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Treatment Methods of Distillary Spent Wash: A Review

Prof. Yogesh. S. Khandekar [1], Dr. Narendra. P. Shinkar [2]
[1](Civil Engineering Department, Sipna COET, Amravati, India)
[2](Civil Engineering Department, Government Polytechnic, Nagpur, India)
Corresponding author: Prof. Yogesh. S. Khandekar

Abstract: *Grain based distilleries in India are classified as Red Category because of the large volume of high strength waste water (spent wash) generation. (12-15 liters per liter of alcohol) Spent wash has very high Biological Oxygen Demand (BOD 40,000-65,000 mg/lit.) Chemical Oxygen Demand (COD 80,000-1,40,000 mg/lit) and high BOD/COD ratio. The high amount of inorganic impurities as chlorides, Sulphates, Phosphates, Potassium and Calcium arise critical environmental pollutioncan result in eutrophication of natural water bodies..It's recalcitrant nature is due the presence of melanoidins, ceramal, polyphenols and variety of sugars decomposition products such as anthocyanin, tannius and different xenobiotic compounds. The present study reviews various techniques to treat the spent wash.*

Keywords: *Biological Methods, Spent wash, Thermal Method, Incineration.*

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I. Introduction

India is an agro based country, where most of the rural population depends on agriculture. India is the second largest sugarcane producer with nearly 5 million hectares of cultivated area. In India there are 579 sugar industries producing 14.5 million tonne of sugar by crushing 145 million tonnes of sugar cane annually. The annual byproduct production from these industries is 7 million tonnes of pressmud and 7.5 million tonnes of molasses. Along with this, there are 298 distilleries present in the country producing 3.2 billion liters of alcohol and 45 billion liters of spent wash annually. There are 129 Distilleries, which are using Anaerobic Digesters to partially treat the spent wash to convert it into Biomethanated spent wash. India is ranked fourth in the world for the production of Ethanol and second largest producer in Asia. Distilleries are listed at the top in the “Red Category” industries and having highly top 17th polluting industries by Ministry of Environment, Govt. of India (Pooja Chittargi et. al). Discharge of spent wash with high Total Dissolved Solids will adversely affect on aquatic life and environment are discussed below.

1) Not suitable for drinking purpose and also corrodes the pipe line.
2) Suspended solids cause turbidity and results decreasing in the light penetration capacity in water bodies.
3) High amount of BOD in the wastewater leads to the decomposition of organic matter under the anaerobic condition that produces highly objectionable products including Methane (CH_4), Ammonia (NH_3) and Hydrogen Sulphide (H_2S) gas.
4) Alkaline nature of spent wash will decreases in the plant growth.

1.1 Generation of spent wash

A thick viscous liquid remains at the bottom after the production of Alcohol, called as spent wash or alcohol distillery waste. Distillery waste in the form of ‘spent wash’ or ‘stillage’ is one of the most complex, troublesome and strongest industrial organic effluents. The polluting strength is very high due to the high content of complex biodegradable organic materials, such as sugar, lignin, hemicelluloses, dextrin, resins and organic acids. For every liter of alcohol, maximum 8 to 15 liters of spent wash is generated. The spent wash contains organic matters and nutrient minerals derived from the sugarcane. The spent wash is an aerobically treated in the Digester. During this anaerobic degradation, the organic matters are converted into Biogas (55% methane). On an average for every 100 tonne of Sugarcane crushed will generate around 4.50 tonne of Molasses. Each tonne of Molasses produces 225 liters of alcohol. Fig. 1 shows the generation of spent wash.

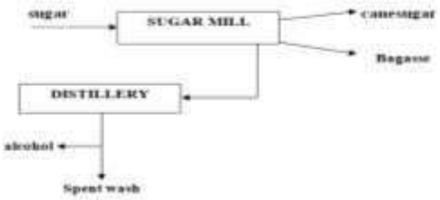

Figure 1: Generation of spent wash

Molasses from the sugar factory is the major constituent in the sugar Industry. Molasses is the by-product of sugar Industries. The effluent of distillery is known as spent wash. Spent wash is the approximately 13-16 times more by volume to that of the alcohol. It is highly organic brown in color. Following values are describes spent wash characteristics.

1. It has a BODof about 30,000 to 60,000mg/lit
2. COD of about 1,00,000 mg/lit
3. pH –acidic (4 –5)
4. Colour-dark brown
5. About 15% solids content
6. Ash contains Potash as K2O

So, it is very troublesome to treat spent wash. It is therefore obvious that some treatment is necessary to minimize the deleterious effects before the waste is discharged onto land. Disposal of these effluents after proper treatment is favorable approach because after by using appropriate measures effluent comes within limits and pollution load is reduced.There are various methods to treat the spent wash some of them are economic, suitable for aerobic and anaerobic conditions, timeless are discussed below with their suitability.

II. Treatments

2.1 Biological Treatment: Biological processes are based on microbes that use carbon andenergy for growth in order to oxidise organic materials in wastewater. Microbial-based systems for organic material have a number of advantages above chemical or physical technologiesdegradation, that's why it gained importance. Biological treatments of wastewater are more effective due to the higher surface-to-volume ratio, they have less operational costs as systems can operate at ambient temperatures and they are more vigorous. Biological treatment methods include aerobic and anaerobic treatments as shown in Table Iand have proven to be successful in treating polluted wastewaters (Michelle de Kock, 2015). Biological treatment is very effective and more eco friendly. But on the other hand it shows that this method is slow and more uncertainiy. In this method removal of organic matter using microorganisms mostly bacteria, fungi, actinomycetis, etc. Organics used for energy and growth to get converted to gases (that escaped the system) and cell mass (has to be removed).

Table I: Biological treatment aerobic and anaerobic:

Aerobic	Anaerobic
In the presence of Oxygen	In the absence of Oxygen
Faster reaction kinetics	Slow reaction kinetics
Smaller reactors	Large reactors
No bad odour	Odour issues are there
No any recovery	Fuel Gas recovery
more sludge to be handled	Less sludge to be handled

2.1.1 Aerobic Methods are explained below:

A. Activated Sludge Process (ASP): This process is the most common biological method for the wastewatertreatment use in industries and municipalities. The most important component in this process is the use of an aeration tank, wherein micro-organisms are mixed with incoming wastewater. The activated sludge process contains three component parts, such as (i) an aeration tank (reactor) where micro-organisms grow (ii) a clarifier, which is responsible for the liquid-solid separation and (iii) a recirculation system for transporting recovered sludge back to the aeration tank. Organic materials are biodegraded by being in contact with micro- organisms within an aerobic environment. Activated sludge treatment is regarded as a suspended growth process due to microbes being suspended in the water.

B. Trickling Filter (TF): Trickling filters are an aerobic treatment system that is applied to wastewater to eliminate the organic material present in them. This system operates by micro-organisms that attach to a medium to ensure the removal of organic matter. Trickling filters are also called attached-growth processes. Filters contain fixed or rotating distributor arms that spray wastewater over mediaor rock that are covered with a biological layer of slime. Due to the open spaces existing between the rock and other media, the process allows air to circulate through and consequently keep it oxygenated. The slime layer mainly consists of bacteria and algae but various other organisms (protozoa and metazoa) are also present that have the ability to break down the organic matter. Micro-organisms within the biofilm metabolise organic material into relatively harmless products.

C. Rotating Biological Contactor (RBC) : RBC is a biological process used for the treatment of carbon-based wastewater and is characterised as an attached growth process. It consists of a sequence of closely spaced circular plastic disks, which are partly submerged into a tank filled with untreated wastewater. Discs usually consist of lightweight, high-density plastic materials. Microbial films develop on the surface of the circular disks which move through the wastewater as they rotate. Micro-organisms degrade organic material while being submerged in the wastewater and are provided with oxygen when the disks rotate into the air. RBC has similarities to the activated sludge and trickling filter treatments but the biofilm process is the principal feature of this treatment option. Advantages of RBC over fixed film processes include less land area requirement, fewer complications with noise and odours, the process control is less complex and high removal rates of Biological oxygen demand (BOD).

2.2.2 Anaerobic methods are explained as below:

A. Conventional Digester: Fig. 2 shows conventional digestor.In the standard rate digestion process, the contents of the digester are usually unheated and unmixed. In this acidification, methane fermentation and sludge thickening takes place in single tank. Standard or low rate digesters have intermittent mixing, intermittent sludgefeeding and intermittent sludge withdrawal. Detention time for this process vary from 30 to 60 days.

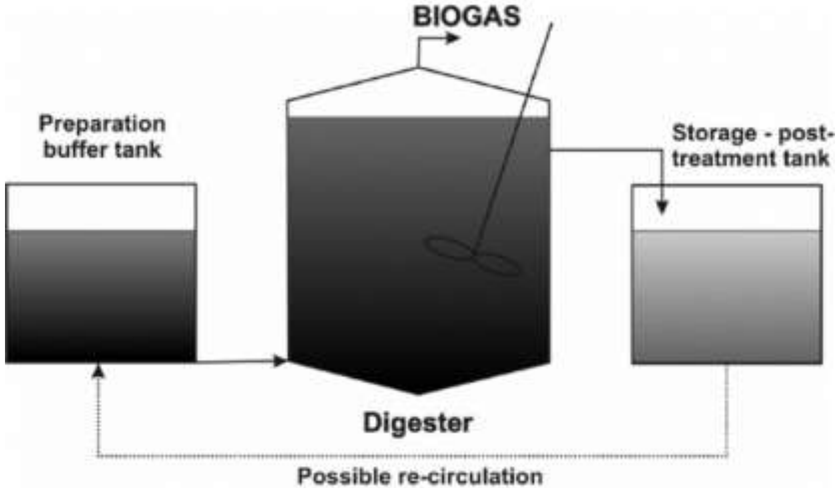

Figure 2: Conventional Digestor

B. Di-phasic digestion: Fig. 3 shows Di-phasic digestor.Generally this type of digester is provided when population served ranged from 30,000 to 50,000. In first stage, mainly liquefaction of organic solids, digestion of soluble organic materials and gasification occurs. First stage is usually high rate digester with fixed cover and continuous mixing is preferred.In second stage, some gasification occurs however main use is supernatant separation, gas storage and digested sludge storage.

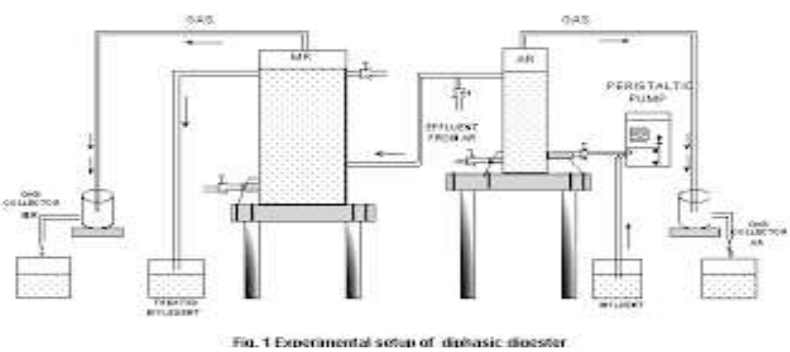

Figure 3: Di-phasic Digestor

C. 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. At the top of the digester, an internal settler hold back the granule into the digester. (Vandana Patyal 2015). The UASB is a well-established and proven technology for the treatment of high-strength organic wastewater due to the high biomass and microbial communities within the reactor. The UASB system is widely applied for treating wastewaters from the food industry, distilleries, tanneries and municipalities. The UASB shown in Fig. 4.The reactor can be divided in three parts, sludge bed, sludge blanket and three phase separator (gas-liquid-solid, GLS separator) provided at the top of the reactor.Treatment occurs as the wastewater comes in contact with the granules and/or thick flocculent sludge.

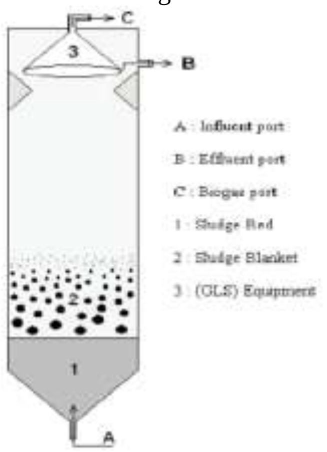

Figure 4: Upflow Anaerobic Sludge Blanket

D. Fluidized Bed Anaerobic Filter: 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. 5 shows fluidized bed anaerobic filter.

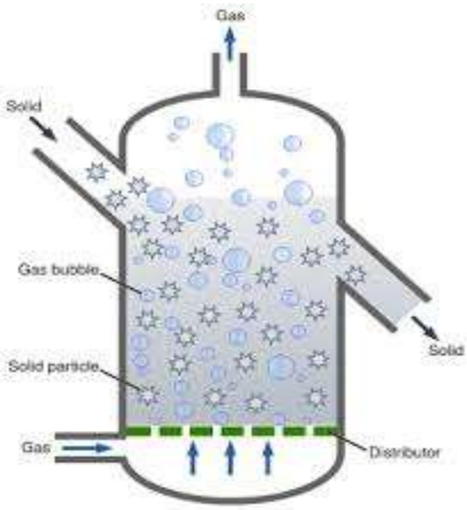

Figure 5: Fluidized Bed Anaerobic Filter

E. Hybrid reactor: As anaerobic digestion is a common treatment option for high strength wastes, newer digesters are being established for treating both high and low strength wastewaters. The hybrid digester is a digester with a sludge bed at the bottom and an anaerobic filter at the top.This reactor is taller than the UASB reactoras shown in Fig. 6(Vandana Patyal 2015).

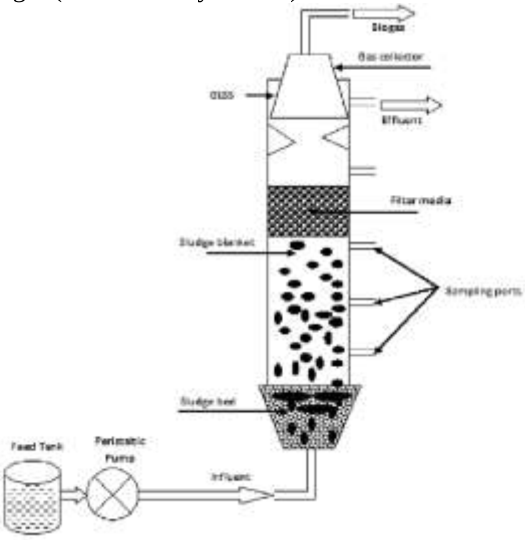

Figure 6: Hybrid Reactor

F. Fixed Bed Reactor: Fixed bed reactor provided 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.Fixed bed reactor as shown in Fig. 7.

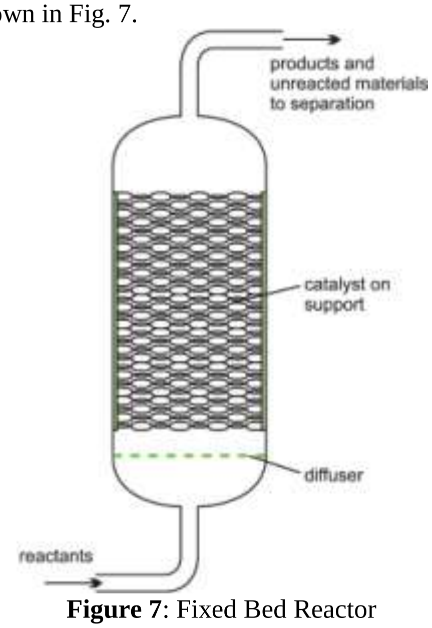

Figure 7: Fixed Bed Reactor

G. The Anaerobic Sequencing Batch Reactor (ASBR): The anaerobic sequencing batch reactors (ASBRs) are high rate anaerobic treatment processes that operate in the following cyclic steps: feed, reaction, settling and decantation. The first step involves the addition of substrate to the reactor where the contents are continuously mixed. The volume of substrate fed depends on a number of factors, including the desired hydraulic retention time (HRT), organic loading, and expected settling characteristics. The conversion of biodegradable organic matter to biogas is achieved. The typical anaerobic sequencing batch reactor as shown in Fig. 8.

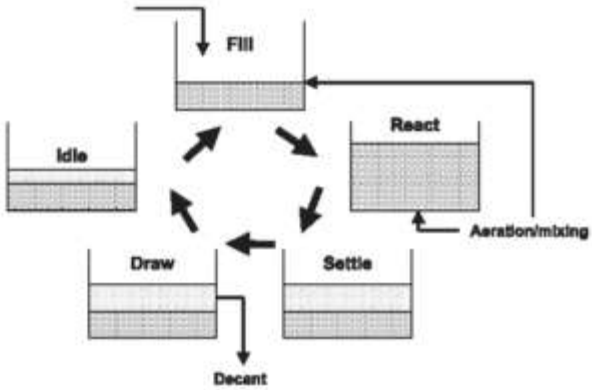

Figure 8: The Anaerobic Sequencing BatchReactor

From the above methods, the selection of anaerobic method is depending upon BOD and COD ratio. The main treatment strategy for biological treatment is
BOD/COD = 50,000/90,000 = > 0.5
The ratio is greater than 5, Hence biological treatment is effectiveSince it is high strength waste water, anaerobic treatment technique is better.There are some drawbacks of anaerobic treatment are:

- Requirement of ‘polishing’
- Uncertainty involved with biological systems
- Influence of external parameters like weather, temperature
- Requirement of energy intensive secondary treatment
- Color problem still persists
- Need for tertiary treatment like adosrption
- CH_4generated in the first step is used in the subsequent steps
- Much slower than thermal systems
- More space/volume required

2.2 Thermal Method- Thermal Methods are usually costlier. It causes probability of pollution, controversial but very fast, compact reactors, less area required, more fool proof, not affected by weather / temperature, less uncertainty.Thermal Methods are useful over biological methods are discussed below in Table II.

Table II: Biological Method over Thermal Method

Biological Method	Thermal Method
Are generally slow	Are costly
Are affected by external parameters like temperature	But rapid
Involves some uncertainty	Involves less uncertainty
Cannot solve the problem completely	Are relatively compact

2.3 Incineration: Incineration is defined as the thermal destruction of combustible waste in an enclosed device. Incineration is the Combustion (controlled burning) of wastes in properly designed and constructed furnace to sterile ash with proper care for air pollution and water pollution. The prime objective of incineration is waste destruction, not power generation or ash recovery Incineration of Distillery Spentwash. Some of the Indian Experience to treat the spent wash by incineration.

•First incineration was reported in early nineteen sixties, but not popular
•Became popular in late nineteen eighties.
Two popular designs were
•Destrotherm from Thermax, Pune
•Sprannihilator from PrajConsultech, Pune.
Problems with Incineration of spent wash are discussed as follows.

A. Solids content of spent wash is to be brought to about 60% before firing into the furnace.
B. This brings the economics down as it is energy intensive. Also, damaging to the material of construction.
C. Spent wash is sticky
D. It swells (up to about 5 times the original volume) while heating.

2.4 Electro coagulation Method: It is an emerging technology that combines the advantages of conventional floatation, coagulation and electrochemistry in water and wastewater treatment. Electro coagulation is a straightforward and successful treatment strategy for wastewater. Electrolysis is a procedure in which oxidation and decrease responses happen when electric current is connected to an electrolytic arrangement.

2.5 Adsorbent Technique: The adsorption process involves a mass transfer procedure where matter (adsorbate) is moved from an aqueous phase to a solid phase (adsorbent). The matter binds to the surface of the solid phase by chemical and/or physical interactions. The adsorbent technique is one of best method for removal of pollutants from distillery spent wash and reuses the effluent characteristics so it could be used for irrigation to reduce pressure over normal irrigation water. It is beneficiary to use diluted effluent for better growth of plants. Activated charcoal is an ideal adsorbent for removal of color of wastewater and 99.7% discoloration was found and maximum COD removal of 58.15% by using activated charcoal. Carbon has been utilized as an adsorbent for a considerable length of time. Enacted carbon capacity to expel mixes from wastewater expanded its utilization from most recent 30 years. Adsorption is normal procedure by which atoms of a broke up compound gather on and hold fast to surface of an adsorbent solid. It is ideal to go for adsorption by utilizing enacted carbon before treating refinery spent wash by electro coagulation.

2.6 Membrane Technique: Membrane processes have been applied in the treatment of water, seawater and brackish water for more than 30 years. Membrane technologies are used for desalinisation and the removal of specific ions that are difficult to eliminate by means of other methods and is often applied to wastewater that is intended for reuse as it provides softening and eliminates organic material, viruses, bacteria and heavy metals. The process is grounded on the occurrence of semi-permeable membranes that work as filters. Technologies include: electrodialysis, reverse osmosis, nanofiltration, ultrafiltration, and electrodialysis reversal (Michelle de Kock, 2015).

III. Conclusions

From this study following conclusions were drawn.

1. The biological method is cost effective and it have green approach but useful for high strength spent wash.
2. Thermal methods are costlier but very fast than biological methods
3. For less quantity of waste the chemical methods are suitable.
4. Adsorption using activated carbon is better choice before treating distillery spent wash before Electro coagulation.
5. The distillery wastewater after adsorbent treatment is suitable for irrigation purpose.
6. Electro coagulation is an economical method for treatment of distillery spent wash but only problem is about secondary sludge developed during EC process.
7. Anaerobic digestion is the most suitable option for the treatment of high strength organic effluents.

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