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Design Conceptions of UASB Reactor in College Campus

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***Abstract*— From the review, India was developing country but still used the old conservancy system at various places, particularly in villages and towns for the treatment of the waste water generated. Although the anaerobic treatment of waste water had been implemented since the beginning of the century, yet conventionally, the anaerobic process was well-thought-out to be a slow process, requires the digesters of large hydraulic retention time (HRT). However, the high rate anaerobic system had been devised and constructed to treat concentrated municipal waste water. The various high rate anaerobic systems had been devised including Upflow Anaerobic Sludge Blanket (UASB) reactor.**

The objective of this paper was to design a UASB reactor for the campus of Government College of Engineering, Jalgaon (GCOEJ) Maharashtra, India. The increase in the sludge retention time (SRT) minimises the sludge production but this however, tend to increase the reactor volume. On the contrary, minimum HRT minimises the reactor volume. Hence, during the design, a proper balancing between these two components was taken into account along with establishing the intimate contact between the incoming waste water and the detailed biological solids in the reactor and maintenance of sufficiently warm temperatures.

The UASB model showed promising results in removal of BOD, heavy metals, pH, turbidity and decrease in microbe content. After characterization of these properties, proper treatment plant was designed and dimension calculated. Diameter of collection pit was calculated to be 6 m and depth to be 5 m. A UASB reactor of diameter 5.5 m and height 5 m was designed such that the amount of methane produced at the end would be 343.852 m^3/d with the daily addition of alkalinity in the form of Sodium bicarbonate of 494.032 kg/d would require to maintain the pH in the reactor.

***Keywords*— Waste water, Environmental engineering, UASB reactor, Anaerobic systems.**

I. INTRODUCTION

The large-scale acceptance of Upflow Anaerobic Sludge Blanket (UASB) method for treating municipal wastewater was comparatively of the recent origin, although the system was developed in the year 1979 by a Netherland's scientist, Mr Gatze Lettinga. The system, however proved very promising, and several such treatment plant came into reality in countries like India, China, some Latin American countries etc. As far as India was concerned, this simple technique was first of all adopted in the year 1989, when a demonstration sewage treatment plant of 5 MLD capacity was installed at Kanpur under the Ganga Action Plan. This has been followed by the installation of a 36 MLD plant at the same place, and 14 MLD plant at Mirzapur. Many more such systems were proposed for treating the municipal wastewater in Haryana and Uttar Pradesh.

The UASB reactor sustains a high concentration of biomass through the development of highly settleable microbial sludge aggregates. The wastewater flows upward through a layer of very active sludge to cause anaerobic digestion of organics of wastewater. At the top of reactor, a 3-phase separation between gas-sold-liquid takes place. Any biomass parting the surface of the reaction zone was directly recirculated from the settling zone. The process was appropriate for both soluble wastewaters as well as wastewater encompassing particulate matter [1, 2, 3].

The X-section of the UASB reactor is shown in Fig. 1. This reactor comprises of an upflowing treatment tank, provided with a feed distribution system at the tank bottom.

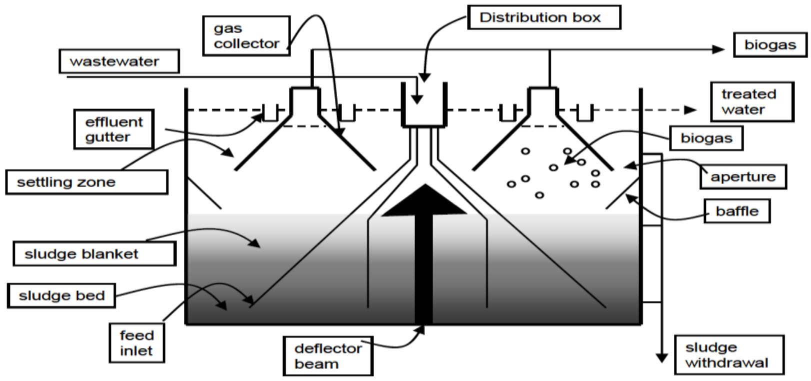

Fig. 1: Working of USAB Reactor [3]

A gas-sold-liquid separator (GSS) device was provided at the top to help deliver a quiescent zone at the top of the reactor. The wastewater enters the tank, from the bottom, and flows upward through the sludge bed, which gets formed during the process itself. The sludge bed develops the micro-organisms capable of thriving in an oxygen deficient environment [1, 2, 3, 4].

The sludge bed called as the blanket ensnared the suspended organics of the upflowing wastewater. The trapped solids were degraded by anaerobic facultative bacterium, producing methane and carbon dioxide found to be a mixture of 65-70% methane, and 30-35% carbon dioxide. The biogas formed during the anaerobic decomposition helps in providing moderate mixing and stirring of the biomass, thereby increasing the efficiency of the decomposition, reducing the BOD and suspended solids of wastewater. The bacteria in the blanket endure to perform their purpose of treating the arriving effluent. The treated effluent was collected in gutters, and discharged out of the reactor. The sludge was intermittently shifted in to the drying beds, to be used as a soil enricher. The methane so produced can be used in domestic or industrial needs etc. [1, 2, 6].

In this paper, a UASB reactor was designed for campus of the Government College of Engineering, Jalgaon (GCOEJ), India. The objective was to characterize the wastewater of the campus, to design the UASBR reactor and to produce methane for the wastewater of the campus. The increase in the sludge retention time (SRT) minimises the sludge production but this however, tend to increase the reactor volume. On the contrary, minimum hydraulic retention time (HRT) minimises the reactor volume. Hence, during the design, a proper balancing between these two components was taken into account along with establishing the intimate contact between the incoming waste water and the detailed biological solids in the reactor and maintenance of sufficiently warm temperatures. The UASB model showed promising results in removal of BOD, heavy metals, pH, turbidity and decrease in microbe content. The scope of this work to study and design the waste water treatment plant using UASB was limited to the GCOEJ campus wastewater generation and its characteristics only.

II. Problem Statement

The GCOEJ campus did not have its own structure for the treatment of the daily wastewater generation within the campus. The wastewater so produced were supplied to the municipal pipeline which was later connected to the sewage treatment plant. This entire process of dealing with the waste was found unsafe in the sense that the wastewater generated contained higher pollutants as Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). This characteristic of sewage imposeed high risk for environment as well as health.

On the other hand, the UASB technology, however, not became so widespread so far, due to the less popularity of this technology. Even the engineers of the Public Health Engineering Departments were usually unaware of this technology [5].

III. Methodology

The UASB, manifestly functioned as a suspended growth system, within packing material in the reactor. In this system, the microbes attached themselves to each other or to small particles of the suspended matter of sewage to form agglomerates and finally the blanket. The gas formed during the process causes adequate agitation to keep the sludge fully mixed.

Under anaerobic circumstances, organic pollutants in wastewater were degraded by microbes liberating methane and carbon dioxide. The wastewater entered the tank, from the bottom, and flows upward through the sludge bed, which get formed during the process itself. The sludge bed developed the micro-organisms capable of thriving in an oxygen deficient environment. The sludge bed called as the *blanket* trapped the suspended organics of the upflowing wastewater. The trapped solids were degraded by anaerobic a facultative bacterium, producing methane and carbon dioxide. The wastewater flows upward through a layer of very active sludge as discussed to cause anaerobic digestion of organics of wastewater. At the top of reactor, a 3-phase separation between gas-sold-liquid takes place [2, 3, 4, 5].

Design of UASB Reactor

The design procedures, data requirement, data collection, data determination and other factors which affected the design of the UASB are described below:

The water sample of the kitchen was collected into a normal air tight bottle of capacity of 2 litres. A mug was used to take the kitchen waste water into the same type of bottle. Similarly, the samples of bathroom and kitchen waste water were collected from hostels of GCOEJ for the experimentation (refer Table I, II, III, IV and V for design information). The samples were collected from the boy's hostel and adjacent pharmacy college.

Using the data obtained from the above process, the following calculation was performed [5, 6]:

TABLE I
ESTIMATION OF FLOW RATE

Units		**No.**	**Daily Demand**	**Water Supplied**	**Wastewater Generated**
			(Lpcd)	L/D	L/D
Hostel	Boys	360	250	90000	81000
	Girls	270	250	67500	60750
Staff Quarter	(3units)	120	250	30000	27000
Institute Building	Students	1680	50	84000	75600
	Staff	200	50	10000	9000
Total		2630	-	281500	253350

Total water supplied = 281500 L/d
Total amount of sewage generated = 0.9 x 281500
=253350 L/d
Total peak flow =1.5 x 253350
= 380025 L/d

$= 380.025\ m^3/d$

TABLE II
DESIGN PARAMETERS FOR UASBR

No.	Property	Units	Value
1	Flowrate	m^3/d	380.025
2	COD	g/m^3	2000
3	sCOD	g/m^3	1600
4	TSS	g/m^3	200
5	VSS	g/m^3	140
6	Alkalinity	g/m^3 as $CaCO_3$	500
7	SO_4	g/m^3	150
8	Temperature	ºC	35
9	Organic Loading Rate	Kg $sCOD/m^3d$	10
10	Reactor Volume Effectiveness	-	0.8
11	Methane production rate	L of CH_4/ gCOD	0.40
12	Free Board Height for Gas Collection	m	2.5

Where values of following parameter y= 0.08 g VSS/ g COD, k_d = 0.03 g VSS/ g COD, Θ_m= 0.35 g VSS/ g COD, k_s = 160 g/m^3, f_d =0.15g VSS cell debris / g VSS biomass Decay [2, 3, 4].

TABLE III
DIMENSIONAL PARAMETERS

Designed Parameters	Values
Effective Volume	60.804 m^3
Total Volume	76.005 m^3
Area of Reactor	22.62 m^2
Diameter of Reactor	5.5 m
Effective Height	5 m
Total Height	7.5 m
Hydraulic Retention Time	4 hr. 44 min.
Sludge Retention Time*	41 days

*assumed from Metcalf and Eddy [6]

TABLE IV
REMOVAL OF SOLUBLE COD (sCOD) FROM REACTOR

Parameters	Values
Total Solid Waste Generated	53203.5 g/day
Effluent sCOD	100.009 mg/L
Fraction Influent sCOD	6.25%
Percentage removal of sCOD	93.74%
TSS in Biomass zone of Reactor	35.87 kg/m^3

TABLE V
ESTIMATION OF METHANE PRODUCTION

Parameter	Values
COD Degraded	1600 g/m^3
COD removed/SO_4 removed*	84.42 g/m^3
COD consumed by Methanogenic Bacteria	575954.49 g/day
Amount of CH_4 Production	230.381 m^3/d
Energy Generated in Reactor	7.324 x10 kJ/d
Estimated Alkalinity	1800 mg/L
Daily $CaCO_3$ requirement	494.032 kg/d

IV. RESULTS ANALYSIS

From the design calculation performed in section III, the dimension of the various units required for setting up the wastewater treatment plant using the UASB reactor technology as shown in Table VI with the amount of proposed production of methane gas, efficiency of the reactor to remove soluble COD can be estimated.

TABLE VI
DIMENSIONS OF UASB REACTOR

Parameters	Values
Height	5m
Diameter (Circular)	5.5m
Hydraulic Retention Time (HRT)	4.74 Hrs.
Sludge Retention Time (SRT)	41days
Methane Produced	343.852 M^3/ D
Percentage Removal of Soluble COD	93.74%
Energy Produced from the Reactor	7.324 x 10^6 kJ/d

From the Table III, it can be inferred that the significant amount of methane gas would produce daily. Anaerobic processes generally produced higher-effluent VSS concentrations compared to aerobic processes. For weak wastewater for which solids production was lower, it may be difficult to maintain long SRT values for high treatment efficiency due to effluent solids loss. Also, in contrast to the situation presented in this example, manual wasting of sludge may be necessary. If the wastewater had a higher-influent COD concentration and the effluent VSS concentration remained the same, the concentration of solids (XTSS) in the sludge blanket would have to be increased and the blanket level would have to be higher. To avoid a rising sludge blanket, manual wasting of sludge would have to be initiated and the SRT value would have to be less than the computed value of 52 d of design, it was best to assume that the average VSS concentration of the sludge be would be less than 25 to 35 kg/m^3.

V. CONCLUSION

The UASB technology had, however, not become so widespread so far, because there was a lack of awareness of this technology. With all the drawbacks, the UASB system had responded well for the treatment of high strength soluble wastewater, like those obtained from food processing, organic chemicals, edible oil, sewage water etc. It had been opined that the installation of a UASB plant should be made a mandatory requirement of developing every institutions, new colony or township, having population of more than 5000 or so.

The wastewater generated at the campus can be treated in the campus itself using cheap and simple method of UASB reactor. The treatment plant not only treated the wastewater but also produced significant amount of methane. This methane can be used for various purposes like fuel for kitchen of Hostel's Mess and at staff quarters by developing a small-scale Biogas Treatment Plant. Similarly, the manure can be obtained from the UASB plant that can be utilised for the development of the agriculture land.

It can be concluded from the research that for considered design parameters and the characteristics of waste water, the output results were satisfied and within the limits of standard specifications thereby not causing any threat to the environment.

From the review, it was found that the India was a tropical country. Due to this the average temperature, even in the GCOEJ campus remained above 20ºC throughout the year. Hence, there lies a lot of scope for anaerobic wastewater treatment due to the fact that for most part of the year temperature conditions was favourable for the construction, installation and development of the UASB system.

REFERENCES

[1] Catherine N. Mulligani and Ilemard I. Gibbs; 2004: Biological treatment procees.
[4] Hulshoff Pol, L. W. (1989). "The phenomenon of granulation of anaerobic sludge PhD thesis, Univ. of Wageningen, Wageningen, The Netherlands.
[1] Lettinga, G., and Hulshoff Pol, L. W. (1991). "UASB-process design for various types of wastewaters." Water Sci. Tech., 24(8), 87-107.
[2] Lettinga, G., van Velsen, A. F. M., Homba, S. W., de Zecuw, W. and Klapwijk, A. (1980). "Use of the upflow sludge blanket (USB) reactor concept for biological wastewater treatment." Biotech. Bioengrg., 22, 699-734.
[3] Sewage Disposal and Air Pollution Engineering by Garg S.K., Khanna pub, 29th edition, 2014, ISBN No. 978-81-7409-2304
[6] "Wastewater Engineering" by Metcalf and Eddy, 4th edition, Mc Graw Hill pub., ISBN: 10-0070495394, 2005.