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'The invisible threat to agricultural lands: Maria Shilova on the path of microplastics and their penetration into plants'

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We speak with Maria Shilova — a researcher at the Center for Clean Technologies and Efficient Use of Biomass (CCBRE) and a doctoral student dedicated to studying one of the greatest environmental threats of our time — microplastics, which permanently pollute soils and roadside areas. Research at the Center for Clean Technologies focuses on developing methods for their detection, quantification, and tracking in the soil environment. This is the first and mandatory step towards creating effective purification technologies.

Together with Maria Shilova, we will also seek answers to the questions: How do microplastics penetrate soil and plants, what technologies do scientists use to detect microscopic particles, the rate at which microplastics spread in soils depending on their type and the type of polymer itself, how municipalities, state institutions, and private businesses could apply the research in practice, and last but not least, why personal example is important for building sustainable habits in the community.

What is your main role at the Center for Clean Technologies (CCBRE) and why did you focus your research specifically on microplastic pollution in roadside and urban soils?

At CCBRE, I work as a junior research associate and am developing my doctoral project "Migration of Microplastics in Soils" under the scientific supervision of Prof. Violina Rizova and Prof. Petar Mandaliev.

Microplastics are a relatively new and extremely topical subject in scientific research. The number of scientific articles on the properties of microplastics, methods for their identification, and their environmental impact is growing exponentially. Until the beginning of the 21st century, the topic of microplastics was relatively poorly studied, and it was only in the last two decades that it attracted serious attention from the scientific community, even though humanity has been widely using polymer-based products for about 80 years. But even with such great diligence from scientists, which we have observed in recent years, there are questions that remain controversial

and unresolved. My task is to seek answers to these questions during my doctoral studies. I will hardly find them, of course, but even a grain of new knowledge about microplastics can be very important for subsequent research.

As for personal preferences in the scientific field — I have always been interested in working with technospheric pollutants; they are not natural to ecosystems, they have completely different physico-chemical properties compared to natural components, and, of course, alongside current global issues, there are always smaller, practical questions, and by solving them, we slowly but surely move towards understanding the overall picture.

What is the mechanism of migration of these microplastics to adjacent agricultural lands, and do you have specific data on how they change soil properties and how they enter plants?

There are many migration mechanisms: atmospheric transport and the movement of living organisms, river, surface, and sewage channels.

For example, if there is a road near agricultural land (and there certainly is, because agricultural machinery needs to move), then a large amount of microplastics, formed as a result of the abrasion of car tires, will be concentrated directly on the road and roadside areas. Under the influence of wind, they, along with other road dust, can be transported over very long distances, as they are very small (microplastics are on the order of microns in size), which means they are quite light and can travel long distances through atmospheric currents.

Microplastics can enter agroecosystems with water during irrigation; surface waters are most often used for irrigation, and they themselves already contain microplastics. There are publications on the detection of microplastic particles in the tributaries of the Danube, Maritsa, and the Batak cascades. In any case, they ultimately end up in the soil of agricultural lands.

And, of course, plastic mulching and the use of slow-release fertilizers are the most significant sources of pollution of agricultural lands. Under the influence of ultraviolet radiation, mechanical impact, biological activity, and temperature stress, large plastic particles break down into smaller and smaller particles, and the process is quite lengthy. At a certain point, microplastics reach sizes at which they practically cease to degrade biologically.

The effect of microplastic particles on soil has already been sufficiently studied. To date, it is known that microplastics are very strong adsorbents and, together with the substances retained on their surface, affect soil acidity, electrical conductivity, geochemical balance, density, and structure. Along with microplastics, heavy metals, dioxins, pesticides, dyes, stabilizers, and other chemicals enter the soil — in general — a wide range of potentially hazardous chemical substances.

Microplastics can penetrate plants during watering (if the water is contaminated), through epidermal cells in plant roots (through interaction with contaminated soil), and through the gas-exchange pores of leaves (more often due to atmospheric transport of particles). If the plastic is larger than 10 microns, it will encounter an insurmountable physical barrier and simply will not be able to enter the plant, unless the plants have damaged areas. Microplastics smaller than a micrometer act on them at the subcellular and molecular level. Microplastics ranging in size from 1 to 10 micrometers migrate inside the plant.

What technologies do you use in the laboratory to detect these microscopic particles, and what specific solutions are you developing at the Center for Clean Technologies (CCBRE) for the detection and quantification of microplastics in the soil environment?

The easiest way to detect microplastic particles is to look at them under a microscope. This is feasible in almost any laboratory, a fairly fast and inexpensive method through which microplastic particles can be visually identified, but it is not always sufficient. First, sometimes the optical resolution of the device does not allow reliable detection of all microplastic particles, and second, some minerals and organic components of the soil may look like microplastics but are not.

Therefore, we use a more reliable method of chemical analysis — Fourier Transform Infrared Spectroscopy (FTIR), through which we obtain reliable confirmation of the chemical composition of the polymer. The essence of the method is that the sample is irradiated with infrared light — molecular bonds in the polymer absorb radiation at precisely defined frequencies characteristic of the respective functional groups. The detector records which frequencies were absorbed, builds a spectrum, and based on the position of the characteristic bands (a kind of "fingerprint"

of the substance), it determines what type of polymer the particle is made of. One of our main tasks in the coming year is to determine the rate at which microplastics spread in soils depending on the soil type and the type of polymer itself. The purification of soils contaminated with microplastics is still a serious scientific challenge worldwide. Therefore, at present, at CCBRE we are focused on developing methods for their detection, quantification, and tracking in the soil environment. This is the first and mandatory step towards creating effective purification technologies. By studying the migration of different polymers and their interaction with different soil types, we are creating a scientific basis for future remediation solutions for contaminated sites and for limiting the risk of microplastics entering agricultural crops and the food chain.

How could municipalities, state institutions, and private businesses apply your research in practice to reduce pollution?

The results of our research can help identify the main sources of microplastics and identify the areas at highest risk of pollution. If we know where the particles come from and how they spread in different soil types, we can propose more effective measures to limit them. For municipalities, this means better monitoring of roadside territories, urban green areas, and zones with intense automobile traffic. State institutions can use the scientific data when developing policies and standards for the control of microplastics in soils and waters, as well as in environmental risk assessment.

For their part, businesses can direct their resources towards the development of more sustainable materials, reducing the use of single-use plastic products, and implementing technologies that limit the release of microplastics already in the production process. In the long term, the most effective approach is prevention. It is much easier to prevent microplastics from entering the environment than to subsequently try to remove them from soils and water resources. This is precisely why scientific research and practical measures must go hand in hand.

Will CCBRE's data help update European environmental legislation, and at the same time — what are the most effective steps to reduce microplastics in our daily lives?

Scientific evidence is the foundation of any effective environmental legislation. The more reliable information there is about the distribution, migration, and impact of microplastics, the more well-founded future regulatory acts can be at the national and European level. Our work can contribute to this common body of knowledge used by the scientific community and institutions in decision-making.

Let us recall the words of René Dubos: "Think globally, act locally." The greatest change that can occur regarding the study of microplastics is the standardization of all methods, from sampling to data verification. Only under conditions where scientists around the world act according to the same protocol during research will we have the opportunity to rationally look at the picture of the world and say with certainty: how dangerous microplastics actually are under given conditions.

We are all consumers. Now we can make the choice to change our consumption habits: choose cosmetics or household chemicals without microplastics (in some countries, the production of such products is already banned at the national level), minimize the use of plastic packaging, use reusable bags or market nets when shopping in grocery stores, and avoid choosing clothes made of synthetic fabrics. The consumer has the power to choose what to use, and if we decide to slowly give up synthetics, merchants and manufacturers will be stimulated to adapt to new consumer attitudes. I think that on such small, personal choices, something very big and important is built every day.

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