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POTENTIAL TO PRODUCE BIOGAS FROM TANNERY WASTE

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Project Summary

The demand for fuel has been rising exponentially as the population is increasing. This calls for a need for alternate sources of energy and clean technology to address global warming problems. Large scale production of tannery waste is associated with land pollution, air pollution and water pollution. Biogas and bio-fertilizer can be co-generated by bio-catalyzed anaerobic digestion of tannery waste and leather by-products. This relieves pressure on the use of electricity, natural petroleum fuels and the environment itself. The key aim of this project is to utilize and make use of tannery waste dumped by leather industries through an anaerobic digestion process to yield the highest biogas yield as possible. The main statement of the problem focuses on the unsuitable carbon- nitrogen ratio in the tannery biomass which cause frequent ammonia production which greatly inhibit the anaerobic digestion process. Therefore the solution of this problem can be achieved through mixing the tannery waste with a different organic biomass such as cow dug in order to provide the desired C/N ratio suitable for anaerobic digestion. This blending of two or more substrates is called anaerobic co-digestion and in this case its aim is to reduce the nitrogen proportion with respect to carbon in the substrate in order to reduce inhibition of biogas production. The major equipment to be designed for the process are the hydrolytic reactor to hydrolyze the organic matter into smaller units, the bio digester for fermentation and the distillation column for biogas purification.

Background

The disposal and treatment of wastes generated in the leather industry has been the focus of several studies around the world. They intend to meet environmental legislation and make the process environmentally and economically viable. The anaerobic digestion process, which occurs in steps that involve acid and methane forming bacteria, can be an alternative since it turns the waste into renewable energy. This work evaluated the anaerobic digestion process and the generation of biogas from leather industry waste shavings and sludge from wastewater treatment plant (WWTP) and from parboiled rice waste. Tannery waste from the leather processing industry was collected and preheated to 150 °C before inoculum addition. Microorganisms isolated from aerobic sludge of WWTP (inoculum) were added. The waste was analyzed for organic carbon and total solids content and then mixed with a different substrate such as parboiled rice. The samples were maintained at 35°C, the volume of gas generated was measured by reading the increase in volume of water in a measuring cylinder connected to the flask and the composition was determined by gas chromatography. The time the tannery substrate remains in the digester varies between 14 and 20 days. The amount of gas produced is not so high since all generated gas flows into the gas storage. The biogas could be converted or upgraded to biomethane through increasing the proportion of methane to 98%. The digester temperature should be 35- 40 °C. Thus, the digester must have a heating system; mostly it is in the digester basement. The other equipment

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basically used to construct a biogas plant include, stirrer/mixer, gas holder, gas cleansing, and a block heat and power plant. The digester should be kept completely air tight and water proof and they should be equipped with a heating system. They are built with steel or ferroconcrete and the base is usually cone shaped. They can be placed partly underground to promote an oxygen free environment. The addition of inoculum increase the volume of biogas generated. The amount of biogas generated by leather waste was 23 ml (composed of 25% of hydrogen, in molar basis).The rice with the addition of tannery WWTP sludge generated 47 ml of biogas.

Beneficiary profile/Benefits

Improvement in quality of life for renewable energy users: Biogas plants help improves beneficiaries' quality of life. First, they reduce the workload usually required for typical tasks such as firewood collection and fire tending. In addition, cooking with biogas stoves is more convenient and faster than with firewood or charcoal stoves. Moreover, biogas is much cleaner than firewood or charcoal. Indeed, cooking with firewood or charcoal usually results in the production of soot which usually soils the kitchen and cooking utensils.

Gender equality: Improved gender equality is a direct consequence of the previous point, since women are predominantly involved in the housework. Thanks to the reduction of their workload, women can spend more time on other activities and on education, hence a reduction of gender disparities.

Health and sanitation: Indoor smoke pollution related to the use of firewood or charcoal may induce health risks such as respiratory diseases (no particulate matter emission unlike firewood or charcoal). In addition, bio-digesters reduce the pathogen content of organic materials. The sanitary condition of the household can consequently be enhanced thanks to domestic biogas units.

Renewable Energy Education: The installation of a biogas lamp can enable children to study later in the evening. Indeed, the lighting quality of biogas lamps is generally better than traditional lighting methods (e.g. kerosene lamps). Children that have access to a proper lighting can study up to 2 hours more per evening than children with poor lighting conditions.

Food *security*: The use of bio-slurry as a fertiliser improves crop yields compared to traditional manure. It consequently contributes to food security for beneficiaries and the community in general

Achievements and challenges

As of yet tannery waste has been collected and preheated for anaerobic digestion to produce biogas. A total of 3 experiments were carried out to determine the optimum process conditions for temperature and pH optimum fermentation temperature found to be 35 and suitable pH for maximum methanogenic activity was 7. The third experiment was carried out to prove the impact of using the co-digestion method to obtain high yield of biogas. The co-digestion experiment produced the highest biogas yield of nearly 44% by mass of tannery waste. All the data recorded in the experiments was used to calculate mass and energy balances and also in the equipment design. Information about potential market of biogas was researched.

Table 1: Results of the experiment to compare the biogas yields in anaerobic digestion and co-digestion experiments

Sample	Initial mass of mixture	Final mixture mass (g)	Mass of biogas produced	Biogas volume	**Bio-gas % yield**
TW	**145.155**	**130.214**	**14.941g**		**29.9**
TC	**145.154**	**122.718**	**22.436g**		**44.9**

The above table of results was obtained for the outcome of the third experiment to investigate the effect of co digestion on the amount of gas produced. All the process parameters were kept constant in both the tannery waste sample and the co-digestion sample (tannery waste + cow dug).The 2 setups were left for 23days at a temperature of 35 °C and PH of 7.

Conclusion and results discussion

The mass yield of biogas or volume of gas produce in a specific time can be greatly increased by blending or mixing of two or more substrates of different organic origination which is the co-digestion method.

In summary the process conditions which proved suitable according to the 3 experiments described above are as follows;

- Temperature should be kept 35^{0}C
- pH should be kept acidic in the hydrolytic reactor and kept neutral or between 6 and 8 in the bio-digester (fermenter)
- The process require absence of oxygen and the co-digestion method will be utilized in the process design to maximize or improve gas yield since it is more feasible compared to the simple anaerobic digestion method
- The results and analysis stage will help to design process equipment and sizing of the bio-digester.

Challenges

There is need for by in from communities, local authorities and the environmental agencies. Biogas development policies can be blamed for increasing GHG emissions, if they encourage more people to switch from crop farming to leather tanning. Tannery waste consists of an unsuitable carbon-nitrogen ratio which is results in the formation of high amount of ammonia which inhibit anaerobic.

Project support and sustainability

The project practically solves real problems in the communities which are clean energy, clean water and provision of bio fertilizers for boosting farming through bio catalysis. However, for the research to move forward the project must be funded. . They are ideally suited for utilizing environmentally harmful waste from leather processing and its post-fermentation products which form valuable natural fertilizer. Under the Zimbabwean law, rural biogas plants may produce agricultural biogas from such raw materials as tannery by products, organic agricultural products, liquid or solid animal manure, agri-food industry by-products or residues and forest biomass with the exception of biogas from wastewater treatment plants and landfills . No biogas plants in Zimbabwe produce biogas from biodegradable municipal tannery waste currently composted or disposed of in municipal landfills. The reason for this is that Zimbabwean legislation fails to deem biogas produced from municipal organic waste as agricultural biogas. This in fact creates a number of administrative and economic challenges. Although plants fired by organic waste generated in food processing produce biogas which does enjoy this status, they are not sufficiently promoted. Another serious difficulty faced by biogas plants relying on organic waste is strong public opposition which results mainly from the lack of reliable information about biogas. Although the method utilizes a biological process known since prehistory, the technology itself remains relatively new. The most common objections have to do with onerous smells, epidemiological risks and environmental pollution.

Future plans

Application of the technologies in various industries including the beer, distillery, dairy and even the municipal plants where resource recovery from the wastewater can be minimized to reduce costs in the plant. The tasks which are outstanding involve the HAZOP analysis, economic analysis, prototype modeling and prototype development. The digester volume will be evaluated as well as its height. Suitable Construction materials are also going to be established depending on costs, availability, durability, and mechanical strength.

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