

Chapter 4 : The Substances (Pollutants)

We can distinguish different types of pollution, each having various origins and different effects.

1. Definition of Pollution

Pollution is the set of toxic compounds released by humans into the receiving environment (continental, oceanic, and atmospheric). Some substances released are of natural origin but still pose a danger to living organisms and disturb the overall balance of the environment.

2. Origins of Pollutants and Main Elements

The three main causes of pollution are:

- The production and consumption of fossil fuels;
- Activities related to various chemical industries;
- Agricultural activities (fertilizers and pesticides).

The main pollutants are shown in the following table:

Tableau 1 Liste des polluants et leurs caractéristiques

Symbol	Designation	Description	Effects on Health and Environment
SO ₂	Sulfur dioxide	Results from the combustion of coal and fuels.	Causes respiratory problems, eye irritation, and contributes to acid rain, which damages vegetation and aquatic ecosystems.
NO _x	Nitrogen oxides	Gases emitted from combustion installations and motor vehicles.	Contribute to the formation of smog and acid rain; irritate lungs and reduce air quality; play a role in ozone layer depletion.
CO	Carbon monoxide	Mainly produced by internal combustion engine vehicles.	Highly toxic; reduces the oxygen-carrying capacity of blood, causing headaches, dizziness, or even death at high concentrations.
CO ₂	Carbon dioxide	The natural product of all combustion processes, largely responsible for the greenhouse effect. The remainder is due to methane and chlorofluorocarbons.	Non-toxic but a major greenhouse gas contributing to global warming and climate change.
Hydrocarbons	Hydrocarbons	Result from the incomplete combustion of fuels in engines,	Some are carcinogenic; contribute to ground-level

Symbol	Designation	Description	Effects on Health and Environment
		producing hydrocarbon vapors. They also originate from the use of certain solvents.	ozone (smog) formation and air pollution.

HCl	Hydrochloric acid	Present in the atmosphere when PVC or similar plastics are burned.	Causes irritation of the respiratory tract, eyes, and skin; contributes to acid rain and corrosion of materials.
Dust / Particles	Particulates	Solid or suspended particles in the air that constitute non-gaseous pollutants.	Cause respiratory and cardiovascular diseases; reduce air visibility; settle on plants and water surfaces, affecting ecosystems.
O₃	Ozone	A secondary pollutant resulting from the action of solar radiation on various pollutants, thereby increasing ozone levels in the air to toxic concentrations.	At ground level, causes respiratory irritation, damages vegetation and materials; in the upper atmosphere, it forms the ozone layer that protects against UV radiation.
CH₄	Methane	The main volatile organic compound responsible for intensifying the greenhouse effect.	Contributes significantly to global warming; non-toxic but has high climate impact potential.
CFC	Chlorofluorocarbon	Pollutants most involved in the degradation of the ozone layer.	Cause depletion of the stratospheric ozone layer, leading to increased UV radiation and higher risks of skin cancer.
Pesticides	Pesticides	Chemical substances used to eliminate harmful organisms.	Toxic to humans and animals; contaminate soil and water; accumulate in the food chain.
Heavy metals	Lead, Cadmium, Arsenic, Mercury	Toxic metallic elements released by industrial and combustion processes.	Bioaccumulate in living organisms; cause neurological, renal, and developmental disorders; contaminate soil and water.
Radioelements	Radioactive elements	Emit ionizing radiation that can persist for long periods.	Cause genetic mutations, cancers, and long-term contamination of ecosystems.

3. Effects of Pollution on the Environment

A. Effect on the Atmosphere:

The effects of pollutants on the atmosphere are increasingly evident and are mainly manifested through:

1. The Increase of the Greenhouse Effect:

Let us begin by defining and explaining the greenhouse effect. It is a **natural phenomenon**, originally **beneficial to human life**, as it allows water to remain in a liquid state and reduces the risk of glaciation.

This effect is caused by **trace gases** present in the atmosphere, such as **water vapor (H₂O)**, **carbon dioxide (CO₂)**, **methane (CH₄)**, **sulfur compounds**, and **nitrogen compounds**.

However, the **increase in the concentration of Greenhouse Gases (GHGs)** in the atmosphere, due to **human activities**, leads to an **additional greenhouse effect**.

To evaluate the rapid growth of these GHGs, it is enough to observe the current increase in the concentration of their main components:

Table 2 – Evolution of pollutants over time

	CO₂	Methane	Nitrous oxide
Unit	ppmv ¹⁰	ppbv	ppbv ¹¹
Before 400,000 years	200 – 280	400 – 700	270
2004	380	1500	310

- **ppmv** = parts per million by volume.
- **ppbv** = parts per billion by volume.

3. Effects of Pollution on the Environment

A. Effect on the Atmosphere:

The **additional greenhouse effect** results in a **global warming** of the planet. Since 1990, the Earth has experienced a global temperature rise of **0.3 to 0.7°C over 20 years**. The **Intergovernmental Panel on Climate Change (IPCC)** has announced an **average global temperature increase ranging from 1.4 to 5.8°C**.

However, this rise is not uniform; on the contrary, it will lead to **extreme events** such as **storms, droughts, and cold waves**. The **water cycle** will also be altered, resulting in increased drought in some regions.

The IPCC predicts certain **imbalances** if the temperature increases by **2.5°C by the end of the 21st century**, including:

- An **average sea level rise of 65 cm**, leading to flooding and the disappearance of some coastal areas;
- The **melting of 50% of the world’s glaciers**;

- **Changes in river flow rates and lake water levels;**
- **A general increase in temperatures and precipitation, promoting the spread of diseases and parasites.**

2. The Thinning of the Stratospheric Ozone Layer:

About **90% of the ozone layer** is located in the **stratosphere**, between **15 and 40 km in altitude**. It is a derivative of oxygen that plays an essential role for the biosphere by **absorbing part of the sun's ultraviolet radiation**, particularly **short wavelengths between 240 and 300 nanometers**.

These radiations are known to cause **carcinogenic and mutagenic diseases** capable of destroying living cells.

In **1985**, a **hole in the ozone layer**—larger than the surface area of the **United States**—was discovered over the **South Pole**. The primary culprits identified were **CFCs (chlorofluorocarbons)**, gases widely used in industry before 1987, later replaced by **HCFCs**, which are less harmful. However, **China** continues to produce CFCs.

This **ozone depletion** affects **materials and ecosystems** such as **forests and water reserves**, among others.

B. Effect on Soil and Aquatic Environments:

Humans, through their biological functions, release **organic waste**, which is eventually discharged into **receiving environments**. Although these wastes are more or less natural, they can become **toxic** when associated with **high population densities** and a **lack of adequate treatment**.

Industrial activities are much more polluting due to their **consumption and production of chemical products**. The discharged waste becomes increasingly **toxic**, and its **storage in the environment** is harmful both to **nature** and to **humans**.

Examples include:

- The **discharge of a large quantity of cyanide** into the **Hungarian River Tisza** and then into the **Danube River** in **March 2000**, contaminating hundreds of kilometers;
- The **methyl isocyanate leak** from a factory in **Bhopal, India**, which caused **3,500 deaths** and **injured hundreds of thousands**;
- The **release of mercury** from a factory in **Minamata, Japan**, over more than **three decades**, leading to **neurological diseases and deaths** among thousands of people (1960);
- The case of **Persistent Organic Pollutants (POPs)**, known for their **bioconcentration phenomenon**, as these substances tend to **accumulate in animal fat tissues**.

C. Effect on Human Health:

The first environmental concerns were mainly related to **human health**, rather than to **ecosystem destruction** or **biodiversity loss**.

Significant **morbidity**—caused by **factory smoke, tannery emissions**, and other industrial processes—appeared **even before the Industrial Revolution**. Similarly, **urban waste and sewage systems** were quickly identified as **sources of disease**.

Thanks to medical advances, **human health has greatly improved**, and **life expectancy** has increased. However, many **infectious diseases** have emerged, along with the **spread of various forms of cancer**.

Industrial activity, through the **emission of toxic gases**, and **liquid and solid waste**, has led to the appearance of several **diseases and cancers**.

Medical research has made it possible to **overcome some of these diseases**, **reduce the impact of others**, but still **cannot solve certain complex cases**.

The most noticeable effect of pollution on human health remains the **increasing prevalence of chronic allergies**.