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POPULAR ARTICLE

Biomethanation of waste water using high rate anaerobic reactors

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Rapid industrialization and urbanization have excessively exploitedthe natural resources in recent years. This indirectly increases the generation of solid and liquid wastes which badly affects the ecology and environmental resources such as land, water and air. In India more than 1000 million tons per year of agro-industrial biomass and food processing wastes and more than 23000 million litersof waste water per day are generated on an average. These are managed by burning, dumping or just bypassing to nearby lakes and rivers creating a massive environmental pollution. Dry agricultural residues can be burnt; but wet wastes reduces the efficiency of combustion. Alternatively, wet biomass and liquid wastes like waste water can be converted to biogas (methane) biologically by the process of anaerobic digestion. The biomethanation process involves the conversion of wet wastes to methane under anaerobic conditions of ordinary temperatures and pressure with a theoretical thermal efficiency as high as 94%. As the calorific value of biogas is about 6 kWh/m^3 (this corresponds to half a liter of diesel oil), this process would lead to saving of an enormous amount of fuel per year. Through this process not only energy is generated, but the major problem of waste handling and disposal is managed effectively.

Similar to the conventional biogas plants used for treating wet solid biomass to biogas through anaerobic digestion, there are bioreactors which are used exclusively for treating liquid wastes like waste water from sewage, residential, industries etc. Unlike the biogas plants having long retention period of 40 days, these bioreactors process liquid wastes at a quick reaction period of less than 24 hours. Thus these reactors are said to be high rate anaerobic reactors (HRAR) which treats waste water to purified form (70-80% reduction in COD) as well as generates biogas (>55% methane) as an energy supplement. High rate reactors can retain active biomass (microbial substrate) in the reactor independently of the incoming wastewater. Slow growing anaerobes can be maintained in the reactors at high concentrations, enabling high reaction rate per unit reactor volume and high resistance of organic or hydraulic shock loads. HRAR can be used to treat wastewater from various sources and strengths like from domestic sources, hospitals or industries.

Aerobic Vs Anaerobic systems

Aerobic systems require some means of supplying oxygen to the biomass, which may be accomplished by wastewater treatment ponds (which work by creating a large surface area for introducing air to the wastewater), and/or by incorporating some type of mechanical aeration device to introduce oxygen into the biomass. Due to the need to circulate the wastewater or otherwise aerate it, aerobic systems tend to be less energy efficient than their anaerobic counterparts.

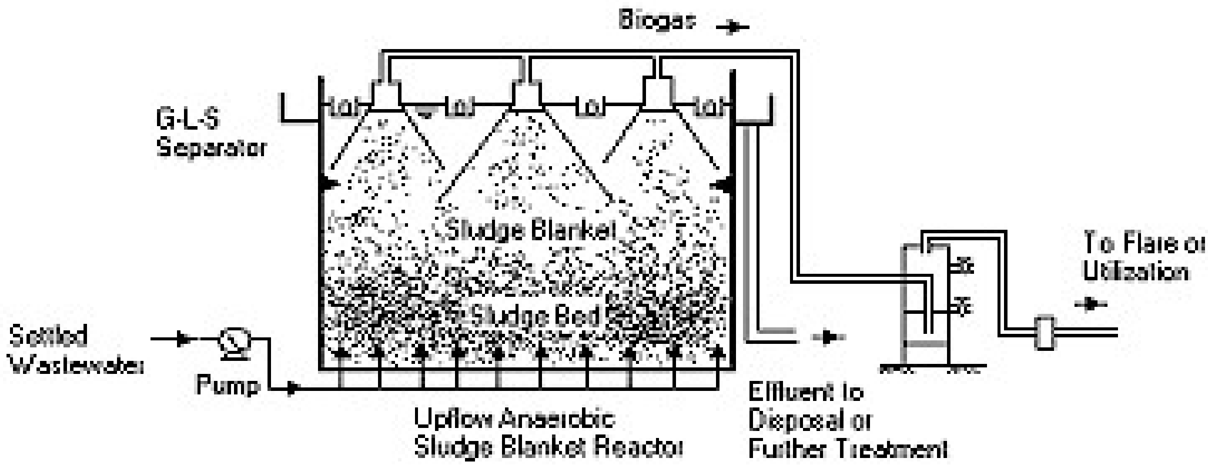
By contrast, anaerobic systems must be designed to prevent the exposure of the biomass sludge to air. This can be accomplished via airtight, enclosed digesters that are primarily used for batch treatment cycles, or by up flow high rate systems that keep the biomass layer submerged below the treated effluent that, as the name suggests, flows upward toward the surface of the tank.

Anaerobic and aerobic systems are paired at times for treatment of streams with a high concentration of organic contaminants. For these setups, anaerobic treatment is used for initial reduction of organic contaminant levels, while aerobic treatment is used as a secondary polishing step to further reduce BOD and TSS. In some cases, the secondary aerobic treatment step is used to oxidize ammonia to form nitrate. In general, using both technologies together results in more efficient treatment than if an aerobic system were used alone, as well as more complete contaminant removal than if anaerobic treatment were used alone.The decision to use both technologies will typically result in higher capital costs, but lower operational and waste discharge costs. The appropriateness of using one or both types of biological treatment ultimately depends on the unique application and process conditions at a given facility.

Some of the commonly used anaerobic systems include Completely mixed anaerobic digester, Anaerobic contact process, Anaerobic sequencing batch reactor (ASBR), Anaerobic packed bed or anaerobic filter, Anaerobic fluidized, Expanded bed reactors, Upflow anaerobic sludge blanket (UASB) reactor andAnaerobic baffled reactor (ABR). Among these reactor types, the most widely used, commercial, well designed and cost effective anaerobic system recommended for all strengths of waste water is UASB reactors.

What happens in a UASBreactor?

Substrate passes first through an expanded sludge bed containing a high concentration of biomass.The sludge in the reactor may exist in granular or flocculent form, but the granular sludge offers advantages over flocculent sludge. Most of the substrate removal takes place in sludge bed. The remaining portion of the substrate passes through a less dense biomass, called the sludge blanket.Provision of sufficient volume of sludge blanket is necessary above the sludge bed, which will provide further treatment to the wastewater bye-passed from the sludge bed due to channeling, and will help in maintaining stable effluent quality. Above sludge blanket the reactor has a three-phase separator, Gas-Liquid-Solid (GLS), which separates the solid particles from the liquid and gas, allowing liquid and gas to leave the system.



UASB system

Significant characteristics of UASB systems

The following are the main characteristics which affects the performance of UASB systems.

- ✓ pH (6.3 – 7.8)
- ✓ Temperature (35 – 38 ºC)
- ✓ COD (>250 mg/l - >400 mg/l)
- ✓ Organic acids
- ✓ Concentration of Ammonia
- ✓ Upflow velocity (0.2 – 1 m/h for low strength waste water and 1 – 2 m/h for high strength waste water)
- ✓ Waste water flow

If these factors are maintained at a given optimum level, high biogas production as well as high waste treatment efficiency may be achieved. In addition the UASB systems offer the following advantages

- ✓ Low land demand
- ✓ Reduction of CH4 emissions from uncontrolled disposal/open treatment(ponds) due to enclosed treatment and gas collection
- ✓ Reduction of CO2 emissions due to low demand for foreign(fossil) energy and surplus energy production
- ✓ Low odour emissions in case of optimum operation
- ✓ Few process steps (sludge and waste water are treated jointly)
- ✓ Low sludge production and high sludge quality
- ✓ Low demand for operational means, control and maintenance

- ✓ Correspondingly low investment and operational costs

Recent developments

In the last few years, the Expanded Granule Sludge Blanket reactor (EGSB) has become the biggest competitor to the UASB technology, mainly because of its distinctive merits such as flexibility, simplicity, ability to accept high influent liquid and gas velocities, high circulation ratios that create inherent hydraulic balancing capacity, and high volumetric loading rates ranging from 15 to 30 kg COD/m^3 (Gavrilescu, 2010).Static Granular Bed Reactor (SGBR) innovated at Iowa State University is another new concept and good performances have been reported for various wastewaters similar to the UASB and the EGSB reactor. The reactor is down flow type unlike other reactors and it is very simple so that additional parts are not needed for this process.

CONCLUSION

The anaerobic treatment is practical and useful process to treat various industrial and domestic wastewaters but a lot of designers and operators have preferred to use aerobic processes than to anaerobic processes due to lack of knowledge, experience and skills. The UASB reactor have overwhelmed with its great performance and is widespread. The EGSB reactor also treats efficiently high-strength wastewater by expanding granules. In addition, this reactor is also applicable to low-strength wastewater (< 1000 COD mg/l), especially low temperature. The SGBR showed great performances like the UASB and the EGSB reactor with very simple and no additional equipment operating in down flow principle.Thus with the utilization of these renewable eco-friendly technologies in the country, the two major problems of waste water management and energy deficiency can be overcome in near future.

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