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# Environmental management course

1st year master Biodiversity and Environment

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# 1.- Water resources management

## 1.1.-Definition of water

Water is a clear, odorless, and tasteless liquid that is essential for life on Earth. It is the most abundant substance on the planet, covering over 70% of the Earth's surface.

## 1.2.- States of water

The main states of water are:

A. Solid (ice): Water freezes into a solid state at 0°C (32°F) under standard pressure. In the solid state, the water molecules are tightly packed in a crystalline structure.
B. Liquid: This is the most common state we encounter, where water exists as a free-flowing liquid between 0°C (32°F) and 100°C (212°F) under standard pressure. In the liquid state, the water molecules are loosely bound and able to flow.
C. Gas (water vapor): When water is heated above 100°C (212°F) under standard pressure, it transitions into a gaseous state known as water vapor or steam. In the gaseous state, the water molecules are dispersed and free-moving.

The transitions between these states occur through phase changes driven by changes in temperature and pressure:

Melting: The transition from solid to liquid state, occurring at 0°C (32°F).

Evaporation/Boiling: The transition from liquid to gas state, occurring at 100°C (212°F).

Condensation: The transition from gas to liquid state, the reverse of evaporation.

Freezing: The transition from liquid to solid state, the reverse of melting.

### 1.3.- Sources water

#### 1.3.1.-Surface water

- Rivers, streams, lakes, and ponds are the primary sources of surface water. The amount of available surface water depends mainly on rainfall.
- Glacier runoff is also considered a source of surface water, particularly in regions like the Himalayas.

#### 1.3.2.-Groundwater

- Groundwater is water found underground in the cracks and spaces in soil, sand and rock. It is drawn up through wells.
- Groundwater and surface water are interconnected, as groundwater can recharge surface water sources and vice versa.

#### 1.3.3.-Other sources

- Rainwater, which can be collected and used as a water source, is another natural source of fresh water.
- Desalinated seawater is a human-made source of fresh water.

### 1.4.- The Global Water Cycle

Water is a renewable resource. Earth's water is naturally recycled through the water cycle or hydrologic cycle. This cycle involves the evaporation of water from different surfaces, followed by condensation to form clouds. These clouds then accumulate and precipitate, resulting in rainfall. The water from rainfall runs across surfaces as surface water bodies. It also percolates into the ground, forming groundwater, which is stored in aquifers. The hydrologic cycle directly impacts the availability of freshwater resources. Human activities, such as excessive withdrawals and pollution, can disrupt this natural process and lead to water-related risks. With 97% of the Earth's water resources being saltwater and only 3% as freshwater, water is a limited resource. It is required to support ecological systems and serve human needs for economic and social development (Fig. 1).

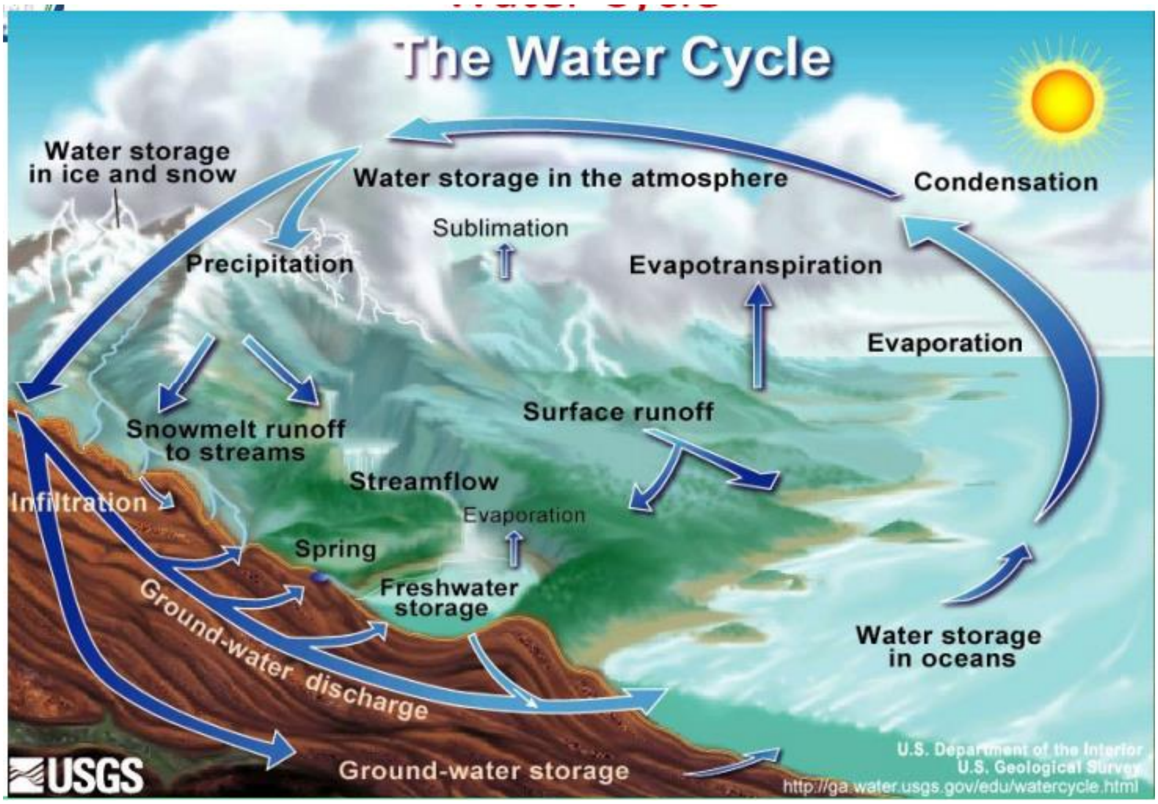


**Figure 1:** Natural water cycle or Hydrological cycle

### 1.4.1.- Stages of the Water Cycle

The water cycle, also known as the hydrologic cycle, is the continuous movement of water on, above and below the Earth's surface. The main stages of the water cycle are:

- Evaporation: The sun's heat causes water from oceans, lakes, and other surfaces to evaporate into water vapor in the atmosphere.
- Transpiration: Plants release water vapor into the air through their leaves in a process called transpiration.

- Condensation: As water vapor rises, it cools and condenses into tiny water droplets or ice crystals, forming clouds.
- Precipitation: When the water droplets or ice crystals in clouds become too heavy to remain suspended in the air, they fall back to the Earth's surface as precipitation (rain, snow, sleet, or hail).
- Surface runoff: Precipitation that falls on the Earth's surface either seeps into the ground as groundwater or flows into streams, rivers, and oceans.
- Groundwater flow: Some of the precipitation that seeps into the ground becomes groundwater, which slowly flows and may eventually discharge into streams, rivers, or oceans.
- Infiltration: Water from precipitation that does not immediately run off or evaporate is absorbed into the soil and becomes part of the groundwater system.

### 1.5.- Use of water

Water usage is a critical global issue, with only 0.3% of water resources being usable and over a billion people lacking adequate drinking water. Worldwide, irrigation accounts for 70% of water use, followed by industry (22%) and drinking water (8%), though these percentages vary by country. Water consumption has increased significantly, with global usage multiplying sixfold in the 20th century.

Water has numerous uses in our daily lives, agriculture, industry, and for medicinal purposes (Fig. 2):

- **Domestic uses**
  - Drinking, cooking, bathing, washing clothes and dishes;
  - Generating electricity for household use;
  - Used in air coolers

- **Agricultural uses**
    - Irrigation, pesticide and fertilizer application, crop cooling;
    - Sustaining livestock and fish farms;
    - Approximately 70% of total water withdrawals are for irrigation.
- **Industrial uses**
    - Used in hotels, restaurants, offices, and manufacturing industries like paper, chemicals, automobiles, steel;
    - Significant amounts used for cooling in power plants and petroleum refineries;
    - Used as a solvent and less commonly as a catalyst in industrial processes
- **Medicinal uses**
    - Used in hemodialysis and dental procedures;
    - Washing surgical tools and equipment
    - Essential for hydrotherapy
- **Other uses**
    - Drinking water is crucial for maintaining health and well-being;
    - Used for hygiene and sanitation within households;
    - Enables transportation via rivers, canals, oceans and seas Hydropower is a renewable source of electricity generation.

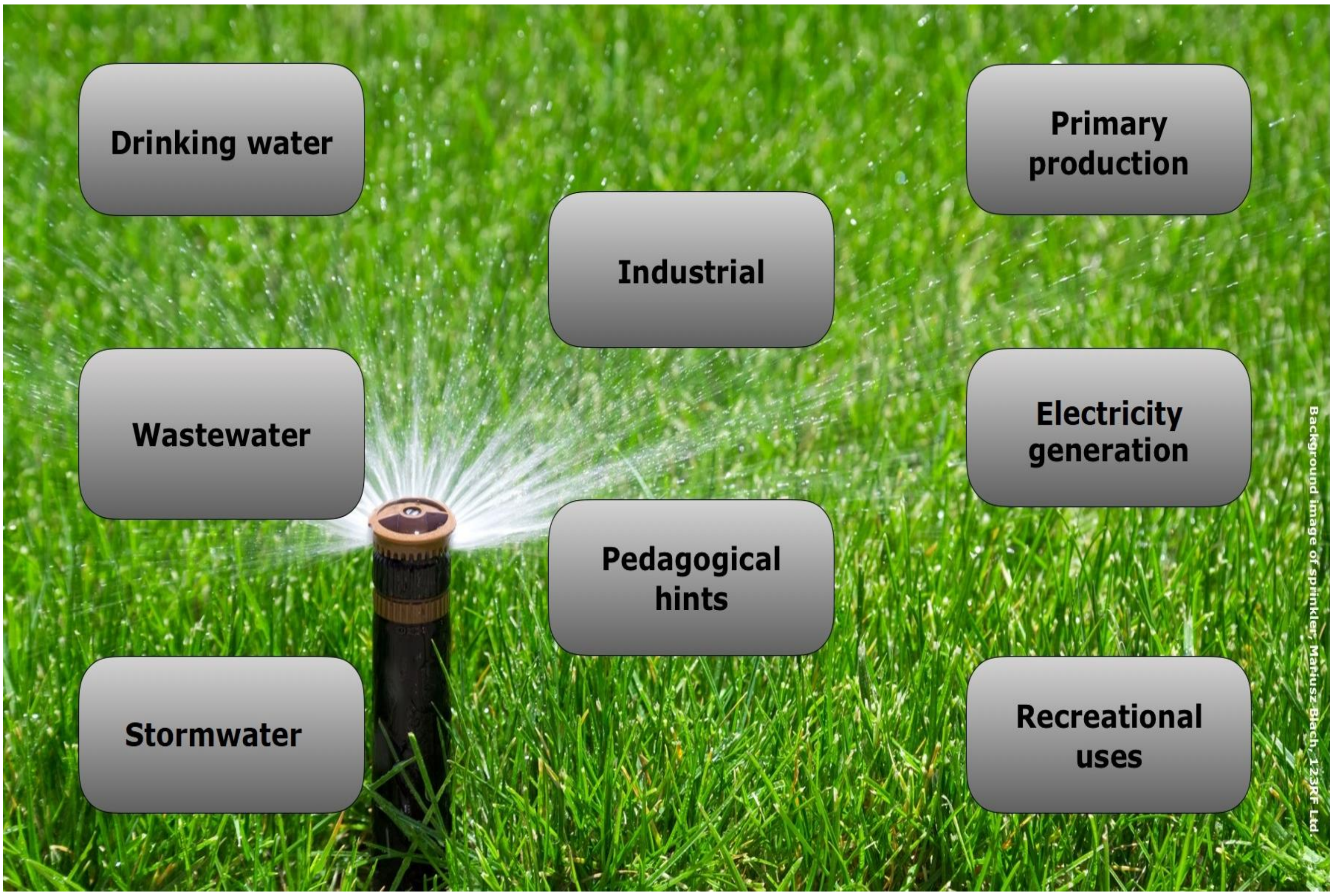


**Figure 2:** Photo represents the use of water

### 1.6.-Water management

Water management is a critical field addressing the optimal allocation and preservation of water resources. It encompasses various aspects, including process water management for industrial operations, and tackles global challenges related to freshwater distribution and availability. Water resources management integrates both constructed systems (e.g., dams, treatment plants) and natural elements (e.g., watersheds, aquifers) to achieve effective control of water flow and quality.

The main goals of water management are to:

- Reduce water usage, wastage, and loss;

Protect water quality and the aquatic environment;

Ensure reliable and sustainable access to water.

The field addresses multiple purposes, such as water supply, flood control, hydropower, and environmental protection, As populations grow and climate changes, water management research becomes increasingly vital to ensure sustainable water resources for human needs, economic development, and ecosystem health.

Some key water management strategies and techniques include:

Water conservation through efficiency measures, recycling, and reuse

Development of new water supplies like surface water, groundwater, and desalination

Improved water infrastructure like dams, reservoirs, and distribution systems

Demand management through pricing, regulations, and public education

Integrated water resource planning and management at the basin or regional level

Best practices in water management involve actions at multiple levels - government, businesses, NGOs, and individuals. This includes constructing water projects, investing in water-saving innovations, conducting public awareness campaigns, and adopting water-efficient practices in daily life.

## 1.7.- Water resources management

Water resources management involves controlling water systems comprising both constructed facilities and natural elements to achieve effective water management. These systems include structural components like dams, treatment plants, and conveyance systems, as well as environmental elements such as watersheds, aquifers, and wetlands. The field addresses challenges arising from increasing water demand due to population growth, urbanization, and industrial development.

### 1.7.1.-Integrated Water Resources Management (IWRM)

IWRM is a process that promotes coordinated development and management of water, land, and related resources to maximize economic and social welfare without compromising the sustainability of vital ecosystems.

It involves stakeholders at all levels, ensuring that water management policies are inclusive and take into account the needs and impacts on all sectors.

### 1.7.2.-Water Supply and Demand Management

Ensuring a balance between water supply and demand is crucial. This involves managing the sources of water (such as rivers, lakes, aquifers) and the infrastructure (like dams, reservoirs, treatment plants) that deliver water to users.

Demand management strategies include promoting water conservation, improving efficiency in water use, and implementing pricing mechanisms to encourage responsible use.

### 1.7.3.-Water Quality Management

Maintaining and improving water quality is essential for protecting human health and ecosystems. This involves monitoring water quality, controlling pollution sources, and treating wastewater.

Regulations and standards for water quality are implemented to ensure that water is safe for consumption and other uses.

### 1.7.4.-Flood and Drought Management

Managing water resources to mitigate the impacts of floods and droughts is a critical component. This includes developing early warning systems, constructing infrastructure to control water flow, and implementing policies for land use planning and disaster response.

Adaptive strategies, such as improving water storage and enhancing ecosystem resilience, are important in the face of climate change.

### 1.7.5.-Ecosystem Conservation

Protecting and restoring ecosystems that provide vital services, such as wetlands and forests, is an integral part of water resources management.

Healthy ecosystems contribute to water purification, flood control, and biodiversity conservation.

### 1.7.6.-Stakeholder Engagement and Governance

Effective water resources management requires the participation of all stakeholders, including government agencies, local communities, businesses, and non-governmental organizations.

Transparent and accountable governance structures are necessary to ensure that decisions are equitable and sustainable.

### 1.7.7.-Technological and Scientific Advances

Advances in technology and science play a significant role in improving water management practices. This includes the use of remote sensing, geographic information systems (GIS), and data analytics for better decision-making.

Innovative solutions such as desalination, wastewater recycling, and smart irrigation systems can help address water scarcity and improve efficiency.

### 1.7.8.-Policy and Legislation

Effective policies and legal frameworks are essential for regulating water use, protecting water resources, and ensuring equitable access.

International cooperation and transboundary water management are important for regions sharing water resources.

# 2.- Soil management

## 2.1.- Soil definition

The soil, or pedological cover, is the loose surface layer that covers the parent rock. It varies in thickness from a few centimeters to a few meters. It supports and provides nutrients for plants. Soil is essential for nutrient cycling, water filtration, climate regulation, and structural support for plants.

## 2.2.-Field study

Examination of the vertical section or Solum, of a pit going down to the parent rock highlights different vertical layers or Horizons. Horizons result from the transformation and migration of soil constituents and are distinguished from each other by the relative proportions of organic and mineral matter (Fig. 3).

- Horizon 0, organic is composed of raw animal and plant debris.
- Horizon A (or surface horizon): This horizon is often referred to as the surface horizon and is characterized by an accumulation of decomposed organic matter, high biological activity, and a generally darker color compared to the underlying horizons.

- Horizon E (or leached horizon): This horizon is marked by the removal or leaching of soluble elements, such as clays, nutrients, and organic substances. It is often lighter in color and texture than adjacent horizons and may be sandier or more silty.

- Horizon B (or accumulation horizon): This horizon is characterized by the accumulation of eroded or leached materials from the upper horizons. It may contain clay minerals, iron oxides, carbonates, nutrient ions, etc.

• Horizon C (or transition horizon): This horizon is often considered a transitional zone between the soil and the underlying parent rock.

• R horizon (or source rock): This layer is located below the C horizon and is composed of the unaltered rock from which the soil forms. These horizons can vary in depth and composition depending on local conditions, soil types, and specific formation processes.

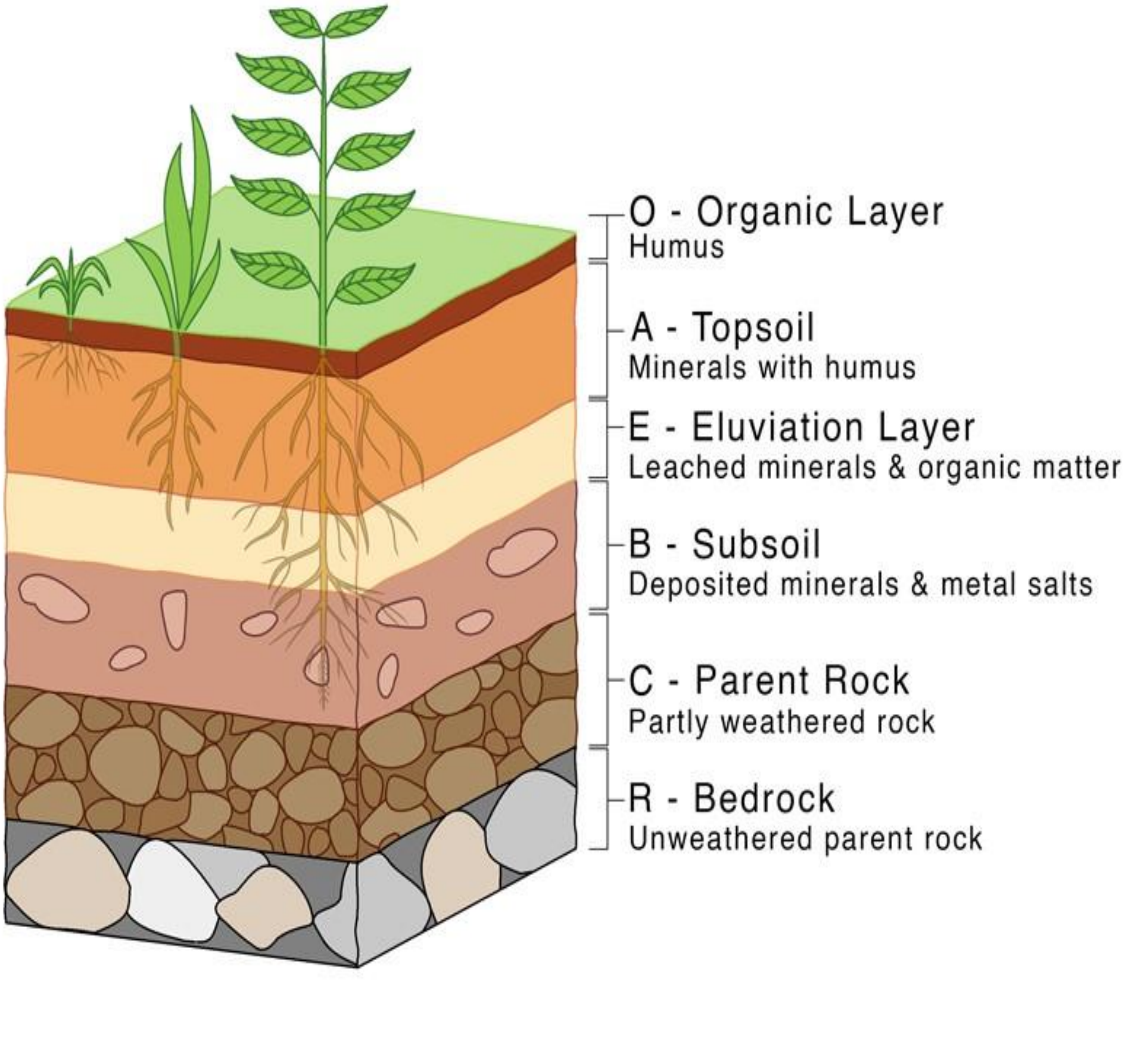


**Figure 3:** Soil layers

### 2.3.- Laboratory study

#### 2.3.1.- Physical characteristics of soils

From a physical and mechanical perspective, soil can be viewed as a porous system consisting of three phases: solid, liquid, and gas. The main edaphic factors consist of the soil's texture and structure, its hygrometry, and its mineral element content.

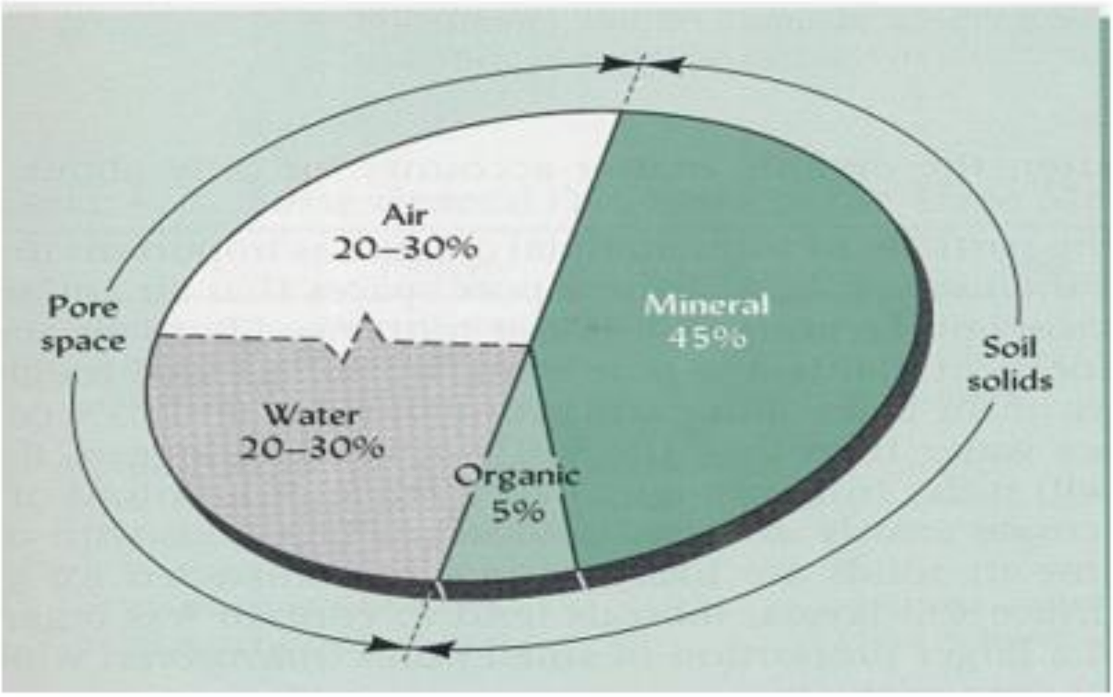


**Figure 4:** Average distribution in % of the different soil phases

##### 2.3.1.1.- Soil texture

###### 2.3.1.1.1.- Definition

The texture of the soil is established according to the proportion (%) of sand, silt, and clay particles that make it up. The texture of the soil depends on the composition of mineral particles. As the parent rock weathers, it breaks down into larger or smaller particles. The size of these particles determines whether the soil is sandy, silty, or clayey. The percentage of each mineral compound determines the soil's texture and various properties like permeability. We can determine if the soil is sandy, loamy, or clayey by analyzing the percentage of each mineral compound (Table 1).

**Table 1:** Particle size classification of soil elements

| Elements | Geological and hydrological classification | Pedological (ecological) classification |
|---|---|---|
| **Pebbles** | > 16 mm | >20 mm |
| **Gravel** | 2 to 16 mm | 2 to 20 mm |
| **Sand**<br>**Rude**<br>**Means**<br>**Endings** | <br>0,5 to 2 mm<br>0,25µ to 0,5 mm<br>0,06 µ to 0,25 µ | <br>0,5 to 2 mm<br>50 µ to 0,5 mm<br>20 µ to 50 µ |
| **Stringers** | 2 µ to 60 µ | 2 to20 µ |
| **Clay** | < 2 µ | < 2 µ |

**2.3.1.1.2.-Classification criteria**

Soil texture classification is often represented by a triangular coordinate system, showing the proportions of sand, silt, and clay (Fig. 5). This representation is based on an equilateral triangle, where the distances from a point inside the triangle to its edges sum up to the length of its side. This allows us to represent the values of three variables in a phenomenon using triangular coordinates. Soil texture is crucial in agriculture as it significantly impacts fertility, crop productivity, and the circulation of water in terrestrial ecosystems.

Depending on the proportion of these different particle size fractions, the following textures are determined:

• **Fine textures:** they contain a high level of clay (>20%) and correspond to so-called "heavy" soils, which are difficult to work but have optimum water retention.

• **Sandy or coarse textures:** they characterize light soils lacking cohesion and tend to dry out seasonally.

• **Average textures: there are two types**: - Clay-sandy loams that contain no more than 30 to 35% silt, which have a perfectly balanced texture and correspond to the best so-called "free" soils. - Soils with a loamy texture that contain more than 35% silt, are poor in humus (organic matter in the soil coming from the partial decomposition of animal and plant matter).

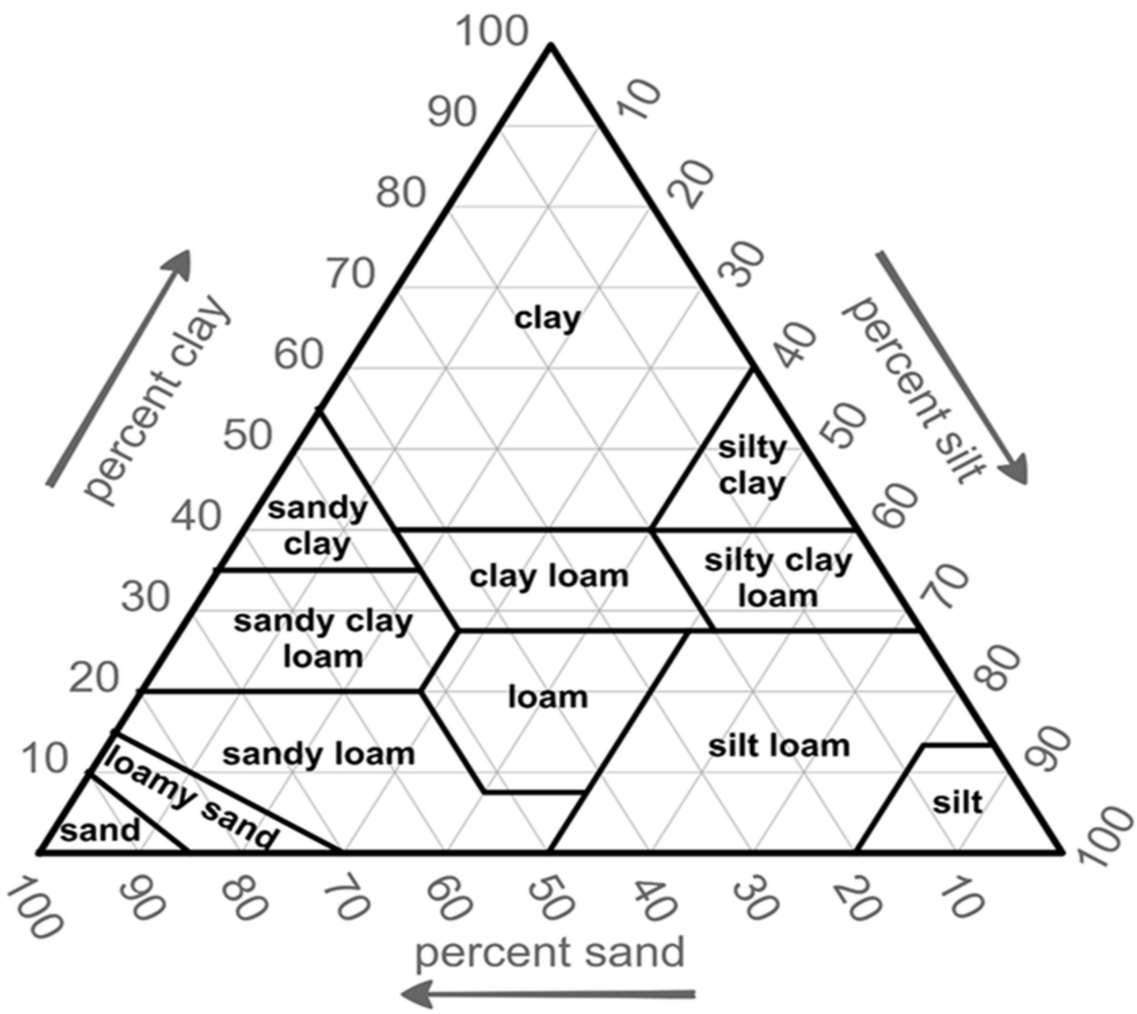


**Figure 5:** Texture Triangle

On a biological level, grain size affects the distribution of animals and groundwater. Certain organisms, like earthworms, thrive in loamy or clay-sandy soils. Some species of beetles also prefer clayey and/or loamy soils, which have a high fine content and good water retention, unlike coarse elements that cause the soil to dry out rapidly.

#### 2.3.1.2.- Soil structure

##### 2.3.1.2.1.- Definition

The structure of the soil is determined by how the solid constituents of the soil are assembled or how the different solid particles of the soil are arranged. This assembly is a result of the cementation of coarse grains (silt, sand) by colloidal elements such as clay and humus, which form clay-humus complexes. The formation of aggregates is a consequence of this assembly, where an aggregate is a cluster of particles held together by clays, iron, organic matter, and water. Aggregates are the natural organization of the solid constituents of the soil. The structure undergoes continuous modifications over time, influenced by various factors, both favorable and unfavorable.

##### 2.3.1.2.2.- Structuring factors

- **Favorable factors**

  -Balanced clay and humus contents, rich in humic acids;

  - Presence of calcium;

  -Sufficient contents of iron and aluminum oxides;

  - Presence of earthworms (especially burrowing species) playing a key role in the formation of clay-humus complexes.

- **Unfavorable factors**

  -Settlement and compaction by the passage of heavy machinery;

  -Mechanical actions of rain;

- Alteration of colloidal cements.

#### 2.3.1.2.3.- Types of structures

There are three main types of structures (Fig. 6):

- Particulate: in this type of structure, the soil elements are not connected, making the soil very loose (sandy soils).
- Massive: in this type of structure, the elements of the soil are held together by cement (organic matter, limestone) that has hardened into a very strong, discontinuous or continuous mass (clayey soils). This soil type is compact and not very porous. However, it hinders the vertical movement of animals sensitive to temperature and humidity, thereby preventing their presence.
- Fragmentary: in this type of structure, the elements are connected by organic matter, forming aggregates of various sizes. This structure is the most conducive to the existence of living beings, as it promotes overall biological activity and allows for the circulation of air and water.

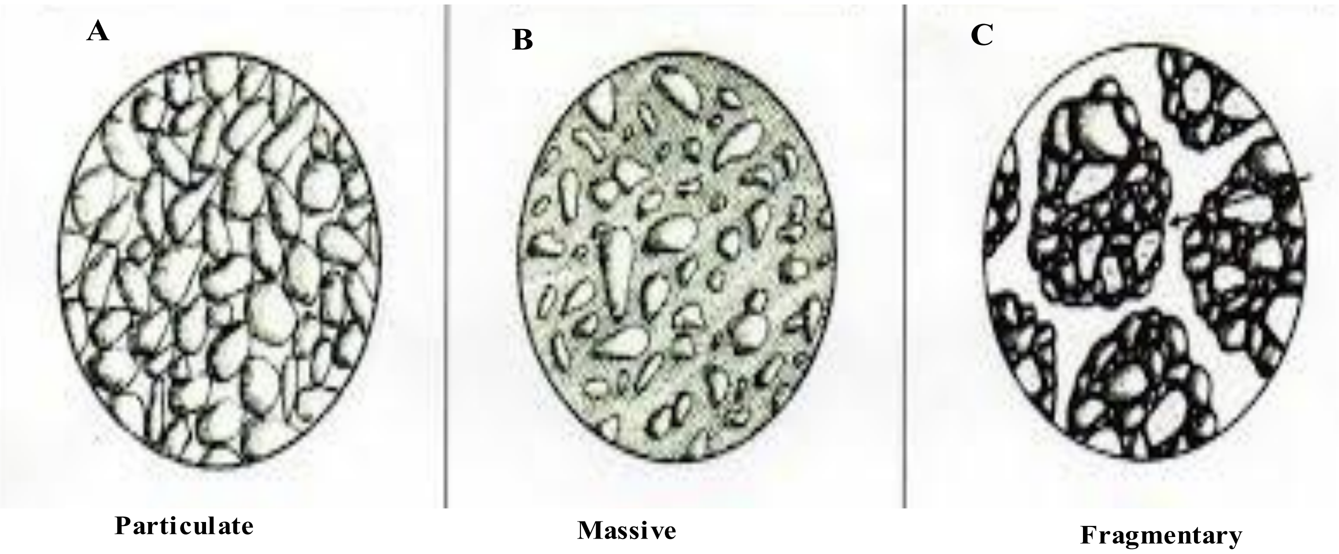


**Figure 6:** Different types of soil structure

### 2.3.1.3.- Porosity

It is the percentage of pores in soil. It regulates the circulation of air and water, as well as the presence of many organisms such as earthworms. Compact soil has low porosity, which hinders the development of living organisms, except for anaerobic species. These soils can be asphyxiating for plant roots due to the lack of $O_2$.

The size distribution of soil pores ranges from macropores (>30 µm) to micropores (<0.2 µm). The pore size distribution affects soil properties such as (Fig.7):

- Water holding capacity and drainage
- Air-water ratio
- Nutrient and gas exchange
- Root penetration

Factors affecting soil porosity include:

- Soil texture: Clay soils have higher porosity due to smaller particle sizes compared to sandy soils.
- Organic matter content: Higher organic matter improves soil aggregation and increases porosity.
- Compaction: Excessive traffic and tillage can reduce porosity by breaking down soil aggregates.
- Shrinking and swelling: Expansion and contraction of clay particles due to wetting and drying can alter porosity.

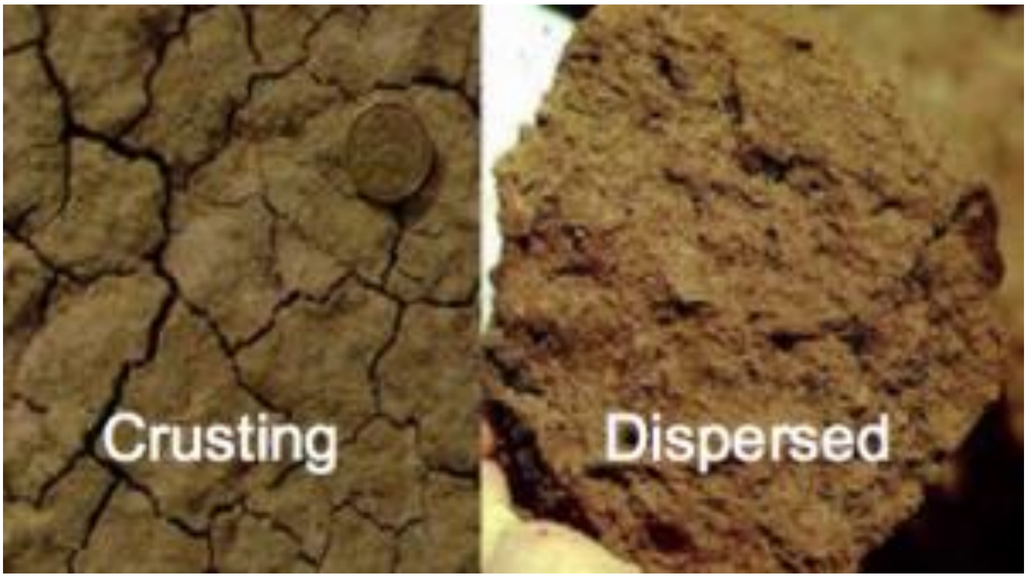


**Figure 7:** Porosity of soil

### 2.3.2.- Chemical characteristics of soils

- The chemical characteristics of soils are important for understanding soil health, fertility, and suitability for various types of vegetation. Here are some key chemical properties of soils:
- pH Level: Measures the acidity or alkalinity of the soil. It affects nutrient availability and microbial activity. Typically ranges from 3 (very acidic) to 10 (very alkaline), with 6-7 being ideal for most plants.
- Organic Matter Content: The amount of decomposed plant and animal residues in the soil. It enhances soil structure, water retention, and nutrient availability. Measured as a percentage of the total soil volume.
- Cation Exchange Capacity (CEC): The ability of soil to hold and exchange positively charged ions (cations). It influences soil fertility and nutrient retention. Measured in milliequivalents per 100 grams of soil (meq/100g).

- Nutrient Content: Levels of essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), and micronutrients (e.g., iron, manganese, zinc). It directly impacts plant growth and productivity. Typically measured in parts per million (ppm) or milligrams per kilogram (mg/kg).
- Soil Salinity: Concentration of soluble salts in the soil. High salinity can hinder plant growth by affecting water uptake. Measured by electrical conductivity (EC) of a soil solution, expressed in Deci Siemens per meter (dS/m).
- Soil Mineralogy: The composition and proportion of minerals present in the soil. It affects soil texture, structure, and fertility. Identified through soil testing and analysis.
- Base Saturation: The percentage of the CEC occupied by base cations (Ca, Mg, K, and Na). It indicates soil fertility and lime requirement. Expressed as a percentage.
- Soil Carbonates: Presence of carbonate minerals such as calcium carbonate ($CaCO_3$). It affects soil pH, buffering capacity, and nutrient availability. Measured through chemical tests.
- Heavy Metals: Presence of metals like lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg) at toxic levels. It can be harmful to plants, animals, and humans. Measured in parts per million (ppm).

### 2.4.- The main problems affecting soils

- **Soil Erosion**

Soil erosion is the removal of soil by wind and water, occurring more rapidly than soil formation processes can replace it.

It is caused by deforestation, overgrazing, faulty agricultural practices, and lack of vegetation cover.

It results in the loss of fertile topsoil, reduced agricultural productivity, and the sedimentation of water bodies.

- **Nutrient Depletion and Imbalance**

Indian soils are generally deficient in nitrogen and phosphorus, while high in potassium.

The long-term imbalanced use of fertilizers, extractive farming practices, and lack of organic matter addition lead to nutrient depletion.

The ideal N-P-K ratio is 4:2:1 but has become skewed due to subsidies favoring urea and high prices of other fertilizers.

- **Soil Compaction**

Soil compaction is caused by heavy foot traffic, machinery, and overworking wet soil, leading to the collapse of soil pores.

It results in poor drainage, reduced aeration, and impaired root growth. It can be managed by avoiding compaction, incorporating organic matter, and loosening compacted layers.

- **Poor Drainage**

Poor drainage occurs when rainfall or irrigation water cannot easily infiltrate or percolate through the soil.

It is caused by high clay content, compaction, hardpans, or lack of organic matter.

It leads to waterlogging, root drowning, and increased acidity. It can be improved by adding organic matter, creating raised beds, and installing drainage systems.

- **Soil Salinity and Alkalinity**

Soil salinity and alkalinity are caused by over-irrigation, leading to capillary rise and the accumulation of salts.

It renders fertile soils unusable, requiring the judicious use of irrigation water.

- **Soil Contamination**

Soil contamination is increasing due to urbanization, with heavy metals and industrial/municipal waste contaminating soils.

Opencast mining disturbs the soil's physical, chemical, and biological properties.

### 2.5.- Management of soil

Implementing these soil management practices can help maintain and improve soil health, enhance agricultural productivity, and promote environmental sustainability (Fig. 8).

#### 2.5.1.- Soil Conservation Practices

- **Contour Plowing:** Plowing along the contours of the land to reduce soil erosion.
- **Terracing:** Creating terraces on slopes to slow water runoff and prevent soil erosion.
- **Cover Cropping:** Planting cover crops (e.g., clover, rye) to protect the soil from erosion and improve soil organic matter.
- **Strip Cropping:** Alternating strips of different crops to reduce erosion and improve soil fertility.

#### 2.5.2.- Organic Matter Management

- **Composting:** Adding compost to the soil to increase organic matter and improve soil structure.
- **Green Manuring:** Growing and plowing under cover crops to add organic matter and nutrients to the soil.
- **Mulching:** Applying organic or inorganic mulch to the soil surface to conserve moisture, reduce erosion, and improve soil health.

#### 2.4.3.- Nutrient Management

- **Soil Testing:** Regularly testing soil to determine nutrient levels and pH, which helps in making informed fertilizer decisions.
- **Balanced Fertilization:** Applying the right amount and type of fertilizers based on soil test results to avoid nutrient imbalances.
- **Integrated Nutrient Management:** Combining the use of organic and inorganic fertilizers to improve soil fertility and crop productivity.

### 2.5.4.-Water Management

- **Efficient Irrigation Systems:** Using drip or sprinkler irrigation systems to reduce water wastage and prevent waterlogging.
- **Drainage Systems:** Installing proper drainage systems to prevent waterlogging and salt buildup.
- **Rainwater Harvesting:** Collecting and storing rainwater for irrigation purposes to reduce dependency on other water sources.

### 2. 5.5.- Soil pH Management

- **Liming Acidic Soils:** Applying lime to acidic soils to raise the pH and improve nutrient availability.
- **Acidifying Alkaline Soils:** Adding sulfur or other acidifying agents to alkaline soils to lower the pH and enhance nutrient uptake.

### 2.5.6.- Soil structure improvement

- **Reduced Tillage:** Practicing no-till or minimum-till farming to maintain soil structure and reduce compaction.
- **Crop Rotation:** Rotating different crops to improve soil structure, reduce pest and disease buildup, and enhance soil fertility.
- **Adding Organic Amendments:** Incorporating organic materials such as compost, manure, and green manures to improve soil structure.

### 2.5.7.- Erosion control

- **Windbreaks and Shelterbelts:** Planting trees or shrubs to protect soil from wind erosion.
- **Grassed Waterways:** Establishing grassed areas in drainage channels to reduce water erosion and trap sediments.

- **Sediment Control Measures:** Using silt fences, sediment traps, and other measures to control sediment runoff.

### 2.5.8.- Integrated pest management (IPM)

- **Biological Control:** Using natural predators or parasites to control pest populations.
- **Cultural Practices:** Implementing crop rotation, intercropping, and proper planting dates to manage pests.
- **Chemical Control:** Using pesticides judiciously and as a last resort, based on pest monitoring and threshold levels.

### 2.5.9.- Organic farming practices

- **Use of Organic Inputs:** Relying on organic fertilizers, such as compost and manure, instead of synthetic fertilizers.
- **Pest and Disease Management:** Employing organic methods, such as crop rotation, biological control, and organic pesticides.

### 2.5.10.- Agroforestry

- **Integrating Trees and Crops:** Combining trees and shrubs with crops or livestock to improve soil fertility, reduce erosion, and enhance biodiversity.
- **Alley Cropping:** Planting rows of trees or shrubs with crops grown in between to improve soil health and provide additional income sources.

### 2.5.11.- Sustainable land management

- **Land Use Planning:** Developing land use plans that consider soil types, topography, and sustainable practices to ensure long-term productivity.
- **Monitoring and Evaluation:** Regularly assessing soil health and management practices to make necessary adjustments and improvements.

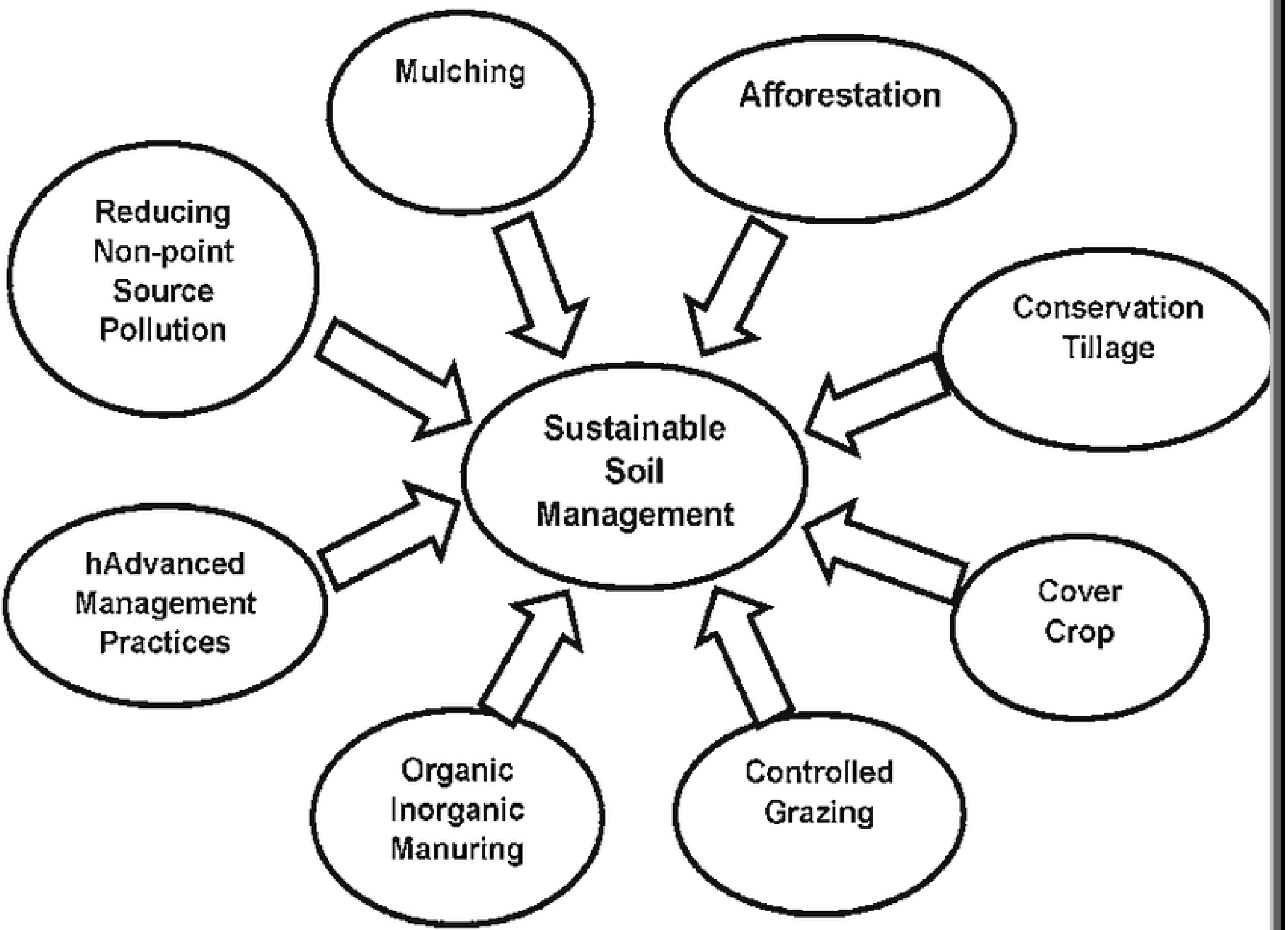


**Figure 8:** Management of soil

# 3.- Gaseous emissions management

## 3.1.- Definition

Gaseous emissions management refers to the techniques and strategies used to control and reduce the release of gaseous pollutants into the atmosphere. The main goals are to minimize the environmental impact of greenhouse gases (GHGs) like carbon dioxide ($CO_2$) and methane ($CH_4$), as well as other harmful gaseous pollutants such as volatile organic compounds (VOCs), sulfur dioxide ($SO_2$), and nitrogen oxides ($NO_x$).

## 3.2.-Causes of Gaseous Emissions

**3.2.1.-Fossil Fuel Combustion**: The primary source of greenhouse gas emissions, particularly carbon dioxide ($CO_2$), comes from burning fossil fuels for energy. This includes coal, oil, and natural gas used in power generation, transportation, and industrial processes.

**3.2.2.-Industrial Activities**: Manufacturing and industrial processes release various pollutants, including volatile organic compounds (VOCs), sulfur dioxide ($SO_2$), and nitrogen oxides ($NO_x$). These emissions contribute significantly to air pollution and climate change.

**3.2.3.- Agricultural Practices**: Agricultural activities, particularly livestock management, produce methane ($CH_4$) and nitrous oxide ($N_2O$), both potent greenhouse gases. The decomposition of organic matter in landfills also releases methane.

**3.2.4.-Urbanization and Population Growth**: Increased urbanization leads to higher energy demands and vehicle emissions, exacerbating air pollution and greenhouse gas emissions.

**3.2.5.-Waste Management**: Poor waste management practices, such as open burning and inadequate composting, can lead to the release of harmful gases like methane and ammonia ($NH_3$) into the atmosphere.

### 3.3.- Management Strategies for Gaseous Emissions

**3.3.1.- Absorption and Adsorption Techniques**: These methods involve passing polluted gases through liquid absorbents or solid adsorbents to capture and remove pollutants. For instance, flue gas desulfurization (FGD) systems are used to control sulfur dioxide emissions from power plants.

**3.3.2.- Incineration**: This technique involves the combustion of gaseous pollutants at high temperatures, converting them into less harmful substances like carbon dioxide and water. Incineration is commonly used for VOCs and other hydrocarbon pollutants.

**3.3.3.-Energy Efficiency Improvements**: Enhancing energy efficiency in industrial processes can significantly reduce emissions. This includes upgrading equipment, optimizing processes, and implementing energy conservation measures.

**3.3.4.- Flaring Reduction**: Flaring is used to burn off excess gases during oil production. Efforts are being made to minimize routine flaring through better gas capture technologies and infrastructure development.

**3.3.5.- Carbon Sequestration**: This emerging technology involves capturing carbon dioxide emissions from sources like power plants and storing it underground or utilizing it in various applications. This method aims to reduce the overall concentration of CO2 in the atmosphere.

**3.3.6.-Sustainable Waste Management**: Implementing better waste management practices, such as composting and recycling, can reduce emissions from landfills. Techniques like covering compost piles and using bulking agents can help minimize methane and ammonia emissions during composting (Fig. 9).

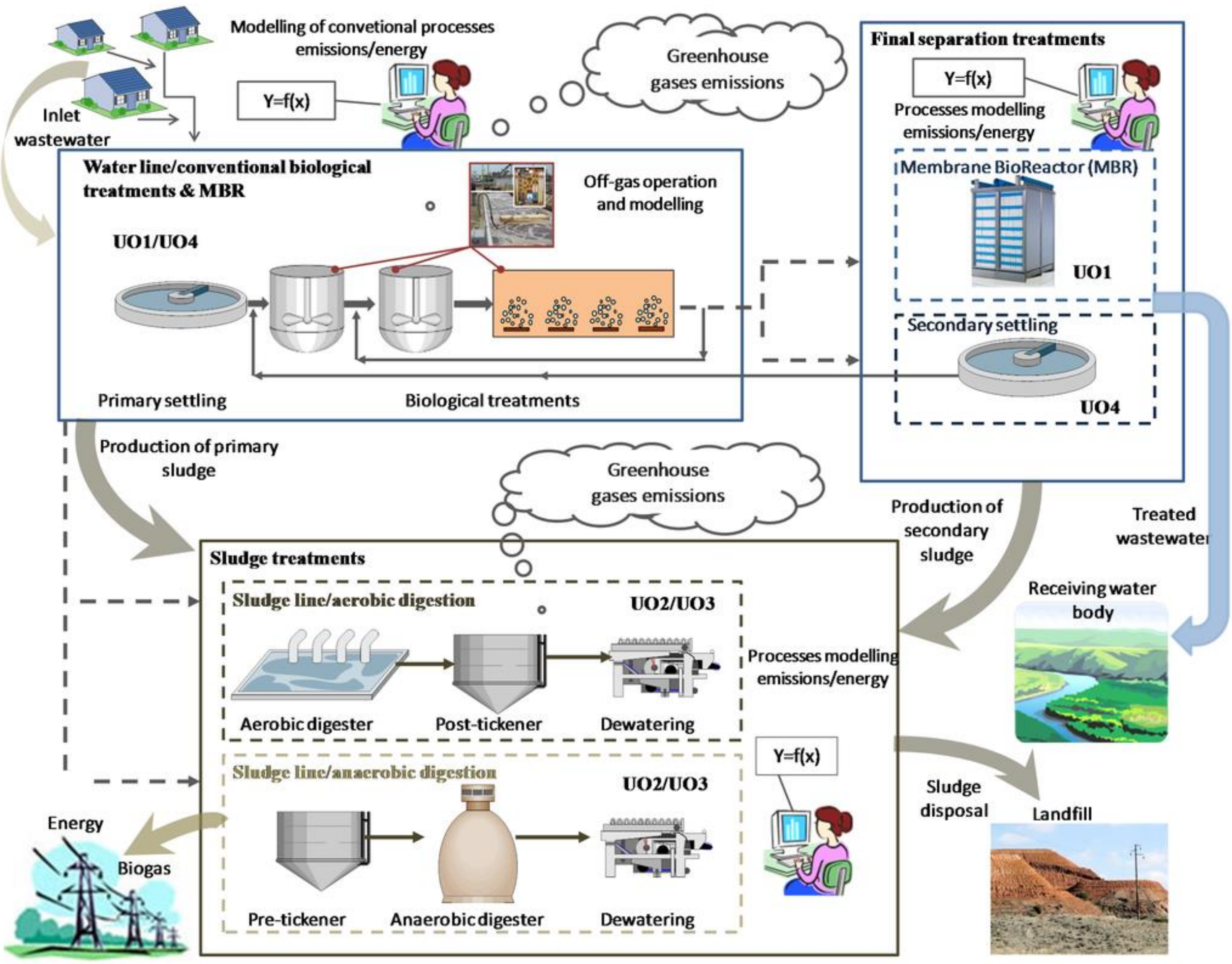


**Figure 9:** Management Strategies for Gaseous Emissions

### 3.4.- Problem that is exposed to the emissions gazeuses

The problem of gaseous emissions is multifaceted and primarily arises from various human activities, particularly in agriculture and energy production. Here are some key issues related to gaseous emissions:

#### 3.4.1.-Agricultural emissions

In the agricultural sector, particularly in pig farming, gaseous emissions from manure management are a significant concern. The decomposition of manure produces methane (CH4) and ammonia (NH3), contributing to greenhouse gas emissions and air quality issues. The management practices used in these farms can exacerbate environmental problems, leading to the need for better strategies to reduce emissions and improve waste management practices.

### 3.4.2.- Biomass combustion

The direct combustion of biomass for energy production is another source of gaseous emissions. While biomass can be a renewable energy source, its combustion can release particulate matter and various gases, including carbon dioxide ($CO_2$) and volatile organic compounds (VOCs). The technical challenges associated with biomass combustion include managing these emissions effectively to minimize their environmental impact.

### 3.4.3.- Odor emissions

Odor emissions from the storage and combustion of biomass are also problematic. These odors can affect local communities and lead to complaints, necessitating effective management strategies to mitigate these emissions. Addressing odor issues is critical for maintaining community relations and compliance with environmental regulations.

### 3.4.4.- Regulatory compliance

As regulations surrounding air quality and emissions become stricter, industries must adapt to meet these standards. The challenge lies in implementing effective emissions control technologies and practices while maintaining operational efficiency. This requires ongoing research and investment in cleaner technologies to reduce gaseous emissions effectively. In summary, the problems associated with gaseous emissions encompass various sectors, with agriculture and biomass energy production being prominent sources. Effective management strategies are essential to mitigate these emissions and comply with environmental regulations.

## 4.- Pollution management

### 4.1.- Pollution definition

Pollution is any anthropogenic modification of an ecosystem resulting in a change in the concentration of natural chemical constituents, or resulting from the introduction of artificial chemicals into the biosphere, a disturbance in the flow of energy, the intensity of radiation, the circulation of matter or the introduction of exotic species into a natural biocenosis.

Degradation of the environment by introducing into the air, water or soil materials that are not naturally present in the environment. It leads to a disruption of the ecosystem, the consequences of which can go as far as the migration or extinction of certain species unable to adapt to change.

### 4.2.- Current causes of pollution

- Pollution related to energy production and use;
- Pollution from industrial sources;
- Solid Waste;
- Pollution from agriculture.

### 4.3.- Pollution classification

Pollution can be classified on the basis of many criteria.

Depending on the nature of the polluting agent:

**A. Pollutants of a physical nature**

- The heat;
- Radioactive pollution;
- Noise;

- Light pollution.

**B. Chemical pollutants**

- Liquid hydrocarbons;
- Detergents and surfactants:
- Plasticizers:
- Phthalates
- Pesticides
- Eutrophying substances:
- Heavy Metals
- Medicines and cosmetics:

**C. Pollutants of a biological nature**

- Algal toxins,
- Pathogens
- Hangers-on

- From an ecological point of view: taking into consideration the environment (air, water, soil), or the compartment of the related biosphere (atmosphere, hydrosphere, pedosphere) in which they are emitted and on the biocenoses of which they exert their disturbances

- From a toxicological point of view: Considers the environment or the way in which pollutants contaminate organisms. Depending on the route of contamination, we can distinguish: in plants, stomatal, transfoliar absorption, or root translocation. In animals, contamination can be distinguished by inhalation (in terrestrial species), transbranchial absorption (in aquatic species), ingestion (orally) or transcutaneous penetration following skin or integument contact with the pollutant.

## 4.4.- Mechanism of dispersion and circulation of pollutants in the biosphere

### 4.4.1.-Physical Properties

We find pollution in the 3 states of matter:

- Water pollution
- Air pollution
- Soil pollution (solid).

### 4.4.2.- Lifespan of substances

The different substances have lifetimes in the biosphere that are extremely variable (Fig. 10).

- **Primary pollutants**: are directly emitted by pollution sources: $CH_4$: year, CO: month, $SO_2$: days to month, Ozone: some days, VOC NM: hours to days, Aerosols: 1-10 µm: minute to days, Aerosols: 1µm days to weeks.
- **Secondary pollutants**: are not emitted, but result from the physico-chemical transformation of primary pollutants during their stay in the atmosphere.

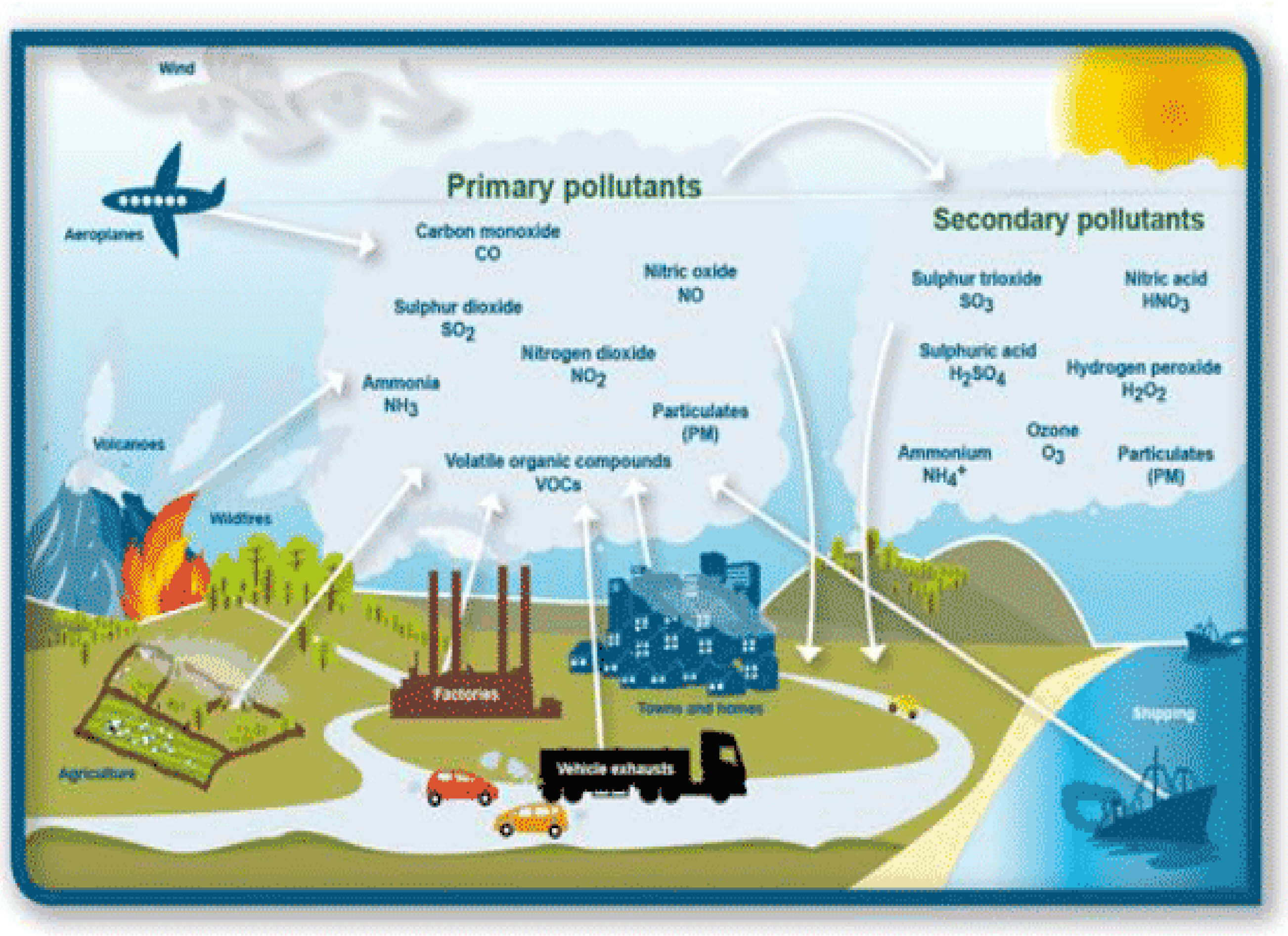


**Figure 10:** Primary or secondary pollutants

### 4.4.3.-Biogeochemical processes

The release of pollutants into the environment is a complex phenomenon. In almost all cases, substances released into the ecosphere will be carried away from the point of release. Atmospheric and hydrological circulation will gradually disperse them throughout the ecosphere.

#### 4.4.3.1.-Atmospheric circulation of pollutants

The processes that govern air pollution are staged in several stages.

- Emissions
- Transport and dispersion (vertical dispersion and horizontal dispersion):
- Chemical transformations by complex reactions:

#### 4.4.3.2.-The movements of the hydrosphere

There are two types of currents: surface currents and deep currents. The surface currents of the seas and oceans, generated by the winds, move very quickly. Deep currents, which are much slower, move only a few millimeters per year.

#### 4.4.3.3.-Transfers of substances into soil

Pollutants, including organic substances, are subjected to biochemical reactions in the environment. These reactions can be done by:

- Photochemical reactions, (on the ground surface),
- Chemical phenomena (including hydrolysis and oxidation of compounds,
- By interactions with bacteria, fungi or algae, we then speak of biodegradation.

## 4.5.- Current causes of biosphere pollution

### 4.5.1.-Energy production, the main cause of pollution

Petroleum products (oil and gas) accounted for 65% of the total energy consumption of the United States in 2000, thus covering most of the energy needs of this country, which alone consumes 25% of the commercial energy used worldwide. The total mass of fossil energy burned in 2000 is equivalent to 11% of the total amount of solar energy fixed each year by photosynthesis by all primary producers present in continental ecosystems. The main air pollutants produced by combustion are $SO_2$ and $NO_X$, which result in acid rain, photochemical smog and solid particles.

### 4.5.2.-Diversification of chemical pollutants and accumulation of waste

Since the end of the Second World War, organic chemistry has made a multitude of new synthetic molecules available to us. It was estimated in the 1990s that 120 thousand molecules were marketed worldwide and that each year 500 to 1000 new chemical substances were placed on the market. Among them, plastics, detergents, insulating materials have brought indisputable elements of comfort to everyday life. One of the most formidable aspects of global pollution by synthetic chemicals is the growth in releases of persistent organic pollutants (POPs) both in industrialized countries and in the Third World. Due to their ubiquity and stability, these substances: polycyclic aromatic hydrocarbons (PAHs), chlorinated solvents, polychlorinated biphenyls (PCBs), organochlorine pesticides, dioxins, etc., are found today in the most remote regions of the biosphere.

#### 4.5.3.- Pollution from agriculture and intensive livestock farming

A last major cause of pollution of the biosphere is the development of a model of agriculture and breeding deemed modern. The intensive agricultural use of synthetic pesticides (insecticide, fungicide, herbicide) and mineral manure by adding nitrogenous fertilizers, phosphate and potassium salts leads to spectacular progress in crop yields. Indeed, these products, in addition to the excrement of farm animals, generate insidious pollution of surface or coastal waters and groundwater.

### 4.6.- Types of pollution

Major forms of pollution include air pollution, water pollution, litter, noise pollution, plastic pollution, soil contamination, radioactive contamination, thermal pollution, light pollution, and visual pollution (Fig. 11).

#### 4.6.1.- Air Pollution

Air pollution can be defined as the presence of impurities in the air that can cause significant discomfort to people and damage to property. Air pollution is therefore strongly influenced by climate and especially by wind, temperature, humidity and atmospheric pressure.

#### 4.6.2.- Soil pollution

Soil pollution can be diffuse or local, of industrial or agricultural origin (following the massive use of fertilizers or pesticides that infiltrate the soil). This agricultural pollution can have several impacts on human health, by touching groundwater on the one hand and by contaminating by bioaccumulation the crops growing on these soils on the other hand.

### 4.6.3.- Emissions to Water

Water pollution can have various origins including:

- Industrial farms: which release various products present in fertilizers (such as nitrate ions: $NO_3^-$) or phytosanitary products can pollute groundwater and lead to the closure of drinking water catchment points if their presence is too high
- Industry: These are mainly chemicals and hydrocarbons (degassing).
- Wastewater: This is a favorable environment for the establishment of a bacterial microfauna (development of bacteria) which if not treated properly can be a source of water pollution. Chemical and biological oxygen demand (COD and BOD) will be useful in assessing the content of pollution in water.

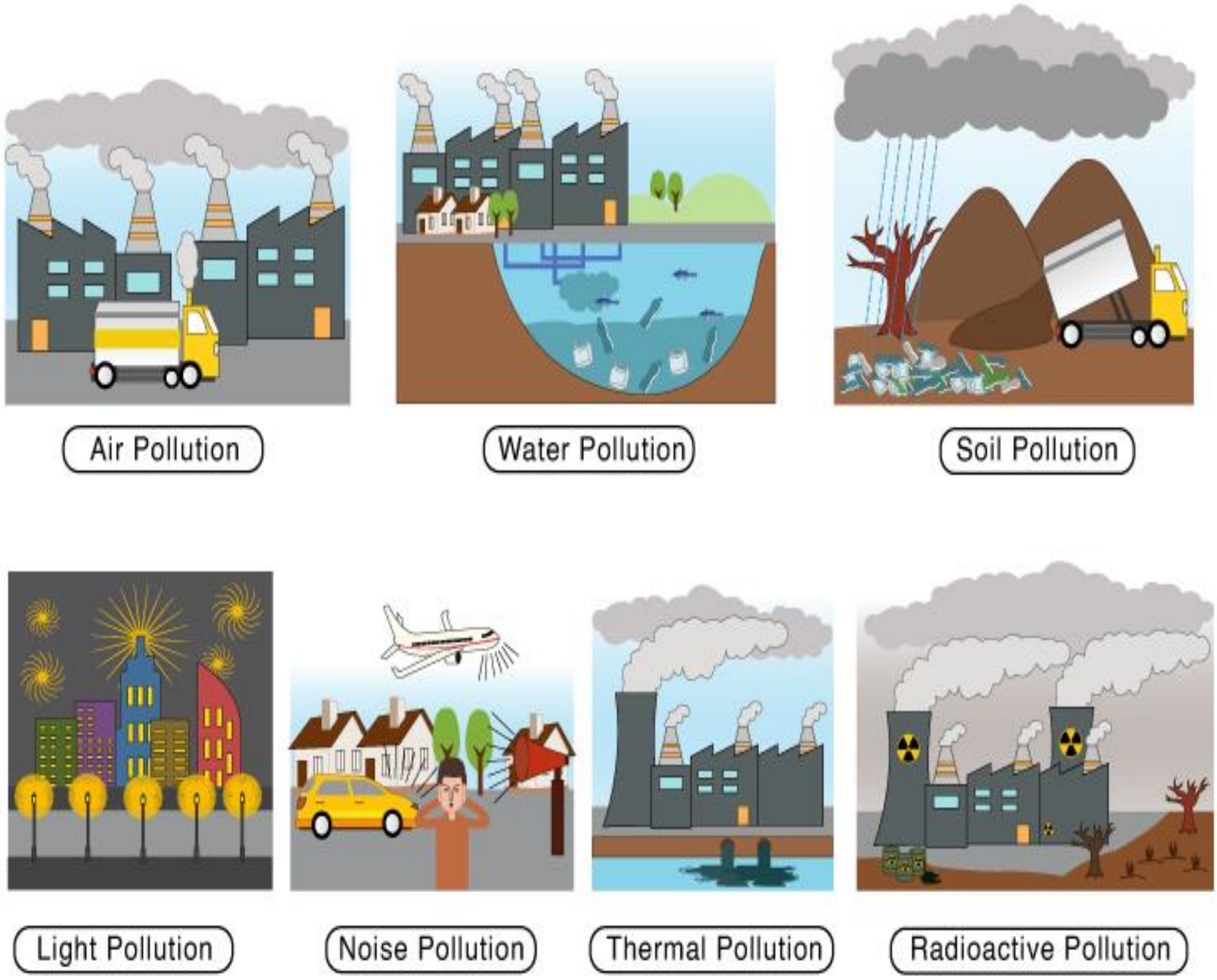


**Figure 11:** Main type of pollution

### 4.6.4.-Pollution by type or pollutants

- Pollution related to transport, including automobile pollution and airplane pollution
- Radioactive pollution, (radioactive products (example: phosphogypsum; Chernobyl disaster),
- Electromagnetic pollution, (pollution related to ionizing and non-ionizing radiation).
- Thermal pollution
- Light pollution: refers to both the abnormal or disturbing presence of light at night and the consequences of artificial night lighting on fauna, flora, ecosystems and effects on human health. It is often associated with the notion of energy waste, in the case of poorly adapted artificial lighting, if it constitutes a preventable expenditure of energy.
- Pollution related to tourism (partly related to transport), DIY and certain leisure activities (e.g. boating) or festivities (e.g. fireworks).
- Space pollution and pollution by weapons or explosives.

## 4.7.-Pollution management

The management of pollution is a critical global issue, particularly as it poses significant risks to human health and the environment. Various organizations and academic institutions are actively engaged in pollution management initiatives, focusing on research, policy development, and education (Fig. 12).

**Laws and Regulations**: Establishing and enforcing laws to limit emissions of pollutants.

The World Bank has established the Pollution Management and Environmental Health (PMEH) Program to address pollution's severe impacts, particularly in low- and middle-income countries. This program aims to provide technical assistance, facilitate knowledge exchange, and raise awareness about pollution's detrimental effects on health and economies. Notably, air pollution alone accounted for approximately 9 million premature deaths in 2016, highlighting the urgency of effective pollution management strategies. The PMEH focuses on several key areas.

**Air Quality Management**: Implementing measures to improve air quality and reduce health risks.

**Water Pollution Management**: Addressing contamination in water bodies to safeguard public health.

**Toxic Sites Management:** Remediating contaminated land to protect communities from hazardous exposures.

**Academic Programs in Pollution Management**

Master's Programs

Several universities offer specialized master's programs in pollution management, equipping students with the necessary skills to address environmental challenges:

University of New England (UNE): Offers a unit on pollution management that covers air, water, and soil pollution, emphasizing proactive approaches to reduce and control pollution. The curriculum includes practical assessments and case studies to enhance students' problem-solving capabilities in real-world contexts

University of Birmingham: Provides a unique MSc in Air Pollution Management and Control, focusing on the causes and effects of air pollution. This program is recognized for its comprehensive curriculum and is supported by industry partnerships aimed at fostering the next generation of clean air leaders

Landau University: Offers a Master of Science in Environmental Pollution Management (Ecotoxicology), focusing on the impacts of chemicals on ecosystems and developing risk management strategies. This program is interdisciplinary, integrating environmental science with social sciences and economics

**Pollution Prevention**

**Source Reduction:** Implementing practices that reduce the amount of pollution produced at the source.

**Cleaner Production:** Adopting production processes that minimize waste and emissions.

Waste Management:

**Recycling and Reuse**: Promoting the recycling and reuse of materials to reduce waste.

Proper Disposal: Ensuring the safe disposal of hazardous and non-hazardous waste.

| Process of pollution | Level of pollution management |
|---|---|
| HUMAN ACTIVITY PRODUCING POLLUTANT | **Altering human activity**<br>The most fundamental level of pollution management is to change the human activity that leads to the production of the pollutant in the first place, by promoting alternative technologies, lifestyles and values through:<br>• campaigns<br>• education<br>• community groups<br>• governmental legislation<br>• economic incentives/disincentives. |
| RELEASE OF POLLUTANT INTO ENVIRONMENT | **Controlling release of pollutant**<br>Where the activity/production is not completely stopped, strategies can be applied at the level of regulating or preventing the release of pollutants by:<br>• legislating and regulating standards of emission<br>• developing/applying technologies for extracting pollutant from emissions. |
| IMPACT OF POLLUTANT ON ECOSYSTEMS | **Clean-up and restoration of damaged systems**<br>Where both the above levels of management have failed, strategies may be introduced to recover damaged ecosystems by:<br>• extracting and removing pollutant from ecosystem<br>• replanting/restocking lost or depleted populations and communities. |

**Figure 12.** Pollution management targeted at three different levels

# 5.- Wastewater management

## 5.1.-Definition

Wastewater is water loaded with pollutants, soluble or not, mainly from human activity. Wastewater is generally a mixture of pollutants meeting these categories, dispersed or dissolved in water that has been used for domestic or industrial needs.

Urban wastewater (URW) or wastewater is water contaminated with pollutants, whether soluble or insoluble, primarily as a result of human activities. Generally, wastewater is a combination of pollutants falling into these categories, which are either dispersed or dissolved in water that has been utilized for domestic or industrial purposes.

## 5.2.-Nature and origin of waste water

We can classify as wastewater:

**5.2.1.-Industrial origin:** Wastewater of industrial origin generally has a more specific composition and is directly related to the type of industry considered. Industrial effluents and waste thin the quality and pollution rate of this wastewater. Industrialists use a huge amount of water in their industrial fields. We can classify the main industrial discharges according to the nature of the disadvantages they meet:

- ✓ Pollution due to mineral suspended solids (coal washing, industries producing phosphate fertilizers,………) ;
- ✓ Pollution due to materials in mineral solution (stripping plant,……..) ;
- ✓ Pollution due to organic matter and fats (agri-food industries, pulp and paper,……..) ;
- ✓ Pollution due to hydrocarbon and chemical discharges (oil refineries, pharmaceuticals,………) ;

- ✓ Pollution due to toxic discharges (untreated radioactive waste, radioactive effluents from nuclear industries, ………..).

**5.2.2.-Domestic origin**: Domestic effluents are a mixture of water containing human waste: urine, faeces and toilet water and soil and food cleaning (household water).

**5.2.3.-Agricultural origin**: These are waters that have been polluted by substances used in agriculture. These are mainly: Fertilizers (commercial mineral fertilizers or animal waste produced or not on the farm). Plant protection products (herbicides, fungicides, insecticides,………

**5.3.- Wastewater characteristics**

Wastewater parameters access to determine the degree of water pollution. Pollution is any degradation of the physical, chemical and biological properties of water, which is then called wastewater.

**5.3.1.-Physical Parameters**

- **Temperature**: when the temperature increases, dissolved oxygen decreases. It also influences the decomposition of organic matter, the development of parasites responsible for certain It is important to know the water temperature with good accuracy. Indeed, it plays a role in the solubility of salts and especially gases, in the dissociation of dissolved salts and therefore on the electrical conductivity, diseases, and the proliferation of blue algae that release toxins.
- **Suspended matter (ESM):** Particulate pollution is due to the presence of large particles, greater than 10 µm, suspended in water, which can be assimilated to suspended matter (ESM).

### 5.3.2.-Organoleptic parameters

- **Turbidity: Turbidity** represents the opacity of a turbid environment. It is the reduction of the transparency of a liquid due to the presence of undissolved materials. It is expressed in NTU
  - ✓ NTU < 5 => Clear water;
  - ✓ NTU < 30 => Slightly cloudy water;
  - ✓ NTU > 50 => Cloudy water.
- **Color**: Pure water observed under transmitted light over a depth of several meters emits a light blue color because short wavelengths are poorly absorbed while long wavelengths (red) are absorbed very quickly

### 5.3.3.-Chemical Parameters

- **Hydrogen potential (pH):** pH plays an important role in biological treatment. It expresses the degree of acidity or alkalinity of wastewater. The pH of domestic or urban water is generally between 6.8 and 7.8, beyond which it is an indicator of industrial pollution.
- **Conductivity:** Conductivity is the property that a water has to help the passage of an electric current. It results from the nature of these dissolved ions and their concentrations. It is the property of water to facilitate the passage of an electric current. It is due to the presence in the medium of ions that are mobile in an electric field. It depends on the nature of these dissolved ions and their concentrations.
- 

### 5.3.4.-Bacteriological parameters (Faecal contamination indices)

They come from fecal matter, which contains anaerobic flora (109-1010 bacteria/g feces) destroyed in the air, and aerobic flora - facultative anaerobic (106-107 bacteria/g feces).

- **Total coliforms**: Coliform bacteria exist in feces but also develop in natural environments. Treated water must not contain coliforms; however, the absence of coliforms does not necessarily mean that the water does not pose a pathogenic risk.
- **Fecal coliforms**: They can develop at 44 °C and help estimate the epidemiological risk in water. They should consider the presence of pathogenic germs. The main fecal bacterium is *Escherichia coli*.
- **Fecal streptococci**: This group is generally not considered pathogenic. However, their presence along with fecal coliforms indicates fecal contamination because streptococci are a better indicator than fecal coliforms for infectious diseases.

## 5.5.-Wastewater management

Wastewater management involves the collection, treatment, and disposal or reuse of water that has been used in households, industries, and businesses. Effective wastewater management is crucial for protecting public health and the environment. Here are some key aspects:

**5.5.1.-Collection**: Wastewater is collected from various sources through a network of pipes, pumps, and infrastructure. This includes domestic sewage, industrial effluents, and stormwater runoff.

**5.5.2.- Treatment**: The collected wastewater undergoes several treatment processes to remove contaminants and pollutants. Treatment typically occurs in multiple stages:

- **Primary Treatment**: This initial stage involves the physical removal of solids from wastewater through screening and sedimentation.
- **Secondary Treatment**: This biological process uses microorganisms to break down organic matter. After this stage, the water is usually free from most pathogens and heavy metals but may still contain nutrients like nitrates and phosphates.
- **Tertiary Treatment**: This advanced treatment stage aims to remove remaining nutrients and pollutants. Methods may include biological, chemical, and physical processes, such as filtration through wetlands or lagoons

**Disposal or Reuse**: Treated wastewater can be discharged into water bodies, used for irrigation, industrial processes, or even replenishing groundwater. Reusing treated wastewater helps conserve fresh water resources and reduce environmental impact.

1. **Sludge Management**: The treatment process generates sludge, which needs to be managed properly. It can be treated further and used as fertilizer, incinerated, or disposed of in landfills.
2. **Regulations and Standards**: Effective wastewater management is guided by regulations and standards set by local, national, and international bodies to ensure public health and environmental protection.
3. **Sustainable Practices**: Emphasis on sustainability includes reducing water usage, recycling water, and using eco-friendly treatment methods.

4. **Challenges**: Key challenges include aging infrastructure, pollution control, climate change impacts, and the need for investment in advanced treatment technologies.
5. **Innovation**: New technologies and methods, such as membrane bioreactors, anaerobic digestion, and resource recovery, are being developed to improve efficiency and sustainability in wastewater management.

# 6.- Waste management

## 6.1.-Definition of waste

Waste is defined as any unwanted or unusable substance that is discarded after primary use. Wastes are normally generated as a result of human and animal activities. Urbanization and rapid advancements in industrialization has led to an increase in the production and consumption processes resulting in the generation of wastes from various sectors that include agricultural, commercial, domestic, industrial, institutional, social and from community activities. Over time, these wastes accumulate and can have real impacts on the health and the environment. Waste management is intended to reduce adverse effects of waste on health, the environment or aesthetics. So, to carry out efficient management of wastes, knowledge about the source of wastes, its types and classification must be known. Hence, this module gives us an overview about wastes and its classification.

## 6.2.- Classification of wastes

Wastes are commonly classified based on the physical state as solid wastes, liquid wastes and gaseous wastes.

**6.2.1.- Liquid wastes**: Liquid wastes can be defined as liquids/fluids that are generated from washing, flushing or manufacturing processes of the industries. They are also called as sewage. The most common practice of disposing liquid waste is to discharge it in ground or rivers and other water bodies without treatment (Fig. 13).

**6.2.2.- Gaseous wastes** It is a waste product released in the form of gases from automobiles, factories, industries, burning of fossil fuels etc and get mixed in the atmosphere. These gases include carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen dioxide, ozone and methane etc (Fig. 13).

**6.2.3.- Solid** wastes are any discarded or abandoned materials that can be solid, liquid, semi-solid or containerized gaseous material discarded by the human society. These include urban wastes, agricultural wastes, biomedical wastes and radioactive wastes. The term refuse is also used for solid wastes. Examples of solid wastes include waste tires, septage, scrap metal, latex paints, furniture and toys, garbage, appliances and vehicles, oil and anti-freeze, empty aerosol cans, paint cans and compressed gas cylinders, construction and demolition debris, asbestos, plastics, styrofoam containers, bottles etc. (Fig. 13).

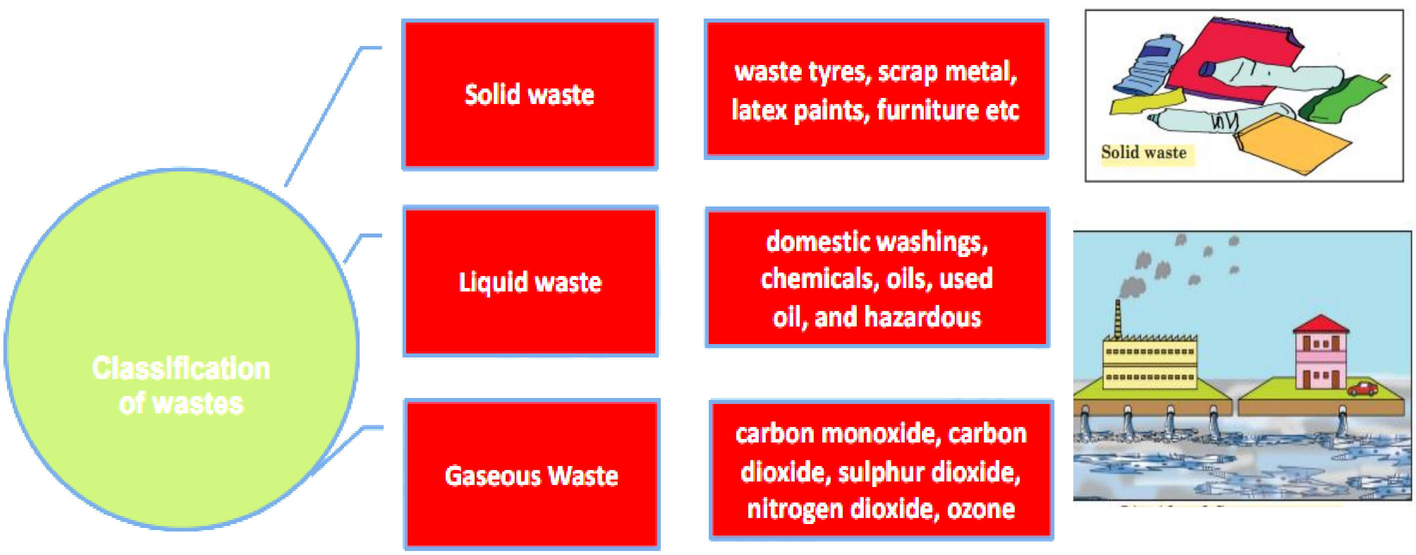


**Figure 13:** Classification of wastes

**6.2.3.1.- Classification of solid wastes**

It is mandatory to classify solid wastes into groups that pose similar risks to the environment and human health for safe disposal. According to the modern systems of waste management, solid wastes are classified based on their source, type, properties and its effect on human health and environment (Fig.14).

**A.- Source based classification**

Wastes are produced from different sources and are categorized as follows:

- **Municipal solid waste (MSW)**

Street wastes, dead animals, market wastes, abandoned cars, domestic garbage, junk, building and demolition debris, sanitation residue, packaging materials, trade refuges, and other things are included in municipal solid waste, often known as trash, garbage, or refuse. Municipalities gather them from streets, marketplaces, residential buildings, and other locations, primarily in metropolitan areas, and dispose of them. The proportion of different constituents of municipal wastes vary from place to place and season to season depending on the food habits, life style, standard of living and extent of commercial and industrial activities in the area. Municipal wastes their contents and source are illustrated in table given below. Municipal solid wastes are further categorized based on their physical, chemical and biological properties.

- **Industrial wastes**

Industrial wastes are produced during the manufacturing and processing processes involved in chemical plants, paint factories, cement factories, metallurgical plants, thermal power plants, petroleum, coal, gas, sanitary, textile, food processing, and paper industries. Chemical solvents, paints, sandpaper, paper goods, industrial by-products, metals, and radioactive wastes are a few types of industrial wastes. Hazardous and nonhazardous wastes are further classifications for industrial solid wastes.

- **Institutional/ Commercial wastes**

Solid waste coming from public, educational, and administrative facilities, including offices, colleges, hospitals, government buildings, jails, and wholesale and retail shops, restaurants, hotels, marketplaces, and warehouses. Examples of industrial and commercial wastes are paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, and hazardous wastes.

- **Agricultural wastes**

Both natural (organic) and non-natural wastes produced by farming operations are categorized as agriculture wastes. Dairy farming, horticulture, seed production, animal breeding, grazing area, market gardens, nursery plots, and even woods are some examples of these operations. Food grains that have gone bad, vegetables, animal and plant wastes, trash, fertilizers, insecticides, etc. are a few examples of agricultural wastes. Additional agricultural wastes are generated by businesses that process agricultural goods, such as sugarcane factories, tobacco processing facilities, slaughterhouses, and facilities that handle cattle and poultry. Most agricultural wastes decompose naturally, but certain wastes—such as fertilizers and pesticides—are hazardous. Agricultural wastes have the potential to be both advantageous and harmful to living things when released into the environment.

- **Biomedical wastes**

Biomedical wastes are those generated by medical facilities, nursing homes, and hospitals. Hospital waste is produced during the diagnosis, treatment, or immunization of humans or animals, as well as during these fields of study and the manufacturing or testing of biologicals. These pollutants are extremely contagious and might be quite dangerous if improperly disposed of. Biomedical wastes include wasted blood, sharps, soiled wastes, disposables, anatomical wastes, cultures, abandoned medications, chemical wastes, and more. They can also be solid or liquid wastes.

**B.-Type based classification**

- **Garbage**

Animal and vegetable wastes from the kitchen, cooking, food serving, slaughterhouses, and market trash are all considered garbage wastes. These wastes have a strong odor because they include putrescible organic materials. They need to be handled and disposed of right away since they draw rats, mice, flies, and other insects.

- **Rubbish**

Rubbish is defined as solid trash that results from residential, commercial, and institutional activity; it does not include ashes or garbage. Wastes are divided into two categories: combustible and non-combustible. All trash and debris that may be burned at temperatures between 1400-1500◦F, such as leaves, plants, clothing, paper, rubber, leather, and grasses, is considered combustible garbage. Non-combustible wastes are defined as wastes, such as glass, metals, plastics, stones, car components, etc., that cannot be burned to a crisp at 1400-1500◦F.

- **Bulk waste**

Bulky home garbage includes things like furniture, appliances (including stoves, washers, and refrigerators), TV sets, carpets, tires, lawnmowers, car components, and brush and tree detritus.

Packing and containers including cardboard, wood boxes, fiber, plastic, and steel drums, loose and bundled paper, bundles of textiles and plastics, cables, furniture, and equipment, etc. are examples of commercial bulky wastes.

Industrial bulky trash comprises rolls and bales of paper, plastic, and textile materials; random metal objects; steel, fiber, and plastic barrels; and boxes and cartons.

- **Ashes**

Ashes are defined as fine powdery residues, cinders and clinkers arising from the burning of wood, coal, charcoal, coke and other combustible materials during cooking and heating in houses, institutions and outer industrial establishments.

- **Street wastes**

The phrase "street wastes" refers to materials collected from parks, beaches, alleyways, streets, pathways, and vacant lots that include debris, leaves, dirt, dust, trash, paper, plastics, and other vegetal matter.

- **Dead animals**

Animals that die naturally or accidentally comprises of dead animal wastes. They are categorized as small animals such as cats, dogs, rats, rabbits, poultry and large animals like horses, cows, goats, Sheep etc.

- **Construction and demolition wastes**

Wastes are the massive volumes of waste materials produced during the building, renovation, destruction, and repair of homes, businesses, highways, and other structures. They are made up of soil, rocks, concrete, bricks, timber, steel, plumbing and roofing supplies, heating systems, and electrical cables.

- **Radioactive wastes**

The dangerous byproducts of nuclear reactions are known as radioactive wastes. They seriously endanger both the environment and human lives. The decay time of radioactive wastes varies, with highly radioactive isotopes taking a few days to decay and somewhat radioactive isotopes taking millions of years.

**C.- Property based classification**

Solid wastes are also classified based on their biological and chemical property (Fig. 14).

- **Biodegradable / Organic wastes**

Wastes classified as biodegradable are ones that may break down naturally by aerobic and anaerobic digestion, composting, and other processes, releasing simple organic molecules, carbon dioxide, and water. Municipal solid wastes (green trash, food waste, paper waste, biodegradable plastics, human and animal wastes, sewage, sludge, slaughter house wastes, etc.) are among the biodegradable wastes.

- **Non-biodegradable /inorganic wastes**

Wastes that are not biodegradable are ones that cannot break down and will always be present in the environment. They are tenacious and pose a threat to overrun landfills, causing disposal issues and raising environmental concerns. Recyclable trash management is the best choice because it can't break down naturally. Non-biodegradable waste materials comprise of plastics, glass, rubber tires, styrofoam, fiberglass, metals, and nuclear waste.

- **Hazardous wastes**

Chemical substance that is no longer able to be utilized for its original function and is recognized to be dangerous, or potentially detrimental, to plants, animals, human health, or the environment is referred to as hazardous waste. Hazardous wastes might exist as gases, liquids, solids, or sludge. Because the active agents are contained in solid containers, they are sometimes categorized as solid waste even though they may be liquid or gaseous.

- **Non-hazardous wastes**

Non-hazardous wastes are defined as substances safe to use commercially, industrially, agriculturally or economically. Some of the non-hazardous wastes produced are from the food processing plants, cotton mills, paper mills, textile mills and sugarcane industries. Other non-hazardous wastes include paint, oil, antifreeze, buffers, salts etc.

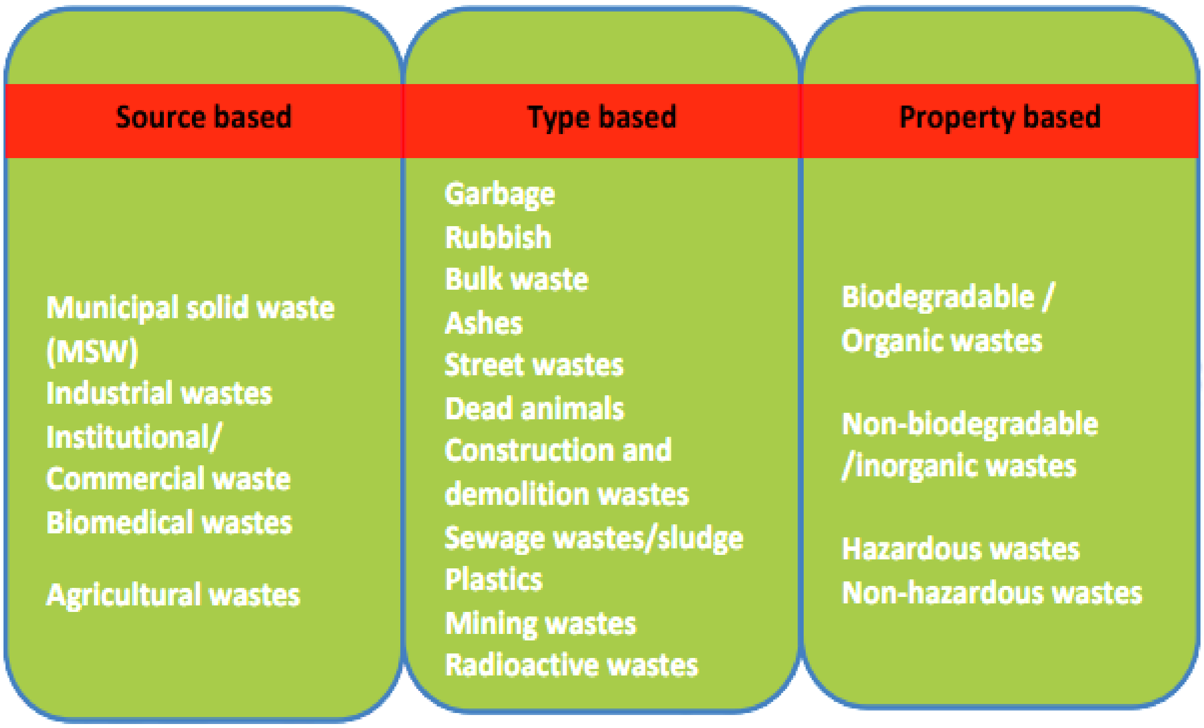


**Figure 14**: Classification solid waste based on source of generation, type and physio-chemical property

### 6.3.-Definition of waste management

Waste management encompasses the processes and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment, and disposal of waste, as well as monitoring and regulation of waste management practices. Waste can be categorized into various types, including solid, liquid, and gaseous, each requiring different management strategies.

### 6.3.1.-The principles of waste management

It’s are essential guidelines that help in effectively managing waste to minimize its impact on the environment and human health. Here are the key principles:

**A. Waste Hierarchy**

The waste hierarchy is a framework that prioritizes waste management strategies based on their environmental impact. It emphasizes the following order of preference:

- Prevention: Avoiding waste generation at the source.
- Reuse: Finding new uses for items without reprocessing.
- Recycling: Processing waste materials to create new products.
- Recovery: Extracting energy from non-recyclable waste.
- Disposal: The least preferred option, involving landfilling or incineration without energy recovery.

**B. The 3 R's: Reduce, Reuse, Recycle**

This principle emphasizes minimizing waste generation by:

Reducing consumption and waste production.

Reusing items whenever possible to extend their lifecycle.

Recycling materials to conserve resources and reduce landfill usage

**C. Polluter Pays Principle**

This principle holds that those who generate waste should bear the costs associated with its management and disposal. This encourages responsible waste generation and management practices among businesses and individuals.

**D. Resource Efficiency**

Resource efficiency involves using resources in a way that minimizes environmental impact. This principle promotes sustainable practices that ensure resources are used wisely and conserved for future generations.

**E. Circular Economy**

The circular economy concept focuses on designing systems that minimize waste and promote the continual use of resources. It encourages practices such as repair, refurbishment, and recycling to keep materials in use for as long as possible, thus reducing the need for new resources.

**F. Life Cycle Thinking**

This principle considers the entire lifecycle of a product, from raw material extraction through production, use, and disposal. By evaluating environmental impacts at each stage, waste management strategies can be more effectively implemented

**J. Public Awareness and Education**

Educating the public about waste management practices is crucial for fostering community involvement and promoting responsible waste disposal behaviors. Awareness campaigns can lead to better sorting, recycling, and overall waste management practices

## 7.- Urban planning and housing management

### 7.1.- Definition of urban

More than half the population of the world is now urban and the numbers are increasing at a swift pace. Here, it becomes important to know how a population is classified as being ‘urban’, as opposed to being rural or tribal or any other type. The simplest definition of an urban population is that of a population residing in towns and cities.

The concrete technical aspects defining ‘urban’ are:

- Population size
- Population density
- Economic base
- Presence of a municipal body

Urban planning involves the design and regulation of the physical, social, and economic environments of urban areas. Planners focus on creating sustainable, efficient, and livable cities by considering various factors such as transportation, land use, public spaces, infrastructure, and environmental sustainability.

### 7.2.-Key components of urban planning

- **Land use planning:** Zoning and land use regulations determine how land can be used (e.g., residential, commercial, industrial).
- **Transportation planning:** Involves designing road networks, public transit systems, and pedestrian pathways to ensure efficient movement within the city.

- **Environmental planning**: Focuses on protecting natural resources, reducing pollution, and promoting green spaces.
- **Urban design:** Involves the aesthetics and functionality of urban spaces, including the design of buildings, streets, and public areas.
- **Community engagement:** Ensuring that the needs and opinions of residents are considered in planning processes.

### 7.3.- Management urban planning

Management in urban planning refers to the organizational and strategic processes involved in implementing, overseeing, and optimizing urban planning initiatives. It is about turning urban planning theories and designs into actionable, effective, and sustainable practices. Management ensures that urban planning goals align with the broader objectives of the city, including economic growth, environmental sustainability, and social equity.

#### 7.3.1.- Key Aspects of management in urban planning

A. **Project Management**

- **Planning and Execution:** Developing detailed project plans, setting timelines, and allocating resources for urban planning projects such as infrastructure development, housing, or public transportation systems.
- **Coordination:** Managing the collaboration between different stakeholders, including government agencies, private developers, community organizations, and the public.
- **Monitoring and Evaluation:** Continuously monitoring the progress of urban projects and evaluating their success against set goals and benchmarks.

B. **Resource Management**

- **Financial Management:** Budgeting and securing funding for urban planning projects, including managing public funds, private investments, and grants.

- **Human Resource Management:** Recruiting, training, and managing the workforce involved in urban planning, from city planners to engineers and construction workers.
- **Material and Technological Resources:** Managing the acquisition and use of materials, tools, and technology necessary for urban development projects.

C. **Policy and Regulation Management:**

- **Policy Implementation:** Ensuring that urban planning projects comply with local, regional, and national regulations and policies, such as zoning laws, environmental regulations, and building codes.
- **Regulatory Compliance:** Managing the process of obtaining necessary permits and ensuring that all aspects of the urban planning process adhere to legal requirements.
- **Policy Development:** Participating in the development of new policies that will guide future urban planning efforts, often based on lessons learned from past projects.

D. **Stakeholder Management**

- **Community Engagement:** Involving residents and community groups in the planning process to ensure that their needs and opinions are considered.
- **Interagency Coordination:** Facilitating communication and collaboration between different government departments and agencies involved in urban planning.
- **Public-Private Partnerships:** Managing partnerships between the government and private sector for urban development projects, such as infrastructure development or affordable housing initiatives.

E. **Risk Management**

- **Risk Assessment:** Identifying potential risks to urban planning projects, such as financial risks, environmental concerns, or community opposition.
- **Mitigation Strategies:** Developing strategies to mitigate identified risks, ensuring that projects can proceed smoothly and within budget.
- **Crisis Management:** Responding to unforeseen challenges or emergencies that arise during the implementation of urban planning projects.

F. **Sustainability Management**

- **Environmental Management:** Ensuring that urban planning projects are environmentally sustainable, incorporating green practices such as energy efficiency, waste reduction, and the preservation of natural resources.
- **Social Sustainability:** Managing projects to promote social equity, ensuring that all residents have access to the benefits of urban development.
- **Economic Sustainability:** Developing urban plans that contribute to long-term economic growth and stability, such as creating jobs and promoting local businesses.

G. **Innovation and Technology Management**

- **Smart Cities Initiatives:** Managing the integration of technology into urban planning, such as smart grids, data-driven traffic management, and digital infrastructure.
- **Innovation in Urban Design:** Promoting the use of innovative design practices and materials to create more sustainable, efficient, and livable urban environments.

H. **Communication and Public Relations**

- **Public Information Campaigns:** Managing the dissemination of information to the public about urban planning projects, ensuring transparency and building public trust.
- **Media Relations:** Engaging with the media to promote urban planning initiatives and address public concerns.
- **Feedback Mechanisms:** Establishing channels for receiving and addressing public feedback and complaints regarding urban planning projects.

### 7.4.- Housing management

Housing management refers to the administration and maintenance of residential properties, ensuring that housing is safe, affordable, and accessible to all residents. It includes the management of public housing, affordable housing programs, and private residential properties.

#### 7.4.1.-Key components of housing management

- **Property Management:** Involves the day-to-day operations of residential properties, including maintenance, rent collection, and tenant relations.
- **Affordable Housing Programs:** Initiatives to provide housing options for low-income families and individuals, often through government subsidies or non-profit organizations.
- **Tenant Services:** Providing support and resources to tenants, such as mediation for disputes, assistance with rent, and access to social services.
- **Policy and Regulation:** Ensuring compliance with housing laws and regulations, including health and safety standards, tenant rights, and fair housing practices.

- **Sustainable Housing:** Implementing practices that reduce energy consumption and promote environmentally friendly housing developments.

### 7.4.2.-Intersection of urban planning and housing management

- **Affordable Housing Development:** Urban planners work with housing managers to develop affordable housing projects that fit within the broader urban plan.
- **Community Revitalization:** Collaboration to improve or redevelop neighborhoods, balancing the needs of current residents with the goals of urban growth.
- **Sustainability Initiatives:** Both fields work together to promote sustainable living environments, such as green buildings and eco-friendly infrastructure.
- **Policy Implementation:** Housing managers often implement policies developed through urban planning, such as zoning regulations or housing standards.

## 8.- Ecosystem management

### 8.1.-Definition of the ecosystem

Ecosystem(s), n. m. (ecosystem). This term, created by Tansley in 1935, refers to the basic ecological unit. The notion of ecosystem is a key concept in ecology, referring to the structural and functional unit of the biosphere. It includes heterogeneous groups of higher complexity such as "regions," biomes, or landscapes. An ecosystem consists of two components in constant interaction: a biotope, an abiotic environment with defined physical characteristics and geographical location, and a biocoenosis, a living community characteristic of the biotope. This relationship was established by Tansley in 1935. The biocoenosis is comprised of all the living beings that populate a given ecosystem. This term, biocoenosis, which is often considered a synonym for community by French-speaking ecologists, refers to all the organisms that populate any ecosystem: producers, consumers (animals), and decomposers (fungi and heterotrophic microorganisms). The biocoenosis is divided into two elements (Fig. 15): Biocenoses are characterized by: (i) a specific composition, (ii) phenomena of interdependence, and (iii) occupation of a defined space (biotope).

### 8.2.-Ecosystem management

Ecosystem management is an integrated approach to managing natural environments that considers the complex interactions between ecological, social, and economic systems. It aims to maintain the health, diversity, and resilience of ecosystems while also meeting human needs and promoting sustainable development.

### 8.2.1.-Key Principles of Ecosystem Management

#### A.-Holistic Approach

- **Ecosystem as a Whole**: Taking into account the interconnectedness of species, habitats, and ecological processes, management strategies concentrate on complete ecosystems as opposed to discrete parts.
- **Integration Across Sectors:** In order to prevent competing objectives and methods, it entails coordinating efforts across a number of sectors, including forestry, agriculture, water management, and urban planning.

#### B.-Sustainability

- **Long-Term View:** The goal of ecosystem management is to make sure that the utilization of natural resources does not jeopardize the ability of future generations to satisfy their own requirements.
- **The sustainable use of ecosystem services**, such as clean water, lumber, and recreational activities, must be balanced with the preservation of biodiversity.

#### C.-Adaptive Management

- **Dynamic Process:** Ecosystems are constantly changing, so management strategies must be flexible and able to adapt to new information, changing conditions, and unexpected events.
- **Monitoring and Feedback:** Regular monitoring of ecosystems is essential to assess the effectiveness of management practices and make necessary adjustments based on the outcomes.

**D.-Conservation of Biodiversity**

- **Safeguarding Species and ecosystems:** Preserving biological variety is a fundamental goal that encompasses safeguarding genetic diversity, endangered species, and important ecosystems.
- **Keeping Ecosystem Functions in Place**: maintaining the connections between predators and prey, pollination, and nutrient cycling—processes and activities that keep ecosystems healthy.

**E.-Stakeholder Participation**

- **All parties involved in ecosystem management,** including local communities, indigenous peoples, governmental organizations, and businesses, must actively participate in the decision-making process. This is known as inclusive decision-making.
- **Collaboration and partnerships:** In order to effectively manage ecosystems, it is imperative that various stakeholders form partnerships in order to ensure that a range of viewpoints and knowledge are taken into account.

**F.-Precautionary Principle**

- **Risk aversion:** In cases of uncertainty, ecosystem management adopts a precautionary approach, erring on the side of caution to avoid harm to the environment.
- **Preventive action:** It emphasizes preventing environmental degradation before it occurs, rather than relying solely on restoration efforts after damage has been done.

**G.- Ecosystem services**

- **Valuing nature's benefits:** Recognizing and quantifying the benefits that ecosystems provide to humans, such as clean air and water, food, and climate regulation, and incorporating these values into decision-making.
- **Payment for ecosystem services (PES):** Implementing mechanisms where beneficiaries of ecosystem services compensate those who manage and protect these ecosystems.

**H.- Resilience and adaptive capacity**

- **Building resilience:** Ecosystem management aims to enhance the resilience of ecosystems to withstand disturbances, such as climate change, invasive species, and natural disasters.
- **Supporting adaptive capacity:** Promoting the ability of both ecosystems and human communities to adapt to changing conditions, ensuring continued provision of ecosystem services.

### 8.2.2.-Application of eecosystem management

Ecosystem management is applicable in various contexts, including (Fig. 15):

- **Grassland Management**: Implementing practices that enhance biodiversity, restore habitats, and improve land productivity while minimizing the use of chemical inputs
- **Forestry and Agriculture**: Integrating sustainable practices that support both ecological health and agricultural productivity, such as agroforestry and conservation tillage.

- **Urban Ecosystems**: Applying ecosystem management principles in urban planning to enhance green spaces, improve air quality, and promote biodiversity within cities.

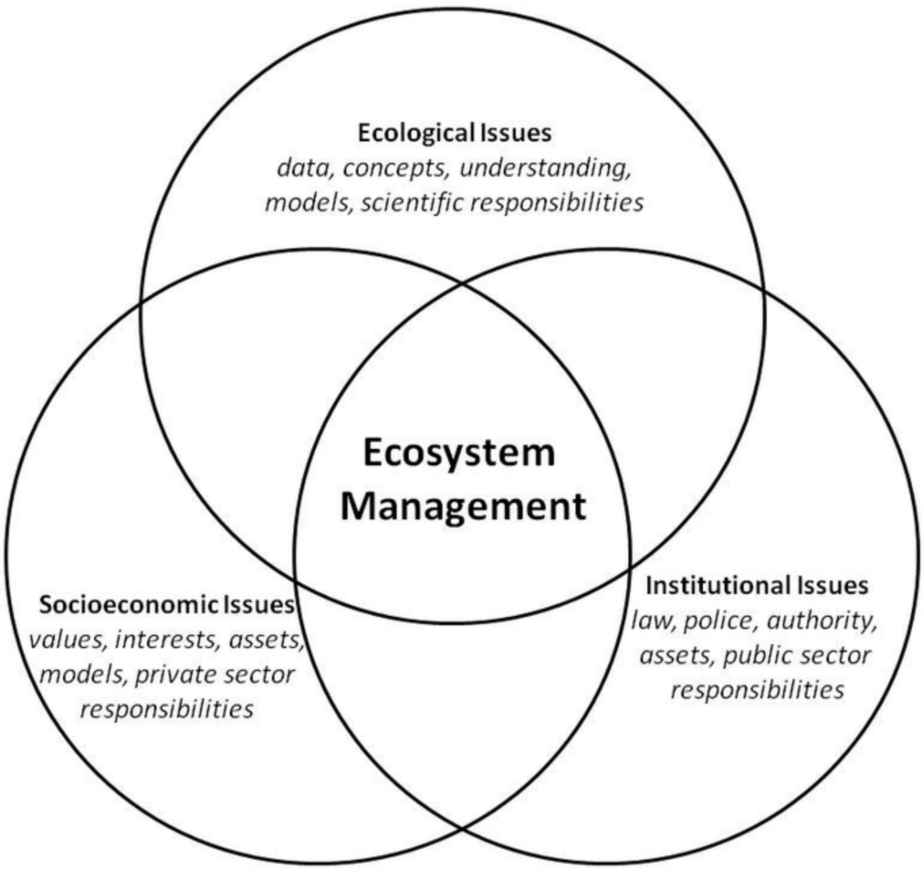


**Figure 15 :** Ecosystem management

# 9.- Patrimony Management

## 9.1.-Introduction

The concept of heritage in ecology encompasses multiple dimensions, including environmental, cultural, and economic aspects. Viel (2019) highlights the convergence of ecology, interpretation, museology, and heritage, emphasizing the educational dimension and identity roots in territorial development. The process of heritage-making in forestry has been transformed by ecological considerations, as demonstrated in the Landes de Gascogne case study (Cazals et al., 2013; Deuffic et al., 2010). Ollagnon (1999) proposes a patrimonial approach to managing nature and living systems, advocating for the creation of "common heritage" to address complex, multi-actor environmental challenges. This approach aims to reconcile economic, ecological, and institutional perspectives. The evolution of forest owners' perceptions of their land as natural heritage in the face of increasing ecological concerns is explored by Deuffic et al. (2010), drawing on theories of heritage-making, public problem construction, and ecologization.

## 9.2.- Patrimony management in ecology

Patrimony management in ecology, often referred to as the management of natural or ecological heritage, involves the preservation, restoration, and sustainable use of natural resources and ecosystems. This approach aims to maintain biodiversity, protect endangered species, and ensure the sustainable use of environmental resources for future generations

### 9.2.1.-Key components of patrimony management

Key components of patrimony management encompass a range of practices and strategies aimed at the preservation, protection, and interpretation of patrimony management. These components are crucial for ensuring that heritage resources are managed effectively and sustainably (Fig. 16).

**A. Biodiversity Conservation**

- **Protection of Endangered Species**: Implementing measures to protect species at risk of extinction, such as creating protected areas, breeding programs, and habitat restoration.
- **Habitat preservation**: Safeguarding critical habitats, like forests, wetlands, and coral reefs, to maintain the ecosystems that support biodiversity.
- **Creation of protected areas**: Establishing national parks, nature reserves, and marine protected areas to conserve key ecosystems and species.

**B. Sustainable Resource Management**

- **Sustainable agriculture:** promoting agricultural techniques including crop rotation, agroforestry, and organic farming that preserve biodiversity, soil, and water.
- **Sustainable forestry** is the practice of managing forests so as to preserve the natural functions of the forest while permitting the production of lumber and other forest products.
- **Water resource management:** safeguarding and controlling water sources to provide a steady supply of potable water for ecosystems, agriculture, and human usage.

**C. Ecological Restoration**

- **Reforestation and afforestation**: Planting trees to restore degraded forests and create new forests in areas where they did not previously exist.
- **Wetland restoration**: Rehabilitating degraded wetlands to restore their ecological functions, such as water purification, flood control, and habitat provision.
- **Rewilding**: Reintroducing native species and restoring natural processes, such as predator-prey relationships, to restore ecosystems to a more natural state.

**D. Climate Change Mitigation and Adaptation**

- **Carbon Sequestration:** The process of keeping natural carbon sinks like forests, peatlands, and seas intact and boosting their ability to absorb CO2 from the atmosphere.

- **Planning for climate resilience** is the process of creating plans to assist human populations and ecosystems in adjusting to the effects of climate change, which include rising sea levels, altered precipitation patterns, and an increase in the frequency of extreme weather events.

- **Renewable Energy Integration**: Encouraging the use of renewable energy sources to lessen climate change and greenhouse gas emissions.

**E. Community Involvement and Education**

- **Community-Based conservation**: Engaging local communities in the management and conservation of natural resources, ensuring that they benefit from sustainable practices.
- **Environmental education**: Raising awareness about the importance of ecological patrimony and promoting sustainable behaviors through education programs, workshops, and public campaigns.
- **Indigenous Knowledge Integration**: Incorporating traditional ecological knowledge from indigenous communities into conservation and resource management practices.

**F. Policy and Legislation**

- **Environmental Laws and Regulations**: Implementing and enforcing laws that protect natural heritage, such as endangered species laws, land-use regulations, and pollution controls.
- **International Agreements**: Participating in global agreements and initiatives, such as the Convention on Biological Diversity (CBD) and the Paris Agreement, to address environmental challenges on a larger scale.
- **Incentives for Conservation**: Providing financial incentives, such as tax breaks, subsidies, or payments for ecosystem services, to encourage individuals and businesses to engage in conservation and sustainable practices.

**G. Monitoring and Research**

- **Ecosystem Monitoring**: Continuously monitoring the health of ecosystems to detect changes and assess the effectiveness of conservation efforts.
- **Scientific Research**: Conducting research to better understand ecosystems, species, and ecological processes, and using this knowledge to inform management practices.
- **Citizen Science**: Involving the public in data collection and monitoring efforts, such as bird counts or water quality testing, to increase the scope and impact of ecological research.

**H. Sustainable Development Integration**

- **Eco-tourism:** Encouraging travel that is kind to the environment, contributes to conservation efforts, and boosts the local economy.
- **Green infrastructure:** Including natural features in urban design, such as permeable surfaces, green roofs, and urban trees, to improve biodiversity and lessen the negative effects of urbanization on the environment.
- **Sustainable Land-Use Planning**: Ensuring that development initiatives balance economic growth with environmental preservation by taking into account the long-term viability of natural resources and ecosystems.

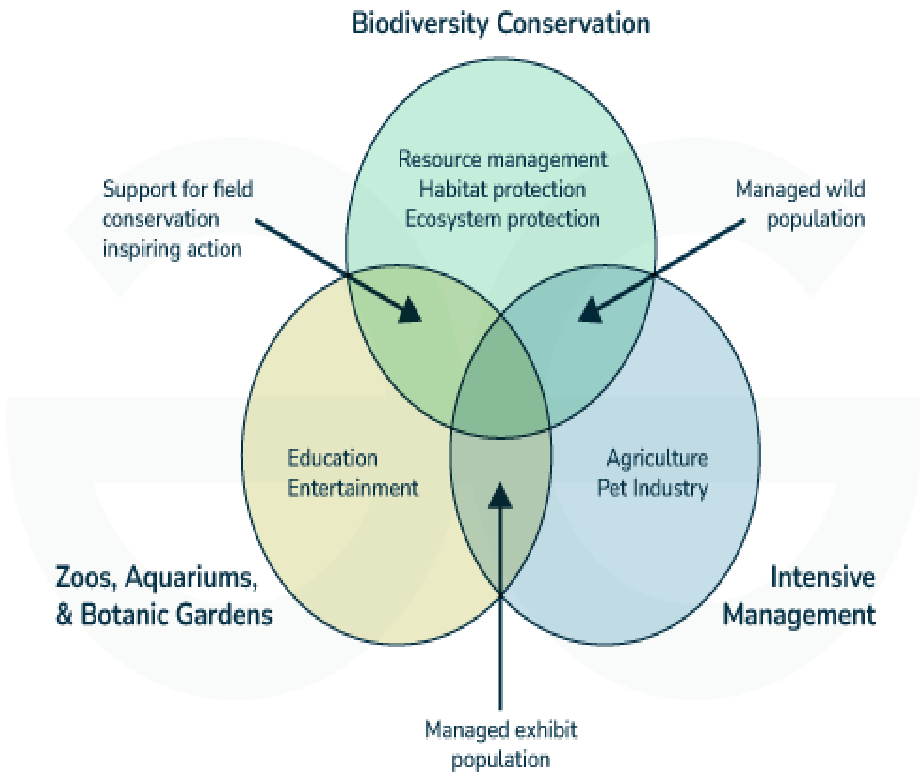


**Figure 16 :** Key components of patrimony management

## 10.-Nuisance management

### 10.1.-Definition

Nuisance management" refers to the strategies, techniques, and policies used to address and mitigate activities, behaviors, or conditions that are deemed disruptive, harmful, or otherwise undesirable to the community or environment. This can involve various forms of nuisances, such as noise pollution, pest infestations, environmental hazards, or public disturbances.

### 10.2.- Key Aspects of Nuisance Management

A. **Identification of Nuisances**
   - Determining what constitutes a nuisance in a specific context. This can vary based on local laws, community standards, or environmental guidelines.

B. **Legal Framework**
   - Many regions have laws or ordinances that define and regulate nuisances. These laws typically outline the rights of individuals and communities to live without undue disturbances.

C. **Reporting and Documentation**
   - Systems for reporting nuisances, which may involve local authorities, environmental agencies, or community organizations. Proper documentation is often required for legal action or enforcement.

D. **Enforcement**
   - Authorities may take action to enforce regulations against nuisances. This could include fines, orders to cease certain activities, or other legal actions.

E. **Mitigation Strategies**
   - Implementing measures to reduce or eliminate nuisances. For example, soundproofing to mitigate noise pollution, or pest control programs to manage infestations.

F. **Community Involvement**

- Encouraging community members to participate in nuisance management by reporting issues, participating in clean-up efforts, or working together to maintain a peaceful environment.

G. **Education and Awareness**

- Informing the public about what constitutes a nuisance and how to prevent or manage it effectively. This might involve public campaigns, workshops, or distribution of informational materials.

H. **Preventive Measures**

- Proactive steps to prevent nuisances from occurring, such as urban planning to avoid noise issues or environmental monitoring to prevent pollution.

### 10.3.- Levels of nuisance management

#### A.- Urban Nuisance Management

Urban nuisance management often involves the use of decision support systems to address disturbances from construction and other urban activities. A study describes a decision support system designed for managing nuisances at urban building sites. This system assists both public space administrators and project owners by providing decision-making support tailored to specific contexts. Key functionalities include an interaction interface that aids in processing and managing nuisances effectively.

#### B.-Nuisance Wildlife Management

Nuisance wildlife management focuses on the control of specific wildlife populations that cause problems for humans, such as property damage or health risks. This field includes various methods for managing wildlife conflicts, such as:

- **Exclusion**: Sealing entry points to prevent wildlife from entering homes or gardens.
- **Habitat Modification**: Altering the environment to make it less attractive to nuisance species, such as removing food sources or shelter.
- **Control Methods**: Utilizing traps, repellents, or other techniques to manage wildlife populations effectively.

Common nuisance species include raccoons, squirrels, and deer, and management practices may require permits for certain protected species.

#### C.-Health-Related Nuisance Management

Nuisance management in health contexts addresses issues like air quality and noise pollution. This includes strategies for managing odors from industrial operations and ensuring that environmental conditions in urban areas promote public health. Effective management practices involve monitoring air quality, implementing noise reduction measures, and designing urban spaces that minimize disturbances. Overall, nuisance management is a multidisciplinary approach that requires cooperation among various stakeholders, including urban planners, wildlife control operators, and public health officials, to create a balanced and healthy living environment.

## 11.- Global strategies for environmental management

### 11.1.- Introduction of environment

The environment refers to the surroundings or conditions in which an organism lives and operates. It encompasses all the living and non-living elements that influence the quality of life for humans, animals, and plants. The environment includes:

- **Biotic elements**: Living components such as plants, animals, forests, fisheries, and birds;
- **Abiotic elements**: Non-living components such as water, land, sunlight, rocks, and air

### 11.2.-Functions of the Environment

The environment serves several crucial functions:

- **Supply of resources**: The environment provides a variety of natural resources necessary for production, including water, soil, minerals, and forests. These resources are vital for creating goods and services that sustain human life and economic activity.
- **Sustaining life**: Essential elements such as sunlight, air, water, and soil are crucial for the survival of all living organisms. The environment supports biodiversity, which is fundamental for ecosystem stability and resilience.
- **Assimilation of waste**: The environment plays a critical role in absorbing and breaking down waste generated from human activities. This function helps manage pollution and maintain ecological balance by recycling nutrients and reducing harmful substances in ecosystems.
- **Enhancing quality of life**: Natural surroundings, including rivers, mountains, and forests, contribute to the aesthetic and recreational value of the environment. These features enhance human experiences and overall quality of life by providing spaces for recreation, relaxation, and connection with nature
- **Ecosystem services**: The environment offers various ecosystem services that occur without human intervention, such as climate regulation, pollination of plants, and the provision of clean air and water. These services are vital for maintaining life on Earth.

- **Spiritual and cultural value**: Many cultures have intrinsic spiritual connections to their environments, which can influence beliefs, traditions, and practices. This aspect highlights the psychological and emotional significance of natural landscapes.

**11.3.-Types of environmental resources**

Environmental resources can be categorized into various types based on their characteristics and availability. Here are the main types of environmental resources (Fig. 17):

**A. Renewable resources**

These are resources that can be replenished naturally over time. They include:

- **Solar energy**: Energy harnessed from the sun, which is abundant and sustainable.
- **Wind energy**: Energy generated from wind, used for powering turbines and generating electricity.
- **Water resources**: Includes rivers, lakes, and groundwater, which are essential for drinking, agriculture, and industry.
- **Vegetation**: Forests and plants that provide timber, fruits, and habitat for wildlife. They can regenerate if managed sustainably.

**B. Non-Renewable Resources**

These resources are finite and cannot be replenished within a human timescale. Examples include:

- **Fossil Fuels**: Such as coal, oil, and natural gas, which take millions of years to form and are depleted with use.
- **Minerals**: Resources like gold, iron ore, and other metals that are extracted from the earth and are limited in supply.

**C. Continuous Resources**

These resources are always available and are not depleted by use. Examples include:

- **Geothermal Energy**: Heat from the Earth that can be used for energy.
- **Tidal Energy**: Energy generated from the movement of tides.

**D. Atmospheric Resources**

These include elements found in the atmosphere that are beneficial to life:

- **Air**: Essential for respiration in living organisms.

- **Rain**: Provides water for agriculture and replenishes freshwater sources.

**E. Land Resources**

Land resources encompass various materials and spaces that are valuable for agriculture, habitation, and industry:

- **Soil**: Vital for growing crops and sustaining agriculture.
- **Minerals and Rocks**: Used in construction and manufacturing.

**F. Human Resources**

This category refers to the human workforce and their ability to manage and utilize environmental resources effectively. It includes:

- **Skills and Knowledge**: The expertise required to sustainably manage resources.
- **Labor**: The human effort involved in resource extraction and management.

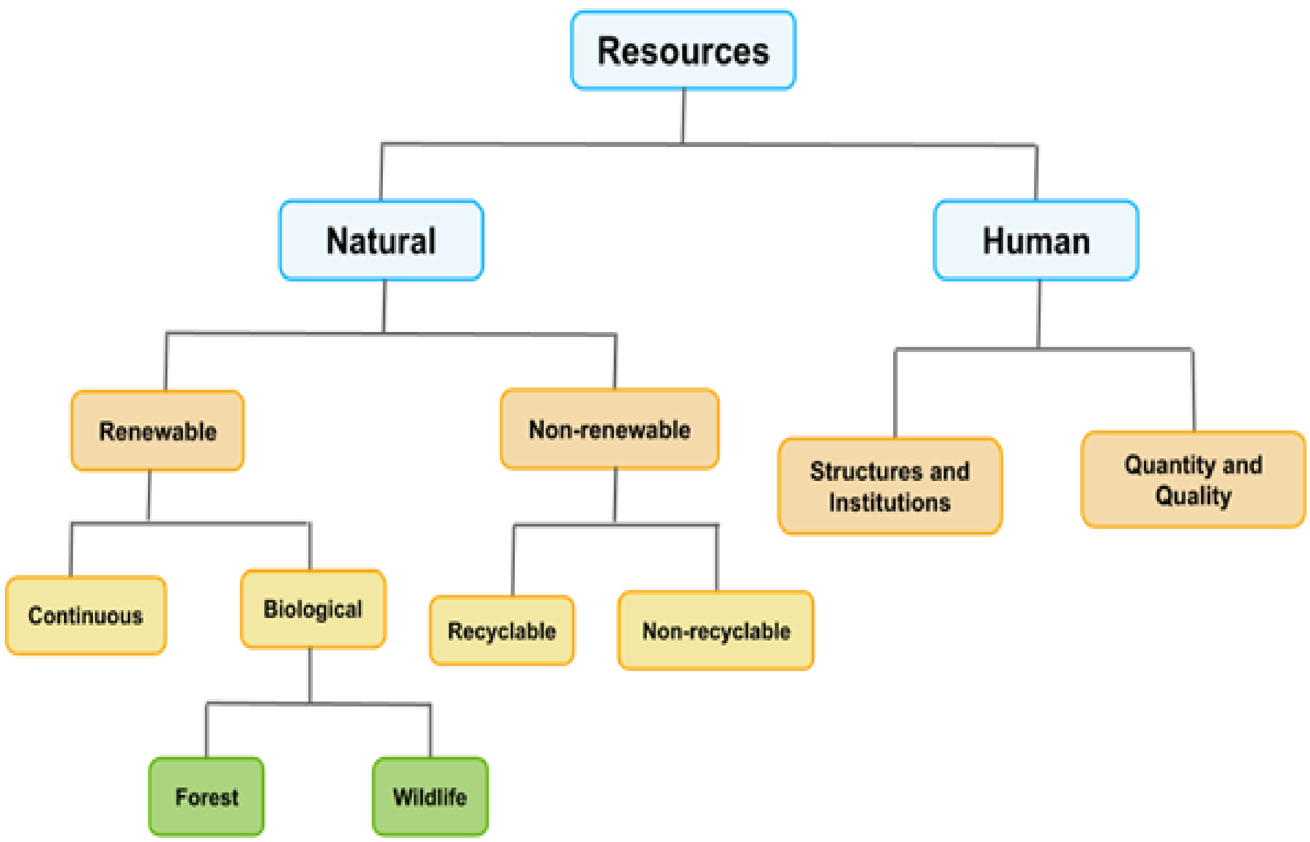


**Figure 17:** Types of environmental resources

## 11.4.- Definition global strategies for environmental management

Global strategies for environmental management encompass a range of approaches aimed at addressing environmental challenges and promoting sustainability. These strategies are essential for mitigating the impacts of climate change, conserving biodiversity, and managing natural resources effectively.

### 11.4.1.- Key environmental management strategies

**A. Sustainable Resource Use**

Promoting responsible use of natural resources, including water, forests, and energy, is crucial. This involves encouraging renewable energy sources and sustainable practices in industries like agriculture and forestry.

**B. Waste Management and Recycling**

Effective waste management practices are implemented to minimize waste generation and enhance recycling efforts. This includes establishing recycling programs and promoting biodegradable materials.

**C.Pollution Control**

Governments and organizations adopt measures to control air, water, and soil pollution. This includes setting emission standards and implementing cleaner production processes.

**D. Conservation and Biodiversity Protection**

Protecting biodiversity through the establishment of protected areas and wildlife sanctuaries is essential for maintaining ecological balance. This strategy also involves habitat restoration efforts.

**E. Climate Change Mitigation and Adaptation**

Strategies to reduce greenhouse gas emissions (mitigation) and adapt to climate impacts are critical. This includes promoting energy efficiency and developing climate-resilient infrastructure.

**F. International Cooperation**

Global collaboration is necessary to address transboundary environmental issues. This includes international agreements on climate change and biodiversity conservation, ensuring that countries work together effectively.

**G. Education and Awareness**

Raising awareness about environmental issues and promoting environmental education fosters responsibility and active participation in sustainability efforts.

**H. Corporate social responsibility (CSR)**

Encouraging businesses to adopt environmentally friendly practices and reduce their ecological footprint is vital for sustainable development. CSR initiatives can significantly impact local communities and ecosystems.

**I. Green technologies and innovation**

Investing in green technologies and innovations is essential for reducing environmental impacts and enhancing sustainability. This includes developing new technologies that support eco-friendly practices.

**J. Climate justice and equity**

Addressing the social and economic inequities exacerbated by climate change is crucial. Strategies must ensure that climate policies do not disproportionately affect vulnerable populations and that benefits are equitably distributed.


**Figure 18.** Global strategies for environmental management

# 12.- Institutional strengthening

## 12.1.-Definition

Institutional strengthening refers to the process of enhancing the capacity and performance of organizations and institutions to effectively carry out their functions and achieve their objectives. It involves improving various aspects such as governance, management, systems, and human resources to enable institutions to deliver better services and drive sustainable development.

## 12.2.-Key principles of effective institutional strengthening

The key principles of effective institutional strengthening focus on enhancing the capacity and performance of organizations to fulfill their roles effectively. Here are the main principles derived from the search results:

### A. Capacity assessment

Conducting thorough assessments to identify existing strengths and weaknesses within institutions is critical. This helps in understanding the specific needs for improvement and tailoring interventions accordingly.

### B. Participatory approaches

Engaging stakeholders in the strengthening process ensures that the interventions are relevant and responsive to the needs of the community. This approach fosters ownership and commitment among all parties involved.

### C. Sustainability

Efforts should focus on creating long-term solutions rather than short-term fixes. This involves building systems and processes that can sustain improvements over time, ensuring that institutions remain effective in the long run.

### D. Tailored interventions

Institutional strengthening should be customized to fit the specific context and challenges faced by the institution. This includes considering local political, social, and economic factors when designing capacity-building initiatives.

### E. Holistic development

Effective institutional strengthening encompasses various aspects, including governance, human resources, financial management, and service delivery. A comprehensive approach ensures that all dimensions of the institution are addressed.

**F. Monitoring and evaluation**

Implementing robust monitoring and evaluation mechanisms allows institutions to assess the effectiveness of their strengthening efforts and make necessary adjustments. This feedback loop is essential for continuous improvement.

**G. Leadership development**

Investing in leadership development is crucial for empowering individuals within the institution to drive change and foster a culture of accountability and responsiveness.

**H. Collaboration and partnerships**

Building partnerships with other organizations, including NGOs and government agencies, can enhance resource sharing and knowledge exchange, leading to more effective institutional strengthening efforts.

## 12.3.-Key Components of institutional strengthening

- **Capacity Assessment**: Conducting thorough assessments to identify capacity gaps, weaknesses, and areas for improvement within the institution
- **Policy and Strategy Development**: Providing policy and strategy advice to help institutions adapt to evolving environments and emerging challenges
- **Process Improvement**: Streamlining institutional services and policies to make them more responsive to the needs of the communities they serve
- **Leadership Development**: Empowering organizations by enhancing the efficiency, effectiveness, and sustainability of their leadership across various sectors
- **Organizational Capacity Building**: Improving the knowledge, skills, and competencies of organizational staff through training, mentoring, and coaching support
- **Institutional Capacity Strengthening in the Humanitarian Program Cycle**: Integrating institutional capacity needs assessments and strengthening plans into

every stage of the humanitarian program cycle, from needs assessment to resource mobilization

### 12.4.-Benefits of Institutional Strengthening

- **Improved service delivery**: Strengthening institutions leads to more efficient and effective delivery of goods and services to the communities they serve
- **Enhanced governance**: Institutional strengthening promotes better governance, transparency, and accountability within organizations
- **Sustainable development**: Strong institutions are critical for achieving sustainable development goals and ensuring that no one is left behind
- **Increased resilience**: Resilient institutions can better navigate challenges, adapt to changing environments, and lead transformative change, even in the most difficult contexts
- **Improved aid effectiveness**: Institutional capacity building is crucial for enhancing the effectiveness of development aid and ensuring that interventions have lasting impact.

## 13.- Case studies

Case studies in environmental management provide real-world examples of how organizations, governments, and communities tackle environmental challenges. These case studies often highlight successful strategies, lessons learned, and best practices that can be applied in similar contexts. Here are some notable examples:

### 13.1.- The restoration of the Chesapeake Bay

- **Location:** United States
- **Overview:** The Chesapeake Bay, the largest estuary in the U.S., faced significant pollution and habitat loss due to agricultural runoff, urbanization, and industrial activities.
- **Approach:** The Chesapeake Bay Program was established as a partnership among federal and state agencies, non-profits, and local communities. Key actions included reducing nutrient and sediment pollution through improved agricultural practices, restoring wetlands and forests, and enforcing stricter wastewater treatment standards.
- **Outcome:** Water quality has gradually improved, and the populations of key species like blue crabs and oysters have started to recover. The case emphasizes the importance of collaborative efforts and adaptive management.

#### 13.1.1.-Restoring the Native Oyster Population

One key focus of restoration efforts is rebuilding the native oyster population in the Chesapeake Bay. Oysters are a keystone species that filter water, provide habitat for other marine life, and support the region's economy. Unfortunately, only 1-2% of the historic oyster population remains due to factors like disease, overfishing, and poor water quality. To address this, NOAA is working with partners to restore oysters in 10 tributaries by 2025. Strategies include:

- Banning dredging and implementing other fishing regulations to allow oyster populations to rebound
- Constructing new oyster reefs using recycled oyster shells and other materials

- Seeding reefs with hatchery-raised oyster larvae

**13.1.2.-Reducing Nutrient and Sediment Pollution**

Excess nutrients like nitrogen and phosphorus, as well as sediment from soil erosion, are major pollutants fouling the Bay's waters. In 2010, the EPA established science-based pollution limits, known as the Total Maximum Daily Load (TMDL), to restrict these pollutants. In response, the seven jurisdictions in the Chesapeake Bay watershed (Maryland, Virginia, Pennsylvania, Delaware, West Virginia, New York and Washington D.C.) created individual Watershed Implementation Plans detailing actions to reduce pollution by 2025. Progress is tracked through two-year milestones, with a goal of achieving 60% of the 2025 targets by 2017. As of 2013, Maryland had completed nearly 41% of its 2025 nitrogen reduction target and 61% of its phosphorus target. Strategies to reduce pollution include:

- Upgrading wastewater treatment plants to remove more nutrients
- Implementing best management practices on farms to prevent nutrient and soil runoff
- Restoring wetlands and forests to filter pollutants

**Restoring Habitats and Living Resources**

The Chesapeake Bay Program has set goals to restore key habitats like wetlands, underwater grasses, and forests, which provide food and shelter for fish, crabs, birds and other wildlife. Over 3,600 species of plants and animals call the Bay home. Since its formation in the 1980s, the Bay Program has made significant strides through a cooperative partnership model, landmark agreements like Chesapeake 2000 and 2014's Chesapeake Bay Watershed Agreement, and state-of-the-art scientific research. While challenges remain, the restoration of the Chesapeake Bay is an inspiring example of what can be achieved through sustained, collaborative efforts to revive a degraded ecosystem. The health of the Bay is vital to the region's ecology, economy and way of life.

**13.2.- The London Congestion Charge**

- **Location:** London, United Kingdom

- **Overview:** London faced severe traffic congestion, leading to high levels of air pollution and significant time lost in traffic.
- **Approach:** In 2003, London introduced a congestion charge zone where drivers had to pay a fee to enter central areas during peak hours. The revenue generated was invested in public transportation improvements.
- **Outcome:** Traffic congestion decreased by 30%, and public transport usage increased. Air quality also improved significantly, reducing emissions of nitrogen oxides and particulate matter.

### 13.2.1.-Key factors behind this success include

#### A. Banning Deforestation

In 1996, the government prohibited deforestation without prior authorization, helping to protect remaining forests.

#### B. Payments for Environmental Services (PES) Program

Costa Rica implemented the PES program in 1996, which provides financial incentives to farmers and landowners for reforestation and forest conservation efforts. The program is funded by a tax on fossil fuels. Under PES, farmers receive around $64 per hectare annually for replanting and maintaining forests on their land. Between 1997-2018, over $500 million was paid out, protecting more than 1 million hectares of forests and planting 7 million trees.

#### C. Expanding Protected Areas

Costa Rica has designated over 26% of its territory as protected national parks and reserves, helping safeguard primary forests and allow secondary forests to regenerate.

#### D. Promoting Sustainable Forestry Practices

The country has invested in sustainable forest management, fire management, and landscape restoration initiatives to further boost forest cover. As a result of these policies, Costa Rica has become the first tropical country to halt and reverse deforestation, making it a model for the rest of the world. Its lush tropical forests now provide habitat for over 500,000 plant and animal species.

### 13.2.2.-Benefits of Reforestation

Reforestation has brought numerous benefits to Costa Rica:

- Restored water sources and created refuges for wildlife like crocodiles, jaguars and pumas.
- Improved incomes for rural populations through sustainable forestry activities.
- Enhanced economic resilience.
- Reduced carbon emissions through increased forest carbon stocks Strengthened national pride and global reputation as an environmental leader.

### 13.3.- Reforestation in Costa Rica

- **Location:** Costa Rica
- **Overview:** In the mid-20th century, Costa Rica experienced rapid deforestation due to agriculture and cattle ranching, leading to biodiversity loss and soil degradation.
- **Approach:** The government implemented a series of policies, including Payment for Ecosystem Services (PES) programs that provided financial incentives for landowners to reforest and conserve land. Additionally, protected areas were expanded, and eco-tourism was promoted.
- **Outcome:** By 2021, forest cover had increased from 21% in 1987 to over 52%. Costa Rica became a global leader in sustainable development and conservation, demonstrating the power of policy-driven environmental management.

### 13.4.- The Clean-Up of the Cuyahoga River

- **Location:** Cleveland, Ohio, United States
- **Overview:** The Cuyahoga River became infamous when it caught fire in 1969 due to extreme pollution from industrial waste. This event highlighted the dire state of water pollution in the U.S.
- **Approach:** The incident spurred the U.S. government to pass the Clean Water Act in 1972, which set strict regulations on industrial discharges and funded

wastewater treatment facilities. Local efforts also focused on riverbank restoration and pollution control.

- **Outcome:** The river, once devoid of aquatic life, now supports over 60 species of fish and is a popular site for recreational activities. The Cuyahoga River case is often cited as a turning point in the environmental movement in the U.S.

### 13.4.1.- Historical Context

- **Severe Pollution**: By the mid-20th century, the Cuyahoga River was notorious for its extreme pollution, with numerous incidents of oil slicks catching fire, the most famous being the fire in 1969. This incident garnered national attention and symbolized the broader environmental issues facing American waterways at the time.
- **Industrial Legacy**: The river had been heavily impacted by industrial activities, with factories discharging waste directly into the water. By the 1960s, it was essentially an open sewer, devoid of aquatic life in many sections.

### 13.4.2.- Clean-Up Initiatives

- **Public Awareness and Policy Change**: The 1969 fire acted as a catalyst for environmental reform, leading to increased public awareness and the eventual passage of the Clean Water Act in 1972. This legislation established a framework for regulating water pollution and improving water quality across the United States.
- **Local Government Action**: Following the fire, Cleveland's city government, under the leadership of Mayor Carl Stokes, initiated a $100 million bond program to rehabilitate the river and improve sewage treatment facilities. This marked the beginning of concerted efforts to clean up the Cuyahoga**.**
- **Collaborative Efforts**: Various stakeholders, including local governments, environmental organizations, and federal agencies, collaborated on clean-up efforts. The Cuyahoga Valley National Park and other partners have worked to remove obsolete dams, reconnect streams, and restore habitats, which has improved water quality and biodiversity

### 13.4.3.- Results of the Clean-Up

- **Improved Water Quality**: Over the decades, water quality in the Cuyahoga River has significantly improved. The river now supports 44 species of fish, and areas that were once devoid of life have seen a resurgence of aquatic ecosystems.
- **Recognition and Designation**: In recognition of these improvements, the Cuyahoga was designated as one of 14 American Heritage Rivers in 1998 and has been acknowledged for its recovery and ecological significance.
- **Ongoing Challenges**: Despite the progress, challenges remain, including urban runoff, combined sewer overflows, and sediment contamination in certain areas. Portions of the river are still classified as Areas of Concern by the Environmental Protection Agency (EPA) due to these ongoing issues.

### 13.4.4.-Community Engagement and Future Directions

- **Public Involvement**: Community engagement has been crucial in the clean-up process. Local organizations and residents have participated in restoration projects, fostering a sense of stewardship for the river.
- **Future Initiatives**: Ongoing projects aim to further improve water quality, enhance habitats, and promote recreational opportunities along the Cuyahoga River Water Trail. The commitment to continued monitoring and restoration reflects the long-term vision for a sustainable and healthy river ecosystem.

### 13.5.- Integrated Coastal Zone Management in the Mediterranean

- **Location:** Mediterranean Region
- **Overview:** The Mediterranean coast faces threats from overdevelopment, pollution, and unsustainable fishing practices.
- **Approach:** The Integrated Coastal Zone Management (ICZM) Protocol under the Barcelona Convention provides a legal framework for coordinating the management of coastal zones across Mediterranean countries. It emphasizes sustainable development, biodiversity conservation, and the participation of local communities.

- **Outcome:** Several Mediterranean countries have adopted ICZM plans, leading to improved coastal management, protection of marine habitats, and better resilience to climate change impacts.

### 13.5.1.- Overview of ICZM in the Mediterranean

A. **Protocol Adoption**:

   - The ICZM Protocol was signed in Madrid on January 21, 2008, and entered into force in March 2011. It represents a significant milestone in the framework of the Barcelona Convention, which aims to protect the marine environment and coastal regions of the Mediterranean.

B. **Objectives**:

   - The primary goal of the ICZM Protocol is to facilitate sustainable development of coastal zones by ensuring that environmental, social, and economic factors are integrated into planning and management processes. This includes addressing the fragility of coastal ecosystems and the diversity of activities that occur in these areas.

C. **Ecosystem-Based Management**:

   - The protocol emphasizes ecosystem-based management, which focuses on maintaining the health of marine and coastal ecosystems while allowing for sustainable use. This approach aims to achieve good environmental status and sustainable development through coordinated efforts among Mediterranean countries.

### 13.5.2.- Key Principles of ICZM

A. **Integration**:

   - ICZM promotes the integration of policies and actions across different sectors and levels of governance. This includes harmonizing coastal strategies with national and regional plans to ensure coherent management of coastal resources.

B. **Participation**:

- Stakeholder involvement is crucial for effective ICZM. Engaging local communities, businesses, and government entities ensures that diverse perspectives and needs are considered in decision-making processes.

C. **Sustainability**:

- The protocol aims to ensure the sustainable use of natural resources, particularly water, and to protect biodiversity. It recognizes the importance of maintaining ecological balance while supporting economic development.

D. **Adaptation to Climate Change**:

- The ICZM Protocol addresses the challenges posed by climate change, including rising sea levels and increased coastal erosion. It encourages the adoption of measures to enhance resilience and reduce vulnerability in coastal areas.

### 13.5.3.-Implementation and Challenges

A. **Regional Cooperation**:

- Effective implementation of ICZM requires cooperation among Mediterranean countries. The protocol encourages collaborative efforts to address transboundary issues and share best practices.

B. **Legal Framework**:

- The ICZM Protocol provides a legally binding framework for coastal management, which is essential for ensuring compliance and accountability among contracting parties. This marks a shift from previous non-binding guidelines to a more structured approach.

C. **Monitoring and Evaluation**:

- Establishing indicators and monitoring systems is vital for tracking progress and evaluating the effectiveness of ICZM initiatives. This helps inform policymakers and stakeholders about the state of coastal environments and the impact of management strategies.

## 13.6.- Waste Management in Sweden

- **Location:** Sweden
- **Overview:** Sweden faced the challenge of increasing waste generation and limited landfill space.

- **Approach:** Sweden adopted a comprehensive waste management strategy focusing on waste reduction, recycling, and energy recovery. The country invested in waste-to-energy plants and implemented strict regulations on landfilling, making it expensive and less attractive.
- **Outcome:** As of recent years, less than 1% of Sweden's household waste ends up in landfills, with the rest being recycled or converted to energy. Sweden's approach is considered one of the most effective waste management systems in the world.

### 13.6.1.-Overview of Waste Management in Sweden

A. **Waste generation and recycling rates**:

- Sweden produces approximately 4.5 million tonnes of municipal waste annually, translating to about 431 kg per person
- The country has achieved impressive recycling rates, with more than 99% of waste being recycled as of 2018, significantly up from 38% in 1975.

B. **Waste-to-Energy**:

- A significant portion of waste is incinerated in waste-to-energy facilities, where it is converted into energy for heating and electricity. This method accounts for about 52% of waste treatment, while only 1% of waste is sent to landfills.
- Sweden even imports about 2 million tonnes of waste from other countries, such as the UK and Norway, to fuel its waste-to-energy plants, generating substantial revenue in the process.

**C. Waste management hierarchy**:

- The Swedish waste management system follows a strict hierarchy that prioritizes waste prevention, reuse, and recycling over disposal. The least preferred option is landfilling.

### 13.6.2.-Key Policies and Regulations

A. **Extended Producer Responsibility (EPR)**:

- Introduced in 1994, EPR mandates that producers are responsible for the entire lifecycle of their products, including waste management. This includes various product categories such as packaging, batteries, and electronics.

B. **Landfill Tax and Bans**:

- Sweden implemented a landfill tax in 1999 to discourage waste disposal in landfills. Additionally, bans on landfilling combustible waste (2002) and organic waste (2005) have further reduced landfill use

C. **Municipal Waste Management Plans**:

- Each of Sweden's 290 municipalities is required to develop a local waste management plan, detailing how waste will be collected, treated, and recycled. These plans are essential for ensuring compliance with national regulations and environmental objectives.

### 13.6.3.-Public Participation and Awareness

A. **Citizen Engagement**:

- Public awareness and participation play a crucial role in Sweden's waste management success. Most households actively separate their waste into various categories, such as food waste, recyclables, and hazardous waste.

B. **Education and Information**:

- Continuous efforts to educate citizens about waste management practices and the importance of recycling have fostered a culture of environmental responsibility

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