

Article

Technogenic Pollution and Its Consequences

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Abstract: Human activities pose a serious threat to global environmental stability. This article examines the major sources of anthropogenic pollution, including industrial processes, transport, energy production and agricultural practices. The harmful effects on air, water, soil and biodiversity are also being studied. Finally, the study examines innovative technological solutions and policy frameworks aimed at reducing pollution and ensuring ecological balance. The harmful effects on air, water, soil, and biodiversity are also being studied. Finally, the study examines innovative technological solutions and policy frameworks aimed at reducing pollution and ensuring ecological balance. In addition to analyzing pollution sources and their consequences, this research evaluates the role of international cooperation in addressing environmental challenges. Collaborative efforts between governments, non-governmental organizations, and private industries play a crucial role in implementing large-scale pollution control strategies.

Keywords: anthropogenic pollution, environmental sustainability, industrial waste, renewable energy, environmental solutions

1. Introduction

Human activities have fundamentally altered the Earth's ecosystems and led to widespread environmental degradation. Anthropogenic pollution, defined as pollution caused by human activities, is a leading driver of climate change, biodiversity loss and health crises. To develop effective strategies for mitigating the sources and consequences of such pollution, it is essential [1].

While technological development of mankind, on the one hand, contributes to the improvement of economic and social life of society, on the other hand, it gives rise to serious problems such as environmental pollution. Man-made pollution is the emission of harmful substances and energy waste as a result of industrial, transport and technological processes that have a negative impact on nature and human health [2].

Environmental pollution has the greatest impact on human life, and this issue has been deeply studied. It is closely related to scientific and technological development, reflecting the harmful effects of this development on nature and the consequences of human activities.

In our time, the greatest threat of anthropogenic factors to nature is the introduction of substances that disrupt the natural cycle and the processes of material circulation in the system. Harmful effects can arise not only from the circulation of substances that are incompatible with nature (such as toxins that destroy decomposers, negative impacts on producers' development, disruption of the consumer chain, and so on), but also from their

Citation: Ismailjonovna K. D. Technogenic Pollution and Its Consequences. International Journal of Biological Engineering and Agriculture 2025, 4(1), 82-88.

Received: 10th Jan 2025
Revised: 11th Jan 2025
Accepted: 24th Jan 2025
Published: 27th Jan 2025



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entry into the cycle. This situation leads to the emergence of energy levels that are quantitatively unusual for nature or a particular season.

Environmental pollution is the introduction of living or non-living substances into a specific ecological system that are not compatible with its natural state (biogeocenosis), which, along with disrupting or halting circulation and metabolic processes, energy, and information flow, leads to a decrease in productivity or the loss of the ecosystem.

The various forms of human impact on natural processes in the biosphere can be categorized into the following pollution categories:

1. The introduction of foreign chemical substances or contamination of ingredients into natural biogeocenoses, either in terms of quantity or quality.
2. Physical (parametric) pollution related to changes in environmental quality (e.g., heat, sound, noise, radiation, light, electromagnetic waves).
3. Biotic pollution that affects the composition and structure of living organism populations in a biogeocenosis.
4. Static-disturbing pollution (station – residential area), which refers to changes in landscapes and ecological systems during the process of managing the environment related to human needs [5].

Human's changing environment is the desire to improve the quality of life. To increase material wealth, reduce production costs, and simplify processes, people were forced to take actions that harm nature – cutting down forests, building dams, and destroying animals. Such actions result from a lack of understanding of the negative impact humans have on the environment, leading to the unpleasant consequences that follow.

Despite the emergence of new production technologies in the XXI st century, the demand for certain technical systems (such as coal-powered power plants) has decreased, and the disruption of the natural balance continues, leading to the following consequences:

Soil pollution. Harmful gases emitted from factories and waste from pipelines spread onto the ground, leading to the destruction of microorganisms and soil animals, referred to as 'lower' by biologists. The food system is disrupted, and many species of animals are deprived of healthy food.

Decreased soil fertility occurs as a result of improper land management, planting seeds not suited to the soil type, and pollution from chemicals and household waste. This problem is solved through the rehabilitation of contaminated land.

Human impact on the soil is directly related to the contamination of underground water. This effect also applies to mineral springs (whose quantity in the Caucasus has decreased several times over the last century) and to ordinary water produced for domestic needs.

Pollution of natural waters (hydrosphere). Pollution of the hydrosphere occurs as a result of industrial waste being discharged into natural water bodies without treatment. In developed countries, legal responsibility for such activities has been introduced, but this has not been able to stop some irresponsible factory owners. A clear example of the negative impact of human activity on the hydrosphere is Lake Baikal, where the largest amount of waste in the world has accumulated, and this issue is currently very urgent.

Air pollution. One of the causes of air pollution is power plants that operate on fossil fuels. As a result of the increase in the number of cars, the concentration of chemicals in the natural air composition rises. As a result, the amount of clean oxygen in the air decreases, and the level of toxic elements increases. [6].

Alienation of humans from nature. Large-scale human activity not only disrupts the natural development of biosphere processes but also alienates humanity from nature. Large-scale human activity not only disrupts the natural development of biosphere processes but also alienates humanity from nature. Typically, humans try to control nature for their own needs, using it as an external factor. Most of his activities do not align

with the natural laws of the ecosystem and sometimes violate them. In practice, humans, in opposition to nature, created a separate environment – the technosphere – for their living conditions and life activities [5].

The technosphere is the collection of artificial objects created as a result of human purposeful activity and the natural objects that have been altered by this activity.

Engineering and technical processes in the Earth's crust, hydrosphere, atmosphere, and the near parts of the cosmos, along with scientific and technological advancements that enable humans to use natural resources and alter the living environment, as well as the reconstruction of the biosphere and the formation of a new planetary crust (technosphere). These processes involve the influence of humanity on geological forces, meaning all activities related to human production are referred to as technogenesis.

Technogenic products are artificial substances formed or additionally created during the process of technogenesis, including discarded equipment, that affect the ecological systems of organisms

Currently, the expansion of anthropogenic pollution and the various stages of societal development have reached such a level that they pose a risk of leading the environment to ecological disaster.

Such situations may arise that lead to irreversible harmful consequences, and addressing them requires engineering and administrative measures.

If, after a negative impact, there is a possibility of restoring the system's damaged structural and functional elements (at least partially), then the state enters a crisis situation. The current situation can be described as an ecological problem.

Ecological crisis is a stage in the interaction between society and nature, where the contradictions between the economy and ecology intensify, and as a result of anthropogenic impacts, the ability of ecosystems to self-regulate is significantly weakened.

The main goal of ecology is to guide humanity out of the global ecological crisis and towards sustainable development, which involves meeting the needs of the current generation without depriving future generations of their opportunities. [5].

Types of technogenic pollution are varied, one of which is air pollution. Industrial emissions, vehicle emissions and energy company emissions cause significant damage to the air environment. For example, gases such as carbon dioxide (CO₂), methane (CH₄), and nitrogen oxides (NO_x) contribute to the warming of the atmosphere. At the same time, toxic gases damage the respiratory system, leading to lung and heart diseases. [2].

In water pollution, industrial and agricultural waste enters rivers and seas, causing significant harm to water ecosystems. The main factors polluting water resources are oil products, chemicals and microplastics. Contaminated water can also be a source of dangerous diseases for humans.

When soil is polluted by pesticides, fertilizers and industrial waste, it degrades. This leads to reduced agricultural productivity and contamination of the food chain. Soil pollution disrupts the nutritional process of plants, which leads to the production of products that are harmful to the human body.

In noise and electromagnetic pollution, noise and electromagnetic radiation from industrial enterprises, vehicles, and other technological devices serve as stress factors for both humans and animals. Excessive noise levels lead to sleep disturbances, hearing damage and psychological problems. Electromagnetic radiation, in particular, affects the nervous system.

Technogenic pollution leads to environmental degradation. This leads to environmental degradation. Natural ecosystems are losing their resilience due to pollution. As a result, there is a reduction in plant and animal species. Such processes not only disrupt the ecological balance, but also lead to economic losses [4].

Global climate change is caused by emissions of man-made gases that trap heat in the atmosphere, raising the Earth's average temperature. This will lead to melting glaciers,

rising sea levels and dramatic climate changes in various regions. As a result, the number of droughts, floods and extreme weather events is increasing [3].

Polluted air and water are harmful to human health, causing respiratory diseases, cardiovascular problems, cancer and other diseases. Children and the elderly are particularly sensitive to these effects. Millions of people lose their health every year due to air and water pollution [2].

Economic damage: Rising costs for environmental restoration and health care are causing serious damage to the economy. Industries such as tourism and agriculture do not develop in polluted areas [2].

Methods for reducing anthropogenic pollution. Use of renewable energy sources. Using solar, wind and hydropower helps reduce anthropogenic emissions. Their implementation will help restore ecological balance in the long term [4].

When processing industrial waste. Modern technologies make it possible to minimize and recycle waste. It is especially important to widely implement a waste recycling system.

Optimization of the transport system, introduction of electric vehicles and development of public transport will reduce environmental pollution. In addition, it is necessary to create convenient infrastructure for pedestrians and cyclists.

Strengthening legislation and supervision. Raising environmental standards and strictly enforcing them are essential to preventing anthropogenic pollution. The state and international organizations must control these processes.

Public awareness. In the fight against pollution, it is necessary to involve the population, raise the level of environmental awareness and develop responsibility. Only through the conscious participation of the population can man-made pollution be reduced.

2. Materials and Methods

This research contains a detailed examination of established literature through merging scientific publications with official reports and environmental research findings. The study investigates where anthropogenic pollution originates along with its different types by examining industrial emissions together with agricultural operations and transportation sector impacts. Major pollution incidents such as Lake Baikal contamination alongside air pollution problems caused by fossil fuels serve as case study examples to determine impacts. The study analyzes contesting technological solutions and policy regimes developed to combat pollution along with their effectiveness. The analysis relies on data obtained from respected environmental organizations together with global climate reports.

Additionally, the research evaluates policy frameworks implemented at international, national, and regional levels, analyzing their effectiveness in controlling pollution. This includes regulations established by entities such as the United Nations Environment Programme (UNEP), the Intergovernmental Panel on Climate Change (IPCC), and national environmental agencies. Data for this analysis is sourced from reputable environmental organizations, peer-reviewed scientific studies, and global climate reports, ensuring a well-rounded and evidence-based assessment.

By merging qualitative and quantitative data, this study aims to provide a nuanced evaluation of pollution's origins, consequences, and the efficacy of existing mitigation strategies, ultimately contributing to a broader understanding of sustainable environmental governance.

3. Results

The analysis shows how human-caused pollution resulting from industry and transportation alongside energy generation systems produces devastating effects on Earth's air, water, and soil systems. Fossil fuel combustion for air pollution causes global

warming and respiratory diseases while it damages air quality. Industrially generated water contamination involving chemicals and waste damages aquatic nature communities and human wellness. Modern agricultural pesticides and industrial leftovers create soil contaminations that damage soil fertility while breaking down food genealogy programs. The technosphere developed by human activities has produced ecosystem degradation while also causing climate change and biodiversity loss. Technogenic pollution levels are responsible for increasing greenhouse gas emissions coupled with unpredictable weather patterns. Environmental problems lead to financial losses in both agricultural production and tourist sectors. The study shows renewable energy methods alongside waste recycling and electric transport as key elements while demanding more stringent environmental regulations for pollution control. Active public engagement combined with broad public understanding stands as the foundation for reducing human-made pollution to maintain sustainability.

The technosphere, shaped by human industrial and technological activities, has accelerated ecosystem degradation, triggering climate change and biodiversity loss. Increasing levels of technogenic pollution have intensified greenhouse gas emissions, leading to unpredictable weather patterns and ecological instability. Environmental problems also translate into financial losses, particularly in agriculture and tourism, as deteriorating ecosystems reduce crop yields and affect natural attractions.

The study highlights renewable energy adoption, waste recycling, and the development of electric transportation as crucial measures for reducing pollution. However, these efforts must be accompanied by stricter environmental regulations to ensure long-term effectiveness. Governments, businesses, and individuals must work together to create a cleaner and more sustainable future. Encouraging public awareness and engagement remains essential, as an informed and active society is key to driving meaningful environmental change. Addressing human-made pollution requires collective responsibility, innovation, and policy reforms to preserve ecological balance for future generations.

4. Discussion

The findings of this study underscore the profound impact of anthropogenic activities on environmental degradation, emphasizing how industrialization, transportation, energy production, and agricultural practices are the primary contributors to technogenic pollution. The pervasive nature of pollution manifests in the contamination of air, water, and soil, leading to detrimental consequences for biodiversity, human health, and global climate stability.

Air pollution, predominantly caused by fossil fuel combustion and vehicular emissions, has escalated greenhouse gas concentrations, contributing significantly to global warming and respiratory diseases. This aligns with existing literature highlighting the correlation between air quality deterioration and increased health risks, particularly among vulnerable populations such as children and the elderly. The degradation of air quality not only affects public health but also exacerbates climate change through the accumulation of carbon dioxide and methane in the atmosphere.

Water pollution emerges as another critical issue, with industrial discharge and agricultural runoff introducing hazardous substances into aquatic ecosystems. The contamination of water bodies, such as Lake Baikal, serves as a stark reminder of the long-term ecological damage caused by unchecked industrial activities. This pollution disrupts aquatic life, diminishes water quality, and poses serious health risks through the bioaccumulation of toxins in the food chain.

Soil contamination, often overlooked, plays a pivotal role in the degradation of terrestrial ecosystems. The use of pesticides, improper waste disposal, and industrial spills reduce soil fertility, impair agricultural productivity, and lead to the contamination of

crops. This has far-reaching implications for food security and public health, as toxic substances infiltrate the human diet.

The technosphere, a product of human industrial and technological advancements, has accelerated ecosystem degradation and biodiversity loss. The increasing prevalence of technogenic pollution has intensified the frequency of ecological crises, characterized by the disruption of natural cycles and the weakening of ecosystems' self-regulatory capacities. These crises underscore the urgent need for sustainable environmental management practices.

Addressing the multifaceted challenges of technogenic pollution requires a holistic approach. The promotion of renewable energy sources, waste recycling, and the development of sustainable transportation systems are critical strategies. However, these measures must be supported by stringent environmental regulations and effective policy frameworks at both national and international levels. The role of organizations like the United Nations Environment Programme (UNEP) and the Intergovernmental Panel on Climate Change (IPCC) is vital in guiding global efforts toward pollution mitigation.

Public awareness and active engagement are indispensable in the fight against environmental degradation. Educating communities about the impacts of pollution and fostering a culture of environmental responsibility can drive collective action. The integration of environmental education into curricula and community programs can empower individuals to make informed decisions and adopt sustainable practices.

In conclusion, the study highlights the interconnectedness of human activities and environmental health. Mitigating the effects of technogenic pollution requires a concerted effort involving technological innovation, robust policy enforcement, and active public participation. By adopting a comprehensive and collaborative approach, it is possible to pave the way for a sustainable future that balances human development with ecological preservation.

5. Conclusion

Anthropogenic pollution is one of the most pressing environmental problems of our time. Solving this problem requires cooperation from every individual, society and state. Only then can we ensure a healthy and sustainable environment for future generations. To achieve this, it is important to consistently implement strategies aimed at restoring ecological balance and continuing technological development in a sustainable direction. Each of us can do our part to achieve environmental sustainability.

The fight against man-made pollution not only solves environmental problems, but also opens up new horizons for economic and social development. After all, environmental safety and sustainability are among the important factors that ensure the future of humanity. Therefore, every citizen and organization must actively participate in these processes.

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