WASTE TO WEALTH-BIODIESEL EXTRACTION FROM SEWAGE SLUDGE AND ENGINE PERFORMANCE STUDIES WITH SEWAGE SLUDGE BIODIESEL (SSB)

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Introduction:
Due to the depletion of available fossil fuels, several methods have been tried to utilize the available resources effectively and to find alternate resources. Production and use of biofuels is one among the methods incorporated to overcome this challenge. The production cost of biodiesel is high due to the fact that 75–85% of the total cost is related to the raw materials like vegetable lipids and animal fats; therefore there is an urgent need for alternative and cheap sources of lipid to produce biodiesel. Sewage sludge is an abundant by-product from wastewater treatment facilities. Sludge treatment comprises a substantial portion of the wastewater treatment costs. Handling and disposing of sewage sludge also pose economic and environmental challenges for wastewater treatment facilities. There is a need to identify cost effective and sustainable solutions to the utilization of raw untreated sewage sludge. Sewage sludge is another non-food feedstock that offers significant potential for biodiesel production. The feedstock cost is typically the major cost items for the biodiesel production. As sludge disposal poses a challenge for waste water treatment plants, the cost of sewage sludge as a biodiesel feedstock is projected to be less than the cost of traditional seed oils.

The current project work has been chosen considering the energy crisis and serious environmental pollution by the use of fossil fuels, and because of the fact that there are considerable lipids in sewage sludge, which can be turned into biodiesel by esterification or transesterification. The whole process is divided into three steps: heat-drying of sewage sludge, extraction of lipids and transesterification. In this work extraction of lipid was done using an organic solvent methanol in a laboratory setup. The extracted lipid was converted in to biodiesel by transesterification. The main objective of the project work is to extract lipid from the sewage sludge collected from the local sewage treatment plant and to convert it into biodiesel.

OBJECTIVES:
Fossil fuel depletion is one among the major contemporary problems facing by human. The search for alternate to fossil fuels and the challenges in waste treatment have motivated this study. Literature shows that lipids can be successfully extracted from sewage sludge from municipal sewage treatment plants and these lipids can be converted to liquid fuel through chemical methods. These liquid fuels can substitute the fossil fuels which are depleting day by day. Blends of these types of fuels along with the ordinary fuel can enhance the engine performance also. The main objective of the project work is to extract lipid from the sewage sludge collected from the local sewage treatment plant and to convert it into biodiesel.

The specific objectives of the study are:
- To study the extraction process of lipids from sewage sludge.
- To convert sewage sludge lipid into biodiesel using transesterification process.
- To study the performance characteristics of a single cylinder CI engine using sewage sludge biodiesel (SSB).

Methodology:
Lipid Extraction from Sewage Sludge
Lipids and oils are extracted from sewage sludge by mixing the dry powdered sludge with organic solvents such as hexane, toluene, ethanol and methanol. Solvent used for lipid extraction from sewage sludge in this study is methanol. Dry sludge cakes from sewage treatment plant of Mangalore city corporation-MSEZ, Kavoor, Mangalore are collected and it is kept inside a microwave oven for 1 hour at 70°C. This drying process is carried out in order to de-watereis the sludge so that all the moisture content in the sludge is removed. The dried sludge is made into fine powder by crushing it manually using a
mortar and pestle. The sludge powder and the solvent are then mixed using a mechanical stirrer at a ratio 1:2 (2g solvent for 1g sludge) for 1 hour. During this process the lipid content in the sludge will get dissolved in the solvent. The mixture is then filtered using a vacuum pump and the solid particles are removed. The solvent having lipids dissolved in it is collected after filtration. The lipid content dissolved in the solvent needs to be separated from the filtered solution. The solution should be transferred to a distillation unit for this purpose. At this stage, the lipid content in the solution will get separated. The methanol content will get condensed and it can be recovered. However, in this work separation of lipids from the filtration output is done by evaporating the solvent from the filtrate. The filtered solution is kept over a hotplate for 1 hour at 65-70°C. As the methanol evaporate out there will be an oily solution remain at the bottom. This oil is the lipid content of the sludge. The oil extraction process is followed by transesterification reaction to convert it into biodiesel.

**Free Fatty Acid test**

Titration was carried out using a chemical indicator called phenolphthalein to find out the free fatty acid (FFA) content of extracted lipid in each batch. In the titration 0.1N of NaOH in distilled water is titrated against the titration sample which is essentially a solution of 10ml of isopropyl alcohol and 1ml of oil sample with 2-3drops of phenolphthalein indicator. The end point of the titration is reached when the titration sample turns pink and stays pink for 10 seconds. The number of milliliters of 0.1N NaOH solution needed is equal to the number of extra grams of pure sodium hydroxide catalyst needed to complete the reaction to make biodiesel from sewage sludge lipid. Thus the amount of NaOH needed for the reaction is taken as (3.5+X) gm per liter of oil, where X is the titration reading in ml. This excess amount of NaOH added is neutralized by the FFA content in the oil.

**Transesterification**

In the esterification process known as transesterification reaction, the sludge oil (lipids) is added with sodium-methoxide solution which is prepared by dissolving NaOH pellets ((3.5+3.5) gm/liter of oil) as catalyst in to analytical grade methanol (for 1000ml of oil 200ml of methanol) by vigorous stirring in a conical flask. The methoxide mixture is added to round bottom flask with oil and maintained at 70°C with continuous stirring using a magnetic stirrer for one and half hour. In order to prevent the evaporation of methanol from the round bottom flask a water cooled condenser is fixed to the mouth of the round bottom flask. After the reaction time the condenser is removed from the round bottom flask and reagent is heated openly with stirring for further one hour to evaporate the unreacted excess methanol. After the reaction the reagents are poured into a conical separating funnel and the solution is left for an overnight for separation into two layers after settlement. In general a successful reaction produces two separate layer viz. esters and crude glycerol. Phase separation can be observed within few minutes after the reaction and can be expected to be completed overnight. The bottom layer that is glycerol layer is drained off and the crude biodiesel is collected, which is water washed later.

**Engine performance studies**

The engine setup consists of a 4 stroke single cylinder diesel engine of 3.5 kW capacity with rope brake dynamometer for loading with instrumentation for measuring different performance parameters. Performance tests were carried out with diesel, 20% sewage sludge biodiesel blend with diesel and honge B20 blend.

**Results and Conclusions:**

Sewage sludge which is obtained from sewage treatment plants are a good resource for producing biodiesel. Production of sewage sludge biodiesel (SSB) helps us in facing the energy crisis as well as the waste management issues.

Based on the laboratory tests and performance tests conducted the following results are summerised.

- The average overall biodiesel yield from sewage sludge is 11.06%. The kinematic viscosity variation of SSB20 is lower than that for honge B20 at elevated temperature.
- Mass flow rate of SSB20 is marginally higher when compared to diesel as well as hongeB20 at full load.
- Brake thermal efficiency with SSB20 has increased by 2% and that with honge B20 by 5% compared to diesel at full load.
- At full load, SSB20 has the highest value of brake specific fuel consumption among the three fuels tested.
- Air-fuel ratio of SSB20 is 12% and 3%lower than diesel and honge B20 respectively at full load.
- SSB20 is having the highest volumetric efficiency among the three. Volumetric efficiency of SSB20 is 9% higher than diesel and 5% higher than honge B20.
The present work showed an increase in brake thermal efficiency compared to diesel as a result of using SSB20, but it is lesser while comparing with honge B20. Thus, it can be concluded that blending of SSB with diesel helps to enhance the performance of CI engine. However the cost of biodiesel produced in this work is Rs. 825 per liter. The higher cost compared to other biodiesels is mainly due to lower lipid content of the sludge used and the higher cost of methanol used (Rs. 228/liter). Yet it is an alternative for fossil fuels and helps to reduce the sewage treatment and waste management problems.

Scope for Future Work

❖ Lipid extraction with other solvents like hexane, toluene etc., may be taken up.
❖ Different sources of sludges having higher lipid contents may be investigated.
❖ Methods and machinery may be built to convert sewage sludge into biodiesel in large quantity. Studies can also be carried out to reduce cost of SSB.
❖ Engine performance using various SSB blends can be conducted to check for better output
❖ Emission test can be conducted with sewage sludge biodiesel.