

The widespread use of plastics in many areas of life has led to a global problem of environmental pollution with plastic waste in recent decades. Research on the impact of plastics on aquatic ecosystems have shown that under the influence of various environmental factors, they decompose into micro- and nanoparticles (MP/NP), which are absorbed by aquatic organisms and become involved in food chains. The intensive use of plastics results in the widespread presence of MPs and NPs in the oceans, soil, atmosphere, and even in drinking water and food, as they have been observed to be released from plastic packaging and bottles. Additionally, they are also intentionally produced and added to everyday products, such as hygiene or cosmetic products. Current knowledge about the toxic effects of small particles of various origins on biological systems rises concerns about the potential health effects of environmental exposure to micro- and nanoplastics. Therefore, in recent years, there has been an intensive development of research on the toxicity of MPs and NPs, especially in aquatic organisms. However, the health effects of mammalian exposure to plastics remain unclear due to the lack of comprehensive risk assessment studies.

Recent reports indicate that plastic particles may accumulate in the brain of mammals. This indicates their ability to cross the blood-brain barrier (BBB) at the level of cerebral microvessels. Based on these data, we assume that nanoplastics, passing through cerebral microvessels, may disrupt their morphology and functions. Therefore, as part of this project, we propose to conduct comprehensive research on the neurotoxic effects of polystyrene nanoparticles (PS-NPs) at the level of the functional unit of brain microvessels called the neurovascular unit (NVU).

The research will be conducted in an experimental model of developmental neurotoxicity, in which PS-NPs will be administered chronically to immature rats, imitating environmental exposure. The dose of PS-NPs was calculated based on available literature data estimating potential daily intake by humans. Oral administration of PS-NPs reflects the most common route of exposure through ingestion of contaminated food or water. The choice of the model is justified by both the knowledge that young organisms are more susceptible to the action of harmful substances, including nanoparticles, than adults, as well as the lack of research on the neurotoxic effect of PS-NPs on organisms at the developmental stage.

The main research goal is to assess whether PS-NPs have a negative effect on cerebral microvessels when entering the brain. We hypothesize that prolonged exposure of immature rats to PS-NPs may lead to disruption and increased permeability of the BBB, the physiological function of which is to ensure homeostasis through the selective transport of substances between the blood and the brain. This may contribute to the increased transfer of toxic nanoparticles to the brain. Functional studies assessing BBB permeability will be complemented by biochemical and molecular studies of protein markers specific to the cellular components of the NVU and extended by ultrastructural analysis of cerebral vessels using electron microscopy.

Moreover, we suggest that PS-NPs, after being absorbed in the intestine and entering the blood, can be transported there via the so-called extracellular vesicles (EVs), which constitute an intercellular communication system that ensures the transport of various substances between cells and tissues. Such vesicles containing nanoparticles may be a mechanism that facilitates the spread of the toxic effect of nanoparticles in the body. In order to confirm this hypothesis, EVs fractions will be isolated from the blood of animals exposed to PS-NPs, in which NPs will be visualized and the molecular and biochemical analyzes of EVs markers will be conducted.

Due to the widespread use of plastics in numerous consumer products and the intensive accumulation of plastic waste, and their low biodegradability, the risk of environmental exposure is constantly increasing. The problem of plastic pollution is currently a priority for many government agencies around the world. Therefore, it is important to investigate and understand the mechanisms of the potential neurotoxic effects of nanoplastics. The planned research is important both in an ecological context and from the public health perspective, and the main goal of this project is closely related to current global research directions that focus on assessing potential health risks arising from long-term exposure to nanoplastics.

