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Treatment of Distillery Wastewater by Anaerobic Methods

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ABSTRACT
One of the major environmental problems faced by the world is management of wastes. Industrial processes create a wide range of wastewater pollutants; which are not only difficult but costly to treat. Characteristics of wastewater and level of pollutants vary significantly from industry to industry. To control this problem today emphasis is laid on waste minimization and revenue generation through by-product and energy recovery. Pollution prevention focuses on preventing the harmful effect of generated wastewater on the environment, while waste minimization refers to reducing the volume or toxicity of hazardous wastes by water recycling and reuse, process modifications and by by-product recovery. Production of ethyl alcohol in distilleries based on cane sugar molasses constitutes a major industry in Asia and South America. The world's total production of alcohol from cane molasses is more than13 million m^3/annum. The aqueous distillery effluent stream known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the product alcohol. This highly aqueous, organic soluble containing residue is considered a troublesome and potentially polluting waste due to its extremely high BOD and COD values. Because of the high concentration of organic load, distillery spent wash is a potential source of renewable energy. The paper reviews the possibility of anaerobic treatment of the distillery wastewater.
***Keywords* -** Anaerobic processes, ASBR, Distillery Spent wash, Ethanol production, UASB

I. Introduction

Production of ethyl alcohol in distilleries based on cane sugar molasses constitutes a major industry in Asia and South America. The world's total production of alcohol from cane molasses is more than13 million m^3/annum. The 295 distilleries in India produce 2.7 billion litres of alcohol and generating 40 billion litres of wastewater annually. The enormous distillery wastewater has potential to produce 1100 million cubic meters of biogas. The population equivalent of distillery wastewater based on BOD has been reported to be as high as 6.2 billion which means that contribution of distillery waste in India to organic pollution is approximately seven times more than the entire Indian population. This massive quantity of wastewater if disposed untreated can cause considerable stress on the water courses leading to widespread damage to aquatic life.

India is facing severe problems of collection, treatment and disposal of effluents due to rapid industrialization and urbanization. Anaerobic biological processes have received high attention in wastewater treatment, owing to high capacity to treat slowly degradable substrates at high concentrations, very low sludge production, low energy requirements and possibility for energy recovery through methane combustion.

II. Alcohol Manufacturing Process

In India bulk of the alcohol is being produced from sugar cane molasses. Molasses is a thick viscous by-product of the sugar industry which is acidic in nature, rich in salts, dark brown in colour and it also contains sugar which could not be crystallized. For manufacturing alcohol, the molasses is diluted with water into a solution containing 15-16% of sugars. This solution is then inoculated with yeast strain and is allowed to ferment at room temperature. The fermented wash is distilled in a series of distillation columns to obtain alcohol of adequate/ requisite strength and quality/specification. This alcohol is used for various purposes including potable and industrial. [1]

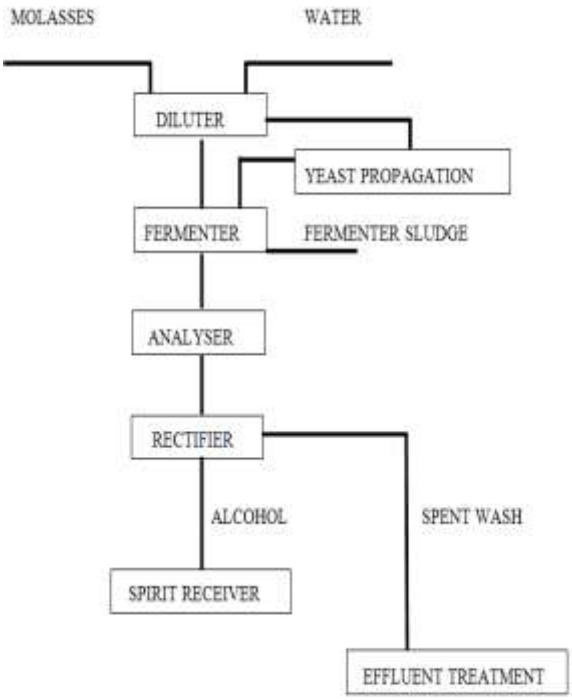

Fig 1 Flow chart of manufacturing process in Distillery

III. Origin and Composition of Distillery Wastewater

The liquid wastes from distillery can mainly be divided into

- **Spentwash** from the separation (centrifuge) and distillation process.
- **Cleaning water** from the different plant components i.e.
  - fermenters,
  - distillation columns,
  - floors;
- **Refrigeration water** from cooling after distillation.

Its chemical composition and characteristics depend mainly on the type and specific cultivar of the raw material used for fermentation. The complex characteristics make the distillery wastewater one of the industrial residues most difficult to treat and dispose of properly. [2]

Table 1: Average Values of Distillery Wastewater

SN	Parameter	Range
1.	pH	4.4-5.4
2.	Colour	brown to dark brown
3.	Temperature	70°C-80°C
4.	Total Suspended Solids(mg/l)	12,500-14,500
5.	Total Dissolved Solids(mg/l)	45,000-75,000
6.	B.O.D(mg/l) , 20 ^{0}C 5 days	30,000-50,000
7.	C.O.D (mg/l)	80,000-1,00,000

IV. Suitability of Anaerobic Treatment For Distillery Wastewater

Physical and chemical treatment options of the residue have not been very successful until now.. Digestion in anaerobic conditions is most typically employed as a primary treatment for distillery effluents. Such solution is favoured by the fact, that during anaerobic degradation about 50% of the COD contained in spent wash can be converted to biogas at only about 10% sludge generation (Wilkie, 2000). [3] The high organic concentration in the effluent can make anaerobic treatment profitable, particularly due to the energy yield in form of methane, combining environmental soundness with economical usefulness due to possible savings in the fuel needs of the distillery.

Prior to the actual treatment steps, some conditioning measures for the spentwash have to be taken: [4]

4.1 Necessary Conditioning of Spentwash

The high temperature of the spentwash from the distillation process have to be adjusted at least to the maximum values tolerable for the biologic degradation.

4.2 Flow Regulation, Mixing

Strong variations in the volumetric flow of the wastewater have to be compensated by storage/equalisation capacities and appropriate dosage/mixing device. The Spentwash should be kept separately from other wastewater streams (cleaning water) in order to ensure maximum control of its concentration.

4.3 Conditioning of pH-Value

The usually low pH-value has to be corrected by neutralisation. Further to the addition of alkaline solution, treated substrate, having a pH-value of about 7, can be re-circulated for this purpose.

4.4 Nutrients, Alkalinity, Suspended Solids

The content of macro-/micro-nutrients and suspended solids as well as the alkalinity of the substrate usually range within the tolerable limits for anaerobic bacterial activity. Should the values exceed the limits in individual cases, these need to be adjusted.

V. Suitable Anaerobic Technologies

Among a number of different treatment alternatives generally applicable, the following processes are considered to be the most suitable ones for the anaerobic treatment of distillery wastes along with diagram (A feed, G biogas, R re-circulation, S output).

5.1 Upflow Anaerobic Sludge Blanket (UASB)

The micro-organisms are in the granule, which are in suspension by the biogas produced and by a recirculation of the wastewater. [5] At the top of the digester, an internal settler hold back the granule into the digester. (Muller 1998)

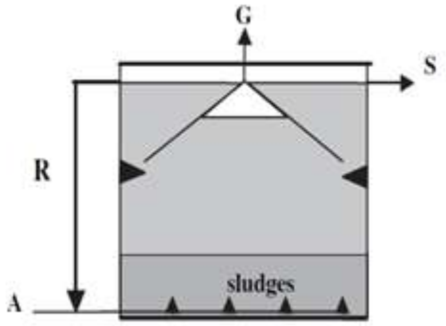

Fig 2 UASB

5.2 Hybrid Digester

The hybrid digester is a digester with a sludge bed at the bottom and an anaerobic filter at the top (Andreottola et al., 1998).

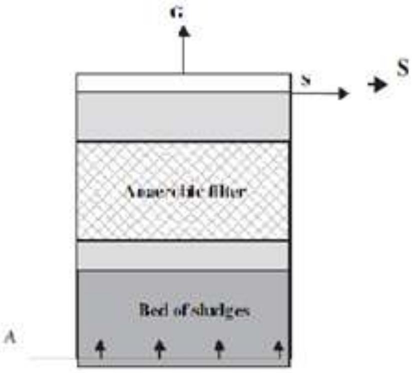

Fig 3 Hybrid Digester

5.3 Fluidised Bed

The fluidised bed is a technology where the carriers for the biofilm are fluidised by liquid recirculation. The carriers are particles or inert material.

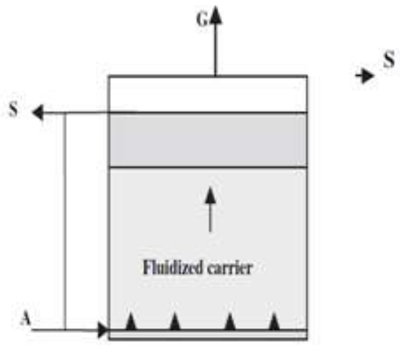

Fig 4 Fluidised Bed

5.4 Anaerobic Contact

Anaerobic contact process is a totally mixed reactor with separation and recirculation of sludge back to the methanogenic reactor. The realisation of sludge-degassing improves the sludge consistency for separation.

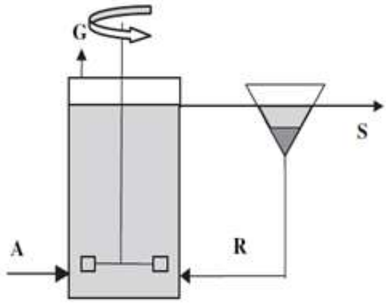

Fig 5 Anaerobic Contact

5.6 Anaerobic Filter (Fixed Bed Reactor)

Reactor with an inert filter medium with a high specific surface for on-growth of biomass (today mostly plastic material),mostly with external separation and recirculation of sludge (Habouzit and Torrijos, 1998). [6]

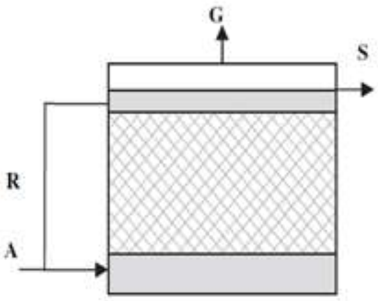

Fig 6 Anaerobic Filter

5.7 The anaerobic sequencing batch reactor (ASBR)

The anaerobic sequencing batch reactor (ASBR) is a very promising technique. It is a fill and draw process. The digester contains the anaerobic sludge. The wastewater is added and the anaerobic digestion starts with mixing. When the production of biogas is finished the agitation stops and the anaerobic sludge settles into the digester. The floating pump P removes the same amount of added wastewater. The level of liquid goes from the H to the B level and the cycle starts again (Ruiz et al., 2002). In order to prevent air introduction during the draw, storage of biogas should be provided.

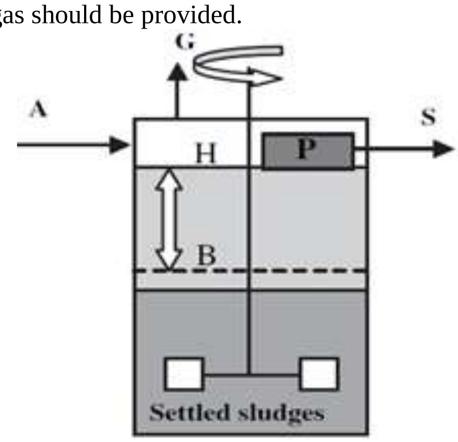

Fig 7 Anaerobic Sequencing Batch Reactor (ASBR)

VI. Characterisation of Anaerobic Digestion

The anaerobic digestion is suitable particularly for distillery wastewater. The COD/N/P ratio for anaerobic digestion could be in the order of 800/5/1. The main parameters used for the characterisation of anaerobic digestion are: input and output concentrations of COD (kg COD or BOD/m3 of wastewater), organic loading rate (kg COD/m3 of digester/d), hydraulic retention time (day), gas productivity (m3 of biogas/m3 of digester/d), methane production (m3 biogas/kg COD removed) and COD (or BOD) removal efficiency (COD removed/COD applied).

The organic load depends on the technology used and on the type of wastewater to be treated. The organic load obtained with suspended micro-organism technologies is between 1 to 5 kg COD/m3/d. [7] With UASB reactors, the load applied is between 5 kg to 15 kg COD/m3/d. For anaerobic filters it is between 5 kg to 20 kg COD/m3/d and generally between 15 kg to 30 kg COD/m3/d for the fluidised bed.

The COD removal yields are generally high for distillery wastewater treatment. The values are generally between 80–98%. The biogas production is around 500 to 600 litres per kg of COD removed with 60–80% methane.

The organic flow should be adjusted to the reaction capacity of the micro-organisms. If the reactor is overloaded, volatile fatty acids will accumulate, pH will fall down and we have a failure of the anaerobic reactor.

Even with high depollution yields, anaerobic digestion treatment is generally not enough to release the effluent in natural environment. Therefore anaerobic digestion is generally followed by an aerobic treatment. Anaerobic digestion of spent wash in a closed digester followed by its treatment under an activated sludge process, especially in an oxidation ditch to reduce costs, might be adopted as the most cost-effective system for the distilleries which are located away from sugar factories. Moreover, the treated effluent can be conveniently used for irrigation of cane fields or other crop lands, subsequently. Biogas generated from the distillery effluents, can be effectively utilized in production plant boilers thus saving about 50 to 60 percent fuel/steam. The treated effluent having almost all the potash retained in it may be utilised for irrigation purposes.

VII. Advantages of Anaerobic Treatment

- Low production of waste biological solids.
- Low nutrient requirements.
- Production of methane as an energy source to meet the steam requirement of distillery to the extent of 75-100%. [8]
- Very high loading rates can be achieved.
- Active-anaerobic sludge can be preserved unfed for many months.

VIII. Limitations of Anaerobic Treatment

- Relatively long periods of time are required to start up the process.
- It is a pre-treatment method. The treated effluent BOD will be in the range of 5000-8000 ppm and hence an adequate post-treatment is usually required before the effluent can be discharged into receiving water.
- Dilution water is required ranging from 20-100%.

IX. Conclusion

- Anaerobic digestion is the most suitable option for the treatment of high strength organic effluents.
- The present study aims at reviewing the existing anaerobic technological status of treatment and disposal of distillery spentwash in our country.
- Application of anaerobic digestion to distillery effluents is a preferable primary treatment option. Conversion of COD into biogas through biomethanation appears to be a reasonable solution. The different way of biogas utilisation is the production of steam, electricity, hot water (for small digester capacities) and co-generation.

- COD plays an important role in biogas production rate.
- COD reduction goes on increasing as the biogas production rate goes on increasing.
- The loading rates permissible in an anaerobic waste treatment process are primarily dictated by the sludge retention in an anaerobic reactor.
- The technologies are simple in construction and operation.

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