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UASB REACTOR TECHNOLOGY FOR WATER TREATMENT

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Abstract:- Treatment of wastewater is becoming even more challenging due to limited water resources, expensive water treatment technology and sludge discharging. Treatment of wastewater can be managed by regulating all the related factors such as protection of environment, low cost water treatment method, public health and socio-economic concerns. Upflow Anaerobic Sludge Blanket Reactor [UASBR] is one of the best techniques for wastewater treatment. Present day UASBR has been found to be more effective and convenient than that of the very first module of the reactor. It is capable of treating high-strength wastewater and produces high quality sludge. The purpose of this study is to provide an overview of UASB reactors, so that performance of UASB reactors can be improved for future endeavors.

Keywords:- Anaerobic digestion, Hydraulic Retention Time [HRT], Organic Loading Rate [OLR], Total Suspended Solids [TSS], Volatile Fatty Acids [VFA]

1. Introduction

Treatment of wastewater has become a global issue which is affecting developing countries more due to the presence of their industries. Many wastewater treatments have been developed over the years but these technologies are costly, require high energy consumption, work less effectively and produce large amounts of sludge. The sludge thus produced creates an issue regarding its disposal. Upflow Anaerobic Sludge Blanket Reactor [UASBR] technology is the solution to all above listed problems. It was invented by *Lettinga and his co-workers* in the late 1970's [1] . As the name suggests, it is anaerobic wastewater treatment technology. It requires less energy as compared to aerobic processes where aeration is done [2] . Most important aspect of UASBR is that it produces very less amount of sludge while also producing energy rich methane which can be utilized as an energy source at various applications [3] . Along with methane, carbon dioxide (CO_2) is also released which can be further utilized in fire extinguishers, etc. Another important aspect of UASBR is its profitability, it requires very low investment and operation cost. The sludge that is produced during the operation is dried and can be added to a landfill for its use as a fertilizer [4].

UASBR was first designed to treat industrial wastewater but later has found an application in treatment of sewage as well. Over the years it found application in treating a variety of wastewater like brewery wastewater, wastewater generated from cattle slaughterhouses, dairy wastewater, industrial wastewater, domestic wastewater and many more, this make this reactor appealing. Not many waste water treatment technologies can effectively function over such a varied range of chemical oxygen demand (COD), biochemical oxygen demand (BOD), total nitrogen value and pH range.

This paper tries to throw light on UASB reactors and factors affecting them. These UASB reactors can be made more efficient by studying the factors affecting the performance of reactors and the number of ways it can be used up for wastewater treatment.

2. Working

Fig.1.UASB reactor in Porur, Chennai

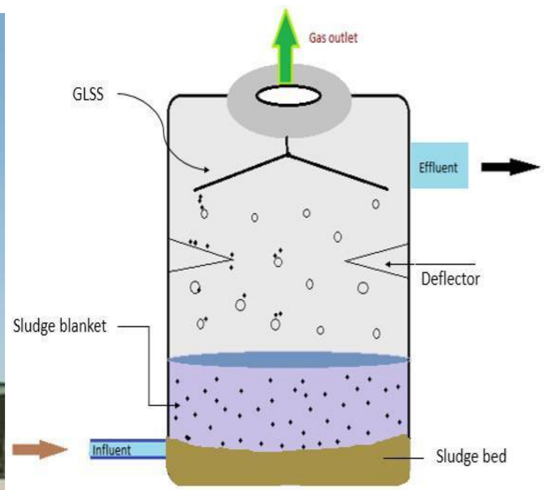

Fig. 2. Schematic diagram of UASB reactor

The UASB reactor works on anaerobic digestion. Anaerobic digestion is a process by which micro-organisms break down biodegradable material in absence of oxygen [5]. UASBR is basically a single tank process in which the wastewater is introduced at the bottom of the reactor and flows upward through the area called sludge blanket where granulation takes place. This resulted in biogas formation. Just above the Sludge blanket, a clarifier zone is present which is useful for solids settling. Once the process is finished, we can separate all the three phases of matter using GLSS [Gas-liquid-Solid Separator]. It separates three phases effectively i.e. gas is collected at the collection pipe, solids is separated on settling zone and water comes out as effluent [6].

UASBR was developed with the two major objectives in mind. Firstly, sedimentation and sludge stabilization while combining both in one reactor to make it preferable technology for high rate wastewater treatment. It also had the aim to be a greener option to other technologies by producing useful by-products like methane enriched biogas and nutrient rich sludge.

Working of a UASB reactor basically depends on an active sludge blanket present at the bottom of the reactor that contains highly settleable granules. As the wastewater comes in contact with granules, gas is produced under anaerobic conditions and granulation occurs. Some particles attach with gas and go to the top of the reactor and strike to the surface of the reactor, due to this gas is released from the granules and is collected in a gas collection pipe and degassed granules go back to the sludge blanket. Gas recirculation is essential to maintain good contact between anaerobic bacteria and biodegradable waste to run a UASB reactor effectively [7].

3. Factors influencing performance of UASB reactor

To improve performance of the reactor, various parameters have been studied over the years. Though they need further detailed study to improve more. Optimizing these parameters has proven to improve the performance. Some of these parameters are

3.1 Hydraulic Retention time (HRT)

HRT is the average time wastewater spends inside the reactor. It is affected by upflow velocity and composition of wastewater in the reactor. More the HRT, higher is the contact time of wastewater and sludge due to which effluent quality is improved and biogas production rate also increases [8]. Whereas decrease in velocity, increases HRT which helps in suspended solids removal from the reactor. Therefore an optimum balance between upflow velocity and HRT has to be maintained for proper water treatment.

3.2 Size of Reactor

As described in the working of the reactor, adequate contact should be ensured between substrate and biomass to produce sludge. Therefore the diameter of the reactor plays an important role. The reactor should not be kept very large because it will cause inadequate contact between substrate and biomass. Hence large reactors lead to less biogas production because of sludge wash out due to insufficient mixing. Good height of the reactor ensures proper mixing which ultimately leads to a good amount of biogas production.

3.3 Organic Loading Rate (OLR)

OLR is the mass of organic matter loaded per day per cross section area of the reactor. If OLR is high, microbial growth increases whereas at low OLR, microorganism starvation takes place. However if OLR is too high, the biogas production increases and ultimately leads to sludge washout. This results in a decrease of reactor performance. Increase in OLR will lead to operational problems like sludge bed floatation and excessive foaming at gas liquid interface in GLS separator [3]. In order to achieve a high system loading rate, short HRT should be applied [9]. Hence optimum range of OLR which depends on the type of waste water to be treated should be maintained during the process.

3.4 Temperature

Reduction in operational temperature does not only retards the hydrolysis step but also leads to significant decrease in maximum growth and substrate utilization rates [3]. Temperature has a strong influence on time needed for stabilization of solids as it affects growth rate of bacteria and activity of enzymes [10]. Temperature plays an important role in methane production and biodegradation. It has been observed that methane production is very slow or does not occur if the reactor temperature is below 30°C[11]. At lower temperature, viscosity increases, hence more energy is required for mixing of soluble compounds[12]. Higher temperature, in the range 37-55°C leads to sludge washout. Hence, to strike a balance UASB must be operated at mesophilic condition [30-35°C].

3.5 Nutrients

Healthy microbes give effective anaerobic digestion. Availability of some nutrients is responsible for growth of anaerobic microorganism in wastewater. Deficiency of nutrients like nitrogen and phosphorus could negatively affect growth of microorganisms and efficiency of reactors[13].

3.6 Mixing

Mixing increases contact time of microbes and wastewater and can be done mechanically or by methane gas recirculation. It increases efficiency of reactors by increasing biogas production rate. Discontinuous mixing is beneficial over vigorous mixing.

3.7 Volatile Fatty Acids

These are intermediate forms formed during methane production. Variation in HRT and OLR can cause accumulation of VFA, leading to breakdown of complex organic matter, and reducing biogas production rate[14]. Therefore accumulation of VFA should be avoided.

3.8 pH and Alkalinity

UASBR results in production of biogas due to anaerobic digestion by microorganisms. These microbes need suitable pH for their growth. There are three kinds of bacteria involved in biogas production, bacteria responsible for hydrolysis, acid producing bacteria [pH requirement is 5-6] and methane producing bacteria which works in pH 6.7-7.4 [5]. Slight variation in pH can cause negative effects on methane production [15]. Hence pH of the UASB reactor should be in the range of 6.5-7.5. Alkalinity plays a major role in fluctuation neutralization in Organic Loading Rate [16]. Alkalinity should be in the range 250-950 mg/l[17] [18].

3.9 Total Suspended Solids [TSS]

TSS are organic or inorganic solid material present in the water, and play an important role in wastewater treatment. In water when TSS concentration is high, water quality decreases. TSS absorbs light and reduces oxygen level in water. During treatment, water may have high concentration of TSS but after treatment, UASB reduces the level of TSS.

4. Conclusion

UASBR has been successfully applied for the treatment of wastewater due to its many advantages. Low land demand, low sludge production, high sludge quality, appropriate post treatment, low odor emission, low investment and operational costs has made this technology a go to solution for wastewater treatment. Considering these advantages, this anaerobic digestion has replaced the old days aerobic process worldwide. Though it boost many positive aspects, UASBR do have some disadvantages like its sensitivity towards toxic substances, long start-up phase requirement, insufficient pathogen removal and non-economical for colder climates with sewage temperature lower than 15°C since it works best only in mesophilic conditions. In order to make UASBR more efficacious for wastewater treatment, these drawbacks should be removed or studied in depth. Considering all the parameters, good and bad, it is crystal clear that UASBR is the future of wastewater treatment and should be modified to meet forthcoming demands.

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