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ENVIRONMENTAL PROBLEM OF MICROPLASTICS IN SOUTHERN BESSARABIA

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Abstract

Plastics are widely used due to the variety of their structure and their chemical and physical properties. At the beginning of the twenty-first century, new environmental problems were discovered related to the accumulation of plastics in the environment. During long-term storage, plastics, which are resistant to aggressive environments, undergo degradation and turn into microparticles. These microplastics are found in the air, soil and sediments, fresh water, seas, oceans, plants, animals and even in the human body. The main problem is solid domestic waste disposal in cities and villages of the Ukrainian part of the Danube Delta since the waste is not either sorted or processed. It is simply buried at a certain depth instead. This method of disposal of municipal solid waste poses a significant threat to the groundwater since microplastic particles can accumulate in the ground composition. We have studied drinking water that was taken at a depth of 40 m from the surface of the earth. Water samples were taken at the enterprise with coconut and coal filters for additional purification of drinking water on an industrial scale. This water is purified in order to be sold to the population. We have examined the obtained samples under an optical microscope MICRO med XS-XXXX. The samples were examined under the magnifications of 400x and 900x. However, particles smaller than 100 µm were not detected. It can be assumed that there are no particles smaller than 100 µm either. However, this assumption has not been experimentally proven.
It is necessary to study the distribution of plastic microparticles in the Ukrainian Danube Delta, including the groundwater of the region. The researchers should use the developed methods for the detection of microparticles and nanoparticles of plastic.

Keywords: microplastic, environment, Danube Delta, Labor Training and Technology

1 INTRODUCTION

Plastics are synthetic polymers that possess a variety of chemical structures. They normally have a set of various properties, like heat resistance, incombustibility, chemical resistance and others. Introducing additional chemicals into the composition of plastics can result in changing of their properties. Substances like plasticizers, stabilizers, hardeners and others can be added to plastics. The combination of these additives increases the diversity of the chemical composition of plastics, which explains their wide usage. [1]. Despite the fact that it is difficult to imagine modern life without these materials, plastics do have some significant disadvantages. For instance, when solid wastes containing plastics are burned, dioxins are produced. Another example is the change in the physical and mechanical properties of substances that happens during long-term storage when the macromolecules of these materials are crushed and their molecular weight changes [2;3].

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At the beginning of the twenty-first century, new ecological problems related to the accumulation of plastics in the environment were discovered. During long-term storage, plastics, which are generally resistant to aggressive environments, undergo degradation and turn into microparticles.

The annual global production of plastics is about 335 million metric tons, about 40% of which are disposable products that are immediately thrown away. Consequently, significant amounts of expired plastics accumulate as waste both in managed systems and as litter in the environment. Plastic pollution is found in a wide variety of marine ecosystems, as well as in soil, and in the air and, sadly, it is also an integral part of living organisms. Once in the environment, plastics become fragile and then get fragmented, which results in the formation of microscopic particles called microplastics [4].

Microplastics are defined as particles in the size range from 1 µm to 5 mm, nanoplastics are in the range from 1 nm to 100 nm, and sizes from 100 nm to 1 µm are called subplastics [5]. This classification follows the definitions of the European Commission for engineered nanoparticles (ENP) [6]. There are certain discussions about classes and sizes of nanoplastics, and, as a result, it has been proposed to define the entire nanometer range (1–1000 nm) as nanoplastics [5].

Primary microplastics are particles that have been produced for a specific purpose (for instance, cosmetics). Secondary MP is generated from larger plastic debris through fragmentation. This classification can be applied to laminates and nanoplastics as well. For example, polystyrene (PS) latex or nanometer-sized particles in cosmetics can be described as primary nanoplastic. Particles that originate from larger fragments as a result of fragmentation in the environment will then be classified as secondary nanoplastics. Nanoplastic particles are polymeric nanoparticles. Nevertheless, they are studied in the field of environmental plasticity analysis because they are part of the whole problem of plastic pollution. There is an ongoing debate about what should be considered as made up of "plastic", and about the meaning of the term "synthetic polymer" (including the additives). Typically, particle size and the fact that a particle is water insoluble are the main determining factors for the analysis of plastic particles. However, this excludes important aspects such as chemical composition (polymer type, additives, aging) or whether "plastic" can be attributed to particles made from modified polymers of natural origin (e.g. natural rubbers in tire wear)

These differences need to be taken into account when determining the analytical question for specific typical scenarios. In MP analysis, the sampling and processing of the MP sample are performed with respect to the system under study. The screening procedure is used for aquatic systems [7], density separation for sediments [8;9;10], and chemical digestion for food or biota samples [11;12]. In the case of the last two, MP particles are collected from filters. However, due to the range limitation of these methods, they only work with the micrometer range (with the exception of membrane filtration, section). Therefore, for sub- and nanoplastics, there is a need for sampling that retains such small particles.

Since plastic contamination can be found in many different places, the analytical process begins with a question to be answered (number of plastic particles, their size, PSD or mass of plastic particles per mass or volume of the sample), which in their turn depend on the sample being analyzed. Samples can range from drinking water to food,

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as well as environmental waters, sediments, biota tissue to wastewater treatment plant (WWTP) inlet/outlet effluents, which have varying matrix content that accompanies plastic particles.

Plastic is a ubiquitous material in our lives. Thus, there is a great risk of sample contamination during sample collection and processing. Consequently, appropriate measures must be taken to prevent particle contamination. Instruments and setups should be made of non-polymeric materials to avoid systemic contamination of the sample. In addition, contamination associated with airborne particles and synthetic clothing fibers must be prevented with laminar flow benches. However, it seems unlikely to completely avoid plastic in all components, so a thorough check and evaluation of the extraction method should be done.

2 METHODOLOGY

Methods for determining the size of particles and their morphology are characterized by great diversity. This is due to the difference in the size of microparticles. The most common method is microscopy, which is not controlled by diffraction-limited incident light. There is optical, electron and scanning probe microscopy kinds.

These methods do not allow determining the presence of nano and subnanoparticles. These can only be determined using infrared spectroscopy, Raman microspectroscopy, X-ray photoelectron spectroscopy, and gas chromatography-mass spectrometric methods.

The problem of solid household waste disposal has not yet been resolved on the territory of the Ukrainian part of the Danube region. Instead of being sorted and recycled, the accumulated household waste is simply buried deep in the ground. This way of plastic disposal can lead to soil and groundwater pollution. There is a high probability that plastic microparticles in the air environment of the region are also present. Research is needed to determine if there are any microplastic particles in the environment, including groundwater. At the initial stage, it is advisable to conduct studies using microscopy, which is not controlled by the diffraction limitation of the incident light. When microparticles are detected using these methods, it can be assumed that both nano and subnano particles are present in the region.

Environmental awareness of the population is essential to reduce the harmful spread of microplastics. Public environmental awareness and understanding of the dangers of microplastics is absolutely necessary. Therefore, high-quality and versatile training of future teachers of labor education and technology is essential. The academic curriculum in the state programs of the subjects "Labor training" and "Technology" covers the topics of environmental pollution, which consequently affects the educational programs for the training of future teachers, as they must acquire the relevant competencies.

We have conducted a survey among the population of the Danube region to determine the level of awareness about the problem of plastic degradation. 973 people in different age categories were selected for the study group. 22% of them were school children and adolescents (from 10 to 17 years old), 28% were students of the Izmail State University of the Humanities (from 17 to 21 years old), 41% were employed adult citizens aged 22 to 60 years, 9 % were people of retirement age (from 61 to 80 years).

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The survey showed that 63% of respondents are unfamiliar with such a problem. Moreover, they did not know the causes of plastic degradation and the consequences of microplastics entering the environment. Only 29% of the respondents were aware of this problem, and among the sources of knowledge, they named the Internet and social networks. 8 percent had general ideas about this problem and found it difficult to answer about the source of their knowledge. Thus, the survey shows low awareness among the population of the Danube region about the problems of plastic degradation in the environment. However, the level of awareness should be increased via environmental education of students in secondary schools.

By examining the curricula of secondary schools, we came to the conclusion that the main focus in the development of environmental competence is on subjects such as Biology, Labor Training and Technology. Since the global impact of microplastics on the environment has been actively studied only in recent years, school teachers are hardly aware of this issue. Therefore, we consider it necessary to study the problem in the context of secondary school teacher training.

The Izmail State University for the Humanities trains specialists in the educational program "Secondary Education: Labor Training and Technology" of the first and second levels of higher education. Among all competencies, it is worth highlighting general (GC1, GC2, GC3, GC6) and professional competencies (PC2, PC10, PC14), which will allow students to put their knowledge into practice [13].

During the study of the Human Rights and Civil Society educational component, it is essential to study the legislative framework of Ukraine and other countries of the world relating to environmental pollution, waste disposal, and waste sorting in order to consider and choose the best decisions and practices concerning this issue.

The educational component of Materials Science offers a broad picture of the chemical and physical properties of microplastics and their behavior in various environments. The subject also teaches methods of cleaning or preventing contamination. We recommend that special attention should be paid to the discipline of Information and Communication Technologies in the professional area, and although this educational component does not directly shape the environmental competence of students, it allows you to master a large number of IT tools that will effectively visualize the necessary information, present it in a form accessible and appealing to the student while developing cognitive abilities of the students. These tools include interactive games, exercises, videos, online multimedia group whiteboards, mobile apps, and so on.

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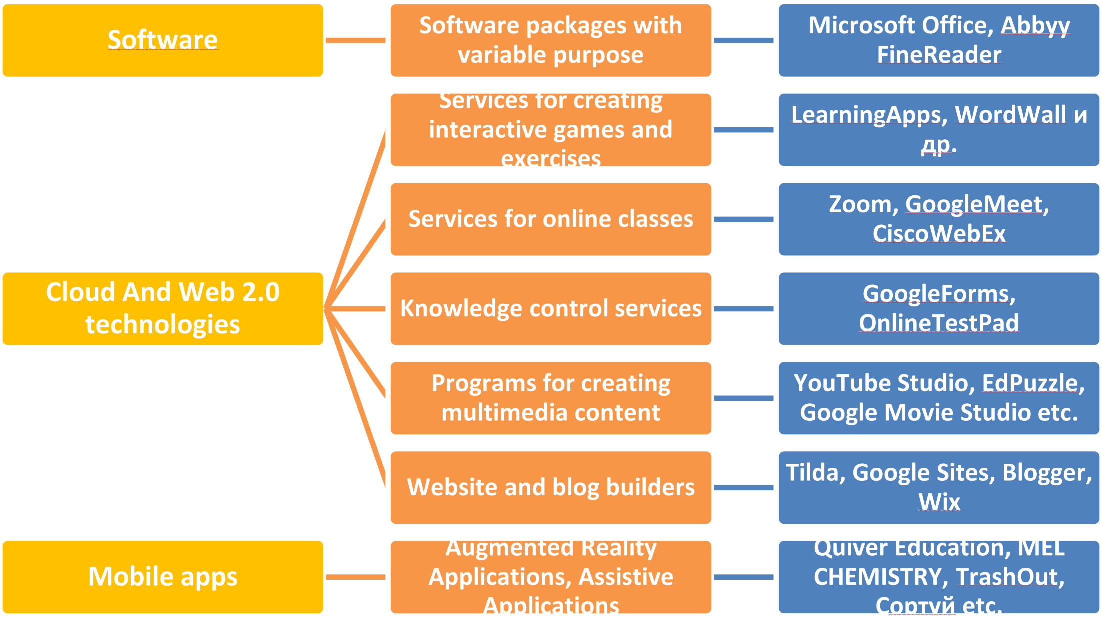

Figure 1. Applications and services necessary for the formation of environmental competence of students in the lessons of labor training and technology

We analyzed drinking water, which was extracted at a depth of 40m from the surface of the earth. There are enterprises in Izmail that use filters for additional purification of drinking water on an industrial scale in order to sell it to the population. We took samples of the water that was used to wash the filters after they were changed. They were washed with distilled water in a metal bucket in order to exclude the possibility of contamination of the samples with environmental microplastics.

We examined the obtained samples under an optical microscope MICRO med XS-XXXX. The samples were examined under the magnification of 100x40 and 100x900. Visual detection of microplastics has a limitation in accuracy. The human eye, equipped with optical microscopes, is not able to see particles smaller than 100 µm. Particles that are 100 µm in size were not detected. It can be assumed that there are no particles smaller than 100 µm either although this assumption has not been experimentally proven.

3 RESULTS

We did not detect any plastic microparticles in the analyzed samples. The wells, from which drinking water is obtained for the population of Izmail, are located at the depth of 40 meters from the surface of the earth and at a distance of 10 km from the burial places of municipal solid waste. Municipal solid waste had been disposed of by incineration for a long period. The burial technology has only been practiced for the last eight years. Obviously, this is an insufficient period for the decomposition of plastic in large quantities and the migration of microplastics over such a distance. However, the fact of plastic decomposition is scientifically confirmed and its burials are inevitably gradually decomposing and will eventually become part of drinking water. We will drink water with plastic that we have buried. To determine the stage of decomposition of buried plastic, it is necessary to continue the analysis of groundwater located directly in the area of the landfill and closer to the surface of the water. It is necessary to explore the possibility of taking samples from private wells located near country houses as well as from the wells located in the ravines. In these areas, groundwater is located at the level of the depth of plastic burials.

4 CONCLUSIONS

Numerous scientific publications confirm the fact of plastic destruction and its fragmentation into microparticles and nanoparticles. The practice of burial of municipal solid waste as a disposal means raises the possibility of contamination of soil and groundwater with microplastics. We analyzed tap drinking water which is supplied on Mira Avenue, in the city of Izmail. No microplastics were found in the analyzed groundwater located at a depth of 40m. Nevertheless, it is still necessary to continue research and determine the presence or absence of microplastics in groundwater located closer to the surface of the earth and to the landfill.

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