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Pre-Treatment of Sugar (Distillery) Waste Water By using Hydrodynamic Cavitation Process

Rutik Malvade[1], Sagar Shirsath[1], Ankita Bhowate[1] and Dr. S. B. Magar[2]

1 UG Student of Department of Chemical Engineering and 2 Prof. of Department of Chemical Engineering, Pravara Engineering College, Loni, Ahmednagar - 413736.

Abstract

Sugarcane distillery waste water have very high Chemical Oxygen Demand (COD) and these effluents are environmental hazards. For production of 1 liter alcohol (ethanol) around 8 – 15 liter of spent wash generated. Pre-treatment by using hydrodynamic cavitation formation and collapse of micro bubble with venturi as a cavitating device. Hydrodynamic cavitation processes the intensity of collapsing bubbles depends on the operating parameter such as pressure. HC carried out at different pressure and checking the waste water characteristics such as Biological oxygen demand, Chemical oxygen demand, Total organic carbon, Color and Biodegradability Index etc. Pre-treatment using Hydrodynamic Cavitation can be effectively utilized for enhancing the biodegradability of B-DWW along with reduction of COD and increase the yield of methane production from B-DWW. Experimental analysis the effect of pre-treatment of Hydrodynamic Cavitation on B-DWW at various contact time from 50-150 min, at different pressure 5-13 bars, with different dilutions 25-50 % for % COD reduction, for increase in B.I. for increase the yield of methane gas from biomethanated waste water (B-DWW). Pre-treatment of H.C. decrease the particle size, increase pumpability, increase B.I., and also reduce COD from B-DWW. The Optimum parameter for H.C. pre-treatment pressure 5 bar, Contact Time 50 min without dilution. The biodegradability index increases with increase in the dilution of B-DWW and also increases with increase in the pressure of cavitation process. It's clear that the % COD reduction increase with increase in the dilution of B-DWW. The % reduction COD reduction also increase with increase in time of cavitation process. These values can be change by changing the conditions.

Keywords - Pre-treatment (Sugar) Distillery Waste Water, Hydrodynamic Cavitation, B-DWW, COD, TOC, B.I.

Introduction

In India Sugarcane industry (Distilleries) are one of the most polluting industries which generating large volumes of high strength wastewater. Waste water produced from distillery containing highly color, COD, BOD, TDS and other organic matter. In India for alcohol production Sugarcane molasses is most useful which is byproduct of sugar industry contains 50 % fermentable sugar. During fermentation of molasses 8 -10L of spent wash generated per liter ethanol production. Distillery spent wash contains melanoidin having high molecular weight nitrogenous brown polymer form by Millard reaction between the amino acid and sugar. Characteristic of waste water (Spent wash) generated from the distillery industry is depending up on the quality of molasses and fermentation process indirectly culture used for fermentation process. Properties of Spent wash (Waste Water) produced from distillery

1. Highly acidic
2. Strong odor
3. Metal sulfides and phenolics
4. Dark brown color
5. High COD, BOD and TDS

Environmental Hazards of Distillery Wastewater

1. Waste water from distillery has very high BOD and COD.

2. High BOD/COD ratio.

3. Large amount of inorganic substances (Nitrogen, Potassium, Phosphates, Calcium)

4. Spent wash disposal in environment is hazardous and has high pollution potential.

5. Distillery effluent toxic effect on common guppy.

6. It also impact of distillery effluent on carbohydrate metabolism of fresh water fish.

7. Distillery effluent disposed on land is equally hazardous to the vegetation.

8. Spent wash also inhibit seed germination, cause soil manganese deficiency

9. Distillery effluent caused damage agricultural crops.

Hydrodynamic Cavitation

Produced by pressure variation in a flowing liquid caused by the velocity variation in the system by changing the flow geometry of the flow system. Hydrodynamic cavitation is a promising application in wastewater treatment due to its simple reactor design and capacity in large-scale operation.

Advantages of Hydrodynamic Cavitation

1. HC capability to oxidize organic substances.

2. HC is efficient to oxidize organic substances such as volatile organic compounds

3. Less operation costs based on energy efficiency.

4. Hydrodynamic cavitation is much more energy efficient.

5. Less time consumption comparing other process

6. Parameters to be controlled such as PH, TOC, COD, BOD

7. Size of unit is small so required space low.

8. Hydrodynamic is continuous in manner.

9. HC equipment's scale-up ratio required are low

Applications of Hydrodynamic Cavitation

1. Waste water treatment

2. Water disinfection

3. Biological cell disruptions

4. Hydrolysis of fatty oils

5. Hydrodynamic cavitation equipment's scale-up ratio required are low

6. Pulp and paper digestion

7. Preparation of nano particle

Literature Reviews

In 2008 studied by Chainable et al., the values of COD and TOC that at 50% dilution has significant effect on the mineralization of distillery wastewater. Reduction of COD is higher at 50% dilution and the total quantum of COD and TOC reduction is lower at 25% and 50% dilution as compared to undiluted wastewater. Experiment shows that by using HC the percentage reduction of COD and TOC with an increase in the inlet pressure 34% reduction in COD and 33% reduction in TOC were obtained at 13 bar pressure as compared to 32% and 31% respectively at 5 bar inlet pressure. [3] **Hydrodynamic cavitation process not only reduce the COD and TOC but also decreasing the color of distillery wastewater**. For undiluted distillery wastewater a maximum 33% color, for 25% to 50% diluted distillery wastewater color reduction 40% to 47% respectively. At pressure of 2.5 bar is significant for the reduction of COD and TOC as well as the 6.5 bar pressure is significant for the increasing B.I. HC treatment can be efficiently and effectively carried out for increasing the biodegradability of composite wastewater with decreasing toxicity, color, COD and TOC. Treatment of waste water at pressure of 2.5 bar the reduction of COD becomes 17% and reduction of TOC becomes 18 %. The considerable reduction of COD and TOC occurs at initial 50 min which is optimum treatment time for the reduction of COD and TOC. [5]. **Waste water quality are mostly expressed in terms of number and nature of pollutants Chemical Oxygen Demand (COD) and desired level of reduction in these** pollutants dictates the selection of process. Degradation of pesticide effluent has been investigated using Hydrodynamic Cavitation process. The effect of Cavitation was examined for the different time intervals from 0 to 150 mins. maximum COD removal achieved was 90.55% and color removal achieved was 83.21% in 75 mins. The Reduction of TDS was observed by 79.77% and TSS reduction by 84.00% in 75 mins. With hydrodynamic Cavitation maximum COD removal achieved was 90.55% in 75 mins also it is observed that between 60- 150mins the removal efficiency is same. [11]. **Experimental analysis shows that pretreatment of (Biomethanated Distillery Waste Water) biomass using Hydrodynamic** cavitation shows the results removal of the COD 60 %, 65%, 70%, 75% for time of cavitation 5, 10, 15, 20 min resp. Results shows HC can adopted as pretreatment for various types of biomass for reduction of COD and increase B.I. which increase the yield of the methane gas production. [1]

MATERIAL AND METHODOLOGY

Characteristics of B-DWW Waste Water (Molasses Spent Wash)

Parameter	Value
pH	4 - 4.5
TDS	65000-100000 mg/l
COD	80000-125000 mg/l
BOD	40000-50000 mg/l

Characteristics of Sugar (Distillery) Industry

Venturi Setup for HC

A single whole venturi and multiple holes on venturi plate or a combination of venture arranged in a sequential manner. The reactor will consist of a closed loop circuit comprising of a holding tank a centrifugal pump controls valve and flanges to accommodate the cavitation's chamber. Pump is connected to the bottom of the tank and discharge from the pump branches into two lines which help in control of the inlet pressure and the inlet flow rate into the main line. In the venturi liquid flow at high velocity entering the tank ensures uniform mixing of the tank contents due to the intense circulation currents generated in the tank.

Experimental Setup

Specifications / Operating condition of Hydrodynamic Reactor

1. Pipe size- ½ inch.
2. Regulating valves –3 in numbers.
3. Feed Tank size – 10 liters.
4. Pump capacity – 150 LPM.
5. Number of orifice plate-1 number.
6. Number of venturi -1 in number.

4. EXPERIMENTAL ANALYSIS

Operating Process

1. Take 10 liters of waste water in to the tank collected from Distillery Spent wash of sugar industry.
2. Installed the venturi plate or orifice meter in union joint as shown in figure.
3. Start the pump to regulate the flow of waste water in the reactor.
4. Circulate the Biomethanated waste water in the rector for 10 - 15 minutes.
5. For operation open the value connected to Orifice or Venturi.
6. The cavitation process carried out 25 - 150 mins and at pressure 5 - 13 bars.
7. Analyzed the various parameters of Biomethanated waste water like COD and B.I.
8. Follow the same procedure for No dilution, 25 % Dilution and 50 % Dilution of Biomethanated waste water by using distilled water.

Result and Discussions

Observations

The B-DWW was subjected to HC pretreatment for which 10 L of Biomethanated wastewater was treated in cavitation reactor and the cavitation was achieved using a circular venturi. Pretreatment process for B-DWW are carried out in lab-based model were conducted at different inlet pressure 5, 13 bar and at different dilutions 25%, 50% of the biomethanated distillery wastewater in the time range of 25-150 minutes. After time of interval 25, 50, 75, 100, 125 and 150 mins the samples were withdrawn from the reactor through a sampling port, centrifuged and analyzed for pH, COD, BOD and B.I. as per the standard procedures as given in above.

Effect of Inlet Pressure on COD of B-DWW

Table shows the effect of HC process on % reduction in COD for the B-DWW at different intervals of time

25, 50, 75, 100, 125 and 150 mins at different pressure of 5 bar and 13 bar. As per table it's clear that the % reduction COD reduction increase slightly with increase in the pressure of cavitation process. The % reduction COD reduction also increase with increase in time of cavitation.

Sr No.	Time in Min	% COD Reduction (5 Bar)	% COD Reduction (13 Bar)
01	25	20	22
02	50	28	30
03	75	29	31
04	100	30	32
05	125	31	33
06	150	32	35

Effect of Dilution on COD of B-DWW

Effect of Different Dilution on COD of B-DWW

Sr No.	Time in Min	% COD Reduction (At NO Dilution)	% COD Reduction (At 25% Dilution)	% COD Reduction (At 50% Dilution)
01	25	15	20	27
02	50	24	27	35
03	75	26	29	38
04	100	28	31	40
05	125	30	33	42
06	150	32	35	45

Effect of Dilution on COD of B-DWW

Table 6.2 shows the effect of HC process on % reduction in COD for the B-DWW at different intervals of time 25, 50, 75, 100, 125 and 150 mins at different dilutions 25 % and 50 %. As per table it's clear that the % reduction COD reduction increase with increase in the dilution of B-DWW. The % reduction COD reduction also increase with increase in time of cavitation process.

Effect of Pressure and dilution on B.I. of B-DWW at 5 bar Pressure

Sr. No.	Time in Min	Biodegradability Index (At 5 bar and NO Dilution)	Biodegradability Index (At 5 bar and 25% Dilution)
01	25	0.19	0.20
02	50	0.20	0.22
03	75	0.20	0.22
04	100	0.21	0.23
05	125	0.22	0.24
06	150	0.22	0.24

Effect of dilution on B.I. of B-DWW at 5 bar Pressure

Table shows the effect of HC process on biodegradability index for the B-DWW at different intervals of time 25, 50, 75, 100, 125 and 150 mins at different dilutions 25 % with pressure of 5 bar. As per table it's clear that the biodegradability index increases with increase in the dilution of B-DWW. The biodegradability index also increases with increase in the pressure of cavitation process.

Effect of Pressure and dilution on B.I. of B-DWW at 13 bar Pressure

Sr. No.	Time in Min	Biodegradability Index (At 13 bar and NO Dilution)	Biodegradability Index (At 13 bar and 25% Dilution)
01	25	0.25	0.26
02	50	0.26	0.27
03	75	0.27	0.28
04	100	0.28	0.29
05	125	0.29	0.30
06	150	0.29	0.30

Effect of dilution on B.I. of B-DWW at 13 bar Pressure

Table shows the effect of HC process on biodegradability index for the B-DWW at different intervals of time 25, 50, 75, 100, 125 and 150 mins at different dilutions 25 % with pressure of 13 bar. As per table it's clear that the biodegradability index increases with increase in the dilution of B-DWW. The biodegradability index also increases with increase in the pressure of cavitation process. There is no much difference in no dilutions and 25 % dilutions on B. I. of B-DWW. This also for pressure 5 and 13 bar. So, we can choose the condition for the H. C. process without dilution and at pressure value of 5 bar with cavitation time 50 min.

CONCLUSION

The effect of pre-treatment of Hydrodynamic Cavitation on B-DWW at various contact time from 50-150 min, at different pressure 5-13 bars, with different dilutions 25-50 % for % COD reduction, for increase in B.I. from biomethanated waste water (B-DWW). The effect of pressure, contact time and dilution on % COD reduction, B.I. Effect of pre-treatment of HC process on biodegradability index of B-DWW at different intervals of time 50-150 mins, at different dilutions 25 % with pressure of 5-13 bar. The biodegradability index increases with increase in the dilution of B-DWW and also increases with increase in the pressure of cavitation process. There is no much variation in the B.I. at time 50 min to 150 min and different dilutions and that also shows the no much variations for B.I. at pressure value 5 and 13 bars. Hence, the optimum value for the B.I. 50 min without dilution at pressure value 5 bar. Effect of Dilution of B-DWW on % COD reduction at different intervals of time 50-150 mins at different dilutions 25 % and 50 %.

It's clear that the % COD reduction increase with increase in the dilution of B-DWW. The % reduction COD reduction also increase with increase in time of cavitation process. As per experimental analysis shows the optimum value for the dilutions will be 25-50 %. The effect of inlet Pressure on % reduction in COD for the B-DWW at different intervals of time 50-150 mins at different pressure of 5 bar and 13 bar. It's clear that the % reduction COD reduction increase slightly with increase in the pressure of cavitation process. The % reduction COD reduction also increase with slightly increase in time of cavitation process. The maximum % COD reduction 32-35 at pressure value 5-13 bar. The optimum value for the pressure will be 5 bar because there is no much variation of values of % COD reduction at different pressure values. As per calculation values of % COD Reduction 28, 30 and 32 % at 5 Bar Pressure and that of at 13 bar Pressure 30, 32 and 35 % with treatment time 50, 100 and 150 mins by Hydrodynamic Cavitation Process.

FUTURE SCOPE AND BENEFITS

Benefits of Pretreatment of B-DWW by using HC process

1. Reduction of organic material size.

2. Reduction of the digested viscosity.

3. Resulting easiness of internal digester mixing.

4. Increase of the digestate homogeneity and better pumpability.

5. H.C. reduce the pumping cost and also reduce the time of operation.

Future Scope

1. Cavitation method can be adopted to treat waste water.
2. To improve the effectiveness of cavitation a series of venturi meter or orifice meter can be connected that can be gives the better results.
3. To improve pH value other substance can be added with it.
4. To improve the efficiency of conventional method cavitation method can be use.
5. By using cavitation method, we can treat the any types of waste water.
6. HC can increase the fermentation by increasing the biodegradability index.

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