Research Article

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Performance Evaluation of UASB Reactor at Sanjivani ETP Treating Distillery Wastewater

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Abstract:

Molasses-based distilleries are one of the most polluting industries generating large volumes of high strength wastewater. Different processes covering anaerobic, aerobic as well as physico-chemical methods have been employed to treat this effluent. A number of technologies have been explored for reducing the pollution load of distillery effluent. Biological treatment of distillery spentwash is either aerobic or anaerobic but in most cases a combination of both is used. Anaerobic treatment is the most attractive primary treatment due to over 80% BOD removal combined with energy recovery in the form of biogas. Also various types of reactors are used for anaerobic digestion. In this UASB reactor at Sanjivani ETP were investigated. Volume of reactor was 2350 m^3. Conventional parameters such as pH, temperature and efficiency of COD, BOD, and TSS removal in reactor were investigated; results are showing COD removal efficiency is nearer to 80 percent. To enhance COD efficiency of UASB reactor, several parameters were needed to be controlled. These included enhancing of OLRs and upflow velocity, decreasing hydraulic retention time and operating with new sludge.

Key words: UASB reactor, distillery wastewater, anaerobic digestion

Introduction:

Distillery wastewater (spentwash) is the aqueous by-product from the distillation of ethanol following fermentation of carbohydrates. (A.Mirsepasi et al.2006) The distillation (i.e. the separation process) with 2 or 3 columns – the number depending on the required concentration of ethanol – produces a highly polluting residue. For the production of every litre of alcohol, 10 to 30 litres of industrial wastewater, called spentwash vinasse, stillage or slops, are generated. Its organic load is high, varying from 20 to 120 g COD (or 2,000-12,000 mg) per litre, the effluent temperature is high (around 90°C), the average pH-value is low (3.5 to 6). (Bau-und Wirtchaftsberatung et al.2000) During alcohol production, large amounts of waste and wastewater are produced. These may have a considerable environmental impact by polluting both water bodies and soil, by causing an adverse climatic effect and odour nuisance. Due to the high concentration of organic matter, both distillery waste and wastewater at the same time do have a great nutrient and energy potential that can be utilised for fertilizing or power generating purposes. The water can principally be reused for irrigation purposes. Due to the agricultural origin of the primary matter used, distilleries are usually located in rural areas. The named characteristics make the distillery wastewater one of the industrial residues most difficult to treat and dispose off properly. Wastewater treatment using anaerobic process is a very promising re-emerging technology which presents interesting advantages as compared to classical aerobic treatment (Gupta S K et al., 2007). It has high capacity of degrading concentrated and resilient substances. It produces very little sludge, requires less energy and can become profitable by cogeneration of useful biogas (Sarayu Mohana et al.2009). However, these processes have been sensitive to organic shock loadings, low pH and show slow growth rate of anaerobic microbes resulting in longer hydraulic retention times (HRT). This often results in poor performance of conventional mixed reactors. In order to solve these problems, several high rate anaerobic redactors have been developed for treating soluble wastewater at relatively shorter HRTs. (Sarayu Mohana et al.2009)

One of the methods that are used for treating ethanol distillery wastewater is the application of upflow anaerobic sludge blanket (UASB) reactor.(Muhammad Asif Latif et al.,2011) Results have shown that efficiency can enhance to 90 percent to eliminate initial pollutants from wastewater. UASB reactors belong to the group of high–rate anaerobic reactors with a sludge bed. The success of UASB depends on the formation of active and settleable granules (Sarayu Mohana et al.2009). These granules consist of aggregation of anaerobic bacteria, self immobilized into compact forms. This enhances the settelability of biomass and leads to an effective retention of bacteria in the reactor. Particularly attractive features of the UASB reactor design includes its independence from mechanical mixing of digester contents, recycling of sludge biomass and ability to cope up with perturbances caused by high loading rates and temperature fluctuations (Sarayu Mohana et al.2009). Fig. 2 modified from Kansal et al. shows the schematic representation of an upflowanaerobic sludge blanket (UASB) reactor. The UASB technology is well suited for high strength distillery wastewaters only when the process has been successfully started up and is in stable operation. To achieve successful startups, the reactors must be operated at a low loading rate of 4–8 kg CODm^{-3} d^{-1} and the COD removal efficiency must be monitored carefully. The loading rate can be increased, when the COD removal efficiencies are above 90% (Sarayu Mohana et. al.2009).

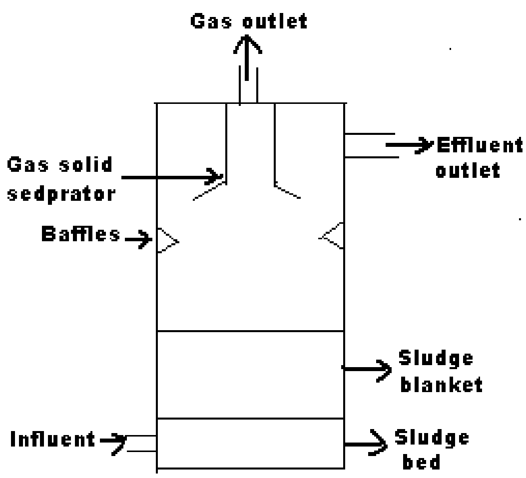

Fig.1 Schematic diagram of anaerobic UASB redactor

Materials and Methods:

This study was done during two months taking samples biweekly. In order to start the examinations, a literature review was made through searching in books, journals and different papers. During the operation of UASB reactors, Chemical Oxygen Demand (COD),

BOD_5 and TSS removal efficiency of reactor is monitored. Examinations were done on the influent and effluent wastewater of reactor. These examinations were conducted in Sanjivani wastewater plant (ETP) laboratory. The numbers of 96 samples were examined. Temperature and pH control were determined for each sample. Total sampling was composite. Total examinations were based on Standard Methods for the Examination of Water and Wastewater (APHA). The influent stream from the process was highly polluted with a COD of 90,000 to 100,000 mg/L and a low pH of 4-5. To pretreat this effluent, upflow anaerobic sludge blanket reactor is installed. The volume of reactor was 2350 m^3. In the UASB, influent was entered into an equalization tank. In this unit wastewater was diluted and then the effluent was discharged into a conditioning tank where pH and temperature were regulated. Then the effluent was pumped in the bottom of the UASB reactor, where the effluent was percolated through the granular sludge bed. The overflow from the UASB reactor was collected and was disposed to the industrial wastewater treatment plant for further treatment. The Influent COD in UASB, wastewater was diluted and COD was decreased to 16,000 to 20,000 mg/L.

Results and Discussion:

Sulfate value in influent wastewater was between 2000-2500 mg/L.Rate of COD/SO_4^{-2} in influent wastewater was 20-25. This value was higher than desirable rate of COD/SO_4^{-2} (1.5–2.7), Of course methanol conversion to methane in upflow sludge bed reactors are very stable in the presence of sulfate (A.Mirsepasi et al.2006). Plots of changes in COD, BOD_5 and TSS removal efficiency of the UASB reactor is shown in table no. 2, present BOD_5, TSS and COD removal efficiency in UASB reactor, as can be seen from same table, efficiency of BOD_5 and TSS removal was 80-90 percent. Rates of TSS and BOD_5 removal efficiencies at the time of this study were steady, efficiency of COD; Chlorides removal was near about 80 percent. The operating temperature and pH were regulated between 28-32°C and 7 ± 0.5, respectively.

Mixed liquid suspended solid value in the sludge blanket was 35 g/L, that this value must be increased to 100-150 g/L. All these results are showing UASB reactor at Sanjivani ETP working with very good efficiency which also affects in very good production of methane gas which saves near about 60% fuel requirement of their boiler.

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Table 1 Characteristics of untreated distillery effluent.

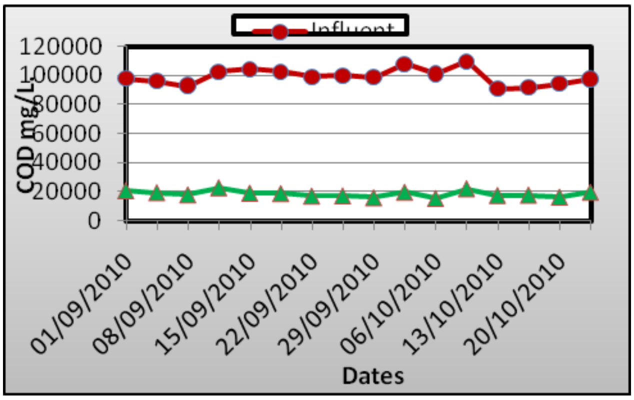
Parameters	Values of distillery effluent	Values of anaerobically treated effluent
pH	3.0–4.5	7.5–8
BOD5 (mg L−1)	50,000–60,000	8000–10,000
COD (mg L−1)	110,000–190,000	45,000–52,000
Total solid (TS) (mg L−1)	110,000–190,000	70,000–75,000
Total volatile solid (TVS) (mg L−1)	80,000–120,000	68,000–70,000
Total suspended solid (TSS) (mg L−1)	13,000–15,000	38,000–42,000
Total dissolved solids (TDS) (mg L−1)	90,000–150,000	30,000–32,000
Chlorides (mg L−1)	8000–8500	7000–9000
Phenols (mg L−1)	8000–10,000	7000–8000
Sulphate (mg L−1)	7500–9000	3000–5000
Phosphate (mg L−1)	2500–2700	1500–1700
Total nitrogen (mg L−1)	5000–7000	4000–4200

Table No. 2: Shows BOD, COD, TSS, Sulphate and Chlorides removal in mg/L

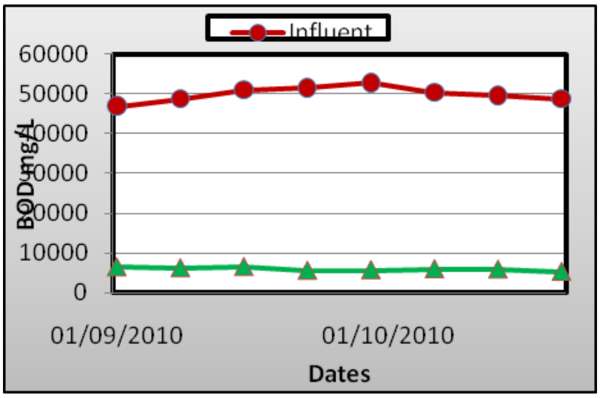
Sam ples No	Date	BOD		COD		TSS		Sulphate		Chlorides	
		Influent (Raw Spent wash)	Effluent (UASB reactor)	Influent (Raw Spent wash)	Effluent (UASB reactor)	Influent (Raw Spent wash)	Effluent (UASB reactor)	Influent (Raw Spent wash)	Effluent (UASB reactor)	Influent (Raw Spent wash)	Effluent (UASB reactor)
1	01-09-10	46900	6565	98000	20580	9860	1528	6170	4072	5570	780
2	05-09-10	---	---	96000	19200	9800	1510	6196	4027	5590	726
3	08-09-10	48680	6330	93000	17670	10050	1538	6230	4050	5585	726
4	12-09-10	--	---	102500	22550	10490	1625	6276	4078	5590	782
5	15-09-10	50950	6625	104300	18774	10300	1586	6334	4053	5630	788
6	19-09-10	---	---	102800	18504	11640	1780	6410	4100	5675	794
7	22-09-10	51490	5663	99000	16830	11080	1717	6464	4135	5675	766
8	26-09-10	---	---	99850	16976	11460	1764	6480	4147	5690	768
9	29-09-10	52850	5815	98680	15678	11850	1824	6418	4171	5710	770
10	03-10-10	---	---	107800	19405	11500	1782	6396	4158	5725	744
11	06-10-10	50430	6050	101250	15185	10620	1635	6365	4130	5760	748
12	10-10-10	---	---	109540	21908	10300	1575	6268	4074	5783	752
13	13-10-10	49570	5948	90950	17280	10450	1609	6274	4078	5804	754
14	17-10-10	---	---	91900	17460	10040	1526	6218	4042	5848	790
15	20-10-10	48780	5365	94580	16080	9840	1515	6172	4076	5780	780
16	24-10-10	---	---	97600	19520	9780	1506	6140	4050	5745	775
Mean		**49956.25**	**6045.12**	**99234.37**	**18350**	**10566.25**	**1626.25**	**6300.68**	**4090**	**5697.5**	**716.75**

Plate: 1

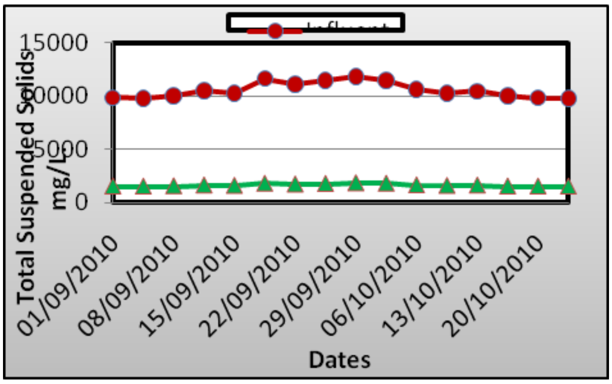
Graphs plotted on basis on table no. 2



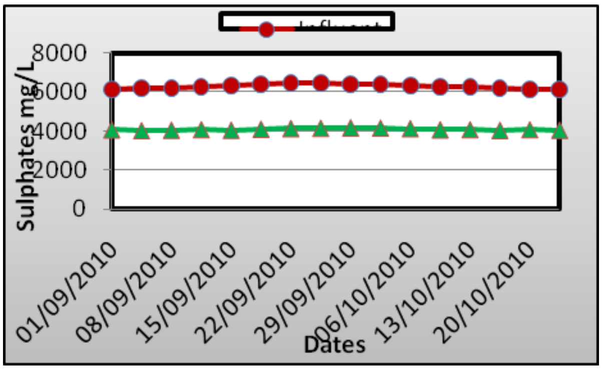
Graph 1: COD



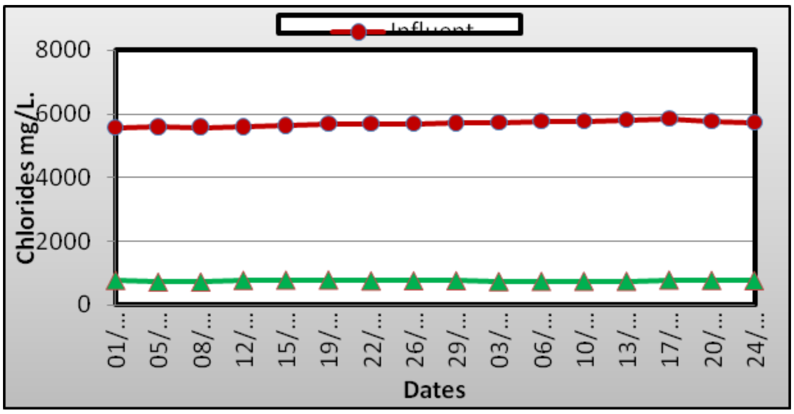
Graph 2: BOD



Graph 3: TSS



Graph 4: Sulphate



Graph 5: Chlorides