Tulsiramji Gaikwad-Patil
College of Engineering & Technology
(An Autonomous Institute)

(EE,ME,ECE,CE)

Department of Artificial Intelligence & Machine Learning

UNIT 1 : Introduction to Solid and Hazardous Waste Management

Presented By

PROF. SHITAL DANDADE

GAIKWAD-PATIL
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Waste Hierarchy

Municipal Solid Waste Management

- Sources, generation, characteristics
- Kollection and transportation
- Waste processing and dispoal
  - reuse options
  - biological methods
  - energy recovery processes
  - landfilling

Management of E-waste

- Sources, generation, and characteristics

Waste Management Practices

- Storage, collection, and transfer

Introduction to Solid and Hazardous Waste Management

- Solid and Hazardous Waste Management involves the safe, scientific, and environmentally responsible handling of waste generated from human activities.
- It includes stages such as generation, segregation, storage, collection, transportation, processing, treatment, and final disposal.
- Solid waste consists of everyday materials like food waste, paper, plastics, metals, and glass from households, institutions, and commercial areas.

Introduction to Solid and Hazardous Waste Management

- Hazardous waste contains toxic, corrosive, flammable, reactive, or infectious substances generated from industries, hospitals, laboratories, and electronic sources.
- Improper management of waste leads to pollution, health hazards, and environmental damage.
- With increasing urbanization and industrial growth, adopting scientific waste management practices and following the reduce, reuse, and recycle principles is essential for sustainable development.

Waste Hierarchy

- The Waste Hierarchy is a priority-based framework for sustainable solid and hazardous waste management.
- It is represented as a pyramid, where the top option is the most preferred and the bottom is the least preferred.

Hierarchy Order:

1. Prevention / Source Reduction – Avoiding waste generation at the source (most preferred).
2. Reuse – Extending product life through repair, reuse, and repurposing.
3. Recycling – Converting waste materials into new usable products.
4. Recovery – Extracting energy or resources from non-recyclable waste.
5. Disposal – Safe landfilling of waste residues (least preferred).

Importance of Waste Hierarchy

- Reduces environmental pollution and landfill burden
- Conserves natural resources and saves energy
- Minimizes waste management and disposal costs
- Encourages responsible consumption and production
- Protects human health and ecosystem
- Supports sustainable development and circular economy goals

Municipal Solid Waste Management

- Municipal Solid Waste Management (MSWM) is the systematic and scientific handling of solid waste generated in urban and semi-urban areas.
- It includes activities such as waste generation, segregation, storage, collection, transportation, processing, and final disposal.
- MSWM aims to protect public health, prevent environmental pollution, and maintain cleanliness and hygiene in cities.
- Efficient MSWM systems are essential for sustainable urban development and improved quality of life.

Sources of Municipal Solid Waste

- Residential Sources: Household waste like food waste, paper, plastics, glass, and metals.
- Commercial Sources: Waste from shops, markets, hotels, restaurants, and offices.
- Institutional Sources: Waste from schools, colleges, hospitals (non-biomedical), and government offices.
- Municipal Services: Street sweeping waste, park waste, drain silt, and public bin waste.
- Construction & Small Industries: Construction debris and non-hazardous industrial waste.

Generation of Municipal Solid Waste

- MSW generation is the waste produced from human activities in urban and semi-urban areas.
- It is the first stage of waste management and is measured in *kg/person/day*.
- Waste quantity and composition vary by region and lifestyle.
- Major influencing factors: population growth, urbanization, economic status, lifestyle, food habits, and seasons.
- In India, MSW generation is increasing due to urban growth and use of disposable products.

Characteristics of Municipal Solid Waste

- MSW characteristics describe its physical, chemical, and biological properties.
- They vary according to population size, lifestyle, climate, and economic conditions.
- Understanding these characteristics is essential for proper collection, transportation, treatment, and disposal.
- Helps in selecting suitable waste processing methods like composting, recycling, or energy recovery.
- Provides insight into health risks and environmental impacts of waste management.

Physical Characteristics of Municipal Solid Waste

- Waste composition: Biodegradable, recyclable, and inert materials.
- Density: Determines storage, collection, and transportation requirements.
- Moisture content: High moisture reduces calorific value but supports composting.
- Particle size: Affects decomposition rate and efficiency of treatment processes.
- Influences handling, storage, and choice of processing methods.

Chemical Characteristics of MSW

- Carbon–Nitrogen (C/N) ratio: Crucial for effective composting.
- Calorific value:Determines suitability for waste-to-energy conversion.
- pH value: Influences microbial activity during decomposition.
- Toxic and hazardous substances: Small amounts of batteries, chemicals, or e-waste can contaminate soil and water.
- Important for selecting safe and efficient treatment methods.

Biological Characteristics of MSW

- Biodegradability: High organic content suitable for composting and biogas.
- Microbial population: Bacteria, fungi, and actinomycetes aid decomposition.
- Putrescibility: Rapid decomposition produces foul odors; frequent collection needed.
- Pathogenic content: May contain disease-causing organisms; proper handling is essential.
- Determines choice of biological treatment methods and public health measures.

Collection and Transportation of Municipal Solid Waste

- Purpose: Safely remove waste from source to processing or disposal sites; prevent pollution and health hazards.
- Collection: Door-to-door, community bins, curbside, segregated; wet waste – daily, dry – alternate days/week.
- Transportation: Handcarts, trolleys, tipper/compactor trucks, covered vehicles; use of transfer stations.
- Route Planning: Optimizes distance, fuel, and collection efficiency; GPS helps.
- Problems: Improper segregation, insufficient vehicles, spillage, high costs, poor planning.

Waste Processing

- Purpose: Reduce volume, toxicity, and environmental impact; enable resource recovery.
- Reuse: Glass, plastics, metal, furniture, clothes, and organic waste (compost/manure).
- Biological Methods: Composting, vermicomposting, anaerobic digestion (produces biogas).
- Energy Recovery: Incineration, Refuse Derived Fuel (RDF), Waste-to-Energy plants.
- Disposal / Landfilling: Safe final placement in sanitary landfills; last resort after all other methods.

Waste Disposal

- Purpose: Safe final placement of residual waste that cannot be reused, recycled, or processed.
- Sanitary Landfilling:
  - Engineered site with liners, leachate, and gas collection.
  - Waste compacted and covered daily to control odor, pests, and pollution.
- Disposal is the least preferred option; should follow reduction, reuse, recycling, and energy recovery.
- Improper disposal can cause soil, water, air pollution, and health hazards.

Management of E-Waste

- Systematic handling of discarded electronics in an environmentally safe way.
- Segregation & Storage: Keep e-waste separate from regular waste; store in secure, dry areas.
- Collection & Transport: Authorized centers, take-back schemes, careful transport to recycling facilities.
- Recycling & Disposal: Recover metals/plastics; treat hazardous components; safely dispose of residues.
- Stakeholder Roles: Producers follow EPR; consumers return e-waste to authorized centers.

Sources of E-Waste

- Households: TVs, refrigerators, ACs, computers, mobile phones, mixers, electronic toys.Commercial & Offices: Desktops, laptops, printers, scanners, servers, routers, telecom equipment.
- Institutions: Schools, colleges, hospitals, government offices – computers, projectors, medical electronic devices.
- Industries: Electronic control systems, automated machinery, industrial computers, measuring instruments.
- Retailers & Service Centers: Unsold or defective goods, discarded spare parts, circuit boards, cables, accessories.

Generation of E-Waste

- Definition: Production of discarded electronic equipment due to obsolescence, damage, or replacement.

- Causes of Increasing E-Waste:
  - Rapid technological advancement → frequent product upgrades.
  - Short product life cycles and costly repairs.
  - Population growth, urbanization, and rising income → more electronics usage.
  - Changing lifestyles and higher dependence on digital devices.
  - Lack of awareness on proper disposal and recycling.

Characteristics of E-Waste

Valuable Materials: Contains recoverable metals like copper, aluminum, gold, silver, and iron.

Hazardous Substances: Lead, mercury, cadmium, chromium, and brominated flame retardants can harm health and environment.

Non-Biodegradable: Electronic components persist in the environment for long periods.

Complex Composition: Mixture of metals, plastics, glass, and chemicals makes recycling difficult.

Health & Environmental Risks: Improper handling (burning, informal dismantling) releases toxic fumes and pollutants.

Waste Management Practices

Definition: Systematic methods for handling waste from generation to final treatment or disposal.

Purpose: Protect public health, maintain environmental quality, and use resources efficiently.

Key Practices:
Storage: Safe and proper containment of waste at source.
Collection: Gathering waste from households, institutions, and public areas.
Transfer: Moving waste to treatment, recycling, or disposal sites.

Storage of Waste

- Temporary containment of waste at the source until collection.
- Use strong, covered, leak-proof containers to prevent scattering and pests
- Segregation: Biodegradable, Non-biodegradable, Hazardous waste.
- Store biodegradable waste briefly; keep areas clean, dry, and ventilated.
- Ensures cleanliness, prevents littering, and improves recycling efficiency.

Collection of Waste

- Removing waste from storage to collection centers or transfer stations.
- Methods: Door-to-door, community bins, segregated collection.
- Regular and timely collection prevents odor, pests, and health hazards.
- Use trained manpower and suitable vehicles (handcarts, tricycles, trucks).

Transfer of Waste

- Definition: Movement of collected waste to transfer stations or secondary transport for processing/disposal.
- Transfer Stations: Unload, compact, and load waste into larger vehicles; reduce volume, fuel use, and cost.
- Features: Covered platforms, compactors, leachate systems, proper drainage, odor control.
- Best Practices: Regular cleaning and maintenance to prevent spillage, pollution, and health hazards.
- Purpose: Maintains hygiene, prevents disease, reduces pollution, and improves recycling efficiency.

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UNIT 2: Global and Regional Environmental Issues Global effects of air pollution

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Pollution
Acid Rain
SO_2, NOx
Transboundary Pollution
Ozone Hole
Greenhouse Gases
Global Warming
Urban Heat Island
Climate Change
Renewable Energy
Solar
Wind
Hydro
Non-Renewable Energy
Oil
Gas
Coal
Sea Level Rise
Cool Rural Area
Biodiversity
Population Growth
Energy Consumption
Environmental Degradation

Global Effects of Air Pollution

- Air pollution occurs when harmful gases, dust, and fine particles are released into the atmosphere due to human activities.
- Major sources include industries, vehicles, and power plants.
- Air pollutants do not remain limited to one place; they travel long distances through wind and atmospheric circulation.
- As a result, air pollution creates regional and global impacts on human health, environment, and climate.
- Common pollutants include $PM_{2.5}$, SO_2, NOx, CO, and ground-level ozone.

Major Impacts of Air Pollution

- Health: Causes asthma, lung and heart diseases, and premature death.
- Environment: Damages plants, forests, and aquatic ecosystems.
- Acid Rain: Leads to soil nutrient loss and damage to monuments.
- Climate Change: Contributes to global warming and glacier melting.
- Ozone Depletion: Increases harmful UV radiation.
- Economy: Raises healthcare costs and reduces productivity.

Natural Resources

- Energy resources are essential for industrialization, transportation, agriculture, and domestic activities.
- Based on availability, energy resources are classified into renewable and non-renewable sources.
- Renewable energy sources are continuously replenished by natural processes and can be used repeatedly without exhaustion.
- They are environmentally friendly, reduce pollution, conserve non-renewable resources, and support sustainable development.
- Proper management of energy resources is necessary to meet present needs without compromising future generations.

Renewable Energy Sources

- Renewable energy sources are obtained from natural processes and are continuously replenished.
- They are environmentally friendly and suitable for long-term use.
- Overuse of fossil fuels has caused pollution, climate change, and resource depletion.
- Renewable energy provides a cleaner and safer solution for present and future energy needs.
- Major sources include solar, wind, hydropower, biomass, geothermal, and tidal energy.

Types and Management of Renewable Energy

- Solar Energy: Used for electricity, heating, cooking, and irrigation; clean but sunlight-dependent.
- Wind Energy: Generates electricity using turbines; non-polluting but irregular.
- Hydropower: Electricity from flowing water; reliable but affects ecosystems.
- Biomass Energy: Energy from organic waste; useful for rural areas.
- Management: Efficient technology, energy storage, grid integration, government support, and public awareness are essential.

Non-renewable Energy Sources

- Non-renewable energy sources are available in limited quantities and cannot be replenished in a short time.
- These resources take millions of years to form and get exhausted after continuous use.
- They have supported industrial growth, transportation, and electricity generation.
- Excessive use has caused serious environmental problems.Major non-renewable energy sources include coal, petroleum, natural gas, and nuclear energy.
- Currently, a large share of global energy demand depends on these sources.

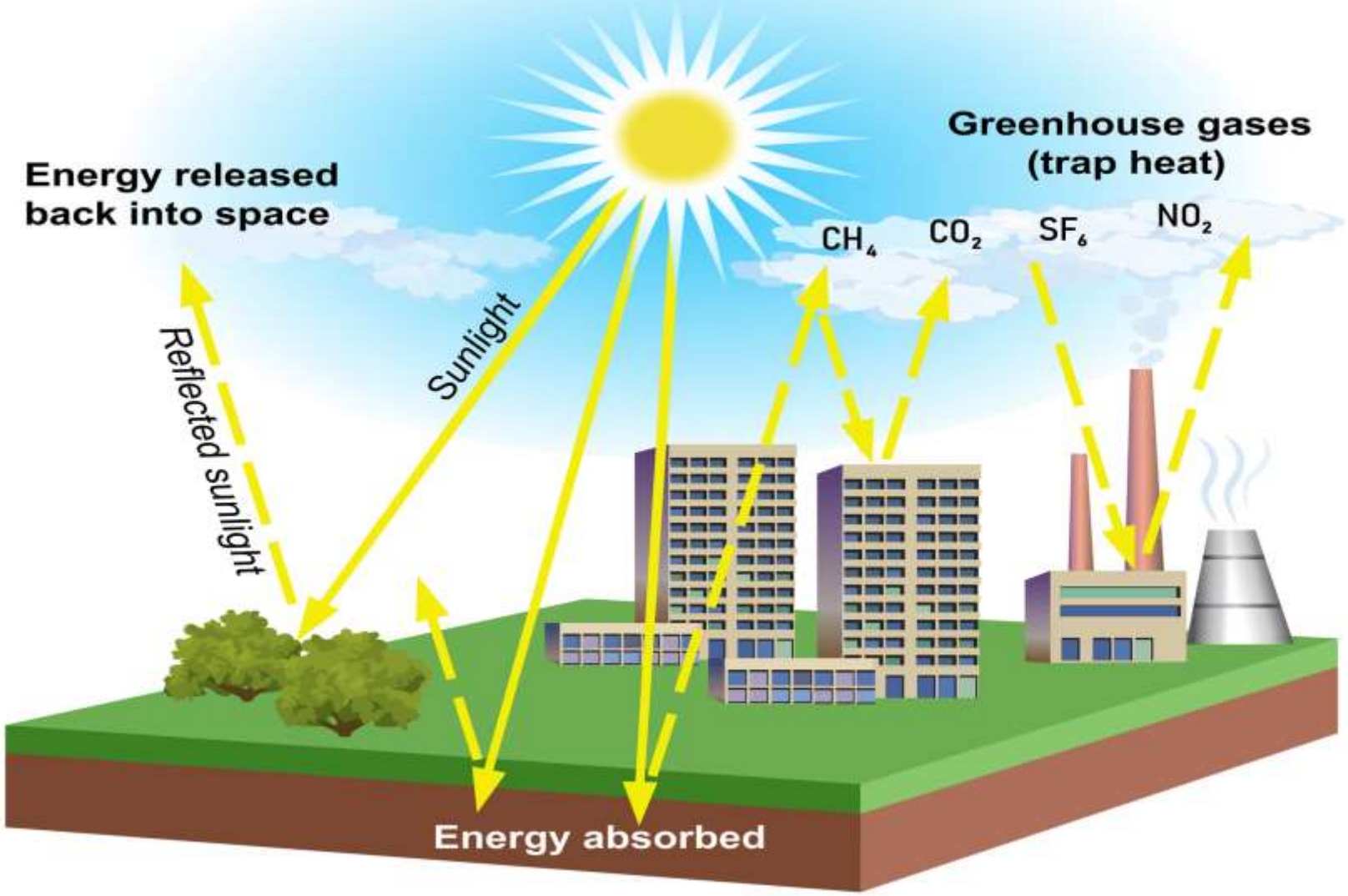
Types and Management of Non-renewable Energy

- Coal: Widely used in power plants and industries; causes air pollution, acid rain, global warming, and land degradation.
- Petroleum: Used in vehicles and industries; causes air pollution and marine damage due to oil spills.
- Natural Gas: Cleaner than coal and oil; still contributes to greenhouse gas emissions.
- Nuclear Energy: Produces large energy with low CO_2 emissions; issues include radioactive waste and high risk.
- Management: Efficient use of energy, pollution control, cleaner technologies, recycling, reduced fossil fuel use, promotion of renewable energy, and public awareness.

Greenhouse Gases & Greenhouse Effect

- Greenhouse gases are gases present in the Earth's atmosphere that trap heat.
- This heat-trapping process is called the greenhouse effect, which helps maintain Earth's temperature.
- Human activities have increased greenhouse gas concentrations, leading to global warming.
- Greenhouse gases allow sunlight to enter but absorb and re-emit outgoing infrared radiation.
- Major greenhouse gases include: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Water vapour, and Chlorofluorocarbons (CFCs).

Greenhouse Effect



Effects and Control of Greenhouse Gases

- Major gases: CO_2 (fossil fuels, deforestation), CH_4 & N_2O (agriculture, waste), CFCs (industries).
- Effects: Global warming, climate change, melting of glaciers, sea-level rise, extreme weather events.
- Control Measures: Reduce fossil fuel use, promote renewable energy, energy conservation, afforestation, sustainable agriculture, and control industrial emissions.
- International agreements and public awareness play an important role in reducing greenhouse gas emissions.

Global Warming

- Global warming is the long-term rise in the Earth's average temperature due to increased greenhouse gases.
- Causes: Burning of fossil fuels, deforestation, industrial activities, agriculture (methane from livestock, nitrous oxide from fertilizers), and improper waste disposal.
- Effects:

Rise in global temperature, melting of glaciers and polar ice caps, sea-level rise, climate change, extreme weather events, reduced crop productivity, water scarcity, biodiversity loss, and health problems.

- Control Measures:

Reduce fossil fuel use, promote renewable energy, improve energy efficiency, afforestation, control industrial and vehicular emissions, adopt sustainable agriculture, and create public awareness.

Climate Change

- Climate change refers to long-term changes in Earth's climate such as temperature, rainfall, and extreme weather events.
- It is mainly caused by human activities that increase greenhouse gases.
- Causes: Burning of fossil fuels, deforestation, agriculture, industries, and urbanization.
- Effects: Global warming, melting of glaciers, sea-level rise, irregular rainfall, droughts and floods, extreme weather, and biodiversity loss.
- Control Measures: Reduce greenhouse gas emissions, use renewable energy, conserve forests, improve energy efficiency, promote sustainable practices, and create public awareness.

Urban Heat Islands (UHI)

- Urban Heat Island refers to the condition where urban areas are warmer than surrounding rural areas.
- It occurs due to buildings, roads, and pavements that absorb and retain heat.
- Causes: Replacement of vegetation with concrete and asphalt, loss of green cover, waste heat from vehicles and industries, dense buildings, and air pollution.
- Effects: Higher temperatures, increased energy consumption, heat-related illnesses, poor air quality, and stress on urban ecosystems.
- Control Measures: Increase green spaces and tree cover, use cool roofs and reflective materials, develop green roofs, improve urban planning and air circulation, and reduce waste heat.

Acid Rain

- Acid rain is precipitation containing sulfuric and nitric acids formed from SO_2 and NOx.
- These pollutants mainly come from fossil fuel burning and can travel long distances.

- Effects:
  - Damage to plants and soil nutrients
  - Acidification of lakes and rivers
  - Corrosion of buildings and monuments

- Control Measures:
  - Reduce SO_2 and NOx emissions
  - Use cleaner fuels and renewable energy
  - Scrubbers in industries and catalytic converters in vehicles

Ozone Hole & Its Causes

- Ozone hole refers to thinning of the ozone layer in the stratosphere, mainly over Antarctica.
- The ozone layer protects life by absorbing harmful UV radiation.
- Ozone depletion is caused by ozone-depleting substances (ODS).Major ODS: CFCs, halons, carbon tetrachloride, methyl chloroform.
- Effects: Increased UV radiation, skin cancer, eye damage, reduced crop yield, harm to aquatic life.
- Control Measures: Phase out ODS, use eco-friendly alternatives, proper disposal of cooling equipment, follow Montreal Protocol, and create public awareness.

Ecology and Ecosystem

- Ecology is the branch of environmental science that studies interactions between living organisms and their environment.
- It explains relationships among plants, animals, microorganisms, and non-living factors like air, water, soil, and sunlight.
- An ecosystem is a functional unit where living and non-living components interact in a specific area.
- Components of an ecosystem:
  - Biotic: Producers, consumers, decomposers
  - Abiotic: Air, water, soil, sunlight, temperature, nutrients
- Ecosystems function through energy flow and nutrient cycling.

Types and Importance of Ecosystems

- Types of Ecosystems:
- Terrestrial: Forest (high biodiversity), Grassland (grazing animals), Desert (low rainfall, special adaptations)
- Aquatic: Freshwater (rivers, lakes, wetlands) and Marine (oceans, seas)
- Importance of Ecosystems:

- Support life and biodiversity
- Provide food, water, and raw materials
- Regulate climate and water cycles
- Maintain soil fertility and nutrient balance
- Support agriculture, fisheries, and other economic activities

Factors Influencing Increase in Population

- Population growth is the increase in number of people over time and is a major environmental concern.
- High Birth Rate: Early marriage, social customs, and lack of family planning increase births.
- Decline in Death Rate: Improved healthcare, vaccination, and sanitation reduce mortality.
- Medical Advancement: Increased life expectancy due to better treatment and nutrition.
- Lack of Education & Awareness: Poor knowledge of family planning, especially among women.
- Poverty & Social Beliefs: Children seen as economic support; cultural preference for large families.
- Migration: Rural–urban and international migration increases population pressure in cities.

Energy Consumption & Its Impacts

- Energy consumption is the use of energy for domestic, industrial, transport, and agricultural activities.
- Causes of Increase: Population growth, industrialization, urbanization, and improved living standards.
- Major Sectors: Domestic, industrial, transport, and agricultural sectors.
- Environmental Impacts: Depletion of fossil fuels, air and water pollution, global warming, and ecosystem damage.
- Sustainable Measures: Efficient energy use, energy-saving appliances, renewable energy, reduced wastage, public awareness, and supportive government policies.

Environmental Degradation & Its Causes

- Environmental degradation refers to the deterioration of natural resources such as air, water, soil, forests, and biodiversity.

- It reduces the quality of the environment and its ability to support life.

- Major Causes:

- Rapid population growth and overuse of resources
- Industrialization and improper waste disposalUrbanization and loss of green cover
- Excessive use of fossil fuels
- Unsustainable agricultural practices (fertilizers, pesticides)

Forms, Effects & Control Measures

- Forms

- Air pollution, water pollution, soil degradation, deforestation, biodiversity loss.

- Effects:

Climate change, ecosystem damage, water scarcity, reduced crop productivity, health problems, and economic losses.

- Control Measures:

Resource conservation, afforestation, pollution control, waste management, renewable energy use, sustainable agriculture, environmental awareness, and strict environmental laws.

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UNIT 3: Environmental Management and Sustainable Development

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Environmental Management Systems
Environmental Audit
Bhopal Gas Tragedy
EPA
1986-2002
Health Risk Assessment
Risk
Low
High
Sustainable Development
Challenges:
Solutions:
Poyerty,
Climate Change,
Inequality
Interational
Clean Energy
Education
Targets & Indicators
SCHOOL

Environmental Management

- A systematic and planned approach to manage human activities
- Aims to minimize environmental damage
- Focuses on conservation of natural resources for present and future generations
- Emphasizes pollution control and ecosystem protection
- Supports sustainable development
- Addresses environmental pressure from industrialization, urbanization, agriculture, mining, and transport
- Balances economic development, environmental protection, and social well-being

Environmental Management Systems (EMS)

- A planned and systematic approach used by organizations to manage environmental impacts
- Helps identify how activities affect the environment
- Aims to reduce pollution and conserve natural resources
- Ensures compliance with environmental laws and regulations
- Integrates environmental protection into routine management practices
- Focuses on prevention of pollution rather than corrective action
- Based on continuous improvement through planning, monitoring, and review
- Applicable to all organizations and commonly follows ISO 14001

Components of Environmental Management System (EMS)

- Environmental Policy: Top management commitment to environmental protection and legal compliance
- Planning: Identify impacts, legal requirements, and set objectives and targets
- Implementation & Operation: Assign duties, train employees, and control activities
- Monitoring & Measurement: Regularly check emissions, waste, energy, and water use
- Corrective & Preventive Actions: Fix problems and prevent their recurrence
- Management Review: Review EMS performance and improve continuously

EMS Implementation Process

- EMS follows a continuous improvement cycle (Plan–Do–Check–Act)
- Management Commitment & Policy: Leadership support and written environmental policy
- Aspect Identification & Legal Requirements: Identify environmental impacts and laws
- Objectives & Implementation: Set targets, assign responsibilities, and control operations
- Monitoring & Audit: Measure performance and conduct internal audits
- Corrective Action & Management Review: Fix problems and improve EMS continuously

ISO 14001 and Environmental Management Systems

- ISO 14001 is an international standard for Environmental Management Systems
- Provides a systematic framework to improve environmental performance
- Applicable to all types and sizes of organizations
- Emphasizes continual improvement
- Ensures compliance with environmental laws
- Promotes pollution prevention
- Compatible with other management system standards

Environmental Auditing

- A systematic, documented, and objective process
- Evaluates an organization’s environmental performance
- Checks compliance with environmental laws, rules, and standards
- Reviews environmental management practices and controls
- Identifies pollution sources and environmental risks
- Assesses effectiveness of Environmental Management System (EMS)
- Helps in early detection of environmental problems
- Suggests corrective and preventive measures
- Supports better management decision-making
- Promotes continuous improvement and sustainable development

Environmental Auditing Process

- Pre-Audit Planning: Select audit team, define objectives, scope, and schedule
- Data Collection & Site Inspection: Collect records and inspect facilities physically
- Evaluation & Analysis: Compare findings with legal and environmental standards
- Audit Report: Document non-compliance, problems, and recommendations
- Follow-Up Action: Implement corrective actions and monitor improvements

Human Health Risk Assessment (HHRA)

- A scientific method to evaluate health risks from environmental pollutants
- Pollutants may be in air, water, soil, food, or industrial waste
- Identifies how dangerous a substance is and its possible health effects
- Starts with hazard identification (toxic chemicals, heavy metals, pesticides, air pollutants)Studies dose and level of exposure to decide whether it is safe or harmful
- Analyzes exposure pathways: breathing, drinking, eating, and skin contact
- Considers duration and frequency of exposure (short-term or long-term)Combines all data to estimate overall health risk
- Helps in setting safety limits and pollution control measures
- Supports environmental planning and sustainable development

Types of Health Effects Considered in HHRA

- Acute Effects:

Short-term exposure to high pollution levels; causes eye/skin irritation, headache, breathing problems; usually reversible

- Chronic Effects:

Long-term low-level exposure; leads to asthma, heart disease, and organ damage; often irreversible

- Carcinogenic Effects:

Long-term exposure causing cancer; examples: asbestos, benzene, arsenic; cancer develops after many years

- Non-Carcinogenic Effects:

Other health problems like growth defects, hormonal issues, and organ toxicity; assessed using safe exposure limits

Steps in Human Health Risk Assessment (HHRA)

1. Hazard Identification
- Identify harmful agents: chemicals, metals, pesticides, air pollutants
- Air → breathing problems; Water → stomach & organ damage; Soil → skin & long-term effects

2. Dose–Response Assessment
- Studies relation between amount of exposure and health effect
- Higher dose → more severe effect; identifies safe limits and threshold levels

3. Exposure Assessment
- Estimates how much pollutant enters the body and how often
- Pathways: Inhalation (air), Ingestion (food/water), Dermal contact (skin)

4. Risk Characterization
- Combines all steps to estimate overall health risk
- Identifies high-risk groups and explains uncertainties in data

Applications of Human Health Risk Assessment (HHRA)

- Environmental Impact Assessment (EIA): Checks health risks of proposed projects
- Pollution Control & Regulations: Helps set safe pollution limits and control measures
- Industrial & Occupational Health: Protects workers from workplace hazards
- Waste Management & Site Cleanup: Guides safe cleanup of contaminated areas
- Air & Water Quality Standards: Helps fix safe limits for pollutants

The Environment (Protection) Act (EPA), 1986–2002

- Major environmental law of India to protect and improve environmental quality
- Introduced after the Bhopal Gas Tragedy (1984)Came into force on 19 November 1986; applicable to entire India
- Covers air, water, land, and living organisms
- Gives wide powers to Central Government to control pollution and regulate industries
- Allows inspection, sample collection, and legal action against violators
- Includes rules on hazardous waste, biomedical waste, plastic waste, and noise pollution (added up to 2002)Helps in protecting public health, conserving resources, and supporting sustainable development

Introduction to Sustainable Development

- Development that meets present needs without harming future generations
- Aims to improve quality of life while protecting environment and resources
- Became important due to industrialization, population growth, and resource overuse
- Problems like pollution, deforestation, climate change, and biodiversity loss made it necessary
- Defined in Brundtland Report (1987) by World Commission on Environment and DevelopmentFocuses on balanced growth — economic, social, and environmental

Pillars and Importance of Sustainable Development

- Based on three pillars:
- Economic: growth, employment, income
- Social: health, education, equality, quality of life
- Environmental: conservation of resources and ecosystems
- All pillars are interdependent; neglecting one causes unsustainable growth
- Promotes wise use of resources and renewable energy (solar, wind, hydro)Supports intergenerational equity (future generations' rights)Encourages pollution control, waste management, and energy conservation
- Helps in poverty reduction, environmental protection, and long-term development

Sustainable Development Goals (SDGs)

- Global goals adopted by the United Nations in 2015 under the 2030 Agenda
- Aim to solve problems like poverty, hunger, inequality, pollution, and climate change
- Focus on balanced development: economic, social, and environmental
- Implemented from 1 January 2016 with target year 2030Applicable to all countries (developed and developing)Promote global cooperation for sustainable future
- Introduced because earlier development caused pollution, resource depletion, and inequality
- Ensure that development benefits everyone while protecting the environment

Sustainable Development Goals (SDGs)

1. **No Poverty:** End poverty; provide basic needs and social protection
2. **Zero Hunger:** End hunger; promote nutrition and sustainable agriculture
3. **Good Health & Well-being:** Ensure healthcare and control diseases
4. **Quality Education:** Inclusive education and lifelong learning
5. **Gender Equality:** Equal rights and opportunities for women and men
6. **Clean Water & Sanitation:** Safe water, sanitation, and hygiene for all
7. **Affordable & Clean Energy:** Access to renewable and reliable energy
8. **Decent Work & Economic Growth:** Jobs, safe work, and economic growth
9. **Industry, Innovation & Infrastructure:** Sustainable industry and technology

Sustainable Development Goals (SDGs)

1. **Reduced Inequalities**: Social and economic inclusion for all
2. **Sustainable Cities & Communities**: Safe, green, and resilient cities
3. **Responsible Consumption & Production**: Reduce waste and use resources wisely
4. **Climate Action:** Reduce emissions and adapt to climate change
5. **Life Below Water**: Protect oceans and marine lifeLife on Land: Protect forests, wildlife, and biodiversity
6. **Peace, Justice & Strong Institutions**: Rule of law and human rights
7. **Partnerships for the Goals:** Global cooperation to achieve SDGs

Targets of Sustainable Development Goals (SDGs)

- Specific objectives set under each SDG to be achieved by 2030Break broad goals into practical and achievable actions
- Total of 169 targets under 17 SDGs
- Focus on solving social, economic, and environmental problems
- Help governments convert global goals into national and local plans
- Guide policy making, programs, and resource allocation
- Emphasize inclusive development for vulnerable groups
- Are time-bound, measurable, and outcome-oriented
- Support long-term sustainability and accountability

Indicators of Sustainable Development Goals (SDGs)

- Measurable tools used to track progress of SDG targets
- Show how much progress has been made towards each target
- Provide numerical and statistical data for evaluation
- Total of 231 global indicators to monitor 169 targets under 17 SDGs
- Help compare progress across countries and regions
- Support monitoring and evaluation of development programs
- Assist in evidence-based policy and decision making
- Ensure transparency and accountability in development efforts
- Help check whether SDGs are achievable by 2030

Challenges in Achieving Sustainable Development Goals (SDGs)

- Poverty and inequality, especially in developing countries
- Lack of access to food, education, healthcare, and employment
- Rapid population growth putting pressure on resources and services
- Environmental degradation: climate change, pollution, deforestation, biodiversity loss
- Lack of financial resources for development programs
- Weak governance and poor policy implementation
- Low public awareness and participation in sustainable practices
- Political instability and conflicts in some regions

Strategies to Achieve Sustainable Development Goals

- Promote sustainable use of natural resources
- Shift towards renewable energy to reduce environmental damage
- Strengthen education and healthcare systems
- Support inclusive economic growth and employment opportunities
- Implement strong environmental laws and policies
- Increase public awareness and community participation
- Encourage technological innovation and digital solutions
- Promote international cooperation and partnerships
- Share resources, knowledge, and technology globally

THANK YOU!