ENVIRONMENTAL STUDIES & LIFE SCIENCES

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Bio-sustainability

Bio-sustainability

- Organic farming
- Vermicomposting

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Bio-sustainability

Sustainability is a social goal about the ability of people to co-exist on Earth over a long time.

Sustainability consists of fulfilling the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth, environmental care and social well-being.

Bio-sustainability: The quality of being bio-sustainable

FAO - The production, use and conservation of biological resources, including related knowledge, science, technology, and innovation to provide information, products, processes and services to all economic sectors with the aim of moving towards a sustainable economy.

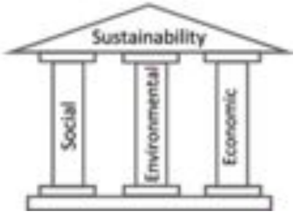

Image source: Sustainability - Wikipedia

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Bio-sustainability – 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

- Holistic system designed to optimize the productivity and fitness of diverse communities within the agro-ecosystem, including soil organisms, plants and livestock

Image source: agritech.ac.in

Bio-sustainability – Organic farming

- **International Federation of Organic Agriculture Movements** (IFOAM), an international organization established in 1972 for organic farming organizations defines the goal of organic farming as:

- “Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved”

Image source: agritech.ac.in

Bio-sustainability – Organic farming

The ***general principles*** of organic production, include the following:

- **Protect the environment**, minimize soil degradation and erosion, decrease pollution, optimize biological productivity
- **Maintain long-term soil fertility** by optimizing conditions for biological activity within the soil
- **Recycle materials and resources** to the greatest extent possible within the enterprise
- 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
- **Rely on renewable resources** in locally organized agricultural systems

Bio-sustainability – Organic farming

- In 1921 the founder and pioneer of the organic movement ***Albert Howard*** and ***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.

Bio-sustainability – Organic farming

- 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

Bio-sustainability – Organic farming

- **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

Bio-sustainability – Organic farming

Advantages

- Farmers can reduce their cost of production as they do not need to buy expensive chemicals and fertilizers.
- Pesticides are not used, hence healthier food & no residues
- Organic farms save energy and protect the environment in the long term.
- Organic farming can slow down global warming.
- Protect Biodiversity (Natural habitat for animals & plants)
- Pollution of groundwater can be reduced.
- Soil is built with natural fertilizers in order to grow crops.
- Soil quality conservation is done due to crop rotation.
- Organic farming creates new living areas for wasps, bugs, beetles and flies by giving them water and food.

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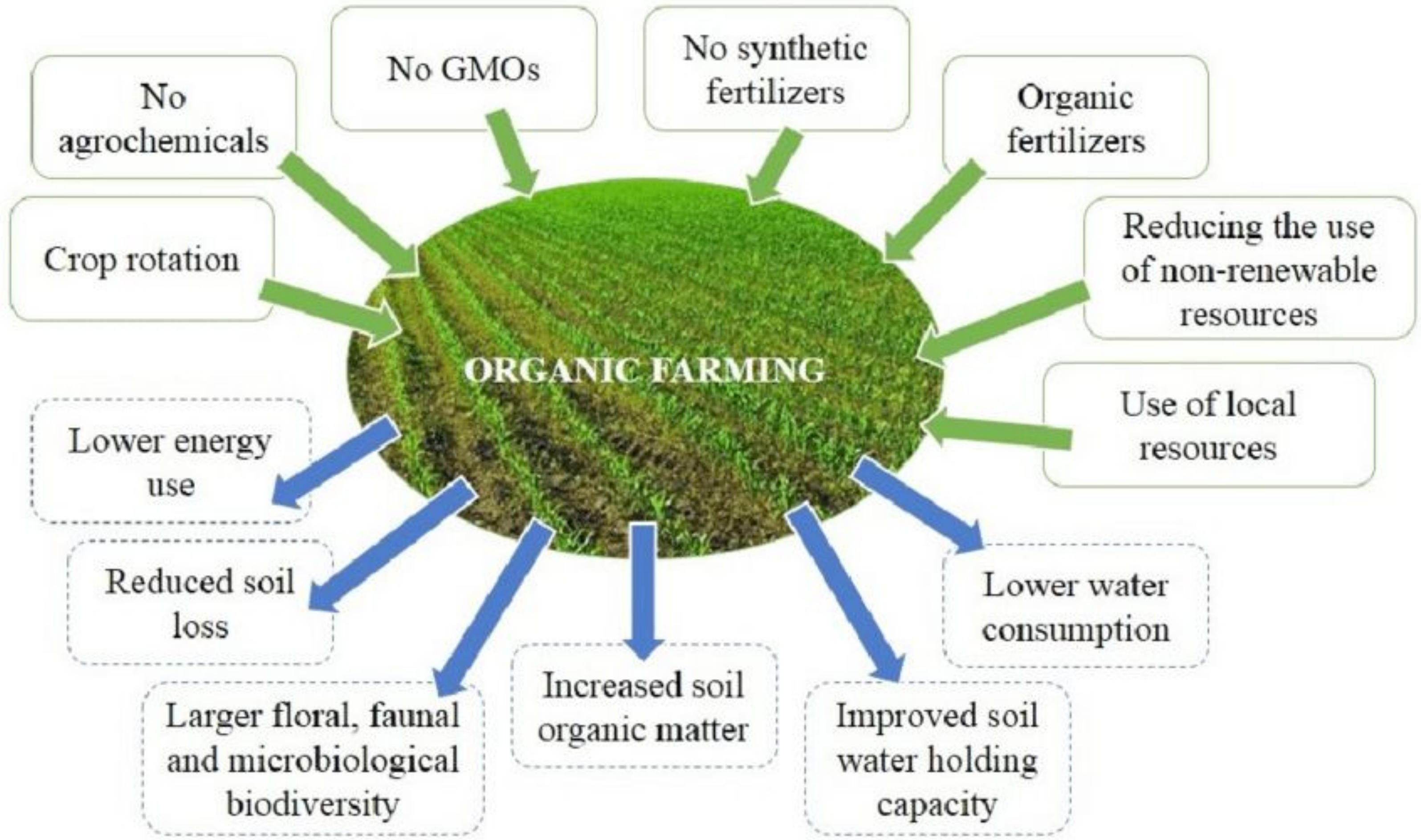
Bio-sustainability – Organic farming

Advantages



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

Bio-sustainability – Organic farming

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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: ***Mission Organic Value Chain Development*** for North East Region (MOVCD) and ***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.

Image source: © 2020 Organic Products India

Bio-sustainability – Organic farming

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Key Highlights

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.




Image source: © 2020 Organic Products India

Bio-sustainability – Organic farming

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 producers to build 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.

Image source: © 2020 Organic Products India

Bio-sustainability – Organic farming

Things to remember before buying a product

PGS Logo - Participatory Guarantee System (PGS) is a quality assurance initiative that is locally relevant, emphasize the participation of stakeholders, including producers and consumers and operate outside the frame of third party certification

- **PGS Organic** - Farmers which have completed full conversion period without any major or serious non-compliance be declared as "PGS-Organic".
- **PGS Green** - Farmers which have one or more major noncompliance or are under conversion period will be declared as "PGS-Green".

Note : In case of mixed/ processed products if minimum of 95% ingredients is PGS-organic the product may be labeled as PGS-Organic. If proportions of organic ingredients are between 95 and 70% the products can be labeled as “Made with PGS-organic ingredients”, but in such cases PGS logo cannot be used.

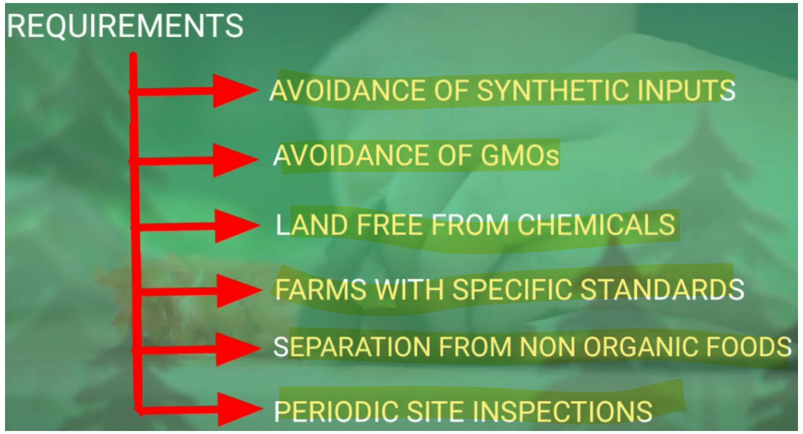


Image source: © 2020 Organic Products India

Bio-sustainability – Organic farming

Things to remember before buying a product

Before Buying PGS certified products, Please check the following

PGS-INDIA ORGANIC

PGS Organic Logo

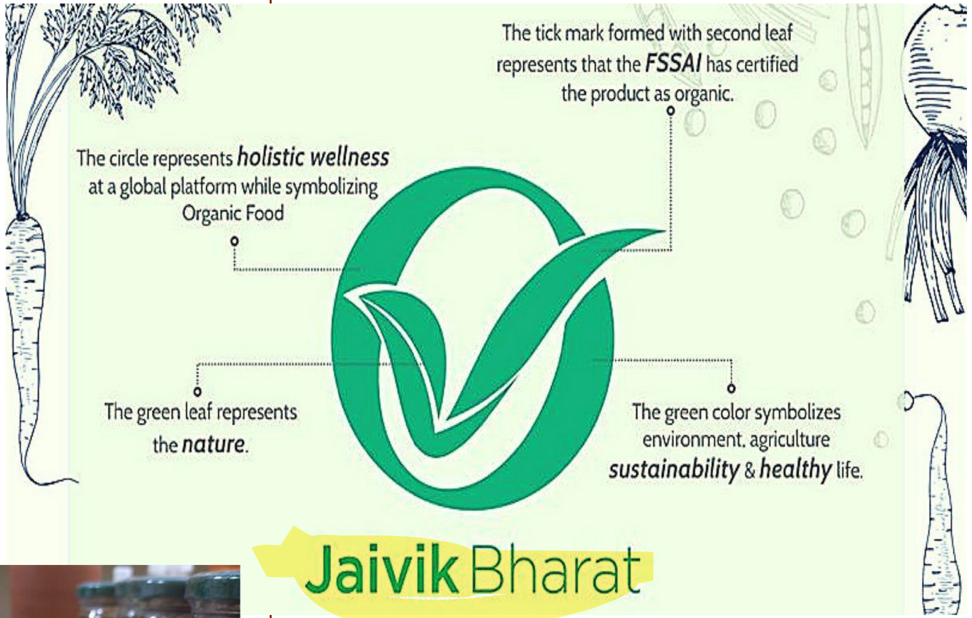
Jaivik Bharat

Jaivik Bharat Logo

Before Buying Third Party certified products, Please check the following

TraceNet Logo

Image source: © 2020 Organic Products India



Source:https://www.prakati.in/jaivik-bharat-certification-organic-food-india/

Bio-sustainability – Organic farming

Types & Techniques

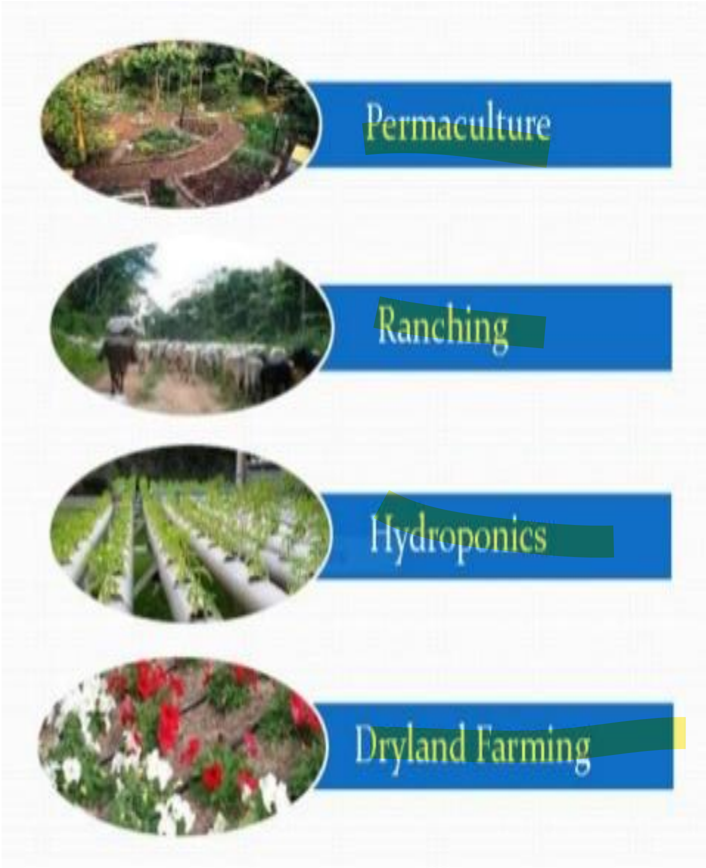


Image source: © 2020 Organic Products India

Bio-sustainability – Organic farming

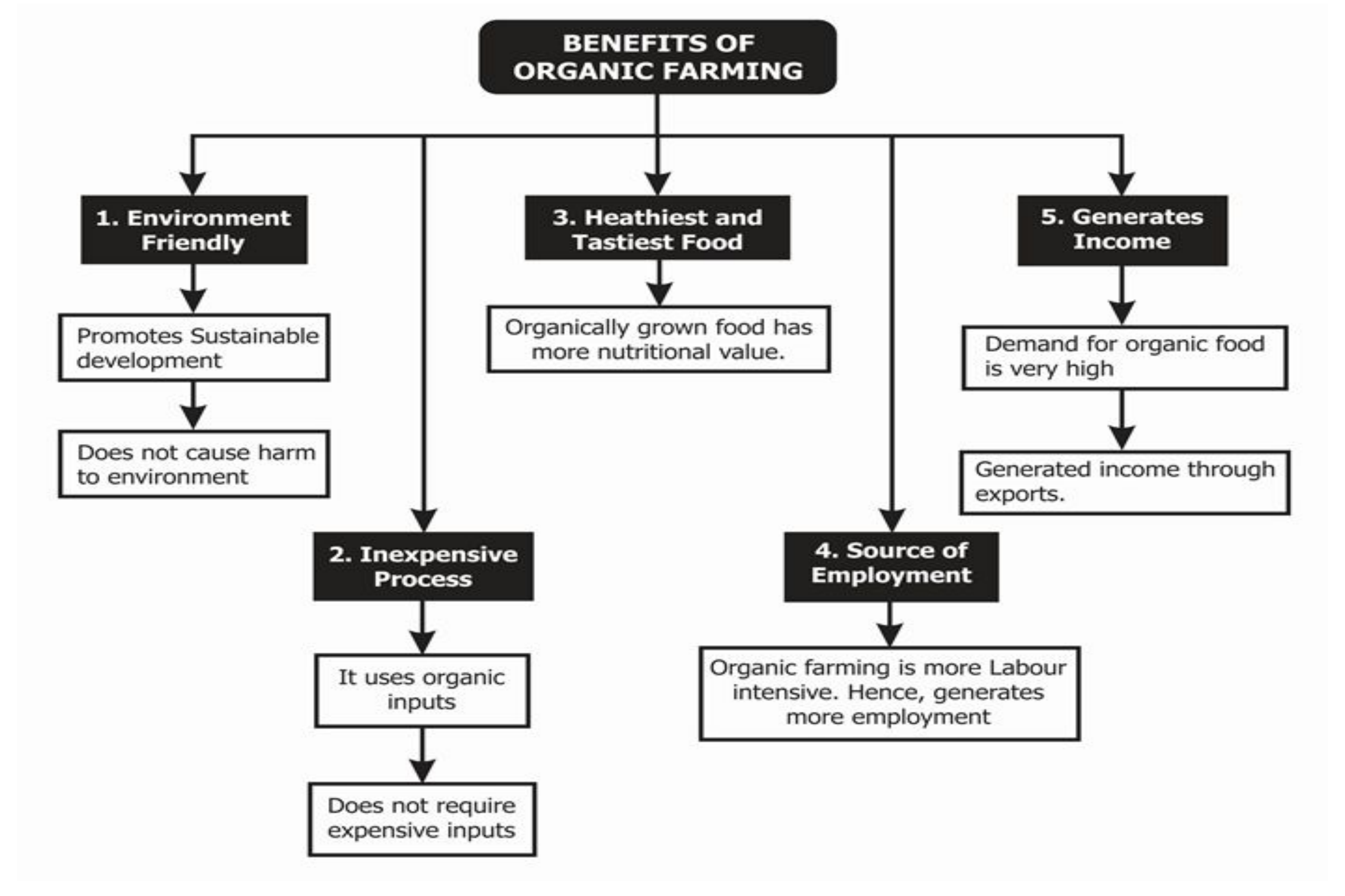


Image source: © 2020 Organic Products India

Bio-sustainability – 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 and this process is called ***vermicomposting***. While the rearing of worms for this purpose is called ***Vermiculture***
- To prepare Vermicompost uses the mixture of decomposing vegetable or food waste, bedding materials etc.

Bio-sustainability – 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.
- It provides a way to treat organic wastes more quickly. The earthworm species most often used are **red wigglers** (***Eisenia fetida***), though **European night crawlers** (***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

Image source: © 2020 - Center for American Progress

Bio-sustainability – Vermicomposting

- **Vermicomposting** contains water-soluble nutrients, & 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 do a 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

❑Collection of Earthworm Species: Collected from the department of entomology, University of Agriculture Sciences, GKVK, Bangalore–65

1. *Eisenia fetida*

2. *Eudrilus euginiae*

3. *Perionyx excavatus*

Bio-sustainability – Vermicomposting

How to do a Vermicompost at home?

- Earthworms thrive at temperatures about 13°-25°C.
- Bedding should be about 75 percent water and 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.
- The material must be clean and non-toxic.

1. Eisenia fetida

2. Eudrilus euginiae

3. Perionyx excavatus

Image source: agritech.ac.in

Bio-sustainability – Vermicomposting

Waste to value added product

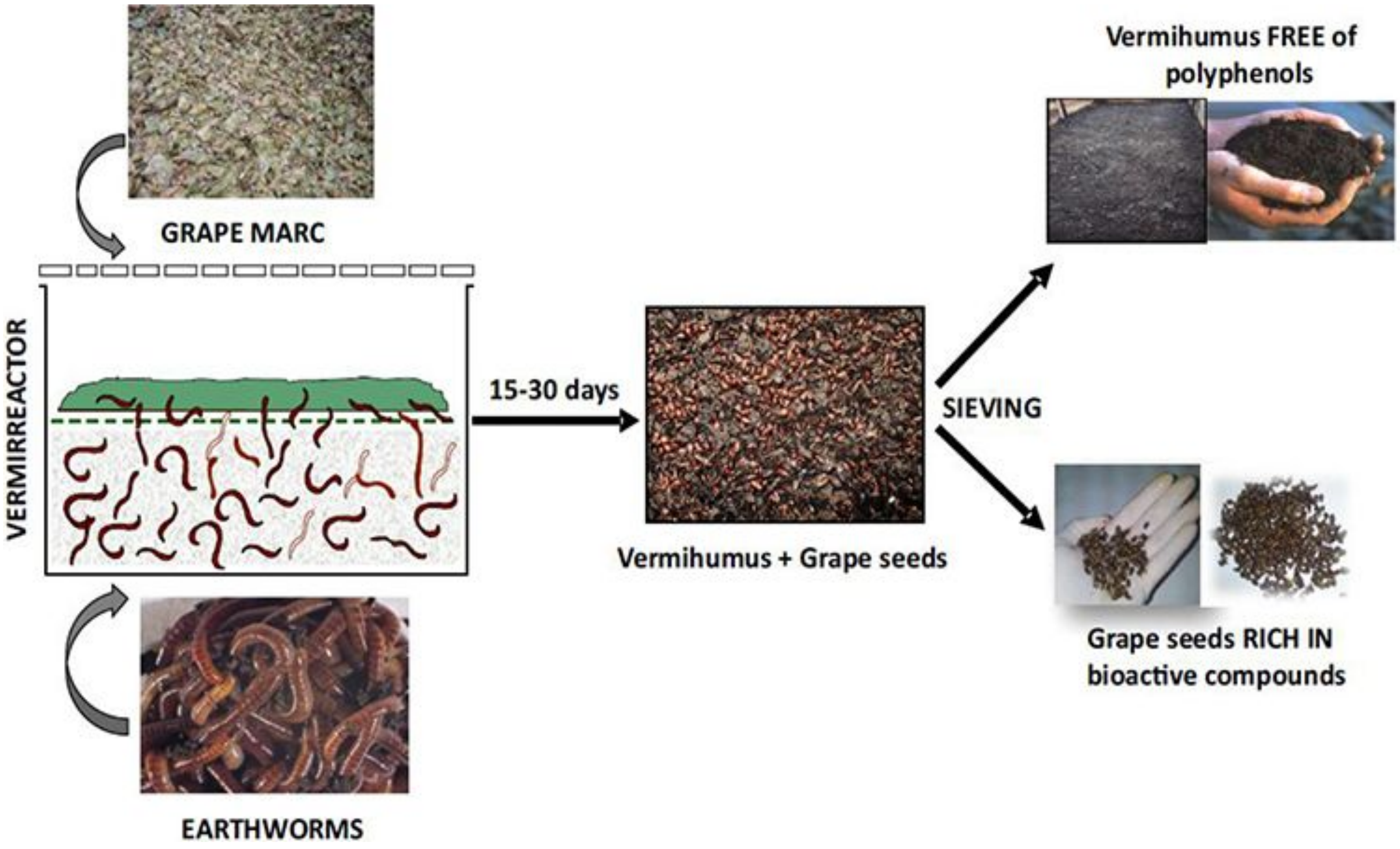


Image source: agritech.ac.in

Bio-sustainability – Vermicomposting

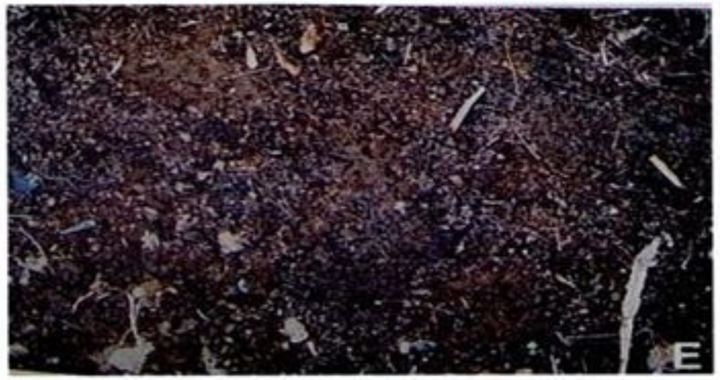
Vermicomposting in large scale

Image source: agritech.ac.in

Bio-sustainability – Vermicomposting

Vermiculture unit for kitchen waste recycling @ PES University

Eisenia fetida, Eudriluus euginiae, Perionyx excavatus



Shade drying of Vermicompost

Sieved Vermicompost

Department of Biotechnology, Vermicomposting unit

Image source: agritech.ac.in

Bio-sustainability – Vermicomposting

Benefits to soil

Improves ***soil aeration***

- Enriches soil with microorganisms (adding enzymes)
- Microbial activity in worm castings is 10 to 20 times higher than in the soil.
- Improves ***water holding*** capacity and increase ***soil fertility***.

Benefits in plant growth

- Enhances germination, plant growth, and crop yield
- Improves root growth and structure
- Enriches soil with microorganisms (adding plant hormones such as auxins and gibberellic acid)

Bio-sustainability – Vermicomposting

Benefits for environment

Bio-wastes conversion reduces waste flow to landfills

Elimination of bio-wastes 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***.

Bio-sustainability – Vermicomposting

Vermicomposting unit

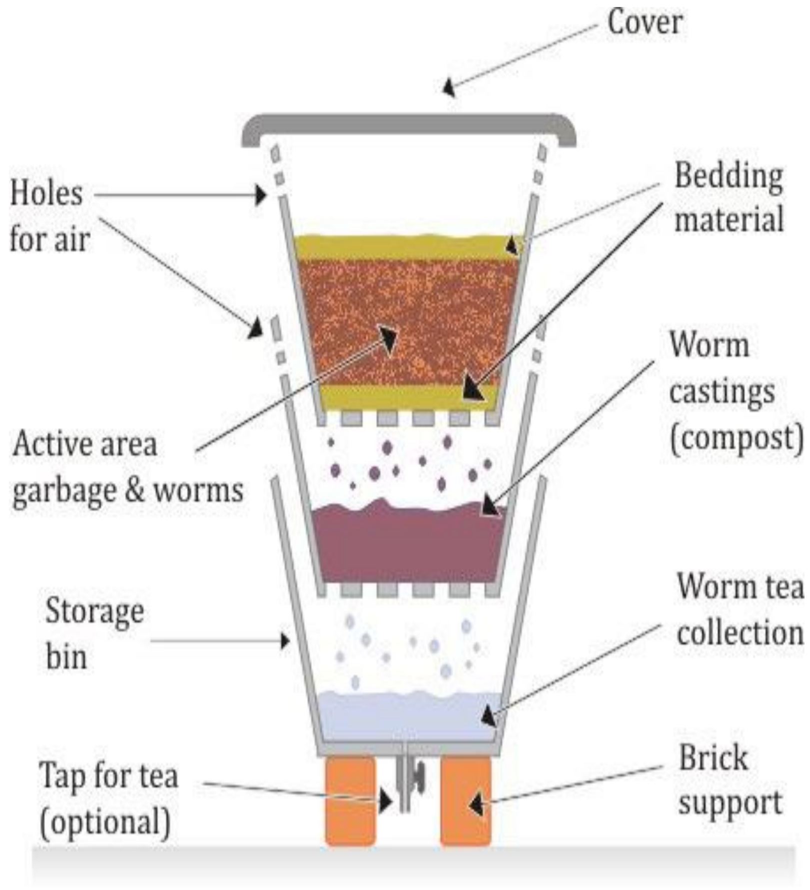


Image source: agritech.ac.in

Bio-sustainability – Vermicomposting

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Large scale methods of vermicomposting

PIT and/or BED method

Windrow method

Bio-sustainability – Vermicomposting

- The implementation of cutting-edge agricultural practices provides tools and techniques to drive climate-smart agriculture, reduce carbon emissions, and lower the carbon footprint.

- Vermicomposting is an integrated biological process of converting organic waste into vermicast by employing earthworms and naturally occurring microbes under a mesophilic environment. Vermicomposting has been reported as a **sustainable technique** for the treatment and management of different organic wastes.

- Earthworms increase the bacterial abundance in the soil as their gut conditions are favourable for the multiplication of bacteria and the suppression of fungi.

Source: https://www.mdpi.com/2071-1050/14/18/11306

Bio-sustainability – Vermicomposting

Vermicomposting - Case study

Source: https://www.mdpi.com/2071-1050/14/21/13828#

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SMART FARMING

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Smart farming - International Science Council

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SMART FARMING

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Agriculture Years Ahead: Smart Farming with IoT Technology:

- Farming has been the oldest sign of human civilization. Through times, we as a human find several damaging effects of our ways in growing crops to the environment including the flora and fauna.

- To restore the damages, people nowadays develop **smart farming with IoT**.

- Not only to revive nature but smart farming is designed to bring more benefits also like higher profit, efficient planting process, premium harvest and others.

Image source: Reserach- International Science Council

SMART FARMING

- **Use of IoT in Smart Farming:**
- Internet of Things (IOT) includes enhanced objects with technology in processing, sensors, and more that can send and receiving data to other networks.
- There have been examples of IoT in daily activities like home automation to save energy, traffic control, NFC tag, etc.
- In agriculture, technologies also have been involved and developed for years. This is called smart farming.

Image source: innovateindia.mygov.in/agriindia

SMART FARMING

- **Use of IoT in Smart Farming:**
- The integration between technology and farmers' skills is aimed to produce the best quality and quantity of the commodity.
- Humans used to take all the roles in farming from planting, growing, harvesting, checking, and so on.
- Yet, with smart farming, some jobs are taken over by technology including sensors, drones, Artificial intelligence (AI) and robotics to optimize the process and especially to ease the farmers.

https://www.sciencedirect.com/computers-and-electronics-in-agriculture

SMART FARMING

- **Use of IoT in Smart Farming:**

Technologies in farming have been utilized in numerous ways. Each kind is installed for a different purpose.

Based on the functions, here are some techniques in using technology for smart farming.

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- **Smart Farming Techniques:**

1. Field mapping or data collection:

Sensor technology is set up to measure environmental aspects such as humidity, temperature, light intensity, wind, water/rainfall, soil composition, and more.
Then GPS and GIS support the bigger picture of the map by providing the geospatial data.

https://www.sciencedirect.com/journal/bioresource-technology

- **Smart Farming Techniques:**

- **2. Predictive analytics**

Based on data required from field mapping, several types of analytic software can predict and suggest the needed actions. Some even are equipped with alert systems of discrepancies or pest attacks.

https://www.sciencedirect.com/journal/bioresource-technology

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- **Smart Farming Techniques:**

3. Data Saving: Using cloud-based, the regularly obtained data are uploaded as a record for future decision making. They are also shareable for wider area analytics.

4. Tracking and monitoring:
This technique might require cameras, drones, tags, and GPS. Drones and cameras provide a visual of the field. Then, tags and GPS supply precise coordinate location of livestock.

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Smart Farming Techniques:

7. Saving energy:

Also using automation, a system could be built in the farm to cut down energy consumption. Smart irrigation could automatically turn the machine off when a sufficient amount of water in the soil is reached. Drone-spraying only on the necessary spots could prevent polluting the land.

https://www.sciencedirect.com/journal/bioresource-technology

Smart Farming Techniques:

5. Labour work: Similar to automation, drones, and robotics are helpful to do labour work such as planting seeds, watering the plant, harvesting, spraying the pesticides, milking the cows, picking fruits, irrigating, and more.

6. Warehousing: In tropical areas like India, farmers are utilizing solar-powered refrigerators to store the fruits and vegetables right on the farm. Since greens and fruits are prone to get withered, storing them in fridges directly is a smart way to provide fresh commodities.

https://www.sciencedirect.com/journal/bioresource-technology

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Application of smart farming:

- Generally, smart farming with IoT is set up to overcome certain problems or to reach some goals.
- As there are various techniques, it is essential to identify the gap and the proper technologies demanded.
- Many parts of farming could be enhanced with technology like tags in cows, the sensor in soil, picking robots, and more.
- After setting up the technology, a regular check is needed to see the technology performance and the result.

https://www.agristudoc.com/farm-mechanization

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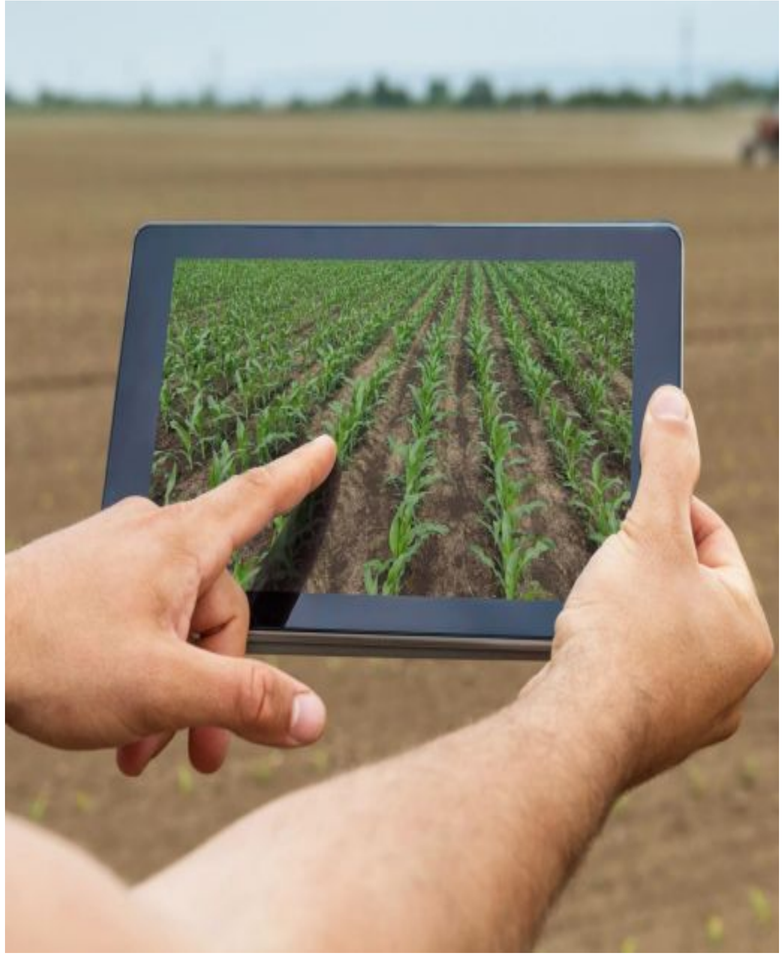
Merits of smart farming:

Improved products:
With high-quality control and experiments, nowadays many farming ‘companies' produce vegetables with a certain taste that is different from other vegetables. The greens mostly are categorized as organic and pesticide free.

Precise data:
Assisted with tools, predictions or actions can be made of accurate data. Because certain plants are better in high temperatures, crops rotation is easier to decide. The data can be saved and used as a reference in the future if there is a similar condition coming up.



https://www.agristudoc.com/farm-mechanization

SMART FARMING

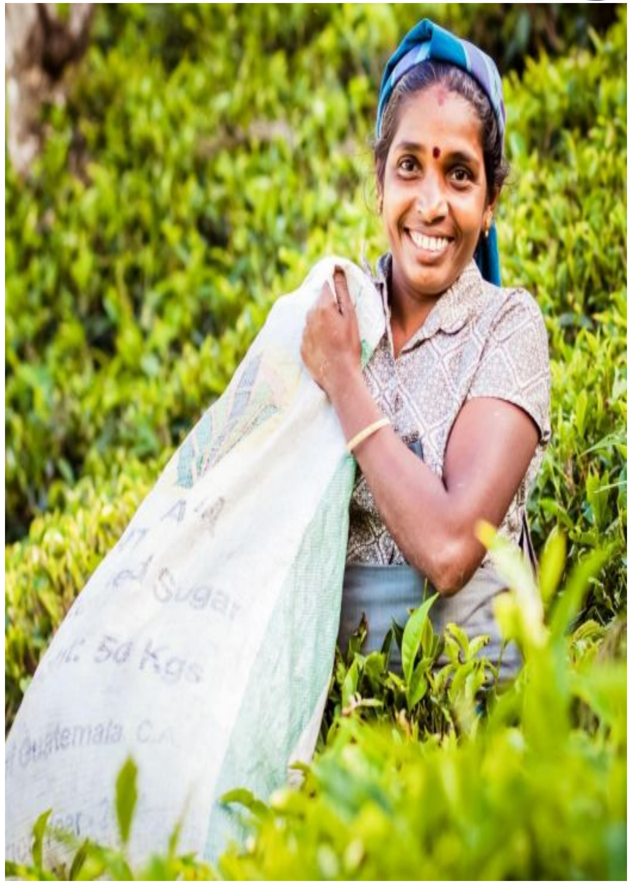
- **Merits of smart farming:**

- Indeed technology brings positive impacts to farm management.
- As the products increase, more profit could be generated.

- Smart farming also helps farmers to distribute their commodities to the most rewarding markets or buyers.

- Some software connects the farmers to connect with the nearest potential buyers. Despite the gained earnings, farmers should be aware also of the maintenance and installation costs.

- Hence, profit is relative and may differ for each farmer.



https://www.agristudoc.com/farm-mechanization

SMART FARMING

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•Merits of smart farming:

Environmental friendly:

As farmers could minimize pesticide use, irrigate water sufficiently, manage waste efficiency, current farming damages are slowly getting revived. It is predicted that years from now, farmers could build a farm with varied commodities without removing the endemic flora and fauna.

- **Efficient management and cost-effective:**

As many labor works are done by the technology, the management costs can be reduced or allocated to maintain the technology. The farmers could also be away, but keep controlling the farm from far away.

https://www.agristudoc.com/farm-mechanization

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- **Limitations of smart farming:**

Despite the benefits above, smart farming also carries several potential risks.

The biggest of them is prone to be damaged.

Without any regular care, technology is prone to get broken by natural factors like heavy rain, strong wind, thunder strikes, and more. It could be a big loss for the farmer.

Moreover, the maintenance cost is not cheap with updates and further research.

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- **Entrepreneurial opportunities of smart farming:**

As mentioned before, you could start by identifying the goals and what aspect you are focusing on.

Then prepare the money and choose the suitable technology.
If your finances do not support it, you can try to collaborate with researchers.

So extensive research in this area leads to get the best crops.
Another way to find potential investors to expand the technology To filed level.

- **Entrepreneurial opportunities of smart farming:**

After the technology is already set, maintaining smart farming is not an intermittent process.

More research regarding the actions to be taken and possible future technology must be carried.

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Awareness among farmers on smart farming:

Smart farming with IoT is a growing business nowadays.

The number of farmers using IoT is increasing and it is projected by the agriculture market in the U.S. that annual growth rate of 19.3%. a survey shows that technology installation in farming also has a similar growth rate that is 20%. In India an average of 10 percent farmers are employed smart farming practices to get better yield and returns.

Awareness among farmers on smart farming:

This happens globally as many countries come up with modern innovations likeIndia, Japan, Canada, Columbia, Mexico, Brazil, Chile, and Argentina.

https://www.agristudoc.com/farm-mechanization

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ENVIRONMENTAL STUDIES & LIFE SCIENCES

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Bio-sustainability

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Hydroponics

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Hydroponics

- The word hydroponics comes from two Greek words, "hydro" meaning water and "ponos" meaning labour
- The concept of soil less gardening or hydroponics has been around for thousands of years
- The hanging Gardens of Babylon and The Floating Gardens of China are two of the earliest examples of hydroponics

Hydroponics

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- Scientists started experimenting with soil less gardening around 1950
- Hydroponics is proved to have several advantages over soil gardening
- The growth rate on a hydroponic plant is 30-50 percent faster than a soil plant, grown under the same conditions
- The yield of the plant is also greater

Hydroponics

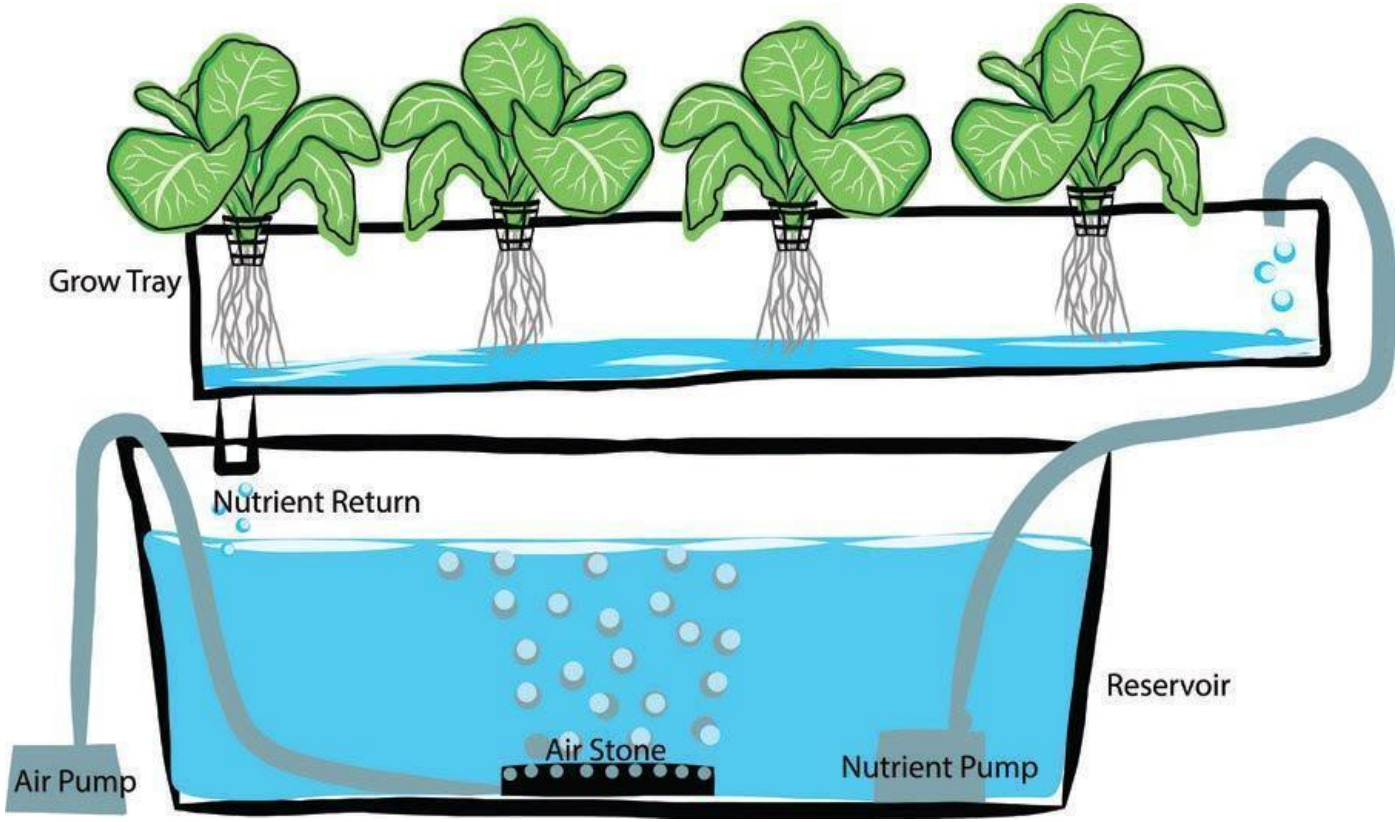

Image source: © AGRITECTURE 2011–2020

Hydroponics

Image source: © 2020 Rimol Greenhouse Systems

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- **Benefits:**

1. The extra oxygen in hydroponic growing medium helps to stimulate root growth
2. The nutrients in a hydroponic system are mixed with the water and sent directly to the root system. The plant does not have to search in the soil for the nutrients that it requires.

3. Those nutrients are being delivered to the plant several times per day

4. The hydroponic plant requires very little energy to find and break down food. The plant then uses this saved energy to grow faster and to produce more fruit.

5. Hydroponic plants also have fewer problems with bug infestations, funguses and disease

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- Hydroponic gardening also offers several benefits to our environment
- Hydroponic gardening uses considerably less water than soil gardening, because of the constant reuse the nutrient solutions
- Since hydroponic gardening systems use no topsoil, topsoil erosion isn't even an issue

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- **Growing mediums:**
- A fast draining medium, such as Hydrocorn
- Hydrocorn is a light expanded clay aggregate
- It is a light, airy type of growing medium that allows plenty of oxygen to penetrate the plant's root system

Hydroponics

- Rockwool has become an extremely popular growing medium
- Rockwool was originally used in construction as insulation. There is now a horticultural grade of Rockwool.
- Since Rockwool holds 10-14 times as much water as soil and retains 20 percent air it can be used in just about any hydroponic system

- Other commonly used growing mediums are perlite, vermiculite and different grades of sand
- These three mediums are stable and rarely effect the pH of the nutrient solution
- Although, they tend to hold too much moisture and should be used with plants that are tolerant to these conditions

Hydroponics

- Like soil, hydroponic systems can be fertilized with organic or chemical nutrients
- A hydroponic nutrient solution contains all the elements that the plant normally would get from the soil
- Most plants can grow hydroponically within a pH range of 5.8 to 6.8, 6.3 is considered optimal. The pH in a hydroponic system is much easier to check than the pH of soil.

Hydroponics

- **Hydroponic systems:**
- Hydroponic systems are characterized as active or passive
- An active hydroponic system actively moves the nutrient solution, usually using a pump
- Passive hydroponic systems rely on the capillary action of the growing medium or a wick

Hydroponics

- The nutrient solution in passive system is absorbed by the medium or the wick and passed along to the roots
- Passive systems are usually too wet and do not supply enough oxygen to the root system for optimum growth rates

Hydroponics

- Hydroponic systems can also be characterized as recovery or non-recovery
- Recovery systems or recirculating systems reuse the nutrient solution
- In non-recovery system the nutrient solution is applied to the growing medium and not recovered

- **Examples:**
- The **Wick System**- passive non-recovery type hydroponic system
- The **Ebb and Flow System**- active recovery type system
- **Nutrient Film Technique**- active recovery type hydroponic system
- **Continuous Drip**- active recovery or non-recovery type system

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Bio-sustainability

Rain water harvesting

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Rain Water Harvesting

- **Rainwater harvesting** is the collection and storage of rain, rather than allowing it to run off
- Rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit (well, shaft, or borehole), aquifer or a reservoir with percolation

Rain Water Harvesting

- It is one of the simplest and oldest methods of self-supply of water for households, and residential and household scale projects usually financed by the user
- However, larger systems for schools, hospitals and other facilities can run up costs only able to be financed by companies, organization and governmental units

Rain Water Harvesting

- Applications of rainwater harvesting in urban water system provides a substantial benefit for both water supply and wastewater subsystems by reducing the need for clean water in water distribution systems, less generated storm-water in sewer systems, and a reduction in storm-water runoff polluting freshwater bodies

Rain Water Harvesting

- Tamil Nadu was the first state in India to make rainwater harvesting compulsory for every building to avoid groundwater depletion
- In Bangalore, Karnataka, adoption of rainwater harvesting is mandatory for every owner or the occupier of a building having the site area for newly constructed building measuring 30 ft × 40 ft and above dimensions

Rain Water Harvesting

- In this regard, Bangalore Water Supply and Sewerage Board has initiated and constructed "Rain Water Harvesting Theme Park" in the name of Sir M. Visvesvaraya in 1.2 acres of land situated at Jayanagar, Bangalore

Rain Water Harvesting Theme Park, Bangalore

Image source: © 2020 Iluminar Media Pvt. Ltd

Rain Water Harvesting

- **Components of a rain water harvesting system:**

1. **Catchments:** The catchment of a water harvesting system is the surface which directly receives the rainfall and provides water to the system.
2. **Coarse mesh:** at the roof to prevent the passage of debris
3. **Gutters:** Channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank

Rain Water Harvesting

4. Conduits: are pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system

5. First-flushing: A first flush device is a valve that ensures that runoff from the first spell of rain is flushed out and does not enter the system. This needs to be done since the first spell of rain carries a relatively larger amount of pollutants from the air and catchment surface.

6. **Filters:** used to remove suspended pollutants from rainwater collected over roof. A filter unit is a chamber filled with filtering media such as fibre, coarse sand and gravel layers to remove debris and dirt from water before it enters the storage tank or recharge structure.

Rain Water Harvesting

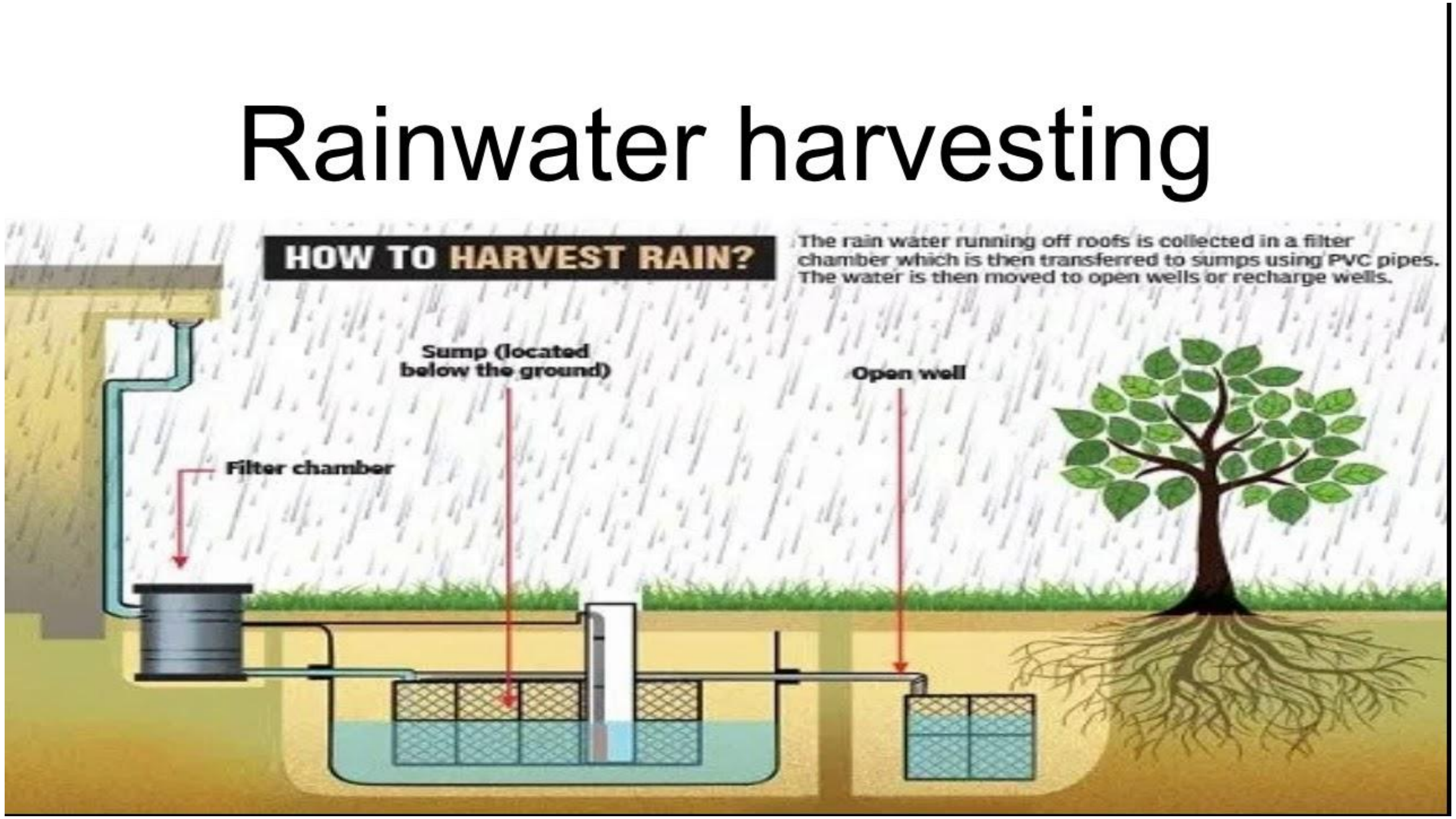

Image source: https://www.edusquad.com/2019/

Rain Water Harvesting

Image source: https://www.edusquad.com/2019/

- **Advantages:**
- It provides water when a drought occurs, can help mitigate flooding of low-lying areas, and reduces demand on wells which may enable groundwater levels to be sustained
- Simple installation
- Easy to operate and maintain
- Needs no power and operates at low gravity pressure (0.1 bar upward)

Rain Water Harvesting

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- The system is capable of providing a constant flow of about 40 litres of rainwater per hour, enough for drinking, cooking and bathing purposes
- Maintains nearly constant volume irrespective of water pressure
- Cost per 1000 litres is as low as US$ 2 to 3

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Bio-sustainability

Bio-sustainability

Biofuels

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Bio-sustainability – 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 biodiesel.
- Biofuels are being promoted as a ***low-carbon alternative*** to fossil fuels as they could help to ***reduce greenhouse gas*** (GHG) emissions and the related climate change impact from transport.
- Rapid increases of energy consumption and human dependence on fossil fuels have led to the accumulation of greenhouse gases and consequently, climate change.

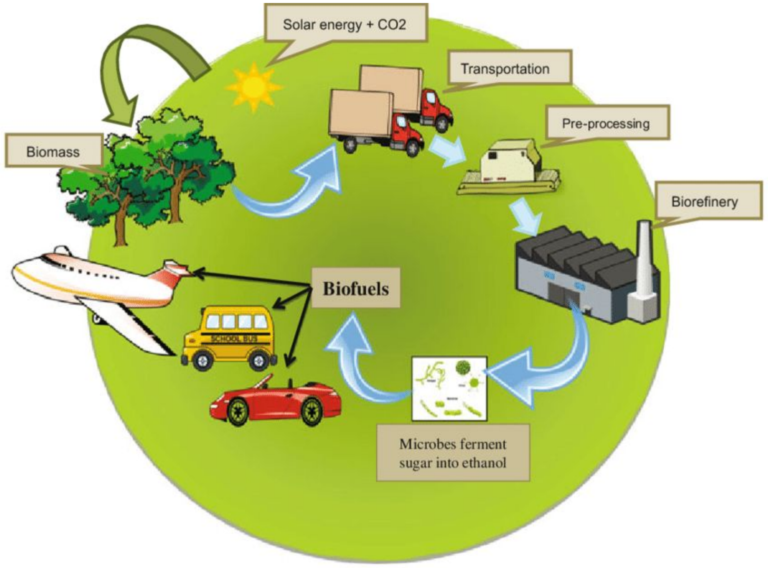

Image source: solarsurge.in

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Bio-sustainability – Biofuels

- The major efforts have been taken to develop, test, and adopt clean renewable fuel alternatives. Production of **bioethanol** and **biodiesel** from crops (is well developed), other feedstock resources have shown high potential to provide efficient and cost-effective alternatives.
- The microbial fermentation can be engineered to increase the product yield and expand the chemical space of biofuels through the rational design and fine-tuning of biosynthetic pathways toward the realization of "***designer fuels***" and diverse future applications.
- 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.

Source: https://www.sciencedirect.com/science/article/pii/S0092867421000957

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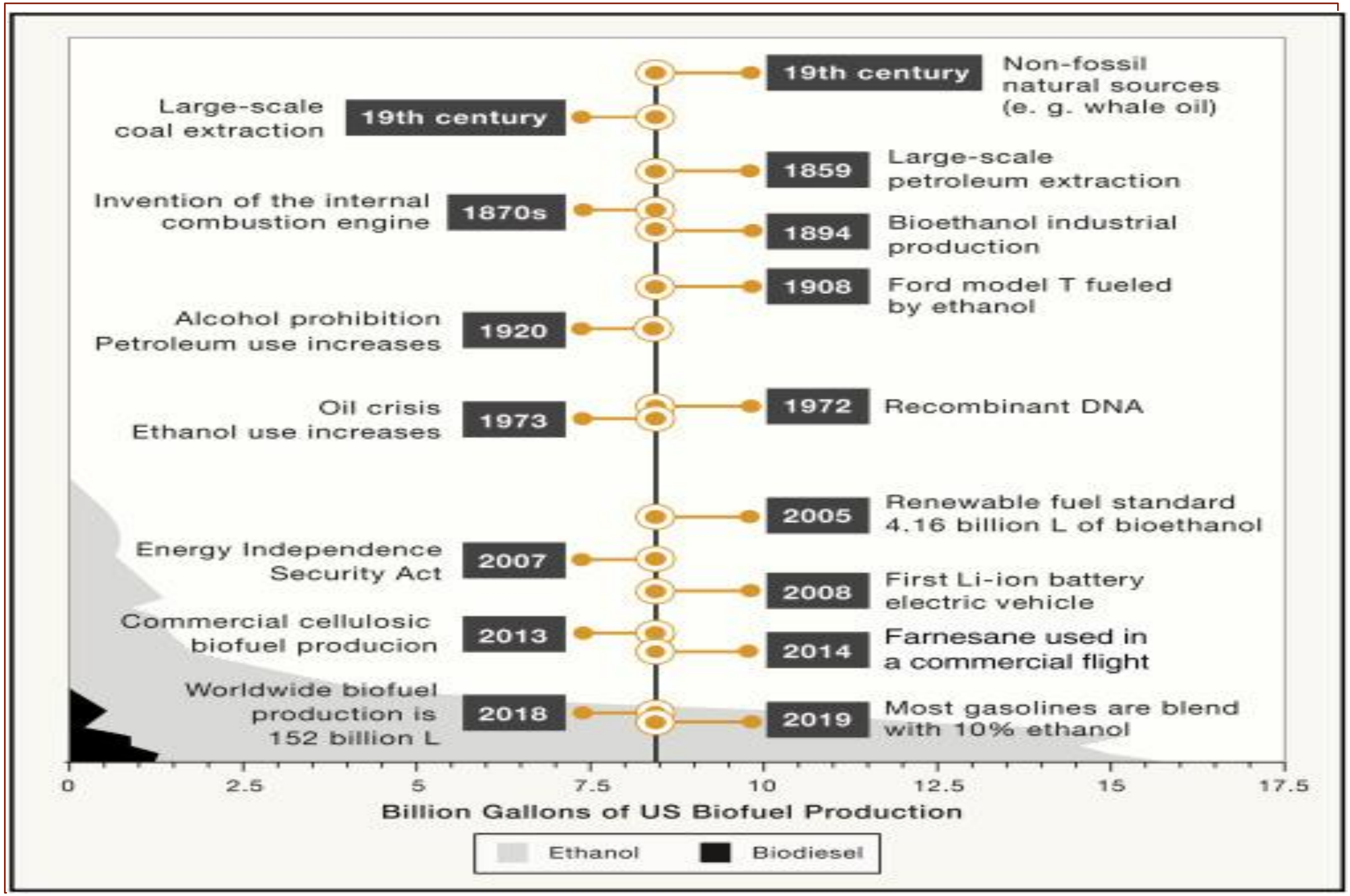
Bio-sustainability – Biofuels



Ref: Biofuels for a sustainable future by Yuzhong *et. al*. 2021

Bio-sustainability – Biofuels

Generation of Biofuels

- ***First-generation*** or ***conventional biofuels*** are those that are produced from edible energy crops such as sugar-based crops (sugarcane, sugar beet, and sorghum), starch-based crops (corn, wheat, and barley) or oil-based crops (rapeseed, sunflower, and canola).
- Initially, these biofuels showed promise in minimizing reliance of conventional fossil fuels and lowering the emission of GHG associated with its combustion.
- However, the production of first-generation biofuels has raised serious concerns on food supply, food security, and arable land requirements.

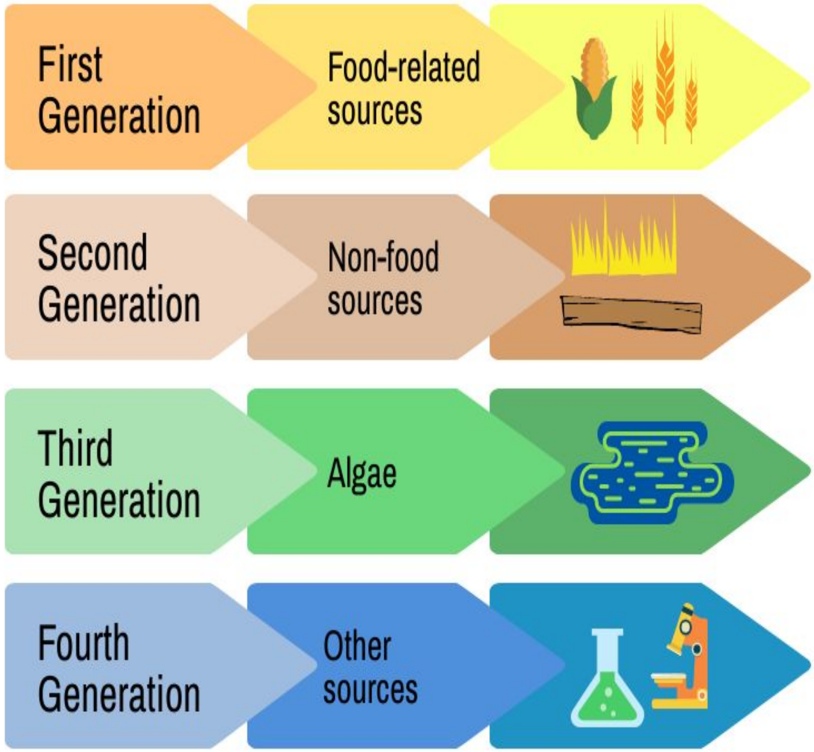


Image source: © 2019 letstalkscience

Bio-sustainability – Biofuels

- **First generation biofuels** (ethanol in particular) face three major criticisms:
  - intensification of their use leads to competition with food resources (the food versus fuel debate),
  - ethanol production from corn grain requires significant consumption of fossil resources, in such a way that there are minimum benefits from the carbon emissions perspective, and
  - there is a requirement of land to grow corn.

Feedstock	Biofuel	Yield
Sunflower	Biodiesel	952–1070 L/ha/year
Canola	Biodiesel	974–1190 L/ha/year
Corn	Biodiesel	172 L/ha/year
Sorghum	Bioethanol	0.51 g/g
Sugarcane	Bioethanol	67 g/L
Oil palm	Bioethanol	11.50 g/L

Source: Preshanthan Moodley, in Sustainable Biofuels, 2021

Bio-sustainability – Biofuels

- **Second-generation biofuels** are fuels manufactured from various types of biomass / lignocellulosic crops. 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.

- This generation technology allows lignin and cellulose of a plant to be separated so that cellulose can be fermented into alcohol.

- These biofuels can be manufactured from different types of biomass as it defines any source of organic carbon. This can be renewed rapidly as part of the carbon cycle.

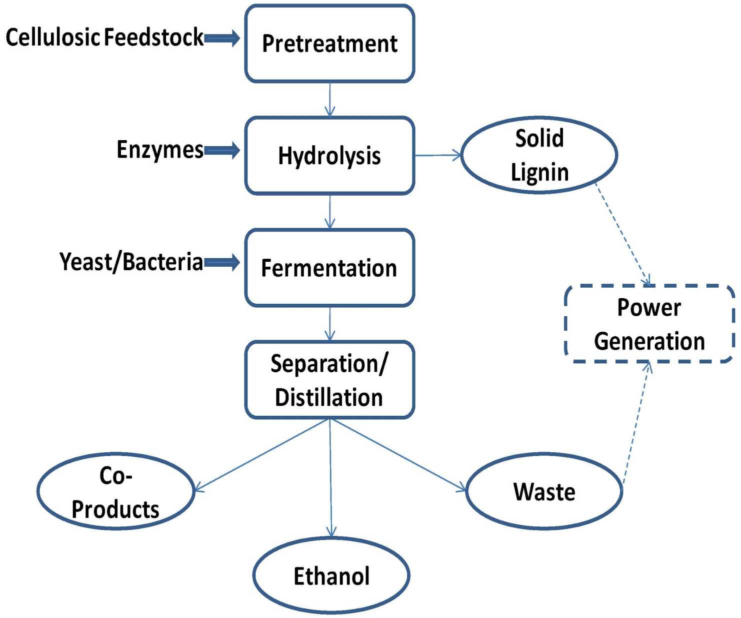


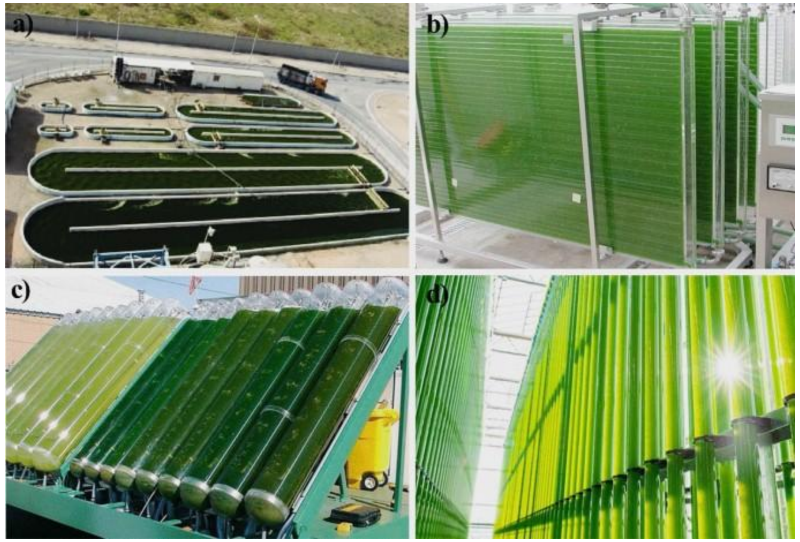
Image source: https://www.mdpi.com/1996-1073/7/7/4430

Bio-sustainability – Biofuels

- The worldwide increase in energy demand has led to the development and analysis of efficient sources capable of producing fuels and chemicals. The microalgae are seen as a promising alternative for the production of fuels due to their high photosynthetic conversion efficiency.

- ***Third generation biofuels*** are also known as "***algae fuel***" or "***oilage***" since they are produced from the algae.

- Algae leads to the production of all types of biofuels such as biodiesel, gasoline, butanol, propanol and ethanol with high yield, approximately 10 times higher than the second generation biofuel.



Source: https://link.springer.com/article/10.1007/s12667-022-00514-7

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Bio-sustainability – Biofuels

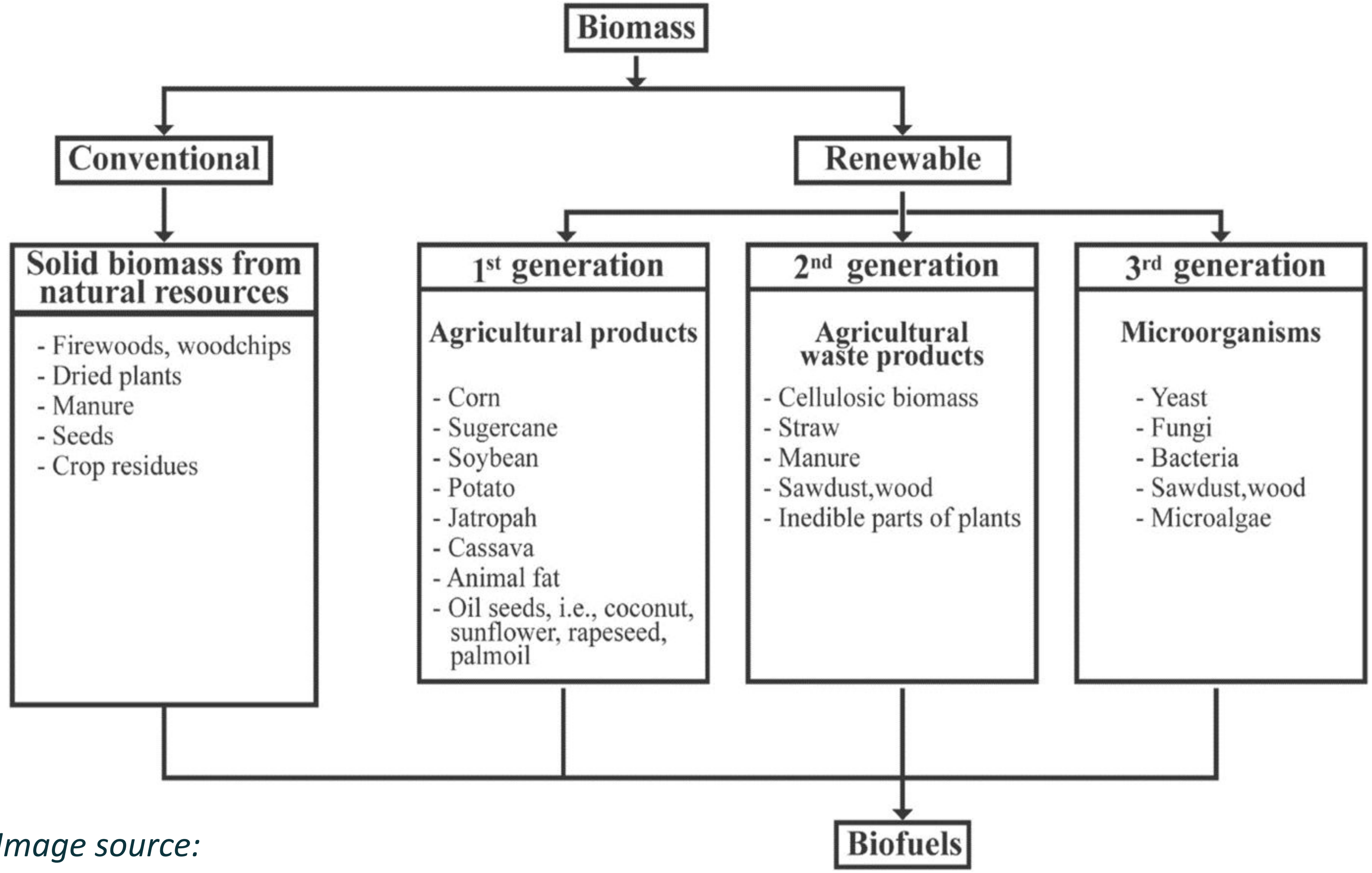
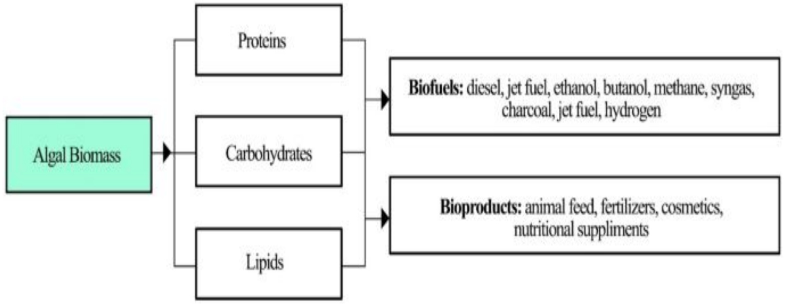


Image source: https://link.springer.com/article/10.1007/s12667-022-00514-7/figures/1



Source: https://link.springer.com/article/10.1007/s12667-022-00514-7

Bio-sustainability – Biofuels

- **Fourth-generation biofuels** are the amalgamation of genomically prepared microorganisms and genetically engineered feedstock.
- Cyanobacteria are engineered to increase the oil yield and are used for the efficient production of bioenergy.
- The implementation of bioengineering principles to modify algal metabolism and properties to enhance the oil content in the cells.
- The 4G ecofuels are the fuels that are got through fixed carbon from the air by new techniques.

Bio-sustainability – Biofuels

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- Currently the following types of biofuels are produced using different approaches

Biogas
Syngas
BioEthanol
Biodiesel
Green diesel
Bio-ethers

Bio-sustainability – Biofuels

Production of biofuels from renewable feedstocks has captured considerable scientific attention since they could be used to supply energy and alternative fuels.

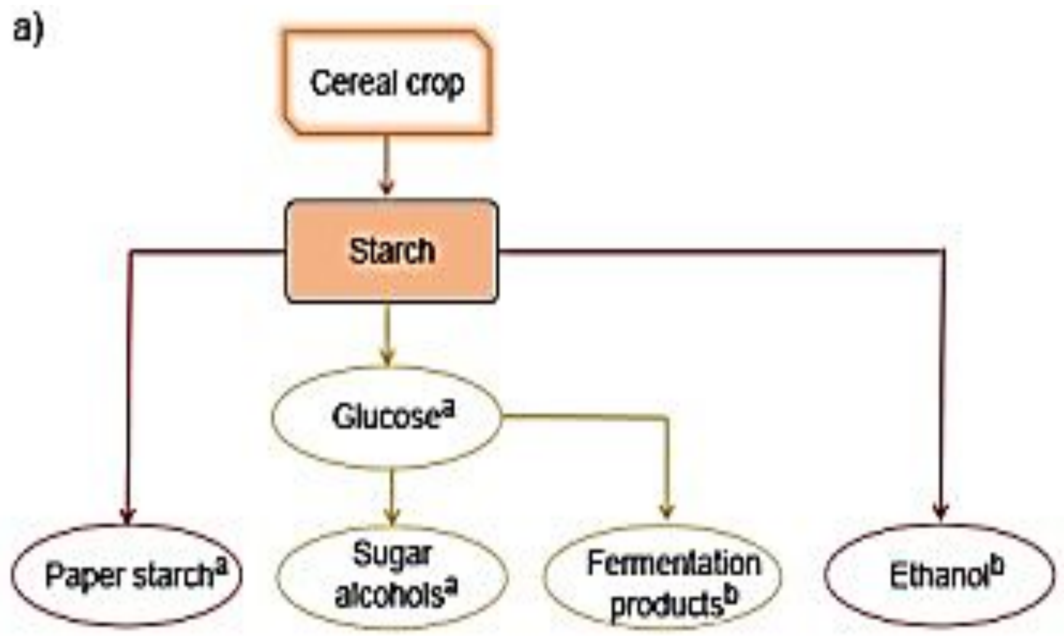
Bioethanol is one of the most interesting biofuels due to its positive impact on the environment. Currently, it is mostly produced from sugar & starch-containing raw materials.

However, various available types of lignocellulosic biomass such as agricultural and forestry residues, and herbaceous energy crops could serve as feedstocks for the production of bioethanol.

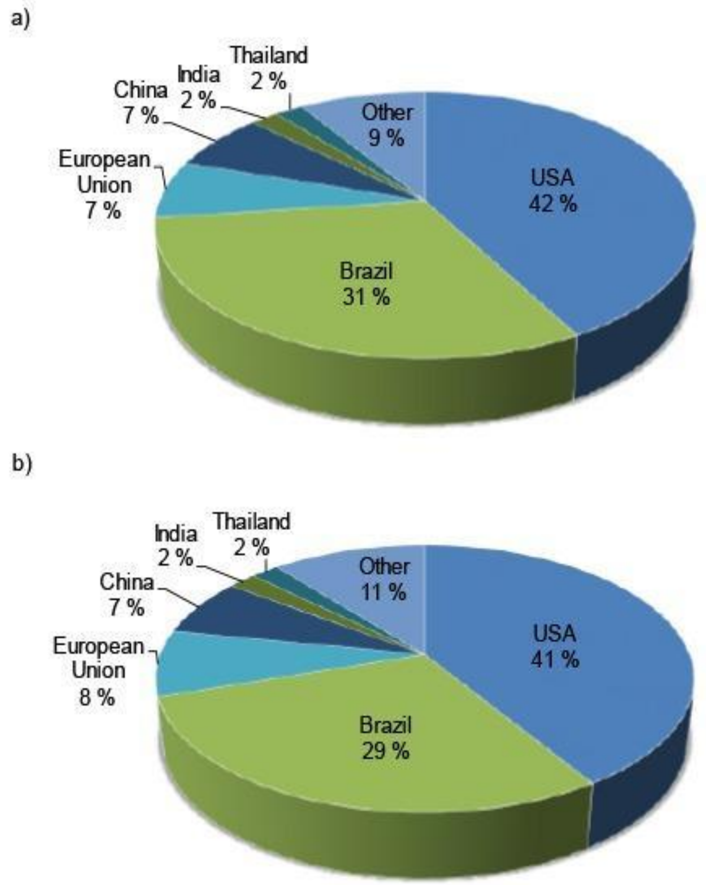
biodiesel plant - Bing images

Bio-sustainability – Biofuels

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



The Predictions of the world bioethanol production (a) and consumption (b) by 2024

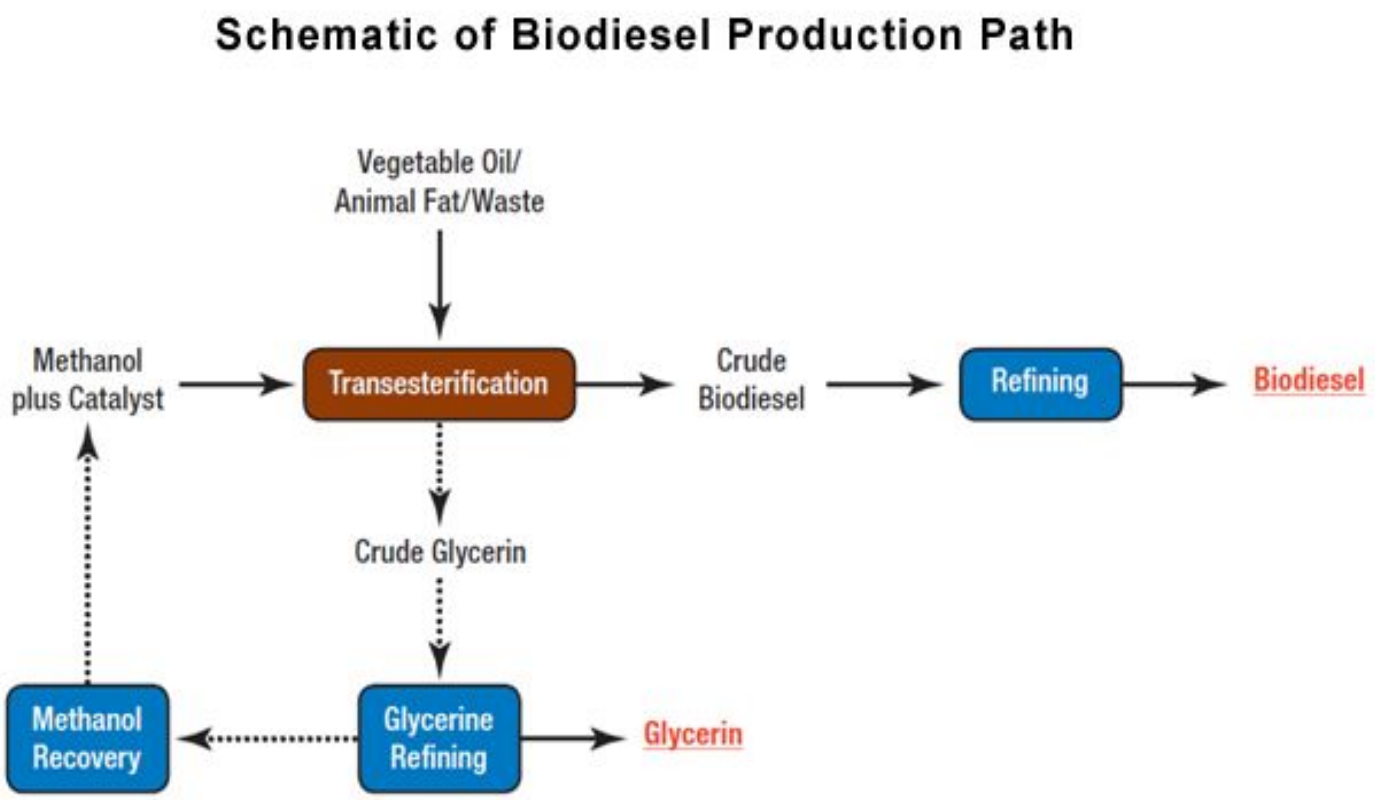


Source: Bioethanol Production from Renewable Raw Materials and Its Separation and Purification: A Review - PMC (nih.gov)

Bio-sustainability – Biofuels

- ***Biodiesel***: It 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.



Bio-sustainability – Biofuels

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- The consumption volume of biodiesel in India in 2022 was approximately 180 million liters. This was an increase from the consumption volume of 165 million liters of biodiesel in the previous year (***Published by Lucía Fernández, Feb 8, 2023***).

- The Biodiesel procurement by OMCs increased from 1.1 crore litres during 2015-16 to 10.56 crore litres during 2019-20.

- Presently, bio-diesel is being produced in the country primarily from imported palm stearin oil.

The Renewable Energy Group (REG) is the largest FAME biodiesel producer in the U.S., with 5 plants and capacity of 432 million gallons. REG was acquired in June 2022 by Chevron (Ramon, 2022).

Bio-sustainability – Biofuels

Advantages of biofuels

- Efficient fuel
- Non-dependency on fossil fuels
- Durability of vehicles' engine
- Easy to source
- Renewable
- Reduces greenhouse gases
- Lower levels of pollution

Disadvantages of biofuels

- High Cost of Production
- Huge amount of crops required to produce biofuels
- Water use
- Land use
- Dependent of weather
- Use of Fertilizers for the crop production

https://www.researchgate.net/figure/Jatropha-curcas-plant_fig1_265151192

Bio-sustainability – Biofuels

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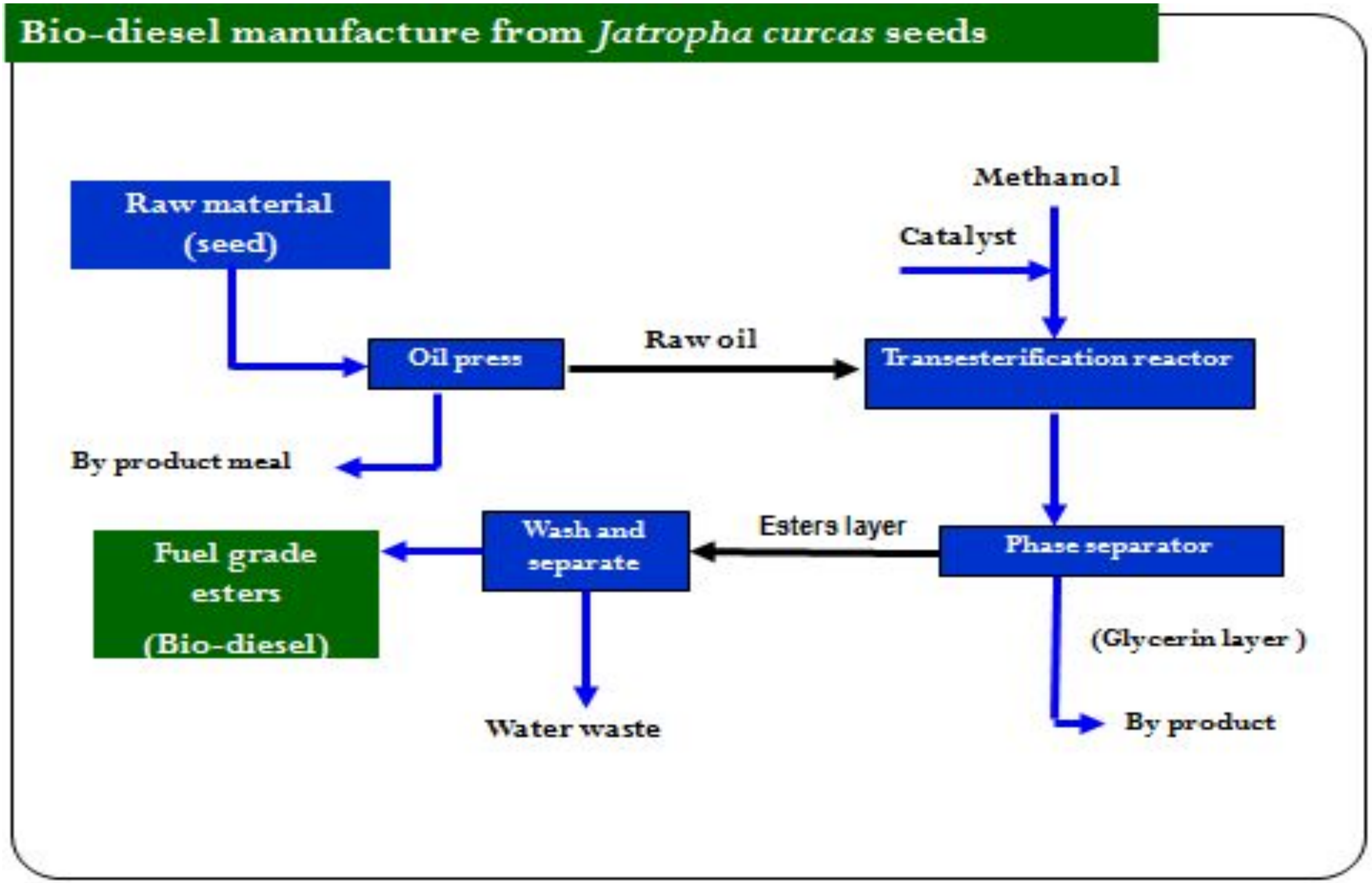
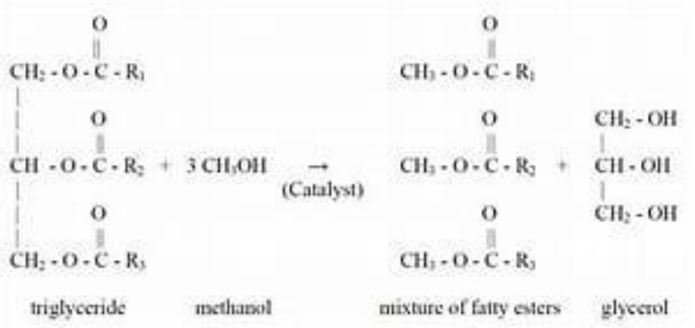
- India's biofuel production accounts for only 1% of the global production
- It is worth noticing that India is the second largest producer of sugarcane in the world but accounts for only about 1% of global ethanol production
- In India, Jatropha seeds were used to produce biodiesel, but the production 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

Bio-sustainability – Biofuels





Bio-sustainability – Biofuels

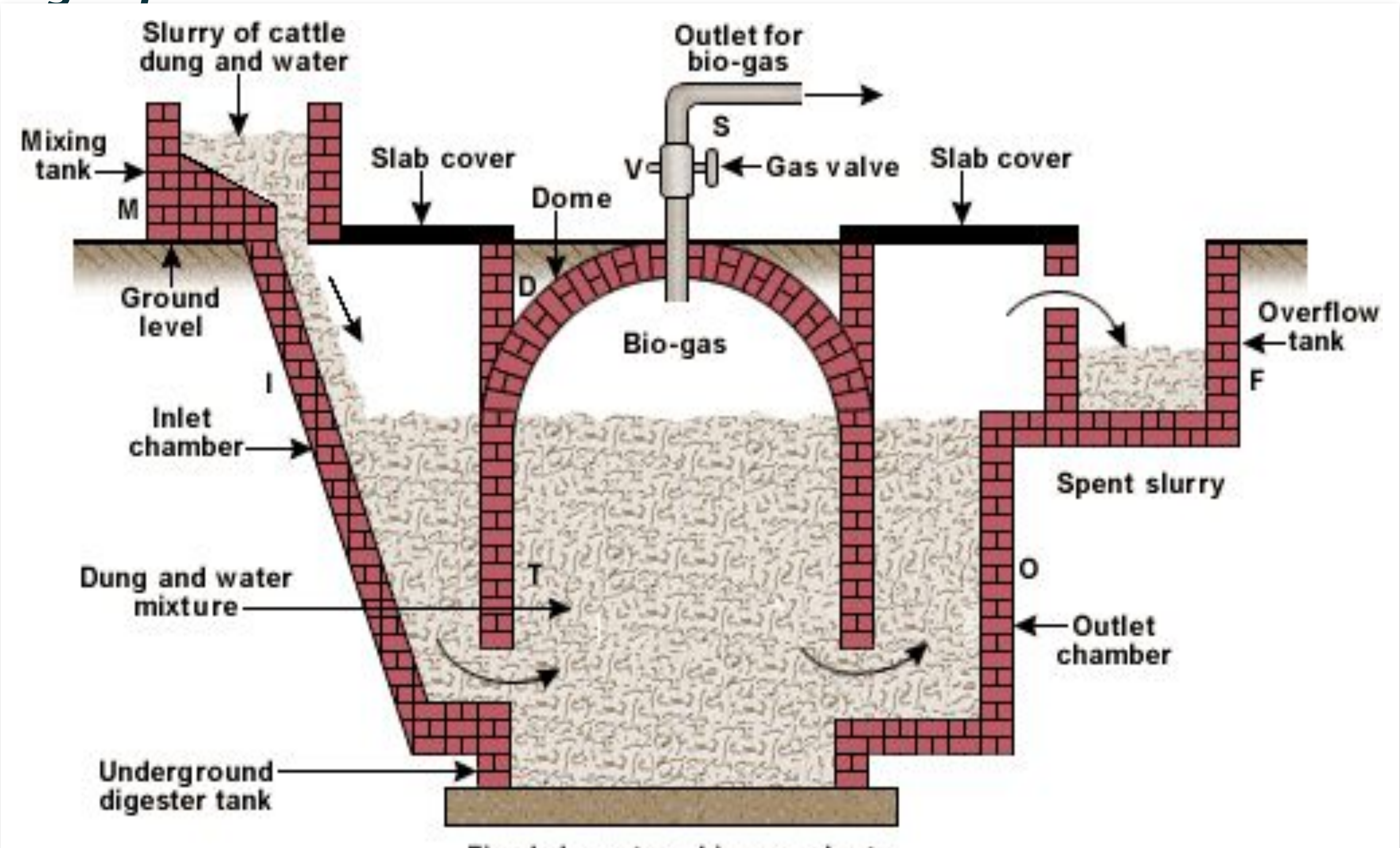
- Bioenergy consists of biomass (biological mass) used in the production of energy;

- Phototrophs use light to survive and propagate (Plants)
  $CO_2 + H_2O$ -->-- Solar energy -->> $CH_2O + O_2$,
  or carbohydrate & oxygen

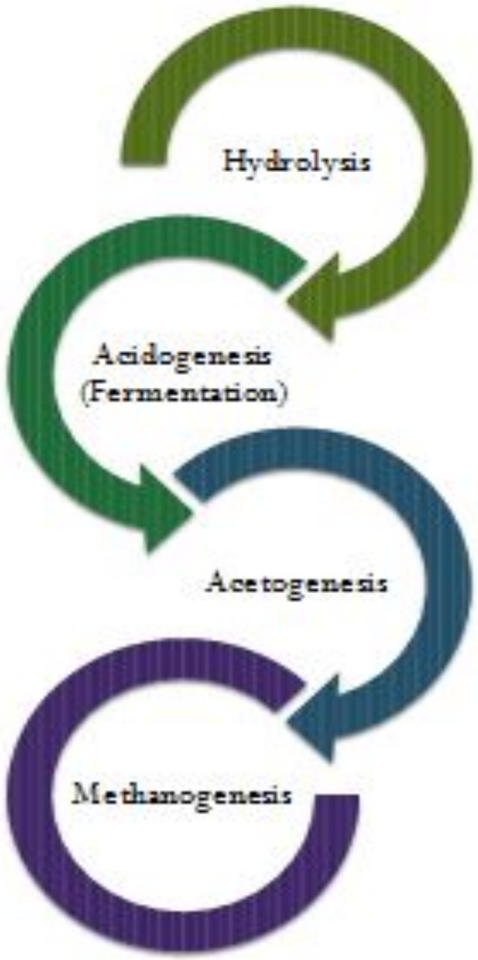
- ***Chemotrophs*** eat phototrophs (green plants). While biomass combustion releases CO_2 into the atmosphere, new plants require CO_2 to grow, balancing the process.

Bio-sustainability – Biofuels

Biogas plant

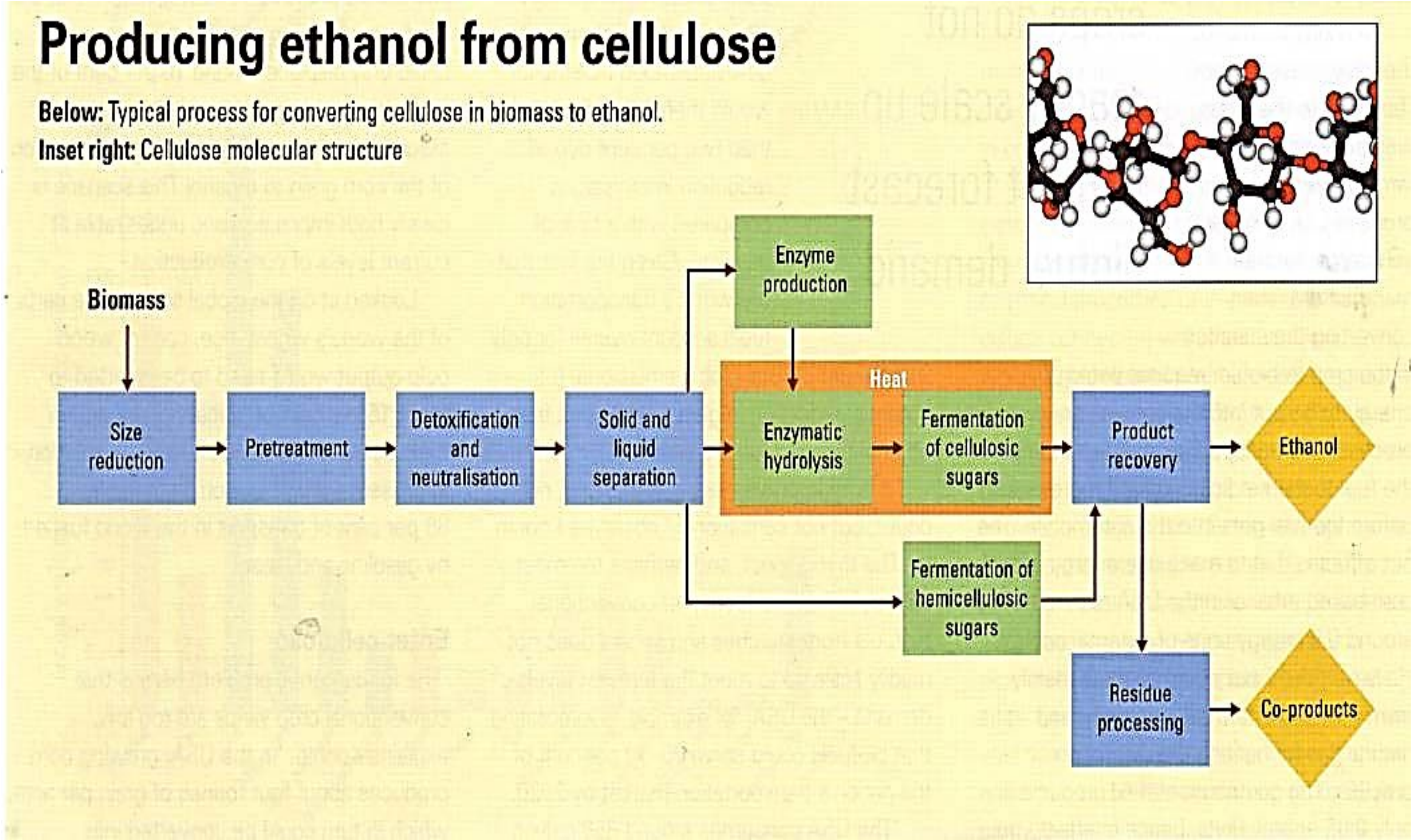


Fixed-dome type bio-gas plant.



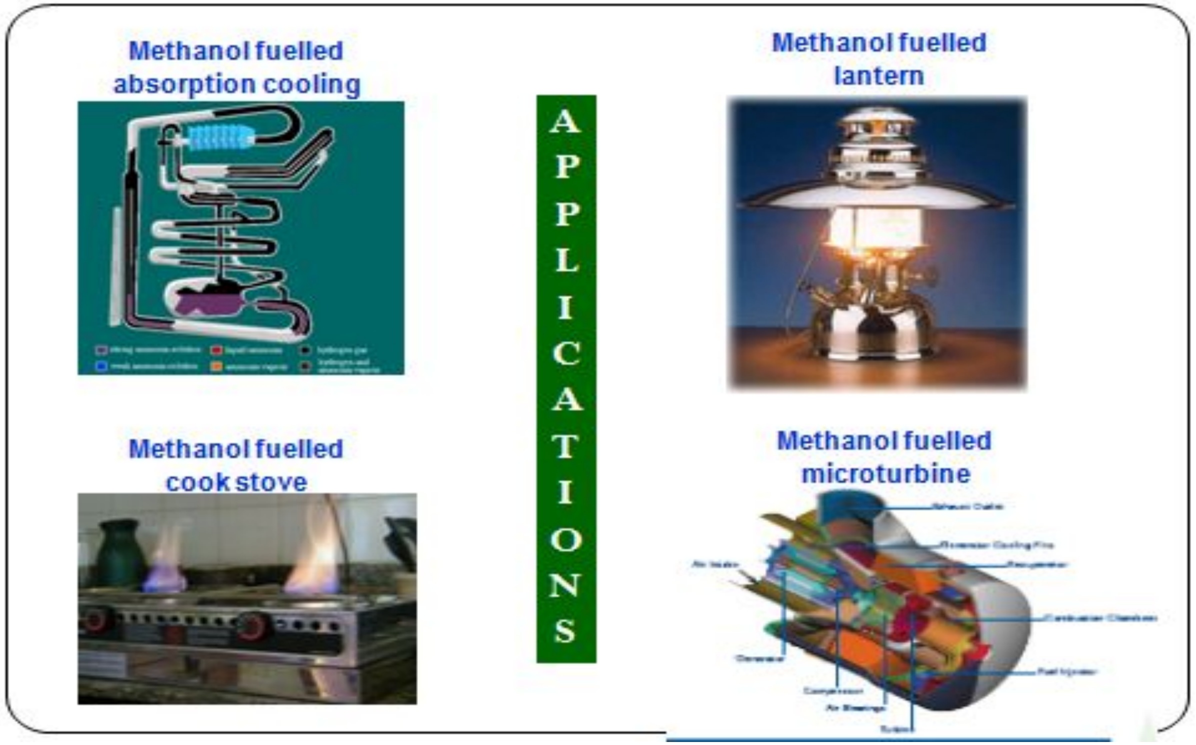
Bio-sustainability – Biofuels

Bioethanol



Bio-sustainability – Biofuels

Applications



Bio-sustainability – Biofuels

Applications

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

Its features are:

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

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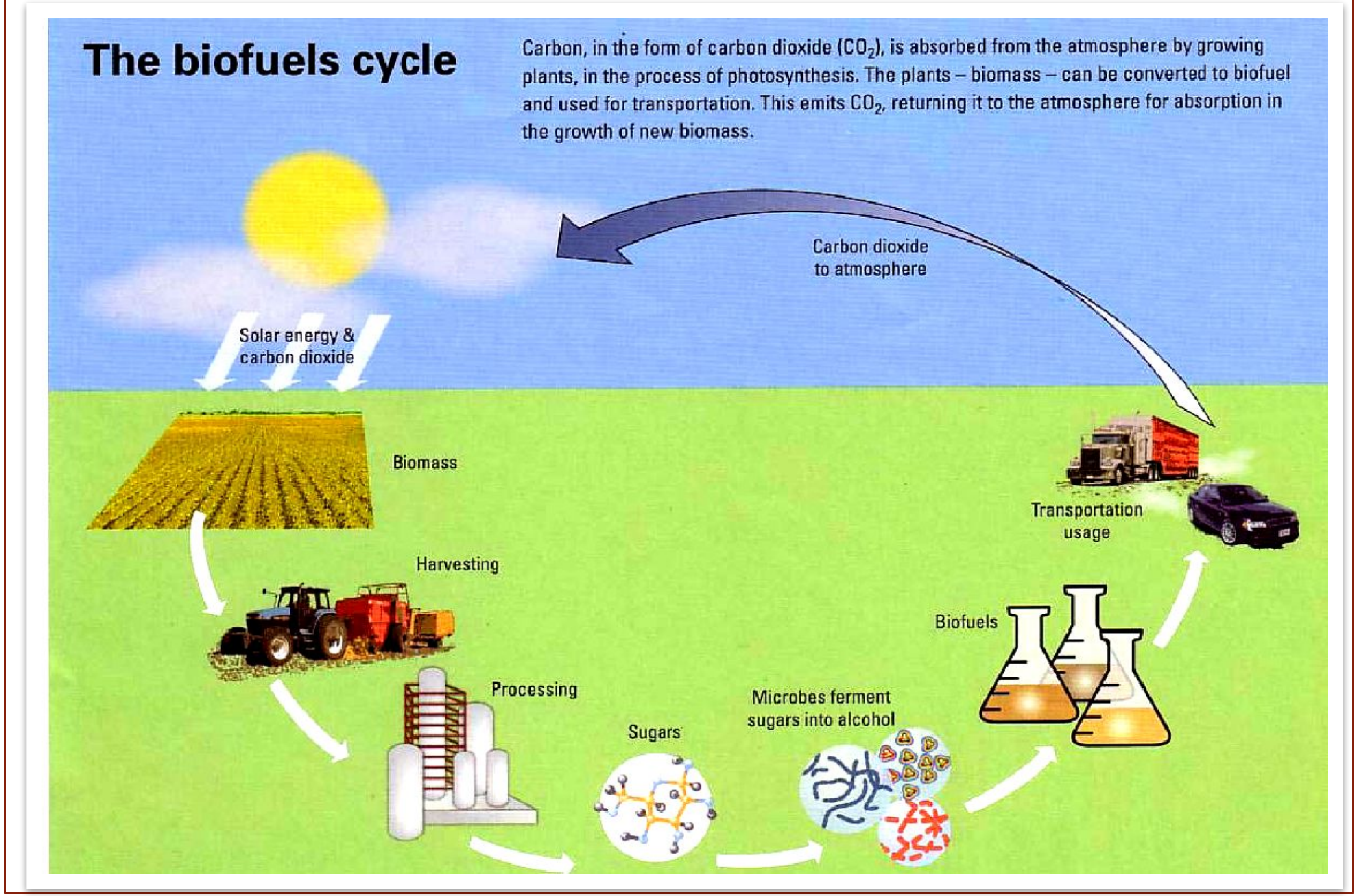
Bio-sustainability – Biofuels



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CELEBRATING 50 YEARS

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Bio-sustainability

Bio-sustainability

Role of Internet of Things (IOT)

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Bio-sustainability – Internet of Things (IoT)

- Apps with advanced computing ability are capable to run multiple advanced application & have tremendous practices in Biotechnology.
- Mobile phones along with various devices & sensors are commonly used for production management, climate control, molecular diagnosis, education, and data management into a portable, simple to use application.
  - Monitoring of Environmental Factors
  - Large-scale industrial production
  - Crop improvement in Agriculture
  - Monitoring of instruments
  - To control climatic parameters
  - Product quality management
  - Data storage and security
  - Publication of new findings and Patenting
  - Automation of tests in the diagnosis of biohazards

https://www.mobiloitte.com

Bio-sustainability – Internet of Things (IoT)

- Sensors, actuators, and devices ("things") embedded in production equipment and networked through computer systems can generate an enormous amount of data.
- The field has evolved due to the convergence of multiple technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems, and machine learning.
- Intelligent apps and software are central components of an IoT system. They allow the "things" in the system to communicate with one another and to initiate or execute processes with less operator intervention.
- In this new world, machines predict failure and trigger maintenance processes autonomously.
- Software automatically adjusts machinery if it detects a measurement has deviated from acceptable changes.

https://www.festo.com

Bio-sustainability – Internet of Things (IoT)

Four ways biotech and pharma can benefit from the IoT today.

Digitization of Pneumatic

Recent introduction of the Motion Terminal revolutionizes pneumatic valve functionality.

It does this by combining mechanics, electronics, and software in the form of a cyber-physical system. The Motion Terminal is the first valve to be controlled by apps.

With installed corresponding Motion apps, functions can be changed with a simple command or at the press of a button, whether for a simple change in the directional control valve functions, energy saving mode, proportional characteristics, or a format change.

https://www.festo.com

Bio-sustainability – Internet of Things (IoT)

Preventative maintenance

The ability to analyze streaming data to assess conditions, recognize warning signs, and service equipment prior to failures prevents costly equipment downtime.

Strategically scheduling preventative maintenance for when equipment is not in use further reduces downtime.

Technology has played a transformative role in our lives and its impact on human health is never felt more than in the current times of the Covid-19 global pandemic.

In this scenario, development of autonomous health sensing and actuating systems, also referred to as closed loop systems that 'sense' and 'act' towards a biological condition, can play a critical role in addressing health crises of the future.

https://www.festo.com and https://bioengineeringcommunity.nature.com

Bio-sustainability – Internet of Things (IoT)

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System Diagnostics

Ability to determine the health of the system can prevent costly downtime.

Data and insights from an IoT-enabled manufacturing system can provide real-time intelligence about the current component and system state.

Failure events can often be pre-empted with the use of data. But if a failure does occur, human reaction time can be much faster because of the real-time data. Production can be stopped more quickly, resulting in less wasted product.

https://www.festo.com

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Bio-sustainability – Internet of Things (IoT)

Modular automation

The biotech and pharma markets are experiencing increasing demand for short product development times and customized products.

Flexible manufacturing systems can be achieved by dividing a complete plant into functional units — a concept called modularization.

Production modules can be combined to produce specific process plants which can then be extended by adding modules. This concept enables immediate adaptation to changing market and production requirements.

https://www.festo.com

Bio-sustainability – Internet of Things (IoT)

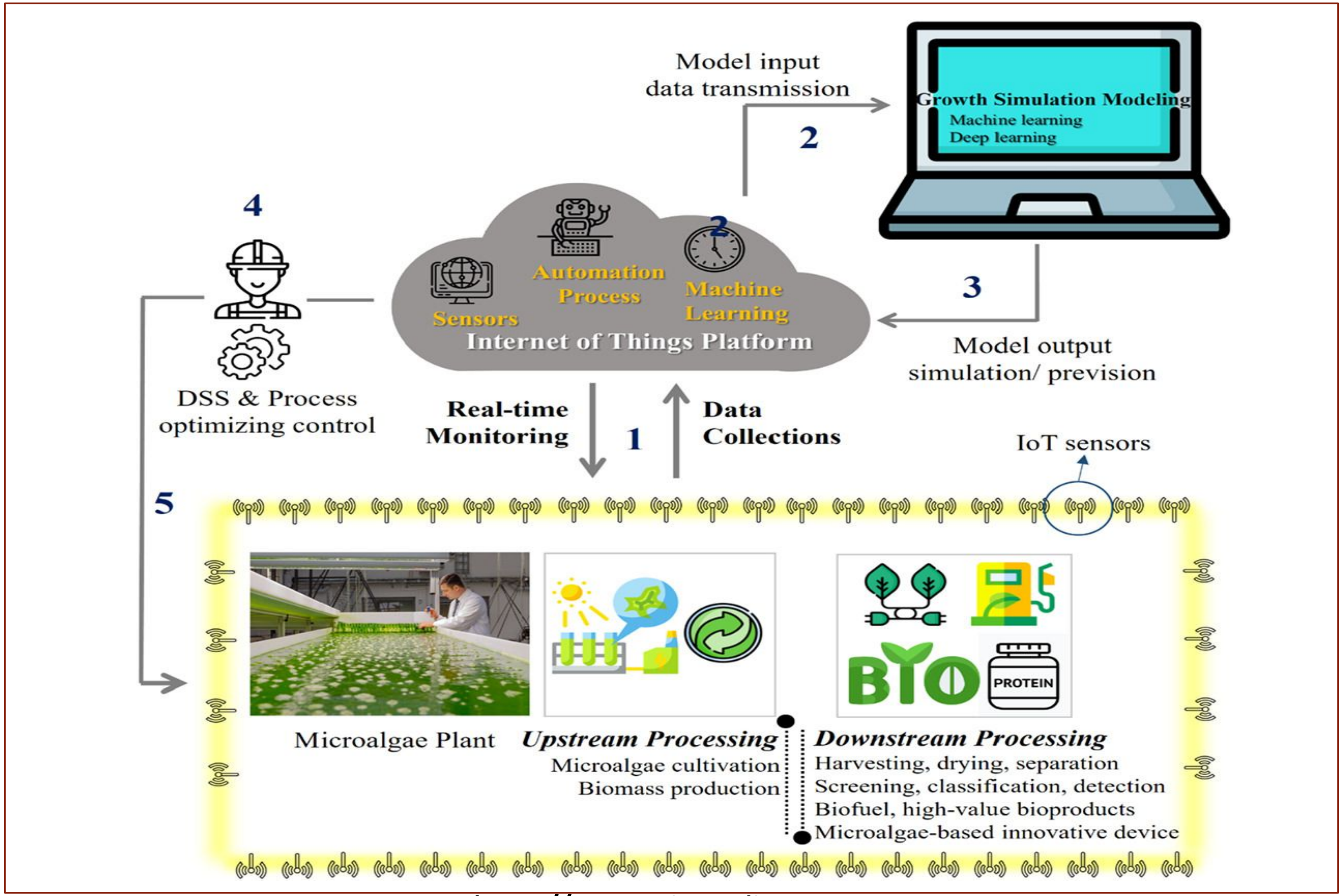
- ***Microalgae bio refinery*** is a platform for the conversion of microalgae biomass into a variety of value-added products, such as biofuels, bio-based chemicals, biomaterials, and bioactive substances.

- Commercialization and industrialization of microalgae bio refinery 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.

https://www.sciencedirect.com

Bio-sustainability – Internet of Things (IoT)



https://www.sciencedirect.com

Bio-sustainability – Internet of Things (IoT)

- 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 bio refinery.
- IoT guides microalgae bio refinery towards low-cost and high efficiency.

https://www.sciencedirect.com

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Bio-sustainability

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- Bio-sustainability
  - Bioremediation
    - Types/ Techniques
  - Phytoremediation
    - Mechanisms

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Bio-sustainability - Bioremediation

Introduction

Bioremediation is a process where biological organisms are used to remove or neutralize an environmental pollutant by metabolic process.

The “biological” organisms include microscopic organisms, such as fungi, algae and bacteria, and the “remediation”- treating the situation.

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.

Bio-sustainability - Bioremediation

Definition

The suitable organisms can be bacteria, fungi, or plants, which have the physiological abilities to degrade, detoxify, or render the contaminants harmless.

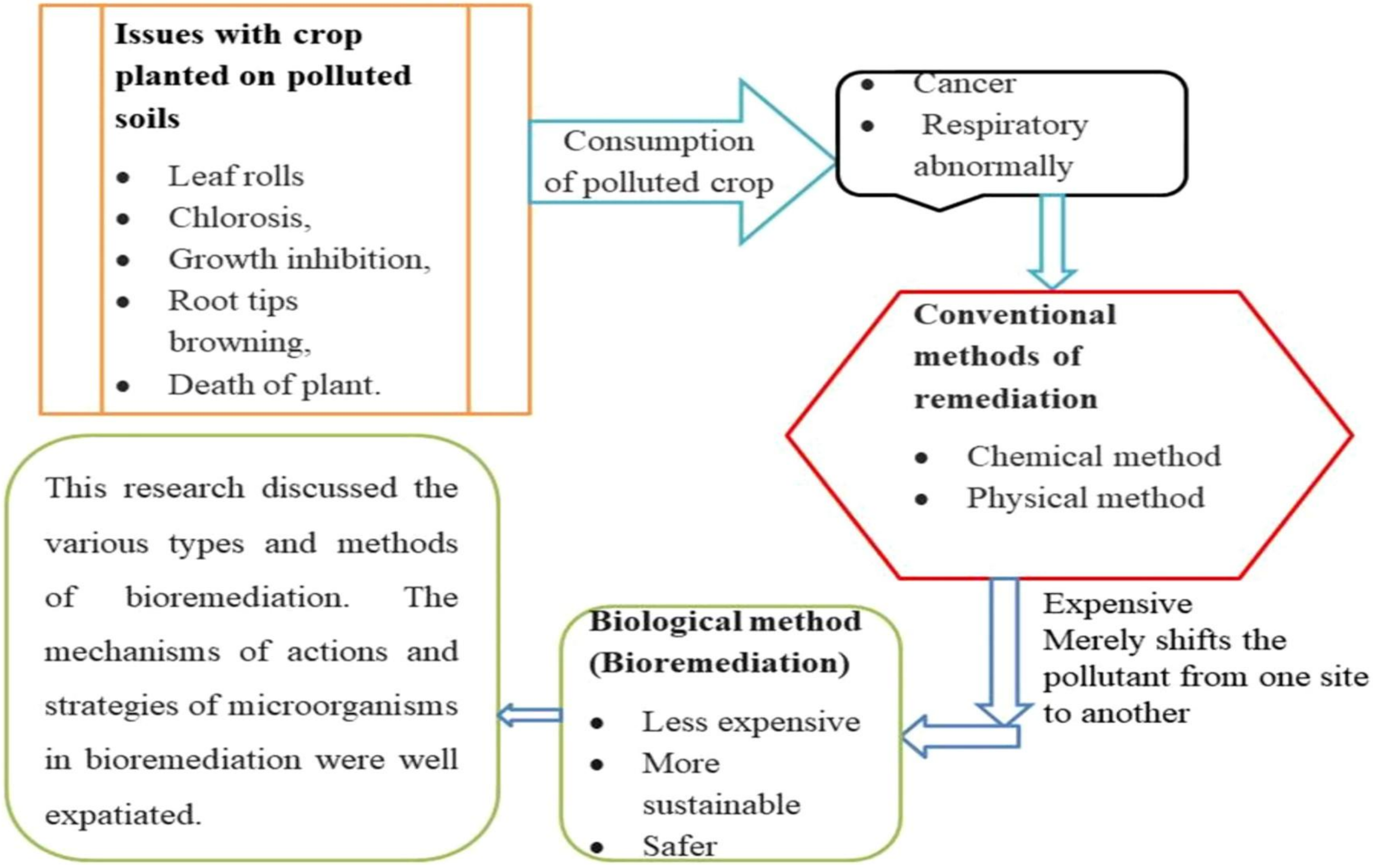
"Bioremediation is a waste management technique that includes the use of living organisms to eradicate or neutralize pollutants from a contaminated site."

"Bioremediation is a 'treatment techniques' that uses naturally occurring organisms to break down harmful materials into less toxic or non-toxic materials."

A mechanism of bioremediation is to reduce, detoxify, degrade, mineralize or transform more toxic pollutants to a less toxic.

Bio-sustainability - Bioremediation

Scope



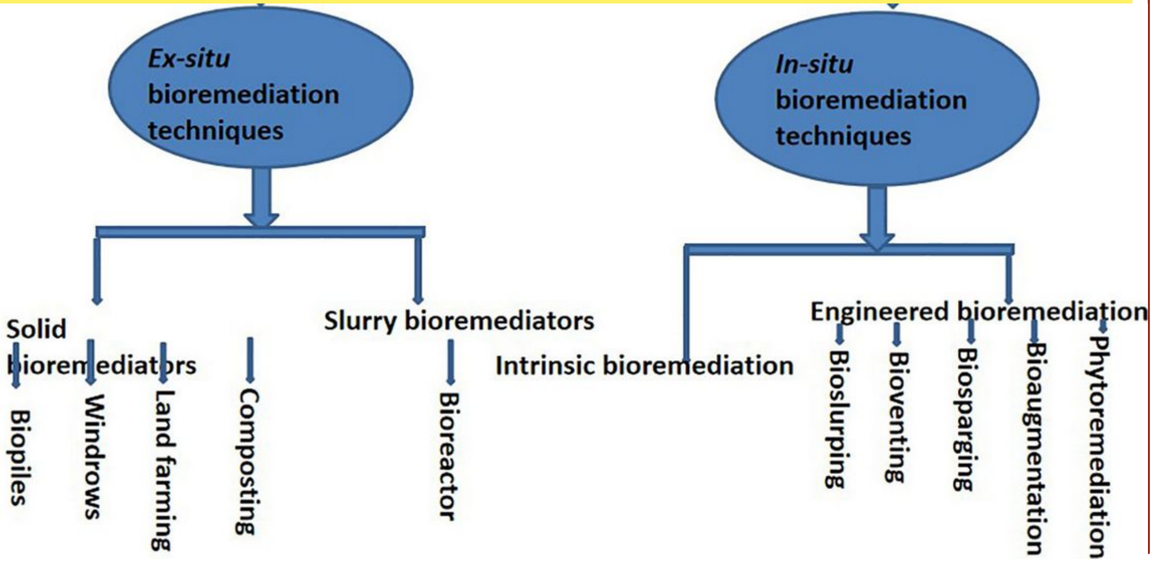
Source: https://www.frontiersin.org/files/Articles/937186/fsoil-02-937186-HTML/image_m/fsoil-02-937186-g003.jpg

Bio-sustainability - Bioremediation

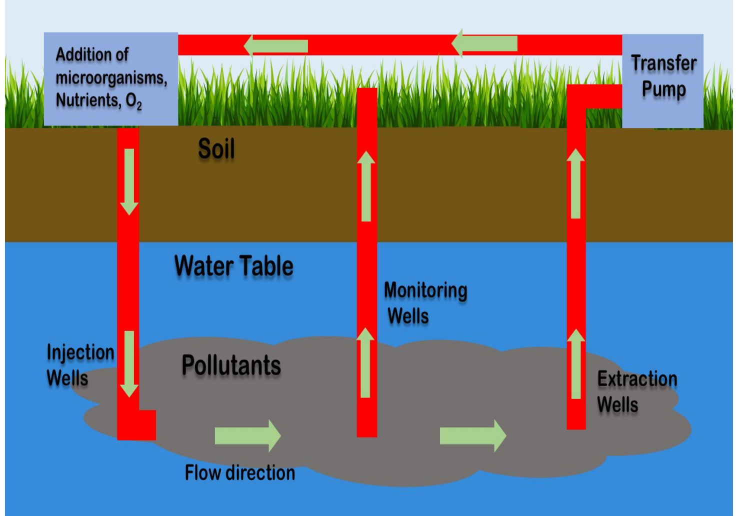
Types / Techniques

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, where as ***in situ*** technologies involve treatment of contaminated material in place.

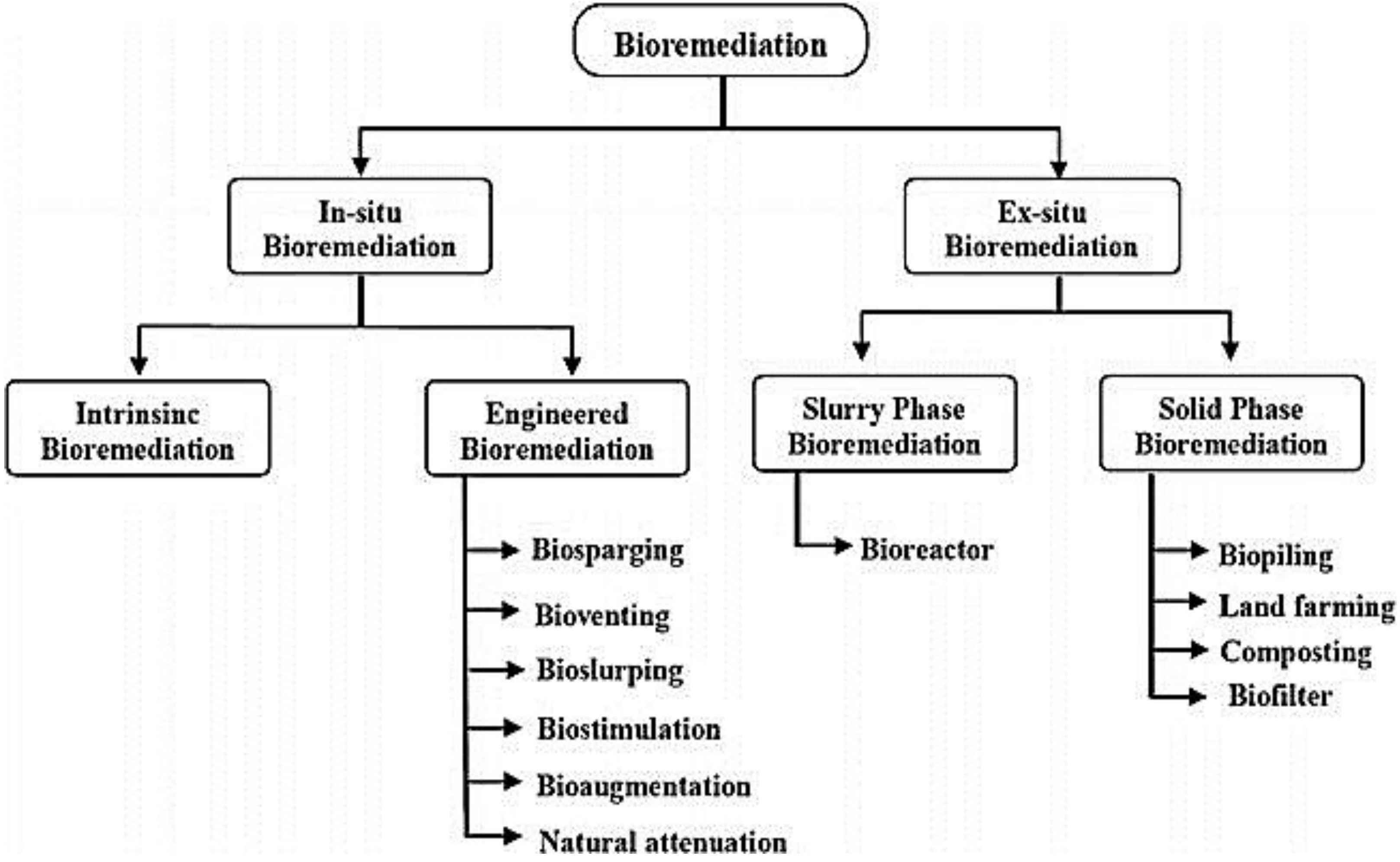


Source: Bioremediation techniques as affected by limiting factors in soil environment By Elizebath *et. al.*



Bio-sustainability - Bioremediation

Types/ Techniques

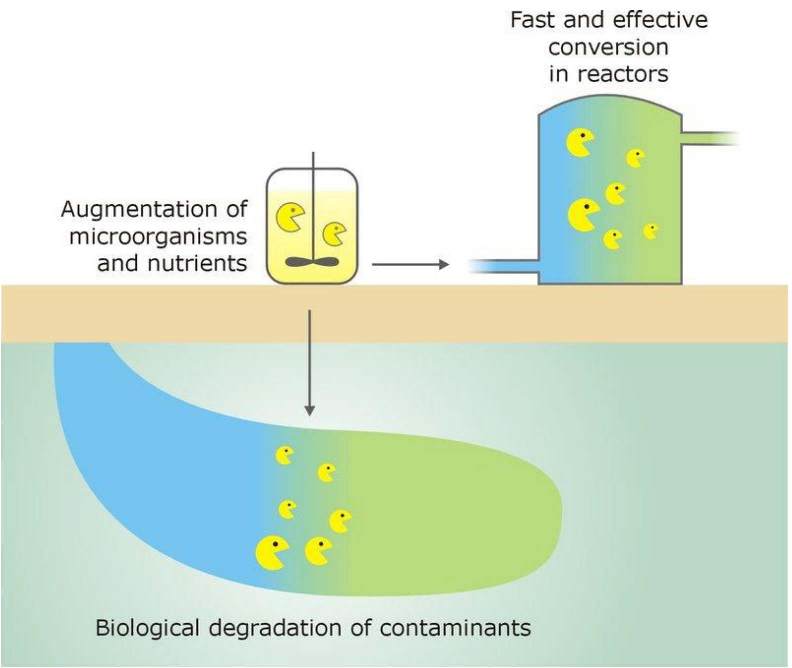


Source: Bioremediation Techniques for Polluted Environment: Concept, Advantages, Limitations, and Prospects | IntechOpen

Bio-sustainability - Bioremediation

Bioremediation Techniques

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



Bio-sustainability - Bioremediation

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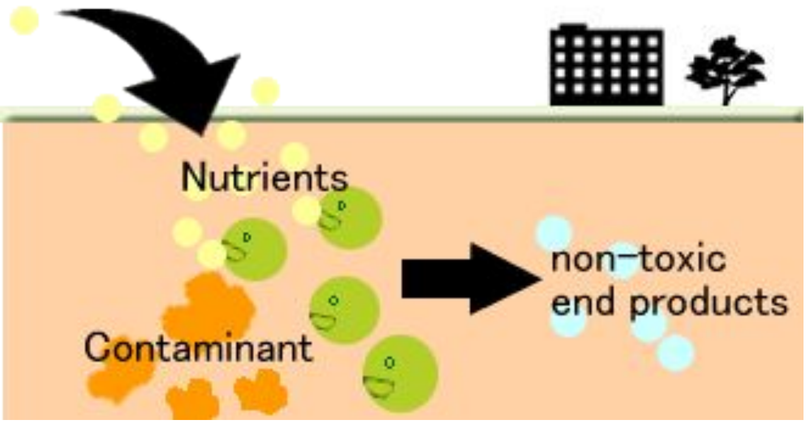

Bio-sustainability - Bioremediation

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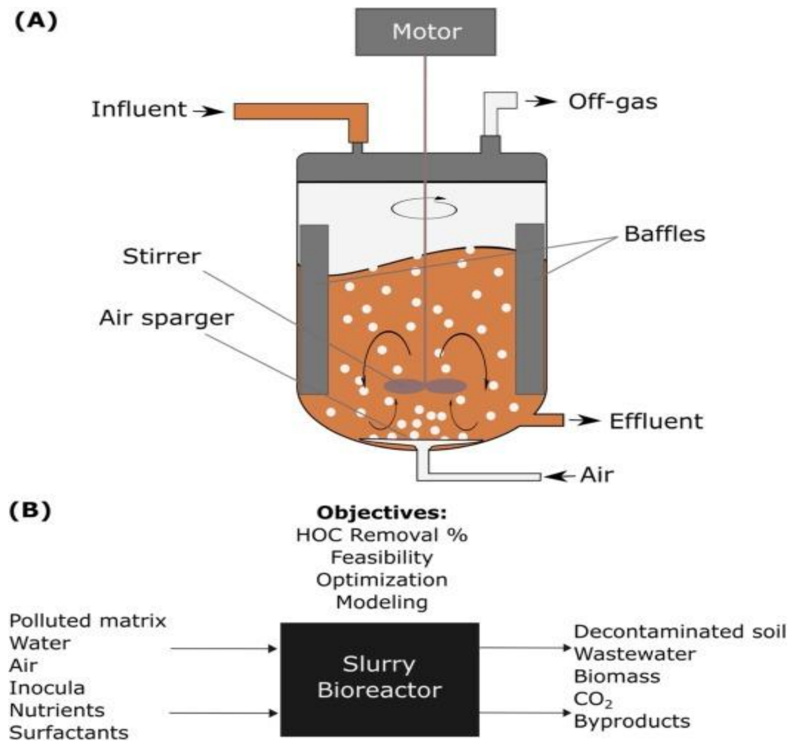
Bioremediation Techniques

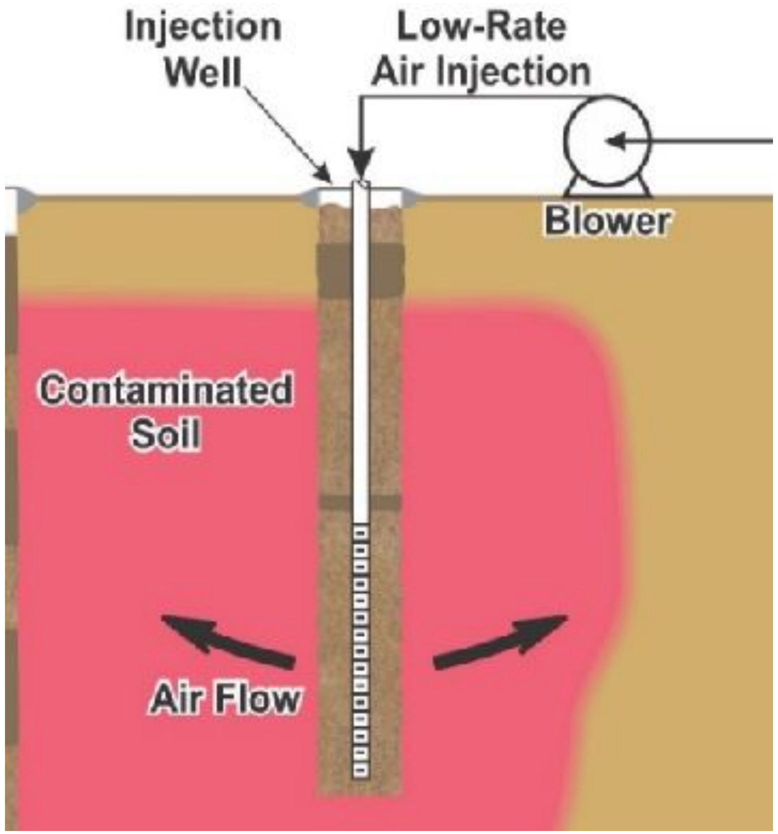
Bioaugmentation	Addition of bacterial cultures to a contaminated medium; frequently used in bioreactors and ex situ systems
Biostimulation	Stimulation of indigenous microbial populations in soils or groundwater by adding nutrients to the existing bacteria; which can be performed either in situ or ex 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**



Bio-sustainability - Bioremediation

Bioremediation Techniques

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



Bio-sustainability - Bioremediation

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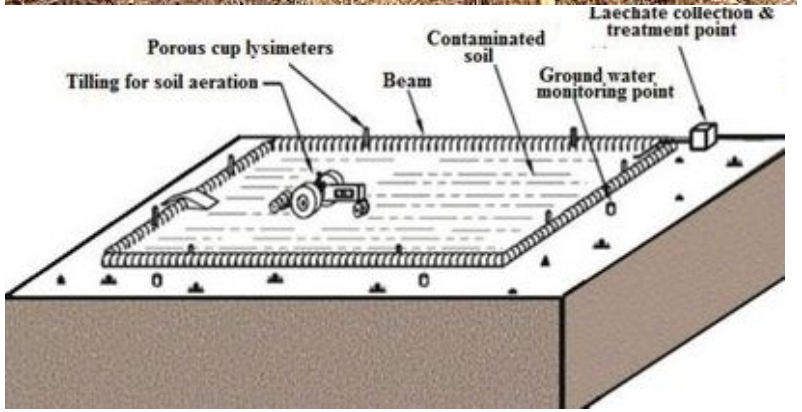

Bio-sustainability - Bioremediation

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Bioremediation Process

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.

Bio-sustainability - Bioremediation

Advantages

- Bioremediation is an eco-friendly cleaning process that treats environmental pollutants like pesticides, oils, solvents, and petroleum products. It helps in the removal of Contaminated groundwater, Clean up oil spills, Pollutants, Toxins from soil, Toxins from water and Other environmental contaminants.
- The residue of the bioremediation process, such as water, carbon dioxide, and cell biomass, is harmless to the environment.
- This is a natural process of cleaning nature by eliminating the pollutants and problems related to the processing and storage of pollutants.
- Suitable microbial populations can degrade a wide range of contaminants, rendering a hazardous compound to a harmless one.
- The potential threats to human health and to the environment are minimal . It can be used for crime scene clean-up.

Bio-sustainability - Bioremediation

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Disadvantages

- The bioremediation process operates under specific conditions that may or may not be present in the field where pollutants exist.
- It is not mandatory that microorganism-treated toxins can be entirely turned into harmless compounds.
- Not suitable for all pollutant and applicable only for biodegradable substances
- 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.

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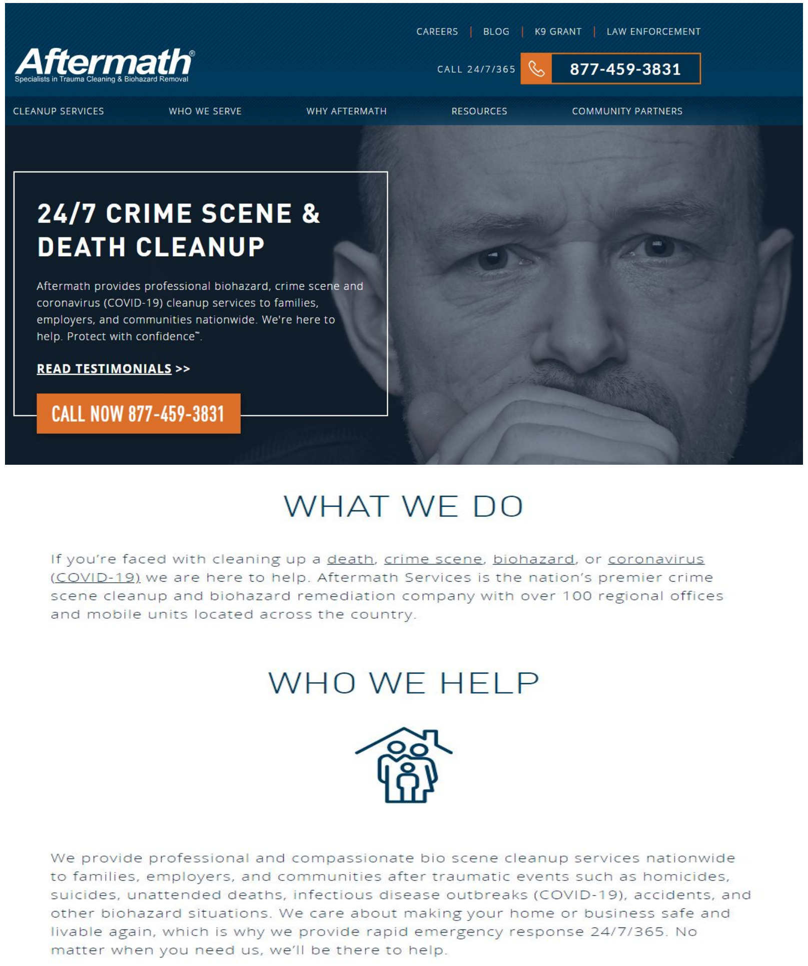
Bioremediation examples

Crime scene cleanup: Bioremediation in this sense involves the cleanup of blood and bodily fluids that can pose health risks such as hepatitis, HIV, and MRSA. Rather than using standard cleaning agents like bleach or ammonia, crime scene cleaners use enzyme cleaners to rid the scene of harmful substances. Aftermath is a company that specializes in this area of bioremediation. Aftermath does not remediate environmental pollutants.

The cleanup of contaminated soil: Human activity has introduced many toxic substances into the environment's soil and groundwater. Microbes utilize chemical contaminants in the soil as an energy source and, through oxidation-reduction reactions, metabolize the target contaminant into useable energy for microbes.



Bio-sustainability - Bioremediation

Bioremediation examples

- **Oil spill clean-up**: The Deepwater Horizon oil spill that happened in 2010, where 3.19 million barrels of oil spilled off the Gulf of Mexico.
- Due to the effectiveness and lower cost of bioremediation, two methods were used to clean-up after the Deepwater Horizon oil spill.

Bio-augmentation: The injection of a small amount of oil-degrading microbes into an affected area.

Bio-stimulation: The addition of nutrients to stimulate the growth of innate oil-degrading microbes to increase the rate of remediation.

E.g.: Exxon Valdez spill, Prince William Sound, Alaska, 1989

Exxon Valdez Oil spill

Image source: RGB Ventures

Bio-sustainability - Bioremediation

Bioremediation examples

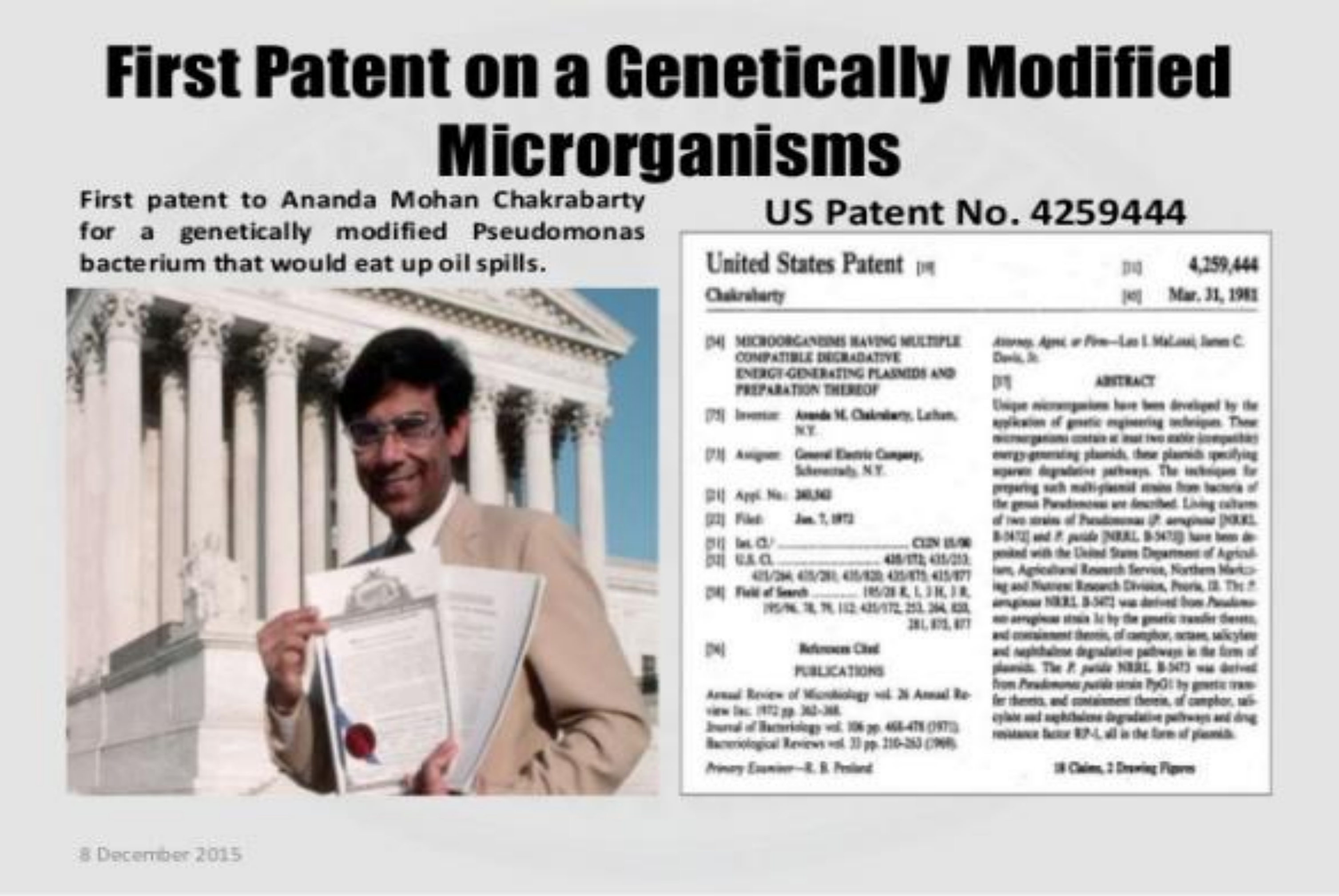
There are species of marine bacteria in several families, including *Marinobacter, Oceanospiralles, Pseudomonas*, and *Alkanivorax,* that can eat compounds from petroleum as part of their diet.

In fact, there are at least seven species of bacteria that can survive solely on oil.

These bacteria are nature's way of removing oil that ends up in the ocean, whether the oil is there because of oil spills or natural oil seeps.

Bio-sustainability - Bioremediation

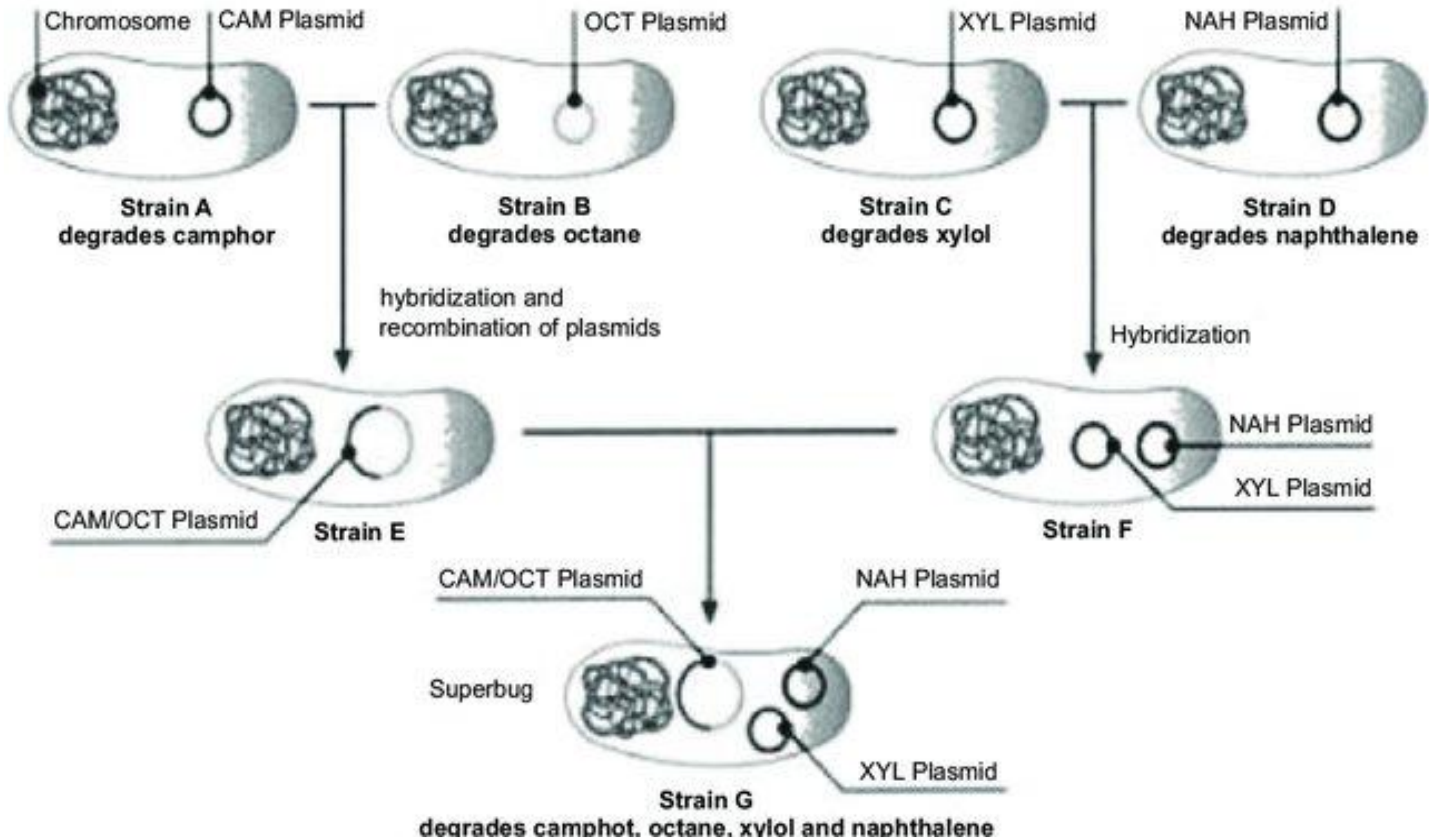
Bioremediation examples



Ananda Mohan Chakrabarty genetically engineered a new species of Pseudomonas bacteria ("The ***Oil-eating bacteria***") in **1971** while working for the R&D Centre at General Electric Company in Schenectady, New York.

Bio-sustainability - Bioremediation

GE approach to improve bacterial oil degradation



Bio-sustainability - Bioremediation

Phytoremediation

Toxic metal contamination of soil is a major environmental hazard.

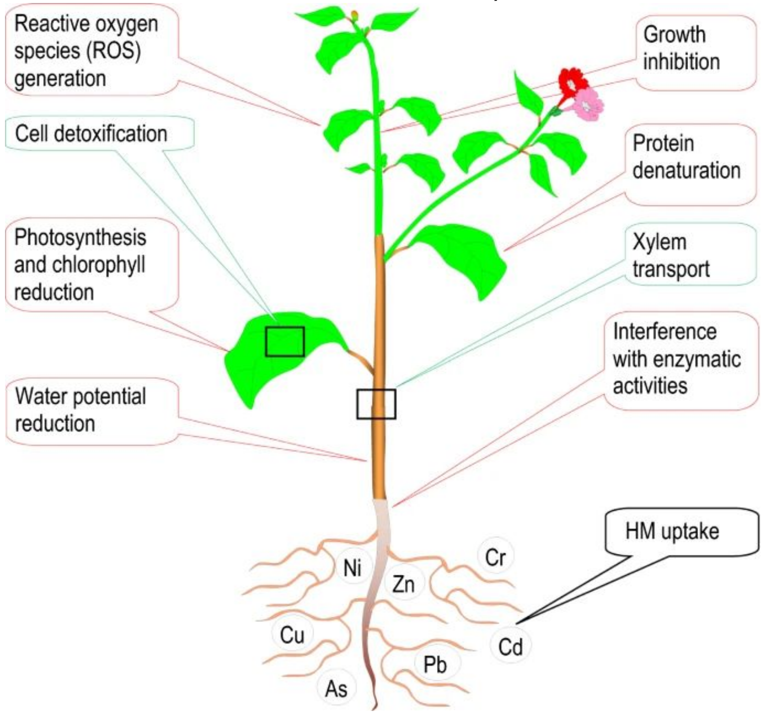
Chemical methods for heavy metal's (HMs) decontamination such as heat treatment, electroremediation, soil replacement, precipitation and chemical leaching are generally very costly and not be applicable to agricultural lands.

The phytoremediation is a promising method based on the use of hyper-accumulator plant species that can tolerate high amounts of toxic HMs present in the environment/soil.

Such a strategy uses green plants to remove, degrade, or detoxify toxic metals.

Five types of phytoremediation technologies have often been employed for soil decontamination: phytostabilization, phytodegradation, rhizofiltration, phytoextraction and phytovolatilization.

Heavy metal toxicity in plants and their tolerance strategies (uptake/translocation and detoxification)

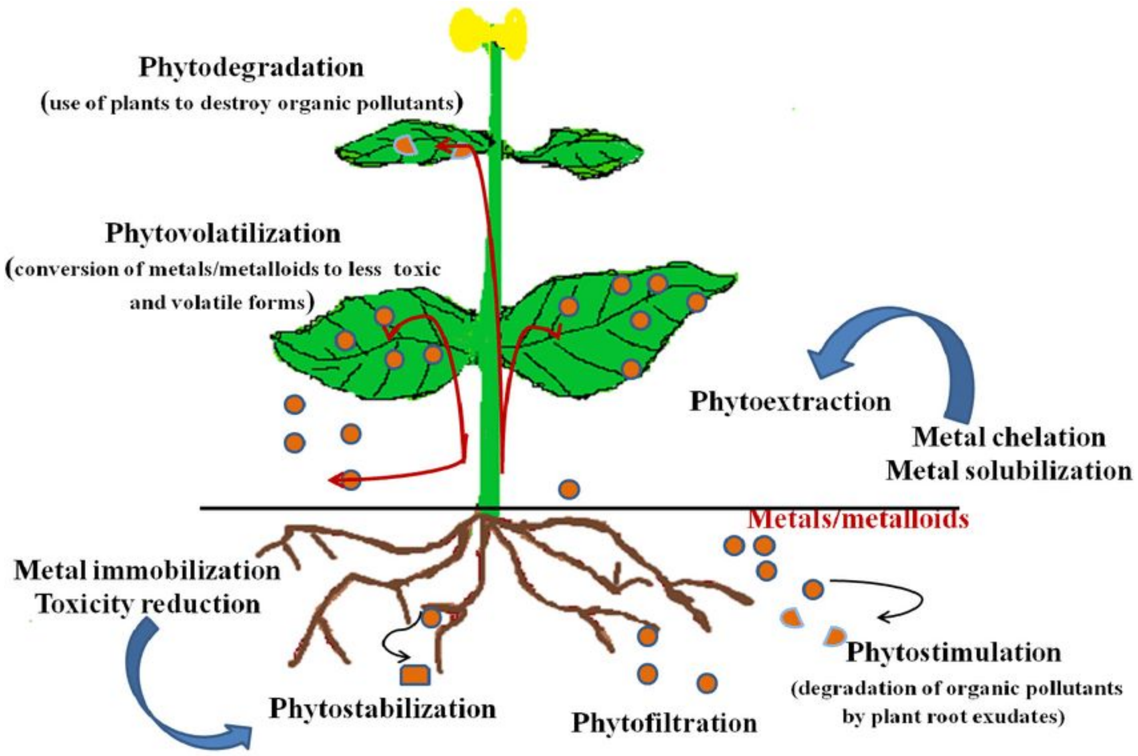


Source: https://link.springer.com/article/10.1007/s42452-021-04301-4

Bio-sustainability - Bioremediation

Phytoremediation - Mechanisms

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.



Bio-sustainability - Bioremediation

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

Bio-sustainability - Bioremediation

Phytoremediation

Bioremediation helps clean up polluted environments, including soils, groundwater, and marine environments. Such systems can include bacteria, fungi, algae, and plant species.

They are capable of metabolizing, immobilizing, or absorbing toxic compounds from their environment.

The a major **advantage** of these systems is that they are less harmful to the environment with minimum or no by-products.

THANK YOU

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