TOPIC 02 Microbes–In Production of Biogas, as Biocontrol Agents and Biofertilisers

Biogas

It is a mixture of gases, but the major content is methane gas. It is produced by the anaerobic microbial activity during digestion of biomass with the help of certain bacteria. Biogas is used as a fuel.

The type of gas produced by microbes during their growth and metabolism depends upon the microbes and the organic substrates they utilise. Certain bacteria, which grow anaerobically on cellulosic material, produce large amount of methane along with CO_2 and H_2.

These bacteria are called **methanogens** and one such common bacterium is *Methanobacterium*. Methanogens produce large amount of biogas [CH_4 (50-70%), CO_2 (30-40%) and H_2 (remaining)].

Methanogens are also present in anaerobic sludge during sewage treatment. They are also present in rumen (a part of stomach) of cattle, where they help in breakdown of cellulosic material in the food and thus, play important role in nutrition of cattle.

Biogas Plant

The excreta of cattle commonly called **gobar** is rich methanogenic bacteria. Thus, cattle dung can be us generation of biogas, commonly called **gobar gas.**

Cattle dung is available in large quantities in rural hence, biogas plants are mostly functional in rural a

Biogas plant consists of a concrete tank (10-15 feet in which bio-wastes are collected and slurry of dung fed. A floating cover is placed over the slurry, which keeps on rising, as the gas is produced in the tank du the microbial activity.

Methanobacterium in the dung acts on the bio-waste to produce biogas. An outlet is also present which connec to a pipe that supply biogas to the nearby houses.

There is another outlet from which spent slurry is removed that can be used as fertiliser. The biogas thus produced is used for cooking and lighting. Biogas production technology was developed in India mainly by

Khadi and Village Industries Commission (KVIC) and Indian Agricultural Research Institute (IARI).

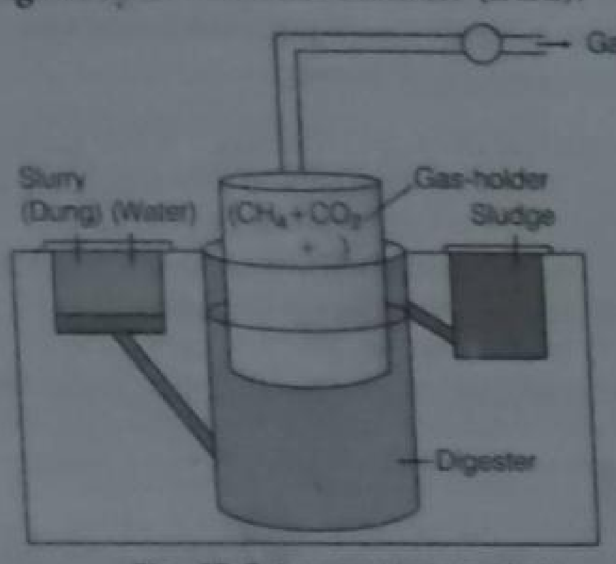

Fig. 10.2 A typical biogas plant

Process of Biogas Production

Biogas production includes three main steps

(i) **Solubilisation** In this process, decomposition of lipids, proteins, cellulose, etc., occurs by hydrolytic enzymes secreted by microorganisms.

(ii) **Acidogenesis** The monomers produced *via* solubilisation process change into organic acids.

(iii) **Methanogenesis** Methanogens act on organic acid and produce biogas.

Microbes as Biofuels

Microbes are also considered as a helpful solution to frequently rising energy crisis. Some microbes are used in production of various biofuels.

Biofuels are fuels of biological origin, which are used for the production of heat and other foum of energy. The energy derived from the biofuels is called **bioenergy**. Biologically generated hydrogen, methane, ethanol, butanol and diesel are referred as biohydrogen, biomethane, bioethanol, biobutanol and biodiesel, respectively. All of these are considered as **biofuels.**

Microbes as Biocontrol Agents

In modern agricultural system, the farmers have increased the use of chemicals such as insecticides, weedicides, etc., to control plant diseases and pests. These chemicals however, are harmful and toxic for human beings, animals and have been polluting environment (soil, groundwater), fruits, vegetables and crop plants, with their increased use. Thus, it is better to use biological agents to save our crop plants from pests, etc. **Biocontrol** refers to the use of biological methods for controlling plant diseases and pests.

Harmful Effects of Chemical Pesticides

(i) Extensive use of organochlorine pesticides causes environmental contamination.

(ii) Accumulation of pesticides in various biological system is called **bioaccumulation.**

(iii) A negative aspect of using pesticides is that repeated applications may cause development of resistant pest.

Biological Control of Pests and Diseases

It is a method of controlling pests in agriculture that relies on natural predation and not on chemicals. Organic farmers believe that 'biodiversity furthers health'. The more diversity a landscape has, the more sustainable it is.

Therefore, they work to create a system where the insects (pests) are not eradicated, but kept at manageable levels by a complex system of checks and balance within a living and vibrant ecosystem.

Unlike 'conventional' farming practices where chemical methods are used to kill both useful and harmful life forms indiscriminately, this is a holistic approach, as it seeks to develop an understanding of the webs of interaction between the myriad of organisms, including both flora and fauna in the field. Biological farming requires following approaches

- Familiarity with various life forms.
- An understanding of their habitat, predators as well as pest, their life cycle, patterns of feeding, etc., to use them in biocontrol measures and reduce the dependence on chemicals and pesticides.

Some examples of biological control agents are given

(i) **Insects**, **ladybird** and **dragonflies** are useful to get rid of aphids and mosquitoes, respectively.

(ii) **Bacteria** To control butterfly caterpillars, bacteria such as *Bacillus thuringiensis* are used in the form of sprays or sachets as dry spores. These are mixed with water and sprayed onto vulnerable plants like brassicas and fruit trees, where these are eaten by the insects larvae. This kills the larvae due to release of toxin in their gut, thereby eradicating the caterpillars, but leaving other insects unharmed.

Bacillus thuringiensis toxin genes are introduced into plants by using genetic engineering methods. Such plants (GMOs) are resistant to attack by insect pests. *Bt* cotton is one such example.

(iii) **Fungi** *Trichoderma* species are free-living fungi in the soil that are very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens eliminating them by mechanisms such as antibiosis, parasitism, competition, etc. e.g. *T. viridae*.

(iv) **Virus Baculoviruses** belonging to genus–*Nucleopolyhedrovirus* are used as biological control agents. These are excellent for species-specific, narrow spectrum insecticidal applications.

They do not have any negative impact on plants, mammals, birds, fish or even on non-target insects. Thus, making them useful in overall **Integrated Pest Management** (IPM) programme, when beneficial insects have to be conserved or when an ecologically sensitive area is being treated.

Integrated Pest Management

Integrated Pest Management (IPM), is a broad-based approach that integrates practices for economic control of pests. IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystem and encourages natural pest control mechanisms.

IPM system is based on four basic components

(i) **Acceptable pest levels** The emphasis is on control, not eradication. Insect and spore traps and other methods are used to monitor pest levels.

(ii) **Mechanical controls** When pest reach unacceptable level, mechanical methods are the first options. They include simple hand-picking, barriers, traps, vacuuming to disrupt breeding.

(iii) **Biological controls** The main approach is to promote beneficial insects that eat or parasitise target disease causing pests.

(iv) **Responsible use** Synthetic pesticides are used as required and often only at specific times in a pest's life cycle.

It involves following steps

Soil preparation, planting understanding pests on crops, pest trapping and their monitoring, biological control, record keeping and evaluation.

Microbes as Biofertilisers

The chemical fertilisers are being used in increasing amounts in order to the increase the agricultural output. However, due to the excessive use of these chemical fertilisers, there is increase in pollution of water bodies.

Thus, there is a pressure to shift to **organic farming**. **Biofertilisers** are organisms that enrich the nutrient quality of soil by enhancing the availability of nutrients to the crops.

The main sources of biofertilisers are as given below

Bacteria

- Nitrogen-fixing bacteria fix atmospheric nitrogen into organic form, which is used by the plant as nutrient, e.g. *Rhizobium* is a symbiotic bacterium that lives in the root nodules of legumes and fixes atmospheric nitrogen into organic compounds.
- *Azotobacter* and *Azospirillum* are free-living bacteria, which absorb free nitrogen from the soil, air and convert it into salts of nitrogen compounds.

Fungi

- They also form symbiotic association with plants, i.e. **mycorrhiza**, which absorb phosphorus from soil and passes it to the plants.
- Many members of genus–*Glomus* form mycorrhiza. Plants with mycorrhizal association show other benefits also such as
  (i) Resistance to root-borne pathogens.
  (ii) Tolerance to salinity and drought.
  (iii) Increase in plant growth and development.

Cyanobacteria

- These are autotrophic microbes found in aquatic and terrestrial environments. Most of them fix atmospheric nitrogen, e.g. *Anabaena*, *Nostoc*, *Oscillatoria*, etc.
- In paddy fields, cyanobacteria serve as important biofertiliser. Blue-Green Algae (BGA) also add organic matter to the soil. Thus, increasing its fertility, but still BGA are not very popularly used.