POST TREATMENT

Based on the literature reviewed it can be said that the UASB reactor is an efficient process for removal of organic material and suspended solids from sewage. Particularly, this process is more attractive for treatment of sewage in warm climate. However, the UASB reactor can hardly remove macronutrients (nitrogen and phosphorous), and pathogenic microorganisms are only partially removed. Hence, depending on the final disposal of the effluent quality, post-treatment may be required for removing residual BOD and TSS to reduce the concentration of nutrients and pathogens.

Nutrients and presence of pathogens in sewage.

Concentration of nutrients: The most important nutrients in sewage are nitrogen and phosphorous. In raw sewage these nutrients are present in organic compounds and as mineral ions, such ammonia (NH_4^+) and forms of phosphorus (HPO_4^{-2} and $H2PO_2^-$). In the UASB reactor the organic substances are largely mineralized and only the inorganic forms remain. Occasionally, traces of oxidized nitrogenous compounds (nitrate, No_2^- and nitrite, No_3^-) may also be present.

The concentrations of the nutrients in sewage (and hence in the UASB effluents) vary significantly for sewage from different origins. This may due to dilution of domestic sewage with rain and infiltration water and also due to difference in the socioeconomic habitats of the population. The low nitrogen concentration is expected for low-income population, as they are forced to use only carbohydrates, rather than proteins as food. The anaerobic process affects TKN/COD and P/COD ratio, treated effluents, as these nutrients are largely unaffected in anaerobic treatment and the COD concentration is reduced.

Pathogens in sewage: These are large group of organism, including viruses, bacteria, protozoa, and nematodes, responsible for transmission of many human diseases. It is impossible to quantity all these pathogens together, hence a group of bacteria has been chosen as most important indicator of the sanitary quality of water. This group composed of thermotolerant coliforms, also called faecal coliforms, among which Escherichia coli(E.coli) are the most numerous. Other less frequently utilized indicators are concentration of faecal streptococci and the helminthes eggs.

Post-treatment in stabilization ponds

Stabilization ponds are widely used in practice for treatment of raw sewage to stabilize organic material and remove suspended solids. It consists of shallow earth basin in which the sewage is treated by biological process. The oxygen is supplemented by transfer of atmospheric oxygen to liquid phase and in addition, oxygen produced due to photosynthetic activity of algae. The oxygen production rate is higher than absorption of atmospheric oxygen in many cases. The top layer of the pond is aerobic and the depth of this aerobic layer depends upon oxygen production rate of algae and oxygen consumption by the bacteria. If the pond is used for treatment of high strength wastewater, the oxygen consumption rate will be higher, making top aerobic layer very thin, and such ponds are called as anaerobic. A pond with significant aerobic top layer, at least during daytime, is referred as facultative. While treating low strength wastewater, the oxygen production rate may be exceed the consumption rate, and contents of pond permanently may remain aerobic. Under such situation (maturation pond) during intense sunshine the pond may release oxygen to atmosphere. As a rough guideline for design, the pond with loading greater than 100 g BOD/m^3.day will function as anaerobic, loading in the rang 200-300 kg BOD/ha .d will be facultative, while loadings less than 50-150 kg BOD /ha .d will be maturation ponds [Haandel and Lettinga, 1994].

A pond configuration for efficient BOD removal requires retention time of 20-30 days in series, with about three ponds with five to ten day retention time in series. This long retention time automatically leads to a high removal efficiency of the pathogens. The pond in series may give pH between 8 to 9 for final effluent. This is due high oxygen production rate over bacterial oxidation, so that the carbon dioxide is removed biologically. The higher pH may escape to atmosphere as undissociated NH_3 and phosphate may precipitate

Removal of pathogens in stabilization pond: When stabilization ponds are used for post treatment of effluent from UASB reactor, the organic concentration will be low and pond can acquire characteristics of maturation ponds. In that case apart from further reduction of BOD and TSS, the objective will be removal of pathogens and / or nutrients present in the wastewater. The removal of pathogens is based on bacterial die-off rate, which increases with increase in temperature. The death rate of algae is notably affected by (a) presence of algae, (b) high pH value, (c) high DO concentration, and (d) high intensity of light [Haandel & Lettinga, 1994]. Hence, it can be said that the bacterial die-off rate will be more in shallow pond than in a deep pond.

Stabilization ponds were used for the post treatment of demonstration UASB reactor treating sewage. Series of stabilization ponds were used (three and four numbers) for the post treatment. The influent BOD and COD concentration for UASB reactor was reported to be 455 and 1017 mg/L, respectively with effluent concentration 53 and 248 mg/L respectively. BOD and COD reduction was observed in first pond reducing the value to 35 and 140 mg/L respectively, where as no reduction or little increase in this was reported in this was reported in second and third pond. The E.coli concentration in the UASB effluent was 4.7×10^6 which was got reduced to 2.8×10^5, 9.0×10^3, and 6.1×10^2 in the series of ponds. Thus, a WHO criterion for unrestricted irrigation (N E.coli < 100/100ml) was met in the third pond of both the system. When fourth pond was used in series with NE.coli ($100ml^{-1}$) in UASB effluent as 9.0×10^6 the NE.coil in the series of pond was 3.9×10^5, 9.8×10^3, 7.7×10^2, and 1.0×10^2 [Haandel and Lettinga, 1994].

The higher BOD, COD, and TSS concentration from effluent of stabilization pond can be attributed to high concentration of algae in the pond. For every kilogram of oxygen produced by photosynthesis, stoichiometrically 1 kg COD in the form of algal mass is produced. If the organic material formed does not settle out completely, the COD of liquid phase will tend to increase if there is net oxygen production in the pond. The algae can be removed by settling by adding flocculent such as lime.

Nutrient removal in stabilization ponds: The shallow stabilization ponds are more efficient for nutrient removal. The high pH in a shallow pond can remove both ammonia and phosphorous. At pH value exceeding 9.3 at 20^0C (8.6 at 30^0C), ammonia present predominantly in the undissociated NH_3 form and can be removed physically from the liquid phase by desorption [Haandel and Lettinga, 1994]. The desorption of ammonia is accelerated when oxygen bubbles evolve from the pond due to over saturation. Depending on operational and environmental conditions phosphate can precipitate as apatite $Ca_5(OH)(PO_4)_3$, or struvite $Mg(NH_4)PO_4$. At Pedregal, Brazil the TKN concentration in the final effluent of stabilization pond, when used as post treatment to UASB reactor was 3 to 4 mg/L with removal efficiency of 95 to 96 %, and removal efficiency for phosphorous was 77 to 87% [Haande and Lettinga, 1994]. It is important that nutrient removal will be efficient only at high pH value and to maintain these shallow ponds (0.3 to 0.6 m) are essential.

Post Treatment Using Activated Sludge Process:

It is widely used treatment method for sewage with advantage of low land requirement compared to stabilization pond and very high treatment efficiency. The major disadvantage of this process is high construction and operational cost required for aeration, and stabilization required for excess sludge produced.

In regions with a warm climate (>20^0C) it is virtually impossible to avoid the development of nitrification in an activated sludge process. Under these conditions, denitrification becomes essential to avoid the formation of nitrogen gas in the settler with the consequential flotation of sludge that eventually leads to sludge loss and failure of system.

The presently available limited experience of anaerobic – aerobic treatment indicates that the effluent COD of a combined anaerobic – aerobic system is lower than that of the activated sludge process. This is an important additional advantage making anaerobic-aerobic treatment more attractive. The advantages of these concepts are as under.

1) Due to removal of organic material and SS in UASB reactor, the sludge mass in the ASP becomes relatively small and consequently the reactor volume required is reduced. The total volume for the anaerobic-aerobic treatment may often be less than half that required for aerobic treatment including sludge digester.

2) The process of the anaerobic reactor eliminates the need for a sludge stabilization unit. The excess activated sludge can be conveyed to the UASB reactor.

3) The sludge production will be smaller in an anaerobic – aerobic system because of the comparably smaller sludge production in an anaerobic system. In addition, due to better characteristics of the sludge of the sludge in anaerobic reactor liquid-solid separation is simpler.

4) Since, part of the organic load is removed anaerobicaly, the oxygen demand of the aerobic part becomes significantly lower, so that less power is required. The produced biogas can be used for power generation, which can make anaerobic - aerobic sewage treatment independent of external energy.

Other Post Treatments:

The other treatment methods which are reported to be successful for further treatment of the effluent from UASBR are aerobic bio-filter, oxidation pond, aerated lagoons, secondary settler, sand filter, land infiltration, rapid sand filter. After any one of the post-treatment chlorination is generally carried out before final discharge of the treated effluent. From the literature reviewed, it appears that A.S.P. followed by chlorination is the popular method for post treating UASB effluent.

Discharge:

The finally treated wastewater can be discharged in river or can be used for irrigation or for recharging ground water.