A REVIEW ON ROLE OF BIOMASS IN PRODUCTION OF GLOBAL RENEWABLE BIOENERGY

O EVALUARE A ROLULUI BIOMASEI ÎN PRODUCȚIA DE BIOENERGIE REGENERABILĂ LA NIVEL MONDIAL

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Abstract: *Global energy demand is growing rapidly. Biomass for energy can play a pivotal role. Energy from biomass can decrease greenhouse gas emissions. Biomass is a solid, non-hazardous cellulosic material made from plant material farmed for fuel, solid wood and agricultural waste. This review outlines different types of biomass used for bioenergy production. It includes the classification, roles and recent studies of biofuels. The role of bioenergy in agricultural sector, as wastewater is an abundant supply of microorganism nutrients; its role in producing bioenergy is discussed. The efficiency of water for development, global scenario of biofuels is discussed in this review.*

Key words: *Bio diesel, Bioenergy, Biofuels, Biomass, Lignocellulose and Waste water*

Rezumat: *Cererea globală de energie crește rapid. Biomasa pentru energie poate juca un rol esențial. Energia din biomasă poate reduce emisiile de gaze cu efect de seră. Biomasa este un material celulozic solid, nepericulos, obținut din material vegetal cultivat pentru combustibil, lemn masiv și deșeuri agricole. Această analiză prezintă diferite tipuri de biomasă utilizate pentru producerea de bioenergie. Include clasificarea, rolurile și studiile recente ale biocombustibililor. Rolul bioenergiei în sectorul agricol, întrucât apele uzate reprezintă o sursă abundentă de nutrienți pentru microorganisme; se discută rolul său în producerea de bioenergie. Eficiența apei pentru dezvoltare, scenariul global al biocombustibililor este discutată în această revizuire.*

Cuvinte cheie: Biomotorină, Bioenergie, Biocombustibili, Biomasă, Lignoceluloză și Ape uzate

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1. Introduction

The bioenergy is produced by various technologies [1]. These methods are categorized into physico-chemical, bio-chemical and thermo-chemical methods. The feedstock, environmental factors and production related factors influences bioenergy production. Energy, heat, fuels and chemicals of commercial significance are products of biomass.

The physicochemical conversions include trans-esterification in which plants and vegetable oils are converted into biodiesel [2], [3]. The bio-chemical method includes anaerobic digestion as well as fermentation. Combustion, pyrolysis, gasification and liquefaction are thermal conversion processes. Thermo chemical methods were proven to be efficient than any other methods as they are capable of converting all types of biomass into bioenergy [4].Biomass is a flexible source of energy that can be converted into fuel that is solid, liquid, or gaseous [5]. Globally, biomass provides around 10% of the total primary energy supply. Worldwide usage, current status, and future scope of bioenergy and biofuels were studied and reported. By 2050 bioenergy will account for 30% of total needed energy of world [6].

Energy generation through biomass attains sustainable development globally. Biomass eliminates the harmful gas emission, enhances carbon sequestration, and produces useful by products such as in concrete Industry. The novel outlook on the usage of biomass also arises as the consequence of industry adopting this sort of energy. Knowledge of biomass resources such as agriculture waste, waste water, aquatic weeds, microorganisms and feed stocks is essential for their effective utilization and generation of biofuels.

2. Biofuels

Biofuels may be conventional oils and advanced oils according to the technologies used to produce them and their respective maturity. Conventional biofuels uses food crops for their production [7]. They have mature and established production technology and are currently being produced on a commercial scale. These biofuels include sugarcane ethanol, starch-based ethanol, biodiesel, fatty acid methyl ester (FAME) and straight vegetable oil (SVO) (Fig 1).

First Generation

These are generated from well-established, traditional processes. They are collected from plant seeds and grains. An example of this form of biofuel is bioethanol obtained from sugar cane as well as sugar beet and corn and so on [8] .

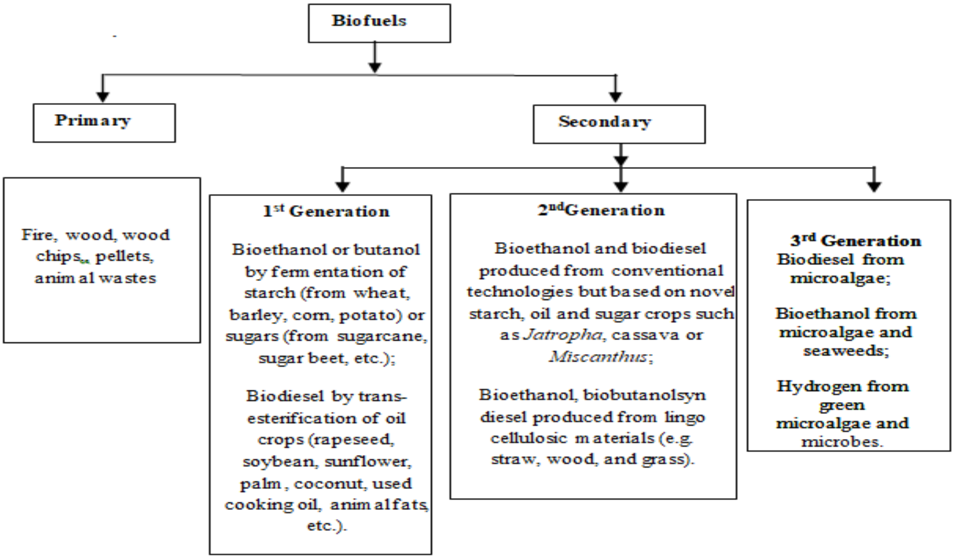

Figure 1. Classification of biofuel

Second generation

These are derived from non-edible food crop residues such as corn or rice husks, or non-edible whole plant biomass such as grasses or energy-specific trees. They are either produced using biochemical or thermo-chemical methods.

Third generation

These are from non-arable soil. These have a precursor to fuel, for example vegetable oil. Algae are the most diversified source for third generation biofuels.

Fourth generation

These are grown from non-arable soil and do not require biomass destruction. It technology aims to turn usable solar energy directly to fuel using inexhaustible, low-cost, and widely available tools. Photo-biological solar and electro-fuels are further researched in this group.

2.1. Substrates for Production of Biofuels

Mainly there are three substrates for biofuel productions which include carbohydrate rich biomaterial, oil rich biomaterial and agriculture waste as shown in Table 1.

Jatropha oil is a vegetable oil and produced from *Jatropha curcas* seeds. After oil extraction, the residual cake can be again processed to get biomass feedstock. The Mahua flower chosen for ethanol production through submerged fermentation was found to be an efficient strategy. By using waste of coconut biodiesel was produced and it is low cast and abundant [9]. Oleaginous yeast, *Wicker hamomyces anomalus* EC28 [10] was tested towards lipid production from different agro industrial wastes like wastewater from baking industries, diary industries and waste frying oils. Waste frying oils from frying fish, potato and meat were tested for lipid production for biodiesel. Cooking oil from waste is food source from seafood restaurants and treated with methanol for biodiesel production. Pine cones are generally a waste used for the creation of bioethanol. Moroccan waste fish oil is utilized as crude material for biodiesel extraction. Garlic industry produces abundant quantities of waste which could be exploited for further industrial purpose as biofuel and bio adsorbents for wastewater treatment. The compositional extent of shoot biomass of *sorghum bicolor* was investigated, which is used in biofuel production [11].

Due to their high oil content (10 factors higher) and quicker cultivation times (4 fold less than standard oil-producing terrestrial plants, such as soybean, maize, and Jatropha), microalgae and cyanobacteria are viable sources of biodiesel. An oleaginous microorganism which produces single cell oils (SCO) can be used as substrates for biofuel production. *Gordonia* sp. and *R. opacus* are known to accumulate 80% oil under optimal conditions with the biomass generated by them only 1.88 g/l. In recent years, few safe (GRAS) organisms such as *Bacillus licheniformis, Paenibacillus polymyxa*, and *B. amyloliquefaciens* have been isolated for 2, 3-butandiol (2, 3-BD) production [12].

Bio oil delivered from macroalgae *Gracilaria gracilis* and *Cladophora glomerata* utilizes the aqueous liquefaction (HLT) process. Currently various methods for converting algae to biofuels, biodiesel, syngas, biogas, and bioethanol were reported. The most significant hindrances in this field are in scalability, stabilizing production processes, and operating costs.

Table 1. **Microorganisms and feedstock's used for biofuel production**

Substrate	Microorganism	Lipid yields (g lipid /g biomass)
Glucose derived from maize starch hydrolysate	*Mortierella alpine*	0.33-0.36
Glucose	*Bacillus subtilis*	-
Glucose, fructose, sucrose	*Thamnidium elegance*	-

Table 1 (continued)

Substrate	Microorganism	Lipid yields (g lipid /g biomass)
Molasses	*Candida lipolytica*	0.16-0.60
	Candida tropicalis	0.12-0.46
	Rhodotorula mucilaginosa	0.39-0.69
Glycerol	*Mortierella alpine*	0.05-0.33
Crude glycerol	*Cryptococcus curvatus*	0.44-0.52
Rice hull hydrolysate	*Mortierella isabellina*	0.64
Cassava starch hydrolysate	*Rhodosporidium toruloides*	0.63
Corncobs	*Trichosporon dermantis*	0.17
Rice straw hydrolysate	*Trichosporon fermentans*	0.04
Wheat straw	*Cryptococcus curvatus*	0.05
Distillery waste water	*Rhodotorula glutinis*	0.25
	Cryptococcus curvatus	0.27
	Lipomyces starkeyi	0.32-0.35
Waste cooking oil	*Yarrowia lipolytica*	0.17-0.55

2.2. Bio ethanol production

Bio ethanol is produced either from sugar or starch (Fig 2). Bioethanol is a biofuel produced from alcoholic fermentation of crops like sugar cane or beet, corn, wheat, rye, or cassava. Bio ethanol also produced by using Cheese whey or grain straw [13].

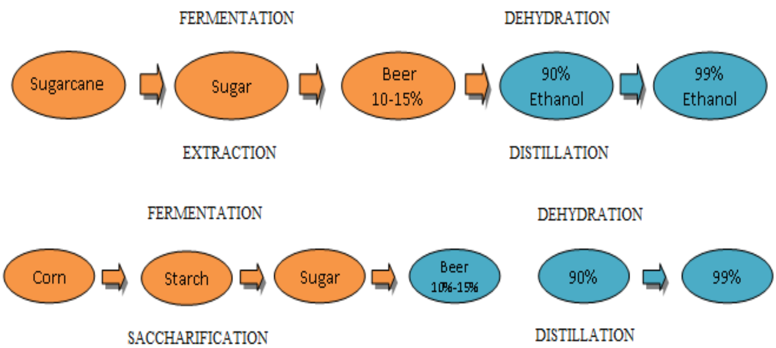

Figure 2. Sugar-based and starch based bio ethanol production process

It is possible to produce both ethanol and additional effluents in combined saccharification and maturation process, with the latter being available as feed of animal origin or in the processing of biogas demonstrated the independence of vitality of a 100 ha natural residence, based on bioethanol and biogas extraction [14]. A comparative system

(Oleskowicz-Popie) techno-financial analysis shows the requirement for up scaling in size of a bio-treatment facility delivering bioethanol and biogas so as to lessen manufacturing costs. The extracts of sweet sorghum were inspected for bioethanol extraction which can additionally improve the vitality yield of the harvest. Cellulosic waste of cassava (*Mani hot esculenta*) was used to make bioethanol [15].

The findings showed that the mixture of enzymatic and corrosive hydrolysis recovered a significant proportion of starch and cellulose relative to the use of both. The juice taken out from the sugar stalks maize crossover and the sugar maize juice (SCJ)'s ability to fill as a tool for extraction of bioethanol and bio butanol via microbial maturation was evaluated [16].

The most suitable conditions for enzymatic hydrolysis and aging of steam-detonated rural banana squanders (rachis and pseudo stem) have been identified to achieve glucose fixation at the saccharification stage of up to 100 g / L and last ethanol concentration of up to 40 g / L at maturation stage [17].

2.3. Advanced biofuels

Advanced biofuels used for the transport sector which is largely dependent on the gasoline. A variety of liquid and gaseous biofuels could be produced from the lingo cellulosic biomass including methanol, ethanol, hydrogen, dimethyl esters, fischer-tropsch diesel, and bio synthetic natural gas (SNG) which is shown in table 2.

Table 2. **Types of advanced biofuels**

Biofuels	Advantage	Disadvantages
Methanol	Biodegradable	The problems of cold start; toxic; harmful to soil's microorganisms.
Ethanol	Biodegradable; lesser problem of cold start; up to 22 % alcohol blend doesn‘t need engine modification	Multiple filters needed for removing the dirt from ethanol
Hydrogen	Low NO_2 emissions; fuel economy is high	Needed engine modifications; transport, distribution and storage is risky and expensive
Synthetic diesel (Fischer-Tropsch diesel)	High cetane number; same as conventional diesel; directly usable in present engines	-
Biodiesel	Biodegradable; similar to diesel; non-toxic; no emission of sulphur and aromatic compounds	Cold start problem; Highly volatile (maximum 5 months shelf life)

Table 2 (continued)

Biofuels	Advantage	Disadvantages
Dimethyl ether (DME)	Higher fuel efficiency and lower emissions; not toxic for man; non- carcinogenic.	-
Synthetic Natural Gas (SNG)	Biodegradable; clean burning	-

2.4. Biofuels from lignocelluloses biomass

Currently lignocellulose bioconversion is achieved in four significant stages, viz. pre-treatment, hydrolysis, ripening and removal / refinement to recover bioenergy/biofuels and buildups.

Pretreatment

The methods of pretreatments are divided into chemical, physical or biological. Physical pre-treatments incorporate techniques of mechanical communication, processing, and ultrasound, just like light irradiation. Chemical methods of pre-treatment include explosion of ammonia fiber (AFEX), treatment of organosolv and application of either acid or alkali. The acid is used as a catalyst, usually H_2SO_4, aims at dissolving hemicellulose with lignin and cellulose remaining as solids, while the addition of alkali, typically NaOH, targets mainly lignin, leaving mainly cellulose with hemicelluloses. By using microorganism's pre-treatment biological method design the material with lignocelluloses [18]. Structured a successive, combinatorial lignocellulose pre-treatment system for microbial biofuel system developed to eliminate the effect of microbial inhibitors and moreover increment in sugar yields [19].

Hydrolysis

It may be namely, acid and enzymatic hydrolysis. Dilute or concentrated acid, typically H_2SO_4 because it is the least expensive, is used in this procedure to hydrolyse the cellulose, and the reaction temperatures depend from the molarity; dilute acids need higher temperatures (over 200^{o}C), whereas concentrated acids need lower temperatures. The acid hydrolysis approaches are less alluring because of low yields with weaken corrosive and the recuperation and ecological components engaged with utilization of concentrated acids**.** In enzymatic hydrolysis, the lignocellulose is separated into the relating monomeric sugars by specific catalysts created from microorganisms or organisms [20].

Fermentation

The third stage of bioconversion, fermentation, transforms hydro lysates, primarily glucose, xylose, arabinose and mannose, into bioethanol using microorganisms. Successive hydrolysis and fermentation regulates the process independently, despite the fact that it can bring about the utilization of a lot of enzymes, for example, glucosidase during the hydrolysis causing this an expensive procedure. Acidogenic anaerobic fermentation was investigated for the creation of bioethanol and unsaturated fats got from sugar plant. Lignocellulosic substrates such as hardwood (birch), and soft wood (spruce, pine, etc.), agri residues are also employed [21].

Bio oil

Bio oil is produced by quick pyrolysis. It is a multi-part blend of various size atoms got from the depolymerisation and of cellulose, hemicelluloses, and lignin [22]. It is used as fuel in burners. The standard of bio oil relies on the sort and nature of the feedstock (counting soil and dampness content), natural nitrogen or protein substance of the feedstock, amount of heat, time and temperature of fumes in the response, proficiency of the char expulsion framework and the condensation mechanism [23]. It is utilized as fluid smoke wood flavors and burning fuel in diesel motors/turbines for power generation [24].

Biodiesel

It is manufactured by the trans esterification of the fats and vegetable oils by the addition of either methanol or other alcohols. The final product of this process includes biodiesel and glycerin. (Fig. 3). Vegetable oils and animal fats are used as reactants with an alcohol along with catalyst to produce an alternative biofuel, biodiesel and glycerol as by-product (Fig 4).

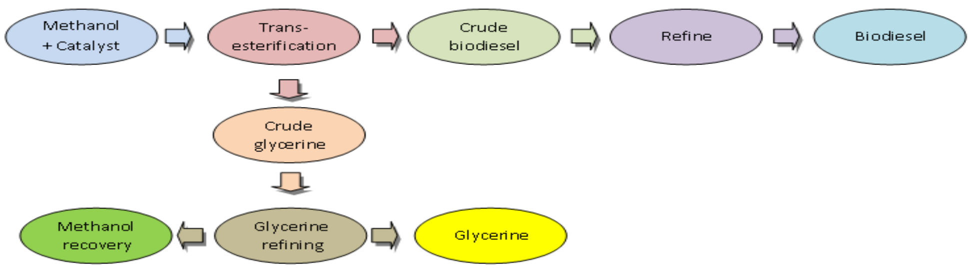

Figure 3. Biodiesel production process.

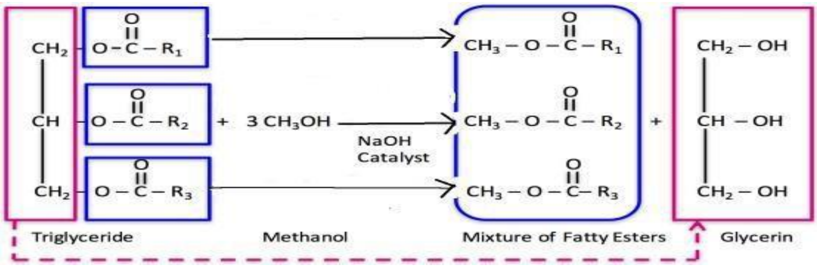

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Figure 4: Trans esterification reaction (Kanakdande AP and Khobragade CN 2018).

Biodiesel is generated by three strategies: 1) Homogeneous 2) Heterogeneous 3) Non-catalytic transesterification.

In biodiesel production from vegetable oil, calcined sodium silicate (CSS) was employed as catalyst. Biodiesel production was studied in a micro device. In this technique, sunflower oil is employed and NaOH as a base catalyst. Calcium oxide catalysts was designed by sol-gel method with different Ca^{2+} concentrations (X =1.0, 1.5, 2.0 M) and studied by using XRD and N_2 adsorption-desorption analysis [25], [26].

In addition to the catalyst designing for biodiesel production, many researchers used byproduct i.e. glycerol obtained after trans esterification reaction. Glycerol has applications in pharmaceuticals, cosmaceutics, food grade, petroleum byproducts like surfactants etc. Crude glycerol is produced as by-product of biodiesel. Ii is the only carbon source employed for lipids production from *Rhodotorula glutinis* TISTR 5159, red yeast [27].

Methyl esters biodiesel from vegetable oils and sunflower and, swine lard were prepared. All these methyl ester are added to mineral diesel to prepare different blends of biodiesel, i.e., B5 and B50. The properties of these blends such as flash points were determined by comparing with the pure diesel and the pure biodiesel. *Cyprinus carpio* fish wastes were utilized for the generation of biodiesel [28]. The fatty acid chain length present in *Cyprinuscarpi*o fish ranges from 12 C to l8, 18C fatty acids as the major fatty acids of 51.94%. Rohu (Labeorohita) fish processing waste were explored for biodiesel production [29]. Physicochemical features have shown that biodiesel quality is feasible and meets the standard fuel properties Biodiesel production was done with the use of sunflower, corn, olive, or mixed waste cooking oils at two stages of degradation [30].

2.5. Bioenergy in agriculture

Among different agricultural waste biomass, rice straw and wheat straw are mainly provided by Asia, while America is the major producer of corn straw and bagasse. In India, rice straw is one of the most abundant lignocellulose wastes which are mainly used as domestic fuel and as fuel to run the boilers. In north Indian region, mainly Punjab and Haryana, post harvesting residue of rice crop is generally burnt in the field which adversely affects the nutritional quality of soil and human health [31].

Anaerobic Digestion

Anaerobic digestion of agricultural biomass generates a gaseous fuel containing varying amounts of methane [32]. Biogas technology has been developed to treat sewage, wastewater, and human excrement in both urban and rural areas. Consequently, the proportion of high-energy biomass (e.g. maize and grass silage) will significantly increase to nearly half of the total biomass production [33]. Through integrated biogas systems, increasing agricultural production yields and quality may also significantly increase the profitability of the overall organic farm system [34].

Woody Biomass

Wood is the ancient bioenergy source. In temperate areas, trees such as willow, poplar, or alder are grown. In the tropical area Acacia sp., *Gmelina arborea*, or *Paraserianthes falcataria* are grown [35]. The tree strips act as multifunctional countryside components that provide ecosystem service and other benefits [36].

Oil Plants

Oil plants are especially suited for straight vegetable oil (SVO). In organic forming mixed oil plant has capable of produce between 4.5 and 11.5 times the amount of locomotive energy needed for one hectare. Through transesterification, fatty acid methyl ester (FAME) (or biodiesel) is derived from oil plants.

2.6. Bioenergy from waste water

Waste water contains a variety of inorganic and organic chemicals; therefore, employing microbial fuel cells (MFC) to produce electrical energy from waste water could provide an affordable solution to the problem of environmental pollution and the current energy crisis in the near future [37]. As indicated in Table 3, a variety of wastewaters, including household and wastewaters from the food and beverage industry, are used to produce H_2 [38].

Packed bed reactors (PBR), anaerobic fluidized bed reactors (AFBR), anaerobic baffled reactors (ABR), membrane bioreactor (MBR) and up flow anaerobic sludge blanket (UASB) reactors are some of the commonly used high rate modifications of batch reactor for H_2 production [39], [40].

In another study, single-chamber air cathode microbial fuel cells with a working volume of 120 mL were designed to treat food waste collected from the Harbin institute of technology student canteen in Harbin, China [41].

Table 3. **Sources and types of waste water used for hydrogen production**

Substrate	**Type of bioreactor**	**Inoculum**
Glucose and cheese whey	AFBR	Poultry slaughterhouse sludge
Cheese processing wastewater	CSTR	Anaerobic digester sludge
Cheese whey	Batch	Anaerobic sludge
Tapioca wastewater	ABR	Anaerobic mixed cultures
Sugar beet wastewater	CSTR	Anaerobic digested sludge
Sugary wastewater	CSTR	Municipal sewage treatment sludge
Sugarcane vinasse	AFBR	Swine wastewater treatment sludge
Sugarcane vinasse	APBR	Natural wastewater fermentation
Molasses	Batch	Soil
Molasses wastewater	CMISR	Municipal wastewater treatment sludge
Rice mill wastewater	Batch	*Enterobacter aerogenes* RM 08
Rice winery wastewater	PBR	Acclimated sludge
Noodle Manufacturing	CSTR	Anaerobic digested sludge
Crude glycerol	UASB	Seafood wastewater treatment sludge
Coffee drink wastewater	UASB	Anaerobic sludge
Beverage industry wastewater	CSABR	Municipal wastewater treatment sludge
Beverage industry wastewater	CSTR	Compost
Sugarcane vinasse	AFBR	Swine wastewater treatment sludge
Dairy industry wastewater	Batch	*Enterobacter aerogenes* MTCC 8100
Cassava ethanol wastewater	Batch	Mixed H_2 producing bacteria
Cassava wastewater	AFBR	Swine wastewater treatment sludge
Biodiesel wastewater	ASBR	Activated sludge from biodiesel plant

(*Note:* ABR anaerobic baffled reactor, AFBR anaerobic fluidized batch reactor, APBR acidogenic packed bed reactor, APBR anaerobic packed bed reactor, ASBR anaerobic sequencing batch reactor, CMISR continuous mixed immobilized sludge reactor, CMTR continuous multiple tube reactor, CSABR continuously stirred anaerobic bioreactor, CSTR completely-stirred tank reactor, UASB up flow anaerobic sludge blanket reactor).

2.7. Aquatic weeds

Aquatic weeds are grown in water habitat and leads to serious ecological damage once they get introduced in an aquatic ecosystem. *Eichhornia crassipes*, *Pistia stratiotes*, *Salvinia molesta* and *Alternanthera philoxeroides* are commonly used in India, these are primary hydrophytic plants.

These hydrophytic plants can be used as a bioenergy feedstock since they are naturally growing plants with a quick growth rate [42]. Aquatic weeds contain large amounts of cellulose, hemicellulose, and low amounts of starch with lignin content (Table 4).

Table 4. **Composition of various Aquatic weeds**

Aquatic weeds	**Cellulose (%)**	**Hemicellulose (%)**	**Lignin (%)**
Water Hyacinth (*Eichhornia crassipes)*	24.5	34.1	8.6
Water Lettuce (*Pistia statiotes*)	27.55	29.71	3.47
Azolla (*Azolla filiculoides)*	21.8	13.5	10.3
Duckweed *(Lemna sp.)**	10- 24.5	3.5	3.1
Giant Salvinia *(Salvinia molesta)*	32	26	13.7
Cattail (*Typha latifolia*)	38.5	37	12.8

* Along with other compositions 5-70% of starch also identified

2.8. Potential Aquatic weeds for Bioenergy Production

Eichhornia crassipes

Because of its availability, and adaptive capacity and massive growth rate, *Eichhornia crassipes* (Water hyacinth) is considered one of the world's aquatic weeds. Water hyacinth is used for the processing of both liquid and gaseous biofuels.

Because of its adequate supply, high cellulose and low lignin content, water hyacinth fulfills the requirement for biofuel production as a possible raw material. The biogas yield of 552 l/ kg volatile solids (VS) from water hyacinth was reported (Table 5).

Duckweed

Duckweed is considered one of the most abundant and tiniest plants in the world. Researchers recently investigated the growth rate of 13 duckweed species representing all five genera under in vitro conditions, and observed doubling times ranging from 1.34 to 4.54 days [43]. Xu et al., 2011 investigated that a starch yield of 9, 4103 kg / ha was achieved by placing duckweed to well water for 10 days, resulting in an ethanol yield of 6,42 l / ha, which is about 50 percent higher than maize yield [44].

Table 5. **Bioenergy Productivity (ton/ha) from potential aquatic weeds**

Aquatic weed	Productivity (ton/ha)	Products
Water Hyacinth	60-100	Bioethanol, Biohydrogen
Duckweed	39.2-44	Bioethanol, Biohydrogen
Azolla sp.	93.4–100	Bioethanol, Biohydrogen
Salvinia sp.	53	Bioethanol
Typha sp.	10.6-14.7	Bioethanol

Azolla sp

Azolla (water fern) is a genus that has a total of seven species and is found in wetlands, rivers, and ditches worldwide [45]. Nitrogen is fixed by Azolla at a rate of up to1.1tons/ ha /year which is substantially higher than the leguminous nitrogen fixation rate, i.e. 0.4 tons / ha / year. Azolla can sequester 32.54 metric tons of CO_2 / hectare / year which can be converted to bio char which, in addition to being an efficient soil enhancer, can also sequester CO_2 in the soil for a longer period of time such as coal. A study investigated 7.92 per cent crude lipid content in *A. Filiculoides* [46].

Hydrothermal liquefaction and pyrolysis confirmed thermochemical conversion of *azolla* to bio-crude oil with a yield of 39 per cent and 29 per cent respectively [47].

Salvinia molesta

Salvinia molesta's high growth rate and lipid content make it an attractive feedstock to the production of biodiesel. A research also recorded yield of 2.0 g / l ethanol from *Salvinia* fermentation using *S. Cerevisiae* and *S. Carlsbergensis* [48].

Pistia stratiotes

Pistia stratiotes generally called water lettuce is also a noxious perennial aquatic plant. *Pistia stratiotes* obtained a total biogas yield of 9667.33 ml during 45 days of digestion time [49].

Typha sp

Typha is an herbaceous, perennial plant. A study reported the highest total glucose yield (97% of cellulose) following typha pre-treatment and enzyme hydrolysis, suggesting a theoretical yield of approximately 90% in ethanol

2.9. Advantages of bioenergy

Bioenergy emits little or no net greenhouse gas emissions. It is a useful way of managing waste disposal for matter that would otherwise be debris. It involves well-established technology that's able to deliver reliable energy; can be stored with minimal energy loss. It is plentiful wherever there are agricultural crops and forestry. It can aid in soil stabilisation, soil quality enhancement and erosion reduction. It will generate both heat and electricity at a cogeneration power plant.

2.10. Limitations of bioenergy

Compared to fossil fuels, it is usually a more costly energy source, since it uses more fuel to produce the same quantity of energy. This requires the use of a lot of wood from natural forests which can contribute to deforestation, and if wood is not completely burned it can release soot-like particles which can cause widespread air pollution.

2.11. Current and future perspectives of biomass resources and bio energy output

Increasing concern about global warming combined with overuse of fossil fuels and the depletion of supplies of fossil fuels has sparked global interest in seeking alternatives, renewable, renewable, cost-efficient and cleaner energy sources.

Table 6 summarizes bioenergy tools used in existing biofuels production projects, possible future tools and the associated bioenergy outputs. Owing to its many and overlapping applications, bioenergy resources are hard to estimate. Current commodities such as corn, sugar, pulp wood and saw logs have production statistics; however, these commodities are actually largely engaged in food, animal feed and materials markets [50].

Table 6. **Current and future perspectives of Biomass resources and bio energy output**

Type of biomass	Current resources	Future resources	Bioenergy output
Sugar Cane	Stem residue remaining after the crushing to remove sugar- rich juice from sugar cane, fibrous residues of sugar cane milling process sugar and C-molasses	Leaves and tops from harvesting Trash	Electricity and heat generation
Energy Crops	Sugar and starch crops, oil crops such as sunflower, canola, juncea and soya beans; palm oil Jatropha	Woody crops, genetically modified (GM) crops, tree crops, coppice, woody weeds, new oilseed, algae (micro and macro), and Halophytes (salt water and coastal/desert plant varieties, e.g. Salicornia, marsh grasses, mangroves)	Electricity and heat generation; Transport biofuel production
Agriculture-Related Wastes and By-Products	Manure Abattoir wastes solids Wheat starch Used cooking oil	Rice husks, cotton ginning, and cereal straw, maize cobs, coconut husks and nut shells; The residue remaining after the harvest of grain crops such as wheat, barley and lupins Grasses such as sorghum, kangaroo grass, tall fescue, perennial ryegrass	Electricity and heat generation; Transport biofuel production
Landfill Gas; Sewage Gas	Methane emitted from landfills mainly municipal solid wastes, Sewage and industrial wastes	Methane emitted from animal waste	Electricity and heat generation
Forest Residues and Wood-Related Wastes	Wood from plantation forests; Wood chips and saw dust Pulp residues; Black liquor and wet wastes	Wood used for processing into paper and related products and harvest residues	Electricity and heat generation; Transport biofuel production
Urban Solid Waste	-----------	Commercial and industrial waste, food-related wastes, paper and cardboard material and urban timber	Electricity and heat generation

2.12. Bioenergy - A global scenario

The fossil fuels are the limited resources in all over the world. The research studies put the date of the worldwide peak in oil production between 1996 and 2035. Renewable energy production technology use waste or plant matter to produce energy with a lower level of greenhouse gas emissions than fossil fuel sources. The worldwide renewable energy scenario by 2040 is presented in Table 7.

Table 7. **Worldwide renewable energy scenario by 2040 (Source: Kralova, 2010)**

Renewable energy / Year	2010	2020	2030	2040
Total consumption (million tons oil equivalent)	10,549	11,425	12,352	13,310
Biomass	1,313	1,791	2,483	3,271
Large hydro	266	309	341	358
Geothermal	86	186	333	493
Small hydro	19	49	106	189
Wind	44	266	542	688
Solar thermal	15	66	244	480
Photovoltaic	2	24	221	784
Solar thermal electricity	0.4	3	16	68
Marine (wave/ocean/tidal)	0.1	0.4	3	20
Total Renewable energy source	1,745.5	2,964.4	4,289	6,351

Installed capacity of renewable sources of energy in India was released by Press Information Bureau, Government of India in which bio power accounts for 10.62GW (Gigawatts) capacity (Table 10)

Table 9: **India's power generation from renewable energy sources**
(Source: Energy world from economic times, March 02, 2020)

Electricity Generation (Conventional and Renewable Sources)								
Jan-2020			**Jan-2019**			**% Growth**		
Conventional Sources	Renewable Sources	Total	Conventional Sources	Renewable Sources	Total	Conventional	Renewable	Total
(BU)	(BU)	(BU)	(BU)	(BU)	(BU)	(%)	(%)	(%)
102.88	10.325	113.2	100.85	9.433	110.28	2.01	9.46	2.65

Table10. **Installed capacity of renewable sources of energy in India**
(Source: Press Information Bureau, Government of India)

Installed capacity of renewable sources of energy in India					
Solar	**Wind**	**Small hydro**	**Large hydro**	**Bio power**	**Nuclear**
48.55 GW	40.03 GW	4.83 GW	46.51 GW	10.62 GW	6.78 GW

3. Conclusion

Bioenergy plays an important part in sustainability and growth. The literature related to renewable energy had attracted growing attention in research and environmental substantially. The future challenges includes, to discover novel technologies to convert biomass to bio energy and bio fuels at lower cost, optimize the process of biomass-based reactions, develop methods to use agricultural wastes, urban wastes along with industrial biomass to produce sustainable and cost effective bioenergy.

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Declaration of competing interest

No conflict of interest

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