EXPLORING THE NORTHERN DIMENSION

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# Marine Plastic Debris Pollution in the Russian Arctic

**Summary: This paper discusses marine plastic debris pollution, particularly the accumulation of microplastics in the oceans, which is one of the most significant environmental problems of our time both globally and in the Russian Arctic.**

**Microplastics are a term used to describe the vast volume of microscopic plastic debris currently found throughout the World Ocean and its coastlines. Primary microplastics are plastic microgranules specially produced and added to various products such as cosmetics, as well as used as the primary macroplastics raw material. Secondary microplastics are plastic fragments less than 5 mm in size, which are formed by the destruction of larger plastic debris, and by washing of synthetic items in washing machines. Some of these micro particles of plastics end up in wastewater, but most of them pass through the water treatment plant filters and penetrate the aquatic ecosystem.**

**Microplastics have a negative impact on living organisms in the ocean. In particular, plastic can cause physical harm and disrupt the body formation of marine animals, as well as cause their death by suffocation or ingestion of plastics. At the same time, plastics are able to accumulate persistent organic pollutants on their surface, which can poison marine animals, causing harm to the entire food chain.**

**As other world oceans, the Arctic Ocean and the Barents Sea have become a place for the accumulation of plastic, which causes great harm to the fragile ecosystem of the Arctic region. Researchers have discovered microplastics not only in the Arctic waters, but also in the Arctic sea ice. The sources of plastic debris include both pollution transport by oceanic currents from more populated areas of the planet, and local sources such as fishing and other commercial activities, as well as sewage.**

**The absorption of microplastics by fish and other marine animals has globally been identified as the most acute problems caused by marine debris pollution. This issue as a new line of research is poorly worked out on the territory of the Russian Federation in general, and in the Arctic zone of the Russian Federation in particular. Therefore, there is urgent need both for research on this issue, and measures that would reduce the flow of marine debris and plastic into the waters of the Arctic.**

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# What is microplastics and why is it a problem?

The problem of marine ecosystems pollution has been quite acute for more than half a century and is increasingly causing concern among environmentalists and eco-activists. The main source of marine pollution is the anthropogenic impact, and the most widespread type of marine debris are plastics. As early as 1907, a number of economically efficient polymer synthesis technologies were optimized, resulting in the mass production of many lightweight, strong, inert and corrosion-resistant plastics. Since mass production began in the 1940s, the amount of produced plastics has grown rapidly and by 2009 it was already about of 230 million tons [1].

Conventional materials such as glass, metal and paper are being replaced by economical plastic packaging of a similar design; and fishing gear such as nets, fishing lines (one of the main pollutants of the marine environment) are also replaced with plastic ones that are lighter and stronger than natural materials. Thus, more than a third of plastic resin production is converted to consumer material, which includes disposable items. Due to their high molecular weight and hydrophobicity, polymers are extremely resistant to biodegradation, with the exception of biopolymers (such as chitin, chitosan, cellulose, etc.). However, certain microorganisms have been identified that are capable of biodegradation of some types of plastics, such as polyethylene, PVC and polystyrene. But the destruction of plastics by biodegradation can take a long period of time. Some additives, such as antioxidants and stabilizers, can slow down the rate of degradation (be toxic to microorganisms) [2, 3].

The annual global demand for plastics is constantly increasing and in 2011 it amounted to 245 million tons [4]. In this regard, according to scientific prognosis, in 2010, from 4.8 to 12.7 million tons of plastics were thrown into the oceans, and these figures are getting higher every year.

The ever-increasing volumes of plastic production, together with its fairly long life span (about 1000 years), make the problem of plastic pollution of the marine environment and the ecosystem as a whole one of the most significant environmental problems of our time.

Currently, another problem related to plastic has arisen – the problem of pollution of marine ecosystems with microplastics. Despite the fact that microplastics in the marine environment were discovered several decades later, than conventional plastics, the problem of ocean microplastics pollution has already become a global environmental problem.

Microplastics are a term used to describe the vast volume of microscopic plastic debris currently found throughout the World Ocean. Microplastics are plastic particles ranging in size from about a few microns to 5 mm. Microplastics can be found almost everywhere: on beaches, coastlines, subtropical ocean gyres, polar icecaps and even the deepest parts of the ocean.

Microplastics are divided into two types by their origin: primary and secondary.

Primary microplastics are plastic microgranules specially produced and added to various products. These plastics are commonly used in facial cleansers and cosmetics, or as fillers for upholstered furniture, toys, and as the primary macroplastics raw material.

Secondary microplastics are plastic fragments less than 5 mm in size, which are formed by the destruction of larger plastic debris, both at sea and on land. Over time, physical, biological and chemical processes reduce the structural integrity of plastic debris, causing it to break down into smaller particles and degrade. Secondary microplastics are also formed in large volumes when synthetic items are washed in washing machines.

Microplastics contained in cosmetics and formed during washing end up in wastewater. The main problem lies in the fact that microplastics are so small (Figure 1) that they are not captured by wastewater filtration systems, and as a result these particles enter water bodies and become an environmental threat [5].

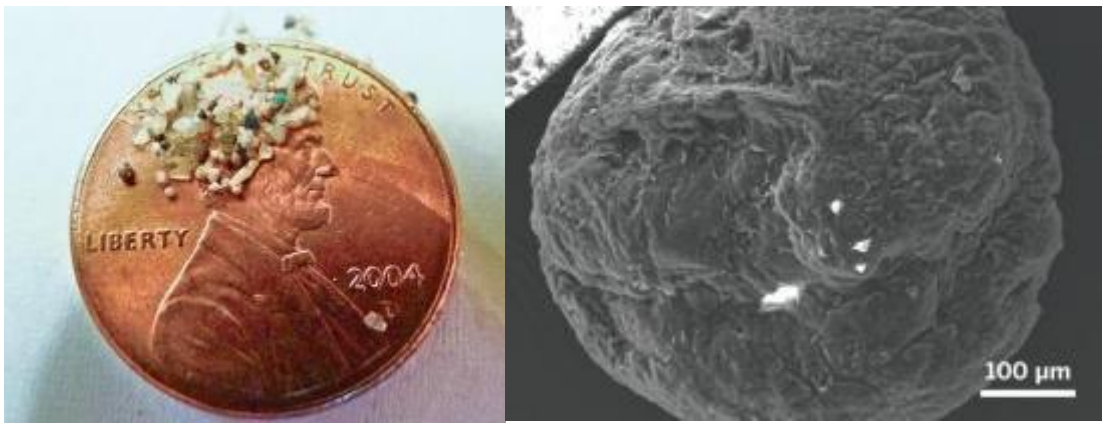


Figure 1. Microplastics from cosmetics

Plastic debris on beaches has high oxygen availability and direct exposure to sunlight, so it degrades quickly, becoming brittle, cracking and “yellowing” over time (Figure 2). As a result of abrasion, wave action and turbulence, these plastics degrade more rapidly in the environment losing structural integrity [1].


(I-II) various types of expanded polystyrene, (III) non-woven geotextile, (IV) facing fiberglass profiles, (V) gabion mesh with plastic coating (PVC / HDPE), (VI) fragments from a woven big bag (PP)

Figure 2. Plastics with traces of fragmentation on the seashore.

Microplastics can have a negative impact on living organisms in the ocean. In particular, plastic can cause physical harm and disrupt the body formation of marine animals, as well as cause their death by suffocation or ingestion of plastics. The scientific literature notes the physical effects of microplastics on small organisms, such as internal abrasions and blockages. Microplastics block the gastrointestinal tract, disrupt the growth of the body and functioning of the reproductive system. In some animals, microplastics have been found in the blood, lymph and liver. At the same time, plastics are able to accumulate persistent organic pollutants on their surface, which can poison marine animals, causing harm to the entire food chain [6]. In addition, plastic has a negative aesthetic impact on the environment.

## Marine plastic debris pollution as a problem in the Russian Arctic

Due to the fact that about half of all plastics is lighter than water, it can move on the water surface by world currents and spread throughout the planet. At the same time, considering the peculiarities of ocean currents, the Arctic, the Arctic Ocean and the Barents Sea can become a place for the accumulation of plastic, thereby causing great harm to the fragile ecosystem of the Arctic region [7]. In addition, the Barents Sea is an active fishing area. In this regard, plastic and paint particles from fishing vessels, pieces of fishing nets, often made of plastic, as well as their whole fragments get into the sea water. The Barents Sea and the Arctic Ocean serve as a place for the flow of large Arctic rivers, such as the Pechora, the Northern Dvina, and others. They also carry plastic particles that enter their waters with industrial and domestic wastewater.

Currently, the territory of the western part of the Russian Arctic is rather poorly studied in terms of marine debris pollution. However, available studies allow us to describe the current situation in this sector of the Arctic.

A group of scientists from the Marine and Freshwater Research Center and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) [8] studied a part of the Barents Sea in the area of the Svalbard archipelago, located on the western border with the territorial waters of the Russian Federation. The authors noted that the content of plastic particles varied from 0 to 1.31 particles per $m^3$, and plastic particles were detected in 95% of the analyzed samples. According to the researchers, the source of this debris can be both pollution transport by oceanic currents from more populated areas of the planet, and local sources such as fishing and other commercial activities, as well as sewage.

The problem is particularly acute for the absorption of microplastics by thalassophilus (including crustaceans, molluscs, fish and marine mammals). This issue as a new line of research is poorly worked out on the territory of the Russian Federation in general, and in the Arctic zone of the Russian Federation in particular. Currently, we have no information on the concentration, type and form of plastic absorbed by marine animals in the western part of the Russian Arctic. At the same time, a number of papers reflects this situation in the regions near the border with the Russian Arctic. According to studies in the Greenland Sea [9], the concentration of microplastics in water was 2.4 ± 0.8 particles / $m^3$, and microplastics in fish were found in 34 and 18% (triglops and cod, respectively) of the fish sampled for analysis. Microplastics have also been found in crustaceans sampled off the coast of the Svalbard archipelago. Particles of plastic were found in each of 20 samples of crustaceans of the Gammarida family. Most of the detected particles consisted of polymethacrylamide, a thermoplastic widely used in the marine industry as a coating to prevent ships fouling, anti-corrosion and waterproof coatings [10].

The results of the study show, that microplastics penetrate even the most remote corners of the planet, causing harm to living organisms. The content of plastic particles here is comparable with the level that has been found in more industrialized regions of the planet, which indicates the transfer of particles by ocean currents.

The fact of the discovery of microplastics in the Arctic sea ice is also worth noting. According to the results presented in the work of a team of scientists from the Thayer School of Engineering at Dartmouth College and Marine Biology and Ecology Research Center [11], the content of plastic particles in ice cores of the central part of the Arctic Ocean was found in the range from 38 to 234 particles per $m^3$, which was significantly even more compared to heavily polluted ocean currents. According to the authors of the work, this is due to the effects of concentration in the process of ice formation.

# Concluding remarks

Summing up, we should note that the existing scientific results indicate an increasingly aggravating situation of the microplastics pollution of the World ocean. Pollution of the Arctic is of particular concern, as its fragile ecosystem is most susceptible to even the smallest changes. Microplastics can harm the ecosystems of the region, which can result in economic, environmental and aesthetic losses for the population of regions and entire countries. In this regard, it is necessary to take measures to identify and reduce the negative consequences of macro and microplastics pollution of the ecosystem.

Based on the above data, we can state the fact of almost complete lack of information on the content of microplastics in surface waters, sea animals and ice in the Russian part of the Arctic. As a consequence, the solution to this problem can be a large-scale international research program aimed at creating a system for microplastics monitoring in the Arctic seas.

Assessment of environmental damage and risks associated with the microplastics pollution of the Arctic ecosystem, based on the results of scientific research, is an important factor for further environmental protection research, including issues associated with a decrease in the number of ichthyofauna in the Russian Arctic.

Reducing the flow of marine debris and plastic into the waters of the Arctic seas and the mitigating anthropogenic load on the region as a whole is an important task. It can be solved by increasing the share of biodegradable plastics in the total volume of plastic production; by the development of plastic recycling facilities; by increasing penalties for waste disposal in the water protection zone; by explanation to the public of the topics of plastic pollution; by the use of alternative to plastic household and daily use items; by the implementation of separate waste collection.

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