

The Problem of Environmental Pollution with Microplastics: Sources, Scale and Possible Solutions

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Annotation: The article examines the problem of environmental pollution with microplastics, its main sources, scale of distribution and impact on the ecosystem. The factors contributing to the increase in the amount of microplastics in nature are analyzed, including the textile industry, wear of car tires and shortcomings of wastewater treatment facilities. The consequences of pollution for marine organisms, food chains and global ecology are considered. Particular attention is paid to the need for standardization of methods for studying microplastics, as well as possible solutions to the problem, such as the development of biodegradable plastics, improvement of cleaning technologies and improved waste management. The importance of an integrated approach, including scientific developments, government measures and public initiatives, to reduce the level of environmental pollution with plastics is emphasized.

Keywords: microplastics, environmental pollution, plastic waste, sources of microplastics,

ecosystem, biodegradable materials, wastewater treatment, plastic recycling, sustainable development, methods of microplastic analysis.

Introduction. Plastics have become an integral part of modern life, widely used in various fields - from medicine and construction to automotive and clothing manufacturing. However, their durability and resistance to decomposition have led to a serious environmental problem - the accumulation of plastic waste in nature. In 2022, global plastic production reached 400.3 million tons, with only 8.9% recycled [1]. The rest ended up in the environment, including the world's oceans, which led to significant disruption to ecosystems [1]. Main sources of microplastics. Microplastics enter the environment from various sources. One of the most significant is the textile industry. A study by P. Arvin and A. Tehrani-Baga showed that washing synthetic fabrics promotes the active release of microfibers, and the transition to materials of biological origin can significantly reduce the level of this pollution [3]. Another important source of microplastics are car tyres: as tyres wear out, large quantities of microparticles are released into the environment – on average, each inhabitant of some European countries produces between 1 and 1.4 kg of tyre dust per year [1]. In addition, poor sewage systems in large cities (such as London) and the peculiarities of winter water supply (as in Helsinki) contribute to the release of plastic waste into water systems [1].

The scale of pollution. A study by Hanwen Chen and colleagues found that microplastic pollution levels are particularly high in Asia and developing countries, where urbanisation is driving the growth of plastic waste [4]. In 2011, it was found in the Los Angeles River basin that within 72 hours of heavy rain, about 30 tons of plastic particles enter the water, with expanded polystyrene (up to 71%) and fragments of an undetermined nature (14%) dominating in quantity, and whole plastic products (37%) by weight [8]. According to the journal Science Advances, Asian countries generate 81% of all plastic waste dumped into the ocean, which is due to high population density and an underdeveloped recycling system [12]. Impact on the ecosystem. Plastic waste poses a serious threat to marine organisms. Studies show that microplastics enter the food chain, accumulating in the tissues of fish and marine invertebrates. Secondary microplastics, formed during the decomposition of large plastic objects, have a high capacity to adsorb organic pollutants and heavy metals, which increases its toxicity. When ingested by animals, such particles can cause inflammatory processes, reproductive system disorders, and even cancer [15,16,17]. In addition, plastic fragments drifting in water bodies create barriers to sunlight, which disrupts photosynthesis in algae and reduces oxygen levels in the water [6]. Additional studies published in Scopus indicate that microplastic particles absorbed by lower trophic level organisms contribute to the biomagnification of pollutants, which leads to the accumulation of toxins in tissues and structural disruptions of food chains [5].

The need for standardization of studies. Effective control of microplastic pollution requires standardization of methods for its analysis. In 2019, a study by Koelmans and colleagues revealed significant differences in the results associated with imperfect sampling methods and identification of plastic particles [7]. It should be noted that similar methodological developments are actively carried out in leading scientific centers in the USA, Germany, Japan, South Korea and a number of developing countries in Asia, which emphasizes the global interest in the problem of microplastics [12]. In addition, the work of Hidalgo-Ruz et al. (2012) offers recommendations for the unification of existing methods for the detection and quantification of microplastics, which allows for comparability of data obtained in studies of different regions [5]. Solutions to the problem. Solving the problem of microplastic pollution requires an integrated approach. One of the key areas is the development of new materials - for example, the transition to biodegradable plastics can significantly reduce the level of pollution, although the properties of polymers after synthesis remain unchanged, regardless of the raw materials [1]. An important

step is also the improvement of wastewater treatment systems, where modern filtration technologies are capable of retaining a significant amount of microplastics, but their effectiveness depends on the design and technological equipment of treatment facilities [14]. In addition, it is necessary to improve waste management strategies: large-scale plastic recycling programs are already being implemented in Europe, but on a global scale, most waste continues to accumulate in the environment [11]. Conclusion. Environmental pollution with microplastics and plastic waste is one of the most pressing environmental problems of our time. Despite numerous studies aimed at studying the scale of this phenomenon and its consequences, a final solution to the problem remains a difficult task. Analysis of existing data shows that the sources of microplastics are diverse, and the routes of their distribution affect all ecosystems - from urban wastewater to open oceans. One of the main factors influencing the level of pollution is the active consumption and production of plastic, which has increased significantly in recent decades. The annual production volume of plastics is estimated at hundreds of millions of tons, and a significant part of it is either not recycled at all or is only partially recycled. As a result, plastic waste ends up in the soil, water and atmosphere, posing a threat to living organisms and the entire ecosystem as a whole.

Microplastics are especially dangerous, since their small particles not only accumulate in the environment, but also penetrate living organisms, including marine animals, birds and even humans. It has been proven that such particles can absorb toxic substances, which are then transferred along the food chain, which can lead to serious health consequences. Moreover, microplastics are found in fresh water, atmospheric air and even in snow deposits in remote regions of the planet, indicating its ubiquity. There are various strategies for reducing plastic pollution, including the development of biodegradable materials, improved recycling technologies, improved treatment facilities and the introduction of strict legislative measures.

A switch to the use of materials with a high decomposition rate, as well as a partial reduction in the use of traditional plastics is recommended. Such measures, combined with improved technology and increased control, can help reduce the negative impact of plastic on the environment and preserve the ecosystem for future generations. In the future, it is necessary to strengthen measures to monitor and control pollution levels, as well as introduce innovative methods for cleaning water, soil and air from microplastics. Only a comprehensive approach, including scientific research, government initiatives and active participation of society, will significantly reduce the negative impact of plastic waste on the environment.

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