Module I

Environement and Ecosystem

- Key environmental problems
- Basic causes and sustainable solutions
- IPAT Equation
- Ecosystem
- Earth – life support system
- Ecosystem components
- Food Chain, Food Web
- Energy flow in ecosystem
- Ecological succession- stages involved,
- Primary and secondary succession,
- Hydrarch, mesarch, xerarch
- Nutrient, water, carbon, nitrogen cycles
- Effect of human activities on these cycles.

Multidisciplinary nature

Physics, Chemistry, Biology, Mathematics, Social studies, Engineering and several other subjects are all needed for environmental studies and can be said to be components of Environmental studies..

Range of Environmental Issues

- **Global Issues**

  Global warming (global surface temperature increased 0.74 ± 0.18 °C during the 20th century)

  Ozone layer depletion

  Depletion of Forest, energy resources

  Loss of biodiversity

- **Local Issues**

  River pollution

  Dams

  Man-animal conflicts

  Solid waste disposal

Need for public awareness

- The goals of sustainable development cannot be achieved by any government without the participatory role of public which is possible only when they aware about ecological and environmental issues.

- Degrading our environment is actually harming our own selves since we are a part of the complex network of environment where every component is linked up.

- Chinese proverb "**If you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people**."

- World environment day 5th of June

Need for public awareness

- The 2004 nobel peace prize was awarded to kenyan environmentalist Wangari Maathai
- This is the greatest recognition given to the cause of environment at international level.
- Maathai kenya's Deputy Environment Minister and Founder of Kenya based Green Belt Movement.
- This movement planted about 30 million trees across Africa.
- This has helped in slowing desertification, preserving forest for wildlife and food for future generation.
- "When we plant new trees, we plant the seeds of peace."

Indian Environmentalists

Rajender Singh

Water Conservation

"Waterman of India"
Ramon Magsaysay awardee

M.C. Metha

Green advocate

Ramon Magsaysay awardee

Indian Environmentalists

Salim Ali

Ornithologist

“Birdman of India”,
Padma Vibooshan awardee

Arundhati Roy

Narmada Bacho Andolan

Indian Environmentalists

Sunderlal Bahuguna

Chipko movement

Padma Vibooshan awardee

Menaka Gandhi

Wildlife protection

Everything surrounding us and affecting us is called Environment.

Environment

Biotic component
Living things (animals and plants)

Abiotic component
Non-living things (soil, air, water and sunshine)

What is environment?

Air, water, land, living organisms and materials surrounding us and their interactions together constitute environment

All these are Earth-Life support systems

Definition

Environment -Surroundings.

- Environmental study means study of our surroundings
- In the present environmental studies we concentrate more on the study of surroundings of we, human beings.

What is meant by surroundings?

Things or conditions around a person or place.

- which include materials (non living), non-materials and living things.

What are the components of our environment?

One way of classification of our surroundings is into Chemical, Physical and Biological components.

Chemical – all material things

Physical – mainly concerned with energy processes

Biological – both flora and fauna, as well as their interactions.

Earth's Life-Support System Has Four Major Components

Figure 3-2 Natural capital: This diagram illustrates the general structure of the earth, showing that it consists of a land sphere (*geosphere*), an air sphere (*atmosphere*), a water sphere (*hydrosphere*), and a life sphere (*biosphere*) (**Concept 3-1A**).

- The four major components of the earth's life-support system are the
  - atmosphere (air)
  - hydrosphere (water)
  - geosphere (rock, soil, and sediment),
  - biosphere (living things).
- Life is sustained by the flow of energy from the sun through the biosphere, the cycling of nutrients within the biosphere and gravity.

Global environmental problems

Problem of waste disposal

The world food problem

Chenges in the Earth's climate

Impoverishment of biological diversity

Air pollution, the greenhouse effect

Land pollution, the destruction of soil cover

The depletion of fresh water? pollution of the world ocean

Destruction of the ozon layer

Ecological Footprint

As our ecological footprints grow, we are depleting and degrading more of the earth's natural capital.

Experts Have Identified Four Basic Causes of Environmental Problems

1. Population growth
2. Wasteful and unsustainable resource use
3. Poverty
4. Failure to include the harmful environmental costs of goods and services in market prices

Causes of Environmental Problems

Population growth

Unsustainable resource use

Poverty

Excluding environmental costs from market prices

Population Explosion

Environmental Impact of Population

$$I = P \times A \times T.$$

Impact (I) = Population (P) × Affluence (A) × Technology (T)

Solutions

Where we are currently	***Where we need to be***
• Current Emphasis	• Sustainability Emphasis
• Pollution cleanup	• Pollution Prevention
• Waste Disposal	• Waste Prevention
• Protecting Species	• Protecting Habitat
• Environmental Degradation	• Environmental Restoration
• Increasing Resource Use	• Less Resource waste
• Population Growth	• Population Stabilization
• Damaging Natural Capital	• Protecting Natural Capital

Environmentally Sustainable Society: Principle

Living sustainably means living off the earth's natural income without depleting or degrading the natural capital that supplies it.

- Rely more on **renewable energy** from the sun, including indirect forms of solar energy such as wind , flowing water, to meet most of our heating and electricity needs.
- **Protect biodiversity** by preventing the degradation of the earth's species, ecosystems, and natural processes, and by restoring areas we have degraded.
- Help to sustain the earth's **natural chemical cycles** by reducing the production of wastes and pollution, not overloading natural systems with harmful chemicals, and not removing natural chemicals faster than nature's cycles can replace them.

Ecosystems

Ecology

Definition:

•Ecology is the study of **interactions among organisms or group of organisms** with their environment.

• The environment consists of both **biotic components** (living organisms) and **abiotic components** (non-living organisms).

•**Habitat** refers to the physical and chemical factors of the place where the organisms live.

Ecosystem

Definition:

- ♣ The term ecosystem was first coined by **A.G. Tansley 1935**.
- ♣ **'*eco*' means environment** and **'*system*' implies a complex of co-ordinated units.**
- ♣ An ecosystem is a community of different species interacting with one another and with their non-living environment exchanging energy and matter.

❖Levels of the organization of matter in nature.

❖Ecology focuses on the top five of these levels.

Biosphere	Parts of the earth's air, water, and soil where life is found
Ecosystem	A community of different species interacting with one another and with their nonliving environment of matter and energy
Community	Populations of different species living in a particular place, and potentially interacting with each other
Population	A group of individuals of the same species living in a particular place
Organism	An individual living being
Cell	The fundamental structural and functional unit of life
Molecule	Chemical combination of two or more atoms of the same or different elements
Atom	Smallest unit of a chemical element that exhibits its chemical properties

Structure of Ecosystem

The environment consists of both **biotic components** (living organisms) and **abiotic components** (non-living organisms).

Biotic

- Producers – Green plants which can synthesize their food themselves (Plants)
- Consumers – All organisms which get their organic food by feeding upon other organisms (Rabbit, man)
- Decomposer – They derive their nutrition by breaking down the complex organic molecule to simpler organic compound (Bacteria, fungi)

- Consumers

  - Herbivores – Plant eaters, They feed directly on producers known as **primary consumers** (e.g. Rabbit, human)

  - Carnivores – Meat eaters, They feed on other consumers

    » If they feed on herbivores they are called **secondary** consumers (Frog)

    » If they feed on other carnivores they known as **tertiary** consumers (snake, big fish)

  - Omnivores – They feed on both plants and animals. (humans, rat)

  - Detritivores - They feed on the parts of dead organisms (ants, earthworm)

- Decomposer
  - They derive their nutrition by breaking down the complex organic molecules to simpler organic compounds and finally into inorganic nutrients. (bacteria and fungi)

Quaternary consumers
Hawk
Tertiary consumers
Snake
Crane
Duck
Sparrow
Secondary consumers
Rat
Frog
Fish(big)
Primary consumers (Herbivores)
Insects
Fish(small)
Snail
Producers
Terrestrial and salt marsh plants
Aquatic plants and algae

Abiotic Structure

- Physical factors:
  - The sunlight, average temp, annual rainfall, wind, soil type, water availability etc. are some of the important physical features which have strong influence on the ecosystem

- Chemical factors:
  - Availability of major essential nutrients like carbon, nitrogen, phosphorous, potassium, hydrogen, oxygen and sulphur largely influence the functioning of the ecosystem

Functions of an Ecosystem

- In the ecosystem, biotic components and other materials like N, C, H_2O **circulated within and outside of the system**.

- The energy is transferred from one trophic level to the other in the form of a chain called as **food chain.**

- Important source of energy is the **Sun**.

- Climatic changes

The major functional attributes of an ecosystems are as follows

- Food chain, Food webs and tropic structure
- Energy flow
- Cycling of nutrients (Biogeochemical cycles)
- Primary and secondary production
- Ecosystem development and regulation

Food Chains

Definition: The transfer of food energy from the source in plants through series of organisms that consume and are consumed is called the *'food chain'*.

Sunlight → Plants → Herbivores → Carnivores

(Producers) (Primary consumers) (Secondary consumers)

Grazing food chain	Detritus food chain
Eagle	Fish
↑	↑
Snake	Crab
↑	↑
Rabbit	Algae
↑	↑
Grass	Dead leaf

FOOD WEB

Definition: The interlocking pattern of various food chains in an ecosystem is known as food web.

In a food web, many food chains are interconnected, where different types of organisms are connected at different tropic levels, so that there are a number of opportunities of eating and being eaten at each tropic level.

Example: Insects, rates, deer's, etc. may eat Grass; these may be eaten by carnivores (Snake, tiger). Thus, there is an interlocking of various food chains called food webs.

Food Web in a Forest

A Food Web in a Grassland Ecosystem With Five Possible Food Chains

Natural Capital:

- The main **structural components** of an ecosystem (energy, chemicals, and organisms).
- Nutrient cycling and the flow of energy—first from the sun, then through organisms, and finally into the environment as low-quality heat

Energy flow in the Ecosystem

- **Energy is needed for every biological activity.**

- **Solar energy is transformed into chemical energy by a process of photosynthesis. This energy is stored in plant tissue, and then transformed in to mechanical and heat form during metabolic activities.**

- **In the biological world, the energy flows from sun to plants and then to all heterotrophic organisms like micro-organisms, animals, and man i.e. from producers to consumers. 1% of the total sunlight falling on the green plants is utilized in photosynthesis.**

- **This is sufficient to maintain all life on this earth. There is no 100% flow of energy from producers to consumers. Some is always lost to environment. Because of this, energy cannot be recycled in an ecosystem *'it can only flow one way'*.**

990 Joules energy lost to environment
9 Joules energy lost to environment
0.9 Joule energy lost to environment
1000 Joules of Light Energy
10 Joules Energy
1 Joules Energy
10 Joules energy available as food (Producer)
1 Joule energy available as food (Herbivore)
0.1 Joule energy available as food (Carnivore)
Progressive Loss of Energy in Food Chain

The flow of energy follows the two laws of thermodynamics

Ist law of thermodynamics: The law states that energy can neither be created nor be destroyed but it can be transformed from one form to another. Similarly, solar energy utilized by green plants (producers) in photosynthesis converted into biochemical energy of plants and later into that of consumers

IInd law of thermodynamics: The law states that energy transformation involves degradation or dissipation of energy from a concentrated to a dispersed form. We have seen dissipation of energy occurs at every trophic level. There is loss of 90% energy, only 10% is transferred from one trophic level to the other.

Models of ecological energy flow

A single trophic level
Universal energy flow model

A food chain
Single channel energy flow model

Matter in Ecosystem

- **Matter, in the form of nutrients, cycles within and among ecosystems and the biosphere**
- **Human activities are altering these chemical cycles.**

The elements and compounds that make up nutrients move continually through air, water, soil, rock, and living organisms within ecosystems, as well as in the biosphere in cycles called biogeochemical cycles (life-earth-chemical cycles), or nutrient cycles.

NUTRIENT CYCLE

- **Imp functional attribute of an ecosystem.**

- **Nutrients move in circular paths through biotic & abiotic components known as biogeochemical cycle.**

  eg:- C,N,S,O,H,P.

- **Water moves in a cycle –hydrological cycle**

- **Nutrients move to foodchain & ultimately reach detritus compartment & causes decomposition.**

- **Dead plants & animals converted into inorganic substances by microbial decomposition that are used plants & the cycle starts afresh.**

WATER CYCLE

Biogeochemical cycle that collects, purifies, and distributes the earth's fixed supply of water from the environment to living organisms and then back to the environment.

Component of Hydrological Cycle

- Evaporation
  - Evapotranspiration
- Condensation
- Precipitation
- Interception
- Infiltration
- Percolation
- Runoff
- Storage

Schematic diagram showing components of hydrological cycle

WATER CYCLE

Condensation
Condensation
Ice and snow
Transpiration from plants
Precipitation to land
Evaporation of surface water
Evaporation from ocean
Precipitation to ocean
Runoff
Lakes and reservoirs
Runoff
Increased runoff on land covered with crops, buildings and pavement
Infiltration and percolation into aquifer
Increased runoff from cutting forests and filling wetlands
Runoff
Groundwater in aquifers
Overpumping of aquifers
Water pollution
Runoff
Ocean
Natural process
Natural reservoir
Human impacts
Natural pathway
Pathway affected by human activities

Human influence on water cycle

❖**We withdraw large quantities of freshwater** from streams, lakes, and aquifers sometimes at rates faster than nature can replace it.

❖**We clear vegetation** from land for agriculture, mining, road building, and other activities, and cover much of the land with buildings, concrete, and asphalt. **This increases runoff, reduces infiltration** that would normally recharge groundwater supplies, **accelerates topsoil erosion, and increases the risk of flooding**.

❖**We increase flooding when we drain and fill wetlands** for farming and urban development. Wetlands provide the natural service of flood control, acting like sponges to absorb and hold overflows of water from drenching rains or rapidly melting snow.

NITROGEN CYCLE

Cyclic movement of nitrogen in different chemical forms from the environment to organisms and then back to the environment.

- **N_2 is present in atm in large amount-78%**
- **N_2 taken up by plants & used in metabolism for biosynthesis of amino acids proteins, vitamins.**
- **After the death of plants & animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying & nitrifying bacteria which convert nitrates into ammonia, nitrates & nitrites again used by plants.**
- **Some bacteria converts nitrates in to molecular nitrogen which is released to atmosphere and the cycle goes on.**

Nitrogen Cycle

Nitrogen cycle consists of the following steps-

1. Nitrogen Fixation
2. Nitrogen assimilation
3. Ammonification
4. Nitrification and
5. Denitrification
6. Sedimentation

NITROGEN CYCLE

CARBON CYCLE

Cyclic movement of carbon in different chemical forms from the environment to organisms and then back to the environment.

- **C in the form of CO_2 taken up by green plants as raw material for photosynthesis.**

- **Through food chain it moves & ultimately organic carbon present in dead matter is returned to atm as CO_2 by micro organisms.**

- **Over use of Fossil fuel leads to imbalance in C cycle.**

CARBON CYCLE

PHOSPHOROUS CYCLE

Cyclic movement of phosphorus in different chemical forms from the environment to organisms and then back to the environment.

- **Reservoir of "P" lies in rocks, Fossils etc.**
- **Farmers use phosphate fertilizers & as a result excess phosphates are lost as run-off causes the problem of over nourishment.**
- **Phosphates moving with surface run-off reaches the oceans & are lost into the deep sediments.**
- **So humans are making phosphrous cycle acylic.**
- **But sea birds eat sea-fishes which are P rich and the droppings or excreta of the birds return the P in land**
- **Eg: Guano deposits on the coasts of Peru**

Phosphorus Cycle

PHOSPHOROUS CYCLE

Sulfur Cycle

- Sulfur circulates through the biosphere in the **Sulfur Cycle.**

- Much of the earth's sulfur is stored underground in **rocks and minerals** and in the form of

sulfate (SO_4^{2-}) salts buried deep under ocean sediments.

- **Hydrogen sulfide (H_2S)**—a colorless, highly poisonous gas - rotten-egg smell - released from active volcanoes, from organic matter broken down by anaerobic decomposers in flooded swamps, bogs, and tidal flats.

- **Sulfur dioxide (SO_2)** a colorless and suffocating gas, also comes from volcanoes.

- Particles **of sulfate salts** enter the atmosphere from sea spray, dust storms, and forest fires.

- Plant roots absorb sulfate ions and incorporate the sulfur as an essential component of many **proteins.**

Sulfur Cycle

Ecological succession

Ecological succession

- **Ecological succession** is the gradual process by which ecosystems change and develop over time. Nothing remains the same and habitats are constantly changing.

- **Types:**

❖ Primary Succession

❖ Secondary Succession

There are two main types of Ecological Succession

- Primary Succession: The process of creating life in an area where no life previously existed.
- Secondary Succession: The process of re-stabilization that follows a disturbance in an area where life has formed an ecosystem.

Primary Succession
Pioneer Species
Intermediate Species
Climax Community
Bare rock
Lichens
Small annual plants and lichens
Grasses and perennials
Grasses, shrubs, and shade-intolerant trees such as pines
Shade-tolerant trees such as oak and hickory
hundreds of years

Regrowth of plants after a disaster.

Process of Succession

- **Nudation :** It is the development of a bare area without any life form.

- **Invasion:** It is the successful establishment of one or more species on a bare area through dispersal or migration.

- **Competition and coactions :** As the number of individuals grows there is competition, both inter-specific and intra-specific for space, water and nutrition.

- **Reaction :** The living organism grow use water and nutrients from the substratum and modify the environment in such a way that it become unsuitable for the existing species and favor some new species and leads to several seral communities.

- **Stabilization:** The succession ultimately stabilize in a more or less stable community called **climax** which is in equilibrium with the environment

Ecological successions starting on different types of areas are named differently

- **Hydrarch or Hydrosere:** **Starting in watery area like pond, Swamp, bog**

- **Mesarch**: **Starting in an area of adequate moisture**

- **Xerarch or xerosere**: **Starting in a dry area with little moisture such as bare rock, sand and saline soil**

Hydrosere

Phytoplankton

Xerosere

Crutose and foliose lichen

Weathering – Disintegrating the rock

Gradual building up of humus, organic matter and soil

Mosses community

Climax - Forest

BIODIVERSITY

Biodiversity

- ❖Importance of Biodiversity
- ❖Types, mega-biodiversity;
- ❖Species interaction
- ❖Extinct, endemic, endangered and rare species
- ❖ Hot-spots
- ❖GM crops
- ❖Threats to biodiversity
- ❖Natural and anthropogenic activities
- ❖Conservation of biodiversity
- ❖Terrestrial biodiversity
- ❖Aquatic biodiversity

Biodiversity is the variety of life on Earth and the essential interdependence of all living things among themselves and with their environment

- **Scientists have identified more than 2 million species. Tens of millions -- remain unknown**

- **The tremendous variety of life on Earth is made possible by complex interactions among all living things including microscopic species like algae and mites.**

Three levels of biodiversity

- **Genetic:** Variation in genes within same species
- **Species:** Variations found in the population of species or different species of a community in a given area
- **Ecosystem:** Variations in food webs, nutrient cycles, trophic structure etc, this diversity has developed along with evolution

Genetic diversity

- Variation in genes within same species
- Basic source of biodiversity
- In the pictures all are dogs but different genes so different names
- Other examples – varieties of rice, varieties of banana

Chihuahua

Beagle

Rottweilers

Species diversity

- Variations found in the population of species or different species of a community in a given area
- Monkeys, dragonflies, and meadow beauties are all different species

Saki Monkey

Golden Skimmer

Meadow Beauty

Ecosystem diversity

- Variations in the ecosystem

  Example: Prairie, rain forest and Pond
- Also show variations in physical parameters

Paines Prairie

Hoh Rain Forest

Florida Sand hill Pond

Global biodiversity

- The biodiversity is huge, more than ten million species are believed to exist on land
- Only about 2% (1-2 millions) of the existing species are identified and named scientifically
- Terrestrial diversity – largest ecological units present in the different geographical areas of the world - biomes
- 50-80% of the species exist in tropical rainforests
- Temperate forests have much lesser than that
- Aquatic diversity
- Marine species are considered to be much more
- The world's diversity is decreasing very quickly due to human activity - tropical deforestation alone is reducing biodiversity at the rate of 0.5% every year (20,000 species every year)

Indian biodiversity

- 6% of the world's species exist in India – 10th among plant richness, 11th in terms of endemic species
- 6th place in origin of agricultural crops
- Total number of living species identified 150,000
- 2 of the hotspots of the world are found in India
- One of the 12 mega-biodiversity countries exists in India

Regional or local biodiversity

Biodiversity at local level is better understood in terms of species richness, which is 4 types

- Point richness: no. of species at a single point
- Alpha richness: no. of species in a given area, community or ecosystem
- Beta richness: Difference in number of species across different habitats/ecosystems
- Gamma richness: is the measure of the overall diversity for different ecosystems within a region

Values of biodiversity

What do we get from biodiversity?
What are the benefits of biodiversity?

- It has intrinsic value - Something that has value in and of itself
- It has utilitarian value - It is useful to others

Utilitarian value

- Consumptive use value
- Productive use value
- Social value
- Ethical value
- Aesthetic value
- Option value
- Ecosystem service value

Consumptive use value

Biodiversity products are consumed directly

- Food from animals: cattle, pigs, chickens, buffaloes, ducks – all are originally belonged to forests we tamed them now.
- Plants: greens and vegetables – all our food crops are originally existed in forests
- Fish – belongs to water bodies
- Herbal medicines, medicines extracted from plants (1/4 th of the drugs are extracted from tropical plants and organisms , eg. Tetracycline, quinine, cancer drugs from periwinkle
- Fuel

Productive use value

Commercially usable – marketed

- Lumber
- Wild gene resources
- Tusks of elephants
- Musk from musk deer
- Silk from silkworms
- Wool from sheep
  - Their respective industries are, Paper , Silk, textile, leather, pearl
  - One of the main reasons for deforestation

Cultural and Social value

- Customs, religion and psycho-spiritual related values
- Certain plants are worshiped or used to worship
  - Holy basil (Tulsi), Mango leaves
  - Palm tree in Egypt
- Dances of tribal people are often related to wildlife -Snake, fish, cow, peacock etc.
- Cows and snakes are worshiped

- Ethical value, also known as existence value
  - Having affection for our other living beings, and feeling that all life should be preserved
  - We do not use several of plant and animal species directly. But we still feel that they should not go to extinction

Aesthetic value

Which do you like better?

A

B

Aesthetic value: We like nature's diversity

We like the variety of species around us.

Ecosystem service value

- Services provided by ecosystem like
  - Maintenance of soil fertility
  - Cycling of nutrients and water
  - Contribution to water cycle
  - Pollution breakdown and absorption (eg: CO_2 is absorbed by forests)
  - Contribution to climate stability
  - Recovery from disaster

Biogeographical classification of India

- Bio = Life, Geo = land
- Biogeographical classification refers to
  - Different types of climate, topography and the flora and fauna induced by these
- India occupies 10th Place in the world in richness of diversity
- Several different regions exist in India

INDIA - Country of Diversity

- It has diverse geographical features and different climates
- The annual rainfall varies from less than 37 cm in Rajasthan to 1200 cm in Meghalaya
- Three different seasons – winter, summer and monsoons.
- The seasonal severity varies considerably
- The diversity in physical and climatic setting produces a markedly diverse fauna and flora
- The vegetation ranges from:
  - Xerophytes in Rajasthan
  - Evergreen in the North-East and the Western Ghat areas
  - Mangroves of coastal areas
  - Dry deciduous forests of central India
  - Conifers of the hills
  - Alpine pastures in the high reaches of the Himalaya

Biogeographical regions of India

1. Trans-Himalayan
2. Himalayan
3. Deserts
4. Semi-arid
5. Western ghats
6. Deccan plateau
7. Gangetic plain
8. North-east India
9. Islands
10. Coasts

Hot spots of biodiversity

- Hot spots - Geographical regions with high biodiversity (species richness) and endemism
- Criteria for recognizing hot spots
  - Richness of the endemic species
  - At least 0.5% of plant species should be endemic

Endemic:

Species which are restricted to a particular area

Eastern Himalayas

- Northern Himalayan states of India, some part in Nepal and Bhutan
- 35,000 plant species of which 30% are endemic species, 63% mammals, 60% of the Indian birds are from North East

  Eg: Orchid species, citrus, jute, Indian tiger

Western ghats

- 40% plants, 62% amphibians, 50% lizards are endemic
- Forests occur up to 500 m elevation - 20% forest evergreen
- Only 6.8% of the original forests are existing now in this region

Eg: Different species of Lizards, reticulated python, Indian salamander, lizard hawk

Should we have concern over biodiversity?

What we know:

<u>The Earth is losing species at an alarming rate</u>

- Some scientists estimate that as many as 10,000 extinctions occur each year – 27 species per day extinct
- when species of plants and animals go extinct, many other species are affected

Some important terms

Endangered species: Species in danger of extinction and whose survival is unlikely if the causal factors continue operating

Extinct: Used for species which are no longer known to exist in the world

Vulnerable: Species believed likely to join the endangered category in the near future if the causal features continue operating

Rare: Species with small world populations that are not at present endangered or vulnerable but are at risk

Threats to biodiversity

- Habitat destruction
- Poaching
- Man-wildlife conflicts
- Pollution
- Species Introductions
- Global Climate Change
- Exploitation

Loss of Habitat: Is the largest cause

- Forests and grasslands have been cleared for
  - agriculture
  - pasturing
  - human settlement and
  - for development projects
- In India forests are lost at a rate of 0.6%/year

Factor influencing Habitat loss

- Habitat fragmentation:
  - Small regions of forest are removed for
    - roads,
    - urbanisation,
    - agriculture
  - It results in division of forests into smaller fragments
  - Some animals need large territories (eg: Bear, tiger)
  - When forests are divided these animals cannot survive

- **Deforestation**

  cutting trees for timber, removal of medicinal plants, construction of dam

- **Raw materials**

  production of hybrid seeds – wild plants used as raw materials. As a result plant species become endangered

- **Production of drugs**

  – wild plants – used for production of drugs

  - therefore several medicinal plant become extinct.

Wetlands are often destroyed due to

- draining,
- filling and
- Pollution

Poaching

- Killing/hunting of animals

- Illegal trade of wild life
  - Despite ban, animals are killed for Furs, horns, tusks, skins (crocodile)
  - Live specimens are smuggled

- Subsistence poaching: Killing animals for food
- Commercial poaching : Hunting & killing animals to sell their products

Man-Wildlife conflicts

❖ **Man-wildlife conflicts arise**

when wildlife starts causing immense damage and danger to the man

Such condition, very difficult for the forest department to compromise the affected villagers & gain village support for wild life conservations.

❖ **Examples 1.** In Sambalpur, Orissa

– 200 humans killed by elephants.

- In retaliation the villagers killed 100 elephants

2. Man eating tiger - In Royal Chitwan National park, Kathmandu

In 2004 - 20 Nepalese people were killed

1 four year old child

Remedy?

- Tiger conservation projects: Making available tranquilizers guns, binoculars and radiosets etc to deal with danger
- Solar powered fencing instead of electric
- Croping near forests should be prevented
- Adequate food should be made available for animals within the forest
- Wild animal hunting rituals should be stopped

Known Causes of Animal Extinctions
Since 1600
Hunting
23%
Species
Introductions
39%
Other
2%
Habitat Destruction
36%

Endangered species

A species is

- Extinct: if not seen for 50 years
- Endangered : if its habitat is reduced to a level that it will not survive unless protected
- Vulnerable: If it population is continuously decreasing
- Rare species: Thinly scattered over a more extensive area.

Endangered species of India

- About 215 species of animals in India are considered threatened
- These include reptiles, birds, carnivores, mammals, primates and plants

Now extinct Indian Species

Himalayan quail

Indian Cheetah

Endemic species of India

About 81,000 animal species are endemic

Eg:

- Lion-tailed Macaque,
- Asiatic Lion,
- Red Panda,
- Black buck
- and slender loris

Endemic species of India

- There are 42 species of Endemic birds in India

Endemic species of India

- Of 47,000 plant species 7000 are endemic to India

- Toothbrush orchid
- Nepenthes khasiana
- Platycerium alcicorne

Species Interaction - Five Major Ways

Ecologists identify five basic types of interactions between species as they share limited resources such as food, shelter, and space:

- **Interspecific competition:**

When members of two or more species interact to gain access to the same limited resources such as food, water, light, and space.

- **Predation:**

When a member of one species (the *predator) feeds directly on all or part of a member* of another species (the *prey).*

- **Parasitism:**

When one organism (the *parasite)* feeds on another organism (the *host), usually by* living on or in the host.

- **Mutualism:**

Interaction that benefits both species by providing each with food, shelter, or some other resource.

- **Commensalism:**

Interaction that benefits one species but has little or no effect on the other.

These interactions have significant effects on the resource use and population sizes of the species in an ecosystem

Interspecific competition

Resource partitioning:

Species competing for similar scarce resources evolve specialized traits that allow them to share resources by using parts of them, using them at different times, or using them in different ways.

Figure 5-2 *Sharing the wealth:* This diagram illustrates *resource partitioning* among five species of insect-eating warblers in the spruce forests of the U.S. state of Maine. Each species minimizes competition with the others for food by spending at least half its feeding time in a distinct portion (yellow highlighted areas) of the spruce trees, and by consuming somewhat different insect species. (After R. H. MacArthur, "Population Ecology of Some Warblers in Northeastern Coniferous Forests," *Ecology* 36 (1958): 533–536.)

The predator–prey relationship

- *Herbivores can simply walk swim or* fly up to the plants they feed on.

- *Carnivores feeding on* mobile prey have two main options: *pursuit and ambush*

➢ Cheetah catch prey by running fast

➢ The American bald eagle can fly and have keen eyesight.

Steve Hilebrand/U.S. Fish and Wildlife Service

Figure 5-4 *Predator-prey relationship:* This brown bear (the predator) in the U.S. state of Alaska has captured and will feed on this salmon (the prey).

Interactions between Predator and Prey Species Can Drive Each Other's Evolution

Prey species have developed specialized ways to avoid their predators:

(a, b) ***camouflage***
(c–e) chemical warfare
(d, e) warning coloration
(f) mimicry
(g) ***deceptive looks***
(h) deceptive behavior.

(a) Span worm
(b) Wandering leaf insect
(c) Bombardier beetle
(d) Foul-tasting monarch butterfly
(e) Poison dart frog
(f) Viceroy butterfly mimics monarch butterfly
(g) Hind wings of Io moth resemble eyes of a much larger animal
(h) When touched, snake caterpillar changes shape to look like head of snake

Coevolution

Langohrfledermaus bat is hunting a **moth. Long-term interactions between bats and their prey such as moths and butterflies can lead to coevolution, as the bats evolve traits to increase their chance of getting a meal and the moths evolve traits to help them avoid being eaten.**

Parasitism

[Species Feed off Other Species by Living on or inside Them].

Parasitism occurs when one species (the *parasite) feeds* on another organism (the *host), usually by living on or* inside the host. In this relationship, the parasite benefits and the host is often harmed but not immediately killed.

***Parasitism: This blood-sucking parasitic sea lamprey has* attached itself to an adult lake trout from the Great Lakes (USA).**

Mutualism

[Both Species Benefit]

In mutualism, two species behave in ways that benefit both by providing each with food, shelter, or some other resource.

Hummingbird benefits by feeding on nectar in this flower, and it benefits the flower by pollinating it.

Mutualism

(a) Oxpeckers and black rhinoceros

Oxpeckers (or tickbirds) feed on parasitic ticks that infest large, thick-skinned animals such as the endangered black rhinoceros.

(b) Clownfish and sea anemone

A clownfish gains protection and food by living among deadly, stinging sea anemones and helps to protect the anemones from some of their predators.

(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone

Commensalism

[One Species Benefits and the Other Is Not Harmed]

- Commensalism is an interaction that benefits one species but has little, if any, beneficial or harmful effect on the other.

- Bromeliad—an epiphyte, or air plant—in Brazil's Atlantic tropical rain forest roots on the trunk of a tree, rather than in soil, without penetrating or harming the tree.

- In this interaction, the epiphyte gains access to sunlight, water, and nutrients from the tree's debris; the tree apparently remains unharmed and gains no benefit.

Terrestrial biodiversity

- Forests,
- Grassland,
- Desert.

Forest Ecosystem

Forest ecosystems provide ecological services far greater in value than the value of raw materials obtained from forests.

Threats to forest Ecosystem:

- **Unsustainable cutting**
- **Burning of forests**
- **Diseases and insects**
- **Projected climate change**

Services of Forests

Consequences of Deforestation

Natural Capital

Forests

Ecological Services

- Support energy flow and chemical cycling
- Reduce soil erosion
- Absorb and release water
- Purify water and air
- Influence local and regional climate
- Store atmospheric carbon
- Provide numerous wildlife habitats

Economic Services

- Fuelwood
- Lumber
- Pulp to make paper
- Mining
- Livestock grazing
- Recreation
- Jobs

Natural Capital Degradation

Deforestation

- Decreased soil fertility from erosion
- Runoff of eroded soil into aquatic systems
- Premature extinction of species with specialized niches
- Loss of habitat for native species and migratory species such as birds and butterflies
- Regional climate change from extensive clearing
- Release of CO_2 into atmosphere
- Acceleration of flooding

Causes of Deforestation

Natural Capital Degradation

Major Causes of the Destruction and Degradation of Tropical Forests

Underlying Causes

- Not valuing ecological services
- Crop and timber exports
- Government policies
- Poverty
- Population growth

Direct Causes

- Roads
- Fires
- Settler farming
- Cash crops
- Cattle ranching
- Logging
- Tree plantations

Natural Capital Degradation

Major Human Impacts on Terrestrial Ecosystems

Deserts

- Large desert cities
- Destruction of soil and underground habitat by off-road vehicles
- Soil salinization from irrigation
- Depletion of groundwater
- Land disturbance and pollution from mineral extraction

Grasslands

- Conversion to cropland
- Release of CO_2 to atmosphere from burning grassland
- Overgrazing by livestock
- Oil production and off-road vehicles in arctic tundra

Forests

- Clearing for agriculture, livestock grazing, timber, and urban development
- Conversion of diverse forests to tree plantations
- Damage from off-road vehicles
- Pollution of forest streams

Mountains

- Agriculture
- Timber and mineral extraction
- Hydroelectric dams and reservoirs
- Increasing tourism
- Air pollution blowing in from urban areas and power plants
- Soil damage from off-road vehicles
- Water supplies threatened by glacial melting

How to sustain Terrestrial Ecosystem?

❖We can sustain forests by **emphasizing the economic value** of their ecological services, removing government subsidies that hasten their destruction, protecting old-growth forests, harvesting trees no faster than they are replenished, and **planting trees**.

❖We can sustain the productivity of grasslands by **controlling the numbers and distribution of grazing livestock, and by restoring degraded grasslands**.

❖Sustaining biodiversity will require more effective **protection of existing parks and nature reserves**, as well as the protection of much more of the earth's remaining undisturbed land area.

❖We can help to sustain terrestrial biodiversity by identifying and protecting severely threatened areas (**biodiversity hotspots**), restoring damaged ecosystems **(using restoration ecology**), and sharing with other species much of the land we dominate **(using reconciliation ecology).**

Aquatic Biodiversity

The general nature of aquatic systems:

Saltwater and freshwater aquatic life zones cover almost three-fourths of the earth's surface, with oceans dominating the planet.

The key factors determining biodiversity in aquatic systems are temperature, dissolved oxygen content, availability of food, and availability of light and nutrients necessary for photosynthesis.

Importance of marine aquatic systems:

Saltwater ecosystems are irreplaceable reservoirs of biodiversity and provide major ecological and economic services.

Human activities affect marine ecosystems:

Human activities threaten aquatic biodiversity and disrupt ecological and economic services provided by saltwater systems.

Importance of freshwater ecosystems:

Freshwater ecosystems provide major ecological and economic services, and are irreplaceable reservoirs of biodiversity.

Human activities affect freshwater ecosystems:

Human activities threaten biodiversity and disrupt ecological and economic services provided by freshwater lakes, rivers, and wetlands.

Aquatic systems include

(a) saltwater oceans and

(b) bays, such as Trunk Bay at St. John in the U.S. Virgin Islands,

(c) freshwater lakes such as Peyto Lake in Canada's Banff National Park, and

(d) wild freshwater mountain streams

We can divide aquatic life forms into several major types:

Plankton, which include

(a) phytoplankton, tiny drifting plants, and

(b) zooplankton, drifting animals that feed on each other and on phytoplankton; one example is this jellyfish, which uses long tentacles with stinging cells to stun or kill its prey.

Other major types of aquatic life are

(c) nekton, or strongly swimming aquatic animals such as this right whale, and

(d) benthos, or bottom dwellers such as this sea star attached to coral in the Red Sea.

Natural Capital

Marine Ecosystems

Ecological Services

Climate moderation

CO_2 absorption

Nutrient cycling

Waste treatment

Reduced storm impact (mangroves, barrier islands, coastal wetlands)

Habitats and nursery areas

Genetic resources and biodiversity

Scientific information

Economic Services

Food

Animal and pet feed

Pharmaceuticals

Harbors and transportation routes

Coastal habitats for humans

Recreation

Employment

Oil and natural gas

Minerals

Building materials

Human activities threaten aquatic biodiversity and disrupt ecological and economic services provided by saltwater systems.

Natural Capital

Freshwater Systems

Ecological Services

Climate moderation

Nutrient cycling

Waste treatment

Flood control

Groundwater recharge

Habitats for many species

Genetic resources and biodiversity

Scientific information

Economic Services

Food

Drinking water

Irrigation water

Hydroelectricity

Transportation corridors

Recreation

Employment

Human Activities Are Disrupting and Degrading Freshwater Systems

- *1.* **Dams and canals fragment about 40% of the world's 237 largest rivers.** They alter and destroy terrestrial and aquatic wildlife habitats along these rivers and in their coastal deltas and estuaries by reducing water flow and increasing damage from coastal storms.

- *2.* **Flood control levees and dikes built along rivers disconnect the rivers** from their floodplains, destroy aquatic habitats, and alter or reduce the functions of nearby wetlands.

- *3.* **Cities and farms, which add pollutants** and excess plant nutrients to nearby streams, rivers, and lakes.

- *4.* **Inland wetlands have been drained or filled to grow crops** or have been covered with concrete, asphalt, and buildings. The rest were lost to mining, logging, oil and gas extraction, highway construction, and urban development.

Conservation of Biodiversity

- National Conservation Programmes
- Approaches and Strategies
  - In-situ conservation
  - Ex-situ conservation

In situ conservation

- Biosphere reserves
- National Parks
- Wildlife sanctuaries
- Conservation reserves
- Tiger reserves
- Seed stands and seed production areas
- Plus trees

Ex-situ conservation

- Botanical gardens
- Arboreta
- Herbal gardens
- Clonal repositories
- Plant herbarium
- Provenance trials
- Seed orchards

In-situ conservation

1. Biosphere reserves

Following the "man and biosphere" approach advocated by the UNESCO, 14 sites have been identified a Biosphere reserves covering area of 49012.62 sq. Km

Eg: Thar Desert, Sunderbans, Gulf of Mannar, etc

2. National Parks

There are 97 existing national parks in India covering an area of 38,199.47 km^2, which is 1.16% of the geographical area of the country.

In addition to the above 74 national parks are proposed covering an area of 16,630.08 km^2 in the Protected Area Network Report.

Eg: Gir, Kaziranga, Periyar, Bandipur etc.

In-situ conservation

3.Wild Life Sanctuaries

There are 508 wildlife sanctuaries covering an area of 118,236.94 km^2, which is 3.60% of the geographical area. Another 217 sanctuaries are proposed in the Protected Area Network Report covering an area of 16,669.44 km^2.

Eg: Mudumalai, Nal sarover, Jaldapara etc

4. Tiger reserves

Project Tiger was launched in the year 1973 to save the tiger. Starting from nine (9) reserves in 1973-74. In number is grown up to 29 in 2006. A total of 38,620 km^2 is covered by these project tiger areas, which is 1.17% of the total geographical area.

Eg: Periyar, Kanha, Corbett etc

In-situ conservation

5. Seed stands and seed production areas

The best natural stands or plantations that are near full stocking are used for the development of seed production areas.

One of the important component is the improvement of seed quality.

6. Plus trees

Tree Plus selection is one of the methods to conserve diversity at species level.

Plus tree is a phenotypically superior tree. It is the utilization part of gene conservation.

Ex-situ conservation

1. **Botanical gardens**

- India has more than 100 botanical gardens under different management systems located in different bio-geographical regions.
- Central and state governments manage 33 botanical gardens that maintain the diversity in the form of plants or plant populations.

Ex-situ conservation

2. **Arboreta**

- An arboretum generally refers to a place established for conservation of tree species.
- FRI (Forest Research Institute) Dehradun
  - an arboretum with 130tree species
  - a bamboosetum of 53 species
- NBPGR (National Bureau of Plant and Genetic resources), Bhubaneswar
  - an arboretum of 1,430 species of trees
  - a palmeretum of 100 different types of palms
  - a bamboosetum with 61 collection of bamboo
  - an orchidarium housing 220 species of orchids

Ex-situ conservation

3. Herbal gardens

- Refers to the gardens that conserve herbs, shrubs that are of medicinal value and aromatic value
- The concept of herbal gardens has been picked up by the NGOs in India
- Several institutions, State Forest Departments and NGOs in different parts of the country, have established herbal gardens

Ex-situ conservation

5. Plant herbarium

- Plant diversity preserved in the form of herbarium
- The Botanical Survey of India has the largest holding of 1,500,000 specimens.
- Forest Research Institute, Dehradun has collection of more than 3.0 lakh specimens.
- There are many more herbaria
  - Presidency College Madras (100,000)
  - The Blater Herbarium at St. Xavier's College, Bombay (100,000)
  - St. Joseph's College, Tiruchirapally (60,000) etc.

Ex-situ conservation

6. Provenance trials

- Provenance trials help in exploration of gene resources called genecological exploration
- More than ninety species provenance trials have been established in different parts of India to screen out best provenance for raising new plantations with increased productivity
- Provenances are collected from different geographical, ecological and environmental conditions and play an important role in gene conservation

Ex-situ conservation

7. Seed Orchards

- Seed orchards contribute greatly to the production of quality planting stock of the desired species
- These are plantations established primarily for the production of seed of proven genetic quality
- Establishment of seed orchards is part of long-term conservation management programme and also a long-term breeding programme

Ex-situ conservation

7. Zoos and aquariums

- Captive breeding programmes of endangered animals
- Semen banks
- Zoo Authority of India
  - 164 recognized zoos
  - Laboratory for Conservation of Endangered Species, Hyderabad
  - captive breeding of Red Panda and its restocking into the wild

Genetically Modified (GM) Crops

History of crop improvement

- By trial and error for almost 9900 years
- By scientific principles of breeding for last 100 years
- **By chemical induced mutation for last 75 years**
- By rDNA technology last 25 years

CHALLENGES AHEAD

-Population in 2050 AD: 1.5 B
-Shrinking area of cultivated land
-Diminishing water resources
-Malnutrition and undernourishment
-Deterioration in soil quality

-Climate change (global warming)

Genetically Modified (GM) Crops

- What is a GM crop?
- GM crops are genetically improved and contain a gene or genes from the same or a different species artificially inserted in its genome.
- Tissue Culture & Transformation – gives the maximum flexibility for moving genes within or between species.

Leaf Disk Method for *A. t.* Mediated Transformation

Leaf Disk Preparation

Co-cultivation with Agrobacterium

Selection for Transformation

Regeneration of Shoots

Bacterium
DNA
Insect resistance gene
1. Cut out the gene.

2. Insert gene into a vector with a selectable antibiotic resistance marker gene.
Antibiotic resistance gene
3. Copy vector in bacteria.

4. Coat tungsten or gold particles with DNA vectors.

5. Load vector-coated particles onto teflon bullet.

6. Load bullet into gene gun.

7. Shooting the gene gun releases the particles at a high velocity penetrating the plant cells.

8. The vector enters the cell. The genes are incorporated into the plant genome.

9. The cells are plated on a selective antibiotic media. Only cells that have incorporated the vector will grow.

10. These cells are transferred to medium containing plant growth factors.

Insect resistant tomato plant

Bt- COTTON

- Bt-cotton - First GM crop – 2002
- Second in global cotton production
- Area – 8.0 million hectares – 2008
- Yield gain - 31%
- Reduction in pesticide sprays – 39%

NUTRITIONAL QUALITY

"Golden Rice"

*Expression of enzymes of β-carotene pathway in rice endosperm

*Amelioration of Vitamin A deficiency

Bt Brinjal: Putting Science into Agriculture

Bt-Brinjal

ADVANTAGES

- *Enhance desired traits*
- *Pest resistance*
- *Improve nutritional content*
- *Less time than controlled breeding*
- *Improves accuracy*
- *Herbicide tolerance*
- *Cold tolerance*
- *Medical advantages e.g. edible vaccines*
- *Virtual end of world hunger e.g. no malnutrition*
- *Cheaper or faster to grow & don't have to be rich in plant*
- *Endless possibilities & anything alive can be genetically modified*
- *Reduce production cost to reduced chemical and mechanical needs in planting, maintenance and harvest.*

Disadvantages of GMO's

- Harm to organisms
- Doesn't taste "natural"
- Spread of superweeds
- Spread of superbugs
- New trade, tariff and quota issues
- May cause health problems
- Larger companies have more power
- Possible greed to GMO manufactures
- Unforeseen allergen risks
- Allergies may become more intense
- New allergies may arise
- Widening corporate size gaps between food producing giants and smaller ones

Advantages and Disadvantages of GMOs

Advantages	Disadvantages
Higher yield of crops due to less crops damaged by insects and disease	GMO foods don't taste as natural as non GMO foods
Less pesticides need to be purchased and used, causing more economically productive farmers and less pollution	Some organisms (such as butterflies and bees) are harmed by pesticides in GMO foods
Food production increased, causing decreasing starvation in LDCs	Labeling GMO foods causes additional expenses in processing and labeling
Added nutritional value in food due to incorporating additional vitamins into crops	Possible cross pollination of GMO foods with non GMO foods result in the inability to track GMOs
Smell of GMO foods are often enhanced	Insects can possibly evolve to be resistant to insect resistant GMO crops
GMO foods do not need as fertile land as natural foods in order to grow	Cross pollination of GMO crops with weeds could result in "super weeds"
Less additives are needed to keep GMO foods fresh	New allergies could develop to GMO foods
GMO crops are less likely to get sicknesses	Possible health complications could arise due to unknown long term affects of GMO foods
GMO crops that freeze less in the winter can be produced	GMO crops sometimes fail like normal crops (genetically modified cotton has failed in India)

Module - 3
Sustaining Natural Resources and Environmental Quality

- Environmental hazards – causes and solutions.
- Biological hazards – AIDS, Malaria,
- Chemical hazards- BPA, PCB, Phthalates, Mercury.
- Nuclear hazards
- Risk and evaluation of hazards.
- Water footprint; virtual water, blue revolution.
- Water quality management and its conservation.
- Solid and hazardous waste – types and waste management methods.

Environmental hazards:

- ❖Biological Hazard
- ❖Chemical Hazard
- ❖Nuclear Hazard
- ❖Risk and evaluation of hazards.

Major Health Hazards

❖**Biological -** Pathogens like bacteria, viruses, parasites, protozoa, and fungi.

❖ **Chemical** - harmful chemicals in air, water, soil, food, and human-made products

❖ **Physical -** fire, earthquakes, volcanic eruptions, floods, and storms

❖**Cultural factors** - unsafe working conditions, unsafe highways, criminal assault, and poverty

❖**Lifestyle choices -** smoking, making poor food choices, drinking too much alcohol, and having unsafe sex

Biological Hazards

Flu, AIDS, tuberculosis, diarrheal diseases and malaria.

A **non-transmissible disease is** a not caused by any living organism.
Eg. Cardiovascular (heart and blood vessel) diseases, most cancers, asthma, and diabetes.

A **transmissible disease (also called a *contagious or communicable*** *disease) is an infectious disease that can be transmitted* from one person to another by living organism - By pathogen such as a bacterium, virus, or parasite. Eg. tuberculosis, flu, and measles

Infectious disease

The life cycle of malaria

Plasmodium parasites circulate from mosquito to human and back to mosquito.

Solutions

Infectious Diseases

- Increase research on tropical diseases and vaccines
- Reduce poverty
- Decrease malnutrition
- Improve drinking water quality
- Reduce unnecessary use of antibiotics
- Educate people to take all of an antibiotic prescription
- Reduce antibiotic use to promote livestock growth
- Require careful hand washing by all medical personnel
- Immunize children against major viral diseases
- Provide oral rehydration for diarrhea victims
- Conduct global campaign to reduce HIV/AIDS

Chemical Hazards

Chemicals that can cause cancers and birth defects and disrupt the human immune, nervous, and endocrine systems

U.S. Environmental Protection Agency (EPA) listed arsenic, lead, mercury, vinyl chloride (used to make PVC plastics), and polychlorinated biphenyls (PCBs) as the top five toxic substances

Carcinogens:
chemicals, types of radiation, or certain viruses that can cause or promote cancer
Eg: arsenic, benzene, chloroform, formaldehyde, gamma radiation, nickel, PCBs, radon, certain chemicals in tobacco smoke, ultraviolet (UV) radiation, X-rays, and vinyl chloride.

Mutagens:
Includes chemicals or forms of radiation that cause mutations, or changes, in the DNA molecules found in cells, or that increase the frequency of such changes.
Eg: nitrous acid (HNO_2), formed by the digestion of nitrite (NO_2^-) preservatives in foods.

Teratogens:
chemicals that cause harm or birth defects to a fetus or embryo.
Eg: Ethyl alcohol, angel dust, benzene, cadmium, formaldehyde, lead, mercury, mescaline, PCBs, phthalates, thalidomide, and vinyl chloride.

Chemicals may affect our Immune, Nervous, and Endocrine Systems

- **Arsenic, methyl mercury, and dioxins** can weaken the **human immune system**

- Natural and synthetic chemicals in the environment, called **neurotoxins**, *can harm the* **human nervous system** *(brain, spinal cord, and peripheral nerves).*
Effects can include behavioral changes, learning disabilities, retardation, attention deficit disorder, paralysis, and death.
Examples of neurotoxins are **PCBs, methyl mercury, arsenic, lead, and certain pesticides**.

- **Hormonally active agents** *(HAAs)* disrupt the endocrine system Certain pesticides and other synthetic chemicals such as **bisphenol A (BPA).**

-HAAs include **aluminum, atrazine and several other herbicides, DDT, mercury, PCBs, phthalates, and BPA.**

-**Estrogen mimics and hormone blockers** are sometimes called ***gender benders*** *because of their possible effects on sexual* development and reproduction

- thyroid disrupters and cause growth, weight, brain, and behavioral disorders.

Mercury (Hg)

❖**Hg** and its compounds HgS and $HgCl_2$, methylmercury (CH_3Hg+) are all toxic.

❖Research indicates that long-term exposure to high levels of mercury can permanently damage the human nervous system, brain function, kidneys, and lungs.

❖ fairly low levels of mercury can harm fetuses and cause birth defects

The BPA Controversy

Estrogen mimic is bisphenol A (BPA).

It is a chemical building block in certain hardened plastics (especially shatter-proof polycarbonate)

- Baby bottles
- Sipping cups
- Reusable water bottles
- Sports drink and juice bottles
- Microwave dishes
- Food storage containers
- Can liner in nearly all canned food
- Beverage products.

BPA adverse effects include brain damage, early puberty, prostrate disease, breast cancer, heart disease, liver damage, reduced sperm count, impaired immune function, type 2 diabetes, hyperactivity, increased aggressiveness, impaired learning, increased addiction to drugs such as amphetamines, decreased sex drive in males, and obesity in unborn test animals exposed to BPA

These ***hormone mimics are chemically similar to*** **female sex hormones called** ***estrogens.***
In males, excess levels of female hormones can cause feminization, smaller penises, lower sperm counts, and the presence of both male and female sex organs (**hermaphroditism**).

Poly Chlorinated Biphenyls (PCB)

❖PCB are a class of more than 200 chlorine-containing organic compounds that are very stable and non-flammable.

❖Paints, fire retardants in fabrics, preservatives, adhesives, and pesticides

❖Soil, air, lakes, rivers, fish, birds, your body, and even the bodies of polar bears in the Arctic.

Phthalates

❖Phthalates are used to soften **polyvinyl chloride (PVC)** plastic found in a variety of products and used as solvents in many consumer products.

❖Phthalates are found in many perfumes, cosmetics, baby powders, body lotions, hair sprays, deodorants, nail polishes, and shampoos for adults and babies.

❖They are also found in PVC products such as soft vinyl toys, teething rings, and blood storage bags, IV bags, and medical tubes used in hospitals.

❖Phthalates has caused birth defects and liver cancer, kidney and liver damage, premature breast development, immune suppression, and abnormal sexual development.

Toxicity Ratings of different Toxins

Toxicity Ratings and Average Lethal Doses for Humans

Toxicity Rating	LD50 (milligrams per kilogram of body weight)*	Average Lethal Dose**	Examples
Supertoxic	Less than 5	Less than 7 drops	Nerve gases, botulism toxin, mushroom toxin, dioxin (TCDD)
Extremely toxic	5–50	7 drops to 1 teaspoon	Potassium cyanide, heroin, atropine, parathion, nicotine
Very toxic	50–500	1 teaspoon to 1 ounce	Mercury salts, morphine, codeine
Moderately toxic	500–5,000	1 ounce to 1 pint	Lead salts, DDT, sodium hydroxide, sodium fluoride, sulfuric acid, caffeine, carbon tetrachloride
Slightly toxic	5,000–15,000	1 pint to 1 quart	Ethyl alcohol, Lysol, soaps
Essentially nontoxic	15,000 or greater	More than 1 quart	Water, glycerin, table sugar

*Dosage that kills 50% of individuals exposed.
**Amounts of substances in liquid form at room temperature that are lethal when given to a 70-kilogram (150-pound) human.

Pollutants in Home products

Nuclear hazards

Radioactive decay

- Radioactive substances undergo radioactive decay – unstable atoms to stable atoms
- Radioactive decay release energy
  - Gamma rays – high energy electromagnetic radiation
  - Alpha particles – fast moving, +vely charged
  - Beta particles – fast moving, -vely charged

Penetration power of ionizing radiations

Sources of radio activity

- Natural sources
  - cosmic rays
  - radioactive radon-222
  - soil, rock, air, food containing radioactive substances
- Anthropogenic sources
  - nuclear power plants
  - X-rays
  - diagnostic kits
  - test labs

Nuclear Hazard

Nuclear power has a low environmental impact and a very low accident risk, but its use has been limited by a low net energy yield, high costs, fear of accidents, long-lived radioactive wastes, and the potential for spreading nuclear weapons technology.

❖ Explosions and partial or complete meltdowns are possible, as we learned in 1986 from the serious accident at the **Chernobyl nuclear plant in Ukraine.**

❖ By 2005, some 56 people had died prematurely from exposure to radiation released by the accident. The number of long-term premature deaths from the accident, primarily from exposure to radiation, range from 9,000 by World Health Organization estimates, to 212,000 as estimated by the Russian Academy of Medical Sciences, to nearly **1 million** according to a 2010 study by Alexey Yablokov and two other Russian scientists, published by the New York Academy of Sciences.

Trade-Offs

Conventional Nuclear Fuel Cycle

Advantages

Low environmental impact (without accidents)

Emits 1/6 as much CO_2 as coal

Low risk of accidents in modern plants

Disadvantages

Very low net energy yield and high overall cost

Produces long-lived, harmful radioactive wastes

Promotes spread of nuclear weapons

Trade-Offs

Coal vs. Nuclear

Coal

High net energy yield

Very high emissions of CO_2 and other air pollutants

High land disruption from surface mining

Low cost when environmental costs are not included

Nuclear

Very low net energy yield

Low emissions of CO_2 and other air pollutants

Much lower land disruption from surface mining

High cost (even with huge subsidies)

High-level radioactive wastes consist mainly of spent fuel rods and assemblies from commercial nuclear power plants, the waste materials from dismantled plants, and assorted wastes from the production of nuclear weapons. They must be stored safely for at least **10,000** years and, by some estimates, up to **240,000** years if long-lived **plutonium-235** is not removed from the wastes.

Effects of radiations

- Genetic damages
  - mutations in the DNA
  - genes and chromosomes affected
- Somatic damages
  - burns
  - miscarriages
  - eye cataract
  - cancer of bone, skin, lungs, breast, thyroid
- Effect depends upon penetration level and period of exposure

Control of nuclear pollution

- Proper assessment of long term and short term effects before siting of nuclear power plants
- Proper protection
- Proper regulations
- Proper disposal of nuclear wastes

Risk - Assessment- Management

Risk

-is the ***probability of suffering harm from a hazard*** that can cause injury, disease, death, economic loss, or damage.

Risk assessment

- is the process of using statistical methods to ***estimate how much harm*** a particular hazard can cause to human health or to the environment

Risk management

-involves deciding whether or how to ***reduce a particular risk*** to a certain level and at what cost.

Figure 17-2 Science: Risk assessment and risk management are used to estimate the seriousness of various risks and how to reduce such risks. **Question:** What is an example of how you have applied this process in your daily living?

Estimating Risks from Technologies

The overall ***reliability or the probability*** *(expressed as a* percentage) that a person, device, or complex technological system will complete a task without failing is the product of two factors:

System reliability (%) = Technology reliability (%) x Human reliability (%)

❖With careful design, quality control, maintenance, and monitoring, a highly complex system such as a nuclear power plant or space shuttle can achieve a high degree of **technological reliability.**

❖But **human reliability** usually is much lower than technological reliability and is almost impossible to predict: ***To err is human****.*

Evaluating and avoiding Risks

❖Scientists use live laboratory animals, case reports of poisonings, and epidemiological studies to estimate the toxicity of chemicals, but these methods have limitations.

❖Because of the difficulty in evaluating the harm caused by exposure to chemicals, many health scientists call for much greater emphasis on pollution prevention.

❖Becoming informed, thinking critically about risks, and making careful choices can reduce the major risks we face.

❖Pollution prevention

The best idea!

Prevention is better than cure

Water pollution

Water pollution - definition

- Alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state

Water pollution - Sources

- Two types of sources

  (i) Point sources – can pinpoint the location

  - industries – tanneries, dyeing units etc
  - power plants
  - oil wells etc.

  (ii) Non-point sources – can not find the exact location

  - drainage overflow
  - run-off water from agricultural fields
  - rain water overflow

Surface water pollution sources

- Sewage
- Industrial effluents
- Synthetic detergents
- Agrochemicals
- Oil spills
- Waste heat (Thermal pollution)

Ground water pollution

- Availability of ground water is more
- Less prone to pollution as it is covered
- Soil retains many contaminants - natural filtration
- Main sources of pollution
  - Septic tanks
  - Mining
  - Industries
- Ground water pollution is irreversible

Effects of water pollution

- <u>Oxygen demanding wastes</u>
  - Dissolved oxygen (DO) - 8 – 15 mg/L
  - DO depends up on temperature and organic matter present in water
  - Lower DO harmful to fish population
  - demand for DO increase with more organic matter present
  - BOD – Biological Oxygen Demand
  - COD – Chemical Oxygen Demand

Temperature-Oxygen Solubility Relationship	
Temperature (°C)	Oxygen Solubility (mg/L)
0	14.6
5	12.8
10	11.3
15	10.2
20	9.2
25	8.6
100	0

RANGE OF TOLERANCE FOR
DISSOLVED OXYGEN IN FISH
PARTS PER MILLION (PPM)
DISSOLVED OXYGEN
0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
< 3.0 PPM
too low for
fish populations
3.0 - 5.0 PPM
12-24 hour
range of tolerance /
stressful conditions
6.0 PPM
supports
spawning
> 7.0 PPM
supports
growth/activity
> 9.0 PPM
supports
abundant
fish populations

Effects of water pollution

- <u>Increased nitrogen and phosphorous levels</u>
  - Eutrophication - growth of algae and other plants are more
  - less DO – anaerobic conditions –foul smelling gases
  - decomposition of plant matter produce CO_2
  - change of pH

Eutrophication

Effects of water pollution

- <u>Pathogens</u>
  - Drainage water contains pathogenic bacteria and viruses & also non-pathogenic bacteria
  - Cholera, dysentery, typhoid & jaundice

Effects of water pollution

- <u>Toxic compounds</u>
  - non-bio degradable organic matter
  - Bio-accumalation
  - Bio-magnification
  - DDT
  - Heavy metals – mercury, cadmium, lead
  - Nitrate – methaemoglobinemia or blue baby syndrome
  - Fluoride - fluorosis

Bioaccumulation of DDT

The Bioaccumulation of Methylmercury
Biomagnification of Methylmercury in the Ecosystem
Methylmercury Bioaccumulation in Organisms

Heavy metal water pollution

- Methyl mercury – Minamata disease
  - Numbness of body parts
  - Nerve problems
  - vision and hearing problems
  - abnormal mental behaviour

- Cadmium - Itai-itai disease
  - bones, liver, kidney, lungs, pancrease & thyroid were affected

Mercury - Minamata disease

Cadmium – Itai -Itai

Fluorosis

Control of water pollution

- Removal of pollutant at the source
- Judicious use of agrochemicals
- Planting nitrogen fixing plants
- Pest management – reduction of pesticides
- Separate drainage for sewage and rain water
- Planting trees
- Legislation

Control of water pollution

- Parameters considered in water treatment
  - Total dissolved solids (TDS)
  - BOD
  - COD
  - Nitrates and phosphates
  - Toxic metals

Waste water treatment

- Different stages of waste water treatment

❑ Primary treatment
- Screening and then grit chamber
- Settlement of suspended particles
- 35% BOD and 60% suspended solids removed

❑ Secondary treatment
- Biological process - 90% BOD and 90% suspended solids are removed
- Trickling filters
- Activated sludge process
- Rotating biological contactor (RBC)

❑ Advanced sewage treatment
- Chlorination
- Ozonation
- UV treatment

Trickling filter

Rotating biological contactor

Waste water treatment

Water Pollutants

Table 20-1 Major Water Pollutants and Their Sources

Type/*Effects*	Examples	Major Sources
Infectious agents (pathogens) *Cause diseases*	Bacteria, viruses, protozoa, parasites	Human and animal wastes
Oxygen-demanding wastes *Deplete dissolved oxygen needed by aquatic species*	Biodegradable animal wastes and plant debris	Sewage, animal feedlots, food-processing facilities, paper mills
Plant nutrients *Cause excessive growth of algae and other species*	Nitrates (NO_3^-) and phosphates (PO_4^{3-})	Sewage, animal wastes, inorganic fertilizers
Organic chemicals *Add toxins to aquatic systems*	Oil, gasoline, plastics, pesticides, fertilizers, cleaning solvents	Industry, farms, households, mining sites, runoff from streets and parking lots
Inorganic chemicals *Add toxins to aquatic systems*	Acids, bases, salts, metal compounds	Industry, households, mining sites, runoff from streets and parking lots
Sediments *Disrupt photosynthesis, food webs, other processes*	Soil, silt	Land erosion from farms and construction and mining sites
Heavy metals *Cause cancer, disrupt immune and endocrine systems*	Lead, mercury, arsenic	Unlined landfills, household chemicals, mining refuse, industrial discharges
Thermal *Make some species vulnerable to disease*	Heat	Electric power and industrial plants

❖**Water pollution** **is any change in water quality that** can harm living organisms or make the water unfit for human uses such as irrigation and recreation.

- various infectious agents such as certain strains of coliform bacteria *Escherichia coli, or E. coli*
- *dissolved oxygen (DO), COD, BOD*
- toxic heavy metals in the ocean.

❖**Eutrophication** **is the natural nutrient** enrichment of a shallow lake, estuary, or slowly moving stream. It is caused mostly by runoff of plant nutrients such as nitrates and phosphates from surrounding land.

❖ Near urban or agricultural areas, human activities can greatly accelerate the input of plant nutrients to a lake—a process called **cultural eutrophication.** Such inputs involve mostly nitrate- and phosphate-containing effluents from various sources

Ground water pollution – Prevention / Cleanup

Solutions

Groundwater Pollution

Prevention

Find substitutes for toxic chemicals

Keep toxic chemicals out of the environment

Install monitoring wells near landfills and underground tanks

Require leak detectors on underground tanks

Ban hazardous waste disposal in landfills and injection wells

Store harmful liquids in aboveground tanks with leak detection and collection systems

Cleanup

Pump to surface, clean, and return to aquifer (very expensive)

Inject microorganisms to clean up contamination (less expensive but still costly)

Pump nanoparticles of inorganic compounds to remove pollutants (still being developed)

❖**Water footprint,** which is a rough measure of the volume of water that we use directly and indirectly to keep ourselves alive and to support our lifestyles.

❖ Water that is not directly consumed but is used to produce food and other products is called **Virtual water**, and it makes up a large part of our water footprints, especially in more-developed countries.

❖ Each of us can help to bring about such a "**blue revolution**" and reduce our water footprints by using and wasting less water

Water Conservation

Solutions

Sustainable Water Use

- Waste less water and subsidize water conservation
- Do not deplete aquifers
- Preserve water quality
- Protect forests, wetlands, mountain glaciers, watersheds, and other natural systems that store and release water
- Get agreements among regions and countries sharing surface water resources
- Raise water prices
- Slow population growth

What Can You Do?

Water Use and Waste

- Use water-saving toilets, showerheads, and faucet aerators
- Shower instead of taking baths, and take short showers
- Repair water leaks
- Turn off sink faucets while brushing teeth, shaving, or washing
- Wash only full loads of clothes or use the lowest possible water-level setting for smaller loads
- Use recycled (gray) water for watering lawns and house-plants and for washing cars
- Wash a car from a bucket of soapy water, and use the hose for rinsing only
- If you use a commercial car wash, try to find one that recycles its water
- Replace your lawn with native plants that need little if any watering
- Water lawns and yards only in the early morning or evening
- Use drip irrigation and mulch for gardens and flowerbeds

Solutions

- ✓ Pollution Prevention to Protect Groundwater
- ✓ Protecting Watersheds Instead of Building Water Purification Plants
- ✓ Using Laws to Protect Drinking Water Quality
- ✓ Sewage Treatment to Reduce Water Pollution

Water conservation practices

1. Decreasing run-off losses

Infiltration into the soil can reduce loss

- Contour cultivation
- Conservation bench terracing
- Water spreading – channeling, lagoon- leveling
- Chemical wetting agents like surfactants
- Chemical conditioners –Gypsum ($CaSO_4.2H_2O$)
- In Sodic soils – HPAN (hydrolysed polyacrylonitrile) improve permeability
- Water-storage structures – ponds, dug-outs

Water conservation practices

2. **Reducing evaporation losses**

   Some methods available

   - Use of asphalt sheets below the soil
   - Super slurper – copolymer of acrylonitrile and starch absorbs water upto 1400 times its weight
   - Planting trees on the edges of fields

3. **Storing water in soil**

   – Some water is stored in soil in the root zone. If the land is left fallow for some time that water will become available

Water conservation practices

4. **Reducing irrigation losses**
   - Covered canals to reduce seepage
   - Irrigation in early morning or evening
   - Sprinklers
   - Use of less water requiring hybrid varieties
   - Drip irrigation

5. **Reuse**
   - Treated water can be reused
   - Water from washings bath tubs etc (grey water) for watering gardens

Water conservation practices

6. **Stop wastage**
   - Close taps
   - Repair leaks
   - Use small capacity flush

7. **Increase block pricing**
   - Put a charge on water

– Introduce proper laws
– Educate people

Rainwater Harvesting

- What is it and why do we need it?
- Why are some of the cities like Chennai or Mumbai facing water problems?
- Because of less rainfall?

Comparison of rainfall in 5 Indian cities

Bangaloru gets 37"annually but the rainfall is more spread out.
Delhi = 32.1" Mumbai=120" Calcutta=62.3" Chennai = 50"

Flood and Drought

Rainwater harvesting

- It is a technique of increasing the recharge of groundwater by capturing and storing rainwater

- This is done by construction of special water harvesting structures like dug wells, percolation pits, lagoons, check dams etc.

Rainwater harvesting

- Obectives
  - Reduce run off loss
  - Avoid flooding of roads
  - Meet the increasing demands of water
  - Raise the water table
  - Reduce groundwater contamination
  - Supplement groundwater supplies during lean season

Rainwater harvesting

Methods of rainwater harvesting are

1. Storing in tanks or reservoirs above or below ground
2. Constructing pits, dug wells, lagoons trenches or check dams on rivers and streams
3. By recharging groundwater

Roof-top rainwater harvesting

Traditional rainwater harvesting

- What were the good deeds of Samrat Asoka?
- In ancient India there were lakes and ponds in every village constructed by kings
- In Rajasthan underground tanks and embankments were found
- In Himalayan regions bamboo pipes were used to draw water from streams
- Collecting rain water from roof-tops is one of the oldest techniques in India
- In villages lake cut ponds were made. In Tamilnadu, they had separate such ponds for bathing, washing and drinking.

What is Watershed?

- Watershed – a delineated area with well-defined topographical boundary
- The land area from which water drains to a drainage channel – stream, river etc.
- Also called as catchment area, drainage basin, river basin etc.
- Watersheds have a well-defined boundary and one water outlet.

A Watershed
DIVIDE
DIVIDE

Solid Waste Management

Soild waste - Problems

How to manage these problems ?

General composition of solid waste

% may vary depend upon the country, city and region

Solid waste

Solid waste contributes to pollution and represents the unnecessary consumption of resources; hazardous waste contributes to pollution as well as to natural capital degradation, health problems, and premature deaths.

- ❖**Industrial solid waste**
- ❖**Municipal solid waste (MSW)**
- ❖**Hazardous,** or **toxic waste**

Urban wastes

- Waste from homes
- Waste from shops
- Biomedical waste
- Construction/demolition waste
- Horticulture waste
- Slaughter house waste

Bio degradable wastes and non-biodegradable wastes

Industrial wastes

- Chemicals
- Packaging materials
- Metals, wood, paint, glass, asbestos, batteries, abrasives, leather
- Thermal power plants – fly ash
- Nuclear power plants – radioactive materials

Solid wastes from developed countries to undeveloped countries !

Effect of improper solid waste disposal

- Dumping of materials on the road side
  - biodegradation – foul smell - pathogens
- Industrial wastes-toxic substances
- Mixing of hazardous substances with garbage
  - unable to separate recyclable materials
- Batteries – lead, cadmium, mercury
- Burning of materials
  - polychlorinated biphenyls, dioxins, furans
- Leads cancer and other ailments

Solid Waste Management

Management of solid waste

- The **3 "R"** mantra
  - **Reduction** in use of raw materials
  - **Reuse** of waste materials
  - **Recycling** of materials

Classification of domestic waste - Tokyo

Combustible trash
(moeru gomi)

Non-combustible trash
(moenai gomi)

Recyclable trash
(shigen gomi)

Over size trash
(Sodai gomi)

Batteries and
electronics

Domestic waste disposal – Bunkyo ward, Tokyo

Day	Type of trash to be disposed
Monday, Thursday	Burnable trash
Tuesday	Non- burnable trash
Wednesday	Recyclable trash

For oversized trash the city office should be contacted

Solid Waste Management

Solid waste management

- We attempt to control wastes in ways that reduce their environmental harm without seriously trying to reduce the amount of waste produced.

- A sustainable approach to solid waste is first to
- reduce it,
- then to reuse or
- recycle it, and
- finally to safely dispose of what is left.

Integrated waste management

Figure 21-6 *Integrated waste management:* Wastes are *reduced* through reuse, recycling, and composting or *managed* by burying them in landfills or incinerating them. Most countries rely primarily on burial and incineration. **Question:** What happens to the solid waste you produce?

Methods of Discarding Wastes

1. Sanitary Land fill

2. Biocompost

3. Incineration

Methods of Discarding Wastes

- **Sanitary landfill**
  - Garbage is spread out in thin layers
  - Compacted and covered with clay or plastic foam
  - The bottom is covered with an impermeable liner (clay, thick plastic and sand).
  - It protects the ground water from being contaminated due to percolation of leachate
  - Methane produced by anaerobic decomposition is collected
  - Used to produce electricity or heat

Typical Landfill
Resource Recovery Landfill Gas to Energy
Vegetation
Topsoil
Cover Soil
Composite Cap
Landfill Gas Collection
Refuse
Leachate Lines
Lysimeter
Drainage Layer
Composite Liner
Gas Monitoring
Groundwater Monitoring Well
Groundwater

Sanitary Land Fill

Sanitary Landfills – Advantages/ Disadvantages

Trade-Offs

Sanitary Landfills

Advantages

Low operating costs

Can handle large amounts of waste

Filled land can be used for other purposes

No shortage of landfill space in many areas

Disadvantages

Noise, traffic, and dust

Releases greenhouse gases (methane and CO_2) unless they are collected

Output approach that encourages waste production

Eventually leaks and can contaminate groundwater

Biocompost

Methods of Discarding Wastes

- **Composting**
  - **Biodegradable waste** is allowed to degrade or decompose in an oxygen rich medium
  - Good quality nutrient rich and **environmental friendly manure** is obtained
  - It improves the **soil conditions** and **fertility**

Brown
Woody materials: Dry leaf, twigs, sticks, etc. Rich in C
Green
Moist green materials: Veggie and fruit peels, etc. Rich in N
Water
H_2O
Compost materials should have moisture content of 40 - 60 %
Air
O_2
Aeration is important as microorganisms in a compost pile need oxygen to live and work
Compost

Incineration

Methods of Discarding Wastes

- **Incineration**
  - **Incinerators** are burning plants capable of burning a large amount of materials at high temperature.
  - **The initial cost is very high.**
  - High levels of dioxins, furans, lead and cadmium may be emitted with the fly ash of incinerator
  - **Remove batteries containing heavy metals** and **plastic containing chlorine** before burning the material
  - Prior removal of plastics will reduce emissions of dioxins and polychlorinated biphenyls

Waste to Energy Plant Diagram

Source: ecomaine.

Incineration

Figure 21-13 **Solutions:** A modern waste-to-energy incinerator with pollution controls burns mixed solid wastes and recovers some of the energy to produce steam to use for heating or producing electricity. Great Britain burns about 90% of its MSW in incinerators and Denmark burns about 54%, compared to 13% in the United States and 8% in Canada. To be economically feasible, incinerators must be fed huge volumes of trash every day. This encourages trash production and discourages reuse, recycling, and waste reduction. **Questions:** Would you invest in such a project? Why or why not?

Incineration – Advantages/ Disadvantages

Trade-Offs

Waste-to-Energy Incineration

Advantages	Disadvantages
Reduces trash volume	Expensive to build
Produces energy	Produces a hazardous waste
Concentrates hazardous substances into ash for burial	Emits some CO_2 and other air pollutants
Sale of energy reduces cost	Encourages waste production

Solid waste management -Priority

First Priority

Primary Pollution and Waste Prevention

- Change industrial process to eliminate use of harmful chemicals
- Use less of a harmful product
- Reduce packaging and materials in products
- Make products that last longer and are recyclable, reusable, or easy to repair

Second Priority

Secondary Pollution and Waste Prevention

- Reuse
- Repair
- Recycle
- Compost
- Buy reusable and recyclable products

Last Priority

Waste Management

- Treat waste to reduce toxicity
- Incinerate waste
- Bury waste in landfills
- Release waste into environment for dispersal or dilution

What Can You Do?

Solid Waste

- Follow the three Rs of resource use: Reduce, Reuse, and Recycle
- Ask yourself whether you really need a particular item, and refuse packaging where possible
- Rent, borrow, or barter goods and services when you can, buy secondhand, and donate or sell unused items
- Buy things that are reusable, recyclable, or compostable, and be sure to reuse, recycle, and compost them
- Avoid disposables and do not use throwaway paper and plastic plates, cups, eating utensils, and other disposable items when reusable or refillable versions are available
- Use e-mail or text-messaging in place of conventional paper mail
- Read newspapers and magazines online and read e-books
- Buy products in bulk or concentrated form whenever possible

What Can You Do?

Reuse

- Buy beverages in refillable glass containers instead of cans or throwaway bottles
- Use reusable plastic or metal lunchboxes
- Carry sandwiches and store refrigerated food in reusable containers instead of wrapping them in aluminum foil or plastic wrap
- Use rechargeable batteries and recycle them when their useful life is over
- When eating out, bring your own reusable silverware and napkin
- Bring your own reusable container for takeout food or restaurant meal leftovers
- Carry groceries and other items in a reusable basket or cloth bag
- Buy used furniture, computers, cars, and other items instead of buying new
- Give away or sell items you no longer use

Trade-Offs

Recycling

Advantages	Disadvantages
Reduces energy and mineral use and air and water pollution	Can cost more than burying in areas with ample landfill space
Reduces greenhouse gas emissions	Reduces profits for landfill and incinerator owners
Reduces solid waste	Source separation inconvenient for some
Can save landfill space	

Hazardous waste

Produce Less Hazardous Waste

- Change industrial processes to reduce or eliminate hazardous waste production
- Recycle and reuse hazardous waste

Convert to Less Hazardous or Nonhazardous Substances

- Natural decomposition
- Incineration
- Thermal treatment
- Chemical, physical, and biological treatment
- Dilution in air or water

Put in Perpetual Storage

- Landfill
- Underground injection wells
- Surface impoundments
- Underground salt formations

Solutions

Physical methods for detoxifying hazardous wastes:
include using charcoal or resins to filter out harmful solids, distilling liquid wastes to separate out harmful chemicals, and precipitating, or allowing natural processes to separate, such chemicals from solution.

Chemical methods are used to convert hazardous:
chemicals to harmless or less harmful chemicals through chemical reactions

Nanomagnets:
magnetic nanoparticles coated with certain compounds that can remove various pollutants from water.

Biological methods for treatment of hazardous waste:
-***bioremediation***, in which bacteria and enzymes help to destroy toxic or hazardous substances, or convert them to harmless compounds.

-***phytoremediation***, *which involves* using natural or genetically engineered plants to absorb, filter, and remove contaminants from polluted soil and water

Vegetation cover to reduce the impact of pollution

Solution to solid waste

Trade-Offs

Plasma Arc

Advantages

Small

Mobile. Easy to move to different sites

Produces no toxic ash

Disadvantages

High cost

Produces CO_2 and CO

Can release particulates and chlorine gas

Can vaporize and release toxic metals and radioactive elements

Trade-Offs

Deep-Well Disposal

Advantages

Safe if sites are chosen carefully

Wastes can often be retrieved

Low cost

Disadvantages

Leaks from corrosion of well casing

Emits CO_2 and other air pollutants

Output approach that encourages waste production

Module – 4
Energy Resources

- ❖Non- renewable energy resources:
- ❖Oil
- ❖Natural gas
- ❖Coal
- ❖Nuclear energy.
- ❖Energy efficiency and renewable energy.
- ❖Renewable Energy Resources:
- ❖Solar energy
- ❖ Hydroelectric power
- ❖Ocean thermal energy
- ❖Wind Energy
- ❖Geothermal energy
- ❖Energy from biomass,
- ❖Solar-Hydrogen revolution.

Renewable Energy

Non-Renewable Energy

Human Energy Use

❖We get most of our energy by burning carbon-containing fossil fuels .

❖Note that oil is the most widely use form of commercial energy and that about 79% of the energy used in the world.

❖ 85% of the energy used by the United States comes from burning non-renewable fossil fuels.

Net Energy

- Net energy is the amount of high-quality energy available from an energy resource minus the amount of energy needed to make it available.
- Net Energy Is the Only Energy That Really Counts.
- Energy Resources With Low or Negative Net Energy Yields Need Help to Compete in the Marketplace.
- Reducing Energy Waste Improves Net Energy Yields and Can Save Money.

Energy Efficiency

❖**Improving energy efficiency can save the world at least a third of the energy it uses**

❖Each unit of energy saved eliminates the need to produce that energy, and it saves us money.

❖II law of Thermodynamics.

Energy-wasting dinosaurs

➢***Incandescent light bulb*** –replaced by energy-efficient compact fluorescent bulbs and more efficient light-emitting diodes (LEDs)

➢The ***internal combustion engine***, which propels most motor vehicles and wastes about 80% of the energy in its fuel.

➢A ***nuclear power plant*** wastes about 75% of the energy in its nuclear fuel and probably closer to 92% when we include the additional energy used in the nuclear fuel cycle.

➢A ***coal-fired power plant***, which wastes about 66% of the energy that is released by burning coal to produce electricity, and probably 75–80% if we include the energy used to dig up the coal

What Can you do for efficient energy consumption?

Attic
- Hang reflective foil near roof to reflect heat.
- Use house fan.
- Be sure attic insulation is at least 30 centimeters (12 inches).

Bathroom
- Install water-saving toilets, faucets, and shower heads.
- Repair water leaks promptly.

Kitchen
- Use microwave rather than stove or oven as much as possible.
- Run only full loads in dishwasher and use low- or no-heat drying.
- Clean refrigerator coils regularly.

Outside

Plant deciduous trees to block summer sun and let in winter sunlight.

Other rooms
- Use compact fluorescent lightbulbs or LEDs and avoid using incandescent bulbs.
- Turn off lights, computers, TV, and other electronic devices when they are not in use.
- Use high efficiency windows; use insulating window covers and close them at night and on sunny, hot days.
- Set thermostat as low as you can in winter and as high as you can in summer.
- Weather-strip and caulk doors, windows, light fixtures, and wall sockets.
- Keep heating and cooling vents free of obstructions.
- Keep fireplace damper closed when not in use.
- Use fans instead of, or along with, air conditioning.

Basement or utility room
- Use front-loading clothes washer. If possible run only full loads with warm or cold water.
- If possible, hang clothes on racks for drying.
- Run only full loads in clothes dryer and use lower heat setting.
- Set water heater at 140°F if dishwasher is used and 120°F or lower if no dishwasher is used.
- Use water heater thermal blanket.
- Insulate exposed hot water pipes.
- Regularly clean or replace furnace filters.

Per capita energy use and GNP

Correlation GNP and energy consumption

BTU = British thermal unit, (252 heat calories)
GNP = Gross National product

- Renewable Energy Resources
  - Solar Energy
  - Wind Energy
  - Hydropower
  - Tidal energy
  - Ocean Thermal Energy
  - Geothermal Energy
  - Biomass Energy
  - Biogas
  - Bio fuels
  - Hydrogen as fuel

- Non-Renewable Energy
  - Coal
  - Petroleum
  - Natural Gas
  - Nuclear Energy

RENEWABLE ENERGY
Solar Energy
Energy from the Sun.
Geothermal Energy
Energy from the heat of the Earth.
Windpower
Energy from the wind.
Biomass
Energy from plants.
Hydropower
Energy from the force of moving water.

Solar Energy

Solar Energy

- Sun is the ultimate source of energy

- The nuclear fusion reaction occurring inside the sun release enormous quantities of energy in the form of heat and light.

- The solar energy received by the near earth space is approximately 1.4 kilojoules/Second/m^2 known as solar constant

Solar Cells - Principle

- Photovoltaic cells
- It is made up of thin wafers of semi conductor material like silicon or gallium
- The potential difference produced by a single PV cell of 4 cm^2 is about 0.4 to 0.5 volts and produce current of 60 milli amperes.

Working of Solar Cells

Solar cooker

Solar power plant

- Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam.
- A solar power plant (50 K Watt capacity) has been installed at guragon, Haryana.

Solar Energy

Passive and active solar heating systems can heat water and buildings effectively, and the costs of using direct sunlight to produce high temperature heat and electricity are coming down

- **Passive solar heating systems** -absorbs and stores **heat from the sun directly** within a well-insulated structure. Walls and floors of concrete, adobe, brick, or stone, and water tanks.
- An **active solar heating system** - captures **energy from the sun by pumping a heat absorbing fluid** (such as water or an antifreeze solution) through special collectors, usually mounted on a roof or on special racks to face the sun.

Trade-Offs

Solar Energy for High-Temperature Heat and Electricity

Advantages	Disadvantages
Moderate environmental impact	Low net energy and high costs
No direct emissions of CO_2 and other air pollutants	Needs backup or storage system on cloudy days
Lower costs with natural gas turbine backup	High water use for cooling

Solar thermal systems *use different methods to collect* and concentrate solar energy in order to boil water and produce steam for generating electricity

Sunlight to Produce Electricity

-using **photovoltaic (PV) cells**, **commonly called solar cells. Most solar cells are thin wafers of purified silicon (Si)** or polycrystalline silicon with trace amounts of metals that allow them to produce electricity

Trade-Offs

Solar Cells

Advantages	Disadvantages
Moderate net energy yield	Need access to sun
Little or no direct emissions of CO_2 and other air pollutants	Need electricity storage system or backup
Easy to install, move around, and expand as needed	High costs for older systems but decreasing rapidly
Competitive cost for newer cells	Solar-cell power plants could disrupt desert ecosystems

Hydropower Energy

Electricity from Falling and Flowing Water

❖*Hydropower uses the* **kinetic energy of flowing and falling** water to produce electricity.

❖A high dam across a large river to create a reservoir.

❖Canada, China, Brazil, the United States, and Russia.

❖Largest human-caused source of **methane**.

❖**Microhydropower generators***:* produce electricity from flowing water by tapping into the energy from **ocean tides and waves**

Hydropower

Hydroelectric power generation
Power transmission cables
Transformer
Power house
Generator
Dam
Sluice gates
Penstock
The bigger the height difference between the upstream and downstream water level, the greater the amount of electricity generated
Dam
Downstream outlet
Turbine
Storage reservoir
Silt
Source: Environment Canada

- The hydropower potential of India is estimated to be about 4 $X10^{11}$ KW-hours, only 11% is utilized.

Ocean Thermal Energy (OTE)

- The energy available due to the **difference in temperature of water at the surface of the tropical oceans and at the deeper levels** is called ocean thermal energy.
- A difference of **20 °C** or more is required.
- The warm surface water is used to boil liquid like **ammonia.**
- The colder water from the deep oceans is pumped to cool and condense the vapours of ammonia into liquid.
- Run 24h.

Wind Energy

When we include the environmental costs of using energy resources in the market prices of energy, wind power is the least expensive and least polluting way to produce electricity.

❖**Wind to Produce Electricity-** The differences in the angles of the sun's rays hitting the earth between the equator and the poles create different amounts of solar heating; together with the earth's rotation, this creates flows of air called *wind.*

❖*We can capture this indirect form of* solar energy with **wind turbines** on land and at sea that convert it into electrical energy. Such wind turbines are being erected in large numbers at some sites to create **wind farms***.*

❖**Denmark**, the world's most energy-efficient country, gets 20% of its electricity.

❖Largest wind-power producers in 2009 were **China, the United States, Germany, Spain, and India.**

❖Minimum wind speed required **15 km/h**

Wind Energy

- A large number of wind mills are installed in clusters called **wind farms**
- Ideal locations are coastal regions, open grasslands, mountain passes where the winds are strong and steady
- The minimum wind speed required for satisfactory working of wind mill is **15 km/hr.**
- Wind potential of our country is about 20,000 MW, we are generating about 1020 MW.
- The largest wind farm of our country is near Kanyakumari in Tamilnadu generating 380 MW of electricity

Wind power – Advantages and Disadvantages

Trade-Offs

Wind Power

Advantages

Moderate to high net energy yield

Widely available

Low electricity cost

Little or no direct emissions of CO_2 and other air pollutants

Easy to build and expand

Disadvantages

Needs backup or storage system when winds die down

Visual pollution for some people

Low-level noise bothers some people

Can kill birds if not properly designed and located

Geothermal Energy

- **At places where there is superheated water below the earth's surface but steam remains trapped below the earth's surface, a different method is used. Two pipes are sunk into the earth. Through one pipe cold water is pumped which is then converted to steam and comes out through the other pipe as super heated steam and is used to rotate the turbines to generate electricity.- USA & NZ**

Geothermal Energy

Geothermal heating

Geothermal cooling

Geothermal Energy

❖**Geothermal energy is heat stored in soil, underground rocks, and fluids in the earth's mantle.**

❖Capture of geothermal energy is by using a *geothermal heat pump system.*

❖*Hydrothermal reservoirs of geothermal energy. This is done* by drilling wells into the reservoirs to extract their dry steam (with a low water content), wet steam (with a high water content), or hot water, which are then used to heat homes and buildings.

Tide Energy

- During **high tide, when the level of water in the sea is high, sea-water flows into the reservoir of the barrage and turns the turbines.** The turbines then turn the generator shaft to produce electricity.

- During **low tide, the sea-water stored in the barrage reservoir is allowed to flow out into the sea.** This flowing water also turns the turbines and generates electricity.
- There are only few sites in the world where tidal energy can be suitably harnessed
- Bay of fundy, Canada
- La Rance, France
- Gulf of cambay, gulf of kutch and sunderban deltas in India

Biomass Energy

- Biomass is the organic matter produced by the plants or animals which includes wood, crop residues, cattle dung, sewage, agricultural wastes
- **Energy plantation**
  - Solar energy is trapped by green plants through photosynthesis and converted into biomass energy
    - Fast growing trees like cottonwood, poplar, crop plants like sugarcane are some of the important energy plantation.
- **Petro-crops**
  - Certain latex-containing plants like euphorbias and oil palms are rich in hydrocarbons can yield an oil like substance at high temperature and pressure.
    - This oily material may be burnt in diesel engines directly or may be refined to form gasoline
- **Agrircultural and urban waste biomass:**
  - Crop residues, sugarcane residue, coconutshell etc., are some of the common agricultural wastes which produces energy by burning
    - In rural areas these forms of waste biomass are burned in open furnaces called chulhas (efficiency < 8%)

Biogas

- Biogas is a mixture of methane, carbon dioxide, hydrogen sulphide, major constituent being methane.
- It is produced by anaerobic degradation of animal waste in presence of water
- It is non-polluting, clean and low cost fuel
- Useful in rural areas since lot of animal waste is available
- India has the largest cattle population in the world (240 million)

Advantages

- It is clean, non polluting and cheap
- No storage problem since it is directly supplied from plant
- The sludge left over is rich fertilizer

Floating gas holder type biogas plant

Floating gas-holder type bio-gas plant.

Floating gas holder type biogas plant

Fixed dome type biogas plant

- Instead of steel gas holder there is dome shaped roof made of cement and bricks

Biofuels

- Ethanol
  - It can be easily produced from carbohydrate rich substance like sugarcane, corn.
  - It burns clean non-polluting.
- Gasohol
  - It’s a mixture of ethanol and gasoline
  - Common fuel in brazil and Zimbabwe
- Methanol
  - Methanol can be easily obtained from woody plants
  - It is very useful since it burns at lower temperature than diesel and gasoline

Biomass energy

Solid biomass is a renewable resource for much of the world's population, but burning it faster than it is replenished produces a net gain in atmospheric greenhouse gases, and creating biomass plantations can degrade soil and biodiversity.

❖*Biomass consists of* ***plant materials (such as wood and*** **agricultural waste) and animal wastes that we can burn directly** as a solid fuel or convert into gaseous or liquid biofuels.

❖*crop residues (such as sugarcane and cotton* stalks, rice husks, straw, corn cobs, and coconut shells) and *animal manure* can be collected and burned.

❖cottonwoods, willows, and poplars, and by growing shrubs, perennial grasses such as switchgrass, and water hyacinths in ***biomass plantations****.*

❖Liquid biofuels such as ***biodiesel*** *(produced from vegetable* oils) and ***ethanol*** *(ethyl alcohol produced from plants* and plant wastes).

❖As they grow, the **algae** remove CO_2 from the atmosphere and convert it to oil, proteins, and other useful products.

❖Gasoline or diesel fuel from rapidly multiplying **bacteria**

Trade-Offs

Solid Biomass

Advantages

Widely available in some areas

Moderate costs

No net CO_2 increase if harvested, burned, and replanted sustainably

Plantations can help restore degraded lands

Disadvantages

Moderate to high environmental impact

Increases CO_2 emissions if harvested and burned unsustainably

Clear cutting can cause soil erosion, water pollution, and loss of wildlife habitat

Often burned in inefficient and polluting open fires and stoves

Trade-Offs

Biodiesel

Advantages

Reduced CO and CO_2 emissions

High net energy yield for oil palm crops

Reduced hydrocarbon emissions

Better mileage (up to 40%)

Disadvantages

Increased NO_x emissions and smog

Low net energy yield for soybean crops

Competes with food for cropland

Clearing natural areas for plantations reduces biodiversity and increases atmospheric CO_2 levels

Trade-Offs

Ethanol Fuel

Advantages	Disadvantages
Some reduction in CO_2 emissions (sugarcane bagasse)	Low net energy yield (corn) and higher cost
	Higher CO_2 emissions (corn)
High net energy yield (bagasse and switchgrass)	
	Corn ethanol competes with food crops and may raise food prices
Potentially renewable	

Hydrogen as fuel

- Due to highest calorific values it can serve as an excellent fuel
- By **thermal dissociation** of water (at 3000 K and above)
- It is produced by **chemical reaction** of water with some other chemicals in 2-3 cycles
- **Electrolytic method** dissociate water to hydrogen and oxygen by making current flow through it.
- **Photolysis** of water involves breakdown of water in the presence of sunlight to release hydrogen.

Hydrogen Fuel

Hydrogen fuel holds great promise for powering cars and generating electricity, but for it to be environmentally beneficial, we would have to produce it without using fossil fuels.

- The **sun produces its energy**, which sustains life on the earth, through the **nuclear fusion of hydrogen atoms.**
- Fuel cells that combine H_2 and oxygen gas (O_2) to produce electricity and water vapor ($2\ H_2 + O_2 \longrightarrow 2\ H_2O +$ energy), which is emitted into the atmosphere.
- H_2 also provides **more energy per gram** than any other fuel, therefore a lightweight fuel ideal for aviation.
- It is a fuel produced by using other forms of energy, and thus **has a negative net energy yield.**
- **Fuel cells** are best way to use H_2 to produce electricity, but current versions are **expensive**.
- Electricity from coal-burning and nuclear power plants to produce H_2 would **add much more CO_2 to the atmosphere** per unit of heat generated than does burning carbon-containing fuels directly.

Trade-Offs

Hydrogen

Advantages

Can be produced from plentiful water at some sites

No direct CO_2 emissions if produced from water

Good substitute for oil

High efficiency (45–65%) in fuel cells

Disadvantages

Negative net energy yield

CO_2 emissions if produced from carbon-containing compounds

High costs require subsidies

Needs H_2 storage and distribution system

Solar Hydrogen Revolution

❖H_2 could be used as fuel if it is made with electricity **produced by low-polluting**, **renewable sources** (Solar/ wind) that emit little or no CO_2.

❖The basic ideas of a solar-hydrogen energy scheme are first that solar energy should be collected where it is most available.

❖The electricity from solar panels thus obtained, would be used to electrolyze water.

❖The H_2 from the electrolysis would be pumped up and piped to distant places.

❖**A fuel cell** takes in *hydrogen gas and separates the hydrogen atoms' electrons from their protons.*

❖The electrons flow through wires to provide electricity, while the protons pass through a membrane and combine with oxygen gas to form water vapor.

❖ Note that this process is the ***reverse of electrolysis****, the process of passing* electricity through water to produce hydrogen fuel.

KSPhotography/Shutterstock

NON - Re - NEW - a - ble

NOT Able to be NEW again

COAL

NATURAL GAS

PETROLEUM

PROPANE

URANIUM

Oil

❖**Petroleum, or crude oil (oil as it comes out of the ground**), is a black, gooey liquid consisting of hundreds of different combustible hydrocarbons along with small amounts of sulfur, oxygen, and nitrogen impurities.

❖Oil supplies about **one-third of the world's commercial Energy**.

❖We use oil to grow most of **our food, transport people and goods**, and make most of the things we use every day.

❖The products of crude oil distillation, called **petrochemicals, are used as raw materials in industries.**

❖Conventional oil is currently abundant, has a high net energy yield, and is relatively inexpensive, but using it causes **air and water pollution** and releases greenhouse gases to the atmosphere.

❖Heavy oils from **tar sand and oil shale** exist in potentially large supplies but have low net energy yields and higher environmental impacts than conventional oil has.

Petroleum

- 13 countries having 67% of the petroleum together form the Organization of petroleum exporting countries) OPEC.
- **OPEC Controls Most of the World's Crude Oil Supplies**
- Saudi Arabia has the largest portion of the world's conventional proven crude oil reserves (20%).
- Saudi Arabia, with the world's largest proven conventional crude oil reserves, could supply the world's entire oil needs for only about 7 years.
- Get exhausted in 40 years
- Fractional distillation

Tar Sand and Oil Shale

❖**Heavy Oil from Tar Sand Tar sand, or oil sand:**

-is a mixture of clay, sand, water, and a combustible organic material called *bitumen*- a thick, sticky, tarlike heavy oil with a high sulfur content.

❖**Oil Shale:**

❖Oily rocks are another potential supply of heavy oil. Such rocks, called ***oil shales,*** contain a solid combustible mixture of hydrocarbons called ***kerogen.***

❖It is extracted from crushed oil shales after they are heated in a large container-a process that yields a distillate called **shale oil.**

Liquefied petroleum Gas (LPG)

- The main component of petrol is **butane**, the other being propane and ethane
- Under pressure petroleum is converted to LPG
- It is odourless
- In domestic gas cylinders ethyl mercaptan, a foul smelling gas, is added
- In India at Digboi (Assam), Gujarat plains, Bombay high, deltaic coasts of Godhavari, Krishna, Kaveri and Mahanadhi.

COAL

- Coal was formed 350 million years ago in the hot, damp regions of the earth during the carboniferous age.
- Anthracite [hard coal, 90% carbon, 8700 kcal/kg)
- Bituminous [Soft coal, 80% carbon]
- Lignite [Brown coal, 70% carbon]
- The coal reserves are likely to last for about 200 years, if the use increased by 2% per year, then it will last for another 65 years
- India has 5% of world's coal and Indian coal is not very good in terms of heat capacity
- Major coal fields in India are
  - Raniganj, Jharia, Bokaro, Singrauli, Godavari valley
- The coal state of India are
  - Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andrhra pradesh, Maharashtra

Trade-Offs

Coal

Advantages

Ample supplies in many countries

High net energy yield

Low cost when environmental costs are not included

Disadvantages

Severe land disturbance and water pollution

Fine particle and toxic mercury emissions threaten human health

Emits large amounts of CO_2 and other air pollutants when produced and burned

Nuclear Energy

Nuclear fission

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3\,^{1}_{0}n + \text{Energy}$$

Nuclear fuel Cycle

Trade-Offs

Conventional Nuclear Fuel Cycle

Advantages

Low environmental impact (without accidents)

Emits 1/6 as much CO_2 as coal

Low risk of accidents in modern plants

Disadvantages

Very low net energy yield and high overall cost

Produces long-lived, harmful radioactive wastes

Promotes spread of nuclear weapons

Nuclear Fusion

$$ {}_{1}H^{2} + {}_{1}H^{2} \longrightarrow {}_{3}He^{2} + {}_{0}n^{1} + \text{Energy} $$

There are four nuclear power stations with an installed capacity of 2005 MW

Tarapur (Maharashtra), Rana Pratap Sagar (Rajasthan), Kalpakkam (Tamilnadu), and Narora (U.P)

Solutions

Making the Transition to a More Sustainable Energy Future

Improve Energy Efficiency

Increase fuel-efficiency standards for vehicles, buildings, and appliances

Provide large tax credits or feebates for buying efficient cars, houses, and appliances

Reward utilities for reducing demand for electricity

Greatly increase energy efficiency research and development

More Renewable Energy

Greatly increase use of renewable energy

Provide large subsidies and tax credits for use of renewable energy

Greatly increase renewable energy research and development

Reduce Pollution and Health Risk

Phase out coal subsidies and tax breaks

Levy taxes on coal and oil use

Phase out nuclear power subsidies, tax breaks, and loan guarantees

Module 5

Environmental Impact Assessment

- Introduction to environmental impact analysis
- EIA guidelines
- Notification of Government of India

  Environmental Protection Act – Air, water, forest and wild life Act
- Impact assessment methodologies
- Public awareness
- Environmental priorities in India
- Sustainable development

Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA)

- Environmental Impact Assessment is a widely accepted and important **tool for Environment Management for ensuring optimal use of natural resources for sustainable development.**

- It is being increasingly adopted in several countries.

- The aim of EIA is to identify and subsequently predict the **impacts of Commercial, Industrial and Legislative proposals, Policies and Operational procedures** and interpret and communicate information to all stake holders about these impacts.

Need for EIA

Any developmental activity in the form of new project proposals (e.g. setting up of chemical/ petrochemical complexes, Metallurgical plants like Iron and Steel mills, Mining activities, Atomic and Conventional Power Generating stations and research facilities, construction of a dam/railway line, introduction new regulations etc.) is likely to **affect Environmental quality and hence calls for the carrying out of an EIA**. In many countries EIA has become mandatory before allowing such project activities to start.

In India the **Ministry of Environment and Forests (MoEF)** has made EIA a statutory requirement in 1994 for 29 specific activities in different sectors like industries, mining, irrigation, power, transport, tourism etc.

- **Mining Projects**
- **Industrial Projects**
- **Thermal Power Projects**
- **River Valley, Multipurpose, Irrigation and H.E. Projects**
- **Infrastructure Development and Miscellaneous Projects**
- **Nuclear Power Projects**

Aims and objectives of EIA

- Modify and improve existing design
- Ensure efficient resource use
- Enhance social aspects
- Identify key impacts and measures for mitigating them
- Inform decision-making and condition-setting
- Avoid serious and irreversible damage to the environment
- Protect human health and safety

Stakeholders Empowerment
Awareness, Environmental capacity
etc.
Scientific Change
Predictive techniques
Accountability, etc
EIA
Institutional change
Environmental capacity, Consent decisions, Accountability, etc.
Design and Engineering Change
Values, visioning, design decisions, etc.
Corporate change
Beliefs, Structure, economics, etc.

EIA—Three core values

- Integrity - the EIA process will conform to agreed standards
- Utility - the EIA process will provide balanced, credible information for decision-making
- Sustainability - the EIA process will result in environmental safeguards

THE EIA PROCEDURE

Project Proposal

↓

Screening

↓

Scoping and consideration of alternatives

↓

Base line data collection

↓

Impact prediction and Assessment of Alternatives

↓

EIA Report

↓

Public hearing

↓

Decision-making

↓

Monitoring the clearance conditions

EIA Process

✓**Screening** – EIA Required or not

✓**Scoping** – Identify the key issues of concern at early stages of plan.

✓**Impact Assessment** – Potential positive/negative environmental, social, economic and cultural impacts including cumulative, regional, temporal and spacial consideration.

✓**Alternatives** – Alternative site/ alternative methodology (clean techniques)

✓**Mitigation** – action to prevent, avoid or mitigate the adverse effect (Pollution control techniques)

✓**Environmental Report** – comprehensive document that reports the finding of EIA

Steps involved in the EIA process

- **Identification and Selection of a competent coordinator for the EIA** and the collection of all relevant background information. This is done immediately after a project is identified.

- Broad analysis of the impacts of project activities with a view to **focus on issues** needing a detailed study.

- Collection of detailed data on the current environmental status of the project site and surroundings (prior to the project implementation) and preparation of the **environmental inventory describing comprehensively all the components of the environment existing** in the area where the proposed project is being considered to be implemented.

- Quantitative Impact evaluation terms including **potential mitigation measures**. Project alternatives should be kept ready before the impact evaluation.

- Impact Assessment taking into account environmental losses and gains as well as economic costs and benefits for each alternative proposed and preparation of an **Environmental Impact Statement (EIS) which will be a formatted public document** specified by authorized national, state and/or local agencies.

Steps involved in the EIA process …(Cont)

- **Public scrutiny** of the EIS and review at public hearings.

- **Detailed documentation** of the work done in the EIA with specific recommendations about the proposed project and **alternatives** with comments on the environmental and economic impacts of each.

- **Decision-making process** by the decision maker. The decisions normally fall into any one of the following categories.

(a) Proposal accepted
(b) Proposal accepted with amendments
(c) Alternate proposal accepted
(d) Proposal is rejected
(e) Further study of the proposal.

- **Post monitoring:** Follow up and monitoring of the project activities during installation and operation phases and conduct audits to compare actual performance with the EIA predictions and suggest improvement measures.

General and industry specific **assessment methods** are available :

❖***Industrial products*** - Product environmental **life cycle analysis (LCA)** is used for identifying and measuring the impact of industrial products on the environment. These EIAs consider activities related to extraction of raw materials, ancillary materials, equipment; production, use, disposal and ancillary equipment.

❖***Genetically modified plants*** - Specific methods available to perform EIAs of genetically modified organisms include GMP-RAM and INOVA.

❖***Fuzzy logic*** - EIA methods need measurement data to estimate values of impact indicators. However, many of the environment impacts cannot be quantified, e.g. landscape quality, lifestyle quality and social acceptance. Instead information from similar EIAs, expert judgment and community sentiment are employed. Approximate reasoning methods known as fuzzy logic can be used. A fuzzy arithmetic approach has also been proposed and implemented using a software tool (TDEIA).

Contents of EIA

(1) Details of the proposed project/action and alternates including all phases of action (Construction, Operation, Shutdown).

(2) Nature and magnitude of the predicted impacts of the proposed action under the following three categories.

(a) Physical: Air, water and land pollution, natural disasters like flood, earthquakes etc.

(b) Biological: Flora and fauna, biodiversity, endangered species.

(c) Socioeconomic.

(3) Identification of human concerns.

(4) Measurement criteria of the significance of the predicted environmental changes.

(5) Estimate the significance of the impacts of the environmental changes.

(6) Recommendations about the acceptability or otherwise of the proposed projects and alternates.

(7) Monitoring procedures during and after implementation of the project.

To quantitatively estimate the impacts of different factors the technique of LEOPOLD MATRIX is often used.

EIA Flowchart

Steps involved in EIA

Advantages of EIA

The EIA Process

The EIA Process comprises

- Screening - to decide if and at what level EIA should be applied
- Scoping - to identify the important issues and prepare terms of reference
- Impact analysis - to predict the effects of a proposal and evaluate their significance
- Mitigation - to establish measures to prevent, reduce or compensate for impacts

The EIA Process (Cont.)

- Reporting - to prepare the information necessary for decision-making
- Review - to check the quality of the EIA report.
- Decision-making - to approve (or reject) the proposal and set conditions
- Follow up – to monitor, manage and audit the impacts of project implementation
- Public involvement - to inform and consult with stakeholders

Benefits of EIA

- **Cost and time saving in project implementation due avoidance of mid course design changes or corrections.**
- **Increases acceptability of the project among all stakeholders.**
- **Laws and regulations of the country/society is fully complied and hence no future conflicts.**
- **Improves project performance by decreased pollutant emissions, effective resource utilization and minimization of treatment and cleanup costs.**
- **A healthy environment (flora, fauna, biodiversity, clean air, water and land).**
- **Improved human health.**
- **Paves way for sustainable development.**

Environment Protection Act

Environmental Legislation

- Protection of environment – needs legislative powers – laws and acts are necessary

  - Wild life protection act 1972
  - Forest conservation act 1980
  - Water (prevention and control of pollution) act 1974
  - Air (prevention and control of pollution) act 1981
  - Environment protection act 1986

First initiative for the protection of environment

- UN conference on human Environment 5 June 1972 in Stockholm

World Environment Day

Indian constitutional provisions

- In 1976 after Stockholm conference – 42nd amendment in the constitution

  - the essence of Article 48A – The state should protect the environment, wildlife and forests

  - the essence of Article 51A(g) – protection and improvement of natural environment, wildlife, forests, rivers, lakes is a duty of citizen of India

Wild Life Protection Act 1972

- In 1976 wild life was transferred from state to central government

- Indian Board of Wild Life (IBWL) – 1952
  - after the act in 1972, it started setting up wild life sanctuaries and parks

Provisions in wild life act 1972…

Provisions in the act

- Defining terminologies
- Appointment of authorities – wildlife wardens, advisory boards etc.
- Listing of endangered species – prohibition of hunting – captive breeding
- Setting up National parks, sanctuaries etc
- Constitution of central zoo authority
- Controlling trading of wild animals
- licensing for sale and possession and transfer of wild animals
- Conservation projects – lion (1972),tiger (1983), crocodile (1974)

Forest Conservation Act 1980

- The act adopted all over India except J& K
- Covers all forests – irrespective of ownership
- Provisions in the act

  - State govt. empowered to use forests only for forestry purpose – non-forestry activity needs approval by central govt. (mining, reforestation with economically important trees)
  - Advisory board and funding for conservation
  - Any non forest illegal activities can be stopped immediately
  - Construction by wild-life authorities allowed (Fencing, water holes, trench, pipelines, check posts, watch tower)

Forest Conservation Act 1980

- 1992 amendment
  - permission for – transmission lines, seismic surveys, exploration, drilling, hydroelectric projects
  - limited cutting of trees with permission
  - in wild life parks and national parks – no exploration or survey without permission
  - cultivation of tea, coffee, spices, rubber – non - forest activity – not allowed in reserve forests
  - cultivation of medicinal trees, fruit-bearing trees – approval from Central Govt. is needed
  - plantation of mulberry – silkworm – non-forest activity
  - mining – prior approval from central Govt.

Forest Conservation Act 1980

- 1992 amendment…

  - removal of stones, boulders etc. from river- beds in forests – non-forest activity

  - Tusser cultivation by tribes allowed as for as it does not involve some specific trees

  - mining needs permission from Central Govt.

  - proposal for non-forest activity – cost benefit analysis and Environmental Impact Statement (EIS) – ecological and socio-economic impacts

Water (prevention and control of pollution) act (1974)

Water pollution – *Contamination or alteration of physical or chemical or biological properties of water by any discharge or any other agent which can cause nuisance to the public or harm or injure the public health or aquatic plants or animal life*

- Maintenance and restoration of quality of all types of water

Water prevention and control of pollution act (1974) contd.

- Establishment of Central and State Pollution Control Boards
- conferring the boards with powers – defining their functions
- provisions for funds, budget, accounts and audit of the boards
- penalties for the offenders and defaulters
- guidelines for the control boards

Roles of Central Pollution Control Board (CPCB)

- advises to central govt.
- coordination of state PCBs – providing technical guidance
- training programs – defining functions
- creating awareness through mass media
- technical and statistical data collection
- manuals for treatment of sewage and industrial effluents
- standards for water quality parameters
- Establish and recognize labs for analysis

State Pollution Control Board (SPCB)

- advises to state govt.
- other activities similar to CPCB
- empowered to take samples for testing from any water body or effluent – how testing conducted?
- any new industry should get consent from SPCB – all technical details in prescribed format and fees should be submitted

Effluent treatment plants ETPs

Air (prevention and control of pollution) act 1981

Air pollution – presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration which is harmful to the environment, animals or plants

- Noise pollution inserted in 1987
- Central and state pollution control boards – take care of air pollution prevention
- section 20 – emission standards for automobiles
- registration of motor vehicles
- state govt. can declare and area as "air pollution control area"

Environment protection act 1986…

- Some definitions were framed

<u>Environment</u> – water, air and land and interrelationship exists among them and between the living beings

<u>Environmental pollution</u> – presence of any gas, solid and liquid substance which is injurious to environment

<u>Hazardous substance</u> – any substance which cause harm to living beings and environment

Environment protection act 1986…

- Standards for quality of air, water and soil
- Maximum permissible limits of pollutants
- Procedures for handling and safeguarding hazardous substances
- Restricting the areas in which hazardous materials are handled
- Safeguards and procedures for the prevention of accidents that can cause pollution

Environment protection act 1986…

Guidelines to PCBs

- Advise the industries about treatment of effluents using advanced technology
- Encourage recycling and reusing wastes
- Encourage recovery of bio-gas, energy and reusable materials
- Emphasize on implementation of cleaner technologies in industries

Enforcement of environmental legislation - drawbacks

- Drawbacks in wild life protection act
- Drawbacks in forest conservation act
- Powers are with central govt. action is delayed
- Penalty is lesser then cost of pollution treatment
- Not included in right to information act
- Legal delays – 60 days notice to central govt.
- Lack of funds
- Out of court settlements
- ETPs are costly for small industries
- Weak govt. policy – political influences on the board heads

Public awareness

- Education does not provide knowledge about environmental and pollution related aspects
- Policy makers – politicians – unaware of environmental and pollution aspects and impacts
- General public are thinking about development but not about the impacts of such development on environment

How to propagate public awareness?

- **Among students – through education**

All stages including school and college level, following the directives of the Supreme Court

- **Among the masses through mass media**

Articles, environmental rallies, plantation campaigns, street plays, real eco-disaster stories and success stories of conservation efforts. TV serials like *Virasat, Race to save the Planet, Heads and Tails, Terra-view, Captain planet*

- **Among policy makers – orientation and training**

Workshops and training programmes, Publication of environment - related resource material in the form of pamphlets or booklets

Sustainable Development

Why did we become a threat to the nature?

- We tried to improve our quality of life
- We want to 'DEVELOP'
- In the process of development we created problems
- Is development wrong? What actually went wrong?

What is wrong in development?

- If a country has sound economy we called it developed – if it does not then it is undeveloped or developing

- We considered "improvement in our economy" as development – That is wrong!

- Economic Development is not the only factor which will decide the quality of life

Focus on Economic development alone led to…

- Over exploitation of natural resources
- Loss of biodiversity
- Human oriented thinking – not bothered about environment and other living beings
- A mentality that don't care about future generation
- Increased economic differences in nations within as well as between different nations

Over fishing

In 2050 there may be scarcity of sea food!

Citizen 1
Citizen 2
Citizen 3
.....Citizen 15
Citizen 1
Oh....
this city is
so dirty !
Don't be the
1st to start
LITTERING

What kind of development we are looking for?

- Two decades back it has been realized that the development should be a

"Sustainable development"

What is Sustainable Development?

- "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

  - Brundtland G.H, former Norweign PM and Director of WHO

Sustainable Development

- A sustainable development is a development in which a balance is maintained between three types of development
  - Social
  - Environment
  - Economic

Sustainable Development

- That means, before going for any developmental activity we should verify,

  How will our action impact people?

  How will our action impact the environment?

  How will our action impact economy?

Everybody *really* wants to…

save money

save the environment

love others

Key aspects of sustainable development

i. Inter-generational equity

We should hand over a safe, healthy and resourceful environment to our future generations

ii. Intra-generational equity

Decreasing the wealth gap between rich and poor, within the country and between the countries should be decreased

Technological developments should aim to solve the problems of poor countries & not always the sophistication of rich

Measures to sustainable development

-How to achieve sustainable development

1. Using appropriate technology
   - Technology employed should be Locally adaptable, eco-friendly, and culturally suitable
   - It involves local resources and local labour – design with nature (ROSATOM)
2. The 3 R's, Reduce, Reuse and Recycle
   - Minimize resource use, reuse again and again, Recycle if not possible to reuse.
3. Prompting environmental education, public awareness and training
4. Resource utilization should be limited to <u>Carrying Capacity</u>

Sustainable development – Indian context

- In the last 50 years our economy has grown – rich poor gap also has grown
- We have become self sufficient in food production
- Our food self-sufficiency came with indiscreet use of fertilizers and pesticides
- We are the largest contributor to population growth – 17 million every year
- Our economy has grown because of increased industries
- Pollution of air, water and land also increased because of these industries
- In the recent past migration from villages to cities has increased tremendously – results in increased need for shelter, food, water, energy-all are concentrated in a small area – threatening the carrying capacity

❖India with rich biodiversity and huge population has a long way to go for sustainable development.

❖**The National Council of Environmental Planning and Coordination (NCPC)** set up in 1972 was the focal agency in this regard.

❖**The Ministry of Environment & Forests (MoEF)** , set up in 1985 has formulated guidelines for various developmental activities keeping in view the sustainability principles.

What can you do?

Personal

- Consumption patterns
- Water & Energy use
- Clothing purchases
- Recreation/hobbies (IPL)
- Yard care, landscaping
- Household Cleaning products
- Home purchase
- Vacation planning
- Family planning
- Transportation choices

Business

- Production methods
- Energy and water use
- Waste disposal
- Employee benefits
- Stockholder relations

Community

- Building a sustainable development center/organization
- Running a summer school
- Conference planning
- Devotional program

Module 6

Human Population Change and Environment

- ❖Urban environmental problems
- ❖Consumerism and waste products
- ❖Promotion of economic development
- ❖Impact of population age structure
- ❖Women and child welfare
- ❖Women empowerment.
- ❖Sustaining human societies
- ▪Economics,
- ▪Environment,
- ▪Policies,
- ▪Education.

Human population Change and the environment

Population growth is exponential

In olden days population was stable

-No modern medical treatments
-Droughts, diseases killed people
-birth mortality was high

In the recent centuries

-More modern medical treatments
-Advancement in science and technology
-more food production
-less birth mortality

Population of India - 1.252 billion (2013)

Figure 6-4 This chart shows the populations of the world's five most populous countries in 2010 and 2050 (projected). In 2010, more than one of every three persons on the earth lived in China (with 19% of the world's population) or India (with 17%). (Data from United Nations Population Division)

- <u>Doubling time</u>

The time needed for a population to double its size at a constant annual rate

$$Td = 70/r$$

Td = doubling time in years

r = annual growth rate

For example, for 2% growth rate the population will double in 35 yrs

- Total fertility rate (TFR)

Average number of children that would be born to a women in her life time if the age-specific birth rates remain constant – key factor that determines population size

In developed nations TFR = 1.9

In developing nations TFR = 4.7

In 1960's in India TFR was ≈6

It is 2.68 in 2007

Total fertility rate of
THE WORLD
ARCTIC OCEAN
N
PACIFIC
OCEAN
PACIFIC
OCEAN
ATLANTIC
OCEAN
INDIAN
OCEAN
SOUTHERN OCEAN
LEGEND
Total Fertility Rate
(Children Born/Woman)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 8
Data not Available
0 2,500 5,000 Km
0 1,250 2,500 Miles
Copyright © 2009 www.mapsofworld.com

- Infant mortality rate

- Percentage of infants died out of those born in a year

- The infant mortality rate is reported as number of live newborns dying under a year of age per 1,000 live births

World historical and predicted infant mortality rates per 1,000 births (1950-2050) UN, medium variant, 2008

Years	Rate	Years	Rate
1950-1955	152	2000-2005	52
1955-1960	136	2005-2010	47
1960-1965	116	2010-2015	43
1965-1970	100	2015-2020	40
1970-1975	91	2020-2025	37
1975-1980	83	2025-2030	34
1980-1985	74	2030-2035	31
1985-1990	65	2035-2040	28
1990-1995	61	2040-2045	25
1995-2000	57	2045-2050	23

Mortality rate map of the world

Deaths per 1000 lives born

- <u>Replacement level</u>

Two parents bearing two children will be replaced by their offspring

- Due to infant mortality replacement level is changed.
- Developing nations replacement level is approx 2.7
- Developed countries it is 2.1

Total Fertility Rate and Infant Mortality Rate in different Countries

Figure 6-5 This graph tracks the total fertility rate for both the more-developed and less-developed regions of the world, 1955–2010, with projections to 2050 (based on medium population projections). Although the world's average TFR has dropped to 2.5, it will have to drop to around 2.1 to eventually halt the world's population growth. (Data from United Nations Population Division)

Figure 6-10 This graph tracks the infant mortality rates for the world's more-developed countries and less-developed countries, 1950–2010, with projections to 2050 based on medium population projections. (Data from United Nations Population Division)

$$\text{Population change} = (\text{Births} + \text{Immigration}) - (\text{Deaths} + \text{Emigration})$$

Age structure

Age structure of population can be represented by age pyramids, based upon people belonging to different age classes

- Pre –reproductive - 0 - 14 years
- Reproductive - 15 - 44 years
- Post –reproductive ≥ 45 years

Population Characteristics

Age structure: Different types -Pyramid, bell and urn shapes – population growth can be predicted

Horizontal axis = Number of individuals

Bell shaped

Pyramid shaped

USA
Canada

Bangladesh
Nigeria
Ethiopia

Stable Population

Increasing Population

Urn shaped

Japan
Germany
Italy
Sweden
Hungary

Declining population

Population Age Structure

CENGAGENOW™ **Active Figure 6-12** This chart represents the generalized population age-structure diagrams for countries with rapid (1.5–3%), slow (0.3–1.4%), zero (0–0.2%), and negative (declining) population growth rates. A population with a large proportion of its people in the prereproductive age group (far left) has a significant potential for rapid population growth. *See an animation based on this figure at* CengageNOW. **Question:** Which of these diagrams best represents the country where you live? (Data from Population Reference Bureau)

- Zero population growth (ZPG)

When Birth plus immigration in a population are just equal to deaths plus emigration, it is said to be zero population growth

- Male-Female ratio

Male to female ratio should be maintained for wellbeing of society

It is altered due to female infanticides

- In china male to female ratio 140:100 created scarcity of brides

- In India male to female ratio 106:100

- <u>Life expectancy</u>

The average age that a new born is expected to attain in a given country

- Life expectancy

  Indian male 60.8yrs female 62.5yrs

  Japanese male 77-77.4 yrs

  female 82.1- 84.2 yrs

Life expectancy is higher in developed countries than developing countries!

Life Expectancy at Birth
Sri Lanka
Pakistan
Nepal
Maldives
India
China
Bhutan
Bangladesh
0
10
20
30
40
50
60
70
80
Years

- <u>Demographic transition</u>

Fall in death rates and birth rates due to improved living conditions leading to low population growth – example developed nations

It occurs in 4 phases

(i) <u>Pre industrial phase</u> – high growth and death rates – net result low population growth

(ii) <u>Transitional phase</u> – death rate become low due to development and birth rate remain high – 2.5-3% growth rate

(iii) <u>Industrial phase</u> – fall in birth rates so lowering growth rate

(iv) <u>Post industrial phase</u> – zero population growth

Demographic Transition

CENGAGENOW™ **Active Figure 6-17** The *demographic transition*, which a country can experience as it becomes industrialized and more economically developed, can take place in four stages. *See an animation based on this figure at* CengageNOW. **Question:** At what stage is the country where you live?

- Due to demographic transition - developed countries growing rate 0.5% with doubling time 118 yrs

- In developing countries – where more than 90% population living – growth rate more than 2%- doubling time less than 35 yrs

Population explosion

- Unprecedented growth of human population in an alarming rate

or

An explosive, i.e. extremely fast, population growth

Population explosion

Adverse effects of population explosion

- resource depletion
- environmental degradation
- increase in waste production
- air, water and soil pollution

Population explosion

- Indian scenario
  - population of India more than 1billion – II populous country next to China
  - in 2050 the expected Indian population 1.63 billion – will surpass China in 2030
  - do we have enough resources to meet this huge population?

Indian population growth

Population explosion

- Malthusian theory – Thomas Robert Malthus

  - Population – exponential growth
  - Food production – very slow growth or remain stable
  - starvation, poverty, disease, crime and misery are expected

  For stabilizing the population growth we need

  – "positive checks" – famines, disease outbreak and violence
  - "preventive checks" – birth control systems

Population explosion

- <u>Marxian theory – Karl Marx</u>
  - Population growth – a symptom rather than cause of poverty, resource depletion, pollution and other problems
  - Social exploitation and oppression of the less privileged people leads to poverty, unemployment, environmental degradation and in turn cause over population

- Population explosion – a time bomb
- How long we can continue with exponential population growth?
- A catastrophic doomsday model warning – earth cannot sustain more than 25 billion

What is the solution?

- need for population stabilization
- developed countries stabilization ratio is 1
- developing country like a Africa the ratio is 3

Stabilization of population possible through "family welfare programmes"

How to slow human population growth?

By

- reducing poverty
- elevating the status of women
- encouraging family planning

Empowering Women Helps to Slow Population Growth

- Women tend to have fewer children if they are **educated**, have the ability to control their own fertility, **earn an income** of their own, and live in societies that **do not suppress their rights**.

- Globally, women account for two-thirds of all hours worked but receive only **10% of the world's income**, and they own less than 2% of the world's land. Women also make up 70% of the world's poor and 64% of its 800 million illiterate adults.

- Thorya Obaid, executive director of the UN Population Fund, "Many women in the developing world are **trapped in poverty by illiteracy, poor health, and unwanted high fertility**. These contribute to environmental degradation and tighten the grip of poverty."

- Bottom-up change by individual women will play an important role in **stabilizing populations, reducing poverty and environmental degradation**, and allowing more **access to basic human rights.**

Family welfare programmes

- Family planning

Allows the couple to decide the size of a family & time space between their off springs

Modern scientific methods

- barriers – condoms
- surgical methods – vasectomy, female tubal ligation
- oral contraceptives – pills
- implants – Copper "T"

United nations family planning agency – funds for 135 countries

WHO estimate – 50% couples use some family planning measure – 10%, 30 yrs ago

Family planning

- *Indian scenario*

•NGO's like Indian family planning association of India (FPA) and Govt.

•Family planning programme in India started in 1952

•In India we are targeting two children per couple

•Several methods are available to reduce birth rate of children but not working that well in India

-Lack of education: many people are scared to use these methods

-Religious misbelieves : It is wrong in almost all religions to stop child birth

Family planning Indian scenario…

- In 1978 the central Govt. raised the legal minimum age for marriage from 18 to 21
- Still the growth rate did not decrease
- It then allowed states to employ their own methods
- The first state to achieve zero population growth in the country is Kerala

Family planning Indian scenario…

Kerala – a case study

- The first state to achieve zero population growth in the country
- Average age of a person at the time of marriage is 21 years
- Female literacy 53% (against 13% average)
- Emphasis on primary education 60% budget allocation – 50% in other states
- Distribution/availability of food – 97%
- Medical facilities – available to all villages
- Reason: Educated took interest in the state. They created awareness among the common. Even people listened.

Andra Pradesh

- Next state to get ZPG AP. There the method is different. They gave incentives to all those who got sterilized
- Population is still growing in UP and Bihar.

Environment and Human Health

What is the definition of health?

- According to WHO: Health is the state of complete physical, mental and social well being, and not merely absence of disease
- Human health is affected by factors
  - nutritional
  - biological
  - chemical and physiological

Environmental factors affecting human health

- Infectious organisms
- Chemicals
- Noise
- Radiations
- Diet
- Settlement

Infectious organisms

- Virus, bacteria and worms

  More in Tropical regions – the temperature and moisture levels are ideal for growth of virus, bacteria, worms – malnutrition adds to it

- Food poisoning

  due to worms and molds, that produce toxins in stale food

Infectious organisms

Diseases

- Respiratory diseases like pneumonia, tuberculosis, influenza
- Gastrointestinal diseases like diarrhea, dysentery and cholera
- Parasitic diseases like malaria, Schistosomiasis, (caused by eggs of worms), filariasis

Chemicals
- Anthropogenic activities

- Industrial effluents: various pollutants are emitted into air and water
  - carcinogenic
  - mutagenic
  - teratogenic
  - nurotoxins

Chemicals
- Anthropogenic activities

- Pesticides - like DDT and other chlorohydrocarbons can bioaccummulate
- Heavy metals – mercury, cadmium, lead
- Metallic containers - Copper in Brass dissolves into food while cooking – acidic food
  - Many metal ions are toxic when taken in excess – including iron salts

Chemicals - Anthropogenic activities

- Minamata disease by mercury
- Parkinson's disease by copper
- Alhzeimer's disease by aluminium

Noise

- Noise can cause various problems
  - Deafness
  - Physiological: Pain in the ears, Increased BP, gastric troubles
  - Psychological: Annoyance, mental instability

Radiation

Radiation: From nuclear leaks, ozone layer depletion

Diseases:

- They cause short term and long term changes in organs
- Can cause DNA mutations
- Cosmic and UV radiations can cause skin problems – skin cancer

Diet

- Malnutrition:
  - Lack of food
  - Lack of awareness
  - Lack of interest
- Diseases caused due to malnutrition are numerous
  eg: All vitamin deficiencies have specific diseases

- Food contamination & Diseases:
  - Dropsy - contamination of mustard with poisonous seeds – *argemone mexicana*

Malnutrition Map

Settlement

- Proper environment - availability of proper ventilation, food, water, sanitation etc
- Security
- Improper settlement causes psychological problems – annoyance, intolerance – can affect physiological process in the body

HIV/AIDS

- HIV - Human Immunodeficiency Virus
- AIDS - Acquired Immuno Deficiency Syndrome
- Discovered in 1983
- World wide 40 million affected - mostly in Africa, India, China, Russia
- 3 million died in 2003 due to HIV/AIDS

Where did it come from?

- Some believe that the origin is from monkeys, and other apes in Africa
  - It spread through HIV contaminated polio vaccine programs
  - Hepatitis B viral vaccine in New York, Los Angeles and San Francisco
  - Through small pox vaccine programs of Africa

- Some believe that it is man made - Genetic Engineering

How does it spread?

- Blood contact
  - Blood transfusion
  - Use of infected injection syringes, surgery tools
  - Can spread in Doctors if they do not use gloves
- Through unprotected sex
- Can pass from mothers to their babies
  - During delivery and breast feeding

How does it not spread?

- It does not spread through sweat, tears, urine or saliva
- It does not spread through mosquito or bed bug bites
- It does not spread through simple touch.
- It does not spread through sharing utensils, towels, clothing etc.
- The virus dies quickly outside blood

Effects of HIV/AIDS on Environment

- Large number of deaths can cause changes in local environment
- Most of the people infected are labours - loss of labour and so production decreases
- With fewer adults, children find it difficult to survive
- People who are infected become weak and cannot do hard physical work like farming – crops and food production will fall
- Without labour, less time will be spent on activities like soil conservation

Effect of AIDS on Population

Figure 6-16 *Global outlook:* Worldwide, AIDS is the leading cause of death for people ages 15–49. This loss of productive working adults can affect the age structure of a population. In Botswana, more than 24% of this age group was infected with HIV in 2008 and about 148,000 people died. This figure shows two projected age structures for Botswana's population in 2020—one including the possible effects of the AIDS epidemic (red bars), and the other not including those effects (yellow bars). See the Data Analysis Exercise at the end of this chapter for further analysis of this problem. (Data from the U.S. Census Bureau) **Question:** How might this affect Botswana's economic development?

Treatment

- HIV/AIDS itself does not kill a person. It has no symptoms – no cure as yet
- Highly Active Antiretroviral Therapy - HAART
- People die due to loss of immunity – which makes them prone to all infectious diseases
- There is treatment available to most of the infectious diseases like pneumonia, tuberculosis etc.
- Vaccine?

Women and Child Welfare

Women Welfare
Why to consider women welfare?

- Women suffer in many ways because they are physically weak and harassed
  - For cultural reasons, domestic violence, mental torture, physical work
- They are often denied of even their fundamental rights
- Gender discrimination exists in many parts of the world – girl children are not sent to school, often not given even enough food and women are not permitted to come out of the house.
- Displacement causes special problems to women.
  - When men go to other places in search of jobs, women are left behind. They do not get any compensation. They will become dependent on males for wages or they may have to take up less decent jobs which are humiliating and give less income.

International level

- United Nations Decade for Women (1975-85)
- It held an international convention on the elimination of all forms of Discrimination Against Women, 1979

What Organizations are working for women?

- There is a need for more stringent laws
- These aspects are looked into in Ministry of Women and Child development
  - Works for education, family planning, health care and awareness.
- Many women groups have formed which take up women welfare issues
- There are legally constituted “women cells” to take care of legal problems of women
- Displacement of women due to mining and associated problems are taken care of by National Network for Women and Mining” – 20 groups in different states
- NGO’s like Mahila Mandals – trying to create awareness amongst women of remote villages about their rights.

CHILD WELFARE

What problems do children have?

- Out of 21 million born, 1 million are abandoned
  - Social and economic reasons

What problems do children have?

- Children are more prone to diseases – especially water borne diseases
- Childhood cancer rates are increasing at the rate of 6%/year
- Toxic pollutants are causing birth defects

What problems do children have?

- 20 million are estimated to be child labours in India
  - Some in hazardous industries
  - Brass, match making, fireworks…

Child labour

- Main cause is poverty
  - They do not get nutritive food even
  - They are often forced to work and not paid well for their work
  - Their working conditions are unhealthy
  - They do not get any education

Solution

UN General Assembly in 1959 adopted the "Declaration of the Rights of a Child"

- It became **INTERNATIONAL LAW** in 1990
- The law defines the rights of children
  - Survival, protection, development and participation

1. Right to survival: Good standard of living, good nutrition and health
2. Right to protection: Freedom from exploitation, abuse and inhuman treatment
3. Right to development: Access to education, early child care and support, social security and right to leisure and recreation
4. Right to participation: Freedom of thought, conscience and religion and right to appropriate information

Solution

- World summit on children in 1990
- Agenda for the well being of children – to be achieved by the new millennium
- India also signed to agree with it.
- Ministry of Human Resource Development has formulated the plan for child development

Strategic Plan for Child Development

- Priority is given for
  - Health, education, nutrition, clean and safe drinking water, sanitation and good environment
  - Access to schooling, specially for girls
  - Education including health and nutrition, diseases and their causes
  - Up gradation of home-based skills for girls,
  - Mid-day meals scheme
  - Low cost early childhood development activities

Urbanization

Urbanization

- What is urbanization
  - Increased population in cities due to migration of people from rural areas
- Why does it occur?
  - In search of employment
  - For better education for children
  - For better commodity availability
  - For better health facilities

Urbanization

What is the impact of urbanization on environment?

- Increase in population density
- Closely constructed houses
- Increased traffic – traffic jams
- More need for resources –energy, water, fuel
  - Stress on locally available resources
- Greater pollution – air, water, soil – waste dumping…
- Increased chance of epidemics
- Decreased aesthetic appeal of landscape
- Loss of farmland
- Reduced species diversity
- Increased stormwater runoff – due to construction of pavements..
- Increased risk of flooding
- Excessive removal of native vegetation
- Ecosystem fragmentation

Urban problems related to energy

- Population in urban areas increases whereas the opposite occurs in rural areas
- More than 50% of the world's population is in urban areas
- Movement of people from rural to urban area – expansion of cities "Urban Sprawl"
- Urban set-up – consumes more energy – produce more wastes

Energy demanding activities in Urban areas

- Lightings
- Transportation
- Modern electrical gadgets
- Industries
- Waste disposal – consume energy
- Prevention of pollution – needs energy

What is carrying capacity?

- **The number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations**

- If the carrying capacity is exceeded it will negatively impact sustainable development

- No population can live beyond the environment's carrying capacity for long time

Carrying capacity

- Two components:
  - Supporting capacity - the capacity to regenerate
  - Assimilative capacity - the capacity to tolerate different stresses

Consumerism

Consumerism

- **Consumer** - someone who buys and uses goods and services
- **Consumerism**

  - a theory that a progressively greater consumption of goods is economically beneficial

  - a preoccupation with and an inclination towards the buying of consumer goods

  - refers to consumption of resources by people

Problem of improper consumerism

- Uncontrolled manufacture of foods leading to inferior quality
- Rampant adulteration leading to health and hygiene problems
- Improper services resulting in dissatisfaction and stress
- Production of lots of waste leads to depletion of natural resources and environmental imbalance

- **Consumerism**
  - increasing exponentially due to increase in population
  - more demanding life-style

Two types of conditions

(i) People over-population

(ii) Consumption over-population

(i) People over-population

- more people than available resources
- over-exploitation of resources
- environmental degradation
- poverty, premature deaths, under-nourishment
- Less developed countries (LDCs) – over all consumption is high – per capita consumption less

(ii) Consumption over-population

- MDCs – more developed countries
- less population but consumption of more resources
- per capita consumption is high – luxurious life style
- more consumption of resources and hence more waste generation

Consumerism and impact on environment

Paul Ehrlich and John Hodlren (1972) model

Number of people x Per capita usage of resources x Waste generated per unit of resource used = Over all impact on environment

More developed country (MDC)

Less developed country (LDC)

Population

Percapita resource use

Waste generated per unit of resource

Overall environmental degradation

Comparison of consumerism and waste generation

Parameter	Percent global values	
	USA	India
Population	4.7%	16%
Production of goods	21%	1%
Energy use	25%	3%
Pollutants/ wastes	25%	3%
CFC production	22%	0.7%

Japan with similar life-style of USA create less impact – 3Rs

Sustaining Human Societies

Politics, Environment, and Sustainability

Economic Systems – Supported by Three Types of Resources

- **Natural capital**

- resources and services produced by the earth's natural processes, which support all economies and all life.

- **Human capital, or human resources, includes**

-people's physical and mental talents that provide labor, organizational and management skills, and innovation.

- **Manufactured capital, or manufactured resources**

- items such as machinery, equipment, and factories made from natural resources with the help of human resources.

Natural Capital | Manufactured Capital | Human Capital | Goods and Services

Figure 23-2 In an economic system, we use three types of resources to produce goods and services.

High throughput Economy
(Negative impact on Environment)

Human Economies are subsystems of Biosphere

CENGAGENOW™ **Active Figure 23-5** *Ecological economists* see all human economies as subsystems of the biosphere that depend on natural resources and services provided by the sun and earth. *See an animation based on this figure at* CengageNOW. **Question:** Do you agree or disagree with this model? Explain.

Ecological economists suggest that:

1. **Resources are limited and we should not waste them**, and there are no substitutes for most types of natural capital.

2. We should **encourage environmentally beneficial and sustainable forms of economic development**, and discourage environmentally harmful and unsustainable forms of economic growth.

3. The harmful environmental and health effects of producing economic goods and services should be included in their market prices **(full-cost pricing)**, *so* that consumers will have more accurate information about the harmful environmental and health effects of the goods and services they buy.

Economic Tools for Environmental Protection

- Economic growth is usually measured by the percentage change in a country's GDP.

- **Gross domestic product (GDP): the annual market value of all goods and services** produced by all firms and organizations, foreign and domestic, operating within a country.

- Changes in a country's economic growth per person are measured by **per capita GDP: the GDP divided by a country's total** population at midyear.

▪New indicators—called **environmental indicators**—to help monitor environmental quality and human well-being.

▪One such indicator is the **genuine progress indicator (GPI)**—GDP plus the estimated value of beneficial transactions that meet basic needs, but in which no money changes hands, minus the estimated harmful environmental, health, and social costs of all transactions.

$$\text{Genuine progress indicator} = \text{GDP} + \text{benefits not included in market transactions} - \text{harmful environmental and social costs}$$

▪**Gross national happiness (GNH)** as a measure of its efforts toward sustainable economic development. Its GNH is based on an evaluation of the country's conservation of its natural environment, preservation of cultural values, fairness in access to its wealth (equity), and good governance

Ways to Sustainable Environment

- Environmental Economic Indicators Could Help Us Reduce Our Environmental Impact
- Include the Harmful Environmental Costs of Goods and Services in Their Prices
- Label Environmentally Beneficial Goods and Services
- Reward Environmentally Sustainable Businesses
- Tax Pollution and Wastes Instead of Wages and Profits
- Environmental Laws and Regulations Can Discourage or Encourage Innovation
- Use the Marketplace to Reduce Pollution and Resource Waste
- Reduce Pollution and Resource Waste by Selling Services Instead of Things

Trade-Offs

Environmental Taxes and Fees

Advantages

Help bring about full-cost pricing

Encourage businesses to develop environmentally beneficial technologies and goods to save money

Easily administered by existing tax agencies

Disadvantages

Low-income groups are penalized unless safety nets are provided

Hard to determine optimal level for taxes and fees

Governments may use money as general revenue instead of improving environmental quality and reducing taxes on income, payroll, and profits

Trade-Offs

Tradable Environmental Permits

Advantages

Flexible

Easy to administer

Encourage pollution prevention and waste reduction

Permit prices determined by market transactions

Disadvantages

Big polluters and resource wasters can buy their way out

May not reduce pollution at dirtiest plants

Caps can be too high and not regularly reduced to promote progress

Self-monitoring of emissions can allow cheating

Environmental Policy life cycle

What Can You Do?

Influencing Environmental Policy

- Become informed on issues
- Make your views known at public hearings
- Make your views known to elected representatives, and understand their positions on environmental issues
- Contribute money and time to candidates who support your views
- Vote
- Run for office (especially at local level)
- Form or join nongovernment organizations (NGOs) seeking change
- Support reform of election campaign financing that reduces undue influence by corporations and wealthy individuals

Poverty and Environmental Issues

Reducing poverty can help us to reduce population growth, resource use, and environmental degradation.

- Mount a massive global effort to combat **malnutrition and the infectious diseases** that kill millions of people prematurely
- Provide universal **primary school education** for the world's nearly 800 million illiterate adults (a number that is 2.5 times the size of the U.S. population).

According to Nobel Prize–winning economist Amartya Sen, **"Illiteracy and innumeracy are a greater threat to humanity than terrorism."** Illiteracy can also foster terrorism and strife within countries by creating large unemployed individuals who have little hope of improving their lives or those of their children.

- Provide assistance to stabilize population growth in less-developed countries as soon as possible, mostly by investing in **family planning, reducing poverty, and elevating the social and economic status of women**. Focus on sharply reducing the total and per capita ecological footprints of their own countries as well as those of rapidly growing less-developed countries such as China and India.
- Make large investments in small-scale infrastructure such as **solar-cell power facilities in villages, as well as sustainable agriculture projects** that would enable less-developed nations to work towards more energy-efficient and sustainable economies.
- Encourage **lending agencies to make small loans to poor people** to increase their income.

Sustainable Economy – A Low throughput Economy

CENGAGENOW™ **Active Figure 23-13** **Solutions:** Learning and applying lessons from nature can help us design and manage more sustainable economies. A *low-throughput economy*, based on

Eco-Economy

Environmentally Sustainable Economy (Eco-Economy)

Economics

- Reward (subsidize) environmentally sustainable economic development
- Penalize (tax and do not subsidize) environmentally harmful economic growth
- Shift taxes from wages and profits to pollution and waste
- Use full-cost pricing
- Sell more services instead of more things
- Do not deplete or degrade natural capital
- Live off income from natural capital
- Reduce poverty
- Use environmental indicators to measure progress
- Certify sustainable practices and products
- Use eco-labels on products

Resource Use and Pollution

- Cut resource use and waste by reducing, reusing, and recycling
- Improve energy efficiency
- Rely more on renewable solar, wind and geothermal energy
- Shift from a nonrenewable carbon-based (fossil fuel) economy to a non-carbon renewable energy economy

Ecology and Population

- Mimic nature
- Preserve biodiversity
- Repair ecological damage
- Stabilize human population

Figure 23-14 Solutions: We can use certain principles for shifting to more environmentally sustainable economies, or *eco-economies*, during this century.

Environmentally Sustainable Economies

We can use the three principles of sustainability as well as various economic and environmental strategies to develop more environmentally sustainable economies.

- To estimate and include the harmful environmental and health costs of producing goods and services in their market prices.

- Phasing out environmentally harmful subsidies and tax breaks, and replacing them with environmentally beneficial subsidies and tax breaks.

- Tax pollution and wastes instead of wages and profits, and to use most of the revenues from these taxes to promote environmental sustainability and to reduce poverty.

Environmental Education

Educational institutions around the world can also play a key role in making the transition to more sustainable economies by giving all students a basic environmental education and developing business schools that integrate sustainable business planning and management into their curricula.

Environmentally Sustainable Careers

Environmentally Sustainable Businesses and Careers

Aquaculture

Biodiversity protection

Biofuels

Climate change research

Conservation biology

Ecotourism management

Energy-efficient product design

Environmental chemistry

Environmental design and architecture

Environmental economics

Environmental education

Environmental engineering

Environmental entrepreneur

Environmental health

Environmental law

Environmental nanotechnology

Fuel cell technology

Geographic information systems (GIS)

Geothermal geologist

Hydrogen energy

Hydrologist

Marine science

Pollution prevention

Recycling and reuse

Selling services in place of products

Solar cell technology

Sustainable agriculture

Sustainable forestry

Urban gardening

Urban planning

Waste reduction

Watershed hydrologist

Water conservation

Wind energy

Module 7

Global climatic change and Mitigation

- Climate disruption
- Green house effect
- Ozone layer depletion
- Acid rain
- Kyoto protocol, Carbon credits
- Carbon sequestration methods
- Montreal Protocol
- Role of Information technology in environment
- Case Studies

The Greenhouse Effect
Sun
Solar radiation
Reflected heat
Radiated heat
Re-radiated heat
Increasing greenhouse gases absorb & re-radiate heat
Carbon dioxide & other gases
Earth

Natural
Greenhouse Effect
Good!
More heat escapes
into space
SUN
Solar Radiation
Less
re-emitted
heat
Re-radiated
Heat
CH_4
N_2O
CO_2
Greenhouse Gases
Atmosphere
Human Enhanced
Greenhouse Effect
Bad!
Less heat escapes
into space
SUN
Solar Radiation
More
re-emitted
heat
Re-radiated
Heat
CO_2
CH_4
N_2O
More Greenhouse Gases

Greenhouse gases

- Water vapor (H_2O)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- CFC

Effects of Climatic disruption

- According to the 2007 IPCC report, projected climate disruption is likely to upset **ecosystems, decrease biodiversity, and degrade ecosystem services.**
- **Agriculture Could Face an Overall Decline**
- **A Warmer World Is Likely to Threaten the Health of Many People**

- Atmospheric carbon level of 450 ppm
- Melting of all Arctic summer sea ice
- Collapse and melting of the Greenland ice sheet
- Severe ocean acidification, collapse of phytoplankton populations, and a sharp drop in the ability of the oceans to absorb CO_2
- Massive release of methane from thawing Arctic permafrost
- Collapse and melting of most of the western Antarctic ice sheet
- Severe shrinkage or collapse of Amazon rainforest

Mitigate Climate Disruption

Solutions

Slowing Climate Disruption

Prevention

Cut fossil fuel use (especially coal)

Shift from coal to natural gas

Improve energy efficiency

Shift to renewable energy resources

Transfer energy efficiency and renewable energy technologies to developing countries

Reduce deforestation

Use more sustainable agriculture and forestry

Put a price on greenhouse gas emissions

Reduce poverty

Slow population growth

Cleanup

Remove CO_2 from smokestack and vehicle emissions

Store (sequester) CO_2 by planting trees

Sequester CO_2 in soil by using no-till cultivation and taking cropland out of production

Sequester CO_2 deep underground (with no leaks allowed)

Sequester CO_2 in the deep ocean (with no leaks allowed)

Repair leaky natural gas pipelines and facilities

Use animal feeds that reduce CH_4 emissions from cows (belching)

What Can You Do?

Reducing CO_2 Emissions

- Calculate your carbon footprint (see websites listed at left)
- Drive a fuel-efficient car, walk, bike, carpool, and use mass transit
- Reduce garbage by recycling and reusing more items
- Use energy-efficient appliances and compact fluorescent or LED lightbulbs
- Wash laundry in warm or cold water
- Dry clothes on a rack or line
- Use a low-flow showerhead
- Eat less meat or no meat
- Heavily insulate your house and seal all air leaks
- Use energy-efficient windows
- Insulate your hot water heater and set it no higher than 49°C (120°F)
- Plant trees to shade your house during summer
- Buy from businesses working to reduce their emissions

Pollution Case Studies

The Bhopal Gas Tragedy

- World's worst industrial accident occurred in Bhopal, M.P
- Incident occurred in **03.12.1984 at Union Carbide Company, which manufacture Carbaryl pesticide using Methyl isocyanate (MIC).**
- **Due to accidental entry of water in the tank, the reaction mixture got overheated and exploded.**
- **40 tons of Methyl isocyanate (MIC) leaked into the atmosphere**

The Bhopal Gas Tragedy contd.,

- Lower conc. of MIC affects lungs, eyes and causes irritation in the skin.
- Higher conc. of MIC remove oxygen from the lungs and can cause death.
- About **2,50,000** persons were exposed to MIC
- **5100** persons were killed
- **65,000** people suffered from various disorders such as respiratory, neuromuscular etc.
- **1000** people become blind.

Chernobyl Nuclear Disaster

- Chernobyl nuclear accident is the worst nuclear disaster in the history occurred at Chernobyl, Ukraine (USSR) on **26.04.1986**
- Chernobyl power plant designed to produce 1000 MW electrical energy.
- It was shut down on **25.04.1986 for intermediate repairs.**
- **Due to faulty operations of shutting down the plant, an explosion occurred in the reactor at 01.23 hrs on 26.04.1986.**
- **Three seconds later another explosion occurred.**

Chernobyl Nuclear Disaster

- Fire started at the reactor due to combustion of graphite rods.
- Fuel, radioactive debris and gases drifted over most of the northern hemisphere (Poland, Denmark, Sweden and Norway were affected.
- The debris was rich in Iodine-131, Cesium 134 and Cesium 137
- Due to this 5,76,000 people exposed to the radiations and suffered from cancer specially thyroid cancer and leukemia.
- More than 2000 people died

Photochemical smog

Photochemical smog is a mixture of pollutants which includes particulates, nitrogen oxides, ozone, aldehydes, peroxyethanoyl nitrate (PAN), unreacted hydrocarbons, etc.

The smog often has a brown haze due to the presence of nitrogen dioxide. It causes painful eyes.

The Cause

- The condition needed for the formation of the smog are present in modern cities. They included sunlight, hydrocarbons, nitrogen oxides and particulates which act as catalyst.
- These are the equations in the formation of photochemical smog.

$$NO_2 \xrightarrow{uv} NO + O\cdot$$

$$O\cdot + O_2 \longrightarrow O_3$$

$$O\cdot + \text{hydrocarbons} \longrightarrow \text{aldehydes}$$

$$O_3 + \text{hydrocarbons} \longrightarrow \text{aldehydes}$$

$$\text{hydrocarbons} + O_2 + NO_2 \longrightarrow \text{lachrymatory substances (like PAN)}$$

Photochemical smog

Where do the reactants come from?

- NO_x primarily from transportation
- VOC from a variety of sources, including refining, other industries, etc.

Effects

- It can cause **headaches**, eye, nose and throat **irritations**. It may cause the **lung function impaired, coughing and wheezing**.
- It can cause **rubbers** and **fabrics to deteriorate**.
- It can **damage plants**, leading to the **loss of crops**.

London smog

On 9 December 1952, in London.

- Being very cold, most houses kept fires burning, with coal as the major fuel.
- The smoke from these fires mixed with the fog and was unable to disperse, resulting in a smog which persisted for 4 days.
- The pH of air during the Great London Smog was as low as 1.6.
- During this period some 4000 more people died than would expected at this time of the year.
- Most of these additional deaths were due to respiratory disorders.
- Coal containing high sulfur content releases sulfur dioxide when burnt. The sulfur dioxide dissolved in moisture caused the low pH.

New York City, before and after a photochemical smog.

Ozone Depletion

The ozone layer is found in the stratosphere

The ozone layer is in the stratosphere

Good up high! →

Bad nearby! →

Ozone Layer is located in the stratosphere

- It protects the Earth from ultraviolet rays emitted by the sun.
- The wavelengths of ultraviolet radiation are absorbed by the ozone molecules.

Figure Q3-1. UV-B protection by the ozone layer.

Ozone absorbs UV-B radiation

There is a natural cycle of formation and depletion of ozone

Ozone Thinning over Antarctica - 2009

Figure 19-21 **Natural capital degradation:** This colorized satellite image shows massive ozone thinning over Antarctica during several months in 2009. The center of this image shows a large area where the concentration of ozone has decreased by 50% or more. (Data from NASA)

Figure 54.27b Erosion of Earth's ozone shield: Thickness of the ozone layer

(b) Thickness of the ozone layer

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Sherwood Rowland, Mario Molina, Paul Crutzen– 1995 Nobel Prize Winners for Atmospheric chemistry

Ozone Depletion

- Chlorofluoro carbons (CFC’s) and other halogenated hydrocarbons contribute to the destruction of stratospheric ozone.

- Just one chlorine and bromine atom can catalyze the destruction of 100,000 ozone molecules

Halogenated hydrocarbons

- CFC's (chlorofluorocarbons)
- Other harmful compounds include HCFCs, methyl bromide, carbon tetrachloride, NO_2, and methyl chloroform.
- CFCs were used in refrigerators, home insulation, aerosols, plastic foam, and throwaway food containers.

Note: Both chlorine and bromine from halogenated hydrocarbons deplete the ozone.

"CFC's?! I've been using this stuff for years!"

Ozone depletion

- Chlorine and bromine-containing compounds (CFC's) are stable in the troposphere, but degraded under intense ultraviolet light in stratosphere.

- UV rays release the chlorine (Cl) from the CFCs, causing ozone (O_3) to be depleted

- The chlorine and bromine atoms catalyze the destruction of stratospheric ozone.

Ozone Destruction Cycle 1
Oxygen molecule (O_2)
Chlorine atom (Cl)
Ozone (O_3)
ClO + O reaction
Chlorine catalytic cycle
Cl + O_3 reaction
Ozone destruction
Oxygen atom (O)
Chlorine monoxide (ClO)
Oxygen molecule (O_2)
$ClO + O \rightarrow Cl + O_2$
$Cl + O_3 \rightarrow ClO + O_2$
Net: $O + O_3 \rightarrow 2O_2$

Effects of UV Radiation to humans

- Linked to skin cancer – a deadly cancer

- Linked to cataracts on the lens of the eye causing blindness

Uv light changes DNA in the skin, this can cause tumors, and can lead to cancer

Natural Capital Degradation

Effects of Ozone Depletion

Human Health

- Worse sunburns
- More eye cataracts and skin cancers
- Immune system suppression

Food and Forests

- Reduced yields for some crops
- Reduced seafood supplies from reduced phytoplankton
- Decreased forest productivity for UV-sensitive tree species

Climate Change

- While in troposphere, CFCs act as greenhouse gases

Wildlife

- Increased eye cataracts in some species
- Decreased populations of aquatic species sensitive to UV radiation
- Reduced populations of surface phytoplankton
- Disrupted aquatic food webs from reduced phytoplankton

Air Pollution and Materials

- Increased acid deposition
- Increased photochemical smog
- Degradation of outdoor paints and plastics

ACID RAIN

INTRODUCTION

- Rain is slightly acidic because it contains dissolved carbon dioxide (CO_2), Sulphur dioxide (SO_2) and Nitrogen oxides (NO_x) which are normally present in the air.
- Acid rain contains more acidity than the normal value
- Due to presence of acid ions & due to the dissolution of these gases present in higher concentration
- Air pollution caused by gaseous emissions from **industrial sources**, **burning of fuels** (thermal plants, chimneys of brick-kilns or sugar mills) and **vehicular emissions**.
- Acid rain will occur locally near the sources of air pollution.
- Due to the movement of air, acid rain may occur for away from the source.

Acid Rain

gases carried
by the wind
acidic gases
(sulphur dioxide and
nitrogen oxides released
into atmosphere)
gases dissolve in
rainwater to form
acid rain
acid rain kills plantlife,
pollutes rivers and streams,
and erodes stonework

Acid Rain

- U.K. contributes 26% of the acidic sulphur deposited in the Netherlands, 23% in Norway and 12% in Sweden.

- Acid emissions arise naturally from volcanoes, forest fires and biological decomposition, especially in the oceans.

- SO_2 pollutions is mostly contributed by thermal power plants, refineries industry and NO_x form road transport, power stations and industry.

- Acid gas concentrations in the air will vary according to location, time and weather conditions.

Effects of Acid Rain

- **Damage to aquatic life**
  - reduction in diversity and populations of fresh water species
  - soil organisms are killed in acid rain
- **Damage to Trees and Plants**
  - SO_2 has a direct toxic effect on trees
  - acidifying soils which may cause loss of essential nutrients such as magnesium, thus impairing plant growth
- **Damage to Buildings and Materials**
  - All historic buildings suffer damage and decay with time
  - SO_2 penetrated porous stones such as limestone and is converted to calcium sulphate

Effects of Acid Rain on Aquatic Life

- **Damage to aquatic life**
  - reduction in diversity and populations of fresh water species
  - soil organisms are killed in acid rain

Effects of Acid Rain on Trees

- **Damage to Trees and Plants**
  - SO_2 has a direct toxic effect on trees
  - acidifying soils which may cause loss of essential nutrients such as magnesium, thus impairing plant growth

- **Damage to Buildings and Materials**
  - All historic buildings suffer damage and decay with time
  - SO_2 penetrated porous stones such as limestone and is converted to calcium sulphate

Effects of Acid Rain on Taj Mahal

REDUCING ACID POLLUTION

- fuels may be treated to reduce their sulphur content
- reduce the eventual emissions of SO_2 by the introduction of a sorbent such as limestone
- No_x can be reduced by adding ammonia and passing it over a catalyst to produce nitrogen and water. This process is called **selective catalytic reduction** (SCR)
- fitting a catalytic converter to the exhaust system reduces NOx emissions by up to 90%
- to develop non-fossil fuel energy sources such as nuclear power or renewable energy (solar, wind, tidal power, etc.)

Kyoto Protocol, Carbon Credits, Montreal Protocol, and Carbon Sequestration

Introduction

- The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change
- It aims at reduction of Green House Gases (GHGs) and others like CFCs
- The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005.
- Currently, there are 192 Parties (191 States and 1 regional economic integration organization) to the Kyoto Protocol to the UNFCCC.
- Countries have committed to cut emissions of CO_2
- Other Green house gases such as Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFC's), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6).

Goals of Kyoto Protocol

- To reduce emissions of greenhouse gases by **5.2% by 2012**
- Individual countries were assigned higher or lower targets
- Due to more than 150 years of industrial activity, developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere
- The total percentage of developed countries emissions is 63.7%
- Protocol places a heavier burden on developed nations
- Any country that fails to meet its **Kyoto Protocol** target will be penalized

Characteristics of Kyoto Protocol

- India and China are not obligated to reduce greenhouse gas production at the moment as they are developing countries
- The Protocol allows developed countries to meet their GHG emission limitations by several "flexible mechanisms"
  - Emissions trading (in terms of carbon credits/Kyoto credits)
  - Clean Development Mechanism (CDM)
  - Joint implementation

Carbon Credits

- Carbon credits and carbon markets are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs)
- One carbon credit is equal to reduction of one ton of carbon dioxide
- The goal is to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions of GHGs into the atmosphere.
- During Kyoto protocol, allocation of carbon credits or Kyoto credits was made to different countries.
- Each credit gives the owner the right to emit one metric tonne of carbon dioxide or other equivalent greenhouse gas.

Carbon Credits

- If a country exceeds its emission quota, it has to pay for it in three possible mechanisms to get back the credits:-
  - Mechanims I – **Emission Trading**
  - Mechanism II – **Clean Development Mechanism**
  - Mechanism III – **Joint Implementation Mechanism**
- Carbon credits can be gained even by individuals within a country by developing projects that reduce GHG emissions.
- Several private and government organizations are existing now for sale and purchase of carbon credits.
- The actual value of each credit may vary, subject to the market position. Currently its value is about 12-20 Euros.

Carbon Credits – India Scenario

- India has generated approximately 30 Million carbon credits
- 140 million in run, the second highest transacted volumes in the world.
- India's carbon market is growing fast
- 850 projects with a huge investment of Rs 650,000 million are in pipeline.
- The revenue from 200 projects is estimated at Rs. 97 billion till 2012 (As per the Prime Minister's Council on Climate Change)
- India has been able to register approximately 350 projects spread across various sectors

Renewable energy status in India

Source/Systems	Approximate potential	Achievements
Biogas plants (nos.)	12 million	3.50 million
Improved cook stoves (nos.)	120 million	35.2 million
Biomass power/ cogeneration	19500 MW	450 MW
Biomass gasifiers		52 MW
Wind energy	45000 MW	1702 MW*
Small hydro power	15000 MW	1461.43 MW
Solar PV	20 MW/sq. km	9.6 MW
Waste-to-energy	1700 MWe	22 MWe
Solar water heating (collector area)	140 sq. m	0.65 sq. m

Montreal Protocol

INTRODUCTION

- The Montreal Protocol on Substances That Deplete the Ozone Layer
- It is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion.
- Treaty was opened for signature on September 16, 1987
- Came into force on January 1, 1989
- In 1987, representatives of 36 nations met in Montreal, Canada, and developed the *Montreal Protocol*. This treaty's goal was to cut emissions of CFCs by about 35% between 1989 and 2000.

- 36 countries signed the treaty and 196 countries has approved the treaty.
- the ozone layer is expected to recover to **1980 levels by 2050**
- Kofi Annan quoted as saying that "perhaps the single most successful international agreement to date has been the Montreal Protocol"
- Seasonal thinning of ozone layer above Antarctica in 1989
- The largest Antarctic ozone hole recorded as of September 2006

Carbon sequestration

- Carbon sequestration is the general term used for the capture and long-term storage of carbon dioxide.
- Capture can occur
  - Point of Emission – Ex: Power plants
  - Through natural resources – Ex: Photosynthesis
- It removes carbon dioxide from the earth's atmosphere

Carbon sequestration

Sequestration methods include:

- **Soil Sequestration** - enhancing the storage of carbon in soil
- **Plant Sequestration** - enhancing the storage of carbon in forests and other vegetation
- **Geosequestration** - storing carbon in underground geological formations
- **Ocean Sequestration** - storing carbon in the ocean
- **Mineral Carbonation** - subjecting carbon to chemical reactions to form inorganic carbonates

Soil sequestration

- Soils contain 700 gigatonnes (Gt, 109 tonnes) to 3000 Gt of carbon
- When forests are converted to agricultural land, the soil carbon content decreases
- Agricultural usages also tend to reduce soil carbon
- Management practices that can retain or increase the carbon content of soils include
  - low-tillage or no tillage
  - use of manures and compost,
  - conversion of monoculture systems to diverse systems
  - crop rotations and winter cover crops
  - establishing perennial vegetation on steep slopes.

Soil sequestration

- Current research is use of "biochar" to increase the soil carbon sink.
- Biochar is a type of charcoal that results from heating organic materials such as crop residue, wood chips, municipal waste or manure in an oxygen-limited environment. This process is known as "Pyrolysis"

Plant sequestration

- Plants use the energy of sunlight to convert CO_2 from the atmosphere to carbohydrates for their growth and maintenance, via the process of photosynthesis.
- Uptake of CO_2 by vegetation will decrease with time as plants grow to their full capacity
- Biological storage could be enhanced through agricultural and forestry practices and revegetation
- It provide a significant shorter-term contribution to climate change mitigation.

Geosequestration

- Geosequestration is the injection and storage of greenhouse gases underground, out of contact with the atmosphere.
- Suitable site - geological formation
  - Depleted oil and natural gas fields, coal beds.
  - Deep natural reservoirs filled with saline water (saline aquifers)
- Enhanced Oil Recovery (EOR) involves injecting CO_2 into the oil-containing reservoir to pressurise the reservoir and improve the rate of flow of oil.
- The displaced oil is pushed through the well bore

Geosequestration

- Canada: Weyburn project (2000 - Largest)
  - injects about 1.5 million tonnes of CO2 per year.
- North Sea: the Sleipner project (1996)
  - one million tonnes of CO2 per year.
- In Australia – Victoria: the Otway Project (2008)
  - injecting about 4500 tonnes of CO2 per month

Ocean sequestration

- The ocean represents the largest carbon store on earth
- It has a significant sink for anthropogenic CO_2 emissions of similar magnitude to the land sink
- It will decrease in strength.
- Proposed to bypass the natural ocean CO_2 uptake mechanism
- inject CO_2 directly into the deep ocean
- It would remain isolated from the atmosphere for several centuries
- Alternative method - large scale ocean fertilisation with iron to stimulate phytoplankton growth and photosynthesis.

Mineral sequestration

- It is also known as mineral carbonation
- It involves reaction of CO_2 with metal oxides that are present in common, naturally occurring silicate rocks.
- It mimics natural weathering phenomena
- There are sufficient reserves of magnesium and calcium silicate deposits to fix the CO_2

ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT

ROLE OF IT IN ENVIRONMENT

Development of internet facilities, worldwide web, geographical information system (GIS) and information through satellites has generated a wealth of up-to-date information on various aspects of environment and health.

❖Database

The Ministry of Environment and Forests (MoEF), Government of India has compiled database on various biotic communities - wildlife database, conservation database, forest cover database and for diseases like HIV/AIDS, Malaria, Fluorosis.

❖National Management Information System (NMIS):

NMIS of Department of Science and Technology has compiled a database on Research and Development Projects along with information about research scientists and personnel involved.

❖Environmental Information System (ENVIS):

- MoEF has created an Information System called Environmental Information System (ENVIS).

- The ENVIS generates network of database in areas like pollution control, clean technologies, remote sensing, coastal ecology, biodiversity, western ghats and eastern ghats, environmental management, media related to environment, renewable energy, desertification, mangroves, wildlife, Himalayan ecology, mining, etc.

- The National Institute of Occupational Health provides computerized information on occupational health i.e. the health aspects of people working in various hazardous and non-hazardous industries, safety measures.

❖Remote Sensing and Geographical Information System (GIS)

▪Satellite imageries provide us actual information about various physical and biological resources, water logging, desertification, deforestation, urban sprawl, river and canal network, mineral and energy reserves.

▪Digital information on a number of aspects like water resources, industrial growth, human settlements, road network, soil type, forest land, crop land or grassland.

▪Monsoon, ozone layer depletion, inversion phenomena, smog.

▪We are able to discover many new reserves of oil, minerals.

▪Disease infested areas prone to vector-borne diseases malaria, schistosomiasis

❖World Wide Web

www.mhhe.com/environmental science