SEWAGE TREATMENT THROUGH UASB TECHNOLOGY –

EXPECTATIONS AND REALITY

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ABSTRACT

With experience of over a decade and half of UASB for sewage treatment in the country, a number of inherent limitations of the technology in particular and that of anaerobic processes in general have been realised. Fundamentally attempting to generate energy or achieve improvement in wastewater quality without commensurate energy inputs is in violation of the second law of thermodynamics. Municipal sewage being a high entropy material with low organic loads, it is not suitable as a feedstock for an apparent 'liquid bioreactor' promising reliable output of energy. The 'Initial Oxygen Demand' of effluent from a UASB reactor has potential to sweep the dissolved oxygen of receiving water bodies in a very short period of time. Post treatment requirement prima facie negate the smaller footprint advantage often claimed by its proponents. The energy generation feature which was considered to be its unique selling proposition is not found to be a sustainable avenue either, because of low and inconsistent biogas yield - high microbial sensitivity to temperature variations which disrupts anaerobic process in winter when virtually biogas generation stops; requirement of supplementary fuel in indigenous duel fuel systems (which define the state of art in the country); inability to adopt cogeneration route for waste heat utilisation etc. On top of this, its environmental footprint is also not desirable – the corrosive ambience created by release of hydrogen sulphide and other gases causes damage to plant, equipment and adjoining public and private buildings and also creates odour nuisance for the adjacent community. This paper attempts to bring out all the limitations of the UASB technology and advocates for alternative aerobic realistic technology solutions.

INTRODUCTION

Upflow Anaerobic Sludge Blanket (UASB) technology was introduced in India in late eighties during the Ganga Action Plan (GAP). A set of pilots were installed at Kanpur initially for treatment of a mix of sewage and tannery effluent and later exclusively for sewage. This development took place when a strong need for an appropriate 'low cost' technology was felt subsequent to the experience of conventional aerobic technology based sewage treatment plants (STPs) where the running costs were perceived to be unaffordable. At that point of time, UASB which was still an evolving technology was positioned as an affordable option with potential for 'resource recovery'. It was argued that this technology will be advantageous for sewage treatment due to its following unique features:

- Low energy requirement
- Less operation and maintenance cost
- Lower skill requirement for operation / supervision
- Less sludge production, and

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- Potential for resource recovery through generation of electricity from biogas and utilization of stabilised sludge as manure.

Based on the limited experience of the two pilots at Kanpur and the above considerations, UASB was the most preferred technology option under the Yamuna Action Plan (YAP-I) which was implemented during 1993-2002. Under this Plan 16 UASB based STPs were constructed in Haryana and UP towns with combined treatment capacity of almost 600 mld.

Subsequent to this up-scaling and wide replication, a large number of STPs based on UASB technology have been constructed in the country and considerable experience has been built-up on the technology which points in other direction. This paper brings out a range of inherent lacunae of this technology and attempts to raise questions pertaining to the policy of its wide scale adoption specifically for sewage treatment. The findings are based on (a) a set of comprehensive case studies covering 25 STPs of 9 different technologies (b) effluent data of eight UASB based STPs and (c) a long term monitoring of the performance of pilots at Kanpur.

TECHNOLOGY PERFORMANCE

UASB technology has been found to be very effective for treatment of high strength industrial effluents particularly from distilleries, pulp and paper, tanneries, and food processing industries. For high organic loads, it certainly offers advantages in terms of almost insignificant energy consumption, low O&M cost and recovery of significant amount of bio-energy. Consistent production of fairly large quantities of biogas from industrial effluents makes electricity generation for captive consumption an attractive financial proposition. Other features of the technology i.e., lower skill requirement and sludge production, perhaps add to its attractiveness under the industrial context to a certain extent. For instance, in distillery industry suitability of the technology has been amply demonstrated where due to bio-energy potential, the pay back period has been found to be less than 3 years.

However, when applied for sewage treatment (where the undiluted BOD is between 200-300 mg/l), the cumulative experience has shown that these ‘unique’ features are not convincing for a variety of reasons. In retrospect it may be stated that for low strength wastewaters, there are more disadvantages than the upfront perceived advantages listed earlier. The issues related to effluent characteristics, requirement for secondary treatment, effluent suitability for disinfection, power generation and resource recovery are discussed in the sections that follow.

Effluent characteristics

- UASB reactor is able to bring down BOD of sewage only to 70–100 mg/l and it perforce requires second stage aerobic treatment to enable compliance with discharge standards.
- The effluent from UASB is highly anoxic and it exerts a high immediate oxygen demand (IOD) on the receiving water body or land. If discharged in to a water body, it immediately sucks up the dissolved oxygen and undermines survival of aquatic life.
- If the raw sewage carries sulphates, it gets reduced to sulphides in the UASB reactor and upon release into an aquatic body it contributes in exerting immediate oxygen demand due to its conversion back to sulphate.
- While the UASB technology is perceived to require low skilled manpower and none or lower instrumentation system for operation control, its performance is characterised by frequent solids washout from the reactor due to these very same inadequacies. As a result the effluent BOD is found to be higher than what is normally claimed.
- While theoretical biogas yield is 0.35 cum/kg of COD removed, the actual yield is not more than 25-30% of this value (0.08-0.1 cum/kg of COD removed). The remaining gas goes out in dissolved form with the effluent, raising its BOD and COD.
- The effluent has a dark brown or blackish colour which represents high concentration of dissolved and suspended humic substances in the effluent. This also leads to poor aesthetic value of the effluent.
- There are no reliable data correlating (a) BOD removal with biogas generation, (b) effluent BOD with COD and (c) effluent BOD with immediate oxygen demand.
- While the effluent BOD after final polishing unit (FPU) at various STPs covered in the study is reported to be under 30 mg/l, an independent study carried out during 2002-03 found COD concentration to be above 200 mg/l.

Secondary treatment

- Under YAP-I, all UASB reactors were followed by a final polishing unit (a pond) of one day retention for second stage treatment. This limited retention capacity while minimised land requirement, but from treatment point of view it at best offered only removal of solids washed out of the reactor.
- A retention of only 1 day does not allow growth of algal cells in the FPU as it is too short of the minimum requirement of 3 days.

- The FPU does not lead to re-aeration of wastewater as there is no energy input for turbulence and neither is there growth of algae which can facilitate this process naturally through the phenomenon of photosynthesis.
- As the settled solids are not removed regularly from the FPU (due to lack of O&M), the bottom depth for sludge storage quickly gets filled up, undermining its efficiency and leading to higher suspended solids/BOD in the final effluent.
- Even though a secondary treatment plant (aerobic system) will be required to bring down BOD from 70 to 30 mg/l, it would not be in any way cheaper than bringing down the raw sewage BOD from 250 to 30 mg/l, since the systems invariably need to be designed on the basis of hydraulic loading rather than the organic loading.
- Secondly, with input BOD less than 70 mg/l, there is not enough food for micro-organisms to grow in the secondary aerobic system.
- Typically the power rating of an aeration system in an aerobic reactor is determined by requirements for keeping the solids in suspension and not on the basis of actual oxygen requirements. Therefore the perception of lower operating cost in the secondary stage after primary treatment in a UASB reactor is also not valid.

Unsuitability of effluent for chlorination

Due to anaerobic conditions, removal of total and faecal coliforms in UASB is about 1-2 on log scale and it entails tertiary treatment for disinfection. However, unlike other technologies, effluent from a UASB plant can not be readily sent for chlorination as it carries much high concentration of humic substances that lead to formation of trihalomethanes and entail higher chlorine consumption towards satisfying a part of the COD and IOD. Incidentally chlorination emerged as the only cost effective disinfection technology among a variety of options tried out under YAP-I.

Power generation

Resource recovery in the form of bio-energy was perceived to be a major factor in favour of a UASB for sewage treatment. However, a number of limitations as listed below have been realised which prevent realisation of the claimed benefits.

- Among others, biogas generation is dependent on quantum of raw BOD and subject to ambient and wastewater temperature and their variations. The anaerobic bacterial culture is adversely affected with even 3-5°C fluctuation in reactor temperature. Therefore biogas production is found to go down significantly in the winter months in North India.

- The quantity of biogas produced in a small to medium sized UASB is not adequate enough to guarantee favourable economics of bio-energy generation.
- The duel fuel engines which are generally installed due to their low cost invariably require large quantity of diesel as the supplementary fuel. Apparently, the cost of diesel turns out to be not only high but disadvantageous as the electricity is made freely available to the STP operating agency. Economics of environment and resource utilisation apart, it does not make business sense for the operating agency to run the duel fuel generators on externally purchased diesel.
- State-of-the-art technology based gas engines are not yet made in India and the imported engines are rather expensive. Their deployment for small scale applications turns out to be unviable. Secondly, utilisation of waste heat from such cogeneration systems is not a techno-economically feasible option under the setting of an STP, which otherwise makes such systems financially attractive in colder climate countries.
- As the energy requirement of the UASB plant is low and the process is not vulnerable to power cuts; and energy bill of the STP is linked to the installed load any way, there in no incentive for the operating agency to generate bio-energy in-house by incurring extra expense on diesel. (These conclusions are corroborated by field observations of typical 1-2 hour operation of duel fuel engines or none at all as against the originally perceived full utilisation of biogas over 24 hour period.)
- Lastly, there is a risk of corrosion of the engine parts as the biogas typically contains hydrogen sulphide. The technology for desulpherisation is on one hand not widely available in India and on the other hand it entails additional recurring expenses. There have been cases of gas engines being taken off due to severe corrosion and desulpherisation plant being abandoned due to lake of required chemicals and resources.

Resource recovery

- Another ‘resource recovery’ option through the sale of sludge has found no takers and its potential to serve as a reliable and major revenue generating stream has not fructified.

- ‘Resource recovery’ through bio-energy generation and sludge, which was the guiding principle of the promoting and implementing agencies at the time of launching the UASB technology, turns out to be a myth as none of the plants have been able to contribute in any significant way towards the cost of operation and maintenance in any form.

Others

- Performance of the UASB based plants is, in general, adversely affected by mixing industrial effluents that contain some toxic materials or high levels of sulphate.
- In general, corrosion of structures in and around a UASB based plant is found to be higher compared to other technology based STPs.

THE CONCLUSION

It is evident that partial primary treatment through a UASB reactor makes the raw sewage more problematic to treat. Such systems neither deliver the required effluent quality nor produce the expected bio-energy. Considering all the pros and cons of the technology, especially the need for an elaborate secondary and tertiary treatment, the rational for adopting a UASB for sewage (and especially diluted sewage under Indian context where the flows are intercepted in open drains) is debatable. In retrospect the less ‘ambitious’ conventional technologies e.g., activated sludge process, trickling filter or facultative aerated lagoons would still be able to perform much better compared to the UASB. The biogas potential of sludge digesters in conventional activated sludge process plants is perceived to be more promising and consistent and therefore it is recommended this conventional option should be preferred for sewage treatment.

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