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# A Review on Treatment of Distillery Wastewater by Physicochemical Approaches

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**ABSTRACT**

*Liquid waste Distillery wastewater is one of the most polluting wastes that must be disposed of because of its low pH, high temperature, dark brown color, high ash content and high percentage of organic and inorganic dissolved matter with high biochemical oxygen requirement. The washed wash has contaminated the water bodies in the forms; firstly, the highly colored nature that can block sunlight, thus reducing the oxygenation of water through photosynthesis and, therefore, becomes detrimental to aquatic life. Secondly, it has a high contamination load that could cause eutrophication of contaminated water sources. Alcohol distilleries are growing all over the world due to the widespread industrial applications of alcohol, such as chemicals, pharmaceuticals, cosmetics, beverages, food and perfumery, etc. The industrial production of ethanol by fermentation causes the discharge of large quantities of high resistance. (BOD) and chemical oxygen demand (COD) values. Its characteristics depend on the food stock and the various aspects of the ethanol production process. The role of various micro-organisms and their enzymes in wastewater treatment has been discussed to develop a better understanding of the phenomenon.Wastewater from the distillery without treatment can cause the depletion of dissolved oxygen in the water currents they receive and pose a serious threat to aquatic flora and fauna. This review presents a list of problems associated with distillery wastewater and a detailed study of existing biological treatment approaches.*

**Keywords:** *distillery wastewater, physicochemical treatment, biochemical oxygen demand (BOD) and chemical oxygen demand (COD)*

## INTRODUCTION

The first distillery in India was founded in Kanpur (then Cawnpore) in 1805 to produce rum for the army. Currently, there are about 315 distilleries with a total capacity of 3250 million liters of alcohol per year with 40.4 billion liters of effluents, each year (Mohana et al., 2009 Mohana, S, Bhavik, KA and Madamwar, D. 2009.

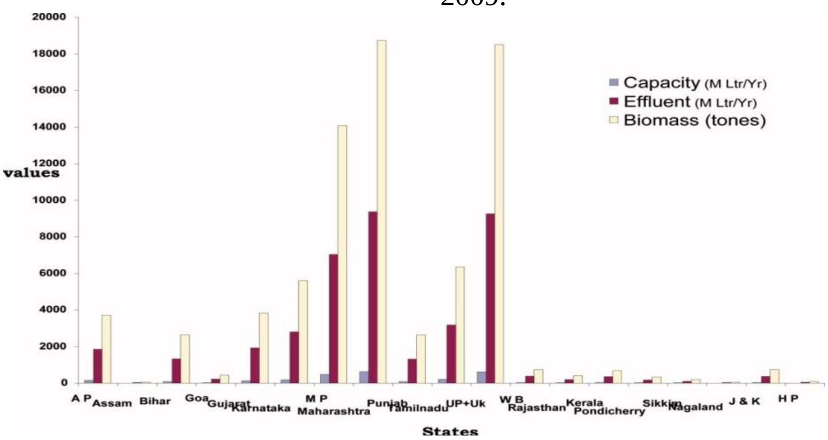



**Figure1**. *Annual capacity and generation of effluents from the distillery industry in various states of India.*

Distilleries are one of the most polluting industries, as 88% of their raw materials are converted into waste and discharged into water bodies, causing water pollution. In the distillery, for each liter of alcohol produced, about 15 liters of spent washing are released (Ravikumar et al., 2007). Alcohol acts as a basic chemical substance for a large number of chemical industries and therefore the demand for alcohol will increase dramatically in the future and distilleries will meet this demand.

### Distillery Washing

Treatment technologies and potential applications most distilleries coexist with sugar factories and use molasses from the production of cane sugar as a starting material for the production of alcohol.A maximum number of distilleries are present in Maharashtra (67) with an annual capacity of about 625 million liters of alcohol per year and a generation of effluents of about 9367 million liters per year, approximately.

The annual capacity and production of effluent from the distillery industry in various states of India are shown in Figure 1 (Chauhan and Dikshit 2007 Chauhan, MS and Dikshit, A K. Discoloration of the distillery wastewater in India: Current state and future trends Conference on environmental science and technology.

## Material And Methods

### Process of Manufacturing and Production of Wastewater

The production of alcohol in distilleries consists of four main phases to be known. Preparation of feed, fermentation, distillation and packaging. Figure 2 shows the different stages of the production process in the distillation industries. Alcohol (preferably ethanol) is produced primarily from cellulosic materials. Raw materials mainly used in distilleries are sugar cane molasses, cereals, grapes, and sugar cane juice and barley malt. These sugars are fermented in the presence of yeast to produce ethanol and carbon dioxide. The alcohol vapor is removed from the fermentation solution under reduced pressure and then distilled.

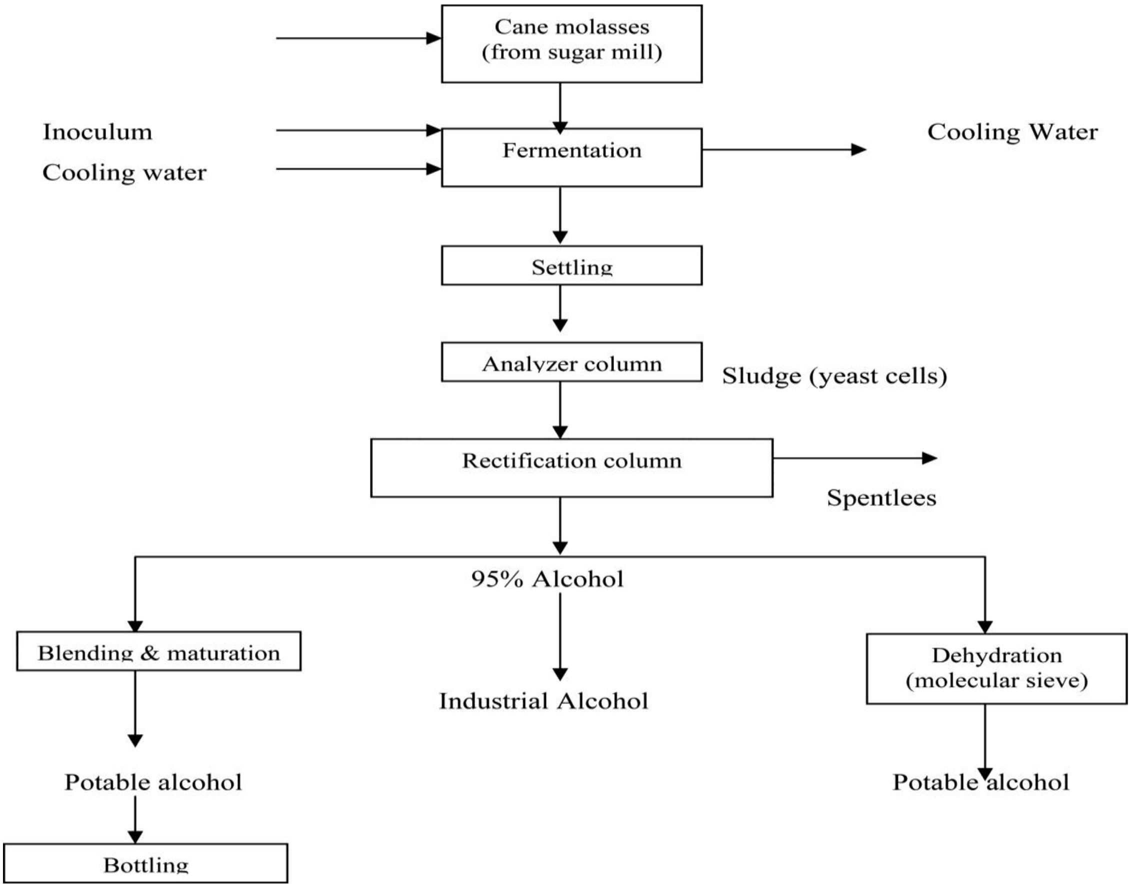



**Figure 2.** *Process* of description

The diluted sugar cane molasses is inoculated with yeast and fermented in a discontinuous or continuous way to obtain a broth containing 6-8% of ethanol. In the continuous process, the first cellulose materials of the delivates and the hemicellulose and the cellulose are subsequently hydrolyzed into simple sugars. Water management initiatives in distilleries based on sugar cane molasses ... in India, Recour Conserve Recycl, 52: 351-367, Satyawali and Balkrishnan 2008). Gaseous carbon dioxide is captured and used to produce additional quantities of ethanol or other basic chemicals.

The gaseous carbon dioxide can be expelled through the fermentation solution to remove alcohol from the fermentation solution (Saha et al., 2005 Saha, NK, Balakrishnan, M and Batra, S. 2005. Improve V industrial water use: case study for an Indian distillery ResourConservRecyTewari et al, 2007 Tewari, PK, Batra, VS and Balakrishnan, M. 2007.

## Characteristics of the Waste Water Generated During the Manufacturing Process

Alcohol distilleries are water-intensive units that generate large volumes of high-strength wastewater that are a major environmental problem. The quantity and characteristics of the waste water generated in the various stages of the production process are shown in Table 1 and their characteristics are shown in Table 2.

**Table 1.** *Wastewater generation in various operations.*

| S. No. | Distillery operations | Average wastewater generation (kLD/distillery) | Specific wastewater generation (kL wastewater/kL alcohol) |
|---|---|---|---|
| 1 | Spent wash (from distillation) | 691.9 | 11.9 |
| 2 | Fermenter cleaning | 118.2 | 3.6 |
| 3 | Fermenter cooling | 575.1 | 5.0 |
| 4 | Condenser cooling | 964.4 | 9.7 |
| 5 | Floor wash | 50.8 | 2.5 |
| 6 | Bottling plant | 313.8 | 3.7 |
| 7 | Others | 341.6 | 3.2 |

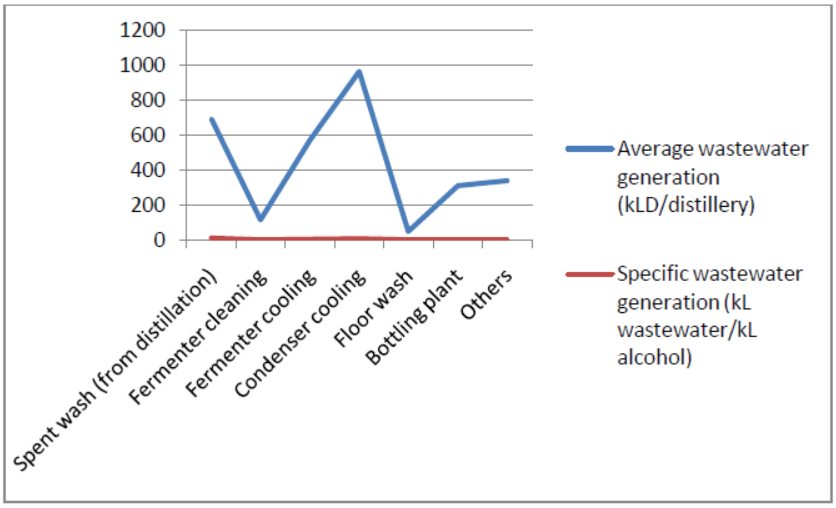



**Table 2.** *Typical characteristics of different wastewater streams.*

| S. No. | Parameter | Spent wash | Fermenter cooling | Fermenter cleaning | Condenser cooling | Fermenter wash | Bottling plant |
|---|---|---|---|---|---|---|---|
| 1 | Colour | Dark brown | Colourless | Colourless | Colourless | Faint | Colourless |
| 2 | pH | 4–4.5 | 6.26 | 5.0–5.5 | 6.8–7.8 | **6** | 7.45 |
| 3 | Alkalinity (mg/L) | 3500 | 300 | Nil | - | **40** | 80 |
| 4 | Total solids (mg/L) | 100,000 | 1000–1300 | 1000–1500 | 700–900 | 550 | 400 |
| 5 | Suspended solids | 10,000 | 220 | 400–600 | 180–200 | 300 | 100 |
| 6 | BOD (mg/L) | 45,000–60,000 | 100–110 | 500–600 | 70–80 | 15 | 5 |
| 7 | COD (mg/L) | 80,000–120,000 | 500–1000 | 1200–1600 | 200–300 | 25 | 15 |

The production and the characteristics of the spent wash are highly variable and dependent on the raw material used and various aspects of the ethanol production process (Wedzicha and Kaputo1992Wedzicha, B L and Kaputo, M T. 1992.The distilleries have been generating huge quantities of high toxic effluents. Melanoidins from glucose and glycine: composition, characteristics and reactivity towards sulphite ion. The characteristics of different types of distillery wastewater are given in Table 3.

**Table 3.** *Chemical characteristics of distillery wastewater (Melamane et al. 2007).*

| S. No. | Parameters | Type of wastewater | | | |
|---|---|---|---|---|---|
| | | Wine distillery wastewater | Vinasse | Molasses wastewater | Lee stillage |
| 1 | pH | 3.53-5.4 | 4.4 | 5.2 | 3.8 |
| 2 | Alkalinity (meq/L) | 30.8–62.4 | - | 6000 | 9.86 |
| 3 | Phenols (g/L) | 0.029–0.474 | 0.477 | 0.450 | – |
| 4 | VFA (g/L) | 1.01–6 | - | 8.5 | 0.248 |
| 5 | CODT (g/L) | 3.1–40 | - | 80.5 | - |
| 6 | CODS (g/L) | 7.6–16 | 97.5 | – | - |
| 7 | $BOD_5$(g/L) | 0.21–8.0 | 42.23 | – | 20 |
| 8 | TOC (g/L) | 2.5–6.0 | 36.28 | – | - |
| 9 | VS (g/L) | 7.34–25.4 | - | 79 | - |
| 10 | VSS (g/L) | 1.2–2.8 | - | 2.5 | 0.086 |
| 11 | TS (g/L) | 11.4–32 | 3.9 | 109 | 68 |
| 12 | TSS (g/L) | 2.4–5.0 | - | – | - |
| 13 | MS (g/L) | 6.6 | - | 30 | - |
| 14 | MSS (g/L) | 900 | 100 | 1100 | - |
| 15 | TN (g/L) | 0.1–64 | - | 1.8 | 1.53 |
| 16 | $NH_4^+$ (g/L) | 0.140 | - | - | 0.0451 |
| 17 | $NO^-_3$ (g/L) | - | - | - | - |
| 18 | TP (g/L) | 0.24–65.7 | - | - | 4.28 |
| 19 | $PO_4^{3-}$ (g/L) | 130–350 | - | - | - |

The spent wash generated from distilleries has high chemical oxygen demand (COD) (80,000–100,000 mg/L) and biochemical oxygen demand (BOD) (40,000–50,000 mg/L), high temperature, is dark brown in colour having low pH (<4.0–4.5) (Central Pollution Control Board 1994). COD and BOD values of this spent wash are due to the presence of a number of organic compounds, such as polysaccharides, reduced sugars, lignin, proteins, melanoidin, waxes, etc.

The amount of inorganic substances such as nitrogen, potassium, phosphates, calcium, and sulfate is also very high (Table 2) (Melamane et al., 2007Melamane, X L, Strong, P J and Burgess, J E. 2007. Treatment of wine distillery wastewater: a review with emphasis on anaerobic membrane reactors. Spent wash contains about 2% melanoidin which has an empirical formula of $C_{17}$–18$H_{26}$–27$O_{10}$N and molecular weight between 5000 and 40,000 Da (Martin et al. 2002; Manisankar et al. 2004Manisankar, P, Rani, C and Viswanathan, S. 2004. Effect of halides in the electrochemical treatment of distillery effluent. These compounds have antioxidant properties, which render them toxic to many microorganisms such as those typically present in wastewater treatment processes (Kumar et al. 1997Kumar, V, Wati, L, FitzGibbon, F, Nigan, P, Banat, I M, Singh, D and Marchant, R. 1997.

Bioremediation and decolorization of anaerobically digested distillery spent wash. According to EPA Guidelines for Wineries and Distilleries (2004), some of the potential effects of the various constituents of liquid and solid waste by-products from the wine making process on the environment are summarized in Table 4.

**Table 4.** *Potential environmental impacts of winery and distillery wastes.*

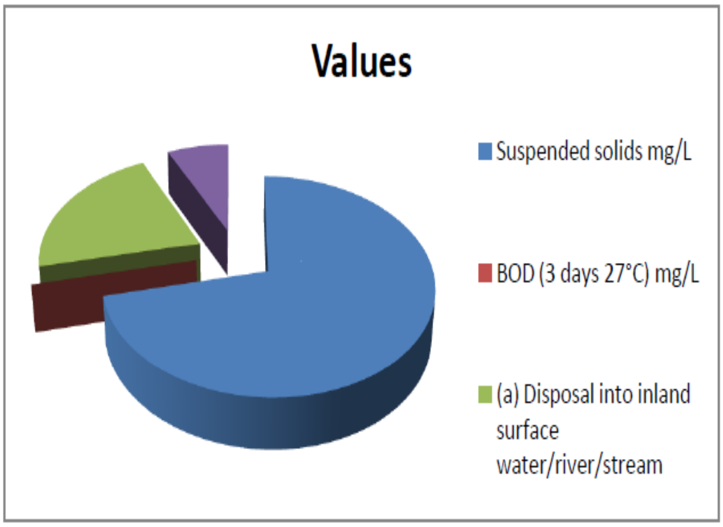
| **S.No.** | **Winery waste constituent** | **Indicators** | **Effect** |
|---|---|---|---|
| **1** | Organic matter | Biochemical oxygen demand, total organic carbon, chemical oxygen demand | • Exhausts oxygen when it is drained into water and kills fish and other aquatic organisms<br>• The smells generated by anaerobic decomposition cause discomfort. |
| **2** | Alkaline or acidic | pH | • Death of aquatic organisms in extreme pH ranges.<br>• Affects microbial activity in biological wastewater treatment processes. |

| | | | |
|---|---|---|---|
| | | | • It affects the solubility of heavy metals in soil and the availability and / or toxicity in water. • Affects crop growth. |
| **3** | Nutrients | Nitrogen, phosphorous, potassium | • Eutrophication or flowering of algae when it is discharged into water or stored in lagoons; The proliferation of algae can cause unpleasant odors in the lagoons. • N as nitrate and nitrite in the drinking water supply can be toxic to babies • Toxic for crops in large quantities. |
| **4** | Salinity | Electrical conductivity, total dissolved Solids | • gives an undesirable taste to water. • Toxic to aquatic organisms. • Affects water absorption by crops. |
| **5** | Heavy metals | Cadmium, chromium, cobalt, copper, nickel, lead, zinc, mercury | • Toxic for plants and animals. • Neurotoxicity |
| **6** | Solids | Total suspended solids | • Reduces the porosity of the soil, which leads to a reduction in oxygen absorption • It can reduce the transmission of light in the water, thus compromising the health of the ecosystem. • Smell the smells of the habitat generated by anaerobic decomposition. |

Many technologies have been tried for the treatment of spent washing, however, none of these methods has been judged effective and economically viable to reach the standard standards (Table 5) established by the Central Pollution Control Board, Government of India.

**Table 5.** *Standard effluents for distilleries, maltries and breweries.*

| S.No. | Parameter | Values |
|---|---|---|
| **1** | pH | 5.5–9.0 |
| **2** | Colour and odour | Absent |
| **3** | Suspended solids mg/L | 100 |
| **4** | BOD (3 days 27°C) mg/L | |
| | (a) Disposal into inland surface water/river/stream | 30 |
| | (b) Disposal on land for irrigation | 10 |




## Result And Discussion

### Treatment Options for Treatment with Washed Distillery

Current treatment options used to treat spent distillery washing include physical, chemical, physico-chemical and biological methods prior to disposal. The choice of treatment methods depends on several factors.

Effectiveness of treatment cost of treatment, local geography, climate, land use, regulatory restrictions and public acceptance of treatment.

## *Physical Treatment*

Physical treatment is used to reduce suspended solids / adjustable wastewater, which can be economically removed by sedimentation using gravity to separate suspended material, oil and grease from wastewater (Jayanti and Narayanan 2004 Jayanti, S and Narayanan, S. 2004 Computational study of the interaction between particles and whirlpools in the sedimentary has been reported to remove total suspended solids (TSS) passing wastewater through a granular medium as well as sand, the particles are acquired in fine pores and absorbed in the granular surface. al. (2006 Nataraj, SK, Hosamani, KM and Aminabhavi, M. 2006.

T purification distiller nanofiltration On the basis of membrane and reverse osmosis processes, it was also reported that the nanofiltration and reverse osmosis membrane processes can used to reduce total dissolved solids (TDS), COD and 99.80, 99.90 and 99.99% respectively in purification distillery potassium ($K^+$).Physical treatment methods are used in the initial phase of effluent treatment. Various methods of physical treatment currently used in the distillate wastewater treatment are sensing, mixing, flow equalization, flotation and sedimentation.

Adsorption is also one of the most commonly used physical methods. Active carbon adsorption is widely used for the elimination of color and specific organic contaminants.

## *Chemical Treatment*

Chemical products are invariably expensive and less dependent on industries, whereas in recent years, biological wastewater treatment systems have attracted workers' attention all over the world and have contributed to the development of efficient and inefficient waste treatment systems. Expensive (Naik et al. 2008 Naik, NM, Jagadeesh, KS and Alagawadi, R. 2008.

During the chemical treatment of wastewater, compounds such as chlorine ($Cl_2$), oxygen ($O_2$), ozone ($O_3$) and permanganate ($MnO_4$) are added to the wastewater to oxidize wastewater components from carbon dioxide ($CO_2$), water, inorganic substances and other innocuous products (Benitez et al., 2003) reported that elanoidins may discolor with various physico-chemical methods. Most of these methods eliminate color or by concentrating the color mud or by the partial or complete decomposition of the color molecules. Adsorption is a physical process, so discuss it in the paragraph of the physical process.

Active carbon adsorption is widely used for the elimination of color and specific organic contaminants. Pikaev et al. (2001 Pikaev, AK, Ponimarev, AV, Bludenko, AV, Minin, VN and Elizarvar, L M. 2001.

Combined purification with electron beam and coagulation of melt distillation runways RadiatPhysChem, 61 (1): 81- 87. Distiller wastewater treatment using iron sulfate (Fe2 ($SO_4$) 3) as a result of coagulants, 40% removal of contaminants from wastewater Beltrain Heredia et al (2005 Beltrain Heredia, J., Domingues, JR and Party, E. 2005) chemical-physical treatment for the purification of waste water wine distillery (vinacce) water SciTechnol, 51 (1): achieved also a reduction of 55% of COD using the integrated coagulant process / flocculants Fenton in the water treatment distiller in another ratio, ferrous sulfate, aluminum chloride, calcium oxide, ferric chloride and coagulants reduced 95% color, 74.4%, 80.2% and 83%, respectively, while the COD was reduced to 78 %, 61.3%, 39.8% and 55%, respectively (Chaudhari et al., 2007 Chaudhari, PK, Mishra, IM and Chandb, S. 2007 discoloration and elimination of the chemical oxygen demand (COD) with energy recovery: treatment of the digestive effluents of an alcohol based inorganic coagulant molasses.

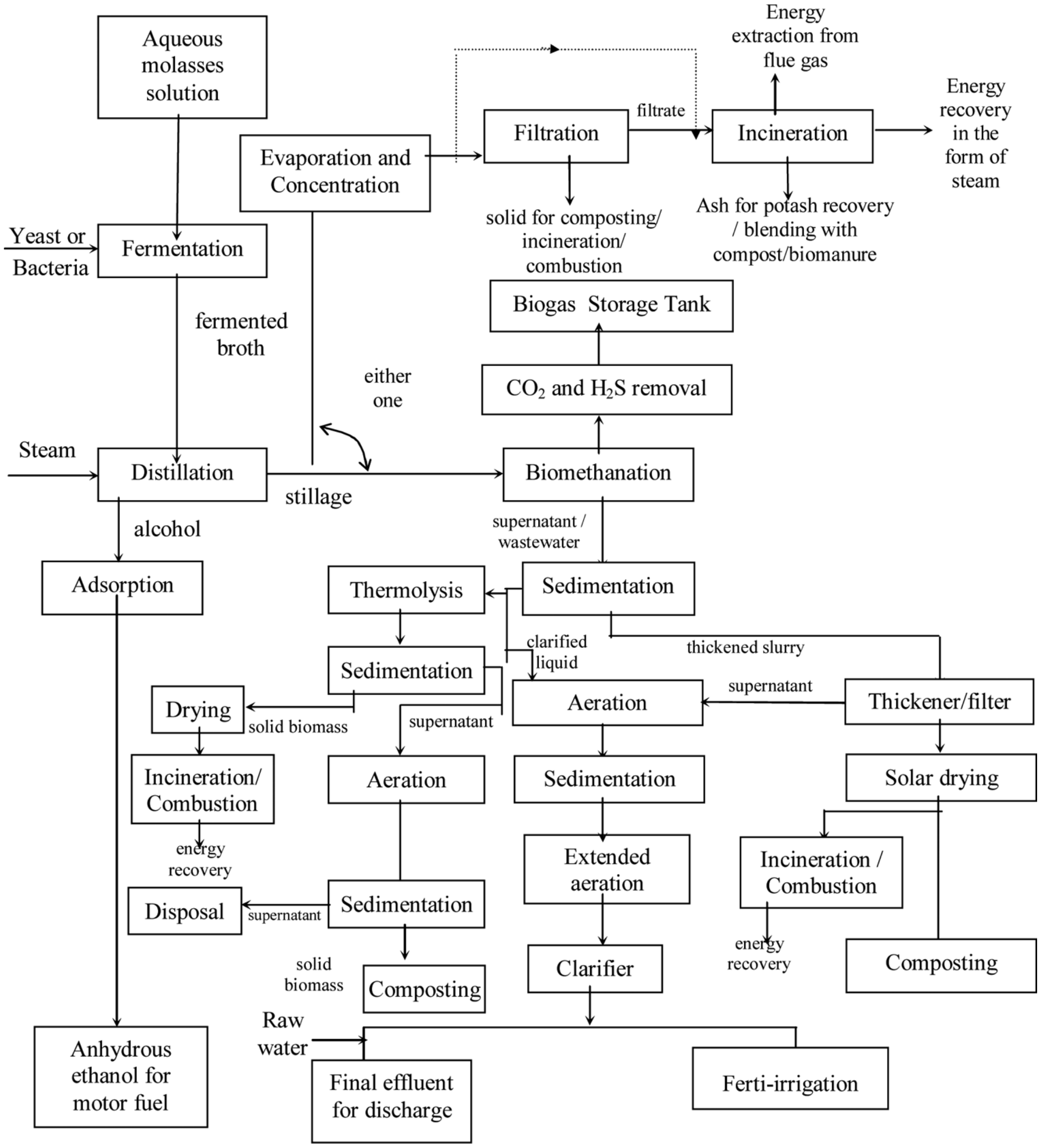
These approach can eliminate most of the extractable organic compounds, COD and color.

Identification and optimization of biotechnological methods of treatment is a necessity today (2006 Thakur Thakur, I have S. 2006.

Industrial Biotechnology: Problems and Solutions, New Delhi 44-69. IK International Pvt Ltd.

There are several reports mentioning the potential biological treatment for wastewater also distilleries aerobic and anaerobic systems are commonly used to treat spent washing distillery in view of potential applications, this section is discussed in detail on biological treatment.

## *Physicochemical Treatment of Distillery Wastewater*




## CONCLUSION

The technologies currently used by distilleries for wastewater treatment are biomethanisation followed by a two-stage biological treatment and disposal in watercourses or land use for irrigation, composting with or without biomethanisation. These technologies treat wastewater to a certain level. However, these technologies set limits for full compliance with the prescribed standards. Researchers have studied various treatment technologies, such as physical-chemical treatment, composting and biological treatment. Physical and chemical treatment methods eliminate low level organic pollutants; they are highly selective to the range of eliminated contaminants (color, turbidity, TSS or bad odors and COD). However, the disadvantages associated with these methods are the excessive use of chemicals, sludge generation with consequent disposal problems, high operating costs and sensitivity to the intake of variable water.

These limitations are due to a high cost of treatment or the inherent inability of the technology to remove certain contaminants such as TDS and color, at safe and acceptable limits for disposal in surface or terrestrial waters. Using a single process alone cannot completely treat wastewater. An anaerobic treatment followed by biological aerobic oxidation is a common technique used to decolorate wastewater. But these processes are not efficient enough to treat these large volumes of colored wastewater. The feasibility of large-scale application of the process would require more research into this continuous culture configuration, in order to minimize the added nutrients and extend the biomass activity for a longer period. Conventional methods of biological treatment (anaerobic digestion, anaerobic lagoons, active sludge process, etc.) are not effective for the complete elimination of color and other contaminants from this stream.

Several researchers have shown that the anaerobic processes that allow biogas recovery seem to be the most promising technology for the treatment of spent washing. An ideal, profitable and commercial treatment scheme is needed that includes biomethanisation as the main step followed by physical-chemical treatment and which ends with aerobic treatment. Emerging treatment methods, such as enzyme treatment, have technological advantages and are, however, in their infancy, which is why they require economic considerations to be able to apply them in the scale of the plant. There seems to be great potential for enzymes in a large number of waste treatment areas.

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