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Production of Biofuels by Sewage Sludge

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Abstract

Globally, biofuels are produced from the agricultural sources or biomass which contains higher feed stock material and agricultural component. These sources are used as a good source for the good yield of biofuels that results to higher energy production. These biomasses comprised of various organic chemicals which are processed for production like sugars, starch and hydrocarbons components. Industrial, agricultural and domestic wastes are treated and converted to biosolids or sewage sludge, which contains a diversity of organic chemicals in different ranges. Organic chemicals like hydrocarbons, alkanes, alcohols, esters, ethers, various amines, and isomers of compounds were studied in the sewage sludge. As with the variety of sewage sludge it might be used for the production of fuels for energy production. Studies and discussions in the way to use sewage sludge give the assumption for the alternative's sources or biomass for the production of biofuel.

Keywords- Biofuels, Microorganism, Biomass, Sewage sludge.

1. Introduction

Fossil fuels like coal and oil have a good role in energy production for the humanity's in recent history, these energy sources have oil-fired up a lot of society's development and industrialization. Biofuels square measure renewable liquid and gassy fuels made by the living organism or from the wastes that they manufacture. organism diversity plays an important role within the production of biofuels. Advanced biofuel production can scale back the dependency on fossil fuels and limit the impact on the atmosphere. Production of biofuels from edible crops square measure known as ancient, or first- generation biofuels. Biofuels square measure the venerable alternative of fuel consumption thanks to their renewability property, biodegradability and generation of acceptable quality exhaust gas. (1). Biofuel made through yeast and bacterium by fermentation of some organic compounds. waste matter as contains high variability of chemical composition egg- high concentration of compound, biogenic parts and serious metals. (2). this text consisted the studies that elements that square measure gift in waste matter sludge may be used for the expansion of organism that results in the assembly of biofuel.

2. Classification of biofuels

Biofuels square measure classifying as primary and secondary biofuels. Primary biofuels used as unprocessed type for heating, preparation or electricity production like fuel woods, wood chips, etc. The secondary biofuels square measure made from processed biomass e.g., ethanol, biodiesel, DME, etc. which will be used for numerous industrial functions and for vehicles. These secondary biofuels additional divided into 1st, second and third generation biofuels on the idea of stuff and technology used for production.

Biofuels on in keeping with the viability of sources square measure classified and kind as they will be derived from forest, agricultural or piscary product or municipal wastes, conjointly enclosed by-products and wastes originated from agro-bussiness, food business and food services. Biofuels will be employed in all the 3 matter states as solid like fuel wood, charcoal, and wood pellets, or liquid like plant product, biodiesel and transmutation oils, or gassy like biogas (methane).

2.1. Primary biofuels vs secondary biofuels

Primary biofuels square measure unprocessed and natural biomass like fuel, wood chips and pellets, and square measure normally those wherever the organic material is used primarily in its natural and non-modified chemical type. These primary fuels square measure directly combusted typically to provide preparation fuel, heating or electricity production that required in small- and large-scale industrial application. Secondary fuels square measure modifications of primary fuels, that are made and processed within the variety of solids (e.g., charcoal), or liquids (e.g., ethanol, biodiesel and bio-oil), or gases (e.g., biogas, artificial gas and hydrogen). Secondary fuels will be used for numerous ranges if applications, as well as extreme temperature industrial processes and for transport. additional advancement and economical conversion technologies exist for the extraction od biofuels in solid, liquid and gassy type - from material like wood crops and waste matter.

3. Biofuel production

Researches on biofuels are done mainly to replace the conventual fuel such as petrol and diesel as these fuels increasing the risk factors that influenced the pollution. Most of the researches for the biofuels are going in the way for leading to liquid biofuel production. A recent classification for biofuel includes 'First generation' and 'second generation' biofuels (4) and the distinction between them is the feed stock used. Some work is also under the progress for production of 'third generation' of biofuels. (5).

3.1. First generation biofuels

The first-generation biofuels are the type of fuels which are generally produced from sugars, grains or seeds (6-16) and requires simple process to produce full finished fuel product. The most common and well-known first-generation biofuel is ethanol that is made by fermenting sugars extracted from crop plants and starch contained in maize kernels or other starchy crops. (4). Bioethanol is produced from the organic matter with high contents of sugars fermentation by the enzymes produced from yeast. Six carbon sugars converted to ethanol by the yeast because starch is much easier than cellulose to convert the glucose. The sugar of raw material separated out after the process of fermentation and use of yeast to convert the glucose into ethanol. Process of distillation and dehydration are used as the last steps for reaching the desired concentration that can be used directly as fuel or blended with fossil fuels. Hydrolysis is used for converting the starches into glucose, when grains are used as raw material. (17).

Another well-known first-generation biofuel are biodiesel which are produced from straight vegetable oils of oleaginous plant by transesterification processes or cracking. Transesterification process can be used alkaline, acid or enzymatic catalyzers and ethanol or methanol and produced fatty acid (biodiesel) and by-product as glycerin. (18). For biodiesel production processes small fraction of the plant biomass is used and left a large fraction of residues.

3.2. Second generation biofuels

Two fundamental different approaches are there for production of second generations biofuels i.e., biological and thermochemical processing, from agricultural lignocellulosic biomass, which are either non-edible residues of food crops production or non-edible plant biomass (e.g., grasses or trees especially grown for production of energy). The important advantage of the production of the second-generation biofuels from non-edible feed stocks is that it limits the food versus fuel competition that is highly associated in first generation biofuels. Breeding of feed stocks involved in process of energy production, enabling higher production per unit land area, and a large amount of above ground plant material can be converted and used to produce biofuels and this will further increase land use efficiency compared to first generation biofuels. Characteristics of feed stock hold potential for cost problems, and significant energy and environment benefits for majority of second generations biofuels. (4).

The production of second-generation biofuel requires most cumbersome processing production equipment, investment per unit of production and large-scale facilities to confine and critical capital cost scale economics. (19). Future aspect of production of ethanol is expected to include both use of traditional grain and sugar crops and lignocellulosic biomass feed stocks. (19-22). Second generation biofuel can also be classified in terms of the process and method used to convert biomass to fuel i.e., biochemical and thermochemical. Some second-generation biofuel such as ethanol and butanol produced through biochemical processes, where as other second-generation biofuels are produced by thermochemical processes. Fuels by thermochemical processes include methanol, refined Fischer Tropic liquids (FTL), and dimethyl ether (DME) and unrefined fuels required refining process for utilization. (4).

Thermochemical biomass conversion involved for processing require much extreme temperature and pressure than those founded for biochemical systems. Some essential characteristics that differentiate the thermochemical process from biochemical process, including the amount of feed stocks that can be accommodated with thermochemical processing and diversity of biofuel production. (23). Production of biofuels by thermochemical process begins with gasification or pyrolysis. FTL, a mixture of straight chained hydrocarbons compounds that resembles to semi-refined crude oil, that refined on site into clean diesel, jet fuel or other products. (23). FTL is synthesized by the catalytic reaction by Carbon monoxide and hydrogen so that any feed stock that can be converted to produce carbon monoxide and hydrogen, can be used for production for FTL. Lower cost of feed material and use of non-edible biomass promoted for the second-generation biofuels.

3.3. Third generation biofuels

This is the latest generation of biofuels where researches are directing the attention to past agricultural substrates and waste vegetable oils to microscopic organisms. Therefore, on the basis of current researches, studies on technical progression, third generation biofuels are derived from microbes and microalgae are considered as a viable source for energy production.

3.3.1. Biofuel from microbes

Many advances showed that microbial species such as yeast, fungi and microalgae can be used as important source for production of biofuels as these microorganisms can biosynthesize and store a large amount of fatty acid in their biomasses. (24). Study reported on microbial oil production from waste rice straw and can be produced from sulphury acid treated rice straw hydroxylate (SARSH) by the cultivation of Trichopteran Ferments microorganism. (25). Without detoxification process the fermentation of SARSH gave a poor lipid yield. Detoxification pretreatment process, including over liming, concentration and adsorption by Amberlite XAD-4 improved the functioning of SARSH. Process of pretreatment increases the lipid yield but removing the inhibitors in SARSH. Deferments was also founded that these are capable of metabolizing other sugars such as mannose, galactose or cellobiose, available in hydroxylates of many other natural lignocellulosic materials used as single carbon source. This organism grows and utilizes rice straw hydrolysates to accommodate lipid within its cell biomass with ahigh yield. Deferments can be used as promising strain for microbial oil production.

Another study reported on production of microbial biofuel from waste molasses and reported that lipid produced in microbial biomass utilized for biodiesel production. (26). In these studies, optimization of the growth medium components for culture cultivation and effects of culture condition on microbial biomass and production of lipid by Deferments microbial strain. Peptone, glucose and other 163 are founded for good yield of lipid as provides good source of carbon and nitrogen. Deferments could be cultivated in the medium consists of waste molasses from sugar industry as it requires 15-20% of sugar concentration for the lipid yield. (26).

Lipid accumulation with in the microbial cells could be enhanced by adding variety of sugars to pretreated molasses and content of lipid was increased as high as 50% of cell mass. (27-28). The microbial lipid is similar to vegetable oils, contained palmitic, stearic, oleic and linolenic acid with the unsaturated fatty acid that amounts for 64% of total fatty acid content.

Ability of growth of yeast on pretreated lignocellulosic biomass could efficiently enhance the accumulation of lipid, and provides a promising option for production of economically and environment dedicated microbial oil from agricultural residues.

3.3.2. Biofuel from algae

Algae are one of the eldest life forms, and presents in all existing ecosystems and represents a variety of species living in wide range of environmental conditions. (29). Under normal growth conditions phototrophic algae absorb sunlight, assimilation of carbon dioxide from air and nutrients from aquatic habitats. (30). Large amount of lipids, proteins and carbohydrates can produce by microalgae in short period of time and these products can be processed to valuable products and in biofuel production. (30). Lipid, protein and carbohydrate production may be limited by available sunlight due to diurnal cycles and the seasonal variations.

Carbon dioxide can be fixed by microalgae from three different sources, viz. atmosphere, discharge gases and soluble carbonates. (31). Under natural growth conditions, assimilations of carbon dioxide by microalgae from the air and can tolerate and utilize high level of carbon dioxide. (32). In common production units, carbon dioxide is fed to algal growth medium either from external sources such as power plants or in the form of soluble carbonates. (33). For algal production, other inorganic nutrients are required includes nitrogen, phosphorus and silicon. (34). Fixation of carbon dioxide by algae has been proposed as a method of removing carbon dioxide from flue gases from power plants and used to reduce emission of greenhouse gases. Many algae or rich in oil, as algal cells found to be enriched with oil globules, which can be converted to biodiesel. (5).

Algae production mechanism phototrophic, heterotrophic and mixotrophic are in use, which all follow the natural growth processes. Photoautotrophic production is autotrophic photosynthetic processes, heterotrophic production requires organic substances e.g., glucose to stimulate growth, and some algae can combine both autotrophic and heterotrophic assimilations of organic compounds in mixotrophic processes. (35). Many microalgae strains have high lipid content and it can be enhanced by optimization of growth determining factor. (32).

Studies demonstrated that algae, when starved forms a suitable source of nitrogen, that produced mainly oil, and in the presence of sunlight algae produces sugars and proteins from carbon dioxide sources. Chlorella prototheorids microalgae when grown under autotrophic and heterotrophic conditions leads to accumulations of lipids, which can be used for production of biodiesel. Nitrogen limitation is most effective method of improving microalgae lipid accumulation of lipids, but results in change of lipid composition from free fatty acid to triacylglycerol (TAG) and these TAG useful for conversion to biodiesel. (36).

Technologies of conversion for utilizing microalgae biomass separated into two basic categories thermochemical and biochemical conversion. Thermal decompositions of organic components to fuel products covers into thermochemical conversion such as direct combustion, gasification, thermochemical liquification and pyrolysis. (37). Energy conversion of biomass into other fuels covers into biological processes which includes anaerobic digestion, alcoholic fermentation and photobiological hydrogen production. (38).

Algae that efficient for oil production should be able to accumulate more than 30% of their cell weights in oils. Microbial cells are like fuel factories and manufacture compounds naturally, which chemically similar to petroleum-based fuels. Specific algae strains of Chlamydomonas synthesized some hydrocarbons, but at large extent produce triacyl glycerides.

3.4. Syngas production

Biomass gasification to produce syngas provides simple precursors carbon monoxide and hydrogen for fermentation. Coupling of gasification with fermentation, the adaptability the acetogenic bacteria reduce the requirements of gas cleaning and adjusted by water gas shift reaction required for catalytic conversion of syngas. (39). In a study, discussed that a fixed bed, a circulating fluidized bed (CFB) and entrained flow gasifiers, preference for CFB for biomass and entrained flow for liquids and solids are easily pulverized. (40). For syngas production, in gasification chamber the low pressure and high temperature promotes carbon monoxide and hydrogen formation and reduce higher molecular weight hydrocarbons in syngas produced. (41).

Biomass which contains nitrogen, sulfur, chlorine and other constituents' elements, with additional complex hydrocarbons structures, such as aromatics that decompose slowly in gasification. These compounds remain in syngas product as nitrogen and other minor components like ammonia, hydrogen sulfides and tars. (42). Residual hydrocarbon tars can foul orifices and acts as inhibitors to fermentation with chemical species produced during combustion like hydrogen cyanide, chemical species like ammonia, carbonyl sulfides and hydrogen sulfide can be used as nutrient components for growth of acetogenic bacteria.

Conversion of carbon monoxide, hydrogen and carbon dioxide from biomass in acetic acid derive from acetogenic bacteria. (43). Intermediate metabolites acetyl CoA is converted to synthesized cell mass and complex chemicals and yields organic acid and alcohols, most likely acetic acid and ethanol. Energy for synthesis of cell mass supplied by production acetic acid, including lipids, proteins and other complex cell components from simple inorganic gas substances. Basis of the biofuel production is the ability of some acetogens to reduce organic acid to alcohols, particularly acetic acid to ethanol.

3.5. Chemical composition of biomass

For the production of biofuels natural biomass which consists agricultural waste material, agricultural products, food grains oil seeds, etc. are used. In the different generations of biofuels various diversity of biomass consumed, as in first generation fuels generated by sugar or grain seeds. (6). Sugarcanes, maize kennels, oleaginous seeds, etc., agricultural products are used for the production of first-generation biofuels. Sugarcane bagasse contained an average of 41% of cellulose, 25% of hemicellulose and 20.3% of lignin. (44). These are the sugars which after the fermentation processed produced a specific amount of ethanol. Maize kennels, seeds, grains and many other starchy (4) crops which contains a polysaccharide that consists numerous glucose unit joined by glycosidic bond and produce biofuel by the fermentation process. Mainly the polysaccharide and saccharide components are founded to be used as a major compound for the production of liquid fuel (ethanol) or first-generation biofuel. Oils of oleaginous plants are used to produce biodiesel by transesterification reaction which is chemical conversion of triacyl glycerides with alcohols into alkyl esters with the help of a catalyst. Vegetable oil which are based on triacyl glycerides consists of three fatty acid linked to one glycerol meiotic. All the studies towards the biofuel production suggested that the biomass that are used for production mainly consists of organic compounds, hydrocarbon chains, sugar units and some of the microbial products which are also related to organic products for the production of biofuels in every generation of production.

3.6. Challenges to biomass

Main challenge is the section of feed stock is the collection network to reach the appropriate stock, storage facilities and the process of storage of stocks and the main is that the fuel-food competition. Several challenges to the production of biofuels leads to the rise in the production cost. The production of first-generation biofuel is always a matter of discussion as it makes conflict with the food supply. (5). Utilization of small fraction of total plant biomass also effect the land use efficiency. Expansion of global biofuel production from sugar, grains and oil seeds crops has also raised the cost of food stuffs and crops. Utilization of total above-ground biomass in the second-generation biofuel production provides better land use efficiency than first generation biofuel. Crops such as corn, sugarcane, palm and soyabeans are being used in production of biofuel, then the dispute arises that if these crops are used for food or for biofuel production. Problems and challenges mainly arise by first generation biofuels as in this generation food crops are used but in case of second generation where the renewable and non-edible sources are used which somehow solved the problem of food and fuel competition. But there will always a discussion about the use of crops and land efficiency in production of biofuels. Many researches are being directed to find the new sources for the production of biofuel.

4. Sewage sludge as biomass

Sewage sludge is the residual, semi-solid material produced during treatment of sewages of industrial or municipal water. Sewage and waste water treatment used to generate biosolids also known as treated sewage sludge. Sewage sludge defined as stabilized organic solids derived from sewage treatment process (resulting from biological treatment of wastewater) and that can be managed safely to be used as soil conditioning, energy or other values. (45). Waste water and sewage treatment plant receive sewage material from domestic, agricultural and industrial sources. Large objects, scum, grit is removed in grit chamber and rest takes to sedimentary tank for the production of primary sludge. Mainly primary sludge contains fecal solids and further treatment are performed for the biosolids production. For the production of biosolids, waste water and sewage treatment plant use various techniques such as activated sludge method, thickening (i.e., flotation, gravity, centrifugation), digestion (i.e., anaerobic and aerobic digestion), dewatering, heating or drying techniques and beta and gamma ray irradiation process. Nutrients and organic matter are the sewage sludges can provide soil benefits, contaminants in these sludges also contains metal, pathogens and organic pollutants.

4.1. Chemical composition

Many reviewed literatures and official ground reports used to compile the data for knowledge regarding the presence and concentration of organic chemicals in sewage sludges. The chemicals grouped into classes and varies in the ranges of concentration. The organic chemical found in various forms but mainly founded in the isomeric compounds. There are various organic chemicals that are founded in the sewage sludge such as, acrylonitrile which consists vinyl group linked to nitrile and this is used for making plastics and chemicals, and also for pesticides. (47). Various derivatives of butane which is a gas at room temperature and highly flammable, butanol is a type of alcohol and butanone is a ketone group that is founded. (48). Volatile chemical such as carbon disulfides also found at some content in the sewage sludge. (48). Hydrocarbons like ethane, ethylene and its isomers are also found to be present in a low concentration. (49). Methane which is already in use as the natural gas for cooking and other purposes also founded. (50). Various isomers of propane and chlorinated propane are seen to be there in the mixture of chemicals. (48,49). Flame retardants such as brominated diphenyl ethers are also founded in low concentration in the mixture. (51). Autophony which is a simple's aromatic ketones and used as a fragrance agent and as a flavoring agent is come to knowledge after the analysis. (48). Benzene derivatives like benzoic acid, benzyl alcohols found to be present in the sewage sludges or from biosolids obtained after the treatment process of sewage. (48). Carcinogenic compounds like nitroimines and its derivatives are also present in low trace in mixture. (52). Small trace of xylene founded in the mixture content. (53). Isomers of phenol compounds such as phenol choro methyl, phenol nitro and other derivatives constitute some content in mixture of various chemicals in sewage material (56). Polynuclear aromatic hydrocarbons such as naphthene, anthracene are presents in total content. (54). Various sterols such as sitosterol, cholesterol, estrone and many other derivatives of sterols are founded in the sewage sludge chemical mixture. (55). Esters like phosphate esters and its derivatives at some context founded in the mixture that also involve in rising of chemical residues in sewage sludge (49). Availability of various chemicals in sewage sludges gives opportunities to produce various useful productions.

4.2. Experimentation

Traditionally, production of biofuels done from the biomass or feed stock from agricultural products using various methods such as fermentation, transesterification and other various process. Agricultural biomass contains simple sugars and starch material which was directly converted to alcohol formation such as ethanol which is used as biofuel and other lipid compounds was came into the use.

Mainly many of the biofuels are present in form of alcohols. Sewage sludge contains various alkenes, ethers, esters and many other chemical. For the chemicals like alkanes are used to produce alcohols by the process i.e., halogenation process in which halogens are added to alkanes then these halogenated alkanes then heated by KOH and then the halogenated alkanes transformed to alcohols. Some amount of carboxylic acid is present but the carboxylic acid when treated with aluminum hydride which is reducing agent may be used for the conversion of carboxylic acid to alcohols. Chemicals like acetophenone may also likely to converted into alcohols such as benzoic acid which may further converted to alcohols. Conversion of acetophenone is occurred by the reaction of alkaline medium such as NaOH and KOH to form sodium benzoate and then to the benzoic acid. Variety of ethers which are presents in sewage sludge, when treated with strong acid in presence of nucleophile, can be cleaved to alcohols. Transesterification of the esters founded in the form of various fatty acids which may be used for petroleum product.

Microbes like Deferments which traditionally use sugar content for lipid production (26) but instead of sugar sewage sludge contains many hydrocarbons which may be used as a constituent for the production of lipid production. Hydrocarbons, alkanes, alcohols derivatives, and other chemicals will also be used as the stock material for the growth of microalgae and may give rise to the production of oil glaciers. Many chemicals such as aromatic hydrocarbons, organic halides, etc. in the sewage sludge can be composed by the process of gasification. Acetogens also used for the decompositions of organic chemicals for production of various useful gases.

5. Result and Discussion

A large number of organic chemicals are reviewed under the sewage that are produced after the treatment of waste water, organic wastes and domestic wastes. Sewage sludge are largely consisted of hydrocarbon compounds. Most of the alkane's compounds founded in the chemical mixture, ethane by the process of halogenation and treatment with the KOH converted to the ethanol which will directly use as a biofuel. The process of halogenation repeated with the others alkanes such as butane and propane which also converted to butanol and propanol which also contains the property of ignition and also flammable, these alcohol products will be used directly and may be blended with the other products that are already in use. Small trace of benzoic acid founded in the sewage sludge; this acid contains low values of usage for fuels so this benzoic acid converted to phenol by the reaction of acid with aluminum hydride. Phenols are also the flammable products and will be used for biofuels for vehicles and industrial use. Acetophenone was also founded and by the reaction with oxidizing agent like NaOH and KOH forms sodium benzoate and then forms benzoic acid which directly by the treatment aluminum hydride converted to the phenols. Ethers such as brominated diphenyl ethers which are flame retardant (51) founded and also by the reaction of these ethers with strong acid in presence of nucleophile leads to cleavage of ethers and forms various forms of alcohols which might be used as product for fuel. Diverse variety of phosphate esters (49) was also founded that can be changed to useful products by the process transesterification that results to production of fatty acid i.e., biodiesel or can be used as other petroleum products. Aromatic hydrocarbons (54) also used for the production of syngas by the process of gasification, which will used for the cooking and other industrial process. Other hydrocarbons, aromatic compounds also used by the various microorganism in the third-generation production which may leads to the products that used as biofuel. Organic chemicals that were founded in sewage sludge might be used for the production of biofuel.

6. Conclusion

Fuel production, consumption and its environmental issues always being a debatable issue among the society. In place of fossil fuels biofuels comes in consideration to fulfill the demand of the fuels. Agricultural products, feed stocks or biomass are used for the production of the biofuels. Microbes that she used for biofuel production also consumes organic feed material. Biofuel production by these agricultural products affect the cost efficiency and also affects the land use.

Instead of using feed stocks or agricultural products, treated sewage sludge will be used for the production of biofuel. As sewage sludge contains a high amount of organic chemicals. These chemicals might be taken in use for production of biofuels and syngas. By the use of various chemical processing techniques or chemical reaction these organic chemicals processed for the production of fuel component.

This article gives the future aspect for the production of biofuel from the organic chemical of sewage sludge. Sewage sludge uses, will help in reduction of waste product and advancement in the biofuel production. Challenges reducing the use of feed stocks may reduce from the use of sewage sludge material. Uses of sewage sludge foe biofuel production will makes a new way for development and technology in the field of fuels.

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