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Pollution

A) Definition

"Any direct or indirect modification or alteration of the natural composition (quantitative) and characteristics (qualitative) of the environment caused by any act that causes or risks causing harm to human health, safety, welfare, flora, fauna, air, water, soil, and collective or individual property." It represents a **break in natural equilibrium**, which can be **occasional or chronic**.

Consequences:

- Disruption of ecosystems
- Dangerous use of resources
- Environmental and economic impacts

B) Types of Pollution

1. Air pollution
2. Water pollution
3. Soil pollution

C) Sources of Pollution

C-1 Natural

- Mineral deposits: As (India), F (Oued Souf)
- Volcanic eruptions (Iceland, April 2010), earthquakes
- Atmospheric fallout, winds

C-2 Anthropogenic

Industrial:

- Energy production / cooling
- Industrial discharges (Minamata Hg, Jinzu Cd, Bhopal CN)
- Incineration

Agricultural:

- Livestock products
- Fertilizers
- Pesticides

Urban:

- Transport (gasoline → CO at idle, diesel → NOx at high speed)
- Heating, air conditioning, waste deposits
- Incineration of household waste
- Domestic wastewater

Nuclear: discharges, nuclear waste

Accidental:

- Chernobyl (Ukraine, 1986)
- Seveso (Italy, 1976: TCDD → cancer)
- Oil spills, shipwrecks
- Fukushima (Japan, March 2011)
- Forest fires (CO, CN, …)

D) Nature of Main Pollutants

- Gases (CO, CO2, O3, SO2…)
- Particles, aerosols, dust, VOCs (volatile organic compounds: hydrocarbons, aldehydes, ketones, alcohols)
- Heavy metals (Pb, Cd, Hg) → bioaccumulation + biomagnification
- Fluorine, nitrogen, phosphates
- POPs (Persistent Organic Pollutants: PAHs, organochlorine pesticides, dioxins, furans, PCBs)
  Bioaccumulative, non-biodegradable, highly lipophilic
  Long-range transport (winds, ocean currents) → pollution in different regions
  Potential endocrine disruptors
- Pharmaceuticals (antibiotic residues, hormones, endocrine disruptors)
- Radioelements
- Pathogenic microorganisms (viruses, bacteria, fungi) → toxins

I- Air Pollution

I-1 Atmospheric Layers

- Troposphere: O2, N2, CO2, H2O, low [O3], photons > 290 nm (UV, visible, IR), weather phenomena
- Stratosphere: O3 (protects against UV) = good ozone
- Mesosphere (vacuum), Thermosphere (hot)

Air pollution: imbalance in the **Chapman ozone cycle**.

- Tropospheric O3 photodegraded into O2 and excited oxygen
- NO2 photodegraded into NO and fundamental oxygen
- Excess NO2 or NOx → accumulation of toxic tropospheric O3 (bad ozone)

I-2 Mechanism of Air Pollution

- Emissions (NOx, CO, SO2, …)
- Production of primary pollutants by photolysis (>290 nm)
- Transport
- Chemical transformation into secondary pollutants (VOCs, H2SO4, HNO3) → acid rain

I-3 Influencing Factors

- Emission volume (density of sources: vehicles, factories)
- Meteorology: wind, temperature gradients, pressure, humidity, precipitation

- Topography: valleys, obstacles, sea/land breezes
- Cyclonic conditions → good dispersion; anticyclonic → pollutant accumulation

I-4 Consequences

- Acid rain
- Photochemical smog (SMOKE + FOG)
- Greenhouse effect exacerbation
- Stratospheric ozone depletion

II- Water Pollution

II-1 Physical

- Thermal: density, viscosity, vapor pressure, gas solubility, biochemical reaction rates
- Turbidity: suspended solids → reduced light penetration → photosynthesis impact
- Acidity: pH variation → metal solubilization → ecosystem damage
- Conductivity: high salts → density increase → reduced oxygen solubility
- Hardness: high Ca^{2+} + Mg^{2+} → corrosion risk
- Radioactivity

II-2 Chemical

- Metals, PAHs, drugs, endocrine disruptors
- Organic matter → bacterial proliferation
- Excess N, phosphates → **eutrophication / algal bloom** → oxygen depletion, water color change, H_2S release, methane and toxins

III- Soil Pollution

- Point/chronical spills, pesticides, fertilizers, nuclear contamination
- Consequences: eutrophication, erosion, leaching, macro/microelement imbalance, plant & microorganism growth disruption

E) Effects of Pollution

Air: ozone layer depletion → UV increase, tropospheric ozone → toxic, smog, greenhouse gases → climate change
Water: acidification, eutrophication, water quality deterioration
Soil: salinization, erosion, desertification, reduced agricultural yield
Species: microorganism imbalance, species scarcity, biodiversity loss, early blooming, premature animal breeding
Human health: respiratory, cardiac, skin diseases

F) Pollution Measurement

Air: delayed analysis (NOx, SO2, O3, VOCs, HAP, suspended particles, heavy metals), continuous analysis → ATMO index
Water: physico-chemical (pH, temp, MES, conductivity, nitrates, phosphates), biological (dissolved oxygen, BOD5, COD)
Soil: sampling, metals (sieving, grinding, SAA), solvents and other pollutants

G) Treatment

- Very expensive, reduce sources or treat at origin
- Water: nanofiltration, complexation
- Soil: ventilation, solvent extraction, thermal or flotation treatment