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Indian Distillery Industry: Problems and Prospects of Decolourisation of Spentwash

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Abstract. India is the fourth largest producer of ethanol in the world and the second largest in Asia. Though, the alcohol production from starchy material is also practiced in India but on a very limited scale, most of the Indian distilleries use sugarcane molasses as raw material. Distillery ranks as the top most industry among the list of 17 heavily polluting industries identified by Ministry of Environment & Forests, Govt. of India. Paper covers the overview of Indian distillery industry, problems and prospects of decolorisation of distillery spentwash and research findings of integrated physico-Chemical and fungal treatment, which could remove upto 85% colour of distillery spentwash.

Keywords: Decolourisation; Distillery; Spentwash

1. Introduction

India produces about 2.75 billion litres of alcohol annually. The demand for potable alcohol has been ever increasing with the more liberal attitude, rising middle class (disposable income) and less taboo/stigma in Indian society. Though practiced all across the globe, the use of alcohol as blend in motor fuel was not permitted in India till recently, which resulted in under-capacity utilization of distillation facility. Due to government promoting ethanol to mix in petrol there will be drastic demand for ethanol, which could overcome the existing unutilized capacity and thus creating an excess demand. Spentwash generated from distillation process has very high pollution potential. Distillery spentwash is not only high on organic and inorganic loading, but also having dark brown colour even after bio-methanation. In some parts, where land application of distillery wastewater is practiced, the colour problem in groundwater is so acute that distilleries have to provide potable water to surrounding villages. Many physico-chemical and biological methods for the removal of colour from distillery spentwash were tried, but a cost effective and efficient treatment method is still awaited.

2. Growth of Indian Distillery Industry

The First distillery in the country was set up at Crwnpore (Kanpur) in 1805 by Carew & Co. Ltd., for manufacture of Rum for the army. The technique of fermentation, distillation and blending of alcoholic beverages was developed in India on the lines of practices adopted overseas particularly in Europe. Distilleries manufacture rectified spirit and extra neutral alcohol for human consumption and for industrial utilization. The distillery industry today consists broadly of two parts, potable liquor and the industrial alcohol. The potable distillery producing Indian Made Foreign Liquor and Country Liquor has a steady but limited demand with a growth rate of about 7-10 per cent per annum. The industrial alcohol industry on the other hand, is showing a declining trend because of high price of Molasses which is invariantly used as substrate for production of alcohol. The alcohol produced is now being utilized in the ratio of approximately 52 per cent for potable and the balance 48 percent for industrial use. Apart from its use for beverage,

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medicinal, pharmaceutical and flavouring, alcohol constitutes the feedstock for large number of organic chemicals, which are used in manufacturing a wide variety of intermediates, drugs, rubber, pesticides, solvents etc. (Mall, 1995). with the advent of ethanol blending with petrol/ motor fuel, the requirement of ethanol/ industrial alcohol has increased manifold in the country to the extent that in case 5 % blending, if made mandatory all over the country, the sugar factory molasses available in the country shall not prove to be adequate for meeting the total requirement of ethanol including its use for potable liquors and other industrial uses. However, the notification no.G.S.R.705(E) dated 27^{th} October, 2004, Ministry of Petroleum and Natural Gas, Government of India, mandates that 5% ethanol-blended petrol (E5), conforming to Bureau of Indian Standards specifications, shall be sold in the following ten states *viz.* Andhra Pradesh (except Chittor and Nellore districts); Goa; Gujarat; Haryana; Karnataka; Maharashtra; Punjab; Tamil Nadu (only in districts of Coimbatore, Dindigul, Erode, Kanayakumari, Nilgiri, Ramanathpuram, Tirunelveli, Tuticorin and Virudhunagar); Uttar Pradesh; and Uttaranchal and the following three union territories *viz.* Daman and Diu; Dadra and Nagar Haveli; and Chandigarh. It is also stipulated that government may extend above notification to all states and union territories in phase 2, and enhance the percentage of ethanol in the ethanol blended petrol from 5% to 10% in phase 3 (MoPNG, 2004). Due to government promoting ethanol to mix in petrol there will be drastic demand for ethanol, which could overcome the existing unutilized capacity and thus creating an excess demand. For example, according to the estimates prepared by the Ministry of Petroleum and Natural Gas, about 410 million litres of anhydrous ethanol (conforming to IS 321: 1964) shall be required to implement 5% blending in the above-mentioned 10 notified states (Ethanol India, 2008).

Looking to its wide use, it can be inferred that the demand for alcohol is likely to increase in the country and so is the number of distilleries producing alcohol. All India Distillers Association (AIDA) and Ethanol India are predicting the birth of many new distilleries along with major expansion in capacity of existing distilleries (AIDA, 2008; Ethanol India, 2008).

3. Wastewater from Distillery Industry : Problems

Distilleries generate (i) spentwash from distillation column; (ii) spent lees from analyser column and (iii) other wastewaters like fermenter washings, fermenter cooling, floor washings, spillage and cooling. Among these, spentwash is of major environmental concern owing to its quantity and quality. About 10-15 litres of spentwash is generated for every litre of alcohol produced and is characterized by high percentage of dissolved organic (52,000–58,000 mg/L BOD; 92,600-1,00,000 mg/L COD) and inorganic matter (1,660–4,200 mg/L form of nitrogen, 225–3,038 mg/L phosphorus, and 9,600–17,475 mg/L potassium etc.), dark brown colour (2,38,000–2,52,000 Pt-Co units), high temperature (70-100^{o}C) and low pH (4-4.5). About 50% of the organic and inorganic matter are present as reducing sugars. Indian spentwash contains very high amounts of potassium, calcium, chloride, sulphate and BOD as compared to spentwash in other countries (Joshi, 1999). The properties of spentwash being dependent on the quality of molasses, fermentation techniques and operating practices could be the main reason for the significant variability. Spentwash is toxic to aquatic organisms as LC_{50} value for distillery spentwash was found to be 0.5% for fresh water fish *Cyprinus carpio* var. *communis* (Gupta, 2007). If disposed untreated on land, it reduces alkalinity of the soil, and crops may be destroyed. In some parts, the colour problem in groundwater is so acute that distilleries have to provide potable water to surrounding villages. It behaves much more hazardously when disposed into water bodies, since it may result in the complete depletion of dissolved oxygen and aquatic life will be destroyed (Kumar, 1991).

Like any other high strength wastewater, anaerobic treatment of distillery spentwash has been favoured over aerobic process because of various advantages. Anaerobic treatment produces biogas which can be used in other units of distillery industry, thus reducing the power consumption. The payback period of the most types of anaerobic digesters being about 3 years has already established anaerobic treatment of spentwash as the industry standard and presently, almost all distilleries have adopted it as the best available technology at the first step.

The effluent standards notified by Ministry of Environment and Forest (MoEF), Government of India vide GSR 176(E), April 2, 1996, require that the effluent from distillery industry should have pH between 5.5-9; suspended solids 100 mg/L, and maximum BOD level of 30 mg/L for disposal into water courses and

100 mg/L for disposal on land. It is suggested that all efforts must be done to remove colour and unpleasant odour, as far as possible. If land application is envisaged as secondary treatment system, BOD is allowed up to 500-1,000 mg/L. However, the drainage water from the land after such treatment has to satisfy BOD limit of 30 mg/L and nitrate as nitrogen should not be more than 10 mg/L. Further, the underlying groundwater should not have a BOD more than 3 mg/L and 10 mg/L of nitrate (CPCB, 2002).

Central Action Plans have been prescribed as "Charter on Corporate Responsibility for Environmental Protection" for each of the 17 heavy polluting industries by Central Pollution Control Board (CPCB), Government of India. Accordingly, existing molasses based noncompliant distilleries are required to furnish bank guarantee and action plan to concerned state boards to ensure compliance with any or combination of the following measures:

- Compost making with press mud/agricultural residue/municipal waste;
- Concentration and drying / incineration;
- Treatment of spentwash through bio-methanation followed by two stage secondary treatment and dilution of the treated effluent with process water for irrigation as per norms prescribed by CPCB /MoEF;
- Treatment of spentwash through bio-methanation followed by secondary treatment (BOD < 2500 mg/L) for controlled discharge into sea through a proper submerged marine outfall at a point permitted by SPCB/CPCB in consultation with National Institute of Oceanography (NIO), so that dissolved oxygen in the mixing zone does not deplete, less than 4 mg/L;
- For taking decision on feasibility of one time controlled land application of treated effluent, a study will be undertaken within three months.

The road map for utilisation of spentwash by the distilleries to achieve zero discharge of spentwash in inland surface water courses was proposed as below:

- 50% utilisation of spentwash —— By March, 2004
- 75% utilisation of spentwash —— By March, 2005
- 100% utilisation of spentwash —— By December, 2005

Till 100% utilisation of spentwash is achieved, controlled and restricted discharge of treated effluent from lined lagoons during rainy season will be allowed by SPCB/CPCB in such a way that the perceptible colouring of river water bodies does not occur. Further, the task force consisting of CPCB, SPCB, experts and industry shall be constituted for monitoring the implementation of action points. For new distilleries and expansion of existing distilleries (molasses based), the proposal without achieving zero discharge in surface water / groundwater will not be considered by MoEF / SPCB (CPCB, 2008).

Anaerobic digestion of spentwash is the best possible technical option for treatment at the first step. Most of the Indian distilleries have installed anaerobic digesters as it is cost effective and easy to use option. The anaerobically treated spentwash is required to be further treated to cope with environmental standards. A few options suggested are (i) evaporation in sludge drying beds or in mechanical evaporators such as multi effect evaporators followed by incineration for potash and/or energy recovery; (ii) two stage aerobic treatment followed by land application for irrigation purposes; (iii) two stage aerobic treatment followed by tertiary treatment for discharge to surface waters and (iv) membrane treatment for reclaiming water for reuse.

This treated spentwash does not meet Central Pollution Control Board (CPCB) standards of discharge into streams or land application. Groundwater colourisation is growing concern for areas having land application of distillery spentwash. Many physico-chemical and biological methods for the removal of colour from distillery spentwash were tried, but a cost effective and efficient treatment method is still awaited. The present study aims at evolving cost effective treatment option, consisting physico-chemical and fungal treatment for decolourisation of anaerobically digested molasses spentwash (ADMS).

4. Wastewater from Distillery Industry : Prospects

Most of the research works reported in the literature for the treatment of distillery wastewater were either carried out on synthetic spentwash or diluted one. Both of these limitations restrict transformation of those works on the field. In this work suitable pre-treatment option for the anaerobiclly digested molasses spentwash (ADMS) were tried so that biological treatment can be given without dilution. The study has been carried out on actual wastewater collected from a distillery, producing rectified sprit using sugarcane molasses as raw material. The distillery is situated in Nashik district of Maharashtra having 30 KLD distillation capacity. Coagulation was tried as the pre-treatment option. To simulate field conditions, all the coagulants used were of laboratory grade, procured from local market. Wide spectrum of coagulants ranging from ferrous sulphate, ferric sulphate, ferric chloride, calcium chloride, calcium oxide, calcium hydroxide, alum, potash alum to poly aluminium chloride were used. Jar tests were performed on undiluted ADMS samples with coagulants. First, the optimum pH was found on the basis of reduction in absorbance in the pH range 2 to 12. Lime or HCl was used for pH correction. At optimum pH, optimum dose was found out by varying dose of coagulant over a wide range.

After pre-treatment, the selection of suitable fungi and the optimisation of various environmental and growth parameters was done. Four sludge samples, two from sludge-line of anaerobic digester and two from the lagoons of the distillery plant under study were collected. Isolation of fungal strains was done followed by Primary and Secondary Screening of fungal species. Those species of fungi, which exhibited growth during primary screening, were further subjected to secondary screening. The isolate exhibiting maximum decolourisation was selected for further studies. Effect of initial pH, Effect of mixing, Immobilisation and Effect of surfactant addition was studied. Type of Nitrogen Source and optimum dose of Sucrose, Nitrogen, Magnesium Sulphate and Potassium Dihydrogen Phosphate were found as part of growth parameters.

Decolourisation efficiency of various coagulants was assessed for pre-treatment of ADMS (Figure 1). Poly Aluminium Chloride (PAC) worked as the best. It removed 62.5% colour and 50% COD from the ADMS. In next stage, fungal isolation and characterization were carried out. Selected fungal strain was grown in undiluted spentwash and could attain over 85% removal of colour and 75% removal of COD. Figure 2 shows UV-VIS spectra of untreated, pre-treated and biologically treated spentwash.

5. Conclusion

Secondary treatment and disposal of spentwash even after anaerobic digestion has always been challenge to the environmental engineers. Above process is ray of hope for imparting biological treatment to the anaerobically digested spentwash without diluting it.

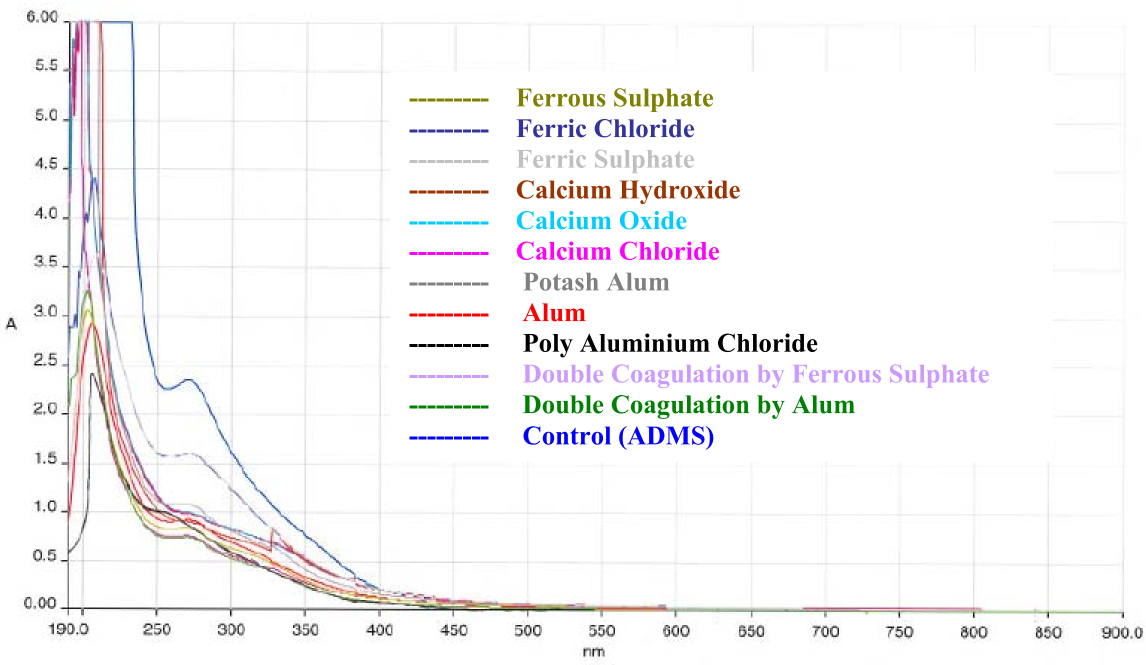

Figure 1 UV-VIS Spectra of Control (ADMS) and those of Samples after various Coagulation options

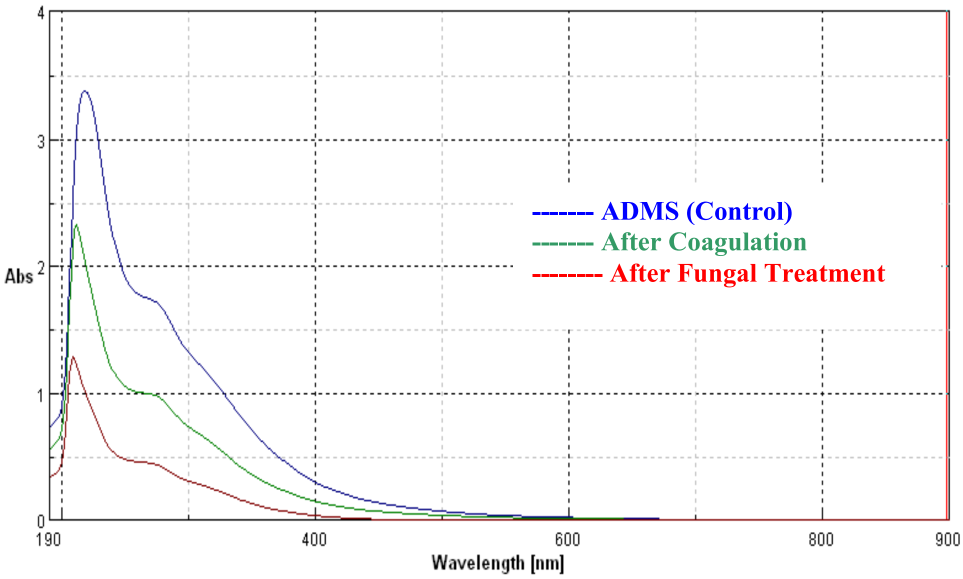

Figure 2 UV-VIS Spectra of ADMS, after Coagulation and after Fungal Treatment

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