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ENVIS NEWSLETTER

MICROORGANISMS AND ENVIRONMENT MANAGEMENT

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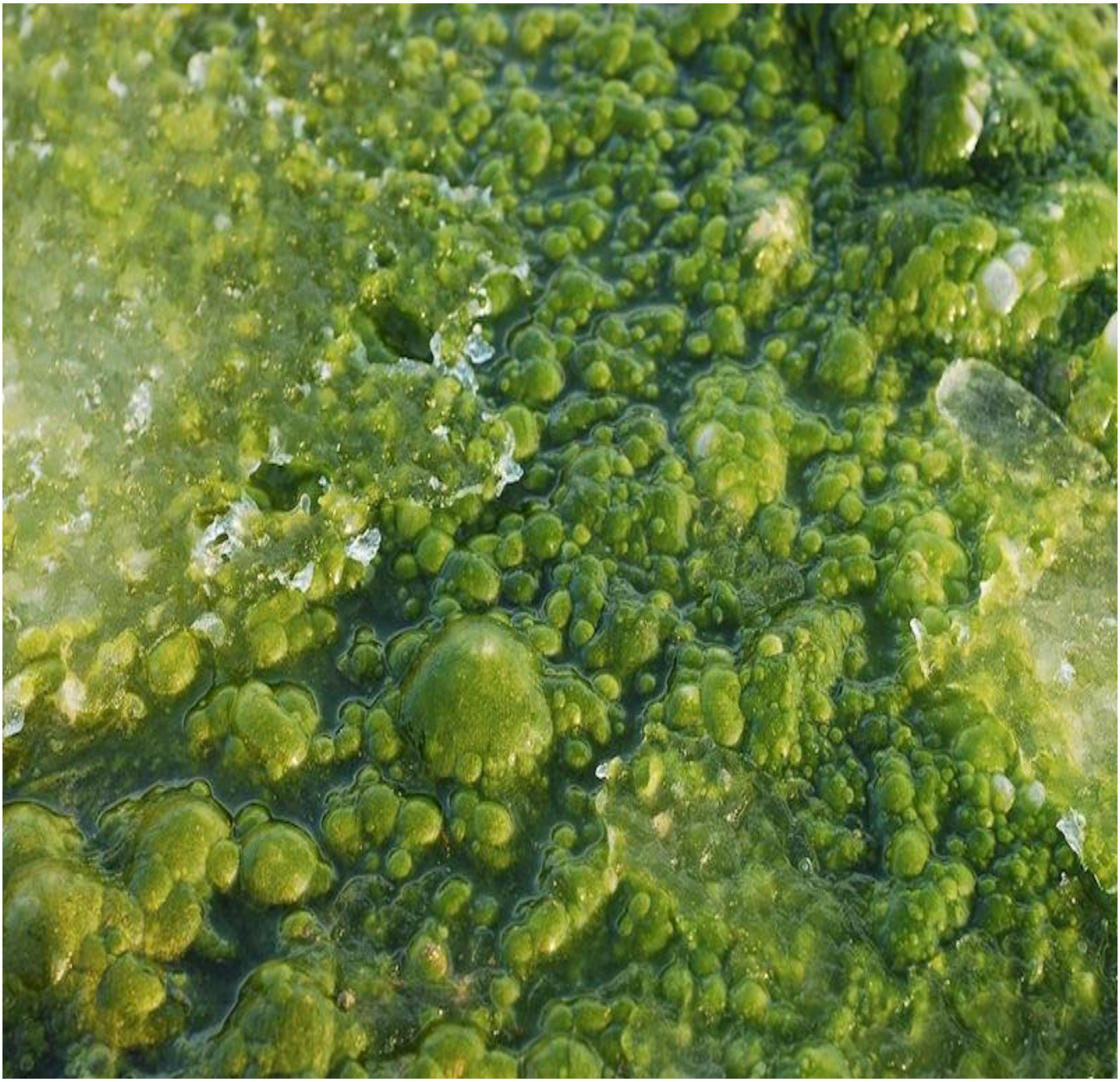

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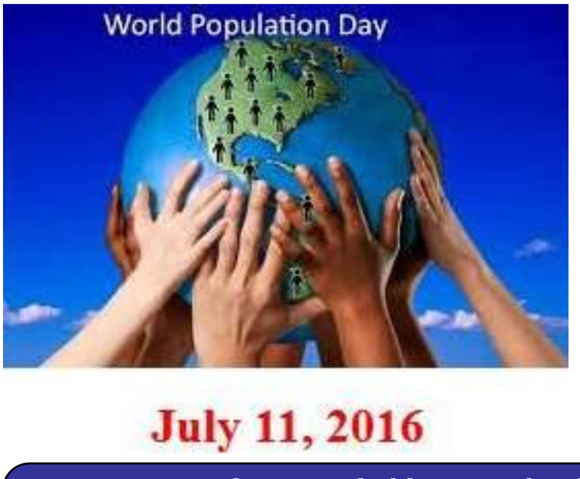

INSTRUCTIONS TO CONTRIBUTORS

ENVIS Newsletter on 'Microorganisms and Environment Management', a quarterly publication, brings out original research articles, reviews, reports, research highlights, news-scan etc., related to the thematic area of the ENVIS Centre. In order to disseminate the cutting-edge research findings to user community, ENVIS Centre on Microorganisms and Environment Management invites original research and review articles, notes, research and meeting reports. Details of forthcoming conferences / seminars / symposia / trainings / workshops also will be considered for publication in the newsletter.

The articles and other information should be typed in double space with a maximum of 8 - 10 typed pages. Photographs/line drawings and graphs need to be of good quality with clarity for reproduction in the newsletter. For references and other details, the standard format used in refereed journals may be followed.

Articles should be sent to:

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Cover page : Algae may hold potential as both the food and the fuel of the future.

Image Credit: *bogdan ionescu, Shutterstock*

Source: www.livescience.com

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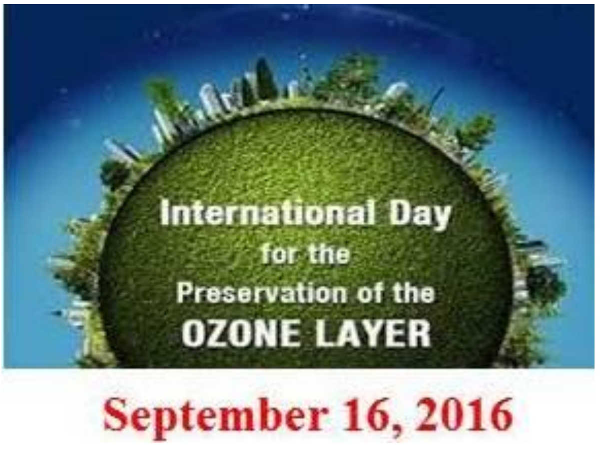

Dear Readers,

Greetings!

With the exhaustion of non-renewable fossil fuels, climate change, industrial, mitigation and economic growth, it is increasingly understood and globally debated for an alternate sustainable renewable energy source. Limited production of energy from food crops and mostly oil seeds as biofuels does not meet the need of the existing demand. Over the time, concerns for renewable, carbon neutral, environmental friendly and economically sustainable alternate source of energy has been raised. In this hour of need, algae especially microalgae appears to be the only source that is capable of meeting the expected global demand as the oil productivity is more efficient than from the other plant sources. Biofuels such as methane, biodiesel, ethanol and several other types could be produced from microalgae. Apart from energy production microalgae can also be used for other applications such as sequestration of CO_2, waste water treatment, human health care, aquaculture etc.

In this context, the present issue includes an article on production of biofuel from microalgae, discusses the potential of a burgeoning alternative strategy: microalgae produced liquid fuels with other interesting topics such as algae in waste water treatment, its use in therapeutics, recent abstracts published on production of biofuels, its future and so on. Hope this issue would bring an impact on the importance of renewable energy.

Dr. C. Arulvasu

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SCIENTIFIC ARTICLE

Microalgal Biomass Production: Lab-to-Land Practices at Bharathidasan University, India

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ABSTRACT

Vast expansion in human population and economic growth had led to continuous demand for more and more energy which threats to exhaust fossil fuels. The extensive use of fossil fuels might cause catastrophic changes in the earth's climate hence; there is an immediate need to develop new renewable energy resources. Microalgae can provide several different types of renewable bio-fuels. There is a strong view among industry professionals that algae represent the most optimal feedstock for biofuel production in the long run. It is also widely accepted that algae alone and no other bio-feedstock have the ability to replace the entire global fossil fuel requirements. Our centre has been engaging in the production of microalgal biomass for biofuel production under the aid of Department of Biotechnology (Govt. of India). In this short communication, the lab to land practices followed for biomass production is described with schematic representation. Additional technology is required for the successful production of biomass and biofuel feed stocks.

Introduction

Microalgae are the most primitive members of the plant kingdom existing as single cells in aqueous habitats, but some are organized in the form of simple colonies, filamentous, and several species have developed further and have organized their cells in more complex structures resembling the leaves, stems and roots of higher plants. The majority of the green algae produce carbohydrates in the form of starches as their storage product that could be used in ethanol production. Lipids are a heterogeneous group of organic compounds that includes fatty acids and other vegetable oils. Microalgae are also characterized by higher lipid productivity that could be trans-esterified for biodiesel production. They constitute a vast potential resource in varied areas such as mariculture, food, feed, fuel, fertilizer, medicine, industry and combating pollution. Apart from microalgae the usefulness of cyanobacteria for these purposes has also been established (Thajuddin and Subramanian, 2005).

The applications of microalgae are enormous such as, in the removal of CO_2 from the flue gases of coal-fired power stations, the development of green algae as producers of biological hydrogen gas, and the use of diatoms as bio-manufacturers of elaborate three-dimensional structures for the nanotechnology industry (Ali *et al*., 2011).

Microalgae share many of the important attributes of higher plants, including similar post-translational processing such as glycosylation, and have a low risk of contamination by human viruses or prions. However, unlike higher plants, microalgae have very fast growth rates and transformants can be generated even within ten days. Furthermore, cultures can achieve high densities, and can be grown in volumes exceeding 500000 litres. Microalgae are photoautotrophic and therefore do not require a carbon source for energy.

Many microalgae grow in saline or hypersaline waters and thus their large-scale cultures do not compete with conventional agriculture for the limited resources of arable land and fresh water. India is the sixth largest country and one of the fastest growing energy consumers in the world. Due to limited crude oil reserves, India meets about 72% of its crude oil and petroleum products requirements through imports, which are expected to go up further in coming years (Baldev *et al*., 2014). Bio-fuels promise to be an appropriate option to be fixed as a solution to these problems. Algae present multiple possibilities for fuel end-products – biodiesel, ethanol, methane, jet fuel, biocrude and more – via a wide range of process routes. There are several advantages of utilizing microalgae for biodiesel production namely: a) Much greater productivity than their

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terrestrial cousins, b) Non-food resource, c) Utilize non-productive land and saline water or waste water, d) Can use waste CO_2 streams, e) Can be used to combine with wastewater treatment, f) An algal biorefinery could produce oils, protein, and carbohydrates, g) High oil content in algae species and h) Lower carbon emissions: When biofuels are being burned, they produce less carbon output and fewer toxins. The various metabolic pathways involved in microalgae could be used for different kinds of biofuel production (Fig. 1). The benefits of microalgae in biofuel production are much higher (Table 1) making it as a strong contender among other potential soures.

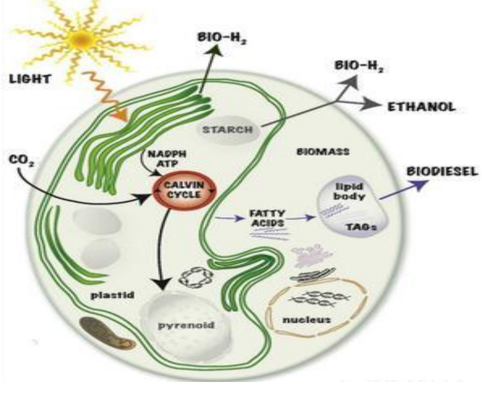

Fig. 1: Metabolic Pathways in Microalgal biofuel Production – Synthesis of Proteins, Carbohydrates, Nucleic acids, Lipids and Hydrogen (Beer *et al.*, 2009).

Table 1: Yield of various plant oils (Demirbas and Demirbas, 2010).

Crop	Oil (Litres/Hectare)
Algae	1,00,000
Castor	1413
Coconut	2689
Palm	5950
Safflower	779
Soy	446
Sunflower	952

At the National Centre in Bharathidasan University, various algae which grow at local conditions are cultured. Besides, selected algal species are grown and culture conditions are optimized in the laboratory. These cultures are scaled up gradually with economic feasibility for the production of high value compounds from the algae. The algae is cultivated in traditional "raceway pond" systems, harvested and processed. Figure 2 shows the diagrammatic schematics of microalgal biomass production followed as lab to land practices at Bharathidasan University.

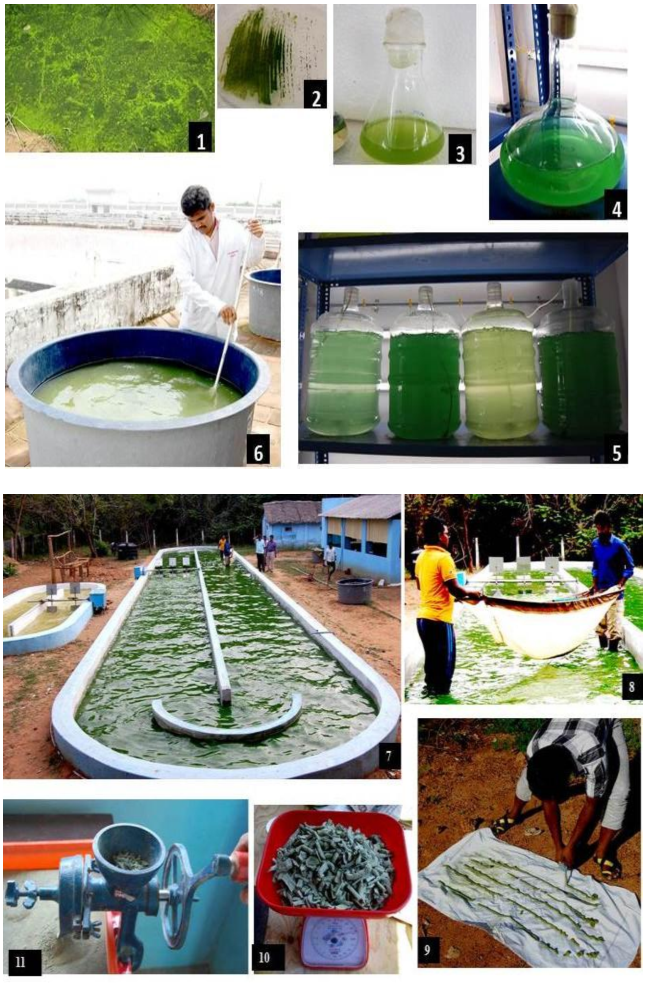

Fig. 2: Microalgal Biomass Production Process - Collection of Specimens from aquatic environment (1), Isolation & purification of microalgae using dilution & streak plate method (2), Scaling up the efficient Microalgal strains in terms of high lipid content 250 ml (3), 5 litres (4), 20 litres (5), 500 litres (6), 5000 litres & 35,000 litres in Raceway Ponds (7), Harvesting of Microalgal Biomass using Plankton net cloth (Filtration) (8), Other methods such as continuous centrifugation, flocculation by chemicals (Alum, Ferric Chloride, Chitosan etc.) and electro-flocculation; Drying the harvested biomass in the form of noodle like flakes (9), Weighing (10) and powdering of dried microalgal biomass (11).

Biodiesel is produced from the algae starting with extraction of lipids from the dried biomass. Various methods such as Supercritical Fluids Method or Oil press could be used for the extraction. Later transesterification of lipids with methanol and suitable catalyst yield

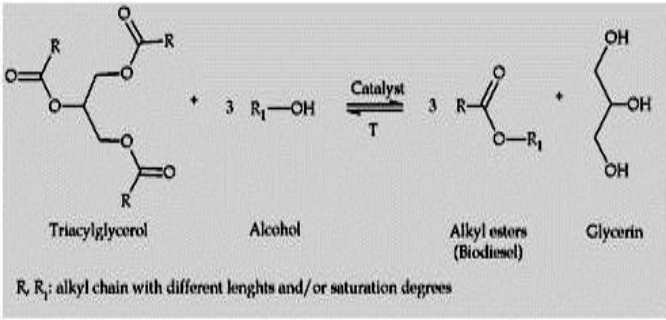

Fig. 3: Transesterification of process to develop fatty acid methyl esters (FAME) (Biodiesel).

biodiesel (FAME) and glycerol (Fig. 3). In the process methanol could be replaced with ethanol, propanol, butanol, and amyl alcohol. Catalysts could be of alkalis (NaOH & KOH), acids (sulfuric acid, sulfonic acids, & hydrochloric acid) and enzymes (e.g. lipase). Finally Biodiesel/Glycerol mixture is purified by separation through centrifuge and biodiesel (top layer) is removed. Sequentially water washing eliminates contaminants such as methanol, free glycerine and catalyst and dried under vacuum with heat to remove water. The final product obtained is biodiesel.

Conclusion:

The oil-rich, CO_2-utilizing microalgae are technically viable and attractive alternatives for biodiesel production. Even though ethanol derived crops addresses the world gasoline market demands, there is a need for biofuels from algal-derived feed stocks to displace our significant petroleum diesel usage. Extensive knowledge on the fundamental algal physiology, genetic manipulation, optimization of mass cultivation, overall system engineering and economic aspects of the microalgal biodiesel production are most warranted.

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RESEARCH REPORTS

Sunshine, seaweed helps to break down dye waste

Scientists at the Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavanagar, Gujarat have been able to completely degrade three industrial dyes — methyl orange, methylene blue and reactive black-5 — in the presence of sunlight. The researchers developed a photocatalyst using titanium dioxide doped with red seaweed polymer carrageenan to degrade the dyes. The results were published recently in the journal RSC Advances.

Despite stringent environmental regulations, a comprehensive method of treating industrial dye is not available. The methods available are expensive and do not completely break down the dye molecules to non-toxic constituents but merely concentrate the contaminants.

The paper reports that annually, more than 500 tonnes of non-degradable textile colour waste effluents are being disposed off in natural streams without adequate treatments. Titanium dioxide has conventionally been used for photocatalytic degradation of industrial dyes, but it takes a long time to degrade dyes. So the researchers doped titanium dioxide nanoparticles with sulphur and carbon by treating it with carrageenan. The nanocomposite was found to behave as an excellent photocatalyst that helped to degrade industrial dyes quickly in a single-step process.

They have demonstrated that the direct use of sulphate rich seaweed polysaccharides, carrageenans, namely kappa (κ), iota (ι) and lambda (λ) as sources of sulphur and carbon in doping TiO_2 synthesis resulted in a highly active photocatalyst. Evaluation of the dye degradation pattern shows rapid degradation of reactive black-5, methylene blue and methyl orange using modified TiO_2 nanocomposites in different light sources. Robust dye degradation was achieved between 1 and 4 h under daylight whereas, the use of a solar concentrator reduced the degradation time of Methylene Blue and Reactive Black-5 to <5 min and Methyl Orange solution was turned colourless within 20 min. The present study elaborates the effect of seaweed carrageenans in inducing heteroatoms like sulphur and residual carbon for the photodegradation of industrially important dyes.

"The energy required to activate the catalyst is less when it is doped and this makes the dye degradation faster," says Dr. Ramavatar Meena, the senior author of the paper from CSMCRI.

"When a solar concentrator is used, the intensity of visible light is more and this plays an important role in the degradation process," says Jai Prakash Chaudhary, the first author of the paper from CSMCRI.

The researchers are planning to conduct studies during winter to assess the photocatalyst's ability to break down the dyes when bright sunlight is not available. The nanocomposites are thermally stable and can be reused up to six times with the degradation efficiency remaining at over 97 per cent. The nanocomposite photocatalyst can safely and completely treat harmful dyes in an eco-friendly and cost-effective manner, the study said.

A view of Common Effluent Treatment Plant.

Source: www.thehindu.com

Modified microalgae converts sunlight into valuable medicine

A special type of microalgae can soon produce valuable chemicals such as cancer treatment drugs and much more just by harnessing energy from the sun. The team of scientists from Copenhagen Plant Science Centre at University of Copenhagen has published an article about the discovery in the scientific journal Metabolic Engineering.

Researchers have succeeded in manipulating a strain of microalgae to form complex molecules to an unprecedented extent. This may pave the way for an efficient, inexpensive and environmentally friendly method of producing a variety of chemicals, such as pharmaceutical compounds.

Post Doc Agnieszka Janina Zygadlo Nielsen, who along with colleagues Post Doc Thiyagarajan Gnanasekaran and PhD student Artur Jacek Wlodarczyk the main researchers behind the study said that their idea is to hijack a portion of the energy produced by the microalgae from their photosynthetic systems. By redirecting the energy produced to a genetically modified part of the cell capable of producing various complex chemical materials and induce the light driven biosynthesis of these compounds.

The researchers have as such modified microalgae genetically to become small chemical factories with a build in power supply. According to the research team's study, this basically allows sunlight being transformed into everything ranging from chemotherapy or bioplastics to valuable flavor and fragrance compounds.

Agnieszka Janina Zygadlo Nielsen described that the problem with many of these substances is that they are extremely expensive and difficult to make, and therefore produced only in small quantities in the medicinal plants.

"A cancer drug like Taxol for instance is made from old yew trees, which naturally produce the substance in their bark. It is a cumbersome process which results in expensive treatments. If we let the microalgae run the production this problem could be obsolete," she explains.

Thiyagarajan Gnanasekaran clarifies that the method can be run sustainably and continuously, and this is what that makes it even more spectacular compared to present methods. "Our study shows that it is possible to optimize the enzymatic processes in the cells using only sunlight, water and CO_2 by growing them in transparent plastic bags in a greenhouse. Theoretically, the water could be replaced with sewage water, which could make the process run on entirely renewable energy and nutrient sources. Recycling wastewater from industry and cities to produce valuable substances would surely be positive," he points out.

The microalgae cultures are able to grow rapidly using waste water and light

(**Image credit:** *Department of Plant and Environmental Sciences, University of Copenhagen*)

Agnieszka Janina Zygadlo Nielsen added that if they can create a closed system that can produce the valued chemicals from water, sunlight and CO_2, it would be a fully competitive method compared to the ones used today, where it is primarily extracted from plants or yeast and E. coli bacteria producing the substances. In theory it should be cheaper on the long run to use their method than adding the large quantities of sugar that the conventional yeast and E.coli cultures amongst other things need to function.

However, the research team emphasizes that the method using genetically modified microalgae has its limitations at present time. As Thiyagarajan Gnanasekaran points out, the microalgae use much of the harnessed sunlight to keep their own metabolic processes running. According to the team the expanding methods and genetic tools for microalgae are likely to overcome these limitations in the near future.

Source: www.phys.org

ONLINE REPORTS

Can we save the algae biofuel industry?

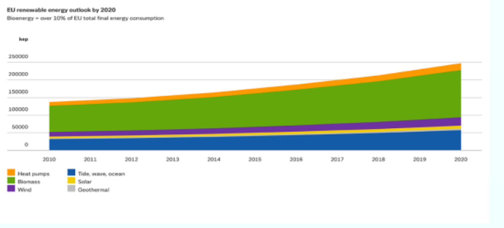
Algal biofuels are in trouble. This alternative fuel source could help to reduce the overall carbon emissions without taking land area used for food production, like many crop-based biofuels do. But several major companies including Shell and ExxonMobil are seemingly abandoning their investments in this environmentally friendly fuel. So why has this promising technology failed to deliver, and what could be done to save it?

Algae are photosynthetic organisms related to plants that grow in water and produce energy from carbon dioxide and sunlight. Single-celled microalgae can be used to produce large amounts of fat, which can be converted into biodiesel, the most common form of biofuel. There are many possible ingredients for making biofuels, from corn to used cooking oil. But algae are

Facts about biomass energy

Biomass has been used as fuel for tens of thousands of years. Development of biomass applications has made great strides in recent decades. There are now a variety of methods for converting biomass into heat and electricity, from pellets for household heating to agricultural waste used to produce electricity in commercial power plants.

Bioenergy expected to make up more than half of EU renewable energy in 2020



Bioenergy is currently the largest form of renewable energy in the EU and is expected to keep its dominant position in the realisation of the EU 2020 targets. This is largely caused by the dominant role of biomass in heat and transport. While alternative renewable energy options exist for electricity production, transport and heating depend largely on biomass.

Four per cent of EU electricity generation

Biomass and waste provided around four per cent of the EU's electricity generation in 2010. Biomass is used primarily in countries with extensive forest industries, where residues such as branches, wood chips and sawdust can be used to produce electricity and heat. Countries with large agricultural industries and industries that produce waste products that can be used as biofuels also have potential to increase their use of biomass.

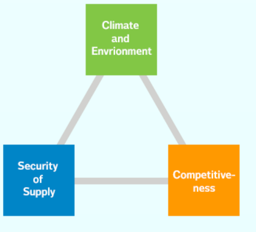
Dramatic increase expected

The number of power plants in Europe that run solely on biomass is expected to increase dramatically in the coming years. In addition, it is used along with coal in many hard coal-fired power plants.

Sustainable biomass makes important contribution to CO_2 reduction

Biomass can contribute to reducing CO_2 emissions. To ensure biomass for energy leads to meaningful CO_2 reduction, cultivation and production must be carried out in a controlled, sustainable manner. Vattenfall continuously improves the checks and balances it has in place to ensure the biomass we use is sustainable. Vattenfall is a member of the Sustainable Biomass Partnership.

Energy Triangle



In supplying society with energy, a balance must be struck between three key dimensions: competitiveness, security of supply, and the environment and climate. No single energy source is optimal from all dimensions. This energy triangle illustrates the pros and cons of biomass.

Climate and environment: By using biomass in power production instead of fossil fuels, CO_2 emissions are significantly reduced. Carbon dioxide is emitted into the atmosphere when biomass is burnt but when biomass grows it binds carbon dioxide through photosynthesis. Properly managed biomass is therefore carbon neutral over time.

Security of supply: Biomass can be converted into a stable and reliable supply of electricity and heat. Biomass can be securely sourced on small scales, but supply of larger volumes is currently difficult to secure. One important step is to establish a global trade and certification system. Biomass resources are geographically diversified and political risk is limited.

Competitiveness: Using biomass to produce electricity is currently more expensive than using energy sources such as coal, gas or nuclear power. The global biomass supply chain is developing and, over time, technological and logistical improvements will bring down prices. An increased CO_2 price will also improve the economic competitiveness of biomass.

Source: www.corporate.vattenfall.com particularly interesting because they can be grown rapidly and produce large amounts of fuel relative to the resources used to grow them (high productivity).

In the last decade or so, vast amounts of money have been invested in the development of algae for biofuel production. This made sense because, ten years ago, there was a need to find alternatives to fossil fuels due to the high oil price and the increasing recognition that carbon emissions were causing climate change. Algal biofuels were touted as the answer to these twin problems, and huge investment followed.

Unfortunately, things didn't go quite well as planned. Companies making algal biofuels struggled to retain their high productivity at a larger scale and found predators often contaminated their farms. They also found that the economics just didn't make sense. Building the ponds to grow the algae and providing enough light and nutrients for them to grow proved too expensive, and to make matters worse the oil price has plummeted.

Beyond biofuels

But algae don't just produce biofuels. In fact, algae are like microscopic factories producing all sorts of useful compounds which can be used to make an amazingly diverse range of products.

For example, algae can produce large amounts of omega-3 fatty acids, an important dietary supplement. This means it could be a sustainable, vegetarian source of omega-3, which is otherwise only available from eating fish or unappetising cod liver tablets. More generally, algae are excellent sources of vitamins, minerals and proteins, with species such as Chlorella and Spirulina commonly being consumed for their health benefits.

Another useful product that can be made from algae is bioplastic. Regular plastic is a product of fossil fuels and takes an extremely long time to break down, which makes it very environmentally unfriendly. Bioplastic from algae can be produced with low carbon emissions, or even in a way that absorbs emissions. Their use could help prevent the buildup of plastic in the environment.

The diversity of these products may be the key to finally developing algal biofuels. Many are high-value chemicals, selling for a much higher price than biofuels. So by combining them with biodiesel production, we could subsidise the price of the fuel and offset the high costs of algal cultivation.

This concept, known as a "bio-refinery", is part of a new wave of algae research that aims to overcome the issues of the past decade or so. We already know that oil refineries produce plastics, fibres and lubricants as well as fuels. Now we are hoping to develop algal biorefineries in exactly the same way.

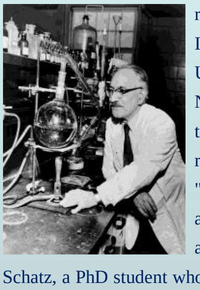
Producing an algal biorefinery

To make this model cost-effective and sustainable, we would need to use waste sources of heat, carbon dioxide and nutrients to grow the algae. These are widely available from power plants, factories and water treatment plants and so could reduce some of the costs of growing algae. After making algal fuel, you're left with lots of proteins, carbohydrates and other

KNOW A SCIENTIST

Dr. Selman Abraham Waksman

Dr. Selman Abraham Waksman was a Ukrainian-born, Jewish-American inventor, biochemist and microbiologist whose research into organic substances—largely into organisms that live in soil—and their decomposition promoted the discovery of Streptomycin, and several other antibiotics. A professor of biochemistry and microbiology at Rutgers University for four decades, he discovered over twenty antibiotics (a word which he coined) and introduced procedures that have led to the development of many others. The proceeds earned from the licensing of his patents funded a foundation for microbiological research, which established the Waksman Institute of Microbiology located on Rutgers University's Busch Campus in Piscataway, New Jersey (USA). In 1952 he was awarded the Nobel Prize in Physiology or Medicine in recognition "for his discovery of "streptomycin," the first antibiotic active against tuberculosis." Waksman was later accused of playing down the role of Albert Schatz, a PhD student who did the work under Waksman's supervision to discover streptomycin.



Schatz protested being left out of the award, but the Nobel committee ruled that he was a mere lab assistant working under an eminent scientist. " In the award speech, Waksman was called "one of the greatest benefactors to mankind," as the result of the discovery of streptomycin.

In 2005 Selman Waksman was granted an ACS National Historical Chemical Landmark in recognition of the significant work of his lab in isolating more than fifteen antibiotics.

Waksman was awarded the Nobel Prize in 1952 "for his discovery of streptomycin, the first antibiotic effective against tuberculosis".

molecules. These can be converted into the kinds of products mentioned above, or used to produce biogas (another fuel source). This biogas can be sold or used at the bio-refinery to produce heat for the algae, closing the loop and making the whole process more efficient.

It's easy to see how this process could be a way forward for sustainable, profitable biofuel from algae. In fact, there are companies already applying this concept to their work. In 2014 Sapphire Energy, one of the world's largest algal biotechnology companies announced that they were diversifying their work to include nutritional supplements as well as biofuels. This move towards bio-refinery is becoming more common and many firms are diversifying their product lines.

Clearly, the algal bio-refinery will not solve all the problems facing commercial algal cultivation today. There are still key issues facing the loss of yield at very large scales, and the contamination of algal cultures by predators that eat your crop of algae. These issues will only be solved by continued research efforts. However, bio-refinery may well be the next step towards a future free from fossil fuels.

Source: www.theconversation.com

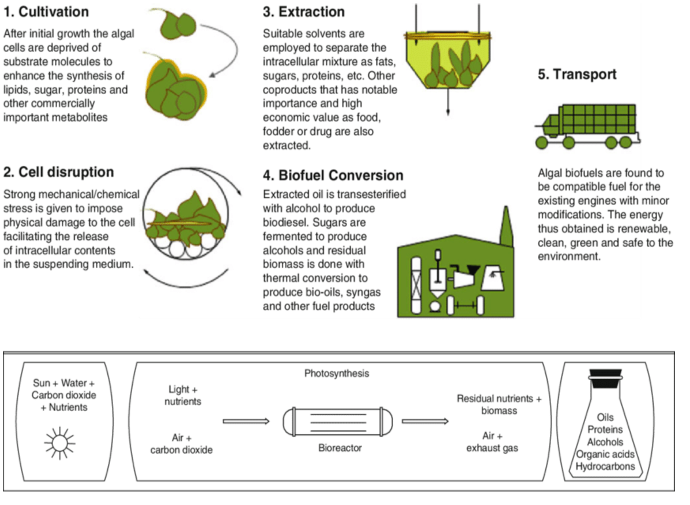
Microalgae: Promising future resource?

Microalgae hold tremendous potential for industrial biotechnology. They are an important resource in the production of food and medications, and in many other applications. In comparison to bacteria and fungi, however, they still play only a minor role. The economic use of these organisms has been difficult in the past primarily because existing production procedures are too costly. The algae specialist Professor Michael Melkonian and his team from the University of Cologne have now developed a new method that could make the production of algae easier -- and hence reduce the costs of the products based on this material. Their findings are published in the journal "Trends in Biotechnology".

Many years of research work on the development of photobioreactors, which use photosynthesis to turn light energy into biomass, have preceded this success. The so called "Porous Substrate Bioreactor" (PSBR), also known as the twin-layer system, uses a new principle to separate the algae from a nutrient solution by means of a porous reactor surface on which the microalgae are trapped in biofilms. Special about this new procedure is that it reduces the amount of liquid needed in comparison to the currently used technology, which cultivates algae in suspensions, by a factor of up to one hundredth. The PSBR procedure thus allows for a significant reduction in energy and for an increase in the portfolio of algae that can be cultivated.

Current successes in PSBR development and the rise in interest in this technology in recent years could signal a turn in the conception of future photobioreactors in microalgae biotechnology.

Microalgae have numerous applications: they are traditional sources of protein and carbohydrates. They can also be used in the sustainable production of natural pigments and antioxidants such as beta-carotene and astaxanthin. Polyunsaturated fatty acids, which usually come from fish oil, can also be synthesized from microalgae. Furthermore, algae can serve as the basis for pharmaceutical agents such as antiviral and anticancerogenous substances. In environmental biotechnology, new concepts are currently being developed to employ microalgae to recover phosphor and nitrogen from sewage and reintroduce them into the nutrient cycle by means of organic fertilizers.



Algae: Promising Future Feedstock for Biofuels (Image Source: www.researchgate.net)

Source: www.sciencedaily.com

NEWS

Algae culture may hold key to cleaning up city's water bodies

Algae, the icky green patch found floating on water bodies, may well be the saviour of Cooum river, Chennai. Researchers from the United Kingdom have suggested that the city should explore micro algae culturing to combat pollution in water bodies.

UK-based researchers participating in the British Council organised Newton Bhabha Researcher Link Workshop on 'Clean water through advanced and affordable materials,' said microalgae culture was a natural and cost-effective waste water treatment process, less explored by governments.

"It is an alternative to chemical treatment of waste water. Algae can survive on intensely polluted water bodies, which other microbes cannot tolerate. It ingests nitrogen, phosphorus and cabon-dioxide released from pollutants and sediments," said Alla Silkina of Swansea University. She researches on the potential of algal biotechnology for waste remediation.

Estimates from her research showed that 1 g of algal biomass can ingest around 2.4 g of nitrogen and phosphorus. "Implementing this idea to remediate polluted ponds and lakes of a smaller geographical area is possible," she added. Such treated water will not be potable but can still be used for domestic and agricultural purposes.

City experts felt that the concept will be tough to incorporate into cleaning the Adyar and Cooum rivers, however, the technique can help as a tertiary step in sewage water treatment process.

"The retention time of algae will be an issue. In flowing water, it will be difficult because such culturing would work only if a certain density of the biomass is maintained over a particular area," said S. Viswanathan, environment specialist at Chennai Rivers Restoration Trust. According to Silkina, the water should be retained while the alga develops for four to 10 days.

Source: www.timesofindia.indiatimes.com

Scientists seek key to converting algae to biofuel

University of Florida Institute of Food and Agricultural Sciences researchers have found a key for converting algae to fuel.

The scientists have found what researchers call a "transcription factor," called ROC40. Bala Rathinasabapathi, a UF/IFAS professor of horticultural sciences, likened a transcription factor's role in controlling the expression of many genes inside the algae cells to a single policeman controlling a large crowd.

Bala Rathinasabapathi, a UF/IFAS professor of horticultural sciences, works in his lab in Gainesville. He and his colleagues have found a key for converting algae to fuel.

To draw lipids out of algae, scientists must starve the algae of nitrogen. Among the hundreds of proteins modulated by nitrogen starvation, the synthesis of ROC40 was the most induced when the cells made the most oil. The high induction of that protein suggested to scientists that it could be playing an important biological role, said Elton Gonçalves, a former UF/IFAS doctoral student in the plant molecular and cellular biology program. In fact, the team's research showed that ROC40 helps control lipid production when the algal cells were starved of nitrogen.

"Our discovery about the ROC40 protein suggests that it may be increasing the expression of genes involved in the synthesis of oil in microalgae," Rathinasabapathi said.

"Such information is of great importance for the development of superior strains of algae for biofuel production," Gonçalves said. "We conducted this research due to the great socioeconomic importance of developing renewable sources of fuels as alternatives for petroleum-based fuels for future generations. In order to advance the production of algal biofuels into a large-scale, competitive scenario, it is fundamental that the biological processes in these organisms are well understood."

Rathinasabapathi said this information is valuable for the future for engineering algae so it overproduces oil without starving the algae of nitrogen.

Lipids from microalgae provide an excellent renewable source for biofuels. The algae grow quickly, tolerate extreme weather conditions and do not pose the same issues as biofuel crops that are grown both for fuel and food.

The rub was if algae are deprived of nitrogen, the cells become stressed and begin to produce lipids, but their growth rate slows. And if alga is going to become a commercially viable fuel source, scientists must ensure that not only can it produce as much oil as possible, but also that it can grow as fast as possible.

Rathinasabapathi and Gonçalves co-authored the study, which has been accepted for publication in "The Plant Journal".

Source: www.phys.org

New method for making biofuels is cheaper and better for the environment

Chemical and Biomolecular Engineers from the Melbourne School of Engineering have discovered a new way to deliver carbon dioxide to microalgae, which in turn, can be harvested to make renewable fuels such as biodiesel.

Carbon dioxide is well known to speed up the growth of microalgae. However, the carbon dioxide has to be free of contamination or the algae die. Published in the research journal "Energy and Environmental Science". The new method purifies the carbon dioxide that is in power station flue gases by absorbing it into a liquid. This liquid is then pumped through hollow fibre membranes. These hollow fibre membranes are like very long drinking straws, which can be immersed into the microalgae beds.

Carbon dioxide delivered to microalgae can be harvested to make renewable fuels

Professor Sandra Kentish, Head of the Chemical Engineering Department at the University of Melbourne and leader of the research team said that supplying purified carbon dioxide by extracting it from flue gases can work, but it is expensive and takes a lot of energy. In their work they have found a way to purify the carbon dioxide and to supply it to the microalgae for a much more moderate cost and using a lot less

The new role of microbes in bio-fuel production

Currently **biofuel** is produced from plants as well as microbes. The oils, carbohydrates or fats generated by the microbes or plants are refined to produce biofuel. This is a green and renewable energy that helps in conserving fossil-fuel usage. But a new research has led to a new discovery of getting the microbes to produce fuel from the proteins instead of utilizing the protein for its own growth. The research is being done at the premises of **University of California** in Los Angeles.

Focus

The focus of the experiment was to induce the microbes under the study to produce a specific kind of proteins rather than what they otherwise might be inclined to produce. This special protein can be refined in to biofuel. The task is to make the microbes produce only this kind of protein, rather than utilizing it for their own growth and growth related activities as they otherwise do.

Different from prior practice

This kind of biofuel production is different from the traditional behavior of microbes where they use the protein only for growth. This is like tricking the microbes to deviate from that and produce fats or material that can be converted to biofuel. In the words of **UCLA** postdoctoral student and lead researcher, Yi-xin Huo -"We have to completely redirect the protein utilization system, which is one of the most highly-regulated systems in the cell."

First attempt at protein utilization

This has been claimed as the first ever attempt to use the proteins as a source for generating energy. Until now the biofuel-producing algae has not made use of the protein like a carbon supply for biofuel. It was only used for growth. But now the scientists have tampered with usual nitrogen metabolism process and induced biorefining process and altered the metabolizing of nitrogen at the cellular level.

A fringe benefit

By this process, they are letting the cells to retain the nitrogen and take out just the ammonia. Once done with the biofuel production, the residue is a better kind of fertilizer thanks to the low nitrogen levels. This in turn will lessen any greenhouse emissions that happen during the fertilizer production. The new process will reprocess the nitrogen back and will help in maintaining a nitrogen neutral state and less harmful emissions during fertilizer production.

Future plans

The Nature Biotechnology Sunday issue has published the team's findings. The team hopes that their findings will rewrite biofuel production by inundating the field with protein eating microbes which will generate fats and substances that can be converted into biofuel. The microbes will feed on proteins that are not fit for animal consumption and keep producing special proteins for biofuel conversion and later can become a better type if fertilizer with less nitrogen and nil harmful greenhouse emissions.

Source: www.alternative-energy-news.info

Another team member, Dr. Greg Martin said that the CO_2 moves directly from the liquid into the microalgae culture by permeating through the fibre walls. Apart from being a cheaper approach, their research has showed that the microalgae grow faster than in other works done now a days.

Other products such as chemicals, proteins and nutraceuticals can also be produced using the same approach. The experiments were completed by PhD student, Qi Zheng, who is now undertaking further experiments to find the optimum liquid composition.

Source: www.phys.org

Abstracts of Recent Publications

01. Algal Research, 2016, Vol. 18 , Pages: 341 – 351.

Biological pretreatments of microalgal biomass for gaseous biofuel production and the potential use of rumen microorganisms: A review.

Carrillo-Reyes, J., Barragán-Trinidad, M and Buitrón, G.

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Pretreatments to break down complex biopolymers in microalgae cells are a key process in the production of gaseous biofuels (methane and hydrogen) from such biomass. Biological pretreatment implies cell degradation by purified enzymes; enzymatic cocktails or by microorganisms with enzymatic activity capable of hydrolyzing the microalgae cell wall. This review presents relevant results using those methods that are less energy intensive and, in some cases, more specific than other strategies, such as chemical and physical pretreatments. Enzymatic pretreatments are specific and efficient, with cellulase, hemicellulase, pectinase, protease and amylase being the most explored enzymes. For biomass pretreatment, enzymatic cocktails have been more effective than single enzymes, as it is more feasible to obtain enzymatic extracts of one or more hydrolytic microorganisms than their purified enzymes. The potential use of hydrolytic cultures for cell disruption to breakdown complex biopolymers has been demonstrated. Their use is less specific than that of enzymatic extracts, but more cost-effective. Pure cultures of hydrolytic bacteria, most of which have carbohydrase activities, have increased the biofuel conversion efficiency from microalgae and from bacterial consortia. The use of natural microbial consortia with hydrolytic activities, such as ruminal microorganisms, represents a potential pretreatment for microalgae. In this review, common hydrolytic activities are highlighted and compared, and the use of ruminal microorganisms as a cell disruption strategy is discussed. Understanding the operational conditions applied to natural consortia, such as ruminal microorganisms, will favor a suitable system for microalgae cell disruption that may increase the biological hydrogen and methane recovery from microalgae.

Keywords: Cell disruption; Ruminal microorganisms; Microalgae; Hydrolytic cultures.

02. Marine drugs, 2016, 14(5), Page: 100.

Impact of Microalgae-Bacteria Interactions on the Production of Algal Biomass and Associated Compounds.

Fuentes, J. L., Garbayo, I., Cuaresma, M., Montero, Z., González-del-Valle, M and Vílchez, C.

Algal Biotechnology Group, Ciderta and Faculty of Sciences, University of Huelva and Marine International Campus of Excellence (CEIMAR), Huelva 21007, Spain.

A greater insight on the control of the interactions between microalgae and other microorganisms, particularly bacteria, should be useful for enhancing the efficiency of microalgal biomass production and associated valuable compounds. Little attention has been paid to the controlled utilization of microalgae-bacteria consortia. However, the studies of microalgal-bacterial interactions have revealed a significant impact of the mutualistic or parasitic relationships on algal growth. The algal growth, for instance, has been shown to be enhanced by growth promoting factors produced by bacteria, such as indole-3-acetic acid. Vitamin B_{12} produced by bacteria in algal cultures and bacterial siderophores are also known to be involved in promoting faster microalgal growth. More interestingly, enhancement in the intracellular levels of carbohydrates, lipids and pigments of microalgae coupled with algal growth stimulation has also been reported. In this sense, massive algal production might occur in the presence of bacteria, and microalgae-bacteria interactions can be beneficial to the massive production of microalgae and algal products. This manuscript reviews the recent knowledge on the impact of

the microalgae-bacteria interactions on the production of microalgae and accumulation of valuable compounds, with an emphasis on algal species having application in aquaculture.

Keywords: microalgae; microalgae-bacteria interactions; microalgae production; aquaculture

03. International Journal of Hydrogen Energy, 2016, Vol. 41(39), Pages: 17257–17273.

Review: Biofuel production from plant and algal biomass.

Voloshin, R. A., Rodionova, M. V., Zharmukhamedov, S. K., Veziroglu, T. N and Allakhverdiev, S. I.

Controlled Photobiosynthesis Laboratory, Institute of Plant Physiology, Russian Academy of Sciences, Botanicheskaya Street 35, Moscow 127276, Russia.

Biofuels are the promising alternative to exhaustible, environmentally unsafe fossil fuels. Algal biomass is attractive raw for biofuel production. Its cultivation does not compete for cropland with agricultural growing of food crop for biofuel and does not require complex treatment methods in comparison with lignocellulose-enriched biomass. Many microalgae are mixotrophs, so they can be used as energy source and as sewage purifier simultaneously. One of the main steps for algal biofuel fabrication is the cultivation of biomass. Photobioreactors and open-air systems are used for this purpose. While former ones allow the careful cultivation control, the latter ones are cheaper and simpler. Biomass conversion processes may be divided to the thermochemical, chemical, biochemical methods and direct combustion. For biodiesel production, triglyceride-enriched biomass undergoes transetherification. For bioalcohol production, biomass is subjected to fermentation. There are three methods of biohydrogen production in the microalgal cells: direct biophotolysis, indirect biophotolysis, fermentation.

Keywords: Biofuel; Biomass; Photobioreactor; Biodiesel; Bioalcohol; Biohydrogen

04. BioEnergy Research, 2016, Vol. 9 (1), Pages: 1 – 14.

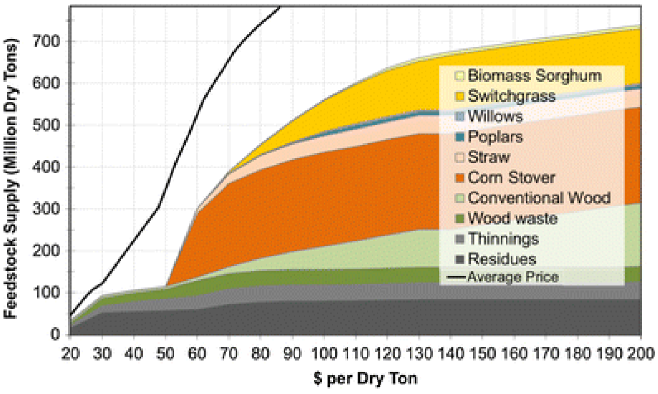
Sources of Biomass Feedstock Variability and the Potential Impact on Biofuels Production.

Williams, C. L., Westover, T. L., Emerson, R. M., Tumuluru, J. S and Li, C.

Biofuels and Renewable Energy Technology Department, Idaho National Laboratory, Idaho Falls, USA.

Terrestrial lignocellulosic biomass has the potential to be a carbon neutral and domestic source of fuels and chemicals. However, the innate variability of biomass resources, such as herbaceous and woody materials, and the inconsistency within a single resource due to disparate growth and harvesting conditions, presents challenges for downstream processes which often require materials that are physically and chemically consistent. Intrinsic biomass characteristics, including moisture content, carbohydrate and ash compositions, bulk density, and particle size/shape distributions are highly variable and can impact the economics of transforming biomass into value-added products. For instance, ash content increases by an order of magnitude between woody and herbaceous feedstocks (from ~0.5 to 5 %, respectively) while lignin content drops by a factor of two (from ~30 to 15 %, respectively).

Graphical Abstract



This increase in ash and reduction in lignin leads to biofuel conversion consequences, such as reduced pyrolysis oil yields for herbaceous products as compared to woody material. In this review, the sources of variability for key biomass characteristics are presented for multiple types of biomass. Additionally, this review investigates the major impacts of the variability in biomass composition on four conversion processes: fermentation, hydrothermal liquefaction, pyrolysis, and direct combustion. Finally, future research processes aimed at reducing the detrimental impacts of biomass variability on conversion to fuels and chemicals are proposed.

Keywords: Biomass; Composition; Variability; Conversion; Biochemical; Thermochemical

E - Resources on Microorganisms

NATIONAL

National Facility for Marine Cyanobacteria, Bharathidasan University, Tiruchirappalli
http://www.nfmc.res.in/

Gujarat Biodiversity Gene Bank (BioGene)
https://btm.gujarat.gov.in/biogene-init.htm

Centre for Conservation and Utilisation of Blue Green Algae (CCUBGA), IARI, New Delhi
http://scsrt.sevas.org.in/centre-for-conservation-and-utilisation-of-blue-green-algae-ccubga-iari-new-delhi

National Collection of Industrial Microorganisms (NCIM)
http://www.ncl-india.org/files/NCIM/Catalogue.aspx?menuid=ql4

INTERNATIONAL

World Federation for Culture Collections (WFCC)
http://www.wfcc.info/index.php/collections/display/

World Data Centre for Microorganisms
http://www.wdcm.org/

Estonian Electronic Microbial database
http://eemb.ut.ee/eng/celms_english_instructions_list.php

Collection of Environmental and Laboratory Strains (CELMS)
http://www.tymri.ut.ee/en/institute/microbial-collection

FORTH COMING EVENTS
Conferences / Seminars / Meetings 2017

Building Biomass Value Chains Series Workshop 2. February 07, 2017. **Venue:** Sault Ste. **Marie.** **Website:** http://www.biomassnorth.org/bbvc.html

Energy from Waste. February 21 - 22, 2017. **Venue:** London, **UK.** **Website:** http://www.efwconference.com/

Biomass & BioEnergy Asia. February 27 - March 01, 2017. **Venue:** Jakarta, **Indonesia**. **Website:** http://www.cmtevents.com/aboutevent.aspx?ev=170303a&pu=269014

Global Forum for Innovations in Agriculture. March 20 - 21, 2017. **Venue:** Abu Dhabi, **UA**. **Website:** http://www.innovationsinagriculture.com/

Value of Biogas East Conference & RNG Workshop. March 23 – 24, 2017. **Venue:** Toronto, **Canada.** **Website:** http://www.biogasassociation.ca/vob

Burning biomass pellets instead of wood or plants in China could lower mercury emissions

"Emission of Speciated Mercury from Residential Biomass Fuel Combustion in China“

For millions of homes, plants, wood and other types of “biomass” serve as an essential source of fuel, especially in developing countries, but their mercury content has raised flags among environmentalists and researchers. Scientists are now reporting that among dozens of sources of biomass, processed pellets burned under realistic conditions in China emit relatively low levels of the potentially harmful substance. The report was published in the ACS journal “Energy & Fuels”.

Wood pellets and other types of plant-based “biomass” serve as fuel for millions of homes, but their mercury content has raised flags.
(**Image Credit:** iStock/Thinkstock)

Xuejun Wang and colleagues explain that mercury is associated with health problems, particularly in children. But reducing exposure to mercury remains a huge challenge. In 2010 alone, coal-fired power plants, gold mining, the burning of biomass for fuel and other sources generated about 2,000 tons of mercury emissions around the world. In China, biomass such as plants and wood contributes to nearly a third of the energy used in the nation’s rural areas. To take steps to reduce mercury emissions, however, researchers first need know how much of the substance comes from burning different types of biomass. The problem is that previous estimates were based on data measured in industrialized countries, which may not be accurate for other locations. To get a clearer picture of what’s happening in China, Wang’s team took measurements there with biomass sources and stoves that rural residents actually use to cook and keep themselves warm.

They found that the levels of mercury released from burning biomass in widely available stoves varied greatly, depending on the source. Some of the highest levels of mercury came from burning certain wood species in raw form, such as Chinaberry and Chinese pine. In comparison, biomass pellets compressed from cornstalks and pine wood released lower levels of mercury. “Biomass pellets can reduce mercury emissions compared with the uncompressed raw materials,” the scientists conclude.

Source: www.acs.org

Nutritional types of Microorganisms

Major Nutritional Types	Energy source	Hydrogen/ electron	carbon source	Representative Microorganisms
Photolithotrophic autotrophy (Photolithoautotrophy) (photoautotrophs)	Light energy	Inorganic hydrogen/electron (H/e–) donor	CO_2 carbon source	Algae Purple and green sulfur bacteria Cyanobacteria
Photoorganotrophic heterotrophy (Photoorganoheterotrophy) (Photoheterotrophs)	Light energy	Organic H/e– donor	Organic carbon source	Purple nonsulfur bacteria Green nonsulfur bacteria
Chemolithotrophic autotrophy (Chemolithoautotrophy) (Chemoautotrophs)	Chemical energy source (inorganic)	Inorganic H/e– donor	CO_2 carbon source	Sulfur-oxidizing bacteria Hydrogen bacteria Nitrifying bacteria Iron-oxidizing bacteria
Chemoorganotrophic heterotrophy (Chemoorganoheterotrophy) (Chemoheterotrophs)	Chemical energy source (organic)	Organic H/e– donor	Organic carbon source	Protozoa, Fungi, Most nonphotosynthetic bacteria (including most pathogens)

Mobile App. For Beneficial Bacteria

For download : http://www.envismadrasuniv.org/images/mobile%20app/ENVIS_Dzum.apk