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STUDIES ON OPTIMIZATION OF BIOFUEL MANUFACTURING PROCESS

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Abstract: Bio-ethanol is one of the energy sources that can be produced by renewable sources. Waste water of food industry was chosen as a renewable carbon source for ethanol fermentation because it is relatively inexpensive. However, a pre-treatment process is needed: specifically, liquefaction and saccharification processes are needed to convert starch into fermentable sugars before ethanol fermentation. In this study, hydrolysis of waste potato mash and growth parameters of the ethanol fermentation were optimized to obtain maximum ethanol production. The objective of this study is to assess the feasibility of using a laboratory scale Reverse Osmosis (RO) system for treatment of food industry waste water. These industries use large amounts of water and therefore produce great quantities of liquid waste. The wastewaters from these industries contain high concentrations of organic materials like starch and proteins, and are therefore very prone to fermentation and frothing. Therefore, the potato-processing wastewater is considered as a very good material for the study. Future studies should be the membrane processes appear to be an effective alternative to traditional biochemical wastewater treatments for reducing the environmental impact and improving the efficiency and recovery in the potato processing industry.

Keywords: Bio-ethanol, enzyme hydrolysis, liquefaction, fermentation, Reverse Osmosis

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INTRODUCTION

Ethanol an important biotechnology product in terms of volume and market values is intensely researched and out of many findings, one good finding suggests that Sugar substances like molasses, sugarcane juice and starch based materials like corn, rice and wheat have proved to be promising raw materials for the ethanol production. In India 120 cores litre ethanol is required to achieve 5% blend in petrol or diesel by September 2016. Last year production was 67 cores litre. We can use agricultural waste like wheat straw, Rice Straw, Corn straw etc. For Production of biofuel ethanol plant at Dehradun it has capacity of 15 tons to 20 tons ethanol from agricultural waste.

Looking for a sustainable solution, Indian scientists have developed a new bio-refinery that converts agricultural waste into high value ethanol which can then be blended with petrol to run vehicles. This second generation ethanol is being produced from so called agricultural waste which becomes an asset to the farmer. It helps the contentious issue of climate change and global warming. It helps us to reduce carbon emissions." A typical plant utilises 10 tonnes any kind of agri-waste per day and then using chemicals, enzymes and broth of yeast, the waste is converted into high value alcohol. Annually India produces 300 million tonnes of agricultural waste. "This is a very successful technology and it will take care of all the biomass that is being burnt all over the country and convert it into a value added product." The plant, experts say, generates almost 300 litres of alcohol for every 1000 kilograms of waste. It is also the most efficient technology solution in the world.

Every year India Import 180 million tone crude oil of cost nearly 6 lacks cores for meeting the Requirement of Diesel & Petrol. This is the fast depleting source of energy so we need to conserve this resource by blending it with ethanol & it is permissible up to 20% blending however to reach the 5% blending target around 120 cores litre ethanol is to be produced. However last year production of ethanol was 67 cores.

There are different processes for biofuel manufacturing depending upon row material, Process parameters & reaction involved there is need to undertake detail study on optimization of biofuel manufacturing as the biofuel manufacturing processes involved various steps such as Pre-treatment, actual chemical reaction& downstream processing for separation, concentration and purification of ethanol. The increasing use of membrane technology has been playing important role in process optimization. It is therefore plan to develop and optimize process for biofuel manufacturing using Membrane technology. After critical literature survey and evaluation of various sources of biofuel manufacturing, the industrial waste is decided passed by-products & Waste water from potato processing industry for existing research work for treatment to produce is deed as it is in every city and presently fasces lots of problems of water consumption, pollution control and value addition, the potato chips manufacturing process is as given below.

1. OVERALL PROCESS:-

Wastewaters discharged by industrial operations are in some cases among the worst sources of water resource pollution. Although the nature of the pollutants

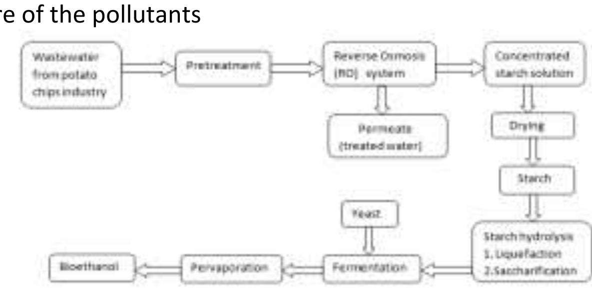

Fig: - Flowchart of overall process

associated with these wastewaters differs greatly from one industry to another, in almost all cases the problems are caused by one or a combination of the following conditions in the wastewater: high Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD), high concentration of suspended solids and / or presence of toxic substances.

Wastewater has been a challenge for the potato processing industry for many years. Potato-processing manufactures produce deep-frozen chipped potatoes, potato crisps, French fries, puree, starch and starch products. The wastewater effluent with high concentration of potassium and chemical oxygen demand (COD) caused by the presence of starch, protein, amino acids and sugars. However this waste effluent contains high amounts of valuable by-products. Starch content of this waste stream that range from 15 to20% is being recovered. Whenever a cut is made in a potato, starch is released. The more cuts that are made, the more starch is released. Advances in membranes technology have showed many advantages for wastewater treatment of food industry. By implementing membranes, the separated substances and clean water are often recoverable in a chemically unchanged form and are therefore easily re-used. Maximum benefits are obtained when one or both the output streams from the membrane system are recycled or re-used, thereby reducing process materials requirement and minimizing waste disposal costs.

The objective of this study is to assess the feasibility of using a laboratory scale Reverse Osmosis (RO) system for treatment of potato-processing wastewater. Potato processing manufactures produce deep-frozen chipped potatoes, potato crisps, French fries, puree, starch and starch products. These industries use large amounts of water and therefore produce great quantities of liquid waste. The wastewaters from these industries contain high concentrations of organic materials like starch and proteins, and are therefore very prone to fermentation and frothing. Therefore, the potato-processing wastewater is considered as a very good material for the study. Future studies should be the membrane processes appear to be an effective alternative to traditional biochemical wastewater treatments for reducing the environmental impact and improving the efficiency and recovery in the potato processing industry.

Membrane Pervaporation System: - 'Polytetrafluoroethylene (PTFE) membrane is used. With the use of pervaporation technique, water from ethanol, can be removed effectively and ethanol concentration & Purification is achieved, this reduces the downstream processing costs.

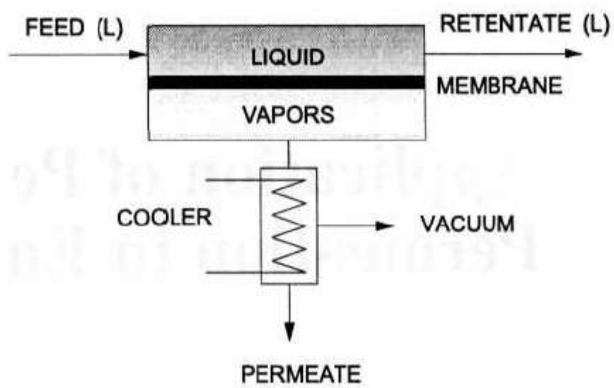

Fig. 1.2 Schematic of Membrane Pervaporation System

Result:

A solution for the recovery of starch in food industry wastewaters resulted at potato washing for chips, snacks or fries production is proposed. The water obtained at washing after peeling and cutting into slices are sent to sedimentation tank (Sedimentation is a physical water treatment process using gravity to remove suspended solids from water) where large amount of starch is settle down this starch is sent for sun drying & we get a starch powder, the remaining water from sedimentation tank is sent to reverse osmosis (Membrane Treatment Process) for further recovery of starch & clean the waste water for reuse for different operation in plant. TDS of the waste water is change from 1110 to 37 after passing through RO system. The waste water from food industry analysed and a large quantity of organic compounds (around 6334 mg $KMnO_4$), starch (1.64%) and protein (0.6%) is found. No pathogenic microorganisms are found.

Bioethanol was produced by *Saccharomyces cerevisiae* from starch obtained from waste water of food Industry. This study was designed to evaluate starch as a medium for bioethanol production, but the hydrolysis of water from food Industry and fermentation parameters were investigated as well. Acid hydrolysis was compared to enzyme hydrolysis to obtain maximum glucose conversion, whereas effect of pH, inoculum sizes and nitrogen sources were evaluated to optimize fermentation of ethanol. Because few studies were conducted on waste water from food Industry, this study provides information about the fermentation conditions of bioethanol from waste water from food Industry by *S. cerevisiae*.

Hydrolysis of Starch

Hydrolysis is a process of breaking down amylopectin and amylose linkages into fermentable sugars and is needed before the fermentation of starchy materials. Starch needs to be hydrolyzed before fermentation. Acid hydrolysis and enzyme hydrolysis were evaluated and compared in production of maximum glucose concentration, which can be utilized later for ethanol fermentation.

1 Acid Hydrolysis

Although pH of Starch solutions was adjusted at pH 5 in the study reported by Fadel (2000), no acid adjustment was needed in this study, because the Starch from waste water were already at acidic pH, in a range of 4.1 – 5.2. After one hour of autoclaving at 121°C, glucose concentrations were measured as 0.011 g/L, 0.014g/L, 0.021 g/L, and 0.026 g/L glucose generated from 5, 10, 15, and 20% (w/v) mixtures, respectively. Even though a linear increase occurred, the highest glucose concentration was still not able to provide enough glucose for fermentation.

Increasing the amount of Starch was not desirable due to an increase in viscosity of slurry which made the agitation more difficult (i.e., more energy intensive). Furthermore, 4.03 g dry weight of Starch/100 ml deionised water (DIW) mixture was determined to be the best combination for enzyme hydrolysis. This was evaluated also for acid hydrolysis. For this case, 16.5 g Starch Powder was dissolved by 100 ml of deionised water, and evaluated for glucose concentration after acid hydrolysis. The average of three replications was 0.0284 g/L glucose which is a low concentration for any fermentation.

2. Enzyme Hydrolysis

The two-step enzymatic hydrolysis of Starch. The maximum glucose concentration obtained for the liquefaction step was 129.12 g/L at time 60 min, α-amylase dose 1% (v/v) and temperature 104 ºC, while the glucose concentration increased to 175.31 g/L at time 60 min, glucoamylase dose 1% (v/v) and temperature 60ºC. The optimized liquefaction and Saccharification conditions were validated with actual glucose concentrations of 129.12 and 175.31 g/L, respectively.

Ethanol Production by using Lab Scale Fermenter:-

1. Effect of pH

Ethanol fermentation was evaluated at two different pH profiles to determine the effect of pH: uncontrolled pH and controlled pH at 5, the cell population and concentrations of glucose and ethanol in the fermentation broth with controlled pH at 5 and uncontrolled pH. The results clearly indicate that a higher growth rate for biomass was obtained with the controlled pH at 5 Furthermore, the maximum ethanol concentration and production rates were 24.1 g/L and 5.92 g/L/h, respectively at controlled pH 5, whereas 19.86 g/L and 1.99 g/L/h were obtained at uncontrolled pH

2. Effect of Inoculum Sizes on Ethanol Production

Five different inoculum sizes (1%, 2%, 3%, 4% and 5% (v/v)) were investigated to determine the effect of inoculum size on kinetic parameters of ethanol fermentation from Starch. The ethanol production (g/L), glucose consumption (g/L), and the cell population (log CFU/ml) observe over 48 h fermentation periods for all cases. The maximum ethanol productivity (5.95 g/L/h) and maximum growth rate (0.3 CFU/ml/h) were obtained with 3% inoculation, which produced 30.05 g/L ethanol. Although 5% inoculum sizes gave a higher ethanol yield, growth rates, production rates, and consumption rates were lower than parameters of 3% inoculum size. Among 1, 2, 3, 4 and 5 % inoculum sizes, 3% was determined to be the optimum inoculum by comparing production rate, maximum growth rate and produced ethanol. The highest production rate, growth rate, and produced ethanol were 5.95 g/l/h, 0.3 log CFU/ml/h, and 30.99 g/L, respectively, which were produced by 3% inoculum size. The 3% inoculum size was suggested to be the optimum level for ethanol. Ethanol Concentration & purification is achieved by Membrane pervaporation system.

CONCLUSIONS:-

1. This research successfully demonstrated that waste water from Food Industry can be used for ethanol production by *Saccharomyces cerevisiae*.
2. 95% starch present in food industry waste water is separated by Sedimentation Process. & remaining water present in sedimentation tank is passing through RO System were TDS is changing from 1110 to 37 and also recovered 5% starch.
3. Between acid and enzyme hydrolysis, enzyme hydrolysis turns out to be the better pre-treatment for starch substrates. Acid hydrolysis only reached 0.03 g/L glucose with a 20% (w/v) Starch. Enzyme hydrolysis, on the other hand, after optimizing liquefaction and Saccharification steps, yields 34.9 g/L glucose. After scaling up, glucose concentration was able to be increased to 93.5 g/L.
4. In terms of the pH strategy for ethanol fermentation from hydrolyzed waste potato mash, controlling pH at 5 is found to be the optimum condition for ethanol fermentation, which yields 27.05 g/L ethanol. Uncontrolled pH conditions did not improve ethanol production because the pH level fell down to pH 4 at the end of 48 h.
5. Among inoculum sizes investigated, 3% (v/v) was determined to be the best choice with production of 30.99 g/L ethanol. To increase amount of culture did increase neither ethanol production nor kinetic parameters of fermentation and 5% inoculum was not able to enhance fermentation of ethanol.
6. From this work it is clearly indicated that waste water from food industry can be an effective fermentation medium for production of ethanol under conditions of controlled pH at 5, & inoculum size of 3%. In order to improve starch hydrolysis and fermentation conditions and decrease the cost of ethanol.
7. By using Membrane pervaporation system 99.99% purity of ethanol is achieved.

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