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# OZONE HOLE, HUMAN HEALTH AND SCHOOL

***Vladislav NAVRÁTIL***

***Abstract***. *Ozone depletion is a potentially serious global environmental problem. We understand the science of the depletion and have positive policy to solve the problem. Ozone chemical and physical properties, the role of polar stratospheric clouds in ozone depletion together with other reasons of this depletion are the focus of the first part of the article. In the second part of the article some consequences of ultraviolet radiation on environment and human health are discussed and some recommendations are given.*

***Keywords:*** *ecology, ozone hole, UV radiation, human health, carcinom of skin, health education*

## Ozone

Air we breathe contains approximately 21% diatomic oxygen $O_2$. Ozone $O_3$ is a triatomic molecule in which three atoms of oxygen are bonded by covalent bond (Figure 1). Ozone is a strong oxidant and reacts with many gases and materials (atoms, molecules, aerosols) in the atmosphere. In the lower part of atmosphere, ozone is a pollutant produced by photochemical reactions (sunlight, $NO_x$, hydrocarbons and $O_2$). In the stratosphere ozone provides an essential shield against damaging ultraviolet radiation (Figure 2) [1].

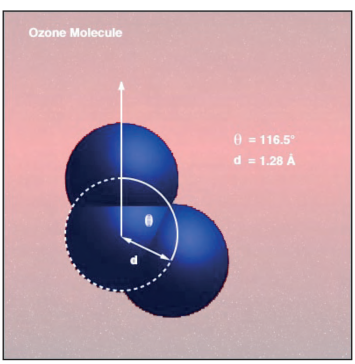


Figure 1. Ozone molecule

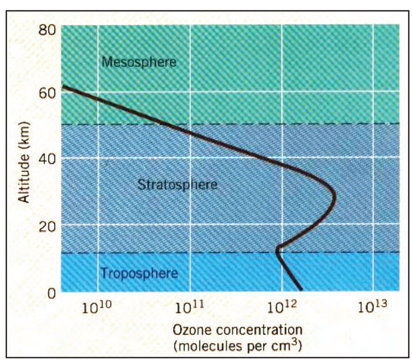


Fig2. Structure of atmosphere and ozone concentration [1]

Ultraviolet radiation consists of wavelength between 0.1 nm and 0.4 nm and is usually divided into UVA (ultraviolet A), UVB (ultraviolet B) and UVC (ultraviolet C). The shortest of them, UVC is the most energetic of the ultraviolet radiation (Figure 3). It breaks down $O_2$ into two oxygen atoms and each of them combines with $O_2$ molecule to create ozone $O_3$ (according to symbolic equation (1)).

$$\begin{aligned} O_2 + UVC &\longrightarrow O + O \\ O + O_2 &\longrightarrow O_3 \end{aligned} \tag{1}$$

As a result of this reaction the UVC is strongly absorbed in the stratosphere and none reaches the surface of Earth [2]. UVA radiation has longest wavelength and it is not affected by stratospheric ozone. This radiation can cause some not very serious damage to living cells. Most of the attention is concerned with UVB radiation which is normally absorbed by stratospheric ozone. But as a result of ozone depletion especially UVB radiation can be extremally dangerous.

In summary, approximately 99% of all UV radiation (all UVC and most UVB) is absorbed or screened in the ozone layer.

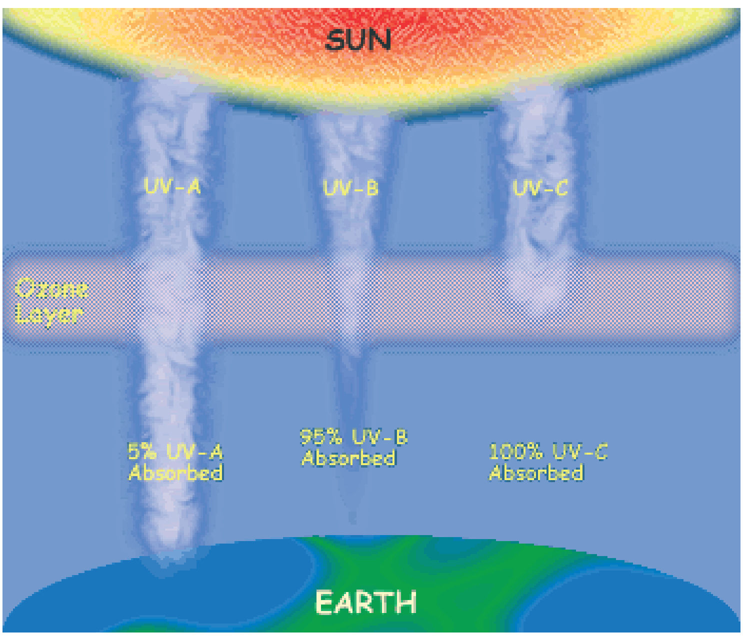


Figure 3. Interaction of ultraviolet radiation with Earth´s atmosphere [3].

## Measurement of Stratospheric Ozone

The concentration of atmospheric ozone was first measured in the 1020s, using an instrument known as Dobson ultraviolet spectrometer. The *Dobson unit* (DU) is still commonly used to measure the concentration of ozone. One DU is equivalent to a concentration of 1 ppb $O_3$ [1,3]. Ozone concentration has been measured by means of many ways as follows from the Figure 4.

Ground – based measurements first identified ozone depletion in the Antarctic. Members of the British Antarctic Survey began measurements of ozone in 1957 and in 1985 published the first data that suggested significant ozone depletion over Antarctica (Figure 5).This depletion in ozone was dubbed the ozone hole (Figure 6). However, there is not an actual hole in the ozone shield where all the ozone is depleted, but rather a relative depletion in the concentration of ozone that occurs namely during the Antarctic spring.

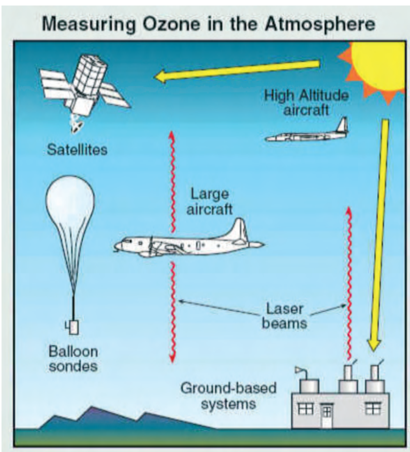


Figure 4. Measuring Ozone in the atmosphere [4]

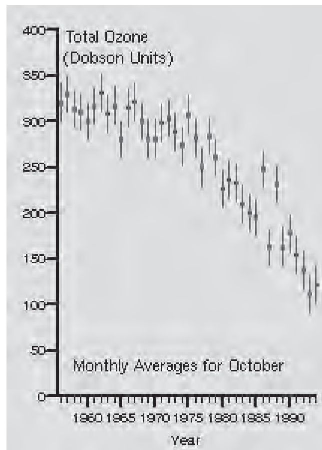


Figure 5. First measurements of ozone depletion [1]

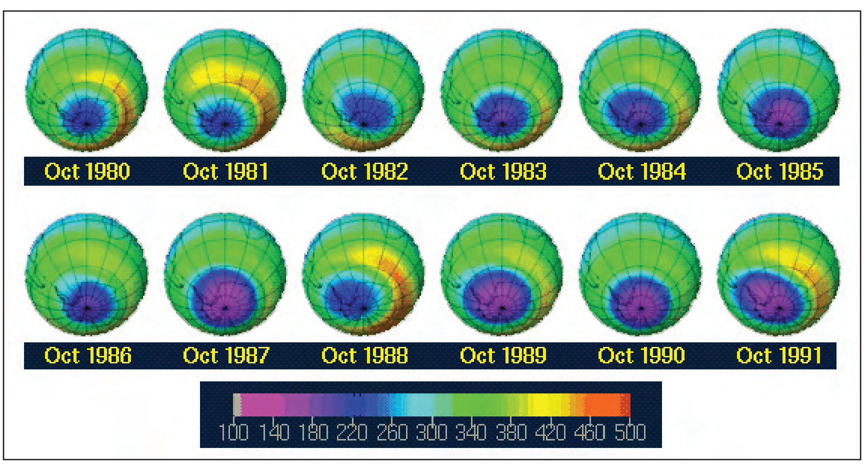


Figure 6. Developing of ozone hole [4]

## Hypothesis of Ozone Depletion.

The hypothesis that ozone in the stratosphere is being broken down by chlorine atoms from chlorofluorocarbons (CFC) molecules and bromine atoms from halons was first suggested in 1974 by M. Molina and F.S. Rowland [4]. CFCs and halons are produced by humans used in many applications such as refrigerators, anaesthetics, aerosols, fire-fighting equipments and manufacture of materials such as styrofoam. These gases are in lower atmosphere unreactive and therefore have very long residence time (about 100 years). Molecules of CFCs and halons wander upward and enter the stratosphere. Once they have reached altitudes above most of the stratospheric ozone, they may be destroyed by the highly energetic solar UV radiation. This process release chlorine, a highly reactive atom. The reactive chlorine released may then enter into reactions that deplete ozone according to the two following reactions:

$$\begin{aligned} Cl + O_3 &\longrightarrow ClO + O_2 \\ ClO + O &\longrightarrow Cl + O_2 \end{aligned} \qquad (2)$$

These two equations define a chemical cycle that can deplete ozone. That is, the chlorine combines with ozone to produce chlorine monoxide, which in the second reaction combines with monoatomic oxygen to produce chlorine again. Following this, the chlorine can enter another reaction with ozone and cause additional ozone depletion. This series of reactions is what is known as a *catalytic chain reaction,* because the chlorine is not removed but reappears as a product from the second reaction, so the process may be repeated over and over again. It has been estimated that each chlorine atom may destroy approximately 100 000 molecules of ozone over a period of 1 or 2 year before the chlorine is finally removed from the stratosphere through other chemical reaction and rain out [5].

The catalytic chlorine chain reaction can be interrupted through storage of chlorine in other compounds in the stratosphere. The most promissible reaction is following: ultraviolet light breaks down CFCs to release chlorine. Chlorine may combine with methane $CH_4$ to form hydrochlorid acid HCl which may diffuse downward and in troposphere can be rain-out removed from the chain reaction [2, 6].

The ozone depletion reactions are responsible for the decline in concentrations of ozone in regions of both northern and southern poles.

## The Antarctic Ozone Hole.

Antarctic ozone hole was first reported in the year 1985 and from that time it has occurred in polar regions every autumn (october in northern altitudes). The amount of ozone depletion has varied from about 15% to 80% (Figure 6) and it was focused that the lowest concentration of ozone has been in the both polar regions and the highest one near the equator.

The question why ozone hole occurs predominantly in polar regions can be explained by means of existence of *Polar Stratospheric Clouds*. These clouds have been observed for at least the past 100 years at altitudes of approximately 20 km above polar regions. The clouds are usually 10 to 100 km in length and several kilometers thick [1,6].

Polar stratospheric clouds form during the polar winter when polar air mass at Antarctica is isolated from the rest of atmosphere and circulates about the pole (so called *polar vortex*). The rotating air mass lose heat through radiation and does not get more heat because of the lack of sunlight. The rotating air mass reaches a temperature between -80 $^0$C to -110 $^0$C. At these very low temperatures small sulfuric acid particles (0,1 μm) are frozen and serve as seed particles for nitride acid ($HNO_3$) and complex chemical reactions (Figure 7) are responsible for considerable ozone depletion. A polar vortex also forms over the North Pole area, but it is generally weaker than over the Antarctica and does not last as long as there. Nevertheless as the vortex breaks up, it sends ozone-deficient air masses southwards, where they may drift over populated areas of Europe and North America (the ozone losses there may be on the order of 30% to 40%, which was observed in 1995).

## The Future of ozone Depletion

The main aspect of ozone depletion is that if the resources of all ozone-depleting chemical were to stop today, the problem would not go away. It is because of long atmospheric lifetimes of CFCs (75–140 years).

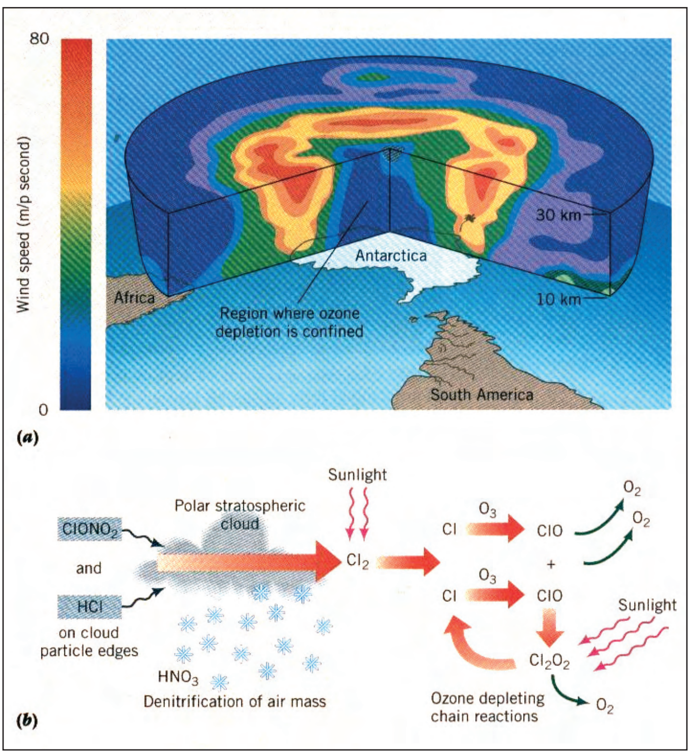


Figure 7. Polar vortex (a) and chemical reactions, responsible for ozone depletion and ozone hole (b) [1].

## Environmental and Health Effects of Ozone Depletion

Ozone depletion has several serious potential environmental effects, including to Earth´s food chains on land and in the oceans and human health effects including increases in all types of skin cancers and cataracts together with suppression of immune systems [7]. Ozone depletion might lead to a reduction of primary productivity in the world´s oceans. 80% decreasing of ozone concentration can lead to increase of UVB radiation and loss of productivity of the phytoplankton. It would have a negative impact at a variety of other marine organisms, because they are at the base of the food chain. Also, because plankton are a sink of atmospheric carbon dioxide, their disruption might increase the concentration of $CO_2$ in the atmosphere, thereby increasing global warming.

If ozone depletion becomes more widespread and affects major food crops (such as beans, wheat, rice and corn), serious social disruption could occur. A loss of 10% to 15% production could be a social and political catastrophe. The range of human health effects of ozone depletion is vigorously researched and debated. There is general agreement that the effects will be negative and will result in an increase in a variety of diseases, perhaps at an epidemic level [1]. One of the most serious hazards anticipated is an increase in skin cancers of all types, including the often fatal melanoma. It is believed that a 1% decrease in ozone causes an increase of UVB radiation of about 1% to 2%, and for each 1% increase in UVB radiation it is projected that skin cancers will increase 2%. Since 1970 ozone depletion in midlatitudes that affect for example Australia, New Zealand, South America and United States has been about 10%. This could cause an increase in skin cancer rates of 20% to 40%. However, the observed increase has been 90%. Thus there are another factors affecting the incidence of skin cancers: there is little doubt that melanoma and other skin cancers are related to exposure to UVB radiation. Especially hazardous are sunburns that produce blistering and severe sunburns in childhood are thought to increase risk of melanoma in later life [1]. In fact, skin cancers often take decades to develop.

Ultraviolet radiation may damage eyes, causing cataracts. An increase in exposure to UV radiation may also damage or reduce efficiency of the human immune system [7].

If we assume that ozone depletion is responsible for all diseases mentioned above, we can recommend following principles of protection against consequences of ozone depletion:

- wearing more clothing and hats as well as using sunblock ointment
- sunbathing only in the morning and late afternoon
- following of ozone layer forecast
- choosing glasses that block ultraviolet radiation.

## OZONOVÁ DÍRA, LIDSKÉ ZDRAVÍ A ŠKOLA

**Abstrakt**: Pokles koncentrace ozonu v ozonosféře se v posledních desetiletích stává globálním problémem. V první části našem článku jsou stručně popsány chemické a fyzikální vlastnosti ozonu a role polárních stratosférických mraků při objasňování mechanismu vzniku ozonové díry. Druhá část článku je věnována vlivu ultrafialového záření na kvalitu životního prostředí a na lidské zdraví a jsou zde uvedeny některé zásady, jak tyto vlivy omezit.

**Klíčová slova**: ekologie, ozonová díra, UV záření, lidské zdraví, rakovina kůže, zdravotní výchova