ORGANIC FARMING

Organic farming-

• is a method of crop and livestock production that involves choosing not to use pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones

• A Holistic system designed to optimize the productivity and fitness of diverse communities within the agroecosystem, including soil organisms, plants and livestock

The general principles of organic production, include the following:

1. protect the environment,

minimize soil degradation and erosion, decrease pollution, optimize biological productivity

2. maintain long-term soil fertility by optimizing conditions for biological activity within the soil

3. recycle materials and resources to the greatest extent possible within the enterprise

4. prepare organic products, emphasizing careful processing, and handling methods in order to maintain the organic integrity and vital qualities of the products at all stages of production

5. rely on renewable resources in locally organized agricultural systems

• In 1921 the founder and pioneer of the organic movement Albert Howard and his wife Gabrielle Howard, accomplished botanists, founded an Institute of Plant Industry to improve traditional farming methods in India

Methods

- ✓ Crop rotation
- ✓ Green manures and compost
- ✓ Biological pest control
- ✓ Nitrogen fixing organisms
- ✓ Natural insect predators

- The science of agroecology has revealed the benefits of polyculture (multiple crops in the same space), which is often employed in organic farming

- Planting a variety of vegetable crops supports a wider range of beneficial insects, soil microorganisms, and other factors that add up to overall farm health

- Biological process, driven by microorganisms such as mycorrhiza and earthworms allows the natural production of nutrients in the soil throughout the growing season

- Organic farmers use a number of traditional farm tools to minimize their reliance on fossil fuels

- In India, in 2016, Sikkim achieved its goal of converting to 100% organic farming

- Kerala, Mizoram, Goa, Rajasthan and Meghalaya, have also declared their intentions to shift to fully organic cultivation

- Andhra Pradesh is promoting organic farming, especially Zero Budget Natural Farming (ZBNF) which is a form of regenerative agriculture

- As of 2018, India has the largest number of organic farmers in the world and constitutes to more than 30% of the organic farmers globally

- India has 835,000 certified organic producers

Advantages of Organic Farming:

•Farmers can reduce their cost of production as they do not need to buy expensive chemicals and fertilizers.

•Healthier farmworkers as no pesticide is used.

•Organic farms save energy and protect the environment in the long term.

•Organic farming can slow down global warming.

•There are fewer residues in food.

•Biodiversity: More animals and plants can live in the same place in a natural way. Organic farming creates new living areas for wasps, bugs, beetles and flies by giving them water and food.

•Alleviates Pollution of groundwater.

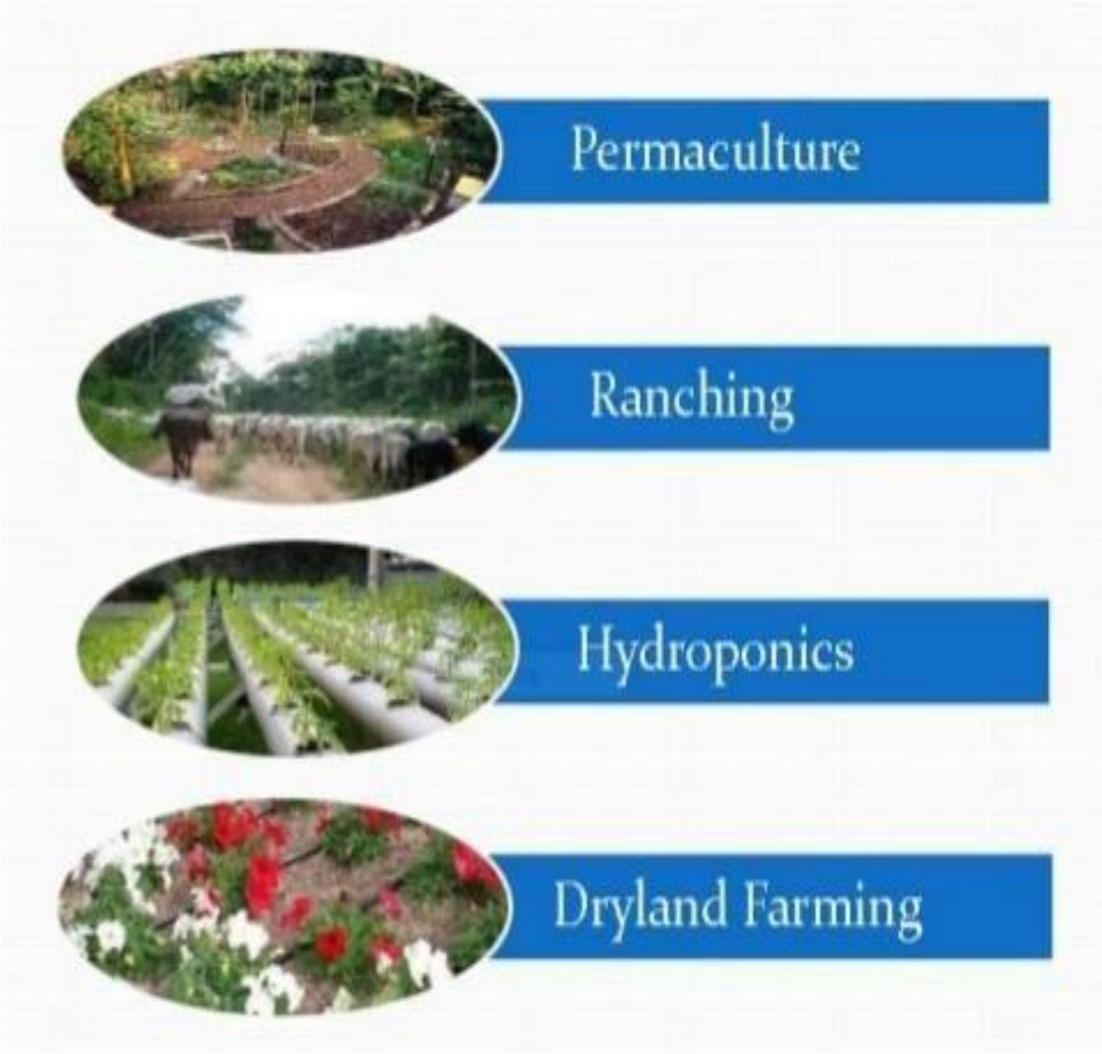
•Soil gets conditioned from natural fertilizers in order to grow crops.

•Soil conservation is done due to crop rotation.

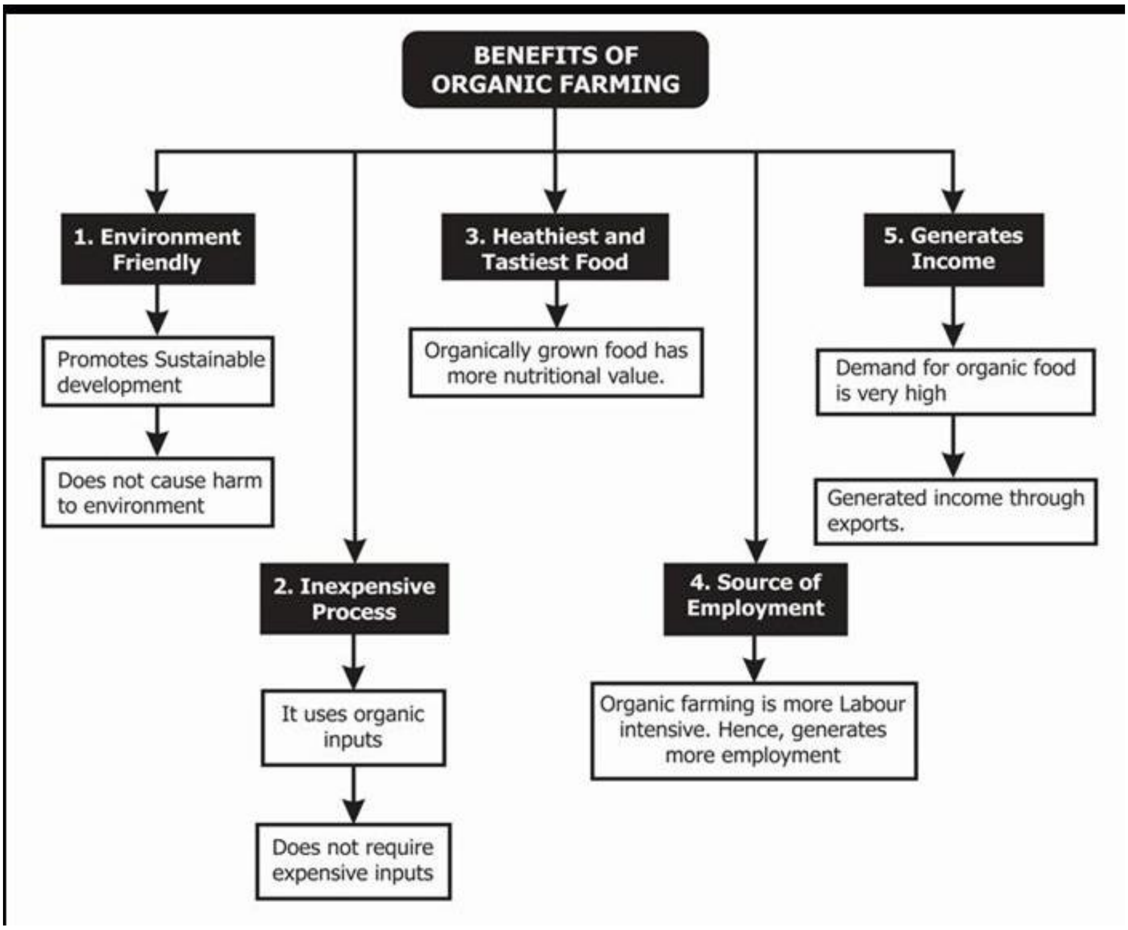
https://www.researchgate.net/figure/The-main-principles-and-effects-of-organic-farming_fig1_338066368

Techniques of organic farming

Types of Organic farming



Benefits of organic farming



Key Highlights

• The central government had launched two dedicated programs in 2015 to provide a boost to natural, organic and chemical-free farming.

The schemes include:

1. Mission Organic Value Chain Development for North East Region (MOVCD)

2. Paramparagat Krishi Vikas Yojana (PKVY)

• The two programmes were launched to assist farmers to adopt organic farming and improve remunerations due to premium prices.

• The Agri-export Policy 2018 also aims to help India emerge as a major player in global organic markets.

• India's major organic exports include flax seeds, sesame, soybean, tea, medicinal plants, rice and pulses. These exports were instrumental in driving an increase of nearly 50 percent in organic exports in 2018-19, touching Rs 5151 crore.

• The centre is further trying to strengthen the organic e-commerce platform www.jaivikkheti.in to directly link farmers with retail as well as bulk buyers. Infusion of digital technology in a much bigger way. This has been one of the major takeaways during the pandemic period.

Certification of Organic Products

The two central programmes PKVY and MOVCD promote certification under Participatory Guarantee System (PGS) and National Program for Organic Production (NPOP) respectively targeting domestic and export markets, as certification is an important element of organic produce to instill customer confidence.

The Food Safety and Standards (Organic Foods) Regulations, 2017 are also based on the PGS and NPOP standards. The consumer should look out for the logos of FSSAI, Jaivik Bharat / PGS Organic India on produce to establish its organic authenticity. PGS Green certification is given to chemical-free produce under transition to 'organic' which takes 3 years.

Vermicomposting

Vermicomposting-

- Vermicomposting is a type of composting in which certain species of earthworms are used to enhance the process of organic waste conversion and produce a better end-product
- It is a mesophilic process utilizing microorganisms and earthworms
- Vermicompost is the product of the decomposition process using various species of earthworms
- To create a mixture of decomposing vegetable or food waste, bedding materials etc.
- This process is called vermicomposting, while the rearing of worms for this purpose is called vermiculture Vermicomposting
- Vermicomposting, or worm composting, turns kitchen scraps and other green waste into a rich, dark soil that smells like earth
- Made of almost pure worm castings, it's a sort of super compost
- Not only is it rich in nutrients but it's also loaded with the microorganisms that create and maintain healthy soil

Image source: © 2020 - Center for American Progress

- It provides a way to treat organic wastes more quickly
- The earthworm species most often used are red wigglers (Eisenia fetida), though European nightcrawlers (Eisenia hortensis) and red earthworm (Lumbricus rubellus) could also be used
- Red wigglers are recommended by most vermicomposting experts, as they have some of the best appetites and breed very quickly

Earthworm species-

Image source: redwormcomposting.com

• Containing water-soluble nutrients, vermicompost is a nutrient-rich organic fertilizer and soil conditioner in a form that is relatively easy for plants to absorb

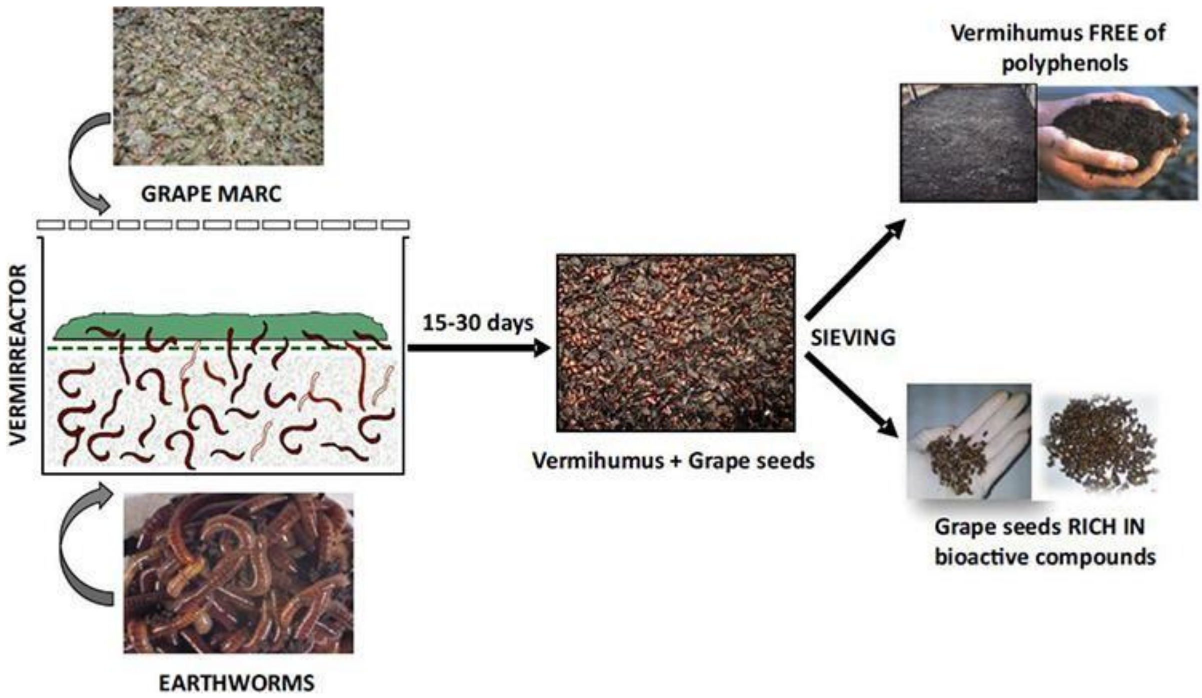
• Worm castings are sometimes used as an organic fertilizer

• Because the earthworms grind and uniformly mix minerals in simple forms, plants need only minimal effort to obtain them

How to vermicompost at home?

- In addition to readily available kitchen scraps, worms, a container, and bedding are required
- One pound of worms, approximately 1,000 worms, to one pound of garbage (worms need to be added gradually)
- Since worms are quite sensitive to both light and noise, a dark corner works best
- They thrive at temperatures between about 13°-25°C
- Bedding should be about 75 percent water
- Bedding can be made out of strips of newspaper or shredded grocery bags, cardboard, or egg cartons, composted manure, old leaves, coconut coir, or a mixture of any of these substances

Vermiculture unit of kitchen waste recycling @ PES University



Vermicomposting in Large Scale

Benefits for plant growth

•Enhances germination, plant growth, and crop yield

•Improves root growth and structure

•Enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid)

Benefits for environment

•Biowastes conversion reduces waste flow to landfills

•Elimination of biowastes from the waste stream reduces contamination of other recyclables collected in a single bin

•Production reduces greenhouse gas emissions such as methane and nitric oxide

Uses

- Soil conditioner
- Vermicompost can be mixed directly into the soil, or mixed with water to make a liquid fertilizer known as worm tea

BIOFUELS

- Biofuels are a renewable energy source, made from organic matter or wastes, that can play a valuable role in reducing carbon dioxide emissions
- Biofuels are one of the largest sources of renewable energy in use today
- In the transport sector, they are blended with existing fuels such as gasoline and diesel

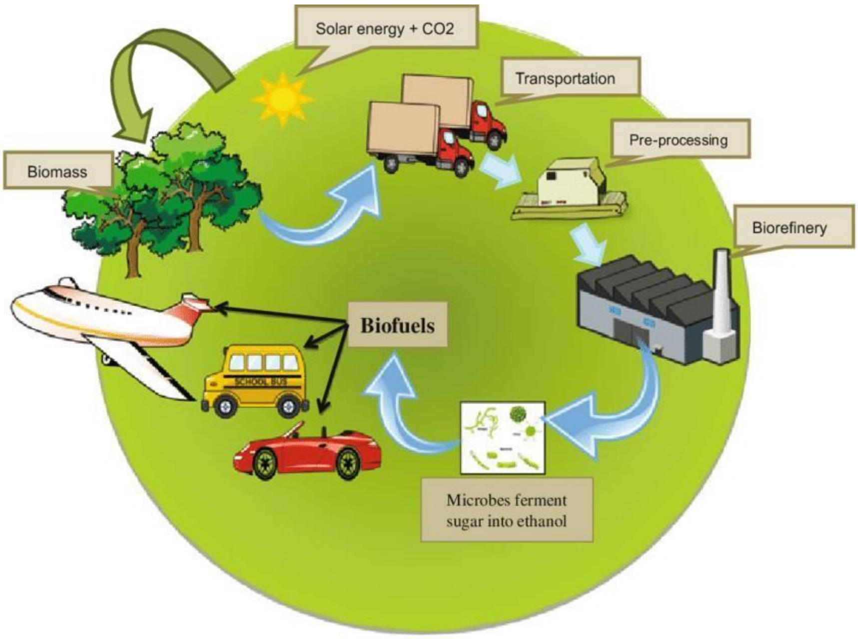


Image source: solarsurge.in

- Biofuels can be produced from plants (i.e. energy crops), or from agricultural, commercial, domestic, and/or industrial wastes (if the waste has a biological origin)
- The two most common types of biofuels in use today are bioethanol and biodiesel, both of which represent the first generation of biofuel technology
- First-generation or conventional biofuels are made from food crops grown on fertile land
- Second-generation biofuels are fuels manufactured from various types of biomass. Biomass means any source of organic carbon that is renewed rapidly as part of the carbon cycle. Biomass is derived from plant materials, but can also include animal materials.
- Third generation biofuels use algae as a source
- Fourth generation class of biofuels include electrofuels and photobiological- solar fuels

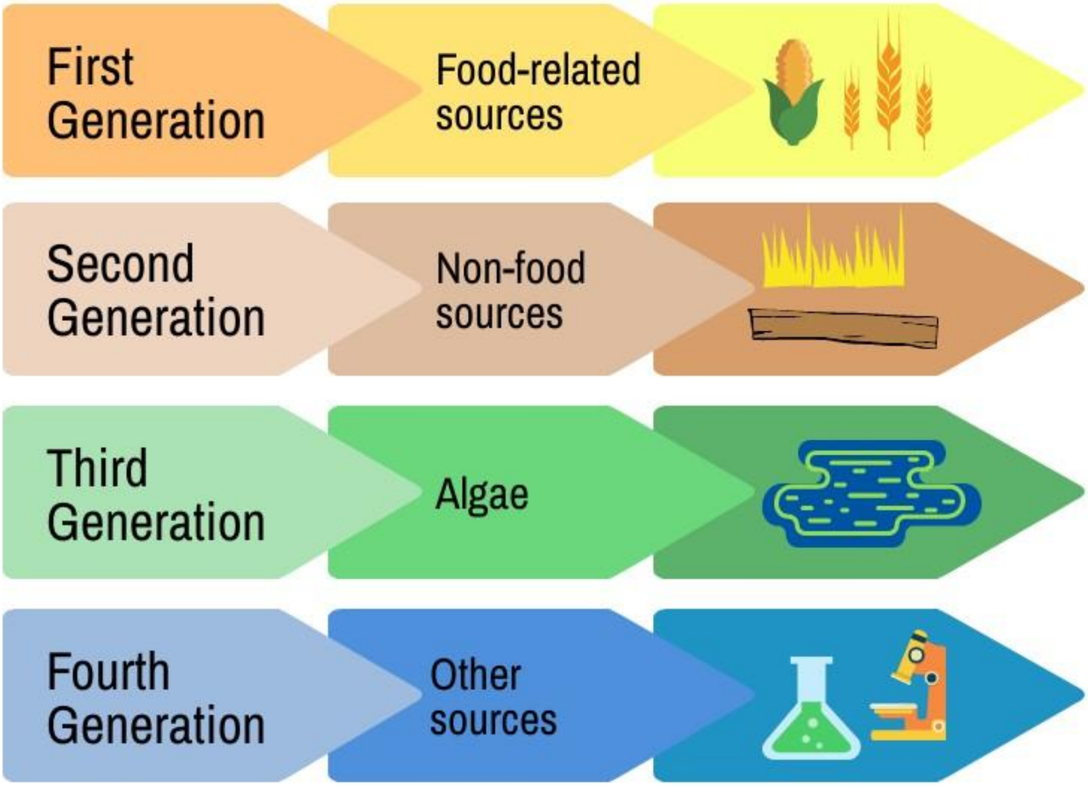


Image source: © 2019 letstalkscience

The following fuels can be produced using first, second, third or fourth-generation biofuel production procedures:

- Biogas
- Syngas
- BioEthanol
- Biodiesel
- Green diesel
- Bioethers

Bioethanol:

• Most ethanol is made from plant starches and sugars, but scientists are continuing to develop technologies that would allow for the use of cellulose and hemicellulose

• The common method for converting biomass into ethanol is called fermentation when microorganisms (e.g., bacteria and yeast) metabolize plant sugars and produce ethanol Biodiesel:

• Biodiesel is a liquid fuel produced from renewable sources, such as new and used vegetable oils and animal fats and is a cleaner-burning replacement for petroleum-based diesel fuel

• Biodiesel is nontoxic and biodegradable and is produced by combining alcohol with vegetable oil, animal fat, or recycled cooking grease

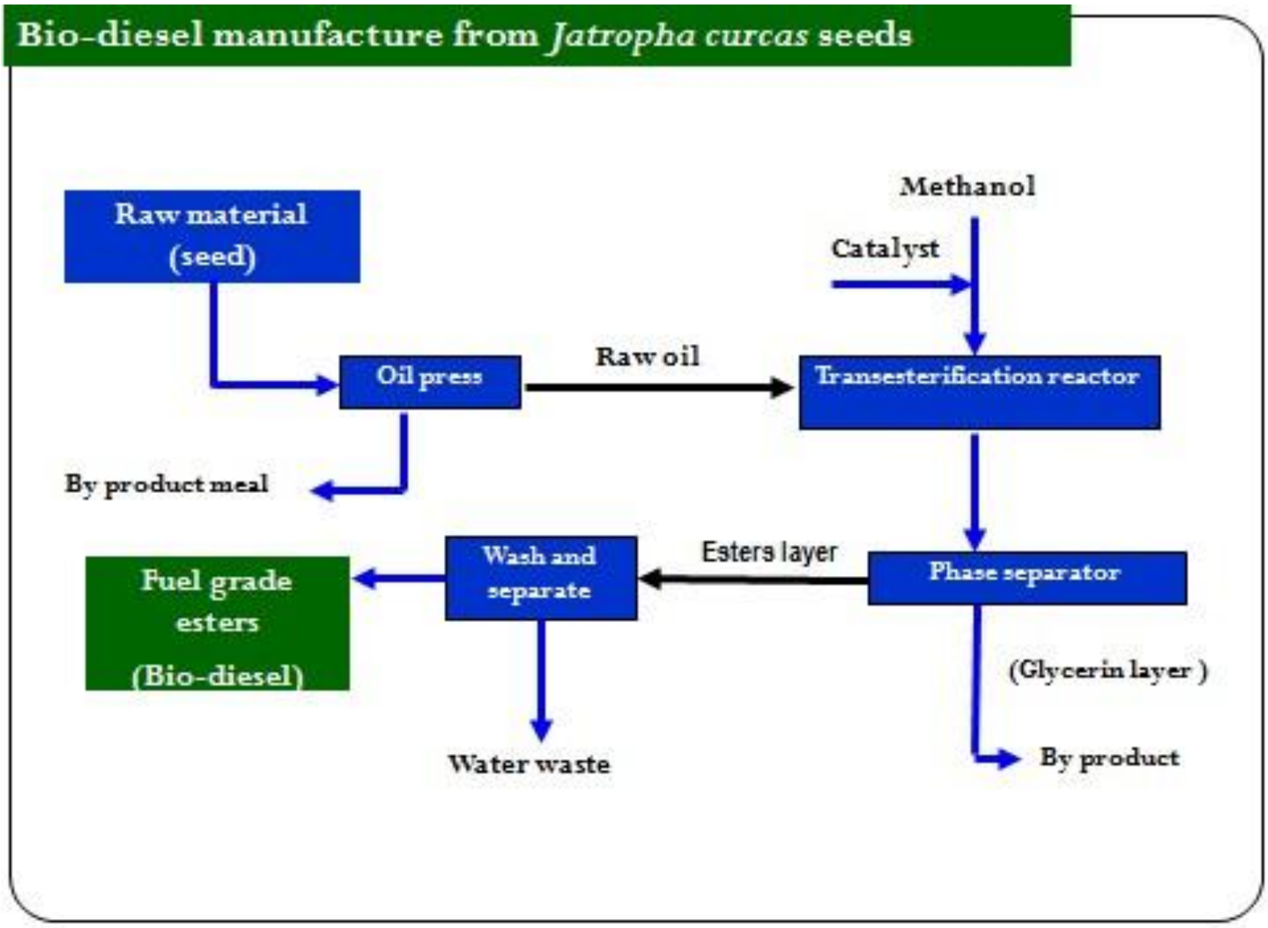
Advantages of biofuels

1. Efficient fuel
2. Non-dependency on fossil fuels
3. Durability of vehicles' engine
4. Easy to source
5. Renewable
6. Reduces greenhouse gases
7. Lower levels of pollution Disadvantages of biofuels

1. High Cost of Production
2. Use of Fertilizers for the huge amount of crops used to produce biofuels
3. Water use
4. Land use
5. Dependent of weather

- India’s biofuel production accounts for only 1% of the global production
- It is worth noticing that India is the second largest producer of sugarcane in the world but accounts for only about 1% of global ethanol production

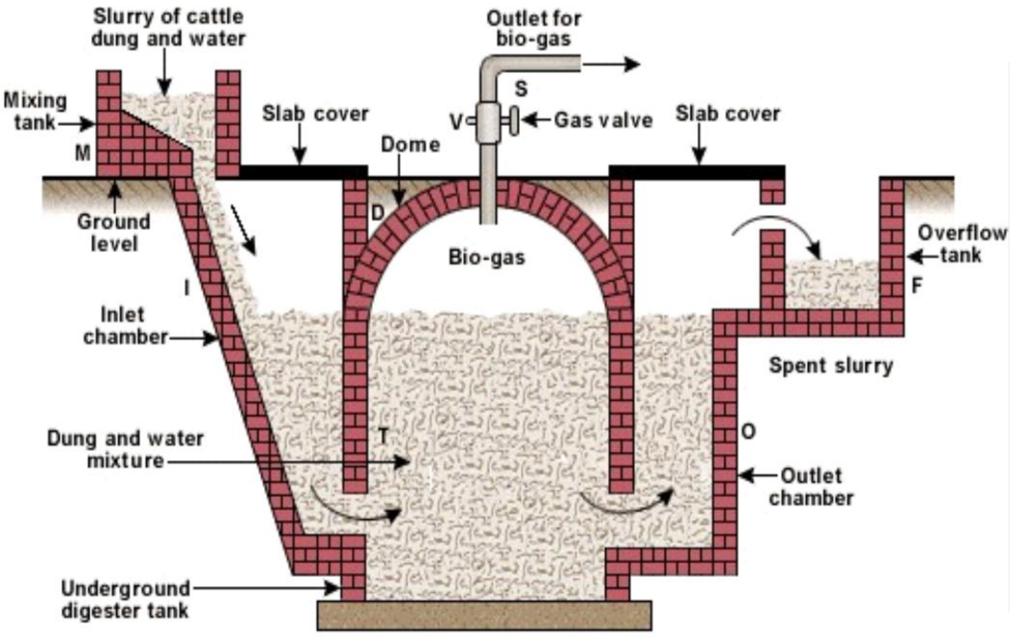
- In India, jatropha seeds were used to produce biodiesel, but the production has not been consistent
- Farmers were encouraged to plant jatropha, but the yield was far below what was expected
- This led to the raw material cost becoming fairly expensive, making biodiesel even more expensive than petroleum based diesel



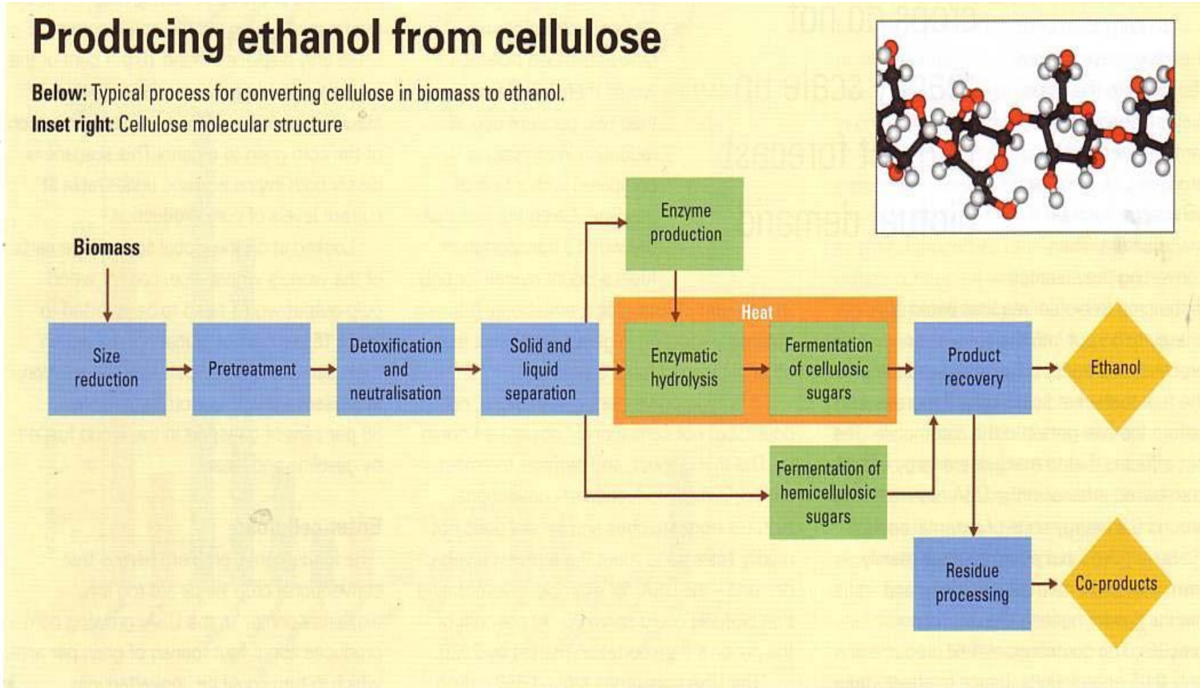
- Bioenergy consists of biomass (biological mass) used in the production of energy
- Phototrophs use light to survive and propagate (plants)

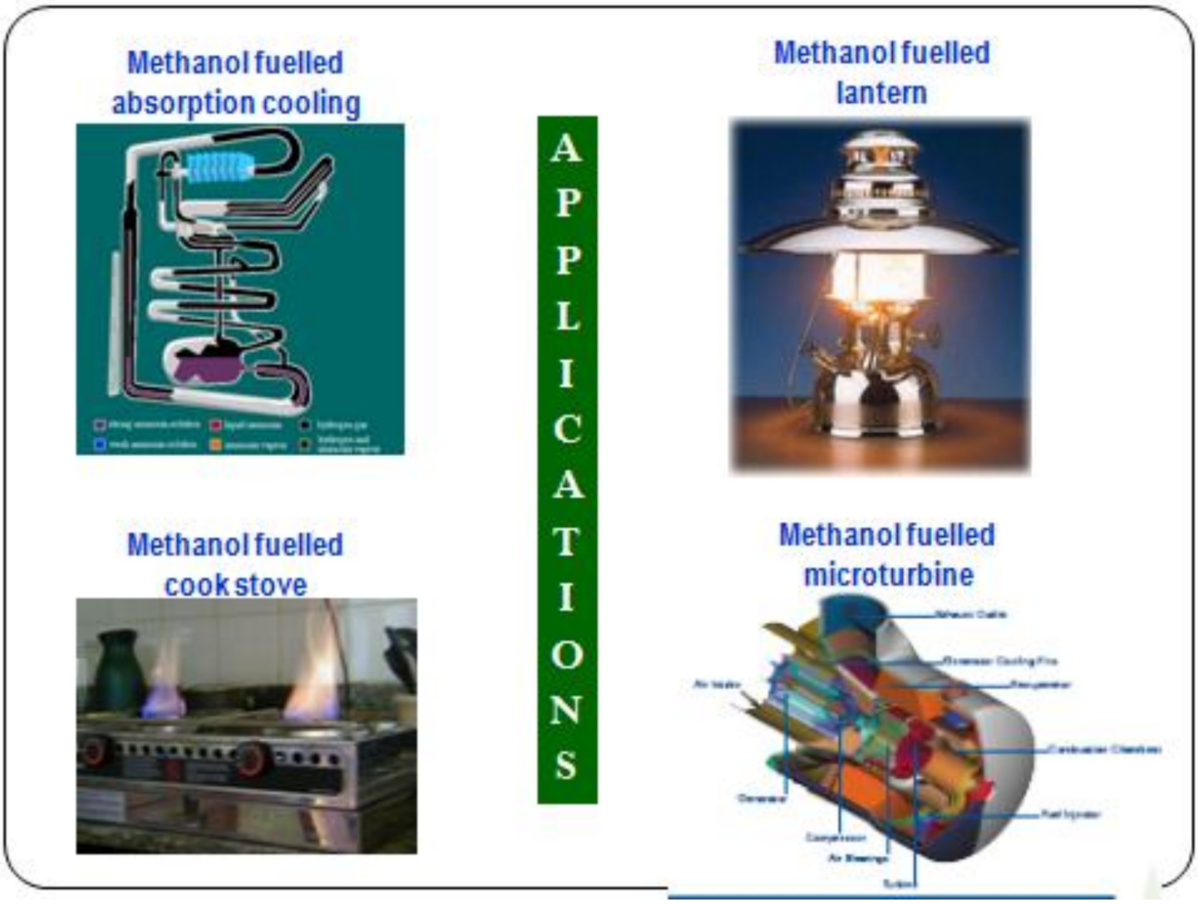
$CO_2 + H_2O$ >--solar energy and ..>>$CH_2O + O_2$, or carbohydrate and oxygen

- Chemotrophs (like us) eat phototrophs (vegetables and salads)
- While biomass combustion releases CO_2 into the atmosphere, new plants require CO_2 to grow, balancing the process.



Fixed-dome type bio-gas plant.


Producing ethanol from cellulose
Below: Typical process for converting cellulose in biomass to ethanol.
Inset right: Cellulose molecular structure
Biomass
Size reduction
Pretreatment
Detoxification and neutralisation
Solid and liquid separation
Enzyme production
Heat
Enzymatic hydrolysis
Fermentation of cellulosic sugars
Fermentation of hemicellulosic sugars
Product recovery
Ethanol
Residue processing
Co-products

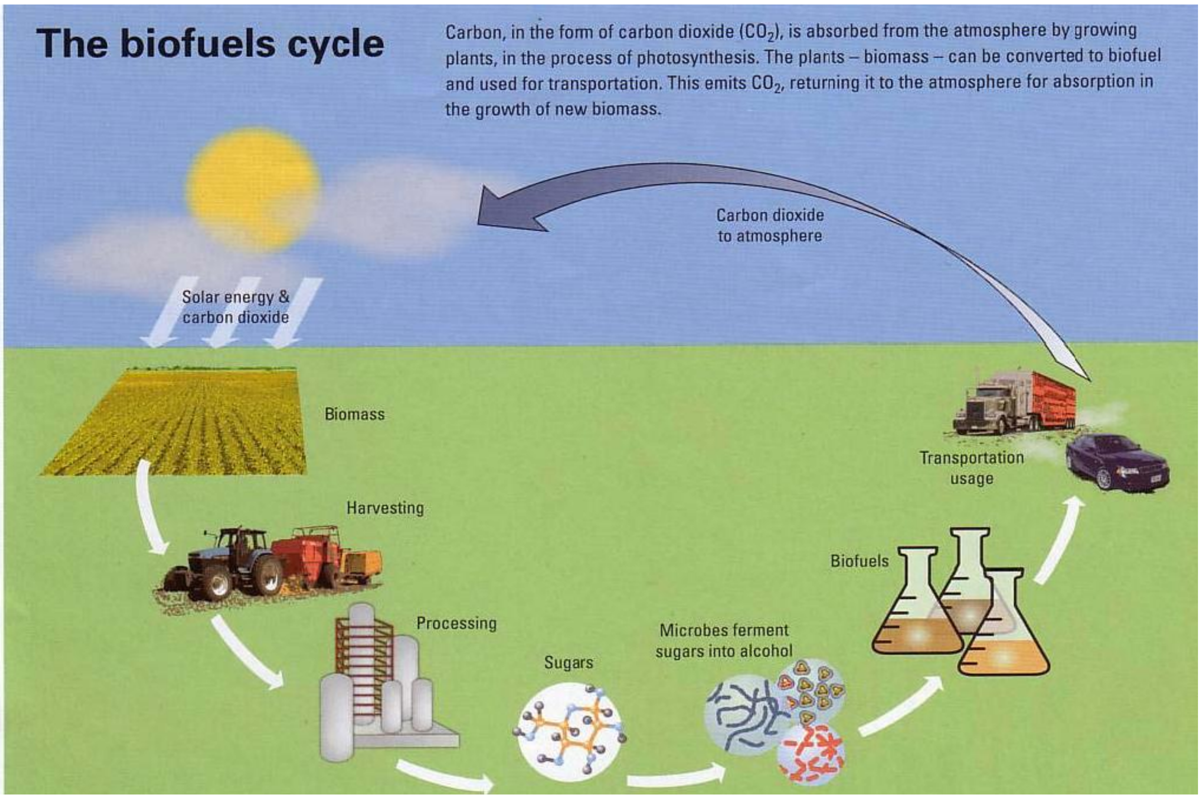

Methanol fuelled absorption cooling
APPLICATIONS
Methanol fuelled lantern
Methanol fuelled cook stove
Methanol fuelled microturbine

- Daimler-Benz, with Ballard, has produced their methanol-driven car, Necar.

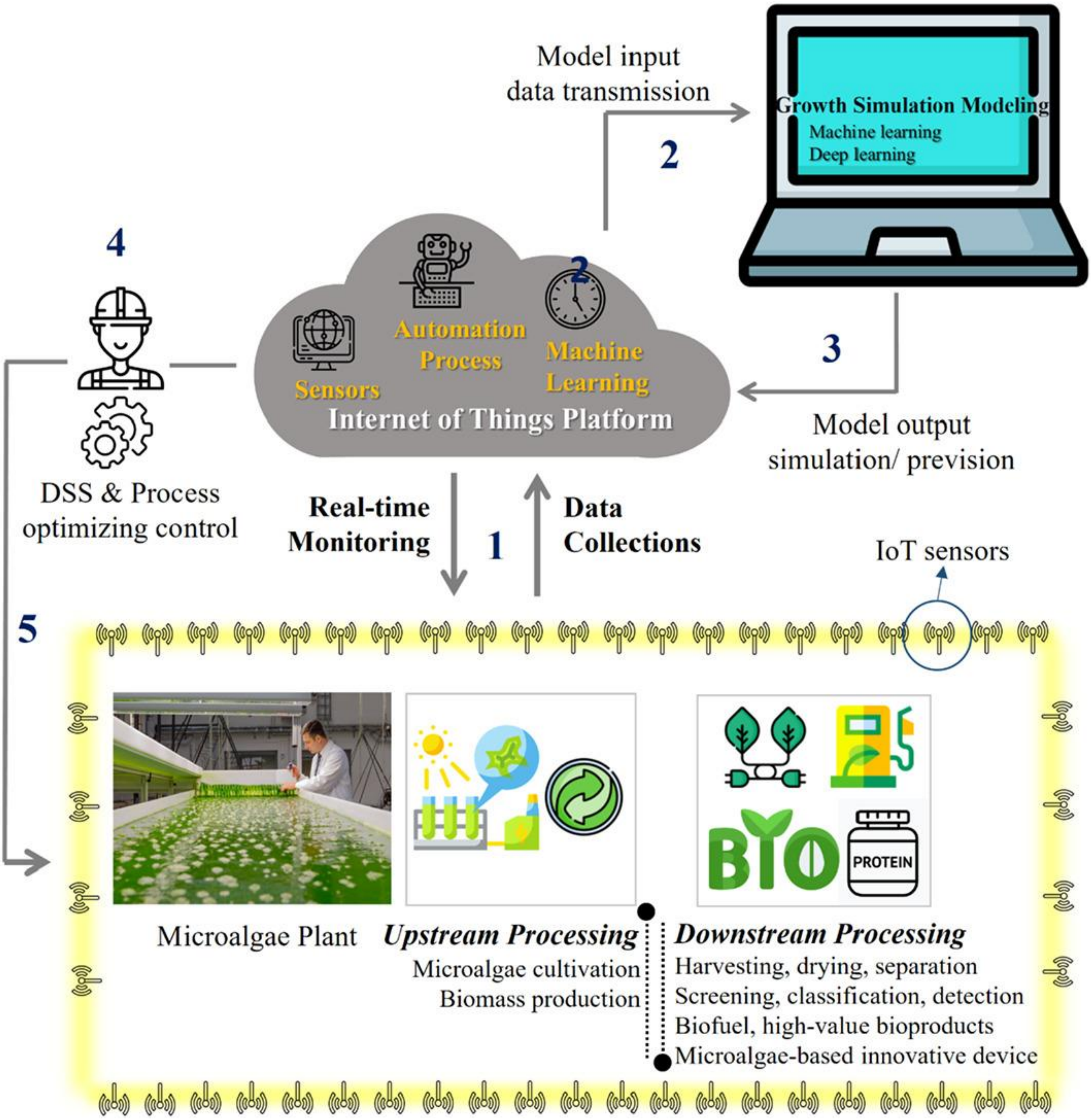
<u>Its features are</u>:

- Top-speed: 120km/h
- Only weighs 1.7 tons
- Upto 400km for 38l of methanol

Other Applications of Methanol


The biofuels cycle
Carbon, in the form of carbon dioxide (CO_2), is absorbed from the atmosphere by growing plants, in the process of photosynthesis. The plants – biomass – can be converted to biofuel and used for transportation. This emits CO_2, returning it to the atmosphere for absorption in the growth of new biomass.
Carbon dioxide to atmosphere
Solar energy & carbon dioxide
Biomass
Harvesting
Processing
Sugars
Microbes ferment sugars into alcohol
Biofuels
Transportation usage

IoT



https://www.sciencedirect.com

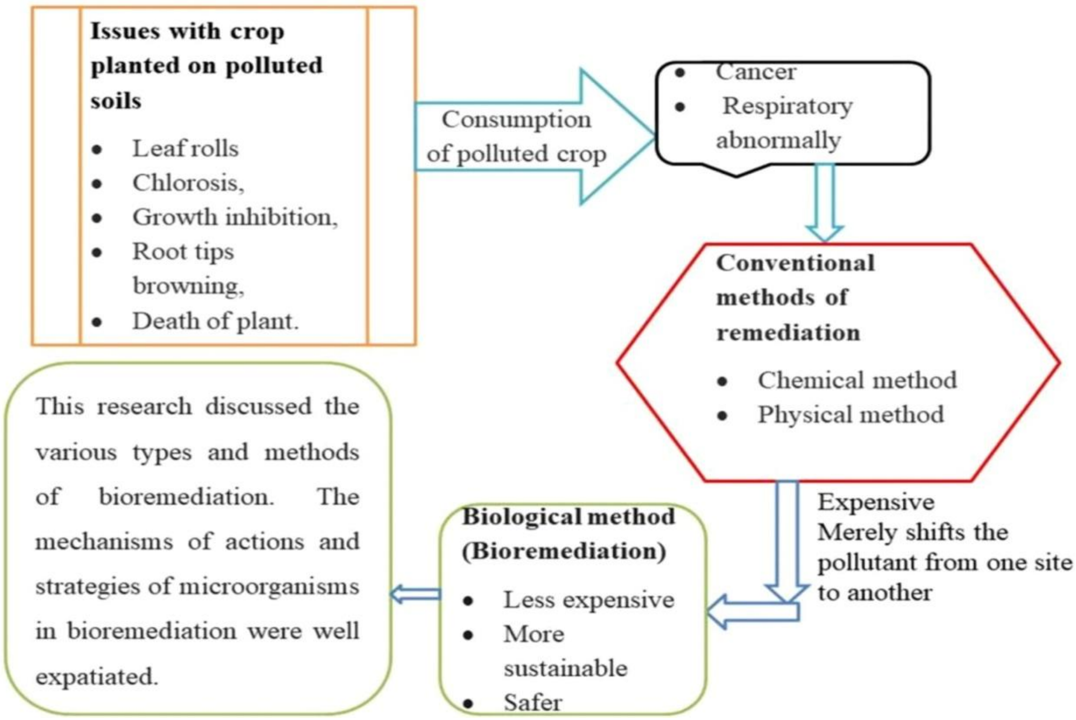
- Microalgae biorefinery is a platform for the conversion of microalgal biomass into a variety of value-added products, such as biofuels, bio-based chemicals, biomaterials, and bioactive substances.

- Commercialization and industrialization of microalgae biorefinery heavily rely on the capability and efficiency of large-scale cultivation of microalgae.

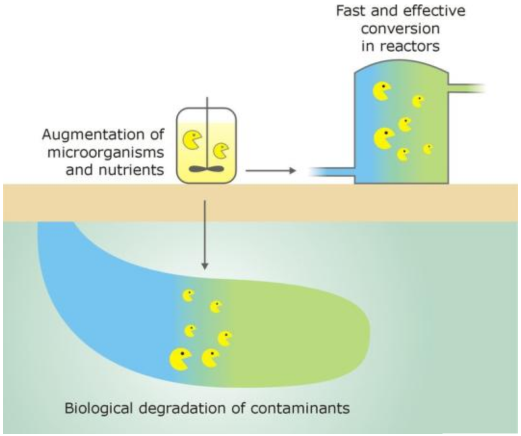
- Thus, there is an urgent need for novel technologies that can be used to monitor, automatically control, and precisely predict microalgae production.
- IoT helps real-time monitoring of microalgae biorefinery process parameters.
- IoT assists in sufficient data collection to make smart prediction and decision.
- IoT promotes automation in microalgae biorefinery.
- IoT guides microalgal biorefinery towards low-cost and high efficiency.

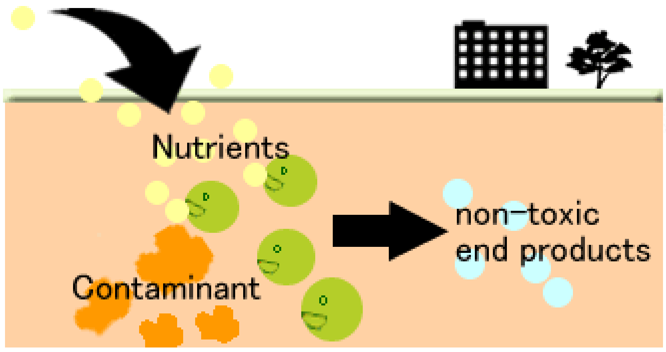
BIOREMEDIATION

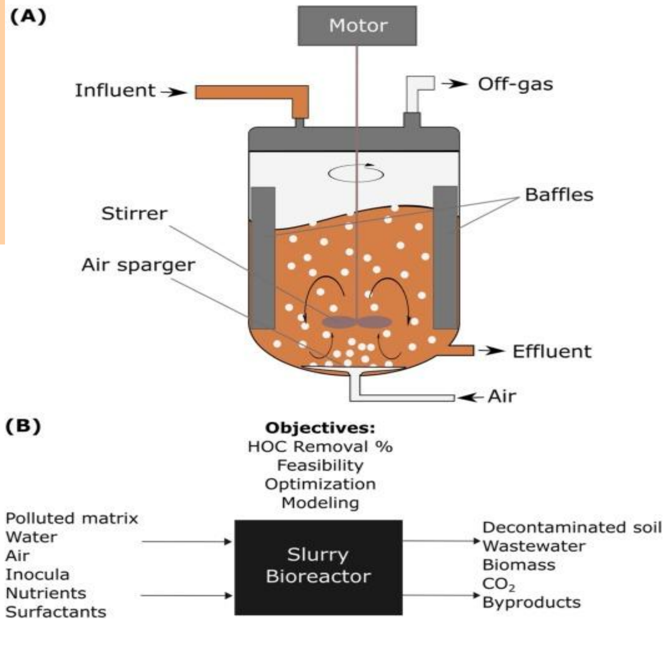
- The use of either naturally occurring or deliberately introduced microorganisms to consume and break down environmental pollutants, in order to clean a polluted site
- Employs the microorganisms, to degrade the pollutants and convert them into less toxic or non-toxic form
- The suitable organisms can be bacteria, fungi, or plants, which have the physiological abilities to degrade, detoxify, or render the contaminants harmless.
- Biological method of remediation is an extremely attractive, important, and productive alternative for cleaning, debugging, managing, and rehabilitating and consequently ameliorating contaminated environments *via* judicious utilization of microbial activities
- Bioremediation technologies can be classified into two general categories: ***ex situ* and *in situ***
- The *ex situ* techniques require the physical removal of the contaminated material and its transportation to another area for further treatment by bioreactors, land farming, or composting, whereas *in situ* technologies involve treatment of contaminated material in place



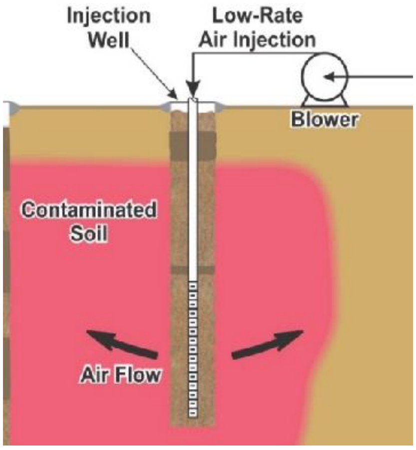
Bioaugmentation	Addition of bacterial cultures to a contaminated medium; frequently used in bioreactors and *ex situ* systems
Biostimulation	Stimulation of indigenous microbial populations in soils or groundwater by adding nutrients to the existing bacteria; which can be performed either *in situ* or *ex situ*
Bioreactors	Biodegradation in a container or reactor; may be used to treat several liquid wastes or slurries but relatively high capital and operational cost

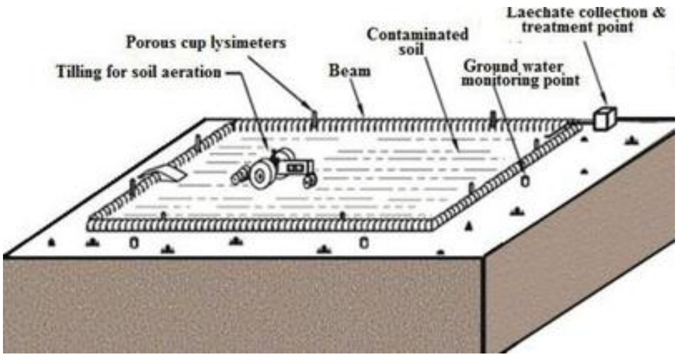






Bioventing	Method of treating contaminated soils by drawing oxygen through the soil to stimulate microbial growth and activity
Composting	Aerobic, thermophilic treatment process; can be performed by using static piles, aerated piles, or continuously fed reactors; extended treatment time
Land farming	Solid-phase treatment system for contaminated soils; may be performed *in situ* or in a constructed soil treatment cell; cost-efficient





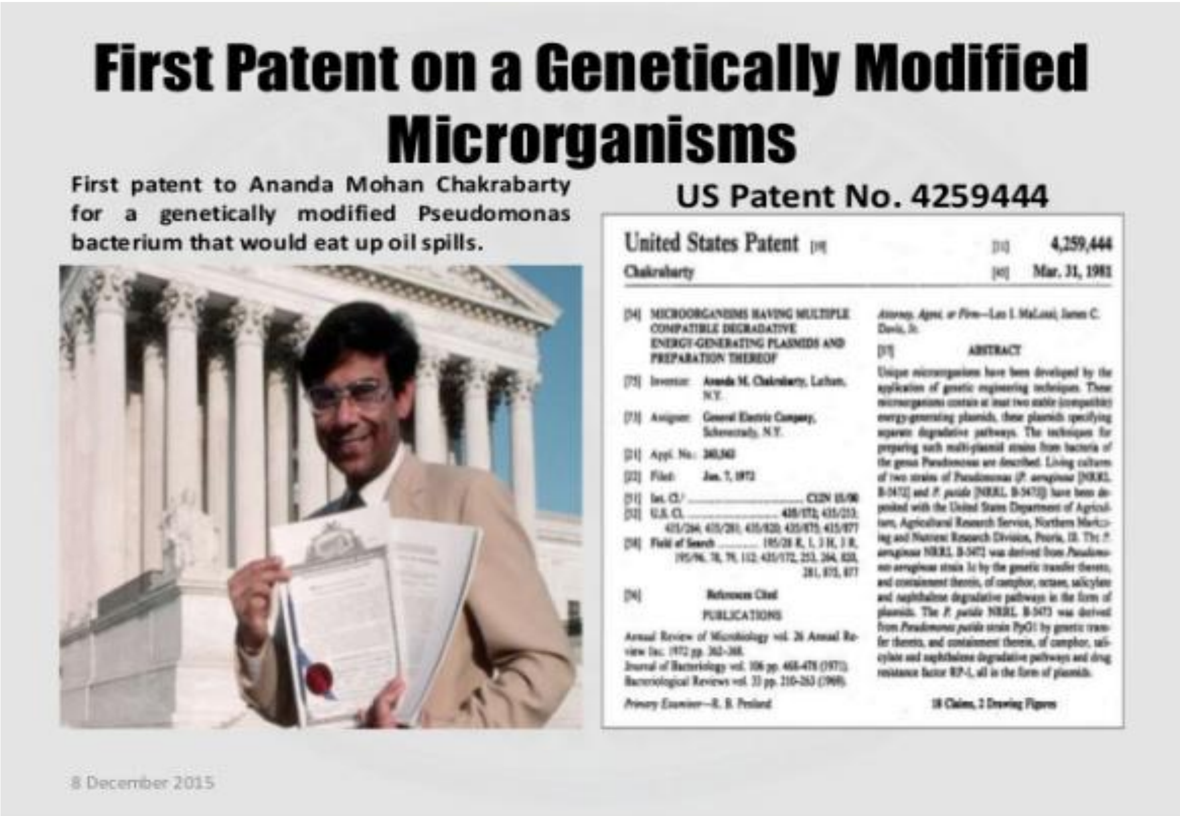
- Most bioremediation systems operate under aerobic conditions; however, anaerobic conditions are also applicable, thus enabling the degradation of recalcitrant molecules by using specific microorganisms
- Mainly microorganisms, microbial or plants or its enzymes are used to detoxify contaminants in the soil and other environments
- Bioremediation, as a technique, can offer several advantages over other more conventional treatment methods
- Firstly, bioremediation, as a natural process for the treatment of wastes, is usually acceptable
- Suitable microbial populations can degrade a wide range of contaminants, rendering a hazardous compound to a harmless one
- Eventually, the residues of the treatment may include simpler compounds, such as carbon dioxide or water, but also cell biomass
- The potential threats to human health and to the environment are minimal
- Crime scene clean-up
- Bioremediation, like any other technology, has certain disadvantages
- In particular, it is limited only to those compounds that are biodegradable
- The effectiveness of bioremediation is highly susceptible to the microbial growth and other environmental parameters of the site
- Bioremediation often requires more time than other treatment options

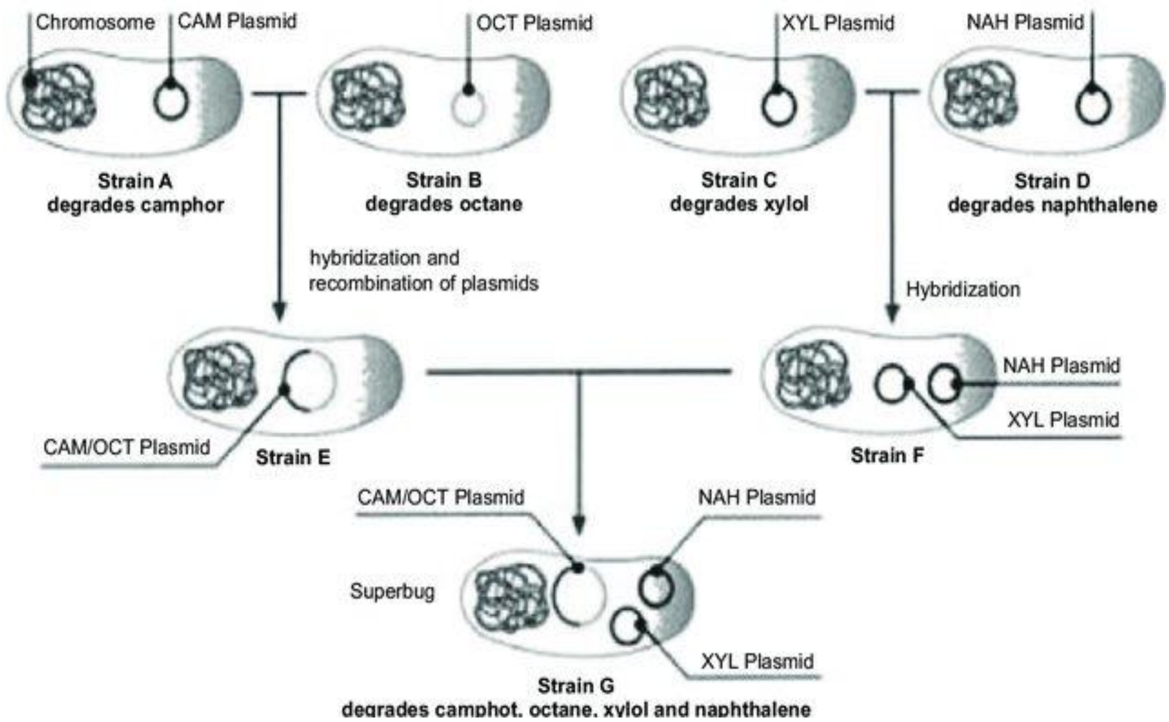
Examples of bioremediation:

- Exxon Valdez spill, Prince William Sound, Alaska, 1989
- Deepwater Horizon oil spill, Gulf of Mexico, 2010

Exxon Valdez spill

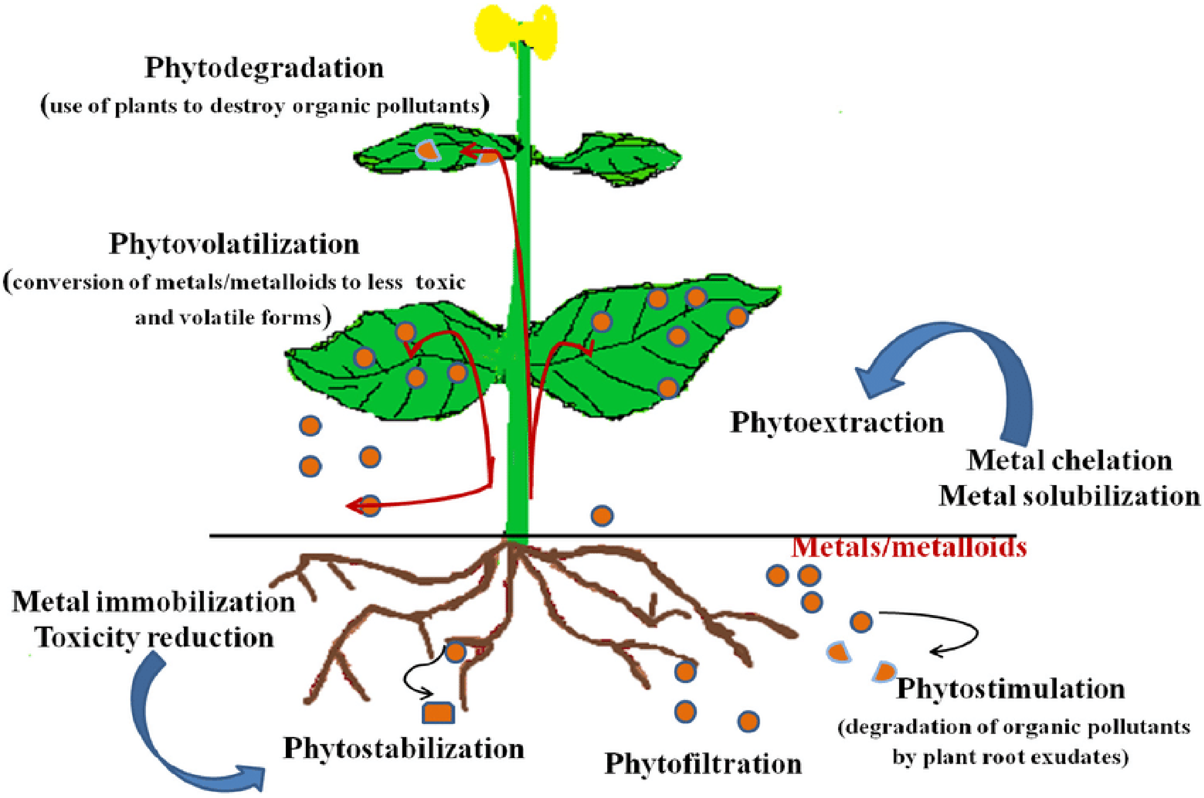
Prof. Chakrabarty genetically engineered a new species of *Pseudomonas* bacteria ("the oil-eating bacteria") in 1971 while working for the Research & Development Center at General Electric Company in Schenectady, New York.





Phytoremediation

Phytoremediation is a bioremediation process that uses various types of plants to remove, transfer, stabilize, and/or destroy contaminants in the soil and groundwater. There are several different types of phytoremediation mechanisms.



Phytotechnology	Mechanism	Pollutants	Plants
Phytoextraction	Hyperaccumulation in harvestable parts of plants	Inorganic: Co, Cr, Ni, Pb, Zn, Au, Hg, Mo, Ag, Cd Radionuclides: Sr, Cs, Pb, U	*Brassica juncea*, *Thalspi caerulescens*, *Helianthus annus*
Rhizofilteration	Rhizosphere accumulation though sorption, concentration and precipitation	Organics/Inorganics: Metals like Cd, Cu, Ni, Zn,Cr Radionuclides	*Brassica juncea*, *Helianthus annus*, Tobacco, Rye, Spinach and Corn
Phytovolatilization	Volatilization by leaves through transpiration	Organics/Inorganics: Chlorinated solvents, inorganics (Se, Hg, As)	*Arabidopsis thaliana*, Poplars, Alfalfa, *Brassica juncea*
Phytodegradation	Pollutant eradication	Organic compounds, Chlorinated solvents, Phenols, Herbicides, Munitions	Hybrid poplars, Stonewort, Black willow, Algae
Phytostabilization	Complexation, sorption and precipitation	Inorganics: As, Cd, Cu, Cr, Pb, Zn, Hs	*Brassica juncea*, Hybrid poplars, Grasses