Economic Importance of Bacteria

By

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ECONOMIC IMPORTANCE OF BACTERIA

- Include both beneficial and harmful aspects.

A : Beneficial aspects of Bacteria

1. Role of Bacteria in soil fertility

- Nitrogen is an essential constituent of many biologically significant organic molecules like proteins, nucleic acids, vitamins, coenzymes, alkaloids etc.
- Certain bacteria play an important role Nitrogen fixation, ammonification , nitrification and thus help to increase the fertility of the soil.

Nitrogen fixing bacteria

- Although 79% of the atmosphere is Nitrogen, it can not be used directly by plants. Plants can absorb Nitrogen only in the form of nitrates. Nitrogen fixing bacteria can fix the free nitrogen of the atmosphere into absorbable form of nitrates.
- Nitrogen fixing bacteria are of two types viz. symbiotic nitrogen fixers and free living (asymbiotic) nitrogen fixers.

Symbiotic nitrogen fixing bacteria

- Establish symbiotic relationship with leguminous plants and fix free Nitrogen of the atmosphere into absorbable form of nitrates and increase the fertility of the soil.
- These are rod shaped, gram negative , motile bacteria that can grow in symbiotic association with leguminous plants and both the partners are mutually benefitted. The bacteria receive nutrients from the plants and the plant in turn get nitrogenous compounds.
- Infection of the roots of a leguminous plant with suitable species of these bacteria leads to the formation of root nodules.

e.g. Bacteria like *Rhizobium leguminosarum*, *Bradyrhizobium japonicum, Sinorhizobium meliloti* etc.

Free- living, aerobic nitrogen fixing bacteria

- Live independently in the soil and fix free Nitrogen of the atmosphere into absorbable forms.
- These bacteria are the chief suppliers of Nitrogen in grass lands and other similar ecosystems that lack plants with nitrogen fixing symbionts.

e.g. *Azotobacter vinelandii*, *Azospirillum lipoferum* etc.

Free – living , anaerobic nitrogen fixing bacteria

- Some species of *Clostridium* such as *Clostridium pasteurianum, Desulphovibrio vulgaris* etc. also fix atmospheric Nitrogen and help to improve fertility of the soil.

Nitrogen fixation by Cyanobacteria

- Cyanobacteria like *Nostoc punctiforme, Anabaena azollae* etc. can also fix free nitrogen of the atmosphere by means of heterocysts and thus increase fertility of the soil.

Ammonification

- Species of bacteria like *Bacillus subtilis*, *Bacillus macerans*, *Proteus terrae* , *Pseudomonas fluorescens* etc. degrade dead organic matter of plants and animals into simple compounds like ammonia and help to enhance the fertility of the soil.

Nitrification

- Nitrifying bacteria like *Nitrosomonas* (*Nitrosomonas europaea*), *Nitrosococcus* (*Nitrosococcus oceani*) etc. oxidise ammonia to nitrites and *Nitrobacter* species (e.g. *Nitrobacter vulgaris*) oxidise nitrites to nitrates and increase the fertility of the soil.

Nitrogen fixation by Filamentous bacteria (Actinomycetes)

- Form nodules in the roots of non –leguminous plants like *Casuarina.* e.g. Frankia

Phosphorous solubilizers or Phosphobacteria

- Solubilize different forms of insoluble phosphates by producing citric acid, succinic acid, fumaric acid etc.

e.g. *Bacillus polymyxa*
B. megatherium var. phosphaticum
Pseudomonas striata

Bacteria as Biofertilizers

- Cultures of improved strains of beneficial bacteria which when applied to the seed or soil, colonize the rhizosphere or the interior of the plants and stimulate plant growth by increasing the availability of nutrients.
- Improve cycling of nutrients and increase soil fertility .
- Increase porosity and water holding capacity of the soil and provide protection against drought.
- Enhance seed germination.

- Increase crop yield to 20 – 30 %
- Cheap, convenient and ecofriendly
- Application of biofertilizers have considerable importance in sustainable agriculture.

e.g. Species of *Rhizobium*

R. leguminosarum - Host - Pea plants
R. japonicum - Soy bean
R. phaseoli - Beans
Azotobacter - Paddy, Maize, cotton, sugar cane etc.
Azospirillum - Banana, Soy beans, Paddy, Maize etc.

Bacteria as decomposers – Nature's scavengers

- Saprophytic bacteria bring about the decomposition of dead remains of plants and animals and thus help in sanitation.
- During this process, the bacteria break down the complex organic molecules into simpler ones and make it available to plants.
- In this way, they help in cycling of nutrients (Biogeochemical cycles) and improve the fertility of soil.

2. Role of Bacteria in food production

Production of Curd , Butter, Cheese

- Milk is converted into curd, butter, cheese etc. by the activity of bacteria .
- Milk is inoculated with the starter culture and kept for a few hours.
- Lactic acid bacteria like *Lactobacillus casei, L. acidophilus, L. lactis , Lactococcus cremoris, Leuconostoc* etc. grow in milk and ferment lactose sugar in milk into lactic acid – results in coagulation of milk protein casein to form the curd. These bacteria are also used in the production of butter, cheese etc.

Production of Yoghurt

- The main (starter) cultures in yogurt are *Lactobacillus bulgaricus* and *Streptococcus thermophilus.*

Production of Vinegar (4 % Acetic acid)

- Ethyl alcohol is oxidized into acetic acid by acetic acid bacteria, *Acetobacter aceti, Gluconobacter* sps. etc. (Acid fermentation).

Probiotics

- Live microorganisms when administered in adequate amounts, confer a health benefit on the host .
- The most commonly used probiotic bacteria belong to the heterogeneous group of Lactic Acid Bacteria (*Lactobacillus, Enterococcus*) and to the genus *Bifidobacterium*.

  e.g. yoghurt and other fermented milk products include *Lactobacillus acidophillus and Bifidobacterium bifidum*.

Production of Fermented foods :

- Bacteria are used for the production of fermented foods.
- They are serving as process organisms and transform the chemical constituents of raw materials of plant/animal sources during fermentation.
- Such biotransformation will enhance the bio-availability of nutrients, impart characteristic flavour as well as preservative effects.
- Fermented foods like 'Dosa' , 'Idli' etc. involves fermentation by *Leuconostoc mesenteroides*, *Streptococcus faecalis* , *Pediococcus cerevisiae etc.* - help in leavening the batter.

Other examples of fermented foods :

- Kimchi (Lactic acid bacteria) - a Korean dish of spicy pickled cabbage.
- Sauerkraut (*Lactobacillus plantarum*) - a German dish of chopped pickled cabbage.
- Kefir(a fermented milk drink with a sour taste, made using a culture of yeasts and Lactic acid bacteria)
- Wine (an alcoholic drink made from fermented grape juice. Bacteria in wine production - strains of *Lactobacillus*, *Oenococcus* and *Pediococcus*
- Bacteria are involved in curing of tea, coffee , cocoa etc.

Bacteria as Single Cell Protein (SCP)

- Pruteen, produced from bacteria, *Methylophilus methylotrophus*, cultured on Methanol had 72% protein content, was the first commercial SCP used as animal feed supplement.
- Species of bacteria like *Cellulomonas*, *Alcaligenes* etc. are also used for the production of single cell protein.

3. Bacteria in production of antibiotics :

- e.g. Antibiotic Bacitracin and Polymixin are produced from *Bacillus* sps.
- Antibiotics Streptomycin, Tetracycline, Erythromycin, Rifamycin etc. are produced from from *Streptomyces* species. (Actinomycetes or Filamentous bacteria).

4. Production of Butanol and Propionic acid

- Industrial production of Butanol by fermentation using the bacterium *Clostridium acetobutylicum.*
- Industrial production of Propionic acid by fermentation by *Propionibacterium* species.

5. Bacteria for the production of medically useful enzymes

- The enzyme Streptokinase - a thrombolytic enzyme used to dissolve blood clots - produced by several Streptococci bacteria (e.g. *Streptococcus mutans, S. feacalis*, *S. uberis* etc.)

6. Role of Bacteria in Bioremediation

- Disposal of sewage and agrowastes - The bacterium *Sphaerotilus natans* , popularly known as sewage fungus , play an important role in the degradation of organic matter in sewage.
- Bacteria for Pesticide degradation : *Klebsiella*, *Acinetobacter*, *Alcaligenes*, *Flavobacterium* and *Bacillus subtilis* could degrade Endosulfan.

- Oil-degrading microorganisms include *Pseudomonas*, *Marinobacter, Acinetobacter etc.*
- Ananda Mohan Chakrabarty, an Indian American microbiologist , developed a genetically engineered super bug, *Pseudomonas putida* capable of degrading Petroleum - the first organism for which a patent has been granted in USA.
- This super bug is a 'multiplasmid hydrocarbon-degrading *Pseudomonas*' or oil eating bacteria created by recombinant DNA technology - contain genes from plasmids of four different species of bacteria – Its multiple plasmids contain genes which govern the degradation of different hydrocarbons like camphor, xylene, octane, hexane, naphthalene, toluene etc. - can degrade simultaneously a number of hydrocarbons of petroleum - can digest about two-thirds of the hydrocarbons that would be found in a typical oil spill.

7. Bacterium as a biocontrol agent

- The bacterium *Bacillus thuringiensis* can be used as a biocontrol agent.

8. Agrobacterium mediated gene transfer technique

- The soil bacterium , *Agrobacterium tumefaciens*, known as natural plant genetic engineer, is used to produce many genetically modified plants.

9. Production of biogas

- Several bacteria are involved in the production of bio gas (methane – biofuel) from cow dung, animal wastes, other biodegradable wastes etc.

10. Retting of Fibers

- Bacteria (e.g. *Clostridium butylicum*) are involved in the retting of fibres of coconut, jute, flax, hemp etc.

11. Leather industry (Tannery):

- In leather industry, removal of hairs, fats and other tissues from raw hide is done by bacteria.

12. Biodegradable plastics

- Poly β-hydroxybutyrate , a type of reserve food in certain bacteria , is used for the production of biodegradable plastic.

13. Uses of genetically engineered bacteria

Genetically engineered *E. coli*

- Used for the production of human insulin .e.g. 'Humulin' to treat diabetes and human growth hormone Somatotropin to treat dwarfism ; production of biofuels e.g. Bioethanol.
- Genetically engineered bacterium for the production of vitamins – e.g. *Propionibacterium freudenreichii* for the production of vitamin B12.

  Genetically engineered *Pseudomonas putida* – super bug – for cleaning oil spills.
- *Deinococcus radiodurans* is another genetically engineered bacterium, which can be used as a bioremediator to degrade toluene and mercury from highly radioactive nuclear wastes.

Bt crops

- Bt gene (cry gene) from the bacterium *Bacillus thuringiensis* is transferred to crop plants by recombinant DNA technology to form Bt crops - e.g. Bt cotton, Bt corn, Bt brinjal etc. which are resistant to insects of specific groups like Lepidoptera (Butterfly, Moth etc.) and Diptera (Mosquitoes, House fly etc.) .

B : Harmful aspects of Bacteria

1. Reduction in soil fertility by denitrifying bacteria.

- Denitrifying bacteria like *Thiobacillus denitrificans*, *Micrococcus denitrificans* etc. convert the nitrates of the soil into free Nitrogen of the atmosphere and thus reduce the fertility of the soil.

2. Bacterial Diseases

Parasitic bacteria are pathogens and cause various diseases in plants and animals including man.

e.g. Blight disease of Paddy caused by *Xanthomonas oryzae*

Blight disease of Paddy

Image : http://www.knowledgebank.irri.org/

Bacterial diseases in man

Diphtheria - *Corynebacterium diphtheriae.*

Cholera - *Vibrio cholerae*

Pneumonia - *Streptococcus pneumoniae* etc.

3. Bacteria causes food spoilage :

Food spoilage is the undesirable change in the food.

- Spoilage causes changes in the appearance of food, formation of unpleasant odour and unpalatable taste.

A large number of bacteria cause spoilage of

- Vegetables and fruits – *Staphylococcus*, *Streptococcus*, *Bacillus* etc.
- Cereals – *Micrococcus*, *Bacillus*, *Pseudomonas* etc.
- Meat – *Bacillus*, *Clostridium*, *Escherichia*, *Pseudomonas* etc.
- Egg – *Salmonella* , *Micrococcus*, *Pseudomonas* etc.

- Poultry – *Bacillus*, *Enterobacter* , *Escherichia*, *Salmonella* etc.
- Fish – *Alcaligenes*, *Micrococcus*, *Pseudomonas* etc.
- Processed foods – *Bacillus subtilis*, *B. licheniformis* etc.

Bacteria causes food poisoning -

Botulism

- An anaerobic bacterium, *Clostridium botulinum* produces a neurotoxin botulin (an exotoxin) which produces food poisoning called botulism.

Salmonellosis

- caused by *Salmonella* bacteria commonly associated with eggs, meat and poultry .

4. Biowar/Bioterrorism:

The improved variety of infective agents (bioweapons) are widely been used as an agent of effective weapon of bioterrorism.

e.g. *Bacillus anthracis* - causes Anthrax

Clostridium botulinum (*botulism*) etc.

THANK YOU