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MICROPLASTIC IS A PROBLEM OF PLANETARY SCALE

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The problem of the World Ocean pollution with microplastic is considered in this article. Nowadays this problem is recognized as the accruing problem of planetary scale, but it is insufficiently highlighted in the domestic scientific press. The processes leading to the formation of micro-plastic are described, the short review of researches of content of microplastic in the marine environment and its impacts on the environment is submitted. Plastic is one of the most demanded materials and because of its durability, lightness and longevity in combination with low prime cost it is used practically in all fields of industry. At the same time a huge part of plastic production is a share of disposable products or products with a short life length. The first mentions about plastic garbage in reservoirs, about harmful and poorly studied influence of microplastic on representatives of biota are met in the published literature since the beginning of the 1970th years. At first, the articles on this subject drew the minimum attention of scientific community, but in the next decades, thanks to accumulation of data on environmental impacts of pollution of the World Ocean with microplastic, this subject arrests a sustained research interest. It was revealed that a number of organisms, both vertebrata and invertebrates, absorb microplastic. Micro-particles of plastic have a wide range of dimensional groups and low density, therefore, a lot of live organisms perceive them as a source of food. As plastic does not decay by their enzymatic system, its ingestion poses a threat for the organisms and can lead to their death. Researches show that for the last forty years the pollution of the World Ocean with plastic reached such scales that this material began to get not only into the food of sea inhabitants, but also into the food of people.The problem of the sea garbage acquires special relevance among a number of the environmental problems caused by the consumer orientation of exploitation of the environment. Russia is not an exception. Researches of content of microplastic in the marine environment are conducted in the Russian Federation since 2005 in the South of the Far East, in the water areas of the Amur, Ussuriysk gulfs and Peter the Great Bay (the Sea of Japan), in the Baltic Sea and on Baikal. However, the organization of the solution of the problem of the sea garbage and processing of plastic in Russia is at the formation stage.

Key words: plastic garbage, microplastic, monitoring, pollution, marine environment, toxic influence.

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В статье рассматривается проблема загрязнения Мирового океана микропластиком, которая в настоящее время признана нарастающей проблемой планетарного масштаба, но недостаточно освещена в отечественной научной печати. Описаны процессы, приводящие к образованию микропластика, представлен краткий обзор исследований содержания микропластика в морской среде и его воздействия на окружающую среду. Пластик является одним из наиболее востребованных материалов и из-за своей прочности, лёгкости и долговечности в сочетании с низкой себестоимостью используется практически во всех областях промышленности. При этом огромная часть производства пластика приходится на одноразовые изделия или изделия с коротким сроком службы. Первые упоминания о пластиковом мусоре в водоёмах, о пагубном и малоизученном влиянии микропластика на представителей биоты встречаются в опубликованной литературе с начала 1970-х годов. Сначала статьи на данную тему привлекали минимальное внимание научного сообщества, но в последующие десятилетия, благодаря накоплению данных об экологических последствиях загрязнения Мирового океана микропластиком, данная тема приковывает к себе устойчивый исследовательский интерес. Было обнаружено, что ряд организмов, как позвоночных, так и беспозвоночных, поглощают микропластик. Микрочастицы пластика имеют широкий спектр размерных групп и низкую плотность, в результате чего многие живые организмы воспринимают их как источник пищи. Поскольку пластик не разлагается их ферментативной системой, его проглатывание само по себе представляет угрозу для них и может привести к летальному исходу. Исследования показывают, что за последние сорок лет загрязнение Мирового океана пластиком достигло таких масштабов, что данный материал стал попадать в пищу не только морских обитателей, но и человека. Проблема морского мусора приобретает особую

актуальность среди ряда экологических проблем, обусловленных потребительской направленностью эксплуатации окружающей среды, и Россия не является исключением. Исследования содержания микропластика в морской среде проводятся в Российской Федерации с 2005 г. на юге Дальнего Востока, в акваториях Амурского, Уссурийского заливов и залива Петра Великого (Японское море), в Балтийском море и на озере Байкал. Однако организация решения проблемы морского мусора и переработки пластика в России находится в стадии становления.

Ключевые слова: пластиковый мусор, микропластик, мониторинг, загрязнение, морская среда, токсическое воздействие.

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The first mentions about plastic garbage in reservoirs, about harmful and poorly studied influence of microplastic on representatives of biota are met in the published literature since the beginning of the 1970th years [18,19,22,32,21]. At first, the articles on this subject drew the minimum attention of scientific community, but in the next decades, thanks to accumulation of data on environmental impacts of pollution of the World Ocean with microplastic, this subject arrests a sustained research interest. A lot of researches were devoted to the tangling of marine mammals [40], of cetacea [20] and of other marine animals [27] in fishing equipment and in the garbage. For example, on the 20th of May in 2019 on Sakhalin the round table devoted to this problem and, in particular, to the holding of a rescue operation on disentangling of sea lions on the breakwater Nevelsk with the assistance of a lot of competent organizations and also the invited experts in disentangling of seals from the Pacific center of rescue of marine mammals (USA) was carried out [56].

Microplastic was, for the first time, noted in the North America in the sea surface water in the 1970th years [18]. Since then microplastic is found in the majority of large reservoirs. Researches showed that various types, including small zooplankton, large cetacea, the majority of sea birds and all sea turtles, absorb plastic packages and bottle caps easily. By 2018 microplastic had been found in the bodies of more than 114 aquatic species, including some deep-water types.

Different researchers unequally define the concept "microplastic". Nowadays the definition is not formed completely. There is a question what size of a particle can be related to microplastic. Most of scientists [38,54,23] consider that these are the particles from 0.5 to 5 mm in size according to the greatest measurement.

It is necessary to allocate two main processes leading to the formation of microplastic: 1) direct intrusion into the marine environment (some fragments, micro and the nanoparticles used in consumer goods get into the water area with sewage, for example, the granules which are a part of cosmetic scrubs, or industrial synthetic abrasives) and 2) aeolation of larger garbage in marine and coastal environment [35,43,47,30]. The significant role in intrusion of plastic into the marine environment is played by the direct disposal of economic and household sewage into coastal zone of the seas, the pollution of shores by vacationers, the plastic garbage arriving from vessels, the remains of fishing equipment. Large plastic is destroyed slowly, but constantly, as a result of influence of solar radiation, mechanical and biological influence. This process generates a huge number macro-micro and nanoparticles which bear the greatest danger for the environment. The destruction of larger plastic materials getting into the water area from the land is the main mechanism of origin of microplastic [36].

According to the agents causing degradation, the degradation of polymers can be classified in the following way: biodegradation, photodegradation, thermooxidation, hydrolysis. All these processes lead to the significant impact on biota and the marine environment in general. However, the rates of destruction of plastic waste on the beaches, in a surface water and in the deep-water environment significantly differ. In the coastal zone the dominating process is thermal influence. The plastic garbage which is on the beach can be heated up to 40 °C in summer, at the same time photooxidizing decomposition accelerates exponentially. Plastic becomes fragile and, during the mechanical influence, breaks up to the powdery fragments available for zooplankton and for other small marine animals. Such fragments can be exposed to further degradation (as a rule, microbic) [5,6,51,16,28,24,9].

The greatest concern causes the fact that particles of plastic are capable to adsorb many pollutants [18,26,50,39,10,48,33,9] on their surface, becoming their secondary source and the conductor of intrusion of pollution into the water organisms [16]. The organisms swallowing plastic garbage can be affected by the pollutants absorbed by plastic [50]. Because of water repellency the concentration of the resistant organic pollutants (ROP) in microplasticity reaches the sizes higher than background. The additives used by plastics industry can be washed away from them to the marine environment [9]. Thus, on the one hand, the plastic garbage promotes the cleaning of the marine environment from the pollutants dissolved in it, and on the other hand, during the intrusion into the organism these fragments become bioavailable and create threat of activity of marine organisms [26]. The risk connected with high concentration of ROP is of particular importance. Sea water, as a rule, contains some volume of such chemicals as pesticides and industrial chemicals getting into the ocean with sewage [55]. ROP possess considerable coefficient of distribution polymer-water in favor of polymer. For example, in the work [39] the distribution coefficient for phenanthrene in the system of plastic/sea water was estimated, its values were 13000 l/kg for polyethylene and 380 l/kg for polypropylene. At the same time concentrated in ROP polymers become bioavailable, microparticles and nanoparticles reach the sizes of phytoplankton entering a diet of some representatives of zooplankton making, for example, the Pacific krill. In the researches [12,46,42,8] it was noted that the Pacific krill absorbs seaweed with granules of polyethylene of the corresponding size. It was revealed that marine worms feeding with bottom deposits have bioavailability of the polycyclic aromatic hydrocarbons arriving from technogenic particles, such as fragments of tires and diesel soot which were located in intestinal liquid [53]. The surfactants which are contained in intestinal liquid of bottom detritophags, perhaps, increase bioavailability of ROP at these types [52.50]. A large number of ROP makes strong toxic impact on plankton having small body weight. At the same time the dose depends not only on microparticle volume, but also on time of its stay in the organism and kinetics of transition of ROP from it into the tela of zooplankton. The volumes of the polluted plastic particles which got into the organisms of large sea types, such as big petrel and ROP in fatty tissue of an adult specimen correlated positively [49]. Data on coefficients of transfer of ROP by microplastic at all sea trophic levels are unknown. As for plastics with high molecular weight, they are not exposed to noticeable biodegradation because species of microorganisms which can metabolize polymers are rare in the nature, they do not meet in high concentration and, besides, in the nature there are always sources of digestible nutrients.

Toxic properties of plastics can be referred to the following factors:

– The Residual monomers which present in the composition of plastic or the toxic additives used during its production can be leached as a result of plastic absorption by marine animals. The potential toxicity of the softeners applied during the production of polymerized vinyl chloride was discussed in literature widely [41];

– Toxicity of some intermediate products of partial degradation of plastics. For example, during the combustion of polystyrene, styrene and other aromatic connections can be formed, at the same time the partially burned down plastic may contain considerable levels of styrene and other aromatic connections;

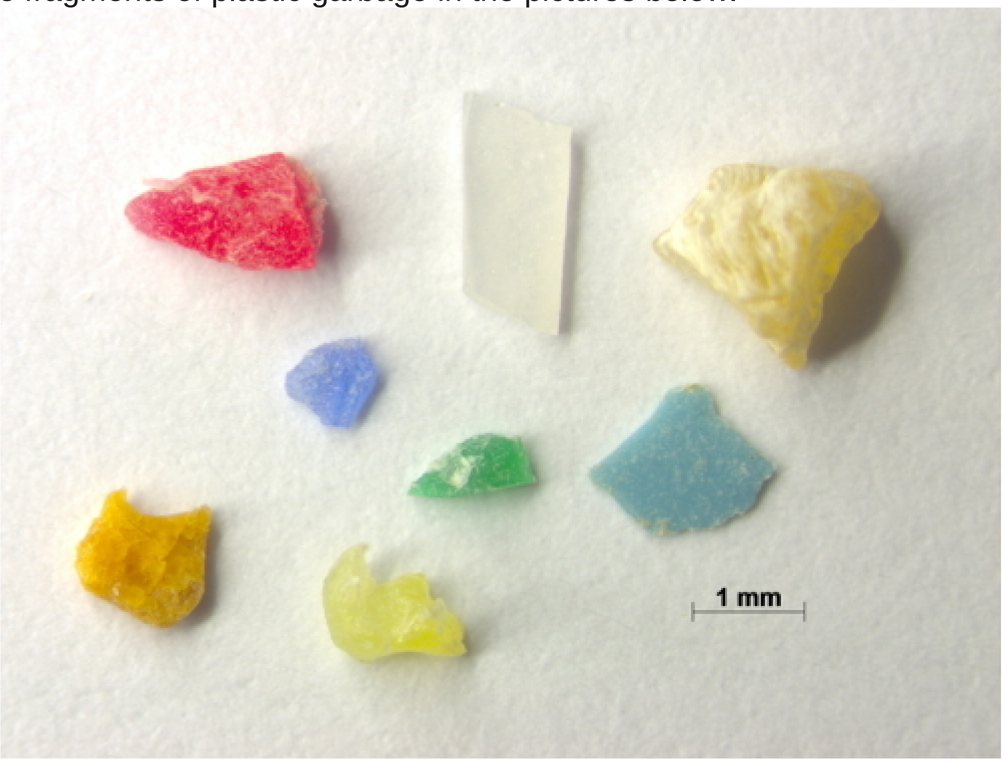
– ROP which present in the sea water are absorbed and they concentrate in plastic fragments gradually.

It was revealed that the pollutant desorption (back into the water) was very slow and that even the deposit desorbed phenanthrene quicker than fragments of polymers. This revelation was important. Some researches confirm that plastic can also accumulate metals [10]. These results were unexpected because plastics are hydrophobic, but the functional groups can be formed on the oxidized surface. These groups are capable to connect metals.

Researches show that for the last forty years the pollution of the World Ocean with plastic reached such scales that this material began to get not only into the food of sea inhabitants, but also into the food of people. One of the brightly shown problems of pollution with plastic is death of sea inhabitants and birds which easily mistake multi-colored pieces of plastic for food, during ingestion of plastic particles fill digestive tract therefore the species perishes from hunger [3.4]. Microparticles of plastic have a wide range of dimensional groups and low density, therefore, a lot of live organisms, both vertebrata and invertebrates, perceive them as a source of food [34,15,5]. As plastic does not decay by their enzymatic system, its ingestion poses a threat for the organisms and can lead to their death [11,40,25,17,37,44,45,29,31,23].

In the Russian Federation, the researches of content of microplastic in the marine environment are conducted since 2005 in the South of the Far East, in the water areas of the Amur, Ussuriysk gulfs and Peter the Great Bay (the Sea of Japan). [13,14,1,4,2].

There are fragments of plastic garbage in the pictures below.




1 mm
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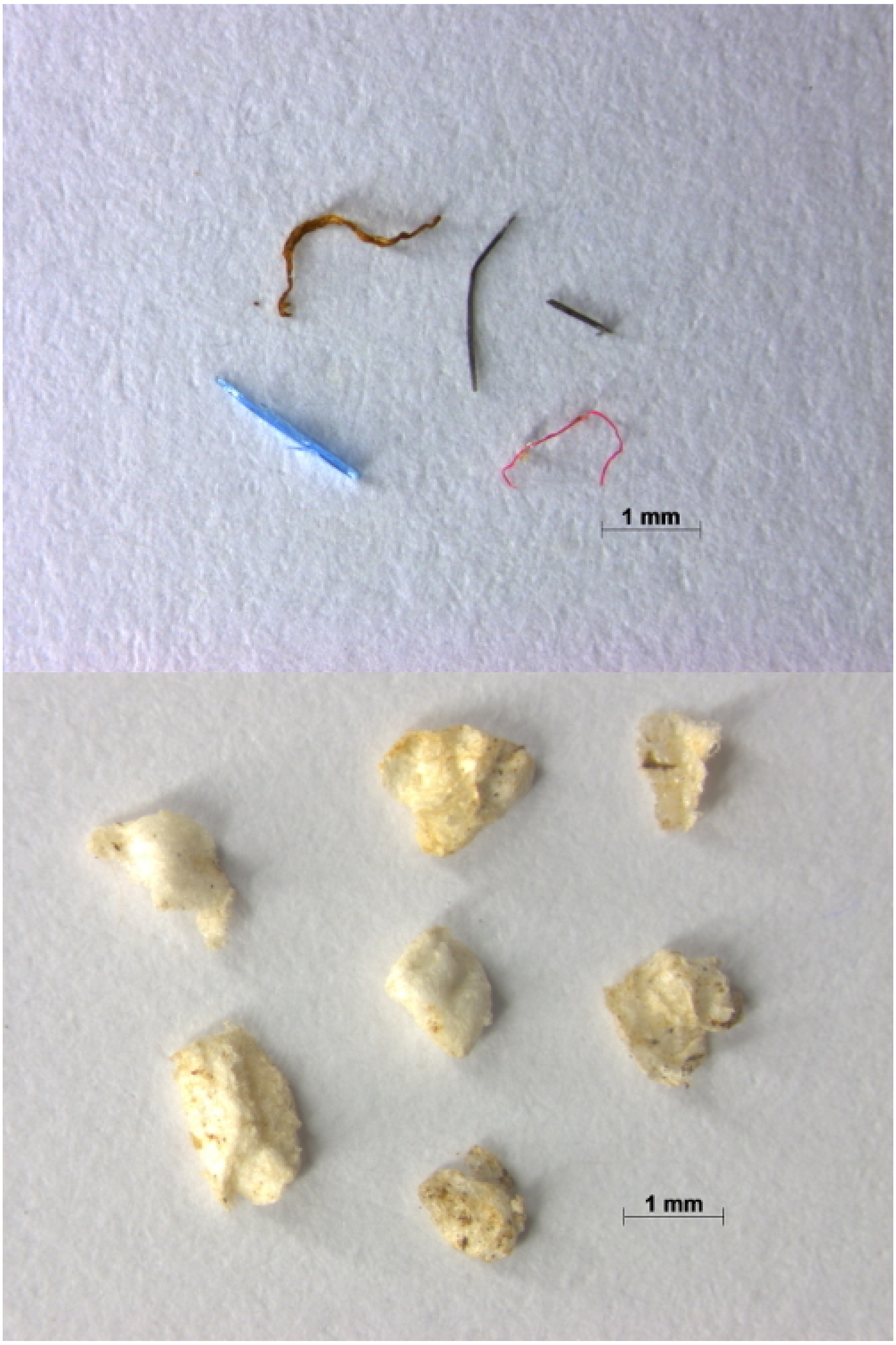

Pictures 1-5. The fragments of plastic garbage found in the water environment.

Thus, it should be noted that plastic waste, including microplastic, represents significant threat for the marine environment. It is obvious that the microplastic problem demands further and detailed studying. Additional researches (especially long-term monitoring) are necessary for assessment of real threat which is posed by the plastic garbage for sea types. Considering the global scales of pollution with plastics, the cost of removal of plastics from the environment will be excessively high. Therefore, the majority of solutions of the problem of pollution with plastics is focused, first of all, on the prevention of the wrong utilization or even on the restriction of usage and production of certain plastic products.

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