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Multi-Omics Approach on the Ecotoxicological Assessment of Microplastics

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Extended Abstract

In recent years, the production of plastic materials has shown dramatic growth worldwide. Their ever-expanding use leads to their subsequent entry into the environment, where these substances pose a significant risk to living organisms. Particularly, microplastics (MPs) are a new type of pollutant, including very small (<5-mm) pieces of plastic. The continuous increase in their concentration has recently become a major environmental issue because of their persistence, ubiquitous occurrence, and potential toxicity in aquatic habitats. Several ecotoxicological studies have reported the potential effects of MPs on aquatic and terrestrial environments. However, there are only a few studies that aim to understand the toxicological analysis of MPs with environmental pollutants in aquatic environments. In addition, MP's toxicological effects on freshwater aquatic organisms are still scarce. Most studies have reported the occurrence and distribution of MPs in freshwater and marine environments, but a comprehensive study of the effects of different types and sizes of MPs on freshwater aquatic organisms is lacking. Therefore, the objective of this study was to assess the ecotoxicological effect of MPs on zebrafish using the multi-omics approach, including genomics, transcriptomics, and metabolomics, to explore the ecotoxicological effects of MPs on gut microbiomes, metabolomic profiles, and genome-wide expression profiles is the scant research of ecotoxicology based on multi-omics (i.e., metabolomics and transcriptomics).

High-throughput untargeted metabolomics using liquid chromatography with tandem mass spectrometry (LC-MS/MS) provided comprehensive insights into the metabolic responses of zebrafish exposed to PE (polyethylene) and PES (polyester) MPs. Statistical analysis of metabolomics data indicated that 39 and 27 metabolites, such as lysophosphatidylcholine, phosphocholine, phosphatidylserine, triglyceride, glycosphingolipid, psychosine, 8-amino-7-oxononanoate, cholesterol fatty acid ester, phosphatidylinositol, n-Triacontanol, were significantly altered in PE- and PES-exposed zebrafish, respectively. Furthermore, the enrichment pathway analysis unveiled the synthesis of the structural and functional lipids, signaling molecules, fatty alcohol metabolism, and amino acid metabolism, which was considerably perturbated in MPs-exposed zebrafish. In addition, high-throughput DNA sequencing was conducted to examine changes in gut microbiota in the MPs-treated zebrafish. The MPs exposure increased in the relative abundance of Fusobacteria and Proteobacteria, while the relative abundance of Firmicutes declined in MPs-treated zebrafish. Also, microbial diversity and linear discriminant analyses indicated microbiota dysbiosis, metabolomic dysregulation, and oxidative stress. Taken together, the acute exposure of MPs at environmentally relevant concentrations could disrupt the metabolic interaction via the microbiota-gut-liver-brain relationship, implying gastrointestinal and neurological/immune disorders in zebrafish.