processing as well as water used for cleaning and washing operations. Chemical basis of chemicals used for cleaning and washing operations decide the acidic or basic nature of effluents (Arvanitoyannis et al., 2006). A typical dairy wastewater has a temperature range between 17 and 32^{0}C with average COD of 2500 mgL^{-1} approximately (Buntner et al., 2013). It also varies according to type of equipment, unit process used and product obtained (Passeggi et al., 2012).

Traditionally dairy effluent is treated by anaerobic and facultative ponds where associated costs are relatively low. However, these treatments are relatively less efficient with large land requirements and uncontrollable actions (Martin-Rilo et al., 2014). Therefore, anaerobic treatment with production of methane as byproduct i.e. UASB is considered. Unlike its other applications, UASB has limiting success in treating dairy effluents. This is because of long hydrolysis time of organic material which later accumulates within the sludge blanket due to entrainment or adsorption. This results in dilution of biomass, poor contact and impaired sludge settling capacity (Passeggi et al., 2012). To avoid this pretreatment method such as dissolved air floatation (DAF) is used to separate fat (Puget et al., 2004; Ross and Valentine, 2008). Contact reactors van also be used for pretreatment methods (Hamilton et al., 2007).

4. Distillery Wastewater Treatment

Composition of distillery wastewater depends upon the raw material used. In most of the cases, cane molasses is used as a raw material. The raw molasses wastewater is typically moderately acidic with very high total chemical oxygen demand. It contains high concentration of mineral salts and has a bad smell and dark brown color. This dark color is very hazardous to aquatic life as it hinders photosynthesis by blocking sunlight. It also contains high concentration of nutrients in the form of nitrogen, phosphorous and potassium (Mahimairaja et al., 2004).

Alcohol distillery effluent is thermophilic (55^{0}C) in nature. It has large concentration of phenolic compounds which are poorly biodegradable and toxic. Conventionally these are treated by adjusting their temperature to mesophilic anaerobic process. But thermophilic sludge has much higher mehanogenic activity than mesophilic sludge which results in higher methane production. UASB is the only anaerobic reactor capable of thermophilic treatment. The HRT can be shortened by increasing volumetric organic loading rates.

5. Slaughterhouse Wastewater Treatment

Slaughterhouses in India generate large amount of wastewater. Consumption of water per animal varies with type of animal and the process employed. Most of this water is discarded as wastewater containing high amounts of biodegradable organic matter. The soluble fraction varies from 40% to 60%. Colloidal and suspended matter is in the form of fats, proteins and cellulose which has a very poor biodegradability [SL02]. Nitrate and sulfate are also present in considerable quantities in slaughterhouse wastewater. These have inhibitory effects on methanogenesis (Balderston et al., 1976).

For successful operation of UASB, an effective pretreatment like DAF can be used to remove fats and suspended solids. Also the upflow velocity needs to be maintained to avoid sludge washout. According to Lettinga, upflow velocity of 0.5 to 0.7 mh^{-1} gives the best results for UASB (Caixeta et al., 2002).

2.5 The Challenges and Limitations of UASB Reactor

UASB reactors are widely employed for most of the wastewaters containing high concentrations of soluble organic matter. However there are some limiting factors. Presence of certain components in the influent has inhibitory effect on the process. Excess of VFA which lacks in alkalinity in the influent leads to acidification of the reactor which causes reactor failure in case of high load reactors. This can be avoided by dilution of influent or by adding alkalinity. High concentration of suspended solids reduces settleability of sludge leading to biomass washout. For this upflow velocity needs to be monitored. All the limitations due to influent composition can be avoided by using suitable pretreatment methods.

There are some operational limitations like delay in startup and granule formation. Startup time decides the effectiveness and stability of UASB. This depends on characteristics of water, operating parameters and growth of microbial population in sludge. The reactor cannot be operated at full design organic loading rates before an acclimatization period to inoculate the seed sludge. This can be speeded up by using pretreated sludge inoculum. The choice of best inoculum source depends on toxicity and biodegradability test of wastewater (Ghangrekar et al., 1996; Sarria et al., 2003). Some nutrients can also be added in order to increase the stability of the reactor. Besides all this UASB alone cannot remove pathogens and coloring agents from the wastewater, hence significant post treatments are suggested for further treatment.

3. Performance Enhancement of UASB Reactor

UASB reactors are ideal for treatment of wastewater in tropical regions. However, recent studies have shown their suitability in subtropical regions as well. There are a number of studies which have suggested several modifications to achieve the optimal performance. Some of them are mentioned below.

3.1 By Modifying Configuration

Considering the strict restrictions for effluent quality, UASB alone is not sufficient to meet those norms. This can be achieved by applying some modifications to the design of reactor. Instead of conventional one step UASB, a two step UASB system is suggested at low temperatures. Here one acts as hydrolytic unit called as hydrolytic upflow sludge blanket (HUSB) reactor and the other acts as methanogenic unit i.e. UASB reactor (Chong et al., 2012).

Using a combined UASB reactor system is one of the most growing trends in the industry. UASB can be coupled with aerobic as well as anaerobic systems for pretreatment or post treatment or both. Various combinations have been used already. A COD removal of 86% was achieved when UASB was followed by two anaerobic packed bed filters operating in parallel (Goncalves et al., 1998). Sawajneh et al treated strong sludge at 15-21^{0}C by incorporating anaerobic filter reactor as a pretreatment unit to a UASB reactor. This AF+UASB system showed satisfactory COD removal in short period of time. Other combinations such as UASB – digester system, UASB – membrane system, UASB – biofilter are also incorporated by other researchers (Chong et al., 2012).

Design of UASB itself can also be modified. A recent study used vertical reticulates polyurethane foam (RPF) sheets on top of the gas – solid – liquid separator. This enhanced the entrapment of colloidal COD. Another modification suggested replacement of gas – solid – liquid separator by plastic filter rings. However this restricted the reactor to low temperatures only but the methane production increased significantly (Gao et al., 2011). Another study proposed a fixed bed model where randomly packed polyethylene ring shaped matrix pieces were fixed at the bottom half of UASB reactor. This increased the contact pattern between biomass and wastewater, lowering the temperature from mesophilic to psychrophilic.

3.2 By Changing OLR and HRT

Effective startup is achieved by using pretreated sludge inoculum. Then keeping influent flow rate fixed, OLR and HRT are manipulated to achieve maximum COD destruction. Substrate degradation rate was also evaluated to assess reactor performance. By gradually increasing the OLR and decreasing HRT at the same time, reactor startup was achieved rapidly. This may vary depending on the inoculum characteristics. If the influent is rich in sludge nutrients, visble granules are formed at much lower HRT. This allows us to operate UASB at high loading rates. In some cases like in dairy wastewater where VFA are more in the influent, OLR needs to be diluted to avoid excess acidic condition in the reactor which may cause reactor failure.

3.3 By Sludge Enhancement

Though UASB reactor can perform efficiently without granules, higher COD removal efficiency can be achieved by granule formation at the reactor startup. Formation of granules is a characteristic of sludge; however it depends greatly on composition of wastewater. Various nutrients can be added to influent or to sludge directly to speed up the granulation time. There are a lot of studies on theories and mechanisms of anaerobic granulation.

Initial development of granules can be divided into four steps (Schmidt et al., 1996): (1) Transport of cells to a substratum which is an uncolonized inert material; (2) Initial reversible adsorption to the substratum by physiochemical forces; (3) Irreversible adhesion of cells to the substratum by microbial appendages and/or polymers; (4) Multiplication of the cells and development of granules. Divalent and trivalent cations neutralize negative charges on bacterial surfaces and serves as cationic bridge between the bacteria. This exerts positive impact on granulation process (Liu et al., 2004). In addition to these, natural polymers such as water extract of Moringa Oleifera seeds, Reetha extract, charcoal; commercial and synthetic polymers such as commercial cationic polymer "AA 180H" and organic – inorganic hybrid polymers can also be added to enhance sludge granulation at the startup of reactor (Chong et al., 2012).

3.4 By Temperature Control

Based on the temperature anaerobic processes are divided into three types – Psychrophilic which is below 20^{0}C, Mesophilic which is between 20 to 50^{0}C and Thermophilic which is more than 50^{0}C. Some reactors can also be operated below 20^{0}C if a significant amount of methane is generated. Generation of methane i.e. methanogenesis step produces heat enabling mesophilic conditions inside the reactor. Research is being done in incorporating UASB process for thermophilic treatment as thermophilic conditions will allow us to remove pathogens effectively. Present studies have shown that when sucrose is used as substrate and cow manure as seed, thermophillic granulation of bacterial matter proceeds easily (Lettinga et al., 1984).

A hot water jacket can also be attached to the reactor at psychrophilic conditions to maintain mesophilic conditions in the reactor externally. This will help in higher COD removal rate at shorter HRT. The gas generated in the reactor can also be used to heat the jacketed water.

3.5 Potential of UASB Technology in Other Developing Countries

In the developing countries emphasis is given more to remove organic pollutants and pathogens to some extent only. Here low cost technologies such as UASB are more favorable as compared to other conventional technologies used in developed countries. Generation of energy in the form of methane is also a bonus. Besides this, the fact that anaerobic sludge can be sustained for a long time without any feed really helps when there is very less or no continuous supply of wastewater in summer season.

Recent studies have shown that UASB can be incorporated with other systems aerobic as well as anaerobic. This means there is no need to discard the previous plant entirely. Methane generated can also be used for lighting the streets as well.

4. Conclusions

Though UASB technology has far more advantages over other conventional wastewater treatment technologies, to meet the strict environmental norms a suitable pretreatment or post treatment or both need to be applied. Also efficient techniques need to be developed to recover essential nutrients like nitrogen, phosphorous, etc. from the treated effluent. Higher loading rates can be used to treat large amount of domestic wastewaters in all the major cities protecting the natural environmental habitat.

Based on the low capital and operational cost, it can be concluded that UASB in combination with adequate post treatment option still offers a best proposition compared to other treatment systems in India. Most of the developing countries have warm tropical and subtropical climates which will give better performance of UASB systems.

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