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PROCEEDINGS

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ENVIRONMENTAL POLLUTION - THE LEADING CHALLENGE OF THE 21ST CENTURY

Abstract

Environmental pollution is one of the leading challenges of the 21st century. Air, water and soil, as components of the environment, are intensively polluted, which tends to bring humanity to a point where recovery will no longer be possible. In this study, environmental pollution is considered, with reference to the possibilities and necessity of recultivation and protection.

Key words: air, water, soil, environmental pollution, protection.

INTRODUCTION

Air, water and soil, as components of the environment, until the second half of the 20th and the beginning of the 21st century acted as boundless recipients, with a large capacity for receiving waste materials, which man creates. However, today tons of different pollutants are released into the atmosphere, huge amounts of waste materials are released into the water ecosystems, and the soil is threatened by physical degradation, the construction of roads and other facilities, as well as intensive agricultural production, which includes the excessive use of mineral fertilizers and pesticides. Intense environmental pollution tends to push humanity to a point where recovery will no longer be possible (Đuković and Bojanić, 2000; Stevanović et al., 2019; Đorđević et al., 2020; Popović et al., 2020; Šarčević-Todosijević et al., 2019a, 2022), as evidenced by the pandemic and climate changes, which have affected humanity in the last few years. In this study, the pollution of environmental components, air, water and soil, is considered, with reference to the possibilities and necessity of recultivation and protection of degraded ecosystems.

AIR, WATER AND SOIL POLLUTION AND POSSIBILITIES OF PROTECTION

Environmental pollution is one of the leading challenges of humanity, especially in the second half of the 20th and the beginning of the 21st century. The environment consists of three basic components, air, water and soil, and they are equally exposed to pollution.

The atmosphere surrounds the Earth up to a height of about 980 km and, in addition to oxygen and nitrogen, as the main components, it contains water vapor, carbon dioxide, carbon monoxide, ozone, nitrogen oxides, various organic compounds, aerosols and particles (Đuković and Bojanić, 2000).

Constituent	Chemical symbol	Mole percent
Nitrogen	N_2	78.084
Oxygen	O_2	20.947
Argon	Ar	0.934
Carbon dioxide	CO_2	0.0350
Neon	Ne	0.001818
Helium	He	0.000524
Methane	CH_4	0.00017
Krypton	Kr	0.000114
Hydrogen	H_2	0.000053
Nitrous oxide	N_2O	0.000031
Xenon	Xe	0.0000087
Ozone*	O_3	trace to 0.0008
Carbon monoxide	CO	trace to 0.000025
Sulfur dioxide	SO_2	trace to 0.00001
Nitrogen dioxide	NO_2	trace to 0.000002
Ammonia	NH_3	trace to 0.0000003

Figure 1. Chemical composition of the atmosphere
(source: https://www.quora.com/what-is-pure-air/)

Ozone in the upper layers of the atmosphere forms a natural protection of the planet's surface from dangerous ultraviolet radiation and thus enables the survival of living beings on Earth. In natural conditions, the mentioned components of the air are in balance, which is determined by climatic factors. However, millions of tons of various pollutants, gases, vapors and particles are emitted into the atmosphere from anthropogenic sources (industrial and energy plants, metallurgy, households). These pollutants often have toxic, mutagenic and carcinogenic effects on living beings (Đuković and Bojanić, 2000; Zejak et al., 2023). The negative consequences of atmospheric pollution that humanity is facing today are primarily due to energy production and increased use of fossil fuels, along with the enormous emission of carbon dioxide, which, together with other gases, caused an increase in the temperature of the atmosphere and climate change. Generally speaking, climate change is caused by the exchange of energy and chemical matter between the atmosphere, oceans, and land

surfaces. Although the pathways of carbon through its global cycle are elucidated, knowledge of the actual extent of change in carbon fluxes in the atmosphere is less available. These processes include oceanic and atmospheric carbon circulation, turbulent mixing, and photochemical processes. The annual anthropogenic input of carbon into the atmosphere between 1980 and 1989 from fossil fuel combustion was estimated at 5.5 ± 0.5 GtC (thousand million metric tons of carbon) and 1.6 ± 0.6 GtC from agriculture and land-use change, yielding a total of 7.1 ± 1.1 GtC. Greenhouse gases, mainly carbon dioxide, but also others such as methane, nitrogen oxides and halocarbons, enter the atmosphere mainly as coal combustion products, natural gas and oil for the production of electricity and heat and powering the world's transport systems, and to a lesser extent through other industrial and agricultural activities. When petroleum fuels are burned, carbon dioxide is emitted as the primary gas, although small amounts of methane and nitrogen oxides are also released. Rates of greenhouse gas emissions into the atmosphere are proportional to the global rate of energy consumption resulting from human activity. Thus, as the human population and per capita energy consumption have increased, the concentrations of these gases have also increased. Higher concentrations of gases with the greenhouse effect, especially carbon dioxide, cause the retention of solar heat energy and the rise of the global temperature on the planet (Keeling, 1997; Popović et al., 2020). Present in the atmosphere and in small quantities, carbon dioxide has the property of absorbing the Earth's heat radiation and preventing its cooling, while allowing short-wave solar rays to pass through and enable its heating. Preventing the warming of the planet by 4^0C, which would cause the melting of the sea ice on the Earth, can be avoided by building solar power plants in the space around the Earth or by scattering fine dust in the upper layers of the atmosphere, which would affect the reflection of the sun's rays and the cooling of the Earth (Dukić, 1998). In addition to climate change, which occurs as a result of atmospheric pollution with greenhouse gases, the use of freon, halon and similar pollutants has led to damage to the ozone layer (Đuković and Bojanić, 2000) and the increase in the incidence of cancerous diseases, especially melanoma.

UV radiation is classified as a "complete carcinogen" because it is both mutagenic and has properties of a tumor initiator and a tumor promoter. Although UV radiation exerts complex and mixed effects on the human organism, through the mediation of the natural synthesis of vitamin D, it is still of all environmental factors, the most significant carcinogen, associated with the occurrence and frequency of skin cancer. Excessive exposure to UV radiation has been scientifically proven to carry profound health risks, including atrophy, pigmentary changes, wrinkling, and malignancy. UV radiation is epidemiologically and molecularly linked to the three most common types of skin cancer, basal cell carcinoma, squamous cell carcinoma, and malignant melanoma, which together affect more than a million people annually in the United States alone. Genetic factors also affect the risk of skin diseases caused by UV radiation. Melanocortin 1 receptor (MC1R) gene polymorphisms specifically correlate with UV sensitivity and increased risk of cancer (Zimonjić et al., 1990; Orazio et al., 2013).

In addition to chemical pollution, it is also necessary to mention biological air pollution. Biological monitoring of the air becomes particularly important considering

the transmission of the SARS-CoV-2 virus through the air during the COVID-19 pandemic.

Microorganisms in the air are carried by air currents and spread over a wide area. Sometimes they cause infectious diseases and epidemics. Dust, droplets in the air, condensation nuclei contribute to the survival and spread of microorganisms in the air, while they are inactivated under the influence of UV radiation, drying, temperature and air humidity. In the formation of air microbiocenosis and its resistance to disinfectant agents, the influence of geographical and climatic zones is significant. Air transmission of microbial aerosol particles can be carried out at distances of hundreds and thousands of kilometers (fungal spores). Numerous scientific studies have confirmed the presence of the following genera of fungi in the air: *Aspergillus*, *Penicillium*, *Rhodotorula*, *Cladosporium*, *Saccharomyces* and numerous others (Đukić et al., 2008).

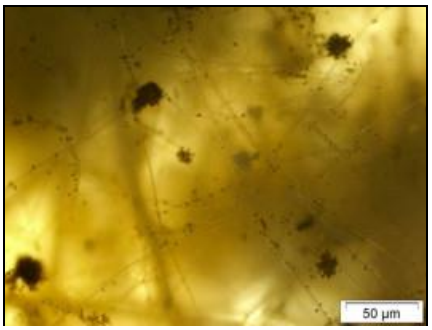

Figure 2. Aspergillus niger spores from indoor air (Pigeot-Remy et al., 2013)

The results of the conducted bacteriological air tests indicate the presence of the following bacterial taxons in the air: *Escherichia coli*, *Klebsiella pneumoniae*, *Citrobacter*, *Enterobacter* spp. and numerous others (Đukić et al., 2008). The survival of *Escherichia coli* in the aerosol was studied in a range of different temperatures and relative humidity. Death occurred in two phases, the first lasted about one minute, in the second phase, the number of of viable microorganisms declined exponentially. The lowest survival was observed at low humidity (less than 50% relative humidity) at 15 and 30^0C, while in humid conditions the survival period was much longer (Wathes et al., 1986). The list of airborne viral diseases includes the following diseases: measles, smallpox, influenza, adenovirus infections, enterovirus infections, varicella, as well as many others (Đukić et al., 2008). Severe acute respiratory syndrome caused by coronavirus 2 (SARS-CoV-2), is a new disease of the respiratory tract, corona virus disease 2019 (COVID-19). A virus from the Coronaviridae family, highly contagious and virulent, took over the world in a short time, leading to the 2019/2020 pandemic. All clinically described cases confirm the possibility of rapid infection within the family, directly and indirectly, as well as transmission of the virus through the air (Todorović et al., 2020). Studies of influenza virus, rhinovirus, respiratory syncytial virus, varicella-zoster virus and aerosols from the breath and cough of infected patients (<4.7 mM) have indicated the presence of viral RNA in hospital room air samples. Very few data are available on SARS-CoV-1 air sampling during the 2002–2003 pandemic.

For COVID-19, respiratory droplets filled with SARS-CoV-2 virus (<5 μm) have been shown to travel up to 6 feet in the air. Also, studies of hospital air samples in China and North America have detected SARS-CoV-2 RNA in aerosols (Parvez and Parveen, 2022).

From the aspect of air pollution, we should also mention the possibility of applying weather warfare, which can reach unsuspected dangerous proportions. It is based on sprinkling the atmosphere over the opponent's territory with special chemical agents, which can cause climate changes, extreme reduction or high rise in air temperature, along with the destruction of vegetation and crops. The greatest danger of the weather warfare is the possible destruction of the ozone layer in the atmosphere above the enemy's territory. The UV radiation of the Sun, which in this way would reach the troposphere, the layer of the atmosphere in which life processes take place, would in a short time fry the living world on the topographic surface, as well as in the surface layer of soil and water ecosystems. In South Vietnam, the USA conducted biological (destruction of forests and crops), as well as weather warfare. They sprinkled the clouds with silver iodide and lead iodide, after which heavy downpours and bad weather occurred. In the event of an atomic war, man would cause changes in weather and then climate changes in larger territories. The same effects would be achieved with even more dangerous methods of weather warfare on a regional and global scale (Dukić, 1998).

In addition to air, water is also a component of the environment that is intensively polluted. Pollutants enter the water through natural and anthropogenic sources. The most prevalent pollutants in municipal wastewater are organic components, nutrients and metals. Pathogenic microorganisms can also enter aquatic ecosystems from natural sources, such as soil and air, or more often from industrial processes and households (Đuković et al., 2000; Đukić et al., 2007; Šarčević-Todosijević et al., 2019b; 2021; 2022). During fecal pollution, *Escherichia coli* and faecal coliforms reach the soil and water. They are used as indicators of fecal pollution and the presence of pathogens, and testing for their presence is recommended for assessing water quality. Safe and healthy drinking water, chemically and microbiologically correct, is one of the main challenges of the 21st century, considering that a large number of people on the planet do not have access to such water. A significant percentage of the world's population still dies from water-borne bacterial infections. According to WHO estimates, mortality from diseases caused by unsafe drinking water exceeds 5 million people per year. Diarrhea and other acute diseases of the gastrointestinal tract, caused by microbiologically unsound drinking water, containing coliforms and potentially deadly pathogens, remain a major public health problem in rural and developing countries (Cabral, 2010; Šarčević-Todosijević et al., 2021).

Petroleum and its products, fertilizers, pesticides and heavy metals are some of the most significant polluters of soil, groundwater, and food chains. Self-cleaning of soil and water from petroleum is a long-term natural process, in which microorganisms play a major role, especially in conditions of almost complete repression of the functional activity of flora and fauna (Đukić et al., 2007). The results of the research by Zhang et al. (2005) indicated that the bacterial species *Pseudomonas aeruginosa* could degrade most of crude oil hydrocarbons, with the addition of rhamnolipids as an effective

biosurfactant, which enable more successful metabolic utilization of of crude oil hydrocarbons. Numerous studies have shown that pure cultures of microorganisms are capable of breaking down pesticides, which are intensively used in agricultural production, which leads to their accumulation in the soil. Recultivation of soil contaminated with heavy metals is still not so successful, but methods are being sought that will affect the reduction of the concentration of mobile forms of heavy metal compounds in the soil and reduce their solubility, and thus toxicity (Đukić et al., 2007; Kolarić et al., 2021; Šarčević-Todosijević and Malivuk, 2019).

CONCLUSION

Atmospheric pollution is caused primarily by the production of energy and the use of fossil fuels, with the enormous emission of carbon dioxide, which, together with other gases, has caused an increase in the global temperature on the planet and climate change. In addition to chemical, monitoring of biological pollution of the atmosphere is especially important considering the transmission of the SARS-CoV-2 virus through the air during the COVID-19 pandemic. Petroleum and other polluting organic substances, mineral fertilizers, pesticides and heavy metals are some of the most important polluters of soil, surface and groundwater, as well as food chains. Therefore, it is necessary to intensify preventive and all available measures in the protection of the environment, given that its pollution tends to lead humanity to a degree of degradation, after which recovery will no longer be possible.

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ZAGAĐENJE ŽIVOTNE SREDINE – VODEĆI IZAZOV 21. VEKA

Apstrakt

Zagađenje životne sredine je jedan od vodećih izazova 21. veka. Vazduh, voda i zemljište, kao komponente životne sredine, intenzivno se zagađuju, što ima tendenciju da dovede čovečanstvo do tačke u kojoj oporavak više neće biti moguć. U ovom radu, razmatra se zagađenje životne sredine, s osvrtom na mogućnosti i neophodnost rekultivacije i zaštite.

Ključne reči: vazduh, voda, zemljište, zagađenje životne sredine, zaštita.

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