ENVIRONMENTAL POLLUTION

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PEOPLE – ENVIRONMENT - POLLUTION

The past, present and potential global threat of environmental pollution and degradation is one of the main factors that has an effect on the formation of society's environment.

Environmental pollution and degradation can be caused by chemical substances, physical factors or the development of undesirable living organisms.

Pollutant is any substance released into the environment as a result of human activity or natural processes that has an adverse impact on living organisms.

Environmental degradation means that the environment becomes unusable for its designed purposes or that the development of living organisms and their communities in the environment is disturbed.

Life on the Earth is fragile, and every living being can continue to live only in the environmental conditions optimal for its life.

Factors which can influence living organisms and life itself:

Natural factors

Anthropogenic factors

Intensive flow of electromagnetic radiation

Depletion of needed nutrients

Rise or fall of temperature above or below the optimum

Chemical substances

Any chemical, biological or physical factor is called toxic if it causes an adverse biological reaction.

Different substances or factors have different effects:

Chemicals	Physical factors	Biological factors
Pollutants, for example, pesticides.	Rise or fall of temperature. Ionising radiation.	Development of the undesirable living forms.

ENVIRONMENTAL DEGRADATION

In the case of environmental degradation:

creation of the unfavourable conditions for living organisms

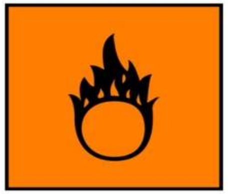
limits for development of the organisms and their communities

Environmental degradation as a soil erosion due to over-grazing

DANGEROUS CHEMICAL SUBSTANCES

Pollution of the environment by chemical substances can be classified depending on the properties and structure of these substances.

Environmental contamination with metals or their compounds (Cu, Pb, Co, Hg and others) and toxic trace elements (F, B, As, Se and others) can be marked out first.



Oxidizing agents

Irritant (kairinošs)

Flammable substances

Toxic substances

Harmful for environment

Explosives

Corrosive mordant

Dangerous Substances Directive 67/548/EEC

Toxic substances

Toxic substances:

Naturally occurring	**Human-made (xenobiotic)**
Plant's toxins, poisons	Produced by synthesis or as by-products in the process of production of other substances.

All toxic substances are hazardous, but not all hazardous substances are toxic.

Pollutants :

Metals and their compounds	Toxic micro-elements	Organic pollutants	Chemically inert compounds in a state of fine particles can also contaminate the environment
Cu, Pb, Co, Hg *etc.*	F, B, As, Se *etc.*	pesticides, industrial by-products *etc.*	dust and aerosols in the air and suspensions in water

Persistent Organic Pollutants

The environmental pollution threat increases if the organic substances that have been released into the environment are persistent (Persistent Organic Pollutants – POP), i.e., if they remain there for a long period of time (even several decades in the soil).

Environmental pollution with POP's :

by destruction of the products, used in households	by use pesticides and other plant's protection chemicals	by industrial (chemical) production

POP's are pesticide DDT, dioxins, polychlorinated biphenyls and others.

CHEMICAL COMPOUNDS IN THE ENVIRONMENT

All kinds of chemical compounds are increasingly released into the environment

approximately 10 million known chemical substances, and a large part of them do not exist in the natural environment

approximately 120 000 industrially produced chemical compounds

widely used and 10 000 substances produced in the amounts exceeding 500 kg per year

the number of types of industrially produced substances is increasing from approximately one to three thousand new ones every year

REACH

Registration, Evaluation, Authorisation and Restriction of Chemicals (EC) No 1907/2006

REACH is a EU Regulation of 18 December 2006. REACH addresses the production and use of chemical substances, and their potential impacts on both human health and the environment.
Its 849 pages took seven years to pass, and it has been described as the most complex legislation in the Union's history and the most important in 20 years.
It is the strictest law to date regulating chemical substances and will affect industries throughout the world.

REACH requirement is to communicate information on chemicals up and down the supply chain. This ensures that manufacturers, importers and also their customers are aware of information relating to health and safety of the products supplied. For many retailers (mazumtirgotājs) the obligation to provide information about substances in their products within 45 days of receipt of a request from a consumer is particularly challenging. Having detailed information on the substances present in their products will allow retailers to work with the manufacturing base to substitute or remove potentially harmful substances from products. The list of harmful substances is continuously growing and requires organizations to constantly monitor any announcements and additions to the REACH scope. This can be done on the European Chemicals Agency 's website.

The European Chemicals Agency has set three major deadlines for registration of chemicals. In general these are determined by tonnage manufactured or imported, with 1000 tonnes/a. being required to be registered by 1 December 2010, 100 tonnes/a. by 1 June 2013 and 1 tonne/a. by 1 June 2018. In addition, chemicals of higher concern or toxicity also have to meet the 2010 deadline.

European Chemicals Agency headquarters in Annankatu, Helsinki.

Chemistry is the science of chemical elements and compounds

Volatile Organic Compound (VOC)

Emission Sources:

Paints
Varnishes (lakas)
Moth balls (kožu tabletes)
Solvents
Gasoline
Newspaper
Cooking
Cleaning chemicals
Vinyl fluors
Carpets
Photocopying
Upholstery (polsteri) fabrics
Adhesives (līmvielas)
Sealing caulks (tepe)
Cosmetics
Airf fresheners
Fuel oil
Vehicle exhaust
Pressed wood furniture
Tobacco smoke

VOC by products:

Benzene
Toluene
Methylene chloride
Formaldehyde
Xylene
Ethylene glycol
Texanol 1,3-butadiene

The quality of the environment

Environment degradation factors :

Physical factors

- electromagnetic radiation
- noise pollution
- thermal pollution

Biological factors

- infectious agents
- parasites
- living organisms whose metabolism or decay products are harmful to humans or other living organisms

AIR POLLUTION

Air is one of the essential factors making life on the Earth possible. Depending on the body constitution, a human being consumes 6–13 cubic metres of air daily or even more in cases of heavy physical loads.

Consequently, trace amounts of harmful substances in the air may have an adverse effect on the human health.

Pollutants spread rapidly and to far distances in the atmosphere; therefore, the problem of atmospheric pollution should be dealt with on a global scale, and international cooperation is vital in this regard.
Air cleanness in dwelling premises and working environment is a special air pollution problem because today people become increasingly exposed to hazardous and toxic substances at home or work.

SOURCES OF ANTHROPOGENIC POLLUTION OF AIR

Industrial pollution mostly occurs in the industrially developed regions of North America, Europe and Asia.

The main sources of anthropogenic pollution that also affect the quality of air are :

- agriculture
- energy production, heating
- industrial production
- transport

THE MAIN AIR POLLUTANTS ARE:

- sulphur compounds
- nitrogen compounds
- carbon compounds
- halogenated organic substances
- metals and their compounds
- aerosols and dust
- radioactive elements

Both industrial processes and heating contributes to air pollution. Incineration of household waste pollutes air significantly.

Indoor air pollution

Air pollution in the human living environment – living rooms and workplaces – are affect the human health considerably.

Main sources of the indoor air pollution

kitchens	stoves	furniture	painted surfaces	domestic animals	polymers

Room ventilation also affects the air pollution level. Ventilation should be balanced with the need to maintain the optimum temperature in dwelling premises.

Typical pollutants in living environment:

Piesārņojošā viela	Vielas avots
Formaldehyde	Plates of wooden chips, smoking, insulating materials, natural gas heating systems
NO_2	Stoves, exhaust gases from road transport
CO	Burning of the timber, coal, petrol
Polyaromatic hydrocarbons	Burning of the fuel
SO_2	Burning of the timber, coal, petrol
Cl_2	Bleach (whitener), chlorinated water
volatile organic compound	Paints, households' chemistry, polymers
aerosols or dust	Burning of the fuel, food cooking, insulating materials, carpets and mats, smoking
Microorganisms, virus	Mould (pelējuma sēnītes), domestic animals
Radon	Buildings, soil, water

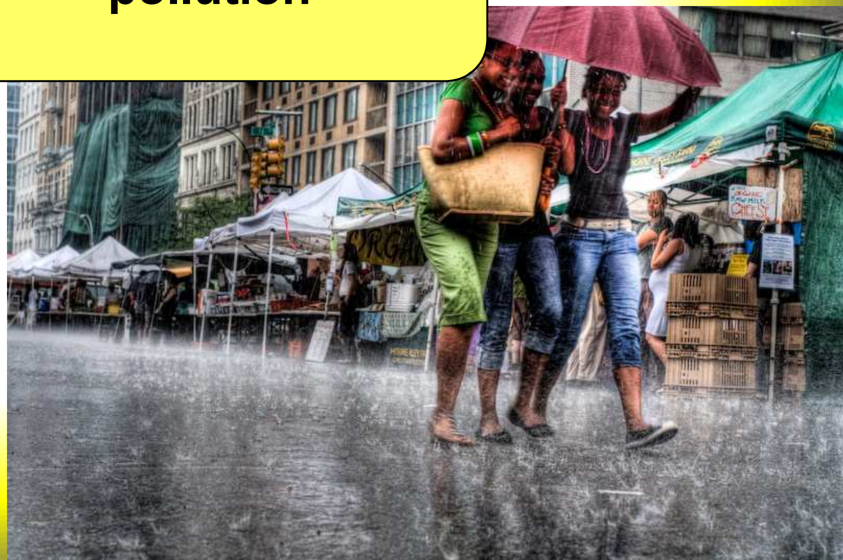
WATER POLLUTION

Water is considered to be polluted if certain substances or physical factors affect the quality of water and functioning of ecosystems and, as a result, the use of water for particular purposes is restricted.

Classification of the water pollution sources:

point source pollution

non-point source pollution



Point source pollution

Point source pollution are:

agricultural wastewater

oil and oil product pipelines

pipes for draining treated or untreated urban or factory wastewater into reservoirs, rivers, lakes and seas

NON-POINT SOURCE POLLUTION

Non-point water pollution sources are dissipated, and it is much more difficult to identify and assess them.

Typical non-point pollution sources are:

- runoff from agricultural fields
- drainage from landfills
- fallout of substances with precipitation
- surface runoff from building areas
- runoff from abandoned and active mining sites and quarries

Pollution of natural waters

The main aquatic environment pollutants are:

Inorganic substances

- Biogenic elements
- Inorganic salts
- Toxic microelements
- Radionuclide's *etc.*

Organic substances

- Biologically degradable substances
- Oil products
- Pesticides
- Surface active substances *etc.*

Physical factors

- Radiation *etc.*

Pollution of natural waters with crude oil, oil products and other persistent substances is particularly hazardous.

Persistent organic pollutants (POP's) have a special place among these hazardous substances.

POP's can be divided:

- plant protection products – pesticides (aldrin, DDT, dieldrin, endrin, hexachlor benzene, hepta chlor, chlordane, mirex, toxaphen)
- by-products (polychlorinated dibenzo-p-dioxins, poly-chlorinated dibenzofurans, polyaromatic hydrocarbons) of production processes
- chemical products for industrial use (hexachlor benzene, polychlorinated biphenyls)

The aquatic environment pollutants are nutrients, *inter alia*, nitrogen and phosphorus compounds:

Nitrogen compounds	Phosphorus compounds	Iron compounds	Silicon compounds
Inorganic ions (NH_4^+, NO_2^+, NO_3^-) and organic compounds	Inorganic (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, poly-phosphate ions) and organic compounds	Chemical substances at different oxidation degree and forms, taking into account their exclusive role for guarantee of the life processes in water bilges	

Nutrients to come into waters with atmospheric precipitation, wastewater and surface run-off.

Eutrophication of the water

Larger or lesser amounts of nutrients enter surface waters all the time, and they provide the necessary conditions for the formation of organic substances in aquatic organisms using energy from sunlight.

These are photosynthesising plants and include different algae, higher aquatic plants – such as reeds, rush, pondweed, duckweed and others – as well some bacteria.

If the inflow of substances containing nutrients increases, their concentration in water increases too, in effect boosting the growth of plants, mostly algae, thus increasing the overall live mass of aquatic organisms.

This process is called eutrophication (from the Greek – *eu*- 'well' + *trophe* – 'nourishment' = 'well nourished').

Overgrown part oo the river Lielupe between Bauska and Mežotne

The main nutrients found in waters, considering their significance for the life processes in water bodies, are the following: nitrogen compounds – inorganic ions (NH_4^+, NO_2^-, NO_3^-) and organic compounds; phosphorus compounds – inorganic (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, polyphosphate ions) and organic compounds; and iron and silicon compounds in different forms and oxidation stages.

Eutrophication

Signs indicate that an intensive eutrophication process is in taking place in water:

Visual signs

- algae thrive, making the water cloudy, so that you cannot see through it deeper than 0.5 m
- rocks and plants have periphyton and filamentary algae on them
- fish are choking even in summer and under ice in winter
- gas bubbles come to the surface from rotting plants and animal remains

Other signs

- abundance of nutrients concentration of oxygen in water decreases oxygen can be absent in deeper water layers
- animal species adapted to living in clean, nutrient-poor water – for example, the salmon fish family – die out

SOIL POLLUTION

Pollutants quite often penetrate soil, affecting the organisms that live there.
However, the effect of the presence of pollutants in soil or the lithosphere on both terrestrial animals and ecosystems is much more considerable as these substances accumulate in food chains.

The mobile component of the soil environment – water, or, more exactly, the underground water – can disperse the pollutants quite quickly.

The soil and lithosphere environmental pollution concentrates at its outlets yet can quickly dissipate, and it intensively interacts with the soil-forming rocks.

SOIL POLLUTANTS

The soil environment and the food depends on the soil composition. Consider, for example, such a trace element as selenium – its shortage or excess in human food may cause specific diseases.

Typical pollutants of the EU cities and soils of industrial use:

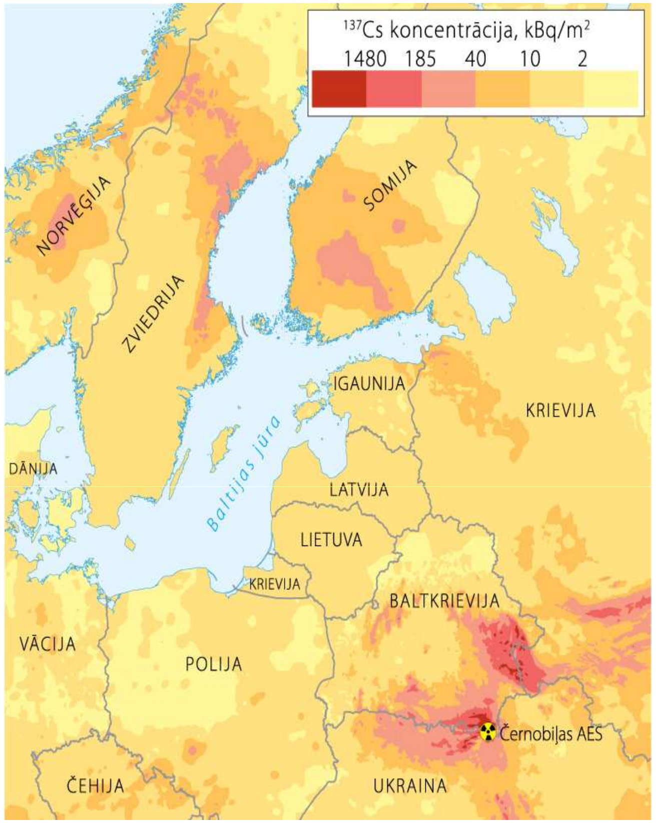
Organic compounds

- Polyaromatic hydrocarbons
- Halogenorganic substances
- Oil products
- Phenols
- Cyanides

Inorganic compounds

- Radioactive elements
- Heavy metals
- Toxic microelements

Soil contamination in Europe after the Chernobyl nuclear disaster



After the nuclear reactor accident, the fallout of radioactive isotopes (as seen in the ^{137}Cs example) occurred for the most part in the region of the accident site, whereas a significant part of radioactive elements was carried away with air masses and reached even the Scandinavian countries.

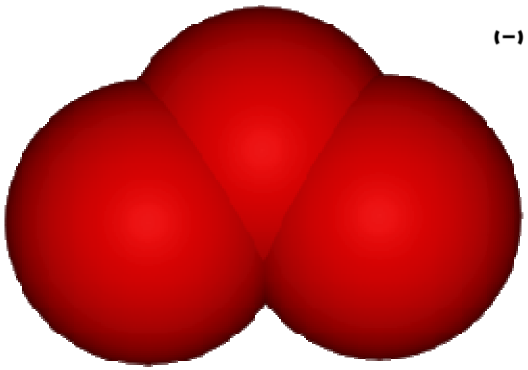
GLOBAL ENVIRONMENTAL POLLUTION PROBLEMS

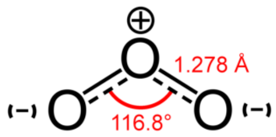
Global environmental pollution caused :

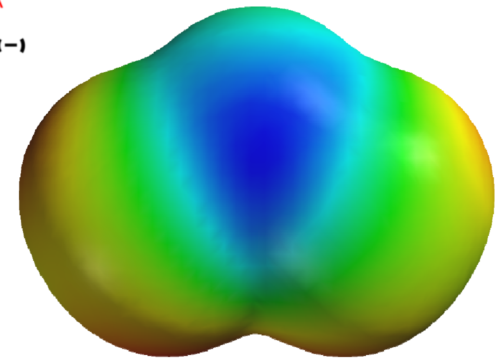
Global warming	Depletion of the ozone layer

EARTH'S OZONE LAYER AND THE CONSEQUENCES OF ITS DEPLETION

Ozone (**O_3**) is one of the oxygen molecule forms composed of three interconnected oxygen atoms.
Ozone is a pale blue gas that has a higher density than air.
Ozone is formed when energy – for example, electromagnetic radiation – splits the oxygen molecules. As a chemical substance, ozone is a powerful oxidant.







The presence of ozone in the atmosphere, its formation and disintegration reactions are vital for the absorption of the UV radiation from the Sun.

SIGNIFICANCE OF THE OZONE LAYER

The ozone layer (its thickness in the atmosphere under normal conditions is approximately 2.5 mm if only the dispersed ozone molecules were gathered together) protects the biosphere from the ultraviolet part of the solar radiation spectrum.

The ozone layer is thickest at the height of 25–30 kilometres in equatorial regions and 15 – 20 kilometres around the Earth's poles.

The ozone concentration near the Earth's surface is ~0.001% by volume, whereas in the stratosphere its concentration may be even more than 100 times higher.

Factors affecting the concentration of ozone:

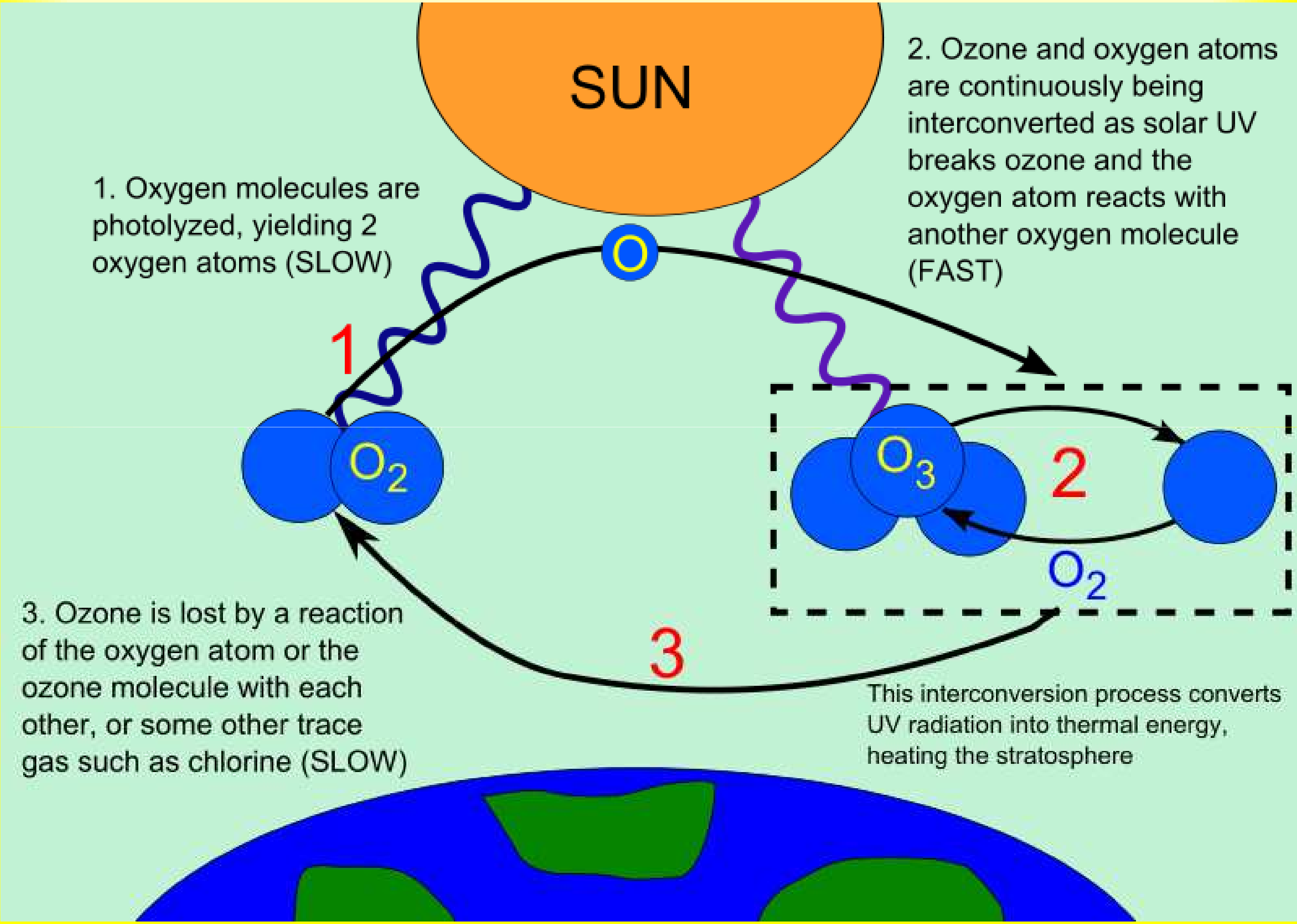
- activity of the Sun
- season
- the movement of air masses
- natural and anthropogenic processes
- geographical latitude

Ozone molecule formation

In the first stage of ozone molecule synthesis, an oxygen molecule is excited by absorbing the UV radiation energy. The excited oxygen molecule splits into two oxygen atoms that are free to react with another oxygen molecule to form an ozone molecule.

UV radiation is absorbed during the ozone molecule formation process, and the new ozone molecule also is capable of absorbing it.
At the same time, UV radiation that has a shorter wavelength (and higher energy) splits the ozone molecules.
As a consequence, the concentration of ozone is decreasing in the upper layers of the atmosphere.

Ozone molecule formation



OZONE CYCLE

Three forms of oxygen are involved in the ozone-oxygen cycle: oxygen atoms (O or atomic oxygen), oxygen gas (or diatomic oxygen), and ozone gas (or tri-atomic oxygen). Ozone is formed in the stratosphere when oxygen molecules photo-dissociate after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm.

This converts a single into two atomic oxygen ions. The atomic oxygen ions then combine with separate molecules to create two molecules. These ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a continuing process which terminates when an oxygen atom "recombines" with an ozone molecule to make two molecules.

$$O + O_3 \rightarrow 2\,O_2$$

The overall amount of ozone in the stratosphere is determined by a balance between photochemical production and recombination.

Ozone can be destroyed by a number of free radical catalysts, the most important of which are the hydroxyl radical ($OH^{\cdot}$), the nitric oxide radical ($NO^{\cdot}$), the atomic chlorine ion (Cl^{-}) and the atomic bromine ion (Br^{-}). All of these have both natural and man-made sources; at the present time, most of the OH· and NO· in the stratosphere is of natural origin, but human activity has dramatically increased the levels of chlorine and bromine.

These elements are found in certain stable organic compounds, especially chlorofluorocarbons (CFCs), which may find their way to the stratosphere without being destroyed in the troposphere due to their low reactivity. Once in the stratosphere, the Cl and Br atoms are liberated from the parent compounds by the action of ultraviolet light, e.g.

$$CFCl_3 + \text{electromagnetic radiation} \rightarrow CFCl_2 + Cl$$

OZONE CYCLE

The Cl and Br atoms can then destroy ozone molecules through a variety of catalytic cycles. In the simplest example of such a cycle, a chlorine atom reacts with an ozone molecule, taking an oxygen atom with it (forming ClO) and leaving a normal oxygen molecule. The chlorine monoxide (i.e., the ClO) can react with a second molecule of ozone (i.e.,) to yield another chlorine atom and two molecules of oxygen. The chemical shorthand for these gas-phase reactions is:

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O_3 \rightarrow Cl + 2\,O_2$$

The overall effect is a decrease in the amount of ozone. More complicated mechanisms have been discovered that lead to ozone destruction in the lower stratosphere as well.

MAIN SUBSTANCES THAT AFFECT THE OZONE LAYER

The atmospheric contamination with halogenated hydrocarbons, produced in relatively large amounts, is considered to be particularly hazardous to the environment.

Halogenated hydrocarbon molecules are composed of carbon, hydrogen and halogen (F, Cl, Br, I) atoms. Those halogenated hydrocarbons whose molecules contain one or two carbon atoms and have their remaining hydrogen atoms replaced by fluorine or chlorine atoms are called freons.

The lifetime of freons in the atmosphere is from 29 to 500 years. After entering the stratosphere, freons interact with UV radiation, releasing chlorine or fluorine atoms that can subsequently become involved in ozone degradation reactions.

FREONS

Considering the wide range of industrial use of freons, their production in industrial quantities began in the 30s of the 20th century.

Initially freons were used as a replacement for such hazardous and toxic gases as ammonia (NH_3) and sulphur dioxide (SO_2) in refrigerators.

Since freons had low toxicity and were non-combustible, they were found useful in a wide range of other applications as well.

At the end of the 1980s, the total production amount of freons reached 1.2 million tons per year.

SOURCES THAT AFFECT THE OZONE LAYER

Freons are emitted into the environment as a result of:

- specific features of technological processes (e.g., refrigeration systems)
- after use of products (e.g., aerosols)
- technological processes (e.g., microchip cleaning)

Principal CFCs			
Systematic name	**Common/trivial name(s), code**	**Boiling point (° C)**	**Formula**
Trichloro fluoromethane	Freon-11, R-11, CFC-11	23	CCl_3F
Dichlorofluoromethane	Freon-12, R-12, CFC-12	−29.8	CCl_2F_2
Chlorotrifluoromethane	Freon-13, R-13, CFC-13	−81	$CClF_3$
Chlorodifluoromethane	R-22, HCFC-22	−40.8	$CHClF_2$
Dichlorofluoromethane	R-21, HCFC-21	8.9	$CHCl_2F$
Chlorofluoromethane	Freon 31, R-31, HCFC-31		CH_2ClF
Bromochlorodifluoromethane	BCF, Halon 1211, H-1211, Freon 12B1		$CBrClF_2$

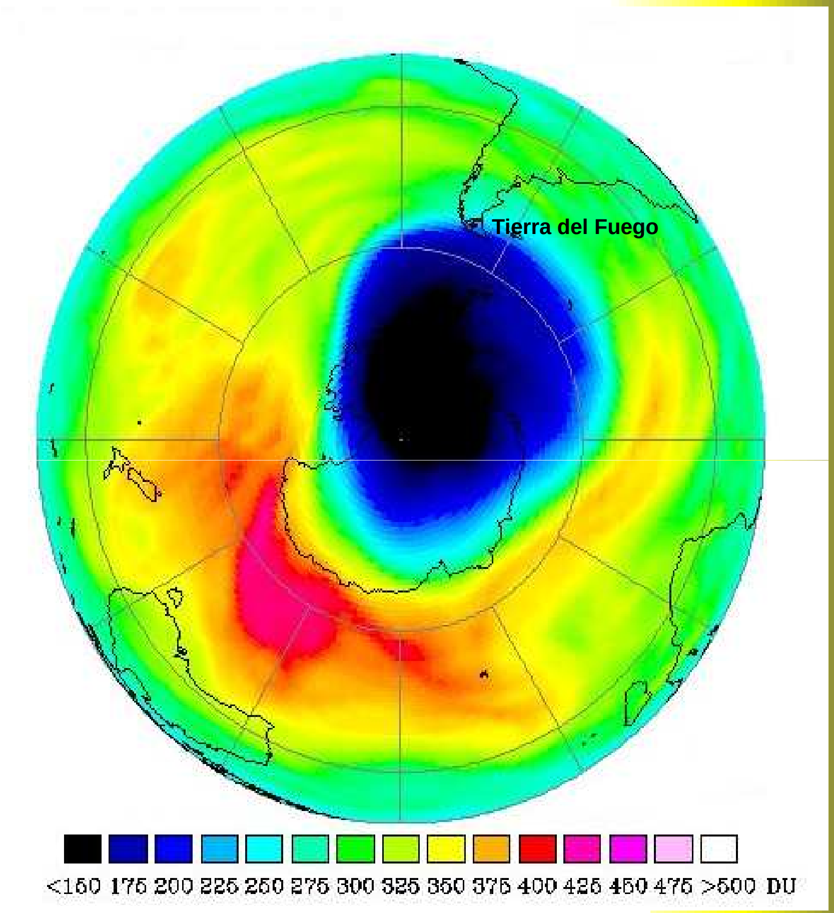
Main freons that affect the ozone layer.

OZONE HOLE

The reduction of the ozone concentration (the ozone layer depletion) was observed for the first time over the Antarctic, where natural processes initiate an especially intensive breakdown of ozone molecules.

At the beginning of the 1970s, the size of the Antarctic ozone hole was a few million square kilometres, while now it exceeds 25 million square kilometres.

The ozone concentration in the atmosphere is expressed in gas concentration units of measure (mg/m3, µg/m3) or in a special unit of measure called the Dobson unit (DU) in honour of Gordon Miller Bourne Dobson, who was one of the first scientists studying the atmospheric ozone. One Dobson unit is a 0.01 mm thick ozone layer under standard temperature and atmospheric pressure.



Profile of the ozone hole over the Antarctic (ozone concentration in Dobson units)

DEPLETION OF THE OZONE LAYER

The depletion of the ozone layer and increase in the intensity of UV radiation reaching the Earth's surface have far-reaching consequences.
Diminishing the negative effects of UV radiation has become one of the central objectives of environmental protection policy.
Suntan has for a long time been regarded as a sign of a healthy lifestyle and good health in general. However, today views about the healthfulness of sunbathing have radically changed. The production and use of various sunscreen cosmetic products and sunglasses that protect the skin and the eyes from UV radiation has been increasing.

In winter air masses in Antarctic are isolated, but temperature fall down to -85 °C. At such conditions nitrogen oxides in atmosphere under reaction with water vapour produce nitric acid, which molecules operate as vapour condensation centres.

Chlorine atoms and radicals take part in reactions with nitrogen compounds producing active substances ($ClONO_2$, HCl, $HClO$), which bring to destruction of ozone molecules and ozone layer.

Threats by ozone layer changes

The depletion of the ozone layer by 5% will substantially increase the intensity of UV-B and UV-C radiation reaching the Earth's surface.

UV radiation is divided into three radiation ranges with different wavelengths according to its biological effect:

- **UV-C** (wavelength λ<290 nm)
- **UV-B** (λ = 290-320 nm)
- **UV-A** (λ = 320-400 nm)

Thickness of the ozone layer might affect :

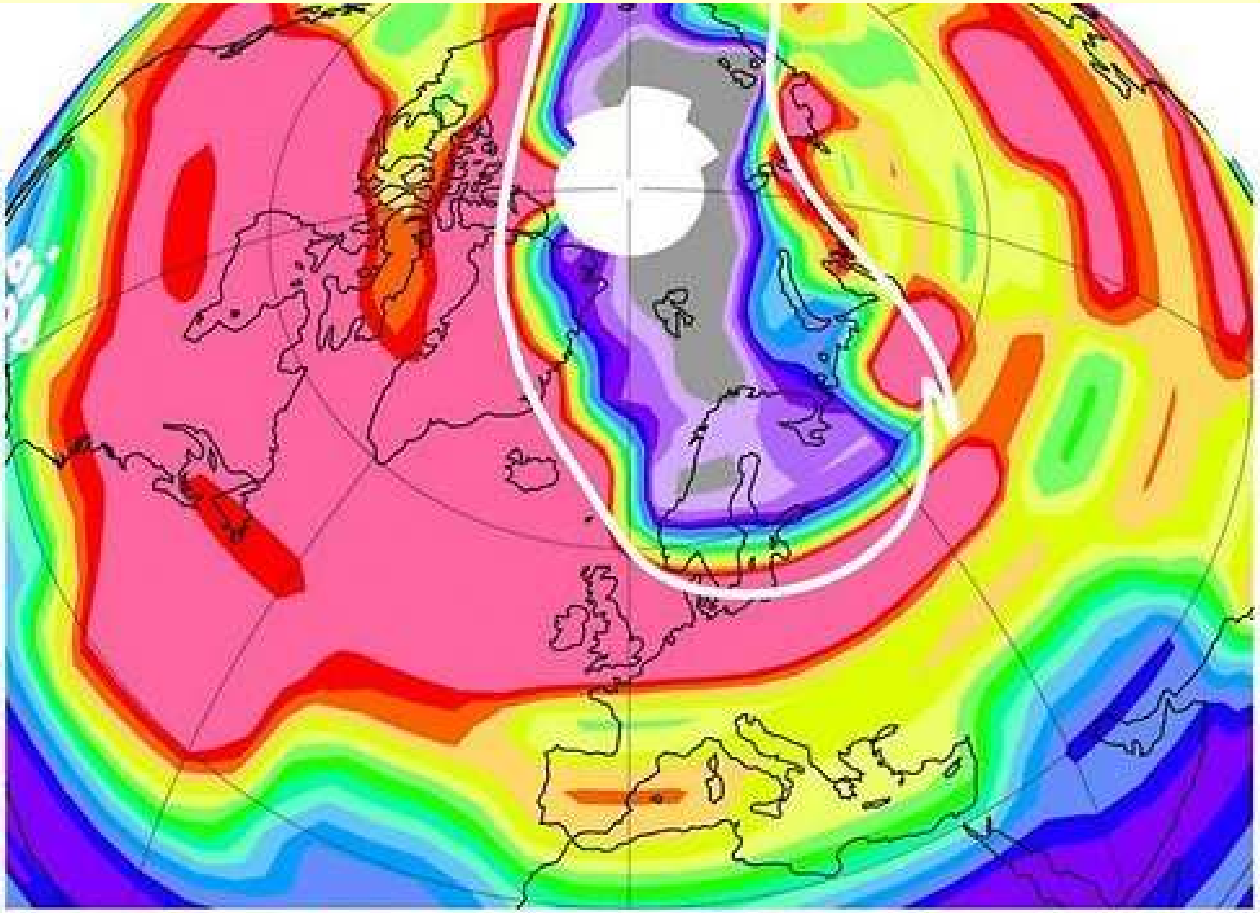
- the immune system
- mortality rate from malignant skin diseases will increase by 20%.
- the agricultural production
- reproduction of living organisms in the World Ocean - plankton

Protection of the ozone layer

To a considerable extent, the legislation restricting the ozone layer depletion had laid the foundations for further development of an effective environmental law system. The environmental legislative acts drafted for the purpose to restrict the use of substances that destroy the ozone layer provide for various activities carried out on an international level, such as the ozone layer study and monitoring, phasing out the production of these substances, compensations to developing countries for the losses incurred due to the high costs of alternative technologies.

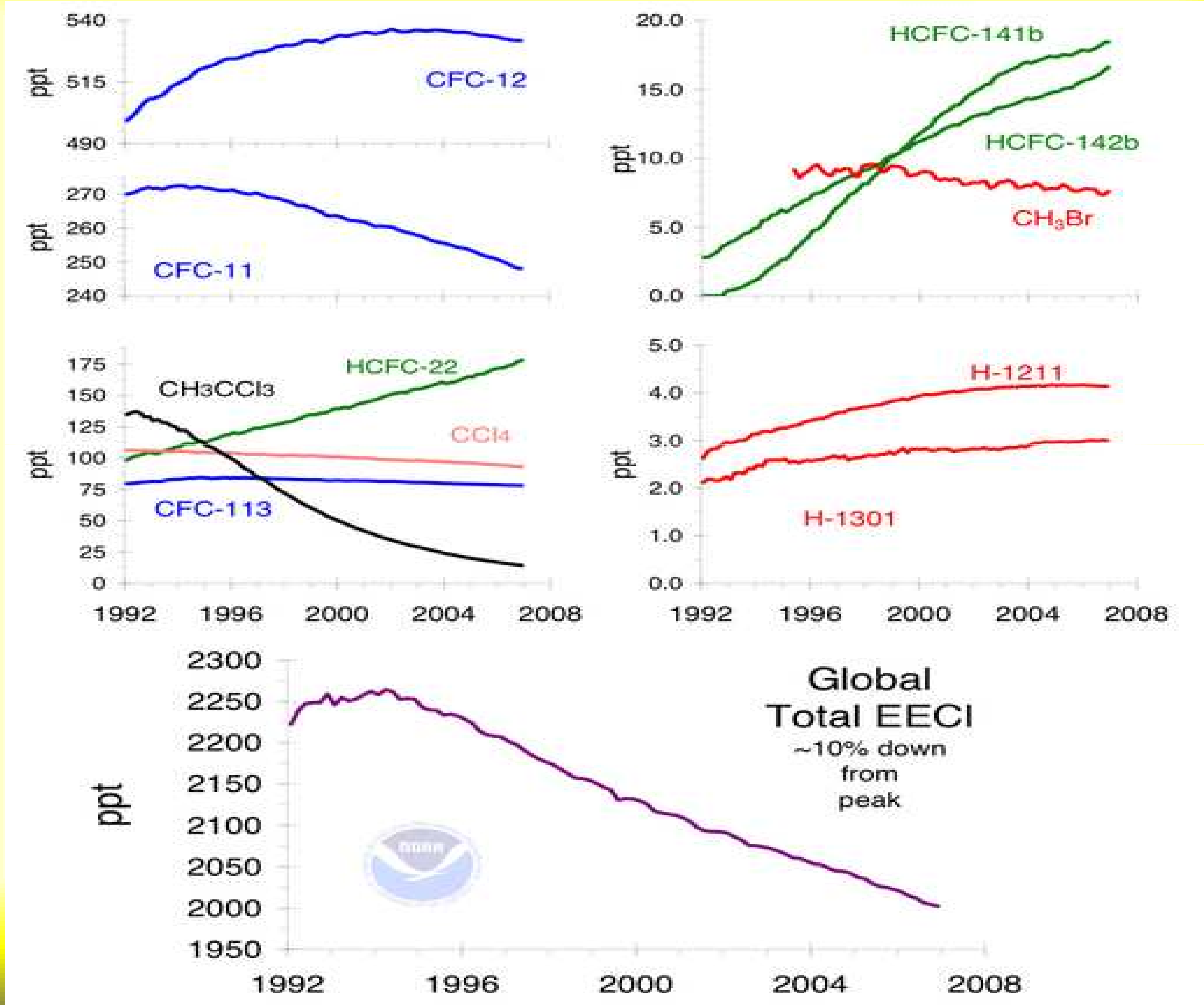
Several legislative acts have been adopted with the aim to reduce the destructive effects of pollution on the ozone layer. The drafting of legislation pertaining to the ozone layer protection began in 1985. The most important international treaty in this regard is the **Montreal Protocol on Substances That Deplete the Ozone Layer** (a protocol to the **Vienna Convention** of 1985 for the Protection of the Ozone Layer) designed to restrict the production of these substances.

Ozone hole in Arctic



Ozone layer in Arctic reduced by 40 % in April 2011. It is almost as in Antarctic, where depletion level is 50 – 60 %.
Concentration of ozone has been les as 250 Dobson units 27 days and less as 230 Db – one weak.

Ozone-depleting gas trends



REGIONAL ENVIRONMENTAL POLLUTION EFFECTS

Pollutants, which influence regional environment substantially:

- Nitrogen compounds
- Sulphur compounds
- Dust and aerosols

Oil refinery in Italy

Sand storm in Sahara

Pollution with sulphur compounds

Today the main source of sulphur compounds in the atmosphere is human economic activity.

Main processes by which sulphur compounds release in environment :

Natural

- Evaporation from water reservoirs
- Volcanic activity
- Forest fires

Anthropogenic

- Ore's mining
- Burning of the fossil fuel (coal, oil, peat)
- Production of the mineral fertilizers

Sulphur dioxide is a colourless gas with a very strong, pungent odour. It is easily liquefiable and soluble in water, making a medium-strong acid – sulphurous acid (H_2SO_3). Sulphur dioxide oxidises easily in the atmosphere, reacts with atmospheric water vapour, and sulphuric acid solution is the end-product of these transformations. The fallout of compounds formed as a result of sulphur dioxide oxidation occurs in the forms of rain and snow (wet deposition) as well as dust (dry deposition).

Pollution with nitrogen compounds

Several nitrogen oxides can be present in the atmosphere as air pollutants:

nitrogen (I) oxide N_2O,
nitrogen (II),
(IV) oxides NO, NO_2,
nitric acid HNO_3.

Nitrogen oxides are also formed in the combustion processes of motor vehicle engines. Intensive release of nitrogen oxides during the process of electrical welding, especially in confined premises, is unsafe from the viewpoint of work safety. Emitted in the stratosphere, nitrogen oxides can participate in the ozone breakdown cycle. Supersonic aircraft exhaust is a significant source of nitrogen oxides in the stratosphere.

Today the emission of nitrogen oxides as well as another environmental pollutant – ammonia – has become, overall, one of the most hazardous environmental pollution factors in Europe.

DUST AND AEROSOLS

Atmospheric air contains particles of every sort, size and composition. Their sizes may vary from micron to milimetric parts. The finer particles (size $< 10\ \mu m$) are called aerosols, whereas the coarser are called dust. Liquid micro-droplets (haze) are also counted as aerosols.

Main sources of aerosols and dust:

Natural

- Sea salts
- Soil
- Volcanoe
- Forest fires

Anthropogenic

- Burning of the fossil fuel (coal, oil, peat, timber)
- Industry (cement, steel)
- Burning of the solid waste
- Agriculture

Since the effects of aerosols on humans, animals, plants and buildings can be detrimental, and aerosols and dust can be considered, by their mass, the largest group of atmospheric pollutants, it is crucial to limit their emission in the main sectors responsible for this kind of pollution, namely the production and energy industry.

THANK YOU FOR ATTENTION !