*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **3(8),** 67-71, August **(2014)** *Int. Res. J. Environment Sci.*

Review Paper

Up-flow Anaerobic Sludge Bed (UASB) Based Sewage Treatment Plant (STP) at Mirzapur: A Review

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Available online at: www.isca.in, www.isca.me
Received 1st May 2014, revised 15th June 2014, accepted 19th July 2014

Abstract

At present, there are many UASB plants that are in operation in India and some are in developing phase which will made next 3 to 4 years. UASB reactor design and construction in past was shows quite different and the very first 5 MLD treatment capacities plant that were demonstrated and constructed at Kanpur, India under the Ganga Action Plan in 80's. This paper was reviews overall UASB technology in Mirzapur, India. 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.

Keyword: Waste water, sludge, life cycle, environment, life cycle.

Introduction

Water is essential for human being survival and it is valuable resource in the world. Human activity are changes the morphology of the river water and causing pollution in river water[1]. There are many Techniques such as solvent extraction, chemical precipitation, electrochemical precipitation, ion exchange, membrane separation, reduction and adsorptions have been applied for waste water treatment[2,3]. The Ganga is important river; it rises in the Gangotri glacier in the Himalaya Mountains at an elevation of 7138 m above mean sea level in the Uttar Kashi district in the state of Uttaranchal, India. Already half a billion people almost one tenth of the world's population live within the river basin at an average density of over 500 per square kilometre. A variety of pollutants can be removed from the sewage by biological and chemical degradation, sorption to sludge or volatilization[4]. River water quality affects the food, health and environment and also deteriorated the surface water[5-7]. By using the anaerobic process in first step chemical oxygen demand (COD) are high in waste water that are more than 2,000 mg/l, it was highly suitable for biogas production economically[8]. Industrial and domestic waste water was treated by using the activated sludge process in the world. This process is more intensive than the fixed film process and also treat 10 times more waste water by per unit reactor volume and the operation cost have low as compare to other process[9]. Application of UASB technology in India has unique and diverse experience has gained and also treats the sludge through this technology and become a leading country[10]. It has the cost effective and suitable sewage treatment process and it environmentally required in India. In India 23 numbers of treatment plants has totally installed ant capacity of these plants are 985 MLD and 20 are in pipeline which are commissioned next 3 to 4 years[11]. For the treatment process of waste water there are many parameters was observed high concentration, and treated water discharge in to the water body and that is possible to treat the water through the UASB process that reduces most of the pollutant[12,13].

In this study, we have collected all the information about the UASB. These studies relate the industrial and domestic wastes like volatile fatty acid, sugar contain wastes, and paper mill effluents, citrate wastewaters, spent fermentation liquors, brewery wastes and concentrated benzoate wastes.

Material and Methods

Study area: The 14 MLD UASB sewage treatment plant at Mirzapur has been constructed as part of Indo- Dutch Environmental and sanitary engineering project under the Ganga Action Plan. The plant was first test commissioned in the month of Feb 1994 and has been under observation since then. The consultants had prepared the first monitoring report at the end of May 1994 which covered the period from February to May 1994 and since then monthly monitoring reports have been prepared. The world's first full scale demonstration of UASB for municipal sewage was built in Kanpur, India, in1989 (5ML/Day capacity) under an Indo-Dutch project and has been

in successful operation since then. Subsequently, under the same project, a 14 MLD unit was designed and built in Mirzapur, UP, and yet another 36 MLD unit has been commissioned for Kanpur to treat sewage mixed with tannery wastes. A plant of 50 MLD capacities has been designed by AIC Watson for Hyderabad city, India, as a part of its master plan for Hyderabad with World Bank funding. A plant was also designed for Pondicherry, India with UASB as pre-treatment followed by a duckweed and fish pond.

In India 80% of UASB treat the wastewater by using UASB reactor and this process is widely adopted in India. Basic approach for selecting these technologies was low costs, low energy requirements, low O and M costs and sustainability aspect. To assess the impact of the wastewater and sludge disposal on the environmental quality of the receiving areas around sewage treatment plants (STPs).

Consideration of UASB Design: The most important feature is the modular approach adopted for the design of UASB reactors. This facilitates in having more flexibility in the operation of the STP. The major treatment units, which includes UASB reactors and final polishing unit (FPU) has been provided in modules of same capacity. Each reactor operation is independent of each other and during trouble shooting in one reactor the flow can be suspended and diverted to the other reactors for its maintenance without disturbing the operation of the STP. Final polishing units (FPU) also have been provided in modules. The basic assumptions and design criteria derived over the years of experience that have been adopted in most of the UASB reactors in India. The design of UASB reactors for domestic wastewater is mainly based on hydraulic principles and the incoming wastewater composition.

Materials for Construction of UASB Reactors: In the present scenario, different places in India the main structure of UASB are made by RCC (Reinforced Cement Concrete) because it was easily available and has been used most in India for construction works. Inside the UASB wall was coated with epoxy paints to avoid the corrosion for protection of layer due to formation of H_2S and CO_2. FRP of Isothelic resin class gas hoods and domes have been provided in the GLSS (gas-liquid-solid separation). The purpose of FRP (Fiber Reinforced Plastic) used is because of easy construction, light weight, anti corrosion and simple maintenance. There are many materials that are constructed by FRP i.e. the feeding boxes, effluent gutters, baffle plates and gas collection pipes. For feeding pipes, HDPE (High Density Polyethylene) pipes are being used to distribute the wastewater uniformly over the surface of the reactor. For sludge discharge, CI (Cast iron) pipe is being generally used. However, further R and D shows that the reactors can be constructed fully in FRP using Isothelic resin instead of RCC for small flows provided modular approach is adopted.

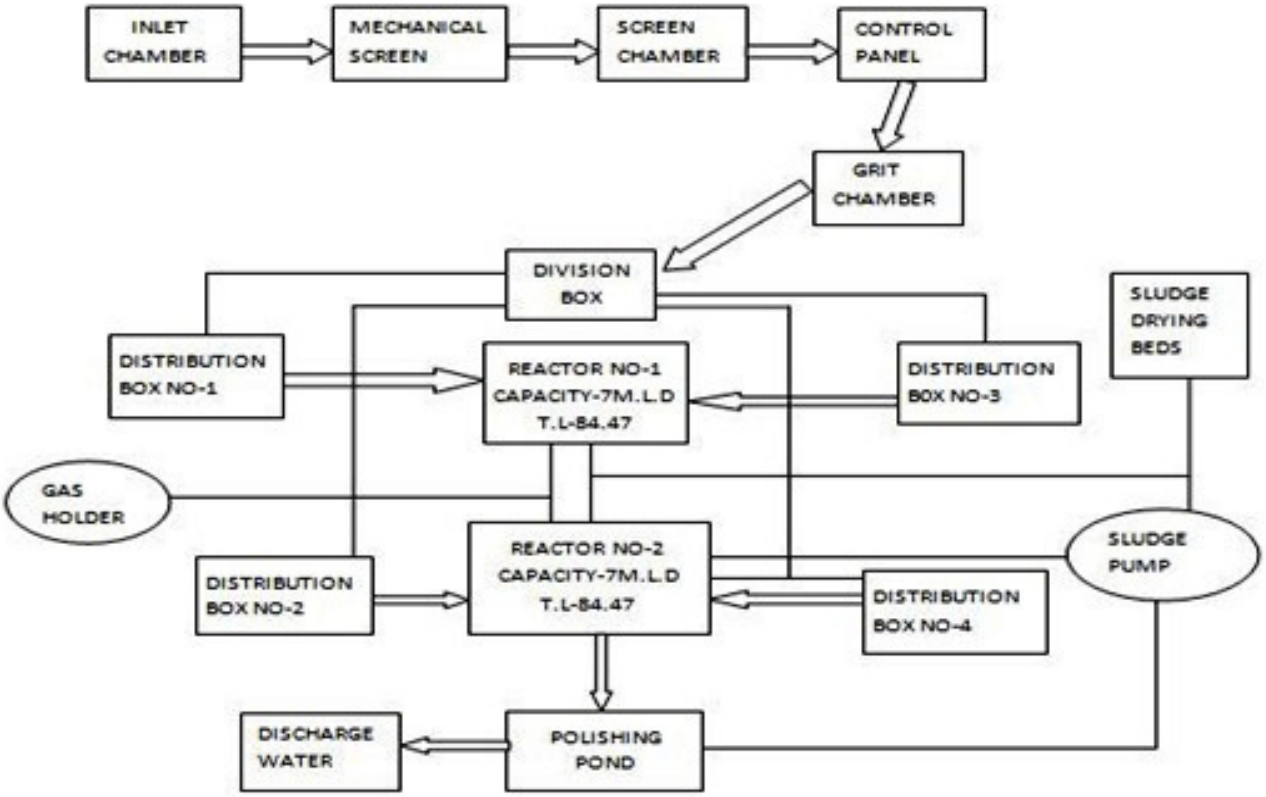

Figure-1
Graphical Representation of UASB at Mirzapur

Table-1
Detail information about UASB in Mirzapur

Details of Required Information	
Place of installation	Pakka pokhra, Mirzapur
Land area required	4.0 hact.
Year of installation	1994
Type of process	Anaerobic process with polishing pond(UASB +POLISHING POND)
Design capacity	14 M.L.D.
Design population	93,500
Cost/MLD of the UASB plant of typical sizes	32.42 lacs/MLD

Raw sewage characteristics	
BOD	150-180 mg/l
TSS	400-500 mg/l
COD	450-550 mg/l
pH	8.5- 9.0

Effluent characteristics (After grit chamber)	
BOD	120-144 mg/l
TSS	320-400 mg/l
COD	405-400 mg/l

Characteristics of final effluents-(After UASB)	
BOD	60-54 mg/l
COD	180-202.5 mg/l
TSS	140-150 mg/l

Over All Performance of UASB STP: The effluent is meeting Ganga Action Plan standard the removal efficiencies are – i. COD Removal = 80% (90 mg/l), ii. BOD Removal = 85% (30 mg/l), iii. TSS Removal = 90% (40 mg/l).

Table-2
Silent Features of 14 MLD UASB Plant At Mirzapur

Feature	**Discription**
A-(1)-Screens	
Number	1 fine mesh screens +1 bye pass bar screen
Size	1.95m x1.55m
Type	Bar
Slope	60 degree
Manual fishnet mesh screen	1.0 cm.x 1.0 cm clear opening
B-Grit Chamber	
1.Number	1+1(one stand bye)
2.Type	Rectangular
3.Size	9.40 m x 2.0 m x o.6m
4.Detention time	30 sec.
5.maximum flow	
6.grit removed particle size	0.15mm
7.Grit removal	425 lit/day=0.043 lit/m3
C-UASB Reactor	
1.Capacity	2 nos. of 7mld each i.e. 14 MLD
2.Size of rector	28.82m x 16.5m x 5.03 m
3.Volume	2413.67 cum.
D-Three Phase Seperator	
1.Gas/liquid surface	Min 10% of the net surface of reactor
2.surface loading in settler	Max 2.0 m3/sq .m/hr.
3.Angle of gas collector	50 degree
4.gas pressure	40m bar, 50M Bar
E-Reactor Compartment	
1.Organic sludge loading	0.3 kg. COD/Kg vss day
2.Minimum sludge blanket height	2.0 m.
3.Retention time	Minimum 3 hr. (Average 8 hr.)
4.No. of feed intlet pipes	1to 8 nos. in each
F-Polishing Pond	
1.Depth	1.25 m.
2.Size	1.75.80 m x 68.00 m (1.19 hact.)
3.organic loading rate	840 Kg./hact./day
4.Hydraulic loading rate	1.26 m3/sqm./day
5.Detention time	1 day
G- Sludge Drying Beds	
1.Bed size	17.00 m x 15.00 m
2.Beds	8 nos.
3.Depth of sludge application	20 cm.
4.cycle	7 day
5.volume reduction	5 cm. to 12 cm.
6.sludge concentration	6%
7.sludge loading rate	520 kg TS/Sq./years.
8.Total sludge production	
As per design adopted for 14 MLD	172 M.T./month
As per actual adopted	110 M.T./month
F-Biogas	
1. Total gas production per kg. COD removed /day	
As per adopted	0.11 to 0.15
As per actual	0.18
G-Gas Utilization	
Generation of electricity-	
As per adopted	37.5 kva
As per actual	20 KVK(3 Nos. generators installed and commissioned)
H-Details of problems encountered	Growth of aquatic weeds and algae
I-Reason for the problems	Paucity of funds

Evaluation of Life Cycle Cost: In past few decades there are many no. of sewage treatment plants was constructed under

various river action plans. There are many technologies like activated sludge process, trickling filter, waste stabilization ponds, UASB and other new technologies have been applied in waste water treatment. Evaluation of life cycle cost (LCC) of different treatment technologies that was operated in India and also compared and forecast the UASB future Prospects by using reliable source of data that was available. The LCC has been used as a reference for selecting these technologies in India and used economically for future STP project. In UASB there are many technologies were used in India such as activated sludge process (ASP), Trickling Filter (TF), Sequencing Batch Reactor (SBR), Moving Bed Bioreactor (MBBR) and Membrane Bioreactor (MBR) have been considered for LCC and some other common technologies Polishing Unit (FPU), and Extended Aeration System (EAS).

Factors Affecting the UASB Reactor: In a UASB reactor, number of events and parameters are influence its behaviour as a settling tank with the purpose of containing as much solid as possible: i. The Up-flow Velocity of the Wastewater in the reactor compartment will be the primary determining factor for the efficiency of the settling of solids. If this parameter is not well designed, solids may even not settle if there would be no biogas production at all. The sludge granules are able to withstand very high liquid upflow velocities up to 4 or even 8 m/h. The lower the upflow velocity, the higher the efficiency will be. ii. The Height of the Sludge Layer (sludge blanket) on the bottom of the reactor will have a distinctly positive effect on the efficiency of the retention of solid in the reactor. If the sludge bed height is too close to the apertures between the gas collectors, sludge will be swept in to the settling compartment because of the increased liquid velocity near the apertures. The reactor design should thus provide for both an effective sludge bed height and enough distance between the sludge blanket and the apertures. iii. The Rate of The Production of Biogas, if the biogas loading is very low, very large aggregates of sludge may rise up and release their biogas. The biogas loading rate is higher; the interface between sludge and liquid will be quite regular. iv. The Area of Liquid –Gas Interface in the Gas Collector will have an influence in the ability of the sludge particles to release any adhered biogas bubbles. The larger the interface area is the better release of the biogas. v. The Upflow Velocity in the settling zone is important for sludge to return in the reactor compartment. vi. The Liquid Velocity in the Apertures is considered important too. This velocity has an effect on the amount of particles swept into the settling compartment of UASB reactor. vii. The Angle of the Gas Collectors has a distinct influence on the amount of sludge in the settling compartment returning in to the reactor compartment. For this reason, the gas collector are always designed with an angle of between 50 and 60^{o}, viii. The Overlap between the Gas Deflectors and The Size of The Gas Collectors is there to minimize the amount of biogas interring the settling compartment. ix. The Length of Overflow Weirs is important to have an equal effluent outflow. If the weir flow rate is too high, sludge from the deeper parts of the settling compartment may be swept along, thereby decreasing the efficiency of solid settling.

Results and Discussion

A "UASB" is like a large septic tank standing on its head. Like septic tank it needs no power to operate. Yet, it is far more efficient in the removal of organic than a septic tank and gives usable biogas. It has also increased the scope for using other treatment systems like polishing pond or oxidation pond which require much less land and used in tandem with UASB.

With all the above speciality and drawbacks, the UASB system has responded well for the treatment of high strength soluble waste water, like those from municipalities and industries like food processing, distilleries, wineries, breweries, and organic chemical, etc. It has been opined that the installation of a UASB plant should be made mandatory requirement of developing every new colony or township. The UASB reactor may achieve high COD and Suspended solid removals at a very short HRT. The efficiency of UASB digesters treating domestic waste waters is in the range of 50 to 75% for COD removals and 70 to 80% for SS removals at typical HRT of 4 to 8 h. Retention of the bacteria containing sludge in the reactor is one of the most important features of the UASB process.

Advantages of UASB System: i. The space requirement of the UASB system is quite comparable to that of an ASP i.e. about 0.5 acre per MLD requires for oxidation pond and 1.5 acres for aerated lagoons. ii. The capital cost investment of UASB plant is about 20 lakh/MLD as compared to about Rs.35 lakh/MLD for an ASP Rs.7.5 lakh/MLD for OP andRs.15 lakh/MLD for aerated lagoons. iii. Biogas is produced in the system as a by product, which can be used to produce electricity to run the system. iv. The sludge production in this system is low, and the produced sludge is having quick dewatering characteristics. v. The system leading to low operation and maintenance costs.

Recommendation: According to municipal body the amount of sewage generated in the area is about 35 MLD. Excluding the probable loss done to evaporation, non interception etc around 28 MLD sewage is left, that requires treatment .But the UASB treatment plant in the city has the capacity to treat only 14 MLD .So, there is balanced around 14 MLD that has to be treated and furthermore, with increasing population the capacity of treatment plant should be increased further.

The discharged water in Ganga River is a long drained known as NEHAR, which have cemented on the base that could not recharge ground water, But it also helpful for irrigation of nearby villagers. The villagers around STP belongs to poor background who discharged their waste directly in NEHAR without aware about the purpose of the plant. So it should be necessary to aware the people about the purpose of this plant that to be avoid the direct pollution of treated discharged wastewater or may be the other option that the NEHAR should be covered.

Mirzapur city, a rural city in U.P. where the temperature is very high during summer season but quite low in winter season. For the proper operation of UASB based STP; temperature is a key factor for controlling the reactor. The summer season is very sufficient for it STP but problem arises in winter. So for it I suggested that one solar system should be installed for proper running of STP in winter season.

Conclusion

In this study, The UASB reactor was found to perform better and the system was demonstrated for the treatment of domestic water, treatment of high strength soluble waste water, like those from municipalities and industries like food processing, distilleries, wineries, breweries, and organic chemical, etc. The successful application of anaerobic digestion to the treatment of biodegradable solid waste and wastewater is critically dependent on the development and use of high-rate bioreactors. There is a considerable amount of biodegradable waste that is suitable for biogas production. One important aspect in promoting anaerobic processes is to demonstrate the appropriate anaerobic technology for waste water, where it is not the common practice today.

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