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Research Article

STUDY OF PHYSIO-CHEMICAL CHARACTERISTICS AND BIOLOGICAL TREATMENT OF MOLASSES-BASED DISTILLERY EFFLUENT

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Abstract: Molasses based distilleries are recognized as of major polluting industries with a large amount of annual effluent production. Modi Distillery, located at Modi Nagar in western Uttar Pradesh, is a molasses-based distillery with a capacity of 26 KLPD. Being an alcohol-processing unit, we estimated capacity and efficiency of Modi distillery that discharges highly polluted effluent to small drainage with a very high biological oxygen demand (BOD) (42,000-51,000mg/ltr) and chemical oxygen demand (COD) (85,000-1,00,000mg/ltr) levels. Analysis of physio-chemical properties of distillery effluent showed higher temperature and proportion of dissolved organic and inorganic compounds. Presence of oxidized dissolved solids and acids lowered pH of effluent and increased toxicity. We measured quality of effluent as per standard recommendations. Investigation of water consumption in different processes of distillery and detailed evaluation of characteristics of effluent generated from above processes was analyzed. Towards management of polluted byproduct, we treated distillery effluent with bacterial consortium of *Pseudomonas grimonti*, *Bacillus sp.* MH-I6 and *Staphylococcus sp*. CSA strain. Treated effluent showed a significant decrease in BOD (76%) and COD (62%) levels. Present study represented an account of physio-chemical characteristics of discharges effluent from sugarcane molasses-based Modi distillery and its biological treatment towards optimization of effective management of distillery byproduct.

Keywords: Molasses, Effluent, Modi Distillery, Physio-Chemical Analysis.

INTRODUCTION

India has the second largest network of molasses-based distilleries in Asia with an estimated annual production of about 2300 million liters of alcohol (Subramanian *et al.*, 2005). Distilleries produce enormous amount of effluent that further makes management of water-pollution complicated (AIDA, 1994). As of 2004 survey, India has 319 distillery units, having an estimated production of $3.25x10^9$ L of alcohol and generating $40.4x10^{10}$ L of wastewater annually (Uppal, J., 2004). Production of one liter of alcohol generates approximately 10-15 liters of effluent that made it one of the most water polluting industries (Y. Satyawali and M. Balakrishnan, 2008).

Modi distillery, located at Modi Nagar (Coordinates-28°49'39"N 77°34'6"E), is a molasses-based modern alcohol-processing unit in sugarcane producing area of western Uttar Pradesh. Modi distillery has acquired a capacity of 26 KLPD towards meeting greater amount of alcohol production (UP Excise Dept. -4843KL). In 2010 survey, conducted by UP Pollution Control Board of grossly polluting industries in Utter Pradesh, it has been estimated that BOD levels of anaerobically treated distillery effluent from Modi Distillery to small drainage that further leads to recipient river viz. Kali East (located at a 0.05 KM distance from distillery) reached to 6800Kg/D (UPPCB, 2010). Distillery effluent has been characterized by its dark brown color, high temperature, very low pH and high percentage of dissolved inorganic and organic matter. Molasses-containing distillery effluent's dark color obstructs photosynthesis and causes adverse effect on aquatic life (FitzGibbon *et al.*, 1998). In present report, we investigated an account of capacity and efficiency of Modi distillery. Analysis of physio-chemical characteristics of molasses-based effluent provided readout of discharged water pollutant. Detailed analysis of input water consumption and investigation of its utilization in several downstream processes was also explored.

Effluent from molasses-based distilleries leads to the high risk of environmental pollution in the sugarcane producing area of western Uttar-Pradesh. Increasingly stringent environmental regulations are enforcing sugarcane industries to investigate alternative methods of molasses processing (Uppal J., 2004). A number of physical, chemical and substitute treatment methods have been performed, though these methods largely altered form of effluent rather than decomposing pollutant. In order to optimize bio-treatment of distillery effluent, we performed biological treatment by using bacterial consortium of *Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* strains and observed significant reduction in BOD and COD levels. Present study is an attempt to evaluate different processes in molasses-

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based distillery and profile of physio-chemical characteristics of discharges effluent from Modi distiller and further, potential of bacterial consortium for effluent treatment was analyzed.

MATERIAL AND METHODS

Physio-chemical analysis:

Detailed analysis of process and parameters of water usage in Modi distillery was conducted by the research staff committee by Dept. of Biotech, MM (PG) Modinagar. Present investigation was limited to Modi distillery, located Modinagar, near Delhi. The physio-chemical characteristics of water were examined in the laboratory following standard methods (APHA, 1989). Details of the volumes of consumed water and effluent generated in the process was investigated during real-time processing in distillery.

Treatment with bacterial consortium:

Bacteria's *viz. Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* were provided by microbial culture collection, maintained by Dept. of Biotech, MM (PG) Modinagar. In brief, a procedure of effluent collection and treatment with bacterial consortium was as followed; subsequent to the optimization of process parameters for the different strains of the consortium, treatment of the distillery effluent was carried out in batch manner. Bacterial consortium was taken in Erlenmeyer flasks containing 15% distillery effluent supplemented with MSM and carbon and nitrogen sources. Upon optimization of growth process parameters *viz.* carbon nitrogen ratio, pH, temperature, agitation, duration and inoculum were further optimized. The BOD and COD levels of the treated effluent were measured as described in standard methods (APHA, 1989).

RESULTS

Modi distillery with capacity of 26 KLPD consumed large amount of molasses and water (900 quintal and 823.6 kL/Day respectively) that produced 14kL/Day potable alcohol (Table.1). Total four batch fermenters led to production of 9kL/Day rectified spirit. End product of such input material produced large amount of wastewater molasses effluent that was subjected to UASBR reactor based anaerobic treatment.

Physio-chemical properties of wastewater generated from Modi distillery showed that effluent generated in processing is acidic in nature, comprise a high BOD and COD value and having dark brown color and brunt glucose odor (Table.2). Physio-chemical characteristics of wastewater generated from Modi distillery found higher as per Indian Standard (I.S.) recommendations. Characteristics of Modi distillery effluent were compared with Mahimairaja and Bolan (2004) towards affirming its physio-chemical properties.

Table.1: Details of capacity and efficiency of Modi distillery

Location	**Modi Nagar, Utter Pradesh**
Total production capacity (kL/day)	26
Potable alcohol (kL/day)	14
Rectified spirit (kL/day)	9
Molasses consumption (quintal)	900
molasses concentration for fermentation (Brix)	24-32
Total water consumption (kL/day)	823.6
Number of fermenters	4
Fermenter type	Batch
Effluent treatment	
Reactor	UASBR

UASBR: Up flow anaerobic sludge attached growth

Table.2: Physio-chemical characteristics of wastewater generated from Modi distillery

Characteristics	**Physio-chemical analysis**	**I.S. -Maximum requirements**	**Mahimairaja and Bolan (2004)**
Color	Dark Brown	Colorless	Dark Brown
pH	3.1 - 4.7	5.5 - 9.0	3.9-4.3
COD(mg/l)	85,000-1,00,000	250	104,000 - 134,000
BOD(mg/l)	42,000-51,000	200 - 500	46,000 - 96,000
COD/BOD ratio	1.98	-	1.81
Odor	Burnt Gelatin/Glucose	-	-
Temperature	85 - 95^{o}C	40 ^{o}C	-
Reducing Sugar (%)	1.16	-	-
Total solids (mg/l)	70,000 - 95,0000	2100	30,000 - 1,00,000
Total suspended solids(mg/l)	2500 - 5000	100	350
Total dissolved solids(mg/l)	9,000 - 21,000	-	80,000
Total nitrogen(mg/l)	800 - 1200	-	1000 - 2000
Total phosphorous(mg/l)	180 - 350	-	800 – 1200
Potassium (mg/l)	6,000 - 12,000	-	8000 – 12000
Sulphate	4,500 - 7,200	1000	2000 - 6000
Ash (mg/ml)	1-3%	-	-

In order to evaluate total discharged effluent, levels of water consumption in different purpose were examined at initial step. Inoculum preparation, boiling and cooling were found to be the processes required enormous amount of water (280, 112 & 210kL/Day respectively) (Table.3). Consumption of water for these purpose suggested generation of huge quantity of polluted processed water in Modi distillery. Towards the examination of properties of input water during these processes, several changes in physio-chemical characteristics were observed in input, demineralized and spent wash samples (Table. 4). Demineralization process led to the increase in dissolved solid concentration and of COD levels (7.4g/L and 920mg/L respectively) and lowered pH of processed water. Cooling process enhanced these levels further (11.4g/L and 2300mg/L respectively). Produced spent wash contained higher temperature, COD, physio-chemical values and acidic pH value. Processing of spent wash water led to significantly higher COD levels and an

increase in the concentration of total solids, dissolved and suspended solids. Such characteristics of spent wash were considered as major source of water population in Kali East River.

Table.3: Details of consumption of water in Modi distillery

Purpose	Utilization (kL/Day)
Molasses dilution	2.1
Input inoculum preparation	280
Washing (Fermenter)	12
Boiler	112
Condensation (Cooling water)	210
Packaging (washing)	18
Alcohol preparation (potable)	9

Towards treatment of Modi distillery spent wash, a bacterial consortium of *Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* used. These strains were collected from molasses sediment samples, isolated from the molasses by serial dilution and screened based on their pollutant degrading and BOD & COD reduction potential. *Pseudomonas grimonti* found capable of lowering BOD levels of the distillery effluent by 52% (24 hrs), *Bacillus sp. MH-16* by 52% (12 hrs) and *Staphylococcus sp. CSA* by 56% (12 hrs). In order to supplement spent wash with alternative carbon source, 1% w/v glucose was provided with 15% spent wash. Combined use of *Pseudomonas grimonti*, *Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* resulted in 62% and 76% reduction in COD and BOD levels respectively (Table. 5).

Table.4: Characteristics of wastewater in different distillery processes

Processes	Total solids (g/L)	Total suspended solids (g/L)	Dissolved solids (g/L)	pH	Temperature (°C)	COD level (mg/L)
Input (Fresh water)	10.4	1.2	6.2	7.9	15 - 40	504
Processed (demineralized) water	8.2	0.2	7.4	5.6	-	920
Condensation (Cooling water)	7.6	0.5	11.4	7.3	-	2300
Waste water (Spent wash)	72.4	15.6	34	3.6	85-95	2,40,200

DISCUSSION

Modi Distillery consumes enormous amount of water in its several processes and produces spent wash of high COD/BOD levels. With present capacity of 4842kL, plant discharges a large amount of effluent to Kali East. We investigated different process consuming fresh water and examined physio-chemical characteristics of processed water at several steps. It suggested the scope of water utilization in Modi distillery through refined measures and reuse. Optimization of water usage at cooling tower, reuse separated wastewater watercourses and switching batch to modern continuous fermentation process can be considered as few steps to reduce water consumption in the distillery. Treatment of bacterial consortium of *Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* to distillery effluent showed 76% and 62% reduction in BOD and COD levels. Degradation potential of Pseudomonas in polluted water habitats has been reported earlier which has shown that *Pseudomonas fluorescens* is capable of decolorizing of distillery effluent (Dahiya *et al.* 2001). *In situ* degradation of water pollutant with bacterial consortium has been considered significant approach towards bioremediation (Glazer *et al,.* 1995).

Table.5: Details of physio-chemical characteristics of distillery effluent after treatment with *Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* bacterial consortium

Physio-chemical properties	Wastewater characteristics after treatment with bacterial consortium
pH	7.2-8.4
BOD (mg/l)	10800
COD (mg/l)	29760
Temperature	32-38°C
Total solids (mg/l)	-
Total suspended solids(mg/l)	0.7 - 1.2
Total dissolved solids(mg/l)	-
Potassium (mg/l)	1500-2200
Sulphate	1200-2300
Sodium (mg/l)	300-400
Ash (mg/ml)	-
Oil and greases	-

CONCLUSION

Present study investigated an account of different process of water consumption and analyzed physio-chemical characteristics of water processed in several practices in Modi distillery. Through physio-chemical analysis, we demonstrated levels of several pollutants in distillery effluent and further shown that treatment of distillery effluent with *Pseudomonas grimonti, Bacillus sp. MH-I6* and *Staphylococcus sp. CSA* bacterial consortium leads to significant reduction in BOD and COD levels.

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