PRODUCTION OF BIO-ETHANOL AND BIOMANURE FROM FOOD WASTE

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Abstract: ***There are 2 canteens in the campus of Uttaranchal University and separate hostel mess for boys and girls from where a lot of food waste is acquired and this was increasing day by day. The acquired food waste was utilized for better research purpose. The project is to create bioethanol and bio manure which will be more cost effective, eco-friendly, generate a high amount of renewable fuel, and reduce toxic emissions. Bioethanol production is done by the process of fermentation which requires anaerobic digestion. Although food waste will be collected this will be used as the organic matter for the bioethanol fermenter. The fermentation of food waste produces bioethanol a valuable energy resource. Fermentation is a biological process for the production of bioethanol by converting sugar complexes into alcohol or carbon dioxide as their by product. Bioethanol can be used as energy source and also for numerous purposes. The continuously fed fermenter requires them to maintain the temperature and pH to 7. For this fermenter the substrates should be installed in batch reactors to which inoculum of the food waste along with sugar cane juice will be added to develop new inoculum. A combination of this mixed inoculum will be used for bioethanol production at 30 to 25^{o}C. In this project the production of bioethanol can be done from the sugar, carbohydrate and starch rich material.***

Keywords – Bioethanol, Bio Manure, Bio Fertilizer, Fermentation, Anaerobic Digestion, Inoculum

1. INTRODUCTION

In today's life the growth and increase in population and urbanization and rise in life standards have contributed to an increase both in quantity and variety of organic wastes generated by industrial, domestic and agricultural activities. The rapidly growing demand for energy, a dwindling and unstable supply of petroleum and the emergence of global warming from the use of fossil fuels have rekindled a strong interest in pursuing alternative and renewable energy sources. Bio manure, Bioethanol as an alternative to fossil fuels has been expanded in the last few decades in the whole world. Use of this resource as a renewable transportation fuel will minimize the amounts of fossil-derived carbon dioxide (CO2) to the Earth's atmosphere. Now these days' biofuels have increased in popularity because of rising oil prices and the need for energy security.
Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn, sugarcane and potatoes. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is a clean burning, renewable resource that can be produced from fermentation of glucose rich substrates (Yu and Zhang, 2004). A new biotechnological approach to produce ethanol by fermentation from the renewable carbohydrate materials for use as an alternative liquid fuel has been attracting worldwide interest (Ward and Singh, 2002). Nowadays, ethanol production from renewable resources has received great attention because of the increasing petroleum shortage (Nadir et al., 2009).

Bioethanol: Bioethanol is a clear, colorless, flammable and oxygenated fuel. It has a chemical formula of C2H5OH. Bioethanol is Fuel ethanol (ethyl alcohol) which is made by fermenting and distilling simple sugars and produced from food crops containing starch, where the sugar crops are the most common types of raw material Bioethanol, has shown great potential in replacing fossil fuels to an extent. It is also commonly used to replace kerosene for cooking and illumination besides being a renewable energy source, bioethanol has other advantages over fossil fuels. The mostly used food in our country is potato and it is rich in starch as it's a starchy crop. In this study we put the first set up of bioethanol was potatoes extract. The total world potato production is estimated at 364,808,768 tons in 2012 (FAO, STAT, 2014). India is a second most potato producer country after china which ranks first. China produces 85,920,000 tons and India 45,000,000 tons in 2012. Due to the presence of starch in potatoes they don't require complex treatment and it is a high value crop. There are about 5 to 20% of crops are potato waste from potato cultivation could be utilized for bioethanol production. Although maximum amount of food waste contains the potato substrate as potatoes are used to be daily in our meal. We observe this thing while collecting food waste from hostel mess and food court. So, potato waste is used to be the main source in the production of bioethanol. In bioethanol production from potato waste fermentation several factors plays an important role to obtain maximum yield like substrate and inoculum size, temperature, pH, incubation period and combination of microbes for saccharification and fermentation. Ethanol is one of the bio-energy sources with high efficiency and low environmental impact.

Biomass:
Biomass is a substance or a fuel that is obtained and produced from organic raw material used for converting in an alternative source of energy which can further used to create many forms of power like electricity. Biomass is generally produced by the photosynthesis of light. Wood is the most common biomass which is used for cooking a very long time and by providing the heat energy. So any substances which work as an alternative fuel and providing energy are said to be biomass which is developed from plants and transferred to the animal bodies and human by the food chain. The waste we have taken in this study also considered as a biomass as it is a food waste which is somehow coming from the plants. In this study we had tried our best to utilize it into an alternative source. As biomass level is increasing day by day so the innovation is needed to utilize it into useful production. Currently the biomass is utilized across the globe.

Food waste and kitchen waste: Organic waste is produced wherever habitation exists, mainly in the form of household kitchen and agricultural wastes. In our university there are a lot of food wastes left in the food court and hostel mess. The amount of this waste has been increasing each year although these wastes are used in composting, or it goes to dumping sites and forms the most hazardous waste.

Organic waste is an unavoidable by-product of most human activity. Management of organic waste is a particularly serious issue. Therefore, there is a great need to find alternative solutions for the treatment of organic wastes (kitchen wastes,). The kitchen wastes are mainly consisting of fruit and vegetable peels, cooked and uncooked food and contain a moisture content equal to or greater than 75%.

Production of bioethanol from food waste is the focus of more interest around the world because bioethanol is a renewable fuel which is contributing to the minimization or we can say that in reduction of the global warming and their negative impact on the environment which is generated by the worldwide utilization of fossil fuels. Food waste which is rich in carbohydrates and starch are very much more useful in the production of bioethanol and their left solid substrate also be used in the production of bio manure which is probably the most important manure to the plant for increasing their fertility and in our university, there is much need as there is greenery all around.

Solid wastes of organic origin including many types of wastes as municipal wastes, agro-industrial wastes, animal wastes, farming wastes and residues. Due to increasing energy demands, and environmental problems, various organizations all over the world have recommended various guidelines and worked on various projects on recycling and use of these wastes into a useful energy fuel. Generally, kitchen and household waste contain high lignocellulose matter like grass or wood straws but majorly they contain the food waste which are rich in carbohydrates and starch and when these food wastes are sent to landfill they produces noxious leachate and greenhouse gases as it decomposes. Due to high moisture content and low calorific value of the kitchen wastes, extra combustible material is needed. It results in both air pollution and increase in expenditure costs. So, utilizing the food waste into valued products is necessary in today's life. Food waste release greenhouse gas which is the methane gas as they are rich in organic matter. Kitchen waste is the mainly the organic material which has very high calorific value and high nutritive value due to the presence of microbes in it this is why the efficiency of methane gas can be increased.

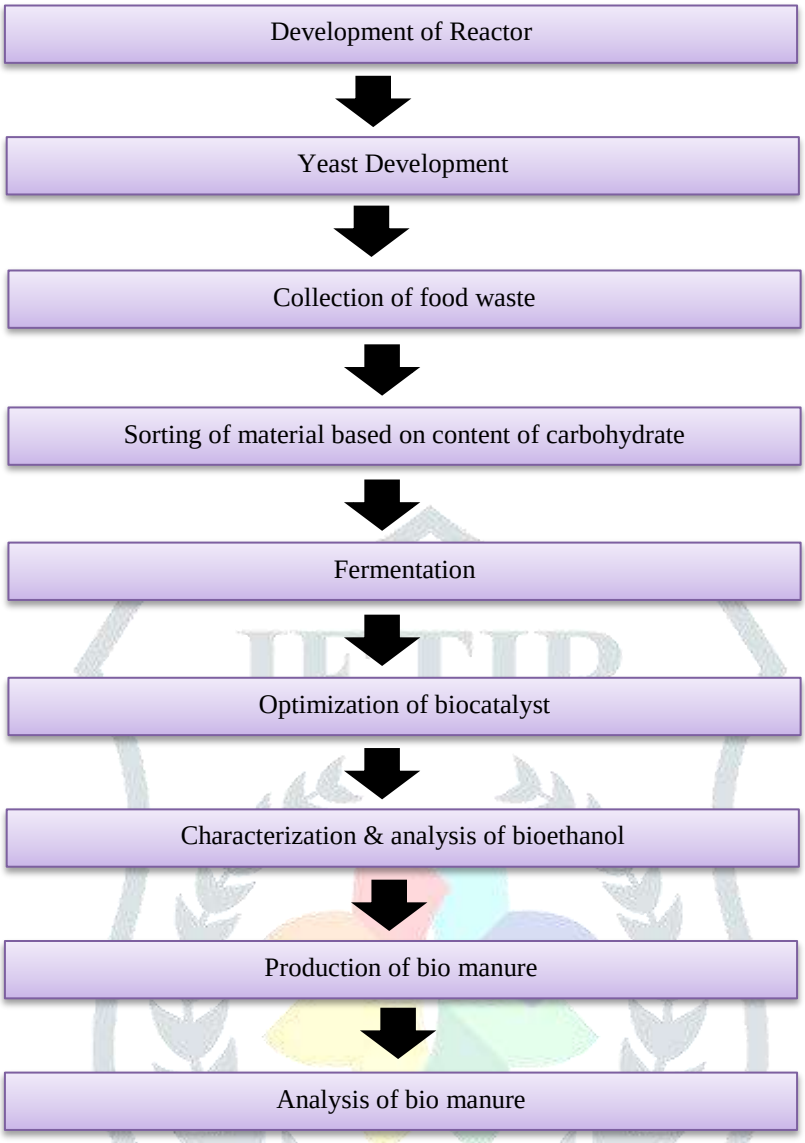
Bioethanol production process:- Pretreatment(lignocellulose material) → Saccharification → Fermentation → Distillation

2. EXPERIMENTAL PROCEDURE

Material required:

• Food & kitchen waste	• Tollen's reagents
• Reactor	• H_2SO_4
• Yeast extract	• Glove's
• Pentose	• Glassware's (test tubes, flasks, glass rod, petri dish, etc.)
• Dextrose	• Apparatus for optimization
• Fehling's A & B solution	

METHODOLOGY:



The present study was conducted in the Bio-science laboratory of Uttaranchal Institute of Applied Life Sciences, Uttaranchal University, Dehradun (U.K.), India. Waste potatoes, food waste was taken from the boy's hostel mess and food court of Uttaranchal University Dehradun. The bioethanol producing microorganisms co-culture viz. Saccharomyces cerevisiae were obtained from Uttaranchal Institute of Applied Life Sciences, Uttaranchal University, Dehradun (U.K.).

In this experiment, before introducing the waste into reactor Firstly the waste potatoes are collected from the source and were taken as starch. After collection mash of potatoes then made slurry of it with the help of mechanical stirrer about 1 hour continuously and then kept in the sun light for heating about 2-3 days. When the substrate become soft thick then it is subjected with an addition of hot water or make it diluted through the sieving process the solid residue was left behind, and the filtered diluted solution of potato substrate were introduced in the fermenter and addition of yeast is done after pouring the diluted potato waste with an amount of sugarcane juice.

The 5ltrs of potato solution is being mixed with the 5ltrs of sugar cane liquid (juice) and 5ltrs of boiled water is added to the solution. Because of boiling, heat will help the yeast to grow more. So, boiling water is used.

When all the solution of potato and sugarcane is mixed properly then some amount i.e.150gms of yeast is being added into 500ml of distilled water and then mixed in the solution. The whole solution is kept in the fermenter in which the limit of fermenter is set to be1000rpm.

The main part of the fermenter is it has 2 outlets and 1 inlet and the capacity of the fermenter is 25 liter and made from the steel –SS316 (stainless steel 316) is to develop the fermenter as this steel prevents the fermenter from rusting and corrosion.

In this method the yeast is developed in the lab by scaling up by the composition of the following components

COMPONENTS	AMOUNT
Yeast extract	5 gm
Peptone	10 gm
Dextrose	20 gm

Table 01- Components used for developing yeast

All components were added in a conical flask under continuous shaking on magnetic stirrer. Media was sterilized using an autoclave at 121°C for 20 min and then used for research work. After introducing yeast in the reactor, the temperature and pH maintained regularly so that the fermentation process could take place easily. For maintaining the temperature, the fermenter was put on the roof to obtain the favorable temperature.

Fig. 01 - Yeast Extract

Fig. 02 - Potato waste

Fig. 03 - Food waste

After setting the whole set up into the fermenter the left behind residue were used a bio manure by drying them under the direct sunlight and about after few days the waste was grinded well and thick powder of waste is obtained which issued as a bio manure then the packing of obtained bio manure from different types of organic matter was obtained. The samples of manure according to its content were also sent for the sampling and for the determining of the essential N, P, and K values. In case of biogas the gas composition was noted in batches. The agricultural waste and the kitchen waste which was mainly potato peels were taken and then they were fed into the digester after the slurry was made the cow dung was also taken along with the kitchen waste. The temperature and the pH of the reactor were maintained regularly so that the anaerobic bacteria could grow easily, and the process could take place easily. The gas in the batches was collected in a balloon and then it was sent for the testing. This was done in batches and then they were compared with each other so that the exact value could be found. The whole process of grinding, stirring of food waste is shown in given figure 04.

Fig. 04 - Grinding of waste

CHARACTERISATION OF FEED STOCK:

1gm of food waste was mixed with 10 ml of distilled water in a clean test tube then the content was allowed to boil for about 5 minutes. Once it attained the room temperature, the content was filtered with the help of filter paper and the obtained filtrate was used for various tests:

- **Presence of starch**

2 drop of iodine solution was added in 2ml filtrate in a clean test tube. When the color of filtrate changes to dark blue/black. The visibility of dark brown color showed the presence of starch in the given food waste.

- **Total solid suspension (TSP)**

It is defined as the amount of solid present in the sample when the water present in it is evaporated. for TSP take 10gm of sample and poured into a foil plate after this dry it till a constant weight is obtained at about 150 in degree Celsius in hot air oven or furnace.

Presence of Starch	Yes
pH	6.7%
Total suspended solid	4%

Table 02 - Characterization of feed stock

OPTIMIZATION OF pH:

The ph is to be varied in the range of 6.5, 5.5 and 7.5 which is not so acidic and not so basic, the ph should be checked time to time for the optimization. The ph in the fermenter initially decreases with the increase in the production of the acids in the fermenter, but when the alcohol forming fungi consume the acids then there is the alkalinity produced in the fermenter which then increases and then stabilizes.

OPTIMIZATION OF TEMPERATURE:

A temperature range of 30-32 degree Celsius is maintained in the fermenter as it is the favorable temperature of yeast to give the yield of the bioethanol So the fermenter was kept in the direct sunlight of the hot summer days so that the fermentation process. Every time the temperature range should be maintained properly in the fermenter.

Drying of bio manure:

Also, the bio manure thus obtained was test for the N, P, K. values which are the major nutrients necessary for the soil. The bio manure was separated according to the source from which it was obtained, and then tested. After the testing it was packed in the packets of plastics and sealed and many of them were stored for the use in the agriculture fields to be used as a fertilizer in the fields.

Hence this process was a very efficient process as the by product from it was used as a very good fertilizer in the fields for the production of the crops. Hence by this way the by product is also utilized.

Fig. 05 - Bio manure

3. RESULT

Result of the project performed was obtained as given below

BIOETHANOL OBTAINED FROM THE REACTOR:

- After the reactor/fermenter was operated for about 8-9 weeks, after the initial filling of the contents in it, the value of ph then became stable in it and was found to be about 6-7.
- The temperature in the reactor was 38ºC - 45ºC during the day time and 32ºC - 38ºC during the night time.

- Therefore there were two parameters considered during the formation of the bioethanol in the reactor. The potato waste and the food waste were fed in the reactor in 3 batches and were sent for the characterization and analysis of obtained ethanol.

The 3 batches had different amount of the wastes present in it,

1. The first batch of 5 kg of potato waste was taken and make a thick slurry of it and 5 liter of sugar cane juice is added to it and diluted it with the 5 liter of water with 500 ml of yeast solution is introduced in the fermenter.
2. The second batch was of 10 kg kitchen waste taken in which the rich carbohydrates substance, left overs of rice, chapattis were taken and form a slurry with the help of a mechanical stirrer by addition of 5 liter of water and with 1000ml solution of yeast were introduced in the fermenter.
3. The third batch contained the both amount of potato waste and mixed food waste was formed by mixing them in 1:1 ratio and then after diluted it with water and poured into the fermenter with 1000ml
4. Solution of yeast for the production of bioethanol.

Sample	H_2O %	C_2H_5OH %	CO_2
PE	5.5	92.4	1.4
FW	5.2	93.2	1.6
PE+FW	7.1	91.5	1.3

Table 03 - Composition of H_2O, C_2H_5OH, CO_2 in ethanol

The composition of bioethanol obtained was

In the first batch the concentration of ethanol was 92.4% as we pored the rich starch material but it is less than 100% due to the addition of yeast is quite low. Then in the second batch when mixed food waste is taken the concentration of ethanol was 93.2% which was the highest concentration from all three batches as it contain mixed nutrients of food. In the last batch both potato waste and mixed food waste were taken which give the concentration of ethanol was 91.5%.

BOILING POINT

The boiling point is determined by using rotator flash evaporator by applying temperature in the range of 75-80^0 C.

Fig. 06 – Bioethanol produced

DETERMINATION OF ETHANOL BY HPLC

High pressure liquid chromatography (HPLC) system is used in various detection of alcohol phenolic compounds and sugars. In this study HPLC was used to determine the characterization and analysis of bioethanol. HPLC is basically a highly improved form of column liquid chromatography. Instead of a solvent being allowed to drip through a column under gravity, it is forced through under high pressures of up to 400 atmospheres. That makes it much faster. All chromatographic separations, including HPLC operate under the same basic principle; separation of sample into its constituents parts because of the difference in the relative affinities of the different molecules for the mobile phase and the stationary phase used in separation. HPLC instruments consist of a reservoir of mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by injecting a sample mixture onto the column. The different component in the mixture pass through the column at differentiates due to differences in their partition behavior between the mobile phase and the stationary phase. The mobile phase must be degassed to eliminate the formation of air bubbles.

BIO-FERTILIZER POTENTIAL OF UNDIGESTED/DIGESTED MANURE FROM THE REACTOR:- The results have shown that the digested samples have higher contents of the nutritional elements present in them when compared to the undigested samples. The importance of K, Na, Mg, Ca, N, and P to plants is very specific and relevant for the process of photosynthesis and the different metabolisms taking place in different types of plants and their roots.

Also N, P, K are the major nutrients required for the formation, growth, flowering, and seed formation in plants. A comparison of the concentrations of these nutrients in the digested samples which were categorized on the basis of the contents of agriculture and the kitchen wastes present in them was an indicator to ascertain the best sludge from the reactor with the highest bio-fertilizer potential in it. This shows that although they considered to be waste samples but still even after the production of biogas anaerobically from them they contain appreciable nutritional values. Also the agro wastes finds usefulness in the animal feeds.
Reactor manure or the bio-fertilizer obtained is the product of biogas fermentation consisting of sludge and effluent. The sludge mainly consists of the primary nutrient elements which are very essential in manure for the plants and also the organic matters. The nutrients present in the manure so obtained from the reactor are different depending on the substrate.

The salts which were present in the reactor in the agriculture waste and the kitchen waste contain essential building blocks like the sodium, potassium, magnesium etc., for the microorganisms. These substances are already present in many of the substrate and do not require to be added to the biogas production process separately. This is how the bio-fertilizer was obtained from the reactor which was very important for the use in the field for the growth of different plants.

The content of different primary nutrients present in the 3 samples was as follows –

Sample	CH_4	CO_2	H_2O
Food Waste (FW)	65	23	5.6
Agriculture Waste (AW)	76	18	4.1
FW+AW	81	14	3.5

Table 04 – Contents used

4. CONCLUSIONS

- Fermentation is a technology that is very efficient for the processing of the organic wastes and has seen a significant growth.
- Fermentation of the organic matter and kitchen wastes to generate bioethanol and biomanure and sludge gives an alternative and effective method for controlling the wastes decomposition in the environment coming from the food court and the mess of the girls and the boy's hostels.
- Instead of depending on the chemical fertilizer bioethanol production also gives the by-product formation of the bio-fertilizer which has the good value of the primary nutrients (N, P, and K) in it.
- Amongst the three batches of the waste it was found that the combination of the different food has found the optimum bioethanol generation.

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