SUCCESS STORY

microONE
Microplastic Particles: A Hazard for Human Health

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Module

Type of project: Labeling–Evaluation–Model Systems,01/2022-12/2025, multi-firm

BIODISTRIBUTION OF NANOPLASTICS IN MICE: ADVANCING ANALYTICAL TECHNIQUES USING METAL-DOPED PLASTICS

COMBINING ANALYTICAL METHODS LIKE XFI, ICP-MS AND IMC WITH PALLADIUM DOPED POLYSTYRENE NANOPLASTICS (Pd-NPs) PROVIDES A SIGNIFICANT ADVANCEMENT IN THE SEARCH FOR HIGH-PRECISION ANALYTICAL APPROACHES TO STUDY PLASTIC PARTICLES IN VARIOUS COMPLEX METRICES AND INVESTIGATE THE SPATIAL DISTIRBUTION OF PARTICLES EVEN DOWN TO THE CELLULAR LEVEL.

The contamination with micro- and nanoplastic particles (MNPs) in environmental and biological systems has raised concerns about their potential negative impacts. The increasing human exposure to microplastics (MP) and nanoplastics (NP) led to a growing awareness of potential adverse health effects related to uptake and chronic exposure. Various studies have already shown that NPs can cross biological barriers and accumulate within cells, triggering stress reactions and immune responses. However, some effects might remain unclear, partly due to the analytical challenges of detecting especially the highly infiltrating nanoplastic particles at trace concentrations.

To overcome analytical challenges when assessing NPs in biological samples in laboratory settings, scientists from the FFG-funded project ***microONE***, joined forces together with international scientists from University of Hamburg, ETH Zürich and University of Bern to resolve these issues in a multimodal approach.

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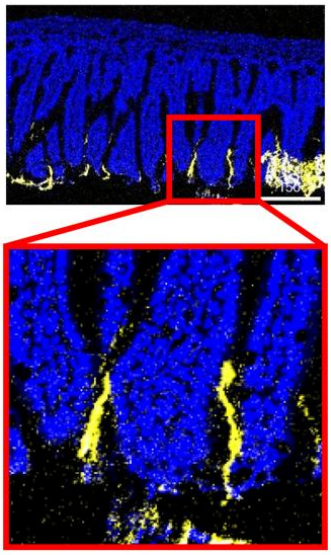
Joining forces – combining analytical methods to track down nanoplastics

Using a workflow combining three complementary methods, namely inductively coupled plasma mass spectrometry (ICP-MS), X-ray fluorescence imaging (XFI), and imaging mass cytometry (IMC) for detection of model metal (palladium)-doped polystyrene NPs (Pd-NPs), we were able to track the time-dependent uptake and biodistribution of these nanoplastic particles in mice and even make quantitative assumptions. While ICP-MS can quantify metals and metalloids in trace concentrations in different matrices, XFI and IMC provide additional spatial resolution, even down to the cellular level.

Shedding light on nanoplastic biodistribution

Using this workflow of complementary analytical methods the team of Lukas Kenner (CBmed and Medical University of Vienna) and Verena Pichler (CBmed and University of Vienna) investigated the temporal distribution and accumulation of Pd-NPs in model mouse systems, covering different biological conditions, dosages, and time frames. Short-term exposure to high particle doses showed a clear excretion pathway from the gastrointestinal tract into feces, however low amounts could be also detected in distant organs like in pancreas, liver, kidney, and blood. Long-term exposure scenarios, including a genetic disease model of intestinal polyps (APCmin+), revealed a delayed transition time through the gastrointestinal tract for nanoparticles in the disease model. Furthermore, increased numbers of Pd-NPs could be detected in liver, kidney, and brain, indicating that continuous MNP exposure could lead to tissue accumulation with currently unknown consequences.

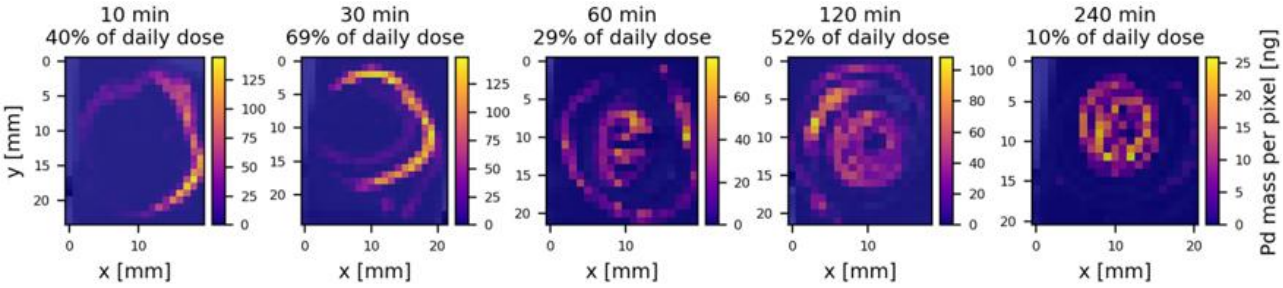


The image shows an IMC tissue image of the small intestine – overview and close-up magnification. Ingested Pd-NPs (in yellow) are located mainly in the intestinal lumen between the villi, but are also taken up into the tissue (blue).

Figure from Paper draft: Staufer et al., Biodistribution of Nanoplastics in Mice: Advancing Analytical Techniques Using Metal-doped Plastics. Submitted to ACS Nano

Impact and effects

The team of the ***microONE*** project together with other international scientists evaluated a valuable new analytical workflow, that alongside model metal-doped Pd-NPs, proved to be a positive advancement in the search for analytical approaches to study plastic particles (even on the nanoscale) in various complex matrices and investigate the spatial distribution of particles down to the cellular level. The striking new data on nanoplastic biodistribution is (to the best of our knowledge) among the first studies to give even quantitative measures and we expect to publish this data soon in 2025.



The image shows an XFI map of Pd-NPs translocating in a timely manner through the small intestine – from the outside (upper part) to the center (lower part).

Figure from Paper draft: Staufer et al., Biodistribution of Nanoplastics in Mice: Advancing Analytical Techniques Using Metal-doped Plastics. Submitted to ACS Nano

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- Medical University of Vienna, Austria
- THP, Austria
- TissueGnostics, Austria

Associated partners

- University of Hamburg, Germany
- ETH Zürich, Switzerland
- University of Bern, Switzerland

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