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THE ROLE OF SYSTEMIC BIO-DIAGNOSTICS IN STABILIZING AND IMPROVING THE ECOLOGICAL STATE IN AZERBAIJAN WITHIN THE FRAMEWORK OF SUSTAINABLE DEVELOPMENT

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Abstract

The article examines the main environmental factors that determine environmental risks in Azerbaijan. Such negative environmental impacts include pollution, salinization, soil erosion mainly in the arid zone of the country, oil pollution of the soil in oil production areas, pollution of aquatic ecosystems (Kura, Araz, Samur, etc.), pollution of irrigation canal waters and their consequences, air pollution, high population density exceeding the biocapacity of the country's territory, reduction in forest area, high urbanization, impact of natural factors. Based on the preliminary analysis and assessment of environmental risks in the country, and the results of bioindication and biomonitoring of various habitats in Azerbaijan, priority tasks have been proposed for the upcoming years.

Keywords: environmental risks, sustainable development, biomonitoring, bioindication.

1. Introduction

Environmental risk is the measure of potential harm to the environment, either from human activity or natural events, that can lead to negative impacts on human health and the environment. Sustainable development aims to balance the socio-economic status of developed and developing countries, minimize disparities in quality of life, minimize harm to ecosystems, and efficiently use natural resources. The concept of acceptable and tolerable risk has been established, forming the foundation of security legislation in highly developed countries. Identifying danger and calculating risk is one of the many tasks involved in assessing the current state and forecasting the future development of a situation. Danger characterizes the typical environment for the formation of risks related to the existence and development of various natural, technical, and socio-economic systems.

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The diverse landscapes in Azerbaijan have been utilized over many decades without considering their resistance to human and technological impact. Natural resources are increasingly used, particularly crude oil and natural gas.

This study aims to systematically analyze the country's ecology to support the development of programs for sustainable socio-ecological-economic development in the face of global changes.

2. Materials and Methods

The research object is Azerbaijan's territory as a single biosystem. The research methodology employed in this study is a comprehensive analysis of literary and archival data, utilizing a stage-by-stage retrospective approach [1, 2].

3. Results and discussion

The main environmental factors that determine environmental risks in Azerbaijan are presented below (Fig.1):

- *Pollution, salinization, and erosion of soil cover mainly in the arid zone of the country*

In Azerbaijan, 3.7 million hectares of soil cover (43.3% of the total area of the country) are affected by erosion, 1.2 million hectares (13.9% of the total area) are affected by salinization, and 0.03 million hectares (0.3% of the total area of the country) are affected by chemical pollution. The area of saline lands in the country is almost 1.5 million hectares, which is more than 50% of all agricultural land.

- *Oil pollution of the soil cover in oil production zones*

Several oil and gas fields operate directly within the city of Baku - in fact, the city is surrounded by oil fields, which have a strong technogenic impact on all elements of urban landscapes - green spaces, atmosphere, and soil cover. The area of oil-contaminated land in the region exceeds 12.000 hectares, and radionuclide pollution on the territory of the Absheron Peninsula is 6-50 times higher than in the oil-producing states of the USA [3].

- *Pollution of aquatic ecosystems: the Kura, Araz, Samur and other rivers*

The Kura, Araz, Samur, and other rivers are being polluted by runoff from areas where more than 40% of the population of Azerbaijan, Georgia, Armenia, and Turkey live, and where three-quarters of the industrial potential of these countries is concentrated. The Kura River receives wastewater from settlements with a total population of more than 8 million people, and up to 700 million cubic meters of polluted water is discharged into the Kura River from neighboring countries annually, leading to increased environmental tension.

- *Pollution of irrigation canal waters and their consequences.*

The total length of water canals in the country reaches 51.755 km, which provides irrigation water to lowland areas in the Garabagh, Mil, Mugan, Salyan, Shirvan, and Samur-Divichi lowlands. At the same time, the waters of the Kura, Samur, and other rivers are heavily polluted with organic substances - oil, oil products, pesticides, surfactants, as well as heavy metals.

- *Air pollution (Apsheron industrial region)*

The Apsheron industrial region is showing signs of a critical ecological crisis. The combined air pollution index (API) in the region, which includes dust, sulfur dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, and hydrogen sulfide, is over 14.0. As a result, the Apsheron region is classified as one of the 10 most ecologically dangerous territories in the world. Additionally, the country ranks among the first in the world in terms of cardiovascular diseases.

- *High population density, exceeding the biocapacity of the country's territory*

Azerbaijan's territory has the most unfavorable indicators of biocapacity reserve. There is a contradiction between the rapid growth of natural resource consumption (bio- and energy consumption) and the reproductive potential of its territory's useful biocapacity, including soil cover, water, and plant ecosystems.

- *Reduction of forest area*

It is increasingly important to assess the ecological state of forest areas in Azerbaijan due to the growing economic activity in the region. The construction of industrial and residential facilities, as well as the expansion of livestock farming, pose risks such as overgrazing and subsequent environmental issues such as erosion and reduced fertility. Approximately 150 years ago, forests covered about 26% of the country, but currently, they only cover about 10.8%. With the ideal ratio of forests and pastures being 1 hectare per person, there are only 0.44 hectares available, which is 2.3 hectares below the norm. The fragmentation of

forest areas in Azerbaijan has created barriers to interpopulation exchange, which previously occurred along the ecological corridors of river valleys.

- *High degree of urbanization and its consequences*

In major cities like Baku and Sumgait, the primary source of air pollution is shifting from industry to motor vehicles as the number of cars continues to increase. This rapid increase in motorization is causing a shift in the balance of emissions into the atmosphere from stationary sources to motor transport in all major cities. As a result, the region's ability to counteract atmospheric pollution is limited [4]. The soil in the Absheron industrial region is contaminated with man-made pollutants, particularly heavy metals, posing a significant risk to human health as their levels exceed permissible limits by 3-60 times [5]. Additionally, the city of Ganja has been home to a landfill of aluminum production waste for many decades, which amounts to 15 million tons of red mud from alunite and bauxite. These toxic materials are carried by winds and rain to nearby habitats, posing a threat to plant communities and the environment as a whole.

- *Impact of natural factors*

The average annual temperature in Azerbaijan has increased by 0.60-1.90C in recent decades, which may have far-reaching environmental consequences: the development of desertification and salinization of landscapes in the Kura-Araz lowland, a decrease in the volume of water resources due to internal resources, deforestation in foothill areas, etc. In general, it can be noted that natural factors potentially contribute to an increase in the temperature of the upper soil horizons, which may lead to a risk of changing the structure of phytocenoses, zoomass, mesofauna, micro-biocenosis with all the subsequent risks of reducing the ecological functions of the soil cover. The deficit of water resources and population growth will directly affect the country's food security.

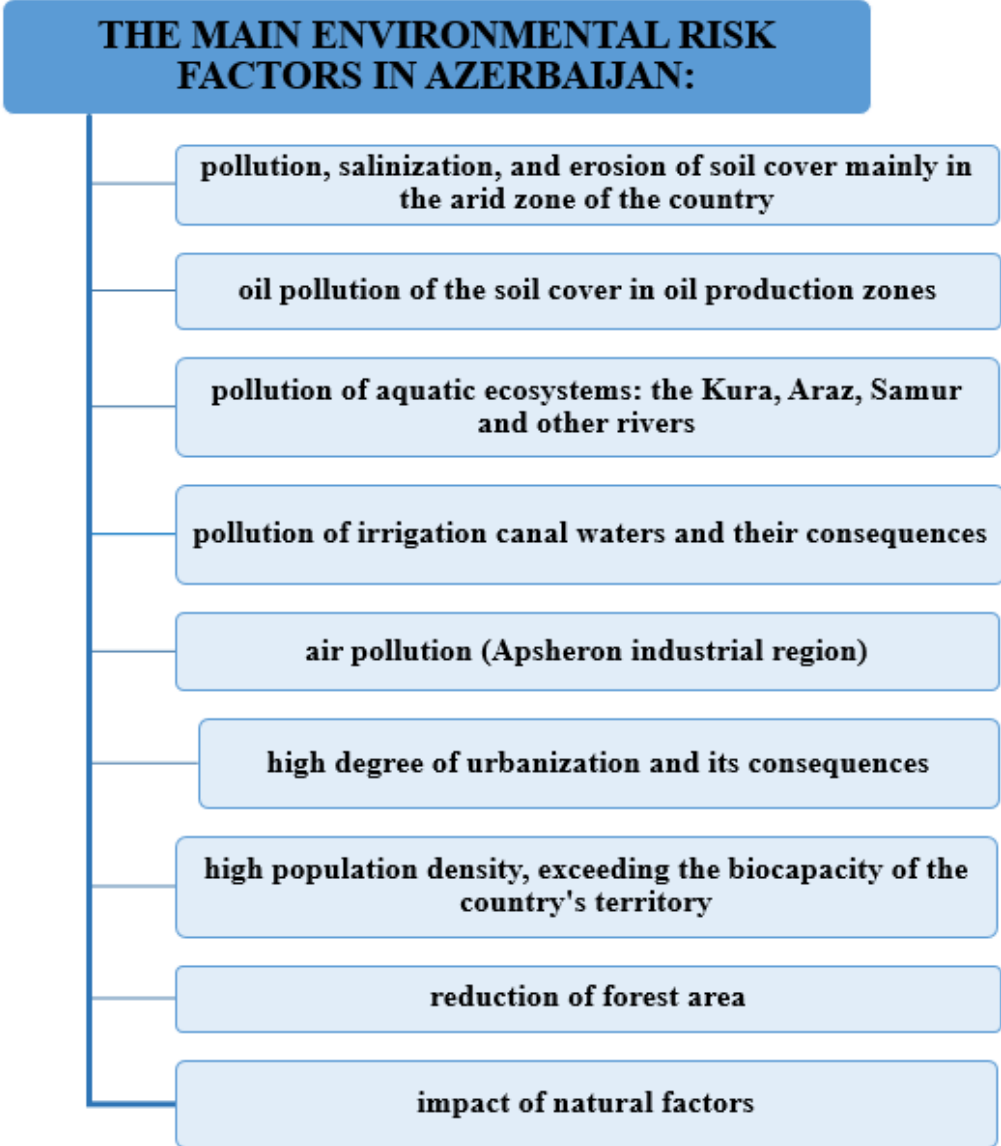


Fig.1.The main environmental factors that determine environmental risks in Azerbaijan

The territory of Azerbaijan as a whole is characterized by a wide variety of technogenic and anthropogenic processes that negatively affect the surrounding natural environment [6].

The number of environmentally harmful processes in the country's economy is continually increasing. As a result, at the beginning of the 21st century, approximately 15% of Azerbaijan's territory, where over 10 million people reside, was in an unfavorable ecological state. The country's territory was marked by 9 areas with critical and 10 with a crisis ecological situation. The list of large settlements where permissible levels of emissions into the atmosphere are consistently exceeded includes more than 50 locations [7].

The country's large, medium, and small rivers are all polluted. These rivers are used to irrigate over 0.83 million hectares of agricultural fields. Human activities have significantly altered ecosystems, leading to a reduction in biodiversity. This is evident in the increasing number of species listed in the Red Book of the country. In 2007, Azerbaijan had the worst ecological footprint in the South Caucasus region. According to the 2023 Environmental Performance Index, Azerbaijan ranked 104th out of 180 countries, with a score of 38.6, indicating its low environmental friendliness.

The basis for ensuring the environmental safety of the country and its regions is a constant systemic analysis of its environmental status to reduce environmental risks and their consequences.

In current scientific literature, there is a significant emphasis on addressing the challenges of bio-diagnostics for natural landscapes impacted by human activities and technological factors, all within the context of "sustainable development". This focus involves the utilization of advanced methods of bioindication and biomonitoring to assess and mitigate the impact of these factors. Furthermore, international symposia are being organized to facilitate discussions and knowledge sharing on this critical subject matter [8, 9, 10, 11].

Recently, several studies have been conducted in Azerbaijan on using plants and soil mesofauna to indicate the health of different ecosystems [12, 13]. Oil pollution can affect the biological activity of soils, change the structure and activity of soil microbiocenosis, the rigidity of its structure, and the rate of biochemical reactions [14]. The phytotoxicity of irrigation waters of the Upper Shirvan Canal, the source of which is the waters of the Kura River, and the low biogenicity of urban soils under the influence of anthropogenic and technogenic factors have been shown [15, 16].

At the same time, conducting single, isolated studies does not provide the opportunity for a reliable assessment of the causes of changes in the biological and ecological functions of the unified biosystem – natural landscapes and their components under the impact of a complex of factors of influence and environmental risks. In this regard, further development of a system of simultaneous systemic complex eco-biomonitoring based on eco-bioindication programs for all components of natural landscapes is of great importance.

The primary goal of bio-diagnostics is to systematically monitor and analyze biological systems, pinpoint any vulnerabilities, evaluate environmental risks arising from human-made, anthropogenic, and natural factors, and establish standardized maximum allowable concentrations (MAC) for pollutants in natural landscapes and their components. Through the systematic analysis and assessment of environmental risks in the country's natural landscapes, a comprehensive database will be created. This database will serve as a foundation for analyzing and implementing strategies to mitigate environmental risks and develop technologies to restore the natural balance. The outcomes of this effort will resemble an Environmental Impact Assessment (EIA), but on a national scale, requiring a sophisticated system of knowledge and assessments. Ultimately, this initiative will lay the groundwork for developing sustainable nature management principles, aligning with the concept of "sustainable development."

4. Conclusions

Azerbaijan's unique diversity of natural landscapes should be carefully developed through the assessment and systemic analysis of the spatio-temporal features of their bio-eco-resistance to technogenesis, and the principles of sustainable development should become the basis of the practice of domestic nature management. The development strategy should be focused on the formation of a single eco-framework, eco-territories (ecological and economic regions), tourism and recreation, "green" agriculture, and the development and implementation of eco-technologies.

Preliminary analysis and assessment of environmental risks in the country, based on the results of bioindication and biomonitoring of various habitats in Azerbaijan, already at this stage, allows us to propose priority tasks for the coming years:

- Restoration of tugay forests, thereby uniting fragmented landscapes and forming a single ecological framework for the country;
- By improving technologies, ensure a reduction in the air pollution index (API) in the territory of the Absheron Peninsula;
- Form a "green infrastructure" around mud volcanoes, the total area of which is over 16,000 km² [17];
- Develop and implement biotechnologies for cleaning the country's water systems - river systems, irrigation canal waters, and polluted lakes [6];
- Widespread use of modern EM technologies to form a soil cover with high ecological and biological properties;
- In industry, a gradual transition to low and non-waste technologies (closed farms);
- Increase the bio-capacity of the country's territory by increasing the area of forests and protected areas;
- In large cities - Baku, Sumgait, Ganja, and others – expand the area of green spaces to 20% (European standard), which will increase the assimilation potential of these territories in relation to technogenic emissions;
- Reduce the energy intensity of production, which will significantly decrease emissions of CO₂ and other greenhouse gases.

Full implementation of the above projects and activities will significantly reduce the negative environmental consequences of technogenic and anthropogenic impacts on the environment, will be preventive measures to mitigate the effects of global warming, and will create conditions for "sustainable development" in the country. The holding of one of such important events, COP 29, in our country will encourage the state and society in Azerbaijan to go deeper into the goals and tasks of the concept of "sustainable development" and open a new stage in environmental protection.

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