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CONVERSION OF SEWAGE SLUDGE TO BIO FUEL BY LIPID EXTRACTION: A REVIEW

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Abstract: The Bio-fuels are gaining worldwide attention as an alternative fuel choice exchange the usage of the mineral diesel derived from typical fossil sources. However, the massive price attributed by the feed stock created it less competitive with the industrial diesel. A large spread analysis goes on worldwide for the production of biofuels from renewable biomass commutation the presently used ancient sources. It's expected that biodiesel industries can quickly grow worldwide within the returning years and data on biodiesel feedstock, production, and characteristics are going to be crucial than particularly for those using vegetable oils as feedstock as those are presently the key sources for creating biofuel. Gene-technology may also be accustomed enhance the assembly of oil and biodiesel contents and stability of algae. By increasing the genetic expressions, we are able to notice the ways that to attain the specified biofuel amounts simply and unendingly to beat the fuels deficiency to boost municipal sludge from effluent treatment plants may be a promising lipid feedstock for bio-diesel production because it contains a major quantity of lipids. The concern of decreasing the obtainable sources thirst towards bio-fuel production has multiplied throughout last decades. Bio-fuels are gaining worldwide attention as another fuel choice replacement the usage of the mineral diesel derived from standard fossil sources. During this review paper, a comprehensive discussion on numerous the varied the assorted aspects of bio-fuel production from various raw materials alongside the key parameters touching the method and its economic science are conferred. This review additionally emphasizes that future studies ought to concentrate on the usage of recent method intensification techniques for a lot of economical production of bio-fuel from renewable biomass.

***Index Terms* - biofuel, biodiesel, wastewater, sludge, Lipid extraction.**

I. INTRODUCTION

Bio-fuels are gaining worldwide attention as another fuel possibility commutation the usage of the diesel derived from standard fossil sources. However there has additionally been a rise within the range of consumers of a fuel engine with associate unbalanced economy. However, the high price attributed by the feedstock created it less competitive with the industrial diesel. An analysis goes on worldwide for the assembly of fuels from renewable biomass commutation the presently used ancient sources. The high lipid-containing municipal sewerage sludge (MSS) will be thought of as a possible feedstock attributable to its low price and convenience. Accordingly, the limit for 'first generation' biodiesel (derived from vegetable oil and animal fat) will be fixed at 7.5%, making the use of alternative resources, such as wastewater from agro-industries, used cooking oil, (slaughterhouses, fish-processing factories) and urban wastewater rich in lipids (fat, oil, grease; FOG) . OECD (Organization for Economic Co-operation and Development 2019), is regularly a priority topic at the World Economic Forum to facilitate a smooth transition toward sustainable resources management. It aims to stimulate shifts from the 'take-make- dispose' (widely cited expression to describe transformation of raw materials into products, which are then used until they are finally discharged as waste) behavior of a classical linear economy to circular system where products and there by materials are reused in new cycles. In addition, the revised Renewable Energy Directive (EU, 2018) submitted that member states must require fuel suppliers to deliver at least 14% of the energy consumed by road and rail transport from renewable sources by Kamila (2019)

Biodiesel is a non-petroleum fuel produced by trans esterification or today biodiesel is so versatile that it can be used in diesel vegetable oil. Reactions involve in biodiesel production can be homogeneously catalyzed to obtain maximum output within a relatively short time. However, one of the reasons biodiesels do not compete favorably neutralized after the reaction. Production of fatty acid methyl esters, namely biodiesel, remains one of the most important European targets for the future in terms of renewable fuel for transportation and various applications .The microorganisms could suppose a significant source of oils, since their cell membranes are lipid-rich and include phospholipids, steroids and fatty acids, mostly in the range of C10–C18. Exploitation of sewage sludge for biodiesel production is a promising alternative that would also account as waste valorization, solving at the same time energy and environmental concerns.

Waste water treatment plants continuously produce huge amounts of sewage .Municipal sewage sludge thus appears as an alternative feedstock offering a significant potential that could help to overcome the competition between biofuel and fossil fuel. One of the potential candidates is the municipal waste water sewage sludge, which is gaining attraction around the world as a lipid feedstock for biodiesel production. Recent research has indicated that the sewage sludge contains significant quantity of free lipids (fats and triglycerides, phospholipids and fatty acids), as well as high concentrations of microorganisms. The lipids remodeled to biodiesel via trans esterification or to bio-oil by shift.

Suliman et al. (2017) extracted biodiesel from vegetable oils bio-butanol, Jatropha curcas and algae .Their remediating role in waste water treatment and rich sources of biodiesel make them suitable sources to be grown on large scale. They are considered as the safe, noncompetitive and rapidly growing organisms among those could be used for biodiesel production. Algae have around 80.3% energy content to that contained by petroleum. Algal cells have 30% lipid content. These concerns are related to increasing the production of biofuels, such as upward pressure on food from production of biofuel feedstock's, as well as the risks of degradation of land, forests, water particularly contentious issue, largely owing to competition with food production and concerns generation feedstock's. However, the economic viability of some second generation of biofuels third-generation (algal) biofuels can also avoid the issue of fossil fuel consumption. This renewable fuel will be an excellent alternative to conventional diesel, also it has chemical properties similar to conventional diesel, and it is compatible. Additionally, biofuel possesses significant environmental benefits as it is highly biodegradable, nontoxic, safe for storage and handling, it burns much cleaner then petroleum diesel and therefore reduces most exhaust emission (CO_2, CO, hydrocarbons, particulate, except NOx).
State Governments realize the problem of pollution of water bodies and pay attention to their liability to set up sewage treatment plants in cities and towns to prevent this pollution. There are many technologies used for sewage treatment in India, performance of 115 sewage treatment plants was studied by Central Pollution Control Board (CPCB) and also discusses the efficacies of various treatment technologies. Overexploitation of resources makes the reutilization of waste is considered topic of recent society, and also the question of the minimizing wastes. Biodegradable pollution sludge (SS) comes from the sewer water treatment plants, thought of necessary unused biomass, and may be used as a biofuel.

II. DIFFERENT SOURCES FOR BIOFUEL

1. ALGAE

Algae have oil contents with totally different compositions relying on the metal money sorts. Some species were known that they need good carboxylic acid values. Within the same approach, some protist has a lot of components of fatty acids by their dry plenty. Small protist will grow in several conditions even in accessibility of fewer nutrients which are best to be chosen for cultivation. The gathering of sample needs care so the entire biofuel contents can be obtained through careful handling of the instruments. The expansion is additionally affected by totally different environmental factors that don't seem to be specifically identified for each region, that the method wants careful attention consequently. The simple technique of fatty acids extraction and separation of biodiesel is that the mixing technique on tiny or experimental scale. It is conjointly necessary to grasp concerning the cultivation unit of the protist cultivation, whether or not it's sensible to settle on the closed system or open system. The method either batch or continuous is confirmed depending on the conditions and facilities, together with pH, temperature, form of protist metal money and therefore the quantity of protist biomass. Gather techniques square measure finalized primarily based on the placement and conditions .Most favorable harvesting techniques recommended square measure supported sinking lake or sedimentation tank. Density and wetness adjustment is needed during the entire method of biodiesel production. The drying technique largely used is spray drying, drum drying was conjointly suggested. The disruption method through mechanical handlings is considered the foremost favorable. The opposite necessities square measure the employment of solvents like dissolving agent and plant product square measure needed for active process. Ultrasound and microwave-based extraction strategies will also be of profit if different sources don't seem to be obtainable.

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Emmanuel et al. (2009) researched about production of biodiesel by trans esterification of pre-extracted oils with an alcohol in the presence of a catalyst to generate the fatty acid methyl/ethyl esters. Microbial biomass present in activated sludge contains lipid compounds which are used in biodiesel feedstock. The activated sludge sample was concentrated by gravity-settling and the supernatant was discarded , the settled solids were after 24hr .The freeze-dried activated sludge was pulverized using mortar and pestle, homogenized, and stored in the freezer .Polymerization fatty acids and their derivatives was and highest percentage biodiesel yield was obtained at 55 ◦C.

2. VEGETABLE OIL

Waste preparation vegetable oil was collected from restaurants and street victuals sellers in national capital town that has been used for food cookery. These waste vegetable oil was settled for 4−6 days at temperature and pressure and later filtered by sieves of hole size 100nm to get rid of any suspended food particles and inorganic residues and followed by heating at 110°C for water removal. CaO Nano catalyst was ready by thermal decomposition methodology following the procedure of Zhen-Xing Tang and David Claveau. 81 g of calcium nitrate tetra hydrate (Ca (NO3)2.4H2O) was dissolved in twenty five cubic centimeter of antifreeze answer and a pair of. Sodium hydroxide was side into on top of mixture underneath vigorous stirring. So as to induce uniform size nanoparticles, after it's been stirred for certain minutes, the gel answer was unbroken regarding 5 hours at static state. It had been washed using H2O followed by vacuum drying. Finally, different sizes of CaO nano-particles were obtained after calcination at 500°C. Biodiesel is made from triglycerides within the presence of alcohol with catalyst through transesterifcation reaction. The biodiesel production from waste vegetable oil with methyl alcohol within the presence of nano-sized quicklime . Nano-catalyst was done at a laboratory scale. Transesterifcation reaction is administered in a flask with overall volume of 300ml flask was placed on a hot plate equipped with a controlled magnetic stirrer and temperature sensing element. Waste vegetable oil was preheated to the specified reaction temperature before methyl alcohol and therefore the catalyst was added into the reaction flask. The calculated quantity of methyl alcohol to grease magnitude relation was poured into the reactor. 100ml of waste vegetable oil was side and temperature of the mixture was set from 35-70°C. Transesterifcation proceeded underneath continuous stirring of the reaction mixture for a desired period. All transesterifcation reactions were carried out at gas pressure with stirring speed of 1500 revolutions per minute. Thermometer was inserted into the flask to watch the reaction temperature. Once the completion of the reaction, the mixture was transferred into a separating funnel and allowed to square long. Three phases were formed thanks to the solid catalyst and glycerin is denser than biodiesel. The separated biodiesel was heated on top of the boil.
Bora et. al. (2019) researched about bio-oil production from sludge through transformation compounds into less complicated molecules pyrolysis solid, gasified and oil pyrolysis to get biodiesel-like oil, or waste sludge transformation oils from the municipal waste pre-digested sludge derived oil than the common vegetable oil-derived biodiesel, different fuel sludge derived oil features a half-hour lower price than the standard petro diesel waste sludge. Diesel obtained from sewerage sludge that is in terms of energy and economic potency. Pyrolysis will manufacture completely different product like solid chemical element reproduce bio-oil from waste sludge and it needs temperature, the biodiesel yield was determined to be reduced.

3. SEWAGE SLUDGE

Biofuels are made from many different sources such as manure, waste from crops, other by products, algae and plants grown specifically for the fuel. The burning of coal and oil increases the temperature and causes global warming. Sulfur is naturally present as an impurity in fossil fuels. To reduce air pollution and emission from vehicles , this compound is also use in acid rain , decrease oil lubricating property Sulphur is removed by treating it with an alkaline solution sodium plumbite , treat gas is used (hydrogen and by product) . To control friction and wear of the surface in contact of the bodies biofuel has high boiling point and low freezing point . Lubrication property of biofuel is very high. It has high flash point than commercial diesel which is greater than 93.3 °C. It can be used as a substitute of petroleum diesel.
Badrolnizam et al. (2019) used the hydrothermal liquefaction (HTL) process for conversion of sewage sludge to bio fuel using ultra-pure water solvent. Hydrothermal liquefaction of sewage sludge were investigated at different temperatures (250°C, 300°C, 350°C and 400°C) and 1 hour reaction time. It was observed that HTL process was efficient than pyrolysis as it can utilize wet biomass, thus produce a bio-oil that contains about twice density of pyrolysis oil. During HTL process sewage sludge was treated by using biological treatment technology. The collected sludge sample was first dewatered and dried in an oven at 105°C for 2 hours to ensure complete removal of water content in the sample. HTL experiments were carried out in a 10 ml stainless steel (SS316) batch reactor at reaction temperature (250°C, 300°C, 350°C and 400°C). For each experiment 5 ml extra-pure water was poured into the bomb reactor. The assembled bomb reactor was placed in the carbolated furnace and heated at the desired temperature for 1 hour. Both solid and liquid phases obtained were separated by using Dichloromethane as washing solvent. Product obtained was analyzed by using CHNS/O elemental analyzer(determining the percentage of Carbon, Hydrogen, Nitrogen, Sulphur and Oxygen of organic compounds) which revealed the bio oil composition. It was observed that significant bio-oils yield of around 52% was obtained using ultra-pure water as a solvent at temperature of 350°C and one hour reaction time. It was found that bio oils produced at this temperature was dominated with ester based compounds compared to bio-oils obtained at 250°C, 300°C and 400°C.

III. STEPS INVOLVED TO MAKE BIOFUEL FROM SLUDGE

A. SLUDGE AVAILABILITY

A production plant with a capability of around 4000 tons/year of biodiesel created from primary waste sludge was studied. The capability of the facility can depend on the waste sludge accessibility. In this sense, a close-by urban waste water treatment plant (WWTP) to feed 60 m3/h of primary waste sludge was considered. This set-up will eliminate the cost of transporting the sludge feedstock into the biodiesel production facility, which wasn't taken under consideration within the economic study in addition because the price of raw sludge, that may be a waste generated throughout treatment of waste. The planned method aims to enhance the biodiesel production from sewage sludge.
Bora et al. (2019) collected sewage sludge from the waste water treatment plant (WWTP) is a heterogeneous mixture of different undigested organic materials, microorganisms, oils, fats, inorganic materials and moisture . Municipal sewage sludge (MSS) is gaining worldwide attention as it is an abundant organic waste and contains a significant amount of lipids, which can make biodiesel production from sewage sludge .The primary sludge is the combination of solids materials and floating grease while the secondary sludge or activated sludge contains primarily microbial cells and suspended solids.

B. SLUDGE COLLECTION AND HANDLING

Primary, secondary and integrated sludge's were collected from the municipal WWTP with a capability to daily 167 MLD. Wherever these differing types of sludge's are generated. Primary sludge was collected when partial gravity thickening. Secondary sludge, made by an activated sludge method was collected when partial thickening by flotation integrated sludge was collected when the mixture of primary and secondary at a magnitude relation of 65:35, v/v. The collected sludge's were straightaway keep at 4 °C prior to use. As a result of the sludge properties may well be modified throughout long storage time, recent sludge was forever used for every experiment. The matter utilized in anaerobic digestion tests was sludge collected from a hemophilic anaerobic sterilizer within the same facility.
Zakaria et al. (2015) investigated the production of sewage sludge increase drastically .The current disposal methods will cause environmental issues such as air, water and land pollution. Thermochemical conversion of sewage sludge into energy had used. The sample of treated sewage sludge was collected from the sewage treatment plant and wet sewage sludge will dried using thermal dryer for dewatering process. This dryer had 240kW burner to supply heat to evaporate the moisture in sludge. After completing the drying process, dried samples were analyzed using ultimate analysis, proximate analysis. Hydrothermal (HTL), as direct liquefaction was the thermochemical conversion of biomass into liquid fuels by processing in hot, pressurized water with enough time to breakdown solid bio polymeric structure into mainly liquids components.
Jarde et al. (2005) characterized sewage sludge's from food-processing, paper-mill, and domestic wastewater treatment plants. The lipid organic fraction containing 48 sewage sludge's that originated from wastewater-treatment plants was characterized by gas chromatography coupled with mass spectrometer (GC-MS). Domestic sludge's contains linear alkyl benzenes (LABs), sterols in food-processing and domestic sludge's. Paper-mill sludge's are characterized by the specific distribution of n-alkanes. They concluded that fatty acids in the range C10 − C18 are predominant in the polar fraction (separated by 1:1 by volume dichloromethane/methanol) of the extracts, regardless of the origin of the sludge. This study defines an average organic composition typical of each group of sewage sludge's.

C. SLUDGE DRYING

According to customary methodology, sludge was dried by victimization magnesium sulfate hydrate however while not previous activity. Using the documented methodology, the sludge sample was thought of as completely dried. Freeze-drying methodology was conducted by victimization the tactic bestowed elsewhere. At first; sludge was centrifuged so allowed to freeze for two days at −20 °C. Afterwards, the frozen sludge was freeze-dried in an automatic vacuum freeze appliance for two days. In the sun drying methodology, the sludge sample was left outside for 10 days, wherever the temperature was within the vary of 25–35 °C. Drying beneath fume hood was performed supported the tactic presented elsewhere .The sludge was first centrifuged so put in a very fume hood for four days at close temperature. Approximately five hundred cc of sludge was used for the drying procedures, except for the quality methodology. In any case drying strategies, sludge was crushed to fine particles to work out the ultimate wet content, 1 gm crushed sludge was placed in Associate in Nursing kitchen appliance at 105 °C and dried till reaching constant weight.
Drying of primary, secondary and integrated sludge's by customary method. The sludges were dried victimization sulfate hydrate according to plain methodology with previous activity. The reference methodology was used for a comparison study to a completely unique liquid–liquid extraction from acidified liquid sludge. Effect of sludge drying methodology time water content before treatment (%), weight before sludge drying (kg) , water content when treatment (%) ,weight when sludge drying (kg) .

D. EXTRACTION OF LIPIDS FROM DRIED SLUDGE

The extraction when drying was administrated in a Soxhlet equipment using paraffin as a solvent in step with customary methodology .After extraction, the paraffin was removed employing a rotary evaporator at 40 °C beneath vacuum at 50 mbar. Then, the remnant macromolecule fraction was stored in a very desiccator long and weighed following day to work out the extraction yield.
Sequential liquid–liquid extraction of lipids was performed in a very batch mixer–settler reactor with mechanical agitation (330 rpm), at ambient temperature, victimization paraffin as solvent and 200 cc of sludge. The result of previous sludge activity to hydrogen ion concentration was evaluated. This hydrogen ion concentration was earned by the addition of roughly 3 cc of concentrated HCl to the sample of 200 cc of sludge.
The mechanical sinking was performed at 60 revolutions per minute for 15 min for primary and blended sludge's and for 30 min for secondary sludge. At each extraction stage, the paraffin section was filtered employing a employing a paper in order to eliminate the remaining solid particles so dried over anhydrous sulfate. Later, paraffin was removed employing a rotary evaporator at 40 °C beneath vacuum at 50 mbar and reused for the consecutive stage. Lipids were kept in a very desiccator long and weighed the next day to work out the extraction yield.
Oils/fats from vegetables and animals have too high viscosity compared with petroleum-based diesel and cannot be used in existing diesel engines due to ignition problems or engine starve of fuel at low temperatures .
However, there are some other properties that also may influence the quality of FAMEs as an alternative fuel, such as cetane number (CN), oxidative stability, cloud point (CP), pour point (PP), cold filter plugging point (CFPP) .The biodiesel must satisfy low temperature (CP, PP and CFPP) operability to avoid wax formation which may lead to engine starve of fuel due to reduced fuel flow.
The fuel quality and properties of biodiesel must meet at certain specifications to be counted and be used as a fuel .Parameters such as air, antioxidants and peroxides may affect the oxidative stability of the biodiesel during storage, which in the end also affect the fuel quality by Marjan Bozaghian (2014).
Melero et al. (2012)studied Zr-SBA-15 to show a high catalytic performance within the in-situ process of wet sludge and thus the energetic requirements for the pre-treatment of the first sludge may be the primary. The results demonstrate that the treatment

may be an additional economical approach in terms of FAME yield for the catalytic chemical method for production of biodiesel from primary sewage sludge that is probably resulting in an additional efficient and environmentally sustainable process, at a similar method the maximum amount because the lipids extraction and transformation into FAME are performed.

Sonia & Pawan (2020) researched that daily generated sewage sludge having more than 65% oil which utilized to form biodiesel. Biodiesel was produced through trans esterification of vegetable oil and animal fat with alcohol in presence of catalyst Fatty Acid Methyl Esters (FAMEs). Sewage sludge obtained from municipal wastewater contains 30 % of lipids. Primary Sludge produced through mechanical treatment on wastewater and collected. At fecal, screening take placed and wastewater was transferred to grease and grit removal from the bottom of primary settler. Activated sludge was tested during aerobic biological treatment .Secondary clarifier sent material for filtration and after that chlorination takes placed .After thickening, remainder of secondary sludge, was mixed with thickened primary sludge and a blend with by-product after wastewater treatment. Sludge samples were dried and oil was extracted. Organic solvents used to extract lipids from Sewage sludge. The extracted lipid was converted to biodiesel by Tran's esterification reaction. Strong base used in Tran's esterification reaction which operated at 50 ° c - 60 °c. Higher temperature increased rate of reaction. Triglycerides treated with methanol to form biodiesel and glycerol. Glycerol was heavy and settled down quickly this way biodiesel get separated. This conversion obtained in 60 – 90 min. This paper reviewed the various lipid extraction techniques and biodiesel production processes from municipal wastewater sludge.

Frkova et al. (2020) has been predicted the assessment of the production of biodiesel from urban wastewater by derived lipids. European market provided 3×10^4 tons activated sludge and 414×10^4 tons grease trap sludge used for extraction of biodiesel. Primary sludge was yielded with the highest methanol and activated sludge composed of microorganisms contains metabolic synthesis of lipids, oleaginous microorganisms (OMO) have been found to accumulate lipid. Sludge dewatering was the primary step for 3 possible routes .Trans esterification was preferred method among all the routes include direct use and blending of raw oils, micro-emulsions and thermal cracking. A combination of mechanical dewatering and thermal drying techniques applied. After dewatering, lipid extraction from the dry sewage sludge using organic solvents (such as n-hexane) or supercritical CO_2 take place. Solvent was removed from the extracted lipid fraction and lipids have been converted into biodiesel by direct esterification or trans esterification of triglycerides and free fatty acids. In situ trans esterification, addition of solvent for lipid extraction and the catalyst for tran's esterification took simultaneously. FAME (fatty acid of methyl esters) was removed by solid-liquid separation followed by phase separation. In thermo-catalytic reforming accepted sewage sludge with a 30% of water content .Hydrogen rich syngas, bio-oil and bio-char produced during this process route .This study addresses to promote sustainable development wastewater sewage sludge has a high potential as a possible feedstock lipid yields and productivity.

Jiaxin et al. (2020) researched about pretreatments for enhancing sewage sludge reduction and reuse in lipid production. Pre-treatments broke down complex materials in sludge which increased the release of total nitrogen (TN) and total phosphorus (TP) from solids. The lipid Content was obtained in the fermentation with ultra-sonication pre-treatment sludge, and the sludge reduction. Wastewater was collected and treated by activated sludge process, biofilm process, or membrane bioreactor process in the wastewater treatment Plants. Sewage sludge (5–8 tones sludge with 80% water content) recovered and stored at 4 °C. Lipid sample was centrifuged at 6500 rpm for 15 min. The remaining solids were dried at 80 °C for 24 h and transferred to 50 mL solvent-proof tubes. Carbon recovery accomplished through direct extraction or converting it to value-added products from sludge. Mentation of sludge increased lipid content and enhance sludge reduction .Biodiesel produced from lipid accumulated by sludge fermentation. 50 ml of sludge was filtered containing solid which was dried at 105 ºC till weight constant. 30 mL of the mixture of chloroform and methanol were added into the tube and then continuously shaken for 12 h. This study is pointed to achieve high lipid production from sludge and high sludge reduction.

Abdissa (2021) demonstrated the oil extraction process from blended sludge and algae for biodiesel production by using lipid extraction method. The process was carried out in three different sections extraction, evaporation and trans esterification section. Experiment was carried out by using both experimental and numerical data analysis methods. 10L sludge sample containing 90% of the moisture and, 10L algae sample containing 95% of the moisture, were collected from the oxidation ponds. The sludge and algae samples were dried in the sun for the 3days. Proximate analysis was used for characterizing blended sample of sewage sludge and algae. Soxhlet apparatus was used to extract lipid components, followed by analyzing the quality of the extracted lipid. Equal proportion of dried sludge and algae was dried and blended. The dried blended sample (20g) was then added to thimble. Then, 200ml of hexane, ethanol, and methanol were added into a 250ml round bottom flask respectively. Heating process was carried out at different temperatures (70, 75, and 80) with different extraction time (4, 5, and 6 hrs.). The solvent was removed from the flask by a rotary evaporator after the lipid had been extracted. The test result shows that different parameters change the product (oil yield). The maximum oil yield was obtained 61% at the temperature of 80ºC, the retention time of 6hrs, and with hexane solvent. Oil was efficiently extracted from blended sludge by using hexane as solvent than methanol and ethanol

E. ANAEROBIC DIGESTION OF LIPID-EXTRACTED SLUDGE

The residual paraffin was removed employing a rotary evaporator at 40 °C beneath vacuum at 50 mbar. The sludge was anaerobically digestible at 33 °C beneath mesophilic conditions .Lipid extracted sludge (LES) and gaseous lipid-extracted sludge (ELES) were digestible so as to judge the impact of the remaining solvent on biogas production. Anaerobic digestion check was conducted in 120 cc blood serum bottles in triplicate. Digestible sludge was used as inoculum and, though acclimatization isn't strictly needed, an anaerobic semi-continuous plant was set to adapt matter to a lot of stable temperature, 33 °C. Substrate to matter ratio was mounted to zero.5:1 in a VS base. Deionized water was additional to reach a final volume of 80 cc and also the reactors were closed with a septum an Al crimp. Finally, the reactors were purged with element to assure an aerobic conditions and placed into a kitchen appliance at 33 °C. Blank assays were ready while not substrate addition, and its biogas production was deducted from the reactors fed with the substrates. Biogas production was volumetrically measured by liquid displacement. The experiment was thought of completed when 25 days, when biogas production was negligible. Each alkane series and carbon dioxide was quantified, and also the results were expressed as alkane series percentage in a very 2 element mixture. Volatile fatty acids (VFAs) were analyzed within the soluble section by gas chromatography employing a flame-ionization detector (GC-FID).

Due to the predominance of saturated fatty acid within the sludge lipids, the results of FFA content were expressed as comparable to saturated fatty acid. The lipids were reborn into FAMEs (biodiesel) through acid catalyzed esterification / trans esterification employing a changed version of Christi's technique i.e., with solvent rather than dissolvent. This technique was chosen due to the high quantity of FFAs within the sludge lipoid fraction. For the calibration of the strategy, a 37 part FAME normal mixture was used. The results of the GC-FID were wont to estimate the quantity of saponifiable (esterifiable) material within the lipoid fraction and therefore the mass of biodiesel (FAMEs) that might yield. Moreover, only a few suspended solid catalysts square measure removed by settling it for 2 to a few days then the biodiesel, specific gravity, water and sediment, total acidity, ash content, sulfur content, Flash purpose and Cloud purpose were checked in line with the yank society for Testing and Materials.

Manyuchi et al. (2017) studied that the potential to totally exploit sewage sludge as a material for bio fermentation alcohol a supply of bio fuel was investigated. Sewage sludge product was initial created by introducing Bacillus flexus so as for scarification to require place before fermenting to bio fermentation alcohol using yeast. Then the product was ready for fermentation by introducing 10 g/L of organic compound, a pair of g/L of KH_2PO_4(Potassium Dihydrogen Phosphate) and one g/L of $MgSO_4$. Afterwards, fermentation was allowed to require place at varying PH, temperature, incubation time and yeast concentrations. Bio ethanol concentrations were characterized its chemistry properties analyzed by normal strategies. Sewage sludge is a material for production of bio ethanol that may be a sensible alternative to fossil fuels. High bio ethanol yields of up to 60 mL/L in amount of 10 days, with associate degree operational temperature of 30 °C. Bio ethanol that is sewage the quality bio fuel was obtained. The conversion of sewerage sludge to bio ethanol promotes each energy potential for developing countries also as waste.

Glaucia et al. (2017) researched and took advantage of the residual sludge generated in sewage treatment plants (STP) for production of bio-oil fuel in order to apply it in thermoelectric plants by reducing the impacts on power generation. The sewage sludge was subjected to the process of pyrolysis in a fixed-bed reactor for the production of bio-oil. The thermochemical processes are considered one of the most promising ways in order to recover the potential energy through the products obtained from the sewage sludge. Among the thermochemical processes, pyrolysis is the thermal decomposition carried out in the absence of oxygen, producing four fractions: aqueous liquid, organic liquid (bio-oil), solid and gaseous. The potential use of the digested sludge as an alternative source of fuel in power generation through the pyrolysis process, integrating the sustainable use of renewable resources with the rational and efficient use of energy as well, producing a biofuel, called bio-oil green, which features chemical and physicochemical characteristics similar to petroleum products (diesel) and perform studies of blends with diesel fuel for future replacement in thermoelectric plants is characterized and assessed.

Zuzana et al. (2020) derived the assessment of the production of biodiesel from urban wastewater-derived Lipids. It aims to provide up-to-date knowledge on the existing reuse of lipids from urban wastewater to produce biodiesel. Water content of the sludge has to be reduced by combination of mechanical dewatering and vacuum drying 60 °C, 100 mbar, to reach approximately 20–30% solid matter. Lipid extraction from the sewage sludge using organic solvents then solvent is removed from the extracted lipid fraction by distillation and the lipids are converted into biodiesel by direct esterification or trans esterification of triglycerides and free fatty acids The alkali reaction catalyzed by NaOH, KOH, carbonates requires a low operating temperature to achieved high conversion .

Mondala et al. (2009) determined the effect of three process parameters (reaction temperature, methanol loading, and catalyst concentration) on the yield of biodiesel from primary and secondary sludge's obtained from a municipal wastewater treatment plant. In situ procedure was utilized with n-hexane as co-solvent. During investigation , two levels of temperature (50 and 75 ◦C), two levels of methanol to sludge ratio (8 : 1 and 12 : 1 weight/weight, which correspond to 10 : 1 and 15 : 1 volume/weight, respectively), and two levels of sulfuric acid concentration (1 and 5% volume/volume) were studied. It concluded that, the biodiesel yield is affected by independent effects of the three investigated process parameters for the secondary or activated sludge. Also, maximum yield of 2.5% was obtained at 75 ◦C, 5% (v/v) sulfuric acid, and 12: 1 methanol to sludge ratio. Results of kinetic experiments showed that for the secondary sludge, reaction completion was achieved after 24 h reaction time.

F. TRANSESTERIFICATION

Transesterification is a chemical action used for the conversion of triglycerides (fats) contained in oils, (Feedstocks) into usable biodiesel. Biodiesel made by the method of transesterification contains an abundant low viscousness, making this biodiesel capable of replacement crude oil diesel in diesel engines.

Bora et al. (2019) demonstrated transesterification or the alcoholysis is that the reaction of triglyceride (C14-C20) present in lipid sources with primary alcohols (C1-C2) with or without the presence of the catalyst. In different words, this reaction may be described because the reaction of the acyloxy (alkoxy promoiety) group of associate ester compound with another alcohol. The essential transesterification reaction is pictured in described one showing the production of biodiesel having alcohol because the main by-product . The reaction is consisting of a series of reversible reactions wherever triglyceride reacts with the primary alcohol and gets regenerate to diglyceride followed by monoglyceride and glycerol in the consecutive steps. The transesterification reaction is thermodynamically reversible in nature. Stoichiometrically excess quantity of the alcohol ought to be used to shift the equilibrium thus on maximize the ester yield. The primary alcohol utilized in this reaction could be a major feedstock; methyl alcohol and ethanol are being extensively used. Methyl alcohol is a lot of desirable because of its characteristics viz. high reactivity, property, interference of saponification, favorable physicochemical properties and no formation of an azeotrope with water which makes it simply recoverable within the purification step of biodiesel production. Although the toxicity level of alcohol is appreciably under that of methyl alcohol, the previous one is absorbent , which could be a negative characteristic for considering it as a chemical for the transesterification reaction because it can enhance the soap forming aspect reaction that leads to decrease of the biodiesel yield .

Olkiewicz et al. (2014) demonstrated a consecutive liquid-liquid extraction method employing a batch mixer-settler reactor considering hexane because the organic phase at ambient temperature. There are 3 kinds of sludge generated in WWTPs were tested. It had been determined that primary sludge contains great amount of lipids compared with secondary and blended sludge. Sludge was dried with 5 completely different strategies. Moisture from the sludge was removed efficiently using sulphate hydrate. Consecutive liquid-liquid extraction of lipids was performed in batch mixer-settler reactor with mechanical agitation (330 rpm), at ambient temperature using hexane as solvent. The sequent steps consisting 3 stages exhibited a rise within the efficiency in the lipid extraction. The lipid extraction potency from primary sludge was found to be exaggerated with acidic treatment before normal drying methodology using MgSO4•H2O. However the acidic treatment was ineffective for the secondary sludge and blended sludge.

Dufreche et al. (2007) obtained biodiesel yield from activated sludge using different extraction procedures. They tested accelerated solvent extraction (ASE) using different organic solvents, supercritical CO2 extraction, and in situ trans esterification. The highest yield of biodiesel (6.23% of dry sludge) given by the in situ trans esterification extraction procedure. It gives the reagents that have access to all lipids in the feedstock.

Melero et al. (2015) investigated completely 2 different approaches for the assembly of biodiesel from glycerides and free fatty acids (FFAs) extracted from sewage sludge. The primary one could be a two-step method consisting of organic solvent extraction followed by acid-catalyzed esterification trans-esterification of the isolated oil fraction. The other could be a one-step direct transformation contains the extraction and conversion of the lipid fraction contained within the waste sludge at the same time. A heterogeneous acid Zr-SBA-15 catalyst has been utilized in each condition. Within the two-step extraction–reaction method, conversion about to 90th of the saponifiable fraction (including FFAs and glycerides) was found. Catalytic tests were performed by two-steps extraction–reaction and in-situ methodology. It shows that the catalytic activity displayed by Zr-SBA-15 was outstanding in both steps extraction–reaction technique and also the in-situ methodology.

Choi et al. (2019) formulated characterization and recovery of in Situ transesterifiable lipids as potential biofuel feedstock from sewage sludge obtained from Sewage treatment Plants. Primary sludge had a more consistent and higher lipid content than waste activated sludge. The sludge samples transferred to the laboratory refrigerator, and then analyzed for water content, total solids, and volatile solids and these samples dried at 65 ◦C for 90 h and stored in a desiccator to keep the water content below 5%. Lipids were separated from the chloroform using a rotary evaporator. 25 g of sludge sample (dried weight) was placed into a volumetric flask together with 250 mL of methanol solution and n-hexane (100 mL) was added as co-solvent. Mixture was heated at 55◦C and the solvent was recirculating through a condenser on top of the flask for 8 hr. Cooled and settled mixture was carefully taken through a separator funnel. The top layer represented transesterifiable lipids including fatty acid methyl esters (FAMEs), the middle layer included water-soluble by-products, such as glycerol and residual methanol, and the bottom layer represented insoluble solids. After washing step, the solvent was evaporated using a rotary evaporator at 50 ◦C under vacuum conditions to collect the final product which was crude biodiesel.

IV. ANALYSIS METHODS

Olkiewicz et al. (2014) due to the predominance of palmitic acid within the sludge lipids, the results of FFA content were expressed as equivalent to palmitic acid. The lipids were converted into FAMEs (biodiesel) through acid catalysed esterification/transesterification employing a changed version of Christi's methodology i.e., with hexane rather than toluene. This methodology was chosen as a result of the high quantity of FFAs within the sludge lipid fraction. The results of the GC-FID were accustomed estimate the quantity of saponifiable (esterifiable) material within the macromolecule fraction and hence the most mass of biodiesel (FAMEs) that might yield. The compounds which may not be known by GC-FID are given as others.

Badrolnizam et al. (2019) analyzed Sewage sludge conversion via hydrothermal liquefaction (HTL). The sludge sample dewatered and dried in an oven at 105°C for 2 hours to remove water content in the sample and Dichloromethane was used as a solvent. Hydrothermal liquefaction was carried out in a 10 ml stainless steel batch reactor at reaction different temperature. For each experiment 5 ml ultra-pure water was poured into the bomb reactor which was placed in the carbolite furnace and after it put down in cold water bath. Solid product collected on the whatman filter was dried at 105°C in an oven the liquid product (Dichloromethane and water) collected in separator funnel which was separated from the solid using the filtration apparatus. Organic fraction was evaporated in a rotary evaporator to extract dichloromethane from the bio-oils product.

V. CONCLUSION

The improvement of the lipid oil extraction method from the blending sludge and algae. Therefore, lipid-rich wastes like algae and sludge are the answer to such a problem by extracting oil compositions (lipids) for biodiesel production. During this study, the method parameters improvement like time, temperature and solvents were performed to urge the best oil yield. About 60% of oil yield was extracted from blending sludge and algae at a temperature of 80ºC, exploitation hexane solvent associated an extraction time of 6 hours. During this study, lipid (non-edible oil) was extracted from the blending sludge and algae for this purpose. This lipid oil that is extracted from sludge and algae is used for biodiesel production.

Municipal waste product sludge is instantly accessible and could be a potential supply of lipid for biodiesel production. The analysis of free fatty acid content within the lipid extracted from primary sewage sludge disclosed that the composition of free fatty acid was dominated by monounsaturated fatty acid. Solvent selection, sludge to solvent quantitative relation, extraction time, temperature and solvent recovery area unit among the factors that have an effect on lipid extraction potency and value. Optimization of those factors is important for economical lipid extraction.

The biodiesel productivity of sewage sludge is often improved by increasing the lipid recovery efficiency. Sewage sludge with a definite level of lipid content has been thought of as a biodiesel feedstock. After lipid extraction, the created solid residue tends to decrease the carbon content by changing the volatile matter and carbon content into lipid content. However there are few challenges for biodiesel production from sludge, lipid extraction from sludge is pricey and needs massive volume of organic solvents and therefore the quantity of lipid depends on the sources and sort of sludge. The elaborate techno-economic study indicates that the proposed biodiesel production method from liquid primary sludge is economically possible and cheaper than alternatives from dry sludge. The municipal sludge features a massive potential as a cost-competitive, plentiful and non-edible feedstock for biodiesel production.

ABBREVIATIONS

HTL – Hydrothermal Liquefaction
FOG – fat, oil, gas
OECD – Organization for fish processing factories.
CPCB – Central pollution control board
FFA – Free carboxylic acid
LES – lipid extracted sludge
ELES – Gaseous lipid extracted sludge
VFAs – Volatile fatty acids
GC-FID – Gas Chromatography employing a flame-ionization detector
FAMEs – Fatty acids of methyl esters
WWTPs – Waste water treatment plants
STP – sewage treatment plant
OMO – Oleaginous Microorganisms
GC-MS – Gas chromatography coupled with mass spectrometer
LABs – Linear alkyl benzene
ASE – Accelerated solvent extraction

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