# TREATMENT OF PHARMACEUTICAL (HERBAL EXTRACT UNIT) WASTE WATER BY ZERO LIQUID DISCHARGE PROCESS USING MEMBRANE TECHNOLOGY

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**ABSTRACT:** Biomass is any organic matter wood, crops, seaweed, animal wastes that can be used as an energy source. Biomass is the oldest source of energy after the sun. Biological organic matter derived from living or recently living organisms is called as biomass . The energy contained or stored in biomass is called as the bioenergy.
The hydrodynamic cavitation can be effectively utilized for enhancing the biodegradability of complex wastewater such as B-DWW along with reduced toxicity ( COD / TOC and color). The hydrodynamic cavitation is capable of enhancing the efficiency of reduction of toxicity as well as increase in biogas generation, along with a significantly net higher reduction in COD and color for B-DWW.
The effect of hydrodynamic cavitation at different dilution on COD reduction with different contact time of biomethanated waste water (B-DWW). When increase the contact time, pressure and dilution the rate of Color and COD reduction then increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution.
The hydrodynamic cavitation at different dilution on biodegradability index variation with different contact time of biomethanated waste water (B-DWW). As increase in contact time, pressure and dilution the biodegradability index increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution.

***Keywords: Pretreatment of biomass, hydrodynamic cavitation, B-DWW Waste Water Treatment.***

## I.INTRODUCTION

Biological organic matter derived from living or recently living organisms is called as biomass. The energy contained or stored in biomass is called as the bioenergy. Biomass is any organic matter wood, crops, seaweed, animal wastes that can be used as an energy source. Biomass is our oldest source of energy after the sun. From lots of years people have burned wood to heat their homes and cook their food.

### 1.1 Benefits of the use of Biomass

1. Reduction of green-house effect
2. Saving of fossil fuels
3. Reduction of costs of heat and electricity production
4. Reduction pollution produce by fossil fuels

### 1.2 Lignocellulosic Biomass (LCB)

LCB is the most readily bioresource amounting to about a global yield of up to 1. 3 billion tons per year. LCB hydrolysis results in the release of various reducing sugars which are highly valued in the production of biofuels such as bioethanol and biogas various organic acids, phenols, and aldehydes. LCB is combination of cellulose, hemicellulose, and lignin which are strongly associated with each other by covalent and hydrogen bonds thus forming a highly recalcitrant structure.

### 1.3 Hydrodynamic Cavitation

HC is the one of alternative techniques for the generation of cavitation's is the use of hydraulic devices where cavitation is generated by the passage of the liquid through a constriction such as valve, venturi plate, venturi etc.

### 1.3.1 Generation of Hydrodynamic Cavitation

HC can be generated by the passage of the liquid and liquid should pass through a constriction such as venturi plate, orifice plate, venture or throttling valve. In the HC process when the liquid passes through the constriction kinetic energy or velocity of the liquid increases at the expense of the local pressure at the constriction.

### 1.3.2 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

Mixing and uniform dispersion

**Pretreated biomass by using hydrodynamic cavitation was more efficient** than untreated biomass its increased methane production by about 30% for 5 min of contact time. As increase in composition of lignocellulose biomass, different plant species can be less or more susceptible to disintegration. **Combined HC with the alkaline improve** pretreatment of reed bagasse observed a high digestibility yield of 85% which was higher than that observed in the untreated sample by about 70%. In the results of the hydrodynamic cavitation on biomass disintegration involve the equipment used, the parameters of pretreatment and the structure of the lignocellulosic biomass higher removal and yield . [1].**Before alcoholic fermentation the Hydrodynamic Cavitation process** was mainly used for the removal of toxic substances and biomass disintegration . Some of the studies shows the investigated the effect of cavitation of lignocellulose biomass on methane fermentation. By the comparative study showed that performance of alkali biomass pretreatment in HC reactor with an orifice plate was better in terms of energy requirement, lignin reduction and bioethanol yield than ultrasound cavitation method.**With the pretreatment using hydrodynamic cavitation** did not change the chemical composition of the lignocellulose biomass but it increased its digestibility which was proven by the higher methane production from the substrate disintegrated for 5 min than that from the control sample. **Rapid hydrolysis rate and digestibility with HC treated** sample exhibited a compared to ultrasound and the fermentation an ethanol yield by 90% was achieved. HC and NaOH as a combined pre-treatment was observed in the methane yield 12.7% more biogas was produced after 20 times of passes.[2] **By Kim et al., 2015, Effect with HC** pretreatment for biofuels production such as ethanol and biogas production is the significant and higher yield. Studied by the Ramirez-cadavid et al. 2013 , investigated a combination with controlled flow cavitation (CFC) and enzymatic cellulose hydrolysis to improve a commercial scale bioethanol production. **HC improved the methane** yield by 9% and increased the kinetic degradation rate constant by 60% and the methane yield by 13% treating fresh food waste despite a kinetic degradation rate constant reduction by 52%. [2]. **HC process capable of reducing the toxicity of distillery** wastewater as well as the pretreatment increases the biodegradability of the B-DWW. The pretreatment with the hydrodynamic cavitation can be effectively utilized for the treatment of complex wastewater such as B-DWW. **By the experimental analysis by Hasashi et al. reported the application of HC** as a novel pretreatment step to enhance biogas production during the co-digestion of oily wastewater and waste-activated sludge while achieving a 30% enhancement in the total biogas production.[3] **By the Saxena et al. reported the efficiency** of the pretreatment method of tannery waste effluent (TWE) by HC before anaerobic digestion (AD) using a slit venturi biogas yield and chemical oxygen demand (COD) reduction were increased 68.57 mL/g of volatile solids with a COD reduction of 43.17% two-fold when HC was used as a pretreatment in 2 L bioreactors with a 10% seed dosage. **By using HC process bioethanol, biogas (methane) has enormous potential to** replace conventional fossil fuels could be effectively synthesized from lignocellulosic biomass and HC could be a suitable pretreatment choice that could reduce the structural hindrance present in lignocellulose biomass for productive digestion. [3] **By the experimental studied by Patil et al. and Maruti et al. HC as the** pretreatment step to enhance biogas yield from wheat straw and agricultural biomass (pig slurry, maize silage, triticale silage, beet molasses, cornmeal) has biogas yield efficiency (172.3 mL/g) indicated the combined HC-based treatment to be better than KOH-mediated alkaline pretreatment. [3]. **In 2008 studied by Chakinala et al. , the values of COD and TOC** that at 50% dilution has significant effect on the mineralization of distillery wastewater. Percentage reduction is marginally higher at 50% dilution, the total quantum (mg of COD/TOC/L) of COD and TOC reduction is lower at 25% and 50% dilution as compared to undiluted wastewater. [6] **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.[6] **By pretreatment with HC undiluted wastewater a maximum of 34% color reduction is observed while for 25% and 50%** concentration of diluted wastewater and maximum color reduction of 41% and 48% are observed respectively. [6] **By the experimental analysis hydrodynamic cavitation studies at optimal inlet pressure of 5 bar indicate that a maximum 36% color** could be removed from undiluted B-DWW at 5 bar operating pressure in 150 minutes of treatment.**The effect of HC on Biodegradability Index ratio of BOD/COD** treatment the increase in the ratio with time is almost constant with a value of 0.22 at 50 min, 0.23 at 100 min and 0.24 at 150 min. At lower pressure of 5 bar with zero dilution the ratio increases to the tune of 0.24 becoming 0.25 when the sample dilution is 25 percent thus dilution is again not aiding in BOD enhancement significantly. [6] **By use of higher pressure of 13 bar the ratio enhances to a value of 0.29 at zero** dilution and is increase to 0.32 at spent wash concentration of 25 percent. At the lower pressure compared with higher pressure yields slightly better BOD/ COD ratio on treatment. [6]. **Biomass pretreatment by using hydrodynamic cavitation process** has gained interest when compared to conventional methods of pretreatment viz., shows the higher removal of lignin, easy accessibility of cellulose for saccharification, less energy consumption, simple geometric configuration. **In the 2017 experimental studied by Zalinski et al., increased** rate and volume of biogas upon AC and HC compared to untreated biomass shows the higher biogas and methane yields were obtained from treated LCB compared to untreated LCB.

**By analysis of Patil et al., in 2016 and by Madison et al., 2017** HC + lime treatment improved enzymatic digestibility and the samples of highest crystallinity corresponded to highest lignin removal. **In 2017 studied by Teran Hilares et al., 90% cellulose and hemicellulose** hydrolysis were observed as compared to untreated LCB < 20 % and Chemical oxygen demand was found to increase with treatment time and rpm. [9].

## II. MATERIAL AND METHODOLOGY

### 2.1 Physical Treatment

Physical pretreatment of LCB is a prerequisite prior to any other pretreatment methods. This treatment is primarily carried out to reduce the particle size that results in the increase in surface area and decrease in degree of polymerization and crystallinity. Physical pretreatment is its high energy consumption that is the main disadvantage of treatment and energy consumption for treatment depends on the type of LCB used**.**

#### 2.1.1 The commonly prevalent physical pretreatment methods

1. Milling
2. Extrusion
3. Microwave treatment
4. Ultrasonication

### 2. 2 Chemical Pretreatment

1. Alkali pretreatment
2. Acid pretreatment
3. Ionic liquids (ILs)
4. Organosolv
5. Deep eutectic solvents (DES)

### 2.3 Physicochemical Process

1. Steam explosion
2.Ammonia Fiber Explosion
3. CO2 Explosion Pretreatment

4. Liquid Hot Water

### 2.4 Biological Pretreatment

Another one most widely used treatment process called biological pretreatment is a low cost and eco-friendly technique to treat LCB prior to enzymatic saccharification. Biological pretreatment process promising as there is no inhibitor formation during the process, requires lesser energy consuming and is eco-friendly. In this process lignin degrading bacteria or fungi, as whole cell or enzymes, are used to pretreat LCB.

For degradation of lignin enzymes are used in dare laccases, lignin peroxidase, manganese peroxidase and versatile peroxidase. The enzyme like fungi are the best suited for such applications as they are capable of degrading cellulose, hemicelluloses, and lignin. This process are not only used for lignin removal but also for removal of specific components such as antimicrobial substances.

#### 2.4.1 Biological treatment as follows

1. Whole cell Pretreatment

2. Enzymatic Pretreatment

3.Laccases (Lac)

4. Manganese peroxidase

## III. EXPERIMENTAL ANALYSIS

### 3.1 Operating Process

Following is the stepwise procedure to operate the reactor.

1. Take 10 liters of Biomethanated waste water in to the tank collected from Distillery (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 waste water in the rector for 15 minutes.
5. For operation open the value connected to Orifice or Venturi.
6. Check samples of waste water for every 30, 60, 90, 120- and 150-min interval.
7. Analyzed the various parameters of waste water like COD, Color and BOD.
8. Follow the same procedure for No dilution, 25 % Dilution and 50% Dilution of waste water by using distilled water.

### 3.2 Characteristics of B-DWW waste water

**Table 3.1 Characteristics of B-DWW**

| Parameter | Value |
|---|---|
| Ph | 3.67 |
| Total Solids | 31000 mg/l |
| Total Dissolved Solids (TDS) | 14,660 mg/l |
| Chemical Oxygen Demand (COD) | 34000 mg/l |
| BOD | 5000 mg/l |
| TOC | 10,000 mg/l |
| BOD5: COD ratio | 0.168 |

### 3.3 Observations

In present work hydrodynamic cavitation (HC) was evaluated as a pretreatment for the complex wastewater such as biomethanated distillery wastewater (B-DWW). The biomethanated distillery wastewater was subjected to HC reactor and the effect of various process parameters were assessed and optimized for maximizing COD/TOC reduction and enhancing biodegradability index ($BOD_{5:}$ COD ratio) of the wastewater. The associated color reduction has also been studied.

### 3.3.1 Hydrodynamic cavitation pretreatment of B-DWW

The B-DWW was subjected to HC pretreatment for which 10 L of 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 30-150 minutes.

After time of interval 30, 60, 90, 120 and 150 mins the samples were withdrawn from the reactor through a sampling port, centrifuged and analyzed for pH, COD, BOD, TOC and Color as per the standard procedures as given in above.

### 3.4 Effect of Different Dilution on COD of B-DWW

**Table No. 3.2 Effect of Different Dilution on COD of B-DWW**

| Time in Min | % COD Reduction (At NO Dilution) | % COD Reduction (At 25% Dilution) | % COD Reduction (At 50% Dilution) |
|---|---|---|---|
| 30 | 10 | 12 | 18 |
| 60 | 15 | 17 | 22 |
| 90 | 20 | 22 | 28 |
| 120 | 25 | 28 | 38 |
| 150 | 30 | 35 | 45 |

Table 3.2 shows the effect of HC process on % reduction in COD for the B-DWW at different intervals of time 30, 60, 90, 120 and 150 mins at different dilutions 25 % and 50 %. As per table its clear that the % reduction COD reduction increase with increase in the dilution of B-DWW. The % reduction COD reduction also increase with increase in the pressure of B-DWW.

### 3.5 Effect of Different Dilution on Color of B-DWW

**Table No. 3.3 Effect of Different Dilution on Color of B-DWW**

| Time in Min | % Color Reduction (At NO Dilution) | % Color Reduction (At 25% Dilution) | % Color Reduction (At 50% Dilution) |
|---|---|---|---|
| 30 | 08 | 14 | 18 |
| 60 | 14 | 20 | 24 |
| 90 | 22 | 25 | 30 |
| 120 | 28 | 32 | 36 |
| 150 | 32 | 40 | 42 |

Table 3.3 shows the effect of HC process on % reduction in Color for the B-DWW at different intervals of time 30, 60, 90, 120 and 150 mins at different dilutions 25 % and 50 %. As per table it’s clear that the % reduction Color reduction increase with increase in the dilution of B-DWW. The % reduction Color reduction also increase with increase in the pressure of B-DWW.

**3.6 Effect of dilution on biodegradability index of B-DWW**

**Table No. 3.4 Effect of dilution on biodegradability index of B-DWW**

| Time in Min | BOD/COD Ratio (At NO Dilution) | BOD/COD Ratio (At 25% Dilution) |
|---|---|---|
| 30 | 0.12 | 0.14 |
| 60 | 0.16 | 0.18 |
| 90 | 0.18 | 0.20 |
| 120 | 0.20 | 0.22 |
| 150 | 0.22 | 0.24 |

Table 3.4 shows the effect of HC process on biodegradability index for the B-DWW at different intervals of time 30, 60, 90, 120 and 150 mins at different dilutions 25 %. As per table it's clear that the biodegradability index increase with increase in the dilution of B-DWW. The biodegradability index also increase with increase in the pressure of B-DWW.

**IV. RESULTS AND DISUSSION**

**4.1 Graph of Effect of Hydrodynamic Cavitation at Different Dilution on COD of Biomethanated Waste Water**

Fig. 4.1 shows the effect of hydrodynamic cavitation at different dilution on COD reduction with different contact time of biomethanated waste water (B-DWW). As the contact time and dilution increase the rate of COD reduction also increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution. Reduction of COD with various time and dilution shows in the fig. Also as the increase in pressure the rate of COD reduction also increase for the B-DWW.

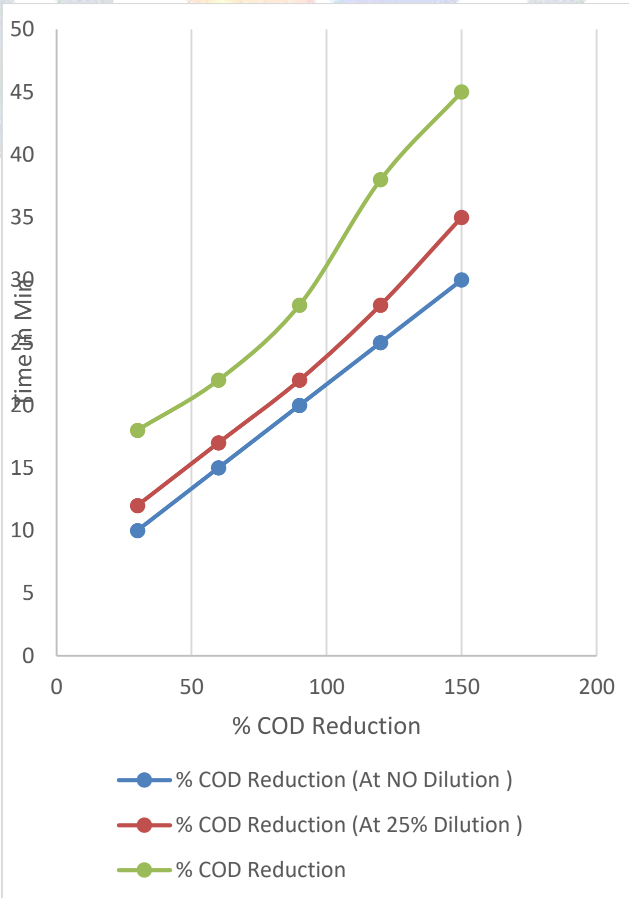


**Fig. 4.1 Effect of HC at Different Dilution on COD of B-DWW**

**4.2 Graph of Effect of Hydrodynamic Cavitation at Different Dilution on Color of Biomethanated Waste Water**

Fig. 4.2 shows the effect of hydrodynamic cavitation at different dilution on color reduction with different contact time of biomethanated waste water (B-DWW). As the contact time and dilution increase the rate of color reduction also increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution. Reduction of color with various time and dilution shows in the fig.

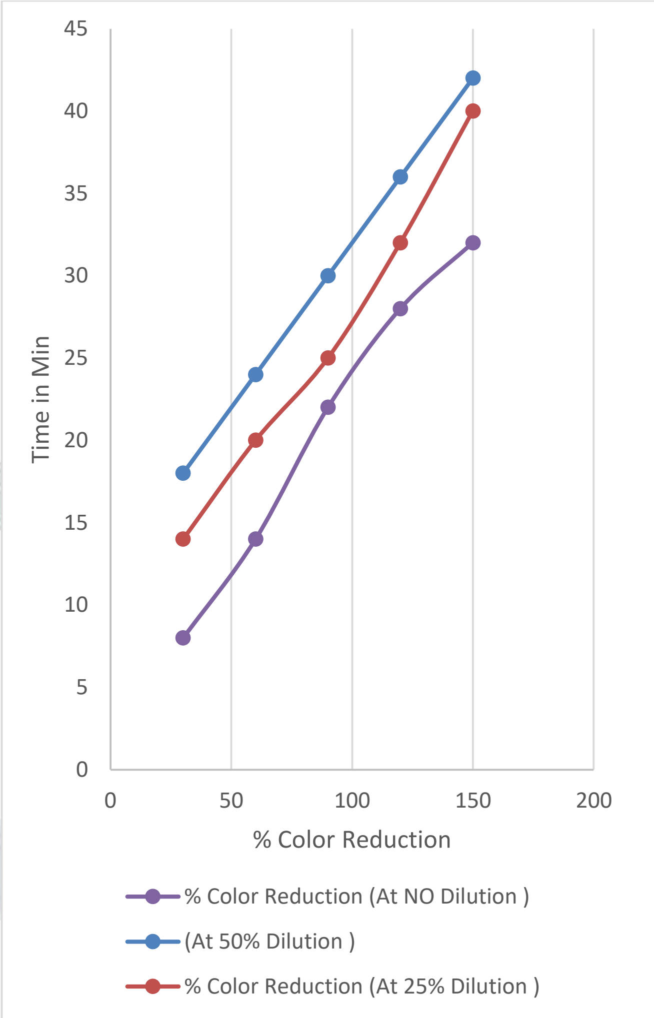


**Fig. 4.2 Effect of HC at Different Dilution on Color of B-DWW**

**4.3 Effect of HC pre-treatment on Biodegradability index of B-DWW**

Fig. 4.3 shows the effect of hydrodynamic cavitation at different dilution on biodegradability index (BOD/COD ratio) with different contact time of biomethanated waste water (B-DWW). As the contact time and dilution increase the rate of biodegradability index (BOD/COD ratio) also increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and NO dilution, 25% dilution. Changes in the biodegradability index (BOD/COD ratio) with various time and dilution shows in the fig.

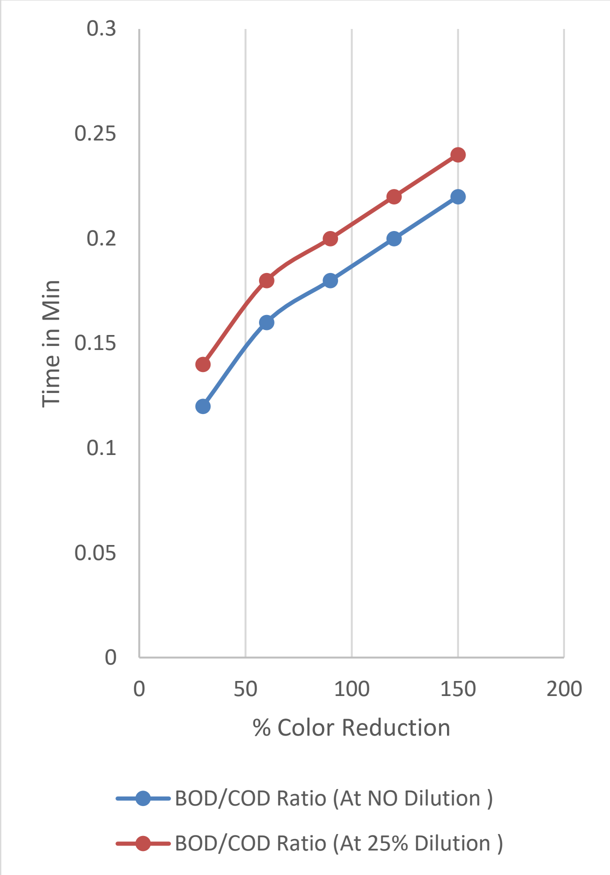


**Fig. 4.3 Effect of cavitation pretreatment on Biodegradability Index**

**4.4 Effect of various parameters on hydrodynamic cavitation**

**1. Effect of Inlet Pressure**

As the pressure increase growth of cavity also increase and also rate of degradation of pollutants. Optimum inlet pressure should be adjusted individually for a specific pollutant. Optimum pressure value of pressure will be 5 – 15 bars.

**2. Effect of Bulk Liquid Temperature**

Temperature of liquid increases liquid properties such as viscosity, surface tension and gas solubility decrease and both the cavitation intensity and the number of cavity nuclei are reduced.

The value of increase in temperature promotes the vapor pressure inside the bubble and leads to cushioning effect making the bubble collapse less violently. Due to this freer radical will also be generated in a cavitation bubble at higher temperature. Rate of degradation increased with increase in the temperature in the range of 30 – 40 oC and decreased when the temperature exceeded 40°c.

**3. Effect of pH**

The rate of pollutant degradation by hydrodynamic cavitation acid condition is recommended in favors the generation of hydroxyl radicals due to the decomposition of hydrogen peroxide and impedes the recombination reaction among free radicals.

The maximum rate of degradation was obtained at an optimum pH of 3. Above cases shows that the alkaline conditions the extent of degradation was much lower than that under acidic conditions.

**4. Effect of Initial Pollutant Concentration**

As value of initial concentration of the pollutant increase will decrease the degradation rate and cavitation conditions keep unchanged the amount of $OH^{.}$ radicals in the system would be constant. As the value of the initial pollutant concentration increase also make more pollutants captured by $HO^{.}$ and the total decomposition amount becomes higher.

**5. Effect of Initial Radius of the Nuclei**

At lower initial size cavities will grow to a larger extent and give rise to more violent collapse and if we decreasing the initial radius will promote the pressure pulse caused by the bubble collapse and enhance the overall effect of hydrodynamic cavitation.

### 6. Effect of Physicochemical Properties of the Liquid

Physicochemical properties such as low liquid vapor pressure, low viscosity and high surface tension cavitation effects are more. As value of vapor pressure increase of will enhance the vapor content inside the cavity. The intensity of bubble collapse decreases due to the cushioning effect caused by the continuous condensation of vapor.

The lower vapor pressure will generate higher cavitation intensity. Increasing the viscosity will raise the threshold pressure of the cavitation event since it has to overcome a stronger natural cohesive force. The better cavitation effect shows those fluids with lower viscosity.

## V. CONCLUSION

The hydrodynamic cavitation can be effectively utilized for enhancing the biodegradability of complex wastewater such as B-DWW along with reduced toxicity (lower COD / TOC and color).

The lower inlet pressure (5 bar) is suitable for the reduction in toxicity of distillery wastewater and higher pressure have no additional benefits on the reduction of toxicity. The higher pressure (13 bar) seems to be effective for enhancement of the biodegradability index and biochemical methane potential.

The hydrodynamic cavitation is capable of enhancing the efficiency of conventional biological processes in terms of reduction of toxicity as well as increase in biogas generation, along with a significantly net higher reduction in COD and color.

We concluded by experimental analysis the effect of hydrodynamic cavitation at different dilution on COD reduction with different contact time of biomethanated waste water (B-DWW). As increase in contact time, pressure and dilution the rate of Color and COD reduction increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution with pressure 5 and 13 bar.

We also concluded by experimental analysis the effect of hydrodynamic cavitation at different dilution on biodegradability index variation with different contact time of biomethanated waste water (B-DWW). As increase in contact time, pressure and dilution the biodegradability index increase for the B-DWW. Experiment carried out between the 30 – 150 mins time and 25, 50% dilution with pressure 5 and 13 bar.

## FUTURE SCOPE AND BENEFITS

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.
3. To improve pH value other substance can be added with it.
4. To improve the efficiency of conventional method, cavitation method can be used as an additional treatment to treat waste water.
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.
7. HC can pretreatment of the various types of biomass.
8. HC can adopted with different convectional method for effective treatment of biomass.
9. HC can use to increase the rate of Bioethanol production by increasing the fermentation rate.
10. HC can be adopted to increase the biogas or methane production.

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**Nomenclature**

AOP - Advanced Oxidation Processes
AFEX - Ammonia Fibber Explosion
B-DWW - Biomethanated Distillery Waste Water
BOD - Biochemical Oxygen Demand
BI - Biodegradability Index (BOD5: COD ratio)
BMP - Biochemical Methane Potential
COD - Chemical Oxygen Demand
DES - Deep Eutectic Solvents