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Microplastics' Impact on European Seabass: Unraveling Neurotoxicity, Oxidative Damage, Energy-Related Changes and Mercury Bioaccumulation

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Abstract

Microplastic pollution has become a global concern, posing significant threats to both the environment and human health. This study delved into the deleterious effects of microplastics and mercury on the European seabass (*Dicentrarchus labrax*), a marine fish widely consumed by humans. To investigate this, a short-term (96-hour) laboratory bioassay was conducted, wherein juvenile fish were subjected to varying concentrations of microplastics (0.26 and 0.69 mg/L), mercury (0.010 and 0.016 mg/L), and binary combinations of these substances at identical concentrations. These exposures were administered through test media. The outcomes of the study indicated that microplastics, mercury, and their combinations elicited toxic effects. Isolated exposure to microplastics and mercury led to neurotoxicity, as evidenced by the inhibition of Acetylcholinesterase (AChE) activity. Additionally, there was an observed increase in Lipid Oxidation (LPO) in both brain and muscle tissues, along with altered activities of energy-related enzymes, such as Lactate Dehydrogenase (LDH) and Isocitrate Dehydrogenase (IDH).

Keywords: Dicentrarchus labrax • Microplastics • Mercury

Introduction

In light of these findings, several significant conclusions can be drawn. Microplastics possess the capacity to influence the bioaccumulation of mercury within juvenile *D. labrax*, thus altering the levels of this heavy metal within the fish. Furthermore, the study underscores that microplastics, mercury, and their combined exposures at concentrations within the parts per billion range induce neurotoxicity, oxidative stress, and cellular damage in the studied juveniles. Importantly, mixtures featuring the lowest and highest concentrations of these components evoke distinct effects on certain biomarkers, reinforcing the complexity of their interactions.

These results, combined with existing literature, raise concerns about the potential impacts on higher-level predators and humans who consume fish exposed to microplastics and heavy metals. Consequently, this study emphasizes the necessity for further research to comprehensively understand and address the intricate interplay between microplastics, pollutants, and marine organisms, as well as the potential implications for human health.

Microplastics, small plastic particles measuring less than 5 millimeters in diameter, have emerged as a global environmental concern due to their widespread presence in aquatic ecosystems. Among the numerous consequences of microplastic pollution, its potential to affect marine organisms, including the European seabass (*D. labrax*), has raised alarms within the scientific community. Recent studies suggest that microplastics not only endanger marine life by their direct ingestion but also amplify the effects of other pollutants, such as mercury. This article explores the intricate relationship between microplastics, neurotoxicity, oxidative damage, energy-related changes, and the bioaccumulation of mercury in the European seabass.

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Description

Microplastics: A growing threat

Microplastics originate from various sources, including the fragmentation of larger plastic items and the degradation of plastic waste. These minute particles find their way into aquatic ecosystems, where they are ingested by marine organisms at various trophic levels, including fish. The European seabass, a highly-valued species for both fisheries and aquaculture, is particularly susceptible to microplastic exposure due to its feeding habits and ecological niche.

When the substances were combined, all mixtures exhibited substantial inhibition of brain AChE activity (ranging from 64% to 76%) and a notable rise in LPO levels in both brain (2.9 to 3.4-fold) and muscle (2.2 to 2.9-fold). However, the concentration-dependent relationship was not consistent across all effects. Remarkably, mixtures containing varying concentrations of microplastics displayed divergent impacts on IDH and LDH activity.

Mercury was found to accumulate in both brain and muscle tissues, with calculated bioaccumulation factors of 4 to 7 and 25 to 40, respectively. Notably, an intriguing interaction between mercury and microplastics emerged from the analysis of mercury concentrations in these tissues. It was observed that the presence of microplastics influenced the decay of mercury in the surrounding water. Moreover, this decay rate was notably higher when fish were present in the environment compared to their absence.

Neurotoxicity and oxidative damage

Research has demonstrated that microplastics can cause adverse effects on the nervous system of marine organisms, including fish. In the European seabass, exposure to microplastics has been linked to neurotoxicity, which may lead to altered behavior, impaired sensory perception, and disrupted neurological functions. Furthermore, microplastics can trigger oxidative stress, a condition in which there is an imbalance between the production of reactive oxygen species (ROS) and the organism's ability to detoxify them. ROS-

induced oxidative damage can result in cellular dysfunction, tissue damage, and even cell death [1-3].

Energy-related changes

The energy balance of marine organisms is crucial for their growth, reproduction, and survival. Microplastic exposure has been shown to disrupt the energy-related processes in fish, including alterations in metabolism, reduced feeding behavior, and compromised energy storage. Such changes can impact the overall health and fitness of the European seabass, affecting its ability to withstand environmental challenges and maintain its population.

Mercury bioaccumulation and microplastics interaction

Mercury is a toxic heavy metal that is naturally present in the environment but has been significantly amplified by human activities, such as industrial processes. It poses a serious threat to marine organisms, as it can accumulate in their tissues over time through a process known as bioaccumulation. Interestingly, recent studies have indicated a potential interaction between microplastics and the bioaccumulation of mercury in fish.

Microplastics have been shown to facilitate the transport of pollutants, including mercury, in the aquatic environment. When ingested by the European seabass, microplastics may absorb and concentrate mercury from the surrounding water, leading to increased mercury exposure for the fish. This synergistic interaction between microplastics and mercury bioaccumulation can intensify the toxic effects of both pollutants, heightening the risk for neurological damage and other health issues in marine organisms [4-6].

Conclusion

The consequences of microplastic pollution extend far beyond its physical presence in marine ecosystems. As evidenced by the case of the European seabass, microplastics have the potential to induce neurotoxicity, oxidative damage, and energy-related changes, further exacerbated by their interaction with the bioaccumulation of mercury. To address these complex challenges, interdisciplinary research is essential, involving ecologists, toxicologists, and policymakers. Efforts to mitigate microplastic pollution should be prioritized to ensure the long-term health and sustainability of marine environments and the species that inhabit them.

Acknowledgment

None.

Conflict of Interest

None.

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