UNIT II - WATER RESOURCES AND ENVIRONMENT MICROBIOLOGY

2.6 CLASSIFICATION OF MICROORGANISMS

1. What are Microorganisms?

- Microorganisms are tiny living organisms visible only under a microscope.
- Include bacteria, viruses, fungi, protozoa, and algae.

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2. Classification of Microorganisms

Microorganisms are classified into five major groups:

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1. Bacteria

- Characteristics:
  - Single-celled organisms (prokaryotes).
  - No nucleus; DNA floats in the cytoplasm.
  - Reproduce rapidly by binary fission.
- Examples:
  - *E. coli*, *Streptococcus*.
- Types (Based on Shape):
  - Cocci (spherical), Bacilli (rod-shaped), Spirilla (spiral), Vibrios (comma-shaped).

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2. Viruses

- Characteristics:
  - Non-living outside a host; require a host cell to reproduce.
  - Made of genetic material (DNA or RNA) enclosed in a protein coat.
- Examples:
  - Influenza virus, HIV, Coronavirus.
- Size:
  - Smaller than bacteria.

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3. Fungi

- Characteristics:
  - Eukaryotic organisms (have a nucleus).
  - Can be unicellular (yeast) or multicellular (molds, mushrooms).
  - Decompose organic matter.
- Examples:
  - Yeast (*Saccharomyces cerevisiae*), Mold (*Aspergillus*).

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4. Protozoa

- Characteristics:

  - Single-celled eukaryotic organisms.
  - Move using cilia, flagella, or pseudopodia.
  - Often parasitic.
- Examples:
  - *Amoeba*, *Plasmodium* (causes malaria).

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5. Algae

- Characteristics:
  - Photosynthetic organisms (produce their own food).
  - Can be unicellular (e.g., *Chlamydomonas*) or multicellular (e.g., seaweed).
  - Found in water or moist environments.
- Examples:
  - *Spirogyra*, *Chlorella*.

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3. Importance of Microorganisms

- Beneficial Roles:
  - Decompose organic waste.
  - Produce antibiotics (e.g., *Penicillium*).
  - Aid in food production (e.g., yogurt, bread).
  - Fix nitrogen in soil (*Rhizobium*).
- Harmful Roles:
  - Cause diseases (e.g., tuberculosis, malaria).
  - Spoil food and materials.

2.6.1 ROLE OF MICROORGANISM IN WASTE WATER TREATMENT

1. What is Wastewater Treatment?

- Wastewater treatment is the process of cleaning sewage or industrial waste to make it safe for reuse or discharge into the environment.
- Microorganisms play a key role in breaking down pollutants.

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2. Microorganisms in Wastewater Treatment

Microorganisms help remove organic and inorganic waste by digesting it. They are used in three main stages of treatment:

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1. Primary Treatment (Minimal Role of Microorganisms)

- Focus: Removal of large solids and floating debris.
- Microorganisms are not significantly involved at this stage.

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2. Secondary Treatment (Key Role of Microorganisms)

- Purpose: Breakdown of organic matter using microorganisms.

- Key Processes:
    - Activated Sludge Process:
        - Wastewater is aerated to allow bacteria to grow and digest organic pollutants.
        - Common microbes: *Nitrosomonas*, *Nitrobacter*.
    - Trickling Filters:
        - Wastewater flows over a bed of stones or plastic with biofilm (microorganisms).
        - Microorganisms digest waste.
    - Anaerobic Digesters:
        - In oxygen-free conditions, anaerobic bacteria break down organic material to produce biogas (methane).
        - Example microbes: *Methanobacterium*, *Clostridium*.

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3. Tertiary Treatment (Specific Role of Microorganisms)

- Purpose: Further purification to remove pathogens and nutrients.
- Key Processes:
    - Use of specific microbes to remove nitrates, phosphates, and harmful chemicals.
    - Example microbes: Denitrifying bacteria like *Pseudomonas*.

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3. Types of Microorganisms Used

1. Bacteria:
    - Decompose organic pollutants into simpler compounds.
    - Examples: *Bacillus*, *Pseudomonas*.
2. Fungi:
    - Break down complex organic materials like lignin and cellulose.
    - Examples: *Trichoderma*, *Aspergillus*.
3. Protozoa:
    - Consume bacteria and organic debris, helping to clarify water.
    - Examples: *Paramecium*, *Amoeba*.
4. Algae:
    - Produce oxygen during photosynthesis, supporting bacterial growth.
    - Examples: *Chlorella*, *Spirogyra*.

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4. Benefits of Microorganisms in Wastewater Treatment

- Cost-effective and natural method.
- Produces biogas as a renewable energy source.
- Reduces harmful pathogens and pollutants.
- Converts waste into usable by-products like fertilizers.

5. Challenges

- Sensitive to environmental changes (e.g., pH, temperature).
- Toxic chemicals in wastewater can harm microbial communities.
- Requires proper management to maintain microbial balance.

2.6.2 BACTERIAL NUTRITION AND GROWTH

1. Bacterial Nutrition

Bacteria require nutrients for energy, growth, and reproduction. Nutrients are obtained from their environment and can be classified based on how they obtain energy and carbon.

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1. Types of Bacterial Nutrition:

1. **Autotrophic Bacteria:**
    - Make their own food using inorganic substances.
    - Photoautotrophs: Use sunlight for energy (e.g., *Cyanobacteria*).
    - Chemoautotrophs: Use chemical reactions for energy (e.g., *Nitrosomonas*).
2. **Heterotrophic Bacteria:**
    - Depend on organic substances for food.
    - Saprophytic: Feed on dead organic matter (e.g., *Bacillus*).
    - Parasitic: Feed on a living host, often causing harm (e.g., *Salmonella*).
    - Symbiotic: Live in mutual benefit with other organisms (e.g., *Rhizobium* in plants).
3. **Mixotrophic Bacteria:**
    - Combine autotrophic and heterotrophic modes (e.g., *Beggiatoa*).

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2. Nutrient Requirements:

- Macronutrients: Needed in large amounts (e.g., carbon, hydrogen, oxygen, nitrogen, phosphorus).
- Micronutrients: Needed in small amounts (e.g., iron, zinc, copper).

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2. Bacterial Growth

1. Growth Process:

- Bacterial growth refers to the increase in the number of cells, not the size of individual cells.
- Bacteria reproduce asexually by binary fission (one cell divides into two).

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2. Phases of Bacterial Growth (in a culture):

1. **Lag Phase:**

- Bacteria prepare for growth by synthesizing enzymes and absorbing nutrients.
- No significant increase in number.

2. **Log (Exponential) Phase:**
   - Rapid cell division.
   - Population doubles at a constant rate.
3. **Stationary Phase:**
   - Growth slows as resources are depleted.
   - Number of new cells equals the number of dying cells.
4. **Death (Decline) Phase:**
   - Cells die due to lack of nutrients and accumulation of waste products.

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3. Factors Affecting Bacterial Growth:

- Temperature:
  - Optimal ranges:
    - *Psychrophiles*: Cold-loving (0–20°C).
    - *Mesophiles*: Moderate temperatures (20–45°C).
    - *Thermophiles*: Heat-loving (45–80°C).
- pH: Most bacteria prefer neutral pH (6.5–7.5).
- Oxygen:
  - Aerobes: Require oxygen.
  - Anaerobes: Grow without oxygen.
  - Facultative Anaerobes: Can survive with or without oxygen.
- Nutrients: Availability of essential nutrients.
- Water: Necessary for metabolic processes.

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3. Importance of Bacterial Nutrition and Growth

- Used in biotechnology for producing medicines, enzymes, and fermented foods.
- Helps in waste decomposition and nutrient cycling.
- Pathogenic bacteria can cause diseases, so understanding their growth helps in control.