Chapter 12: Ecosystem

Comprehensive Study Notes

Class 12 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for NEET and Board Examinations

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Introduction

Ecosystem: A functional unit of nature where living organisms interact among themselves and with the surrounding physical environment.

Size Range: From small pond to large forest or sea

- **Global Ecosystem**: Entire biosphere as composite of all local ecosystems

Basic Categories:

1. **Terrestrial**: Forest, grassland, desert
2. **Aquatic**: Pond, lake, wetland, river, estuary
3. **Man-made**: Crop fields, aquarium

Key Processes:

- **Input**: Productivity
- **Transfer**: Food chain/web, nutrient cycling
- **Output**: Degradation and energy loss

12.1 ECOSYSTEM - STRUCTURE AND FUNCTION

Components Integration:

Biotic + Abiotic interaction → Physical structure → Characteristic ecosystem

Structural Features:

1. Species Composition

- Identification and enumeration of plant and animal species

2. Stratification

- **Definition**: Vertical distribution of different species occupying different levels
- **Example in Forest**:
  - **Top layer**: Trees
  - **Middle layer**: Shrubs
  - **Bottom layer**: Herbs and grasses

Functional Aspects:

1. **Productivity**
2. **Decomposition**
3. **Energy flow**
4. **Nutrient cycling**

Example: Pond Ecosystem

Self-sustainable unit demonstrating all ecosystem functions:

Abiotic Components:

- Water with dissolved inorganic and organic substances
- Rich soil deposit at bottom
- Solar input, temperature cycles, day-length
- Climatic conditions

Biotic Components:

Autotrophic Components (Producers):

- Phytoplankton
- Algae
- Floating, submerged, and marginal plants

Consumer Components:

- Zooplankton
- Free swimming forms
- Bottom dwelling forms

Decomposer Components:

- Fungi, bacteria, flagellates (abundant at pond bottom)

System Functions:

1. **Conversion**: Inorganic → Organic (by autotrophs using solar energy)
2. **Consumption**: Autotrophs → Heterotrophs
3. **Decomposition**: Dead matter → Minerals (for reuse by autotrophs)
4. **Energy Flow**: Unidirectional toward higher trophic levels
5. **Energy Loss**: Heat dissipation to environment

12.2 PRODUCTIVITY

Solar Energy Requirement:

Constant solar energy input = Basic requirement for ecosystem function

Primary Production:

Definition: Amount of biomass or organic matter produced per unit area over time period by plants during photosynthesis

Expression:

- **Weight**: g m^{-2}
- **Energy**: kcal m^{-2}

Productivity Types:

1. Gross Primary Productivity (GPP)

- **Definition**: Rate of production of organic matter during photosynthesis
- **Total organic matter produced** by plants

2. Net Primary Productivity (NPP)

- **Formula**: GPP - R = NPP
- **Where R** = Respiration losses
- **Definition**: Available biomass for consumption by heterotrophs
- **Significance**: Actual energy available to ecosystem

3. Secondary Productivity

- **Definition**: Rate of formation of new organic matter by consumers

Factors Affecting Primary Productivity:

1. **Plant species** inhabiting the area
2. **Environmental factors**
3. **Nutrient availability**
4. **Photosynthetic capacity** of plants

Global Productivity Statistics:

- **Annual NPP of biosphere**: ~170 billion tons (dry weight)
- **Ocean productivity**: 55 billion tons (despite 70% surface coverage)
- **Land productivity**: 115 billion tons
- **Ocean limitation**: Low nutrient availability in surface waters

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12.3 DECOMPOSITION

Definition:

Process where decomposers break down complex organic matter into inorganic substances (CO_2, water, nutrients)

Raw Material:

Detritus: Dead plant remains (leaves, bark, flowers) + dead animal remains + fecal matter

Steps in Decomposition:

1. Fragmentation

- **Agent**: Detritivores (e.g., earthworms)
- **Process**: Break detritus into smaller particles

2. Leaching

- **Process**: Water-soluble inorganic nutrients go down into soil
- **Result**: Precipitate as unavailable salts

3. Catabolism

- **Agent**: Bacterial and fungal enzymes
- **Process**: Degrade detritus into simpler inorganic substances

4. Humification

- **Product**: Humus (dark-colored amorphous substance)
- **Properties**:
  - Highly resistant to microbial action
  - Extremely slow decomposition rate
  - Colloidal nature
  - Serves as nutrient reservoir

5. Mineralisation

- **Process**: Humus degraded by microbes
- **Result**: Release of inorganic nutrients

Factors Controlling Decomposition:

Chemical Composition of Detritus:

- **Slower decomposition**: Rich in lignin and chitin
- **Faster decomposition**: Rich in nitrogen and water-soluble substances (sugars)

Climatic Factors:

- **Temperature and soil moisture**: Most important factors
- **Favorable conditions**: Warm and moist environment
- **Unfavorable conditions**: Low temperature and anaerobic conditions
- **Result of unfavorable**: Build-up of organic materials

Note: Decomposition is largely an **oxygen-requiring process**

12.4 ENERGY FLOW

Energy Source:

Sun: Only source of energy for all ecosystems (except deep sea hydrothermal)

Solar Radiation Utilization:

- **PAR (Photosynthetically Active Radiation)**: <50% of incident solar radiation
- **Plant capture**: Only 2-10% of PAR
- **Significance**: This small amount sustains entire living world

Energy Flow Characteristics:

1. **Unidirectional flow**: Sun → Producers → Consumers
2. **Follows First Law of Thermodynamics**
3. **Follows Second Law of Thermodynamics**: Constant energy supply needed

Trophic Levels:

Producers (1st Trophic Level):

- **Terrestrial**: Herbaceous and woody plants
- **Aquatic**: Phytoplankton, algae, higher plants
- **Function**: Convert solar energy to chemical energy

Consumers:

- **Primary Consumers (2nd Trophic Level)**: Herbivores
  - **Terrestrial**: Insects, birds, mammals
  - **Aquatic**: Molluscs
- **Secondary Consumers (3rd Trophic Level)**: Primary carnivores
- **Tertiary Consumers (4th Trophic Level)**: Secondary carnivores

Food Chains:

1. Grazing Food Chain (GFC):

Example: Grass → Goat → Man

- **Starts with**: Living producers
- **Major in**: Aquatic ecosystems

2. Detritus Food Chain (DFC):

- **Starts with**: Dead organic matter
- **Decomposers**: Fungi and bacteria (saprotrophs)
- **Function**: Break down dead material into inorganic substances
- **Major in**: Terrestrial ecosystems

Food Web:

Natural interconnection of food chains through:

- DFC organisms as prey to GFC animals
- Omnivores (e.g., cockroaches, crows)

Energy Transfer:

- **10% Law**: Only 10% energy transferred to next trophic level
- **Energy decrease**: At successive trophic levels
- **Standing Crop**: Mass of living material at particular time
- **Biomass measurement**: Fresh or dry weight (dry weight more accurate)

12.5 ECOLOGICAL PYRAMIDS

Definition:

Graphical representation of relationship between organisms at different trophic levels in terms of number, biomass, or energy

Structure:

- **Base**: Producers (1st trophic level)
- **Apex**: Tertiary/top consumers
- **Shape**: Broad base narrowing toward apex

Types of Ecological Pyramids:

1. Pyramid of Numbers

- **Representation**: Number of organisms at each trophic level
- **Usually**: Upright (producers > herbivores > carnivores)
- **Exception**: Inverted when few large producers (trees) support many consumers

2. Pyramid of Biomass

- **Representation**: Total biomass at each trophic level
- **Usually**: Upright (biomass decreases with trophic level)
- **Exception**:
  - **Inverted in aquatic ecosystems**: Fish biomass > Phytoplankton biomass
  - **Explanation**: Rapid turnover rate of phytoplankton

3. Pyramid of Energy

- **Representation**: Energy content at each trophic level
- **Always**: Upright (never inverted)
- **Reason**: Energy always lost as heat at each transfer
- **Unit**: Energy per unit area per unit time

Important Considerations:

1. **Include all organisms** at each trophic level for calculations
2. **Organisms can occupy multiple trophic levels** simultaneously
3. **Trophic level = functional level**, not species
4. **Example**: Sparrow - primary consumer (seeds) + secondary consumer (insects)

Limitations of Ecological Pyramids:

1. **Same species** in multiple trophic levels not accounted

2. **Assumes simple food chain** (doesn't exist in nature)
3. **Doesn't accommodate food webs**
4. **Saprophytes not included** despite vital ecosystem role

NEET-Specific Important Points

High-Yield Topics:

1. **Energy flow and 10% law**
2. **Types of ecological pyramids** and their exceptions
3. **Decomposition process** and factors affecting it
4. **Primary vs Secondary productivity**
5. **Trophic levels** and food chains
6. **Pond ecosystem components**
7. **PAR and energy capture** by plants

Common NEET Question Patterns:

1. Conceptual Questions:

- Energy flow direction and efficiency
- Pyramid types and characteristics
- Decomposition steps and factors

2. Analytical Questions:

- Calculate energy transfer between levels
- Identify trophic levels of organisms

- Explain inverted pyramids

3. Application Questions:

- Ecosystem function analysis
- Productivity comparisons
- Food web relationships

Memory Aids and Mnemonics

Decomposition Steps:

"FLCHM" - Fragmentation, Leaching, Catabolism, Humification, Mineralisation

Energy Flow:

"Sun Produces Consumer Energy" - Sun → Producers → Consumers → Energy loss

Trophic Levels:

"Producers Have Primary Secondary Tertiary" - P_1 → H → P_2 → S_3 → T_4

Factors Affecting Decomposition:

"TCMA" - Temperature, Chemical composition, Moisture, Availability of oxygen

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Practice Questions for NEET

Multiple Choice Questions:

1. **The 10% law of energy transfer was proposed by:** a) Odum b) Lindeman c) Tansley d) Clements

2. **Pyramid of energy is always:** a) Upright b) Inverted c) Spindle-shaped d) Variable
3. **Primary productivity is expressed as:** a) g m^{-2} yr^{-1} b) kcal m^{-2} c) Both a and b d) g m^{-2} day^{-1}

Short Answer Questions:

1. Why is energy flow unidirectional in ecosystems?
2. Explain why pyramid of biomass is inverted in aquatic ecosystems.
3. What factors affect the rate of decomposition?

Long Answer Questions:

1. Describe energy flow in an ecosystem with suitable examples.
2. Explain the process of decomposition and factors affecting it.
3. Compare and contrast grazing and detritus food chains.

Summary Tables

Productivity Comparison:

Type	Definition	Formula	Significance
GPP	Total organic matter produced	Total photosynthesis	Gross production
NPP	Available biomass after respiration	GPP - R	Net production
Secondary	Consumer organic matter formation	Consumer assimilation	Consumer productivity

Food Chain Comparison:

Aspect	Grazing Food Chain	Detritus Food Chain
Starting point	Living producers	Dead organic matter
Major in	Aquatic ecosystems	Terrestrial ecosystems

Aspect	Grazing Food Chain	Detritus Food Chain
Energy source	Solar (via photosynthesis)	Chemical (decomposition)
Organisms	Herbivores → Carnivores	Decomposers → Detritivores

Ecological Pyramids:

Type	Usual Shape	Exception	Reason for Exception
Numbers	Upright	Inverted (tree ecosystem)	Few large producers
Biomass	Upright	Inverted (aquatic)	Rapid phytoplankton turnover
Energy	Always upright	Never inverted	Energy loss as heat

EXAM SPRINT - Master ecosystem concepts with focus on energy flow, productivity, and ecological relationships. Practice numerical problems and comparative analysis for NEET success!