A REVIEW:

Treatment and disposal of distillery spentwash

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The spentwash is coloured, highly acidic with very offensive in odor, which poses serious environmental problems.Control of pollution arising from distillery spentwash is done by a variety of methods, consisting of biogas generation and aeration, composting, evaporation and incineration, ferti-irrigation. Pollution prevention focuses on preventing the generation of wastes, it is achieved by using physical, chemical and biological methods either alone or in combination. While, waste minimization refers to reducing the volume, water recycling and reuse, process modifications and the byproduct recovery as a fall out of manufacturing process creates ample scope for revenue generation thereby offsetting the costs substantially.

The paper reviews the status and appropriate treatment alternatives for disposal of the distillery wastewater.

Key words :
Spentwash, Biogas, Composting, Evaporation and incineration, Ferti-irrigation

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The world's total production of alcohol from cane molasses is more than 13 million m^3/annum. The aqueous distillery effluent stream known as spentwash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the produce alcohol. It is one of the most complex, troublesome and strongest organic industrial effluents, having extremely high COD and BOD values. Because of the high concentration of organic load, distillery spentwash is a potential source of renewable energy.

Till the mid 1980s, Indian distilleries used to adapt an open anaerobic lagoon treatment system for treating the spentwash, before it discharges. The primitive treatment method removed only 60 to 70% of organic load present in the spentwash, which was converted into bio-gas predominantly containing methane. Methane, until it is recovered and utilized is a potent green house gas with many untold ecological damages that go with it. Many alternate methodologies were conceived and practiced, keeping the environmental and industrial sustainability on the main agenda (Rao, 2008).

On account of the need for earliest possible implementation of the environmental standard prescribed by Central Pollution Control Board (CPCB), the topic of pollution control in ethanol distilleries has gained paramount importance. Pollution arising from alcohol distilleries has been recognized as one of the most difficult problems to be solved to the entire satisfaction of the Pollution Control Act. Irrespective of removal of large quantities of BOD and COD from the spentwash by a variety of methods, the caramels contained in the same on account of their high colour value defeat the valid claims of any process of treatment. Caramels are formed during the sugar manufacture and are carried over into molasses. Irrespective of microbial action during fermentation, they still get carried over into spentwash without any change. So long as any passer by can see a dark colour to whatever way treated spentwash, he cannot accept the treatment to be practically valid. This notorious colour shall continue to play havoc with the fields and water bodies. Thus, removal of colour is the key to any sound pollution control process for spentwash.

Current status of distillery industries in India:

The 295 distilleries in India produce 2.7 billion liters of alcohol and generating 40 billion liters 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. The wastewater from distilleries, major portion of which is spent wash, is nearly 15 times the total alcohol production. This massive quantity, approximately 40 billion liters of effluent, if disposed untreated can cause considerable stress on the water courses leading to widespread damage to aquatic life.

Treatment methods used for spentwash:

Waste treatment methods aim at the removal of unwanted compounds in wastewater for safe discharge into environment. This can be achieved by using physical, chemical and biological methods either alone or in combination (Nagaraj *et al.*, 2008). Physical treatment methods such as screening, sedimentation and skimming remove floating objects. Chemical treatment methods such as precipitation, pH adjustment, coagulation etc., remove toxic materials and colloidal impurities. Colouring compounds are more difficult to treat because of their synthetic origin and complex aromatic molecular structures. Such structures resist fading on exposure to water, light or oxidizing agents and this render them more stable and less amenable to biodegradation (Wesenberg *et al.*, 2003).

Decolorization of distillery spentwash by biological systems:

Physical or chemical methods of decolorization invariably cost intensive and can not be employed in industries. Hence, in recent years, the importance of biological wastewater treatment systems has attracted the attention of workers the world over and has helped in developing efficient low cost waste treatment systems. Increased attention has been directed towards utilization of microbial activity for the mineralization and decolorization of spentwash (Tamaki *et al.*, 1989, Kumar *et al.*, 1997, Agasibagil *et al.*, 2003). Diverse microorganisms involved in decolorization of spentwash are furnished in Table 1.

Bio-energy potential from distillery effluents:

The post methanation wastewater if used carefully for irrigation of agricultural crops can produce more than 85000 tonne of biomass annually. This biogas normally contains 60% methane gas, which is a well-recognized fuel gas with minimum air pollution potential. If this source of energy is tapped, it will fetch additional energy units worth 5 trillion-kilo calories annually. Besides, the Post Methanation Effluent (PME) can provide 24, 5000 tones of potassium, 1, 2500 tones of nitrogen and 2,100 tones of phosphorus annually. Thus, the manorial potential of effluent can be measured by the fact that one year's

Table 1 : Microorganisms capable of decolorizing distillery spent wash

Microorganism	Additional carbon source	Extent of Decolorization (%)	Reference
Bacteria			
1. *Pseudomonas sturzeri*	Glucose	Up to 60.00	Ramachandra (1993)
2. *Bacillus* sp.	Glucose	35.5	Nakazima Kambe *et al.* (1999)
3. *Pseudomonas* sp.	Molasses	60.00	Asthana and Ramachandra (1999)
4. Lactic acid bacteria	Molasses	70.00	Sharma *et al.* (2000)
5. *P. fluorescens*	Glucose	76.00	Jagroop Dahiya *et al.* (2001)
6. *Acetogenic bacterium N0BP103*	Glucose	70.00	Sirianuntapiboon *et al.* (2004)
7. *P. aeruginosa*	Glucose	67.00	Sarayu *et al.* (2005)
8. *Pseudomonas* sp.	. Glucose	56.00	Chavan *et al.* (2006)
Fungi			
1. *Aspergillus G-2-6*	Glycerol	75.00	Ohmomo *et al.* (1985)
2. *Mycelia sterilia*	Glucose	93.00	Sirianuntapiboon *et al.* (1988)
3.*Coriolus versicolor*	Glucose	71.00	Kumar *et al.* (1998)
5. *Aspergillus niger*	Glucose	80.00	Dhamankar and Patil (2001)
6. *Flavodon flavus*	Sucrose	80.00	Raghukumar and Rivonkar (2001)
7. *Aspergillus niveus*	Sugarcane bagasse	37.00	Angayarkanni *et.al.* (2003)
8.*Coriolus versicolor*	Cotton stalk	62.00	Kahraman and Yesilada (2003)
Yeasts			
Citeromyces sp.	Glucose	75.00	Sirianuntapiboon *et al.* (2004)
Cyanobacteria			
Oscillotoria boryana	Glucose	60.00	Kalavathi *et al.* (2001)

effluent can meet the potassium requirement of 1.55 million hectare land, nitrogen requirement of 0.13 million hectare land and phosphorus requirement of 0.025 million hectare land if two crops are taken in a year (Jalgaonkar, 1993).

The annual bio-energy potential of distillery effiuent in various states of India has been depicted in Table 2.

Present practices for spentwash treatment and disposal:

Out of the variety of processes tried and demonstrated at different times, the technically most accepted ones are Biogas followed by aeration, Biogas followed by composting, Concentration and Incineration of raw spentwash and Direct composting of raw spentwash. Except for the concentration and incineration, all the other methods carry a fear of letting the caramel colour appear in the discharge. The method (a) can never remove the colour, though practiced at many locations. It will only end in wasting precious electricity. Apart from being capital intensive, the concentration and incineration process too carries its own difficulties of clogging and clumping, either during evaporation or in incineration, due to presence of potassium. Many ambitious projects have come across insurmountable difficulties, preventing any consistency in the results.

The incineration process involves an investment of the order of 400% of the distillery cost, whereas the other two processes along with the secondary treatment require an investment of 200-300% of the distillery cost. The unfavourable economics make it difficult to implement these treatment processes on the plant scale. Because anaerobic digestion and wet oxidation are less expensive, these alternatives are more attractive. However, there is a need for development of a suitable process with lower investments and higher energy recovery. Many distilleries in India are allowing their effluent for application on land as direct irrigation water, spent wash cake and spent wash-press mud compost. The advances manifesting the possibilities of energy conservation are also discernible in the case of distilleries. The methane gas generated in the digesters is used as a fuel to compensate the energy needs of the industry. A general estimate suggests that the cost of an anaerobic biological digester is recovered within 2-3 years of installation because of substantial saving of coal and other fuels.

Cost recovery methods from the distillery effluents:

The wastewaters generated during the distillery and

Table 2 : Annual bio energy potential of distillery effluent in various states of India (http://www.environmental-expert.com/ Treatment of distillery wastewater.doc.)

State	Units	Capacity (M Lit/Yr)	Effluent (M Lit/Yr)	Biogas (M m^3)	Total N (tones)	Total Ka (tones)	Biomass (tones)
A.P.	24	123	1852	50	566	11115	3704
Assam	1	2	24	0.7	7	144	48
Bihar	13	88	1323	35.7	397	7940	2646
Goa	6	15	218	6	65	1304	436
Gujarat	10	128	1919	51.8	576	11511	3838
Karnataka	28	187	2799	75.6	840	16794	5598
M P	21	469	7036	190	2111	42219	14072
Maharashtra	65	625	9367	253	2810	56217	18734
Punjab	8	88	1317	35.6	395	7902	2634
Tamilnadu	19	212	3178	86	953	1971	6356
U.P.	43	617	9252	250	2776	55512	18504
W.B.	6	24	371	10.1	111	22223	742
Rajasthan	7	14	202	3	61	1215	404
Kerala	8	23	343	9.3	103	2064	686
Pondicherry	3	11	165	4.5	50	990	330
Sikkim	1	7	98	5.5	29	585	196
Nagaland	1	2	24	0.7	7	144	48
J & K	7	24	366	11	110	2196	732
H.P.	2	3	39	1	12	234	78
Haryana	5	41	615	16.6	185	3690	1230
Total	285	2703	40,508	1096.1	12,154	263,070	81016

brewery operations contain high organic loads. It has a BOD from 30,000 to 60,000 mg/1. So, due to this high organic content, the wastewaters can be subjected to treatment for the production of biogas, composting, aquaculture and potash recovery.

Bio-gas process:

For the production of biogas from distillery effluent, anaerobic biomethanation of the effluent is adopted, generally. High rate anaerobic technologies are utilized for biogas generation (Basu *et al.*, 1994). Fluidised Bed Reactors and Up flow Anaerobic Sludge Blanket (UASB) Reactors are mostly utilized for the production of biogas from the effluents. Some of the biogas production processes being commercial1y established in India at present are:-

Bio-thane process:

This process uses the UASB reactor for the production of biogas. This is a stable and automatic process with low operational costs.

Biobed process:

It is similar to Bio thane process. It uses UFB reactors. It needs less installation area and its construction cost is lower compared to any other system.

Bio-paq process:

In this process anaerobic bacteria are used to treat the distillery effluents for the production of biogas. UASB process is utilized here. The separated sludge in this process makes excellent manure. The generated biogas is used to produce steam for the distillation of alcohol and thus it replaces 50-60% of the total required energy in the process of distillation. For a plant having 40-45,000 kg COD/day 75-80% of COD can be reduced and nearly Rs. 25.50 lakhs can be saved annually for a distillery having 300 working days in a year. The generated biogas from UASB reactor of BioPaq process can be collected and be used as a fuel in gas/dual engine. Through suitable coupling the engine can be coupled with the A/C generator for generation of electricity from biogas. For a 45 KLPD distillery 11 KV of power is generated which is then utilized in the distillery, thus, cutting down the power consumption.

Sulzer's process:

The technology of this type of biogas plant is provided by Sulzer Brothers Limited, Switzerland. It is specifically

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made for Indian conditions. A biogas plant at the distillery of Padmashri Dr. Vitthalrao Vikhe Patil S.S.K. Ltd., Pravaranagar, District Ahmednagar (M.S) is based on Sulzer's technology.

Bio-gas utilization:

The methane rich bio-gas is combusted in a boiler for generation of process steam and captive power through a turbo generator. The bio-gas can also be combusted with other GHC neutral biomass residue fuel such as rice husk, etc. to supplement biogas fuel in the boiler. The typical capacity of power generation required by a 45 KLPD distillery would be 1.0 MW (Rao, 2008).

Future application of biogas may include electrical power production from gas turbines or fuel cells. Biogas can substitute for natural gas or propane in space heaters, refrigeration equipment, cooking stoves or other equipment. Compressed digester gas can also be used as transportation fuel (Rao, 2008**).**

Composting:

In this process, press mud generated from sugar mill, is utilized to produce compost by mixing distillery effluent. Both anaerobic and aerobic composting systems are practiced. In some plants composting with treated effluent through bio-methanation plant is also practiced. This system can achieve zero effluent if the press mud quantity matches with the effluent generated.

Organic wastes when applied correctly to soil have beneficial fertilizing effect, resulting in cost savings and reduced inorganic fertilizer requirement. It also includes environmental benefits like soil conditioning and indirectly resource conservation. Nitrogen and other nutrients are mostly bound to organic matter and are not immediately available, thus in effect it acts as a slow-release fertilizer. (Nagda *et al.,* 2009) Alternatives for disposing of effluents rich in organic matter are currently being sought as a valuable resource for soil amendments (Edwards, 1997; Carpenter and Fernandez, 2000).

Potash recovery:

It is done by incinerating the distillery spent wash. In this process, the raw distillery spent wash is first neutralized with lime and filtered. This is further concentrated to about 60% solids in multiple-effect forcer circulation evaporators. Now this thick liquor from the evaporator is burnt in an incinerator and is converted into ash. The dry solids of the spent wash in the form of coke in the incinerator has an average calorific value of 2 Kcal/kg, which is sufficient for supporting self-combustion of the thick liquor in the incinerator. The resulting ash is found to contain about 37% of potash as potassium oxide on an average. This ash is further leached with water to dissolve the potassium salts. Then it is neutralized with sulphuric acid and is evaporated. The potassium salts are crystallized in a crystal1izer. The crystallized mixed potassium salt contains 73.5% of potassium sulphate (K_2SO_4) 16.5% potassium chloride (KCl) and 5% of sodium salts. It is estimated that a distillery discharging about 300 m^3 of spent wash per day could recover 3 tonnes of Potassium as Potassium oxide or about 5.34 tonnes of Potassium sulphate and 1.2 tonnes of Potassium chloride per day. This potassium is used as a fertilizer. (Chakrabarty and Bhaskaran, 1964).

Distillery wastewater utilisation in agriculture:

Molasses fermentation effluents and post biomethanation effluents rich source of potassium besides high concentration of organic pollutants and cannot be discharged directly. They were shown to be safe for fert-irrigation using 10 to 50% dilutions with irrigation water (Saliha, 2003). However, practical difficulties in handling bulk volume in liquid form and monitoring of proper dilution rendered such organic rich effluent unacceptable to the farmers, besides its obnoxious odor (Pathak *et al.,* 1999).

Being very rich in organic matters, the utilisation of distillery effluents in agricultural fields creates organic fertilization in the soil which raises the pH of the soil, increases availability of certain nutrients and capability to retain water and also improves the physical structure of soil. Mostly the distillery wastewaters are used for pre-sowing irrigation **(**Jadhav *et al.,* 2009). The post-harvest fields are filled with distillery effluents. After 15-20 days, when the surface is almost dried, the fields are tilled and the crops are sown and subsequent irrigation is given with fresh water. However, the effluent is diluted 2-3 times before application on crops. Apparently, the irrigation with distillery wastewater seems to be an attractive agricultural practice which not only augments crop yield but also provides a plausible solution for the land disposal of the effluents (Sindhu *et al.,* 2007). One cubic metre of methanated effluent contains nearly 5 kg of potassium, 300 grams of nitrogen and 20 grams of phosphorus. If one centimetre of post methanation effluent is applied on one hectare of agricultural land annually, it will yield nearly 600 kg of potassium, 360 kg of calcium, 100 kg of sulphates, 28 kg of nitrogen and 2 kg of phosphates. The distillery effluent contains 0.6 to 21.5 per cent potash as KO, 0.1 to 1.0 per cent phosphorus as PO and 0.01 to 1.5 per cent Nitrogen as N_2.

Reduction of green house gases:

Methane recovery is the form of biogas and utilization as fuel helps in GHC emission reduction in two ways methane capture through its controlled recovery in an anaerobic digestion plant and reduction of emission from firing of fossil fuels to produce the same amount of process steam and electric power, either through captive mean or through drawing the power generation activity of grid (Rao, 2008).

Recommendations:

Anaerobic digestion of spentwash 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 per cent fuel/steam. The treated effluent having almost all the potash retained in it may be utilised for irrigation purposes.

For recovery from the treatment of distillery spent wash, depending on the availability and cost of land in a particular area, simple treatment in anaerobic lagoon to generate biogas followed by treatment in aerated lagoon or oxidation ditch may be considered. Where the availability and cost of land are the main constraints, activated sludge type of aeration treatment in a deep oxidation ditch would be more economical than the conventional or extended aeration sludge process.

Where the availability of land is a severe constraint, evaporation and incineration of distillery spent wash to recover potash would appear to be the only choice. In spite of high capital investment required for such type of plants, heat recovery would defray significantly the organisation and maintenance costs and contribute towards conservation of energy.

In the countries like India, where indigenous sources of potash are scarce or not available, recovery of potash from crude ash by evaporation and incineration of spent wash would appear to be an economically attractive alternative. If heat recovery is simultaneously used, the pay back period of the plant can be substantially reduced.

The utilisation of the distillery effluent in agricultural fields will not only enrich them, but, further with essential plant nutrients like nitrogen, phosphorous and potash but also compensate the expenditure on fertilizers for crop growth. This practice will result in revenue generation and further lead to offsetting the costs substantially.

Similarly, spent wash utilization in bioearth composting, where adequate land is available, being a simple process and not involving any heavy machinery is also one of the cost effective methods of disposal. Moreover, it is feasible alternative for utilization of treated effluent; as the same generates revenue thus offsetting the costs and further leading to reduction in pay back period.

Conclusion:

Like India, production of chemical fertilizers is still insufficient to meet the demand. This leads to intake of chemical fertilizers on a large scale. Biocompost has a beneficial role to play. It is a viable process of controlling the distillery effluent load without any huge investment, and thus, can reduce the pollution load to the stream. Besides, it is a better substitute to chemical fertilizers. As it promotes healthy agricultural products. The agro products with use of Biocompost are usually disease free. It is, therefore, concluded that biocomposting of organic matter, including distillery waste should be given its due importance. A movement by the government and non-governmental agencies through awareness training programme, workshops, etc. should be' organized for farmers, so that the existing biocomposting efforts may get a quantum leap and it may prove to be a viable alternative to chemical fertilizers.

One of the most important environmental problems faced by the world is management of wastes. Now-a-days emphasis is laid on waste minimization and revenue generation through byproduct recovery. Pollution prevention focuses on preventing the generation of wastes, while waste minimization refers to reducing the volume or toxicity of hazardous wastes by water recycling and reuse, and process modifications and the byproduct recovery as a fall out of manufacturing process, creates ample scope for revenue generation thereby offsetting the costs substantially.

The cost of effluent treatment in distilleries is likely to be compensated substantially by availability of methane gas. Effluent application will reduce the nutrient requirement through fertilisers. However, high salt load, mainly potassium and sulphur, into the soil system may hamper the sustained crop yields due to continued long-term application of effluents. Therefore the effect on crop productivity has to be visualized on long-term and sustainable basis. Application of post methanation effluent suitably diluted according to crop requirements and soil conditions seems to be viable alternative. If all the distilleries present in India resort to biomethanation, then approximately 2.0 million cubic meters of biogas shall be generated per day, with a calorific value of approximately 5000 kcal/m. This is equivalent to saving of 2240 tonnes of coal per day, in turn avoiding CO of about 3100 tonnes per day.

The present study coupled with the corresponding techno market survey has been aimed at reviewing the existing technological status of treatment and disposal of distillery spentwash in our country and comparing with that of the contemporary international technologies, thus identifying the gaps in the technologies and suggesting an action plan for overcoming these. It will help to control the pollution created by the distillery wastewaters and also enable to derive by-products which are commercially beneficial.

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