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# DESIGN OF STP USING UASB TECHNOLOGY

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**ABSTRACT**

*At present, there are many UASB plants that are in operation in India and some are in developing phase.UASB technology potential was shows in developing countries for future use on the bases of evaluation of life cycle cost of UASB. UASB's plant used for waste water treatment and it is most favourable methods. Waste water treatment plants have challenges to treat the excess sludge and disposal of sludge and it was economically, environmentally supported. For using UASB technology to explore, develop and reduce sludge production though biologically process. This paper reviews the mechanism of sludge reduction by UASB plants. By using the cost analysis and environmental impact assessment to reduce the sludge and its practical approach to treat the water through UASB process.Under anaerobic conditions, organic pollutants in wastewater are degraded by microbes producing methane and carbon dioxide.Among anaerobic technologies, the most popular ones are the upflow anaerobic sludge blanket (UASB). In the UASB process, the waste to be treated is introduced in the bottom of the reactor. The wastewater flows upward through a sludge blanket composed of biologically formed granules or particles. Treatment occurs as the waste comes in contact with the granules.*

***Keywords:Effluent, Hydraulic Retention Time(HRT), Organic Loading Rate(OLR), sludge, UASB***

## I.INTRODUCTION

UPFLOW Anaerobic Sludge Blanket (UASB) reactor also called as anaerobic reactor was used to treat various industrial wastewaters like petroleum, distillery, Canning industry, Heavy metals, Paper and Pulp, Tannery , Pharmaceutical, domestic waste wateretc. The sludge blanket in the UASB comprised of microbial granules, i.e. small agglomerations (0.5 to 2mm in diameter) of microorganisms and because of their weight able to resist being washed out in the upflow. Bacteria living in the sludge, break down organic matter by anaerobic digestion and transforming it into biogas. The rising bubbles mix the sludge without the assistance of any mechanical parts. Sloped walls push down the material that reaches the top of the tank. The gas that rises to the top is collected in a gas collection dome and can be used as energy (biogas).

### 1.1 Hydraulic Retention Time (HRT)

HRT is considered as an important for operating parameter which controls the performance of UASB reactor. Very long HRT will affect adversely on the process of sludge granulation in UASB reactor and very short HRT is disadvantageous due to the fact that the biomass may move out with effluent.

## 1.2 Organic Loading Rate (OLR)

This is another important parameter to control the performance of UASB reactor. Increase of OLR will cause an operation problem. OLR is an important factor for the removal of COD. Aerobic biological treatment involves microbial degradation and oxidation of waste in the presence of oxygen. Conventional treatment of dairy wastewater by aerobic processes includes processes such as activated sludge, trickling filters, aerated lagoons, or a combination of these. All compounds of dairy wastewater are biodegradable except protein and fats which are not easily degrades.

Organic matter + microorganisms + $O_2$ $5CO_2$ + 2 $H_2O$ + $NH_3$ + energy

Anaerobic microorganisms are those that do not have oxygen as a terminal electron acceptor. The oxidation of organic matter in anaerobic respiration is coupled with the reduction of other electron acceptors such as sulphate (sulphate reduction), ferric iron (iron reduction), nitrate (denitrification), $CO_2$ (methanogenesis) or some organic compounds. An anaerobic process involves the degradation of complex high-molecular- weight organic compounds to mainly methane ($CH_4$) and car- bon dioxide ($CO_2$).The chemical reactions (fermentation) involved in the reactor to produce hydrogen are

$CH_3CH_2CH_2COOH + 2H_2O \longrightarrow 2CH_3COOH + 2H_2$

Butyric acid water Acetic acid Hydrogen

$CH_3CH_2COOH + 3H_2O \longrightarrow CH_3COOH + 3HCO_3 + 3H_2$

Propionic acid water Acetic acid Hydrogen

$CH_3COOH + 2H_2O \longrightarrow 4H_2 + 2CO_2$

Acetic acid water Hydrogen Carbon-di-oxide

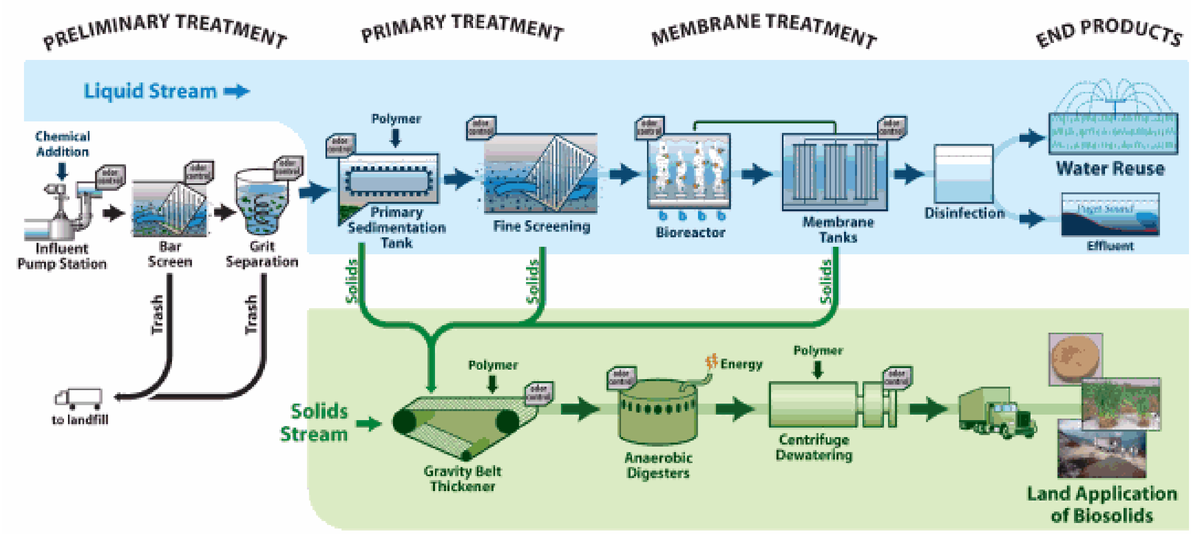


**Fig.1.2Sewage treatment process**

## II.CHARACTERISTICS OF UASB REACTOR

The hydrodynamic characteristics of UASB bioreactors operated under different OLR and hydraulic loading rates were explained by Siby John and Vinod Tare (2011). The investigators used three laboratory scale models to treat concocted sucrose wastewater. With the help of these models, the characterization of fluid flow pattern in the reactors, the correlation of the hydraulic regime with the biomass content and biogas production were studied. The empty bed reactors followed a plug flow pattern and the flow pattern changed to a large dispersion mixing with biomass and gas production. Effect of increase in gas production on the overall hydraulics was insignificant. The UASB reactor was operated under different organic loading and hydraulic loading rates. The reactor consists of two components i.e. biological dead space and hydraulic dead space. The biological dead space includes both the volume occupied by biomass and dead space that results from the interference of biomass particles in fluid flow. Hydraulic dead space tends to occur wherever the stagnant zones form.

### 2.1 Kinetics and Models used in UASB reactor

Mathematical model was developed by Florencio et al (1996) in order to achieve the optimum alkalinity dosage for good pH stability in a reactor treating methanol. The model estimates pCO2 and pH expected from certain stoichiometry yield of acetic acid and methane from methanol. It was mentioned that the model did not considered nitrogen and phosphorous uptake by the biomass that would contribute for loosing alkalinity. With this model it is possible to predict the pH in the reactor and the CO2 composition of the biogas. [1] Romli et.al (1994) investigated the effect of reducing the pH of the acidification reactor on the overall performance of a two stage anaerobic wastewater treatment system both experimentally and to simulation of a dynamic structural model. The system operated at low pH was subjected to a short-term step increase in feed concentration. The measured and the predicted dynamics responses of reactor variables to the shock load were evaluated. The dynamic response of the system to a shock load indicated a decrease in effluent quality during the disturbance. But the system was recovered quickly as soon as the shock load terminated. The comparison between the experimental and the simulation results demonstrated the feasibility model that can be applied for reactor design and operational evaluation purposes. [2]. The sulfide toxicity effects are studied by Paula and Foresti (2009) using kinetics of a UASB reactor. The two lab-scale UASB reactors (10.5L) were used and operated in continuous mode for 12 months. The reactors were fed with synthetic waste using glucose, ammonium, acetate methanol and nutrient solution. The authors reported that one of the reactors received the increasing concentration of sodium sulfide. Both the reactors were operated at the substrate COD of 2000mg/L, HRT 15.6h, the COD removal was observed as 98%. The overall kinetic parameters obtained with the bench scale UASB reactor operated under progressive increase of total sulfide concentration at pH in the alkaline range.

## III. NEED OF SEWAGE TREATMENT PLANT

Many municipal and industrial wastewater treatment facilities are faced with extremely stringent discharge limitations for toxic contaminants through the adoption of state water quality human health criteria and limitations of the Federal Clean Water Act to mitigate the implementation of water quality standards.

Wastewater treatment facilities typically do not generate toxics, but are tasked with treating contaminants that enter the plants as a consequence of consumer products, storm water, ambient deposition, contaminants in the intake water (legacy

compounds and naturally-occurring elements) or manufactured products that contain toxic by-products. The proposed state water quality human health criteria will result in discharge limitations that may be unattainable with currently available technologies or the addition of technologies that are prohibitivelyexpensive and produce little benefit.

### 3.1 Significance of sewage treatment plant

The procedure for removing contaminants from the wastewater basically from the household sewage is called sewage treatment. It has to undergo the chemical, physical and biological procedure to remove these contaminants and give out an environmentally safe treated effluent. A semi-solid slurry called the sewage sludge is the by-product of the sewage treatment. This sludge is further processed before it is suitable for land application.Sewage treatment is also called as wastewater treatment, i.e. it also includes treatment of wastewater from industries. In many cities, the sewer carries a proportion of industrial wastewater to the sewagewater treatment plant which has already undergone a treatment in the factories for reducing the pollutant.If it is a combined sewerit willalso carry
storm water along with it. The sewage waters travel to the sewage watertreatment plants through pipes and pumps. The sewage in the sewage water treatment plant undergoes the following basic processes.

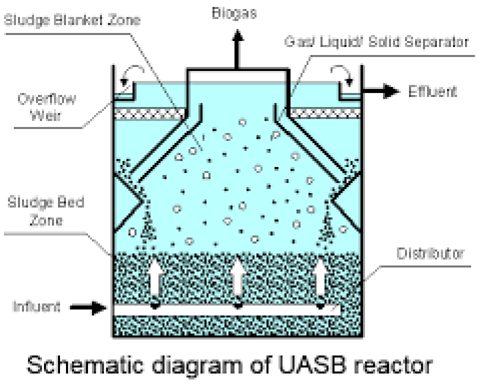


**Fig.3.1 Schematic diagram of UASB reactor**

## IV.ANAEROBIC DIGESTION AND WASTEWATER TREATMENT SYSTEMS

UASB wastewater (pre-) treatment systems represent a proven sustainable technology for a wide range of very different industrial effluents, including those containing toxic/inhibitory compounds. The process is also feasible for treatment of domestic wastewater with temperatures as low as 14-16 degrees C and likely even lower. Compared to conventional aerobic treatment systems the anaerobic treatment process merely offers advantages. This especially is true for the rate of start-up. The available insight in anaerobic sludge immobilization (i.e. granulation) and growth of granular anaerobic sludge in many respects suffices for practice. In anaerobic treatment the immobilization of balanced microbial communities is essential, because the concentration of intermediates then can be kept Total coliforms (TC) is encompassing fecal coliforms as well as common soil microorganisms and is a broad indicator of possible water contamination. Fecal coliforms (FC) is an indicator of water contamination with fecal matter. The common lead indicator is the bacteria Escherichia coli or E. coli. sufficiently low. So far ignored factors like the death and decay rate of organisms are of eminent importance for the quality

of immobilized anaerobic sludge. Taking these factors into account, it can be shown that there does not exist any need for 'phase separation' when treating non- or slightly acidified wastewaters. Phase separation even is detrimental in case the acidogenic organisms are not removed from the effluent of the acidogenic reactor, because they deteriorate the settle ability of granular sludge and also negatively affect the formation and growth of granular sludge. The growing insight in the role of factors like nutrients and trace elements, the effect of metabolic intermediates and end products opens excellent prospects for process control, e.g. for the anaerobictreatment of wastewaters containing mainly methanol. Anaerobic wastewater treatment can also profitably be applied in the thermophilic and psychrophilic temperature range. Moreover, thermophilic anaerobic sludge can be used under mesophilic conditions.

### 4.1 UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR

One of the more interesting new processes is the UASB process, which was developed by Lettinga and his co-workers in Holland in the early 1970's. The key to the process was the discovery that anaerobic sludge inherently has superior flocculation and settling characteristics, provided the physical and chemical conditions for sludge flocculation are favourable. When these conditions are met, a high solids retention time (at high HRT loadings) can be achieved, with separation of the gas from the sludge solids. The UASB reactor is one of the reactor types with high loading capacity. It differs from other processes by the simplicity of its design. UASB process is a combination of physical and biological processes. The main feature of physical process is separation of solids and gases from the liquid and that of biological process is degradation of decomposable organic matter under anaerobic conditions. No separate settler with sludge return pump is required, as in the anaerobic contact process. There is no loss of reactor volume through filter or carrier material, as in the case with the anaerobic filter and fixed film reactor types, and there is no need for high rate effluent recirculation and concomitant pumping energy, as in the case with fluidized bed reactor. Anaerobic sludge inherently possesses good settlingproperties, provided the sludge is not exposed to heavy mechanical agitation. For this reason mechanical mixing is generally omitted in UASB- reactors. At high organic loading rates, the biogas production guarantees sufficient contact between substrate and biomass. Regarding the dynamic behaviour of the water phase UASB reactor approaches the completely mixed reactor. For achieving the required sufficient contact between sludge and wastewater, the UASB-system relies on the agitation brought about by the natural gas production and on an even feed inlet distribution at the bottom of the reactor [3].

## V.ANAEROBIC TECHNOLOGY AS AN ALTERNATIVE TO AEROBIC TECHNOLOGY

Anaerobic technologies should be considered for sewage treatment as an alternative to aerobic technologies in most developing countries for a variety of reasons. Anaerobic treatment can be carried out with technically simple setups, at any scale, and at almost any place. It produces a small amount of excess, well stabilized sludge, and energy can be recovered in the form of biogas. The process can be carried out in both centralized and decentralized modes, and the latter application can lead to significant savings in investment costs of sewerage systems. Anaerobic treatment technologies, as noted by McCarty (1982) were explored as early as 1881. Within the domain of anaerobic technology, a low-cost technology such as the Upflow Anaerobic Sludge Blanket (UASB) has shown considerable promise recently.

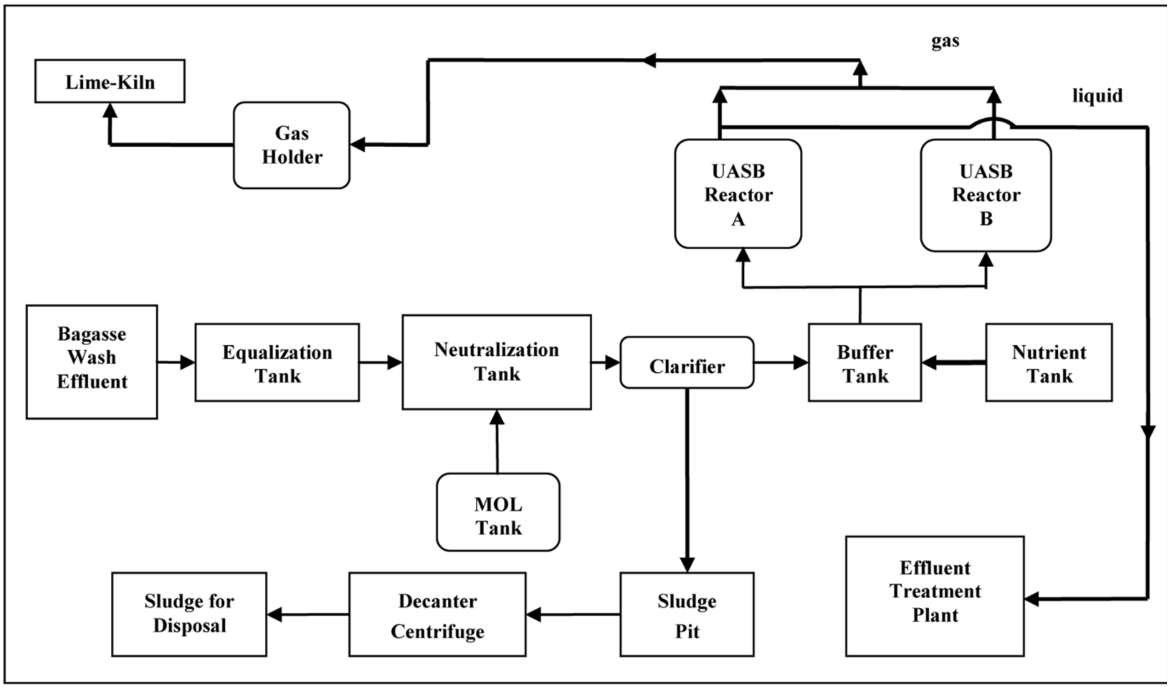


**Fig.5 Flow chart of UASB process**

In 2002, about 100 of UASB reactors were in use for domestic wastewater treatment systems, particularly in the developing countries (Foresti, 2002). At present, over 200 full-scale UASB plants are in operation for the treatment of both domestic and industrial wastewaters worldwide (Khalil et al., 2008).

UASB is a robust high-rate reactor system, generally without moving parts; reducing both capital and operating costs. In the UASB reactor the wastewater enters at the bottom of the reactor and flows upward through the sludge bed. During the flow, it passes through high concentration of biomass in the sludge bed where the organic matter is degraded. The organic carbon is converted to biogas (mainly methane and carbon dioxide) due to high concentration of microorganisms (low food to microorganism ratio) although small amount of biomass is also produced. Upward flow of liquid and rising gas bubbles through the sludge bed provide mixing which enhance wastewater-biomass contact. The syntrophic association between different microorganism lead to selfagglomeration within the biomass. These dense near spherical agglomerates with high settling velocity are known as ―granules‖ . In the granulated sludge bed, a high upflow velocity can be maintained because of higher settling velocity of the granulated sludge thereby reducing the treatment time (Hulshoff Pol et al., 2004; van Haandel and Lettinga, 1994). The cost involved in the operation and maintenance of UASB plants is less than 1% of capital cost per year. It has also been estimated that the annual operation and maintenance cost of the UASB plant is approximately 30 % of the ASP based plants (IWTC12 2008, Alexandria, Egypt1420). The Expanded Granular Sludge Bed (EGSB) reactor is a modified version of the UASB reactor which works on the same principle. This technology was modified to incorporate higher superficial velocities (greater than 4 m/h) by providing a larger height to diameter ratio and with the use of effluent recirculation. The higher upflow velocities expand the bed,

eliminate dead zones and lead to better wastewater/biomass contact (van der Last and Lettinga, 1992).On the other hand higher upflow velocity results in washout of fine biomass particles thattypically form after prolonged at low loading rates (Aiyuk et al., 2004). This UASB reactor technology already have been applied successfully for the treatment of a various types of wastewater, including low-strength wastewaters, particularly under tropical conditions (Banu et al., 2007; Tandukar et al., 2005; Aiyuk and Verstraete, 2004). The process is applied in many countries all over the world. Many places where living standards are high have very diluted domestic wastewater. In India most of the cities, contain COD of sewage in the range of 200 mg/ l to 400 mg/l or even lower, instead of 500 mg/l to 700 mg/l reported forsuccessful operation of UASB reactor by various researchers (Aiyuk et al., 2006; Foresti, 2001; Lettinga, 2001).

### 5.1 UASB Reactor for Low Strength Wastewater Treatment in India

Experiences with UASB technology in India are progressive. In India, UASB was introduced for the sewage treatment during the Ganga Action Plan (GAP) in a bilateral co-operation between India and The Netherlands in 1985. First full-scale UASB reactor of size 5 MLD for the treatment of domestic wastewater was running since April 1989 at Kanpur (Seghezzo, 2004). Subsequently, in April 1994 another unit of size 36 MLD was installed in the same town to treat the wastewater of approximately 180 tanneries after dilution with domestic wastewater in the ratio of 1:3 (Haskoning Consulting Engineers and Architects, 1996a). After studying the performance of the demonstration plant (Kanpur) for a few years, a full scale UASB plant of 14 MLD with a polishing pond of HRT one day was constructed at Mirzapur for treating the domestic wastewater. The plant has been constructed as part of the Indo-Dutch Environmental and Sanitary Engineering project under the Ganga action plan. It has been in full operation since April 1994 (Haskoning Consulting Engineers and Architects, 1996b). In all the cases, COD removal was only 50-70% along with some reduction of sulphate (Seghezzo, 2004; Draaijer et al., 1992). A similar plant designed for 50 MLD was built in the city of Hyderabad, India (Tare et al., 1997). Now the time has changed and at present India is one of the leading countries in terms of the amount of sewage volume treated by the UASB process (Sato et al., 2007). It is reported that 80% of total UASB reactors installed all over the world for domestic wastewater treatment is in India (Khalil et al., 2008). It has been recognized as one of the most cost effective and suitable sewage treatment process considering the environmental requirements in India (Sato et al., 2007; Aiyuk et al., 2006). According to 2005-06 reports of Ministry of Environment and Forests (MoEF), about 23 UASB sewage treatment plants with total installed capacity of 985 MLD were in operation and about 20 were in the pipeline which were likely to be commissioned within next 3-4 years (Khalil et al., 2008). Among the large capacity plants under YAP, in all 28 STPs comprising 16 UASBs, 10 Waste Stabilization Ponds (WSPs) and 2 BIOFOR (Biological Aerated Filtration Process) technology STPs with aggregate capacity of 722 MLD were constructed (MoEF, 2005 and 2006). This reflected, UASBs accounted for an overwhelmingly high 83% of the total created capacity. Reports also cover the types and sizes of the localities where these plants were installed. The Central Pollution Control Board (CPCB) report (CUPS/61/2005-06) of the same period puts the total number of sewage treatment plant based on UASB technology at 30 in the Class-I cities (population of more than 100000) and 3 in the Class II towns(population between 50000 and 99000).

The state of Haryana almost entirely opted for UASB technology where 10 out of the 11 large plants were based on this technology.

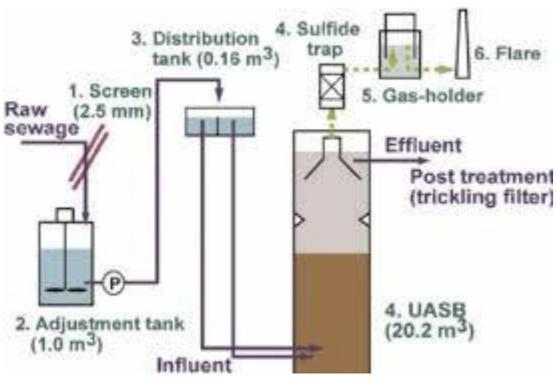


**Fig.5.1 UASB**

## VI.CONCLUSIONS

Sewage treatment is not a cheap proposition. Public bodies have to think twice before making substantial investments particularly in developing countries where environmental issues could not be given priority due to financial constraints. During the past three decades, several new sewage treatment technologies have been developed and are being adopted in many developing countries particularly in the South-East Asian region including India. Recent developments in the field of anaerobic treatment have proved that the anaerobic treatmentprocesses specially UASB reactor are not restricted to the high strength wastewaters, but also they can successfully be applied to low strength domestic wastewaters.The physico-chemical properties and methanogenic activity of sludge from seven treatment plants were determined. The highest activity was found in the sludge from the treatment plan in El Viejo city, which means that this sludge could be used as inoculum in new treatment plants. Very useful experience was acquired working with sludge from the municipal treatment plants. In the case of the brewery wastewater treatment plant, the deficient concentrations of sulphide and iron were probably the reason for the unsatisfactory granular sludge formation. The addition of these elements to the anaerobic reactor was suggested to the authorities of the treatment plant. The ability of small, UASB systems may be suitable for increased use in the urban environment. Two main reasons behind the importance of Using UASB are:

(1) generation of large volume of low-strength wastewaters, which are often disposed untreated due to high costs, and

(2) the potential of stabilizing the organic wastes by producing valuable energy byproduct. Finally, it may be concluded that, UASB reactor has been recognized as one of the most cost effective and suitable sewage treatment process considering the environmental requirements in India.

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