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ASSESSING MICROPLASTIC CONTAMINATION IN FRESHWATER GASTROPODS: A CASE STUDY OF INVASIVE *Potamopyrgus antipodarum* (J. E. Gray, 1843) IN TÜRKİYE

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Abstract

Plastics have become one of the most significant environmental threats due to their widespread use and persistence in ecosystems. Among these, microplastics (MPs) pose severe risks to aquatic organisms. This study investigates MP contamination in the invasive freshwater gastropod *Potamopyrgus antipodarum* from Kocabaş Stream, Türkiye. *Potamopyrgus antipodarum* is widely distributed in freshwater ecosystems and serves as a bioindicator species for pollution studies. Despite the growing concern over MP pollution, research on its impact on gastropods remains limited. Sampling was conducted in September 2024 at Kocabaş Stream, an ecologically important water body exposed to domestic, industrial, and agricultural pollution. A total of 100 individuals were collected using an Ekman-Birge Grab and a D-frame hand net. Samples were preserved in ethanol and dissected to analyze MP ingestion. Laboratory analysis was performed using a Zeiss Stemi 508 stereo microscope. This study provides the first evidence of MP contamination in *P. antipodarum* from this region. The findings highlight the potential role of freshwater gastropods in monitoring MP pollution and emphasize the need for further research on their ecological impacts. Understanding MP ingestion in bioindicator species such as *Potamopyrgus antipodarum* is crucial for evaluating freshwater ecosystem health. Our findings emphasize the ecological significance of freshwater gastropods and highlight their potential use in biomonitoring programs, reinforcing the need for conservation strategies in freshwater habitats

Keywords: Microplastic contamination, *Potamopyrgus antipodarum*, freshwater gastropods, bioindicator species, Kocabaş Stream (Northwestern Türkiye)

Introduction

Plastics, widely used in modern life, have become one of the most pressing environmental threats. Recent studies indicate that in 2023, a staggering 413.8 million tons of plastic were produced globally. Most of these plastics are not recyclable and are introduced into the environment through various direct and indirect pathways (Plasticseurope, 2024).

Microplastics (MPs) are defined as plastic particles smaller than 5 mm. They are categorized into two main types: primary and secondary microplastics. Primary microplastics are intentionally produced for utilize in various products, including cosmetics, personal care items, and cleaning agents (De Sá et al., 2018). Secondary microplastics result from the fragmentation of macro and meso plastic waste over time. Studies have demonstrated the presence of MPs in all water ecosystem, underscoring the alarming nature of this pollution (Xu et al., 2021). Consequently, the detrimental effects of MPs on ecosystems exhibit considerable variation depending on their diverse densities, types, and forms (Yurtsever, 2015; Zilifli & Tunçer, 2021; Gündoğdu et al., 2024; Terzi et al., 2024).

Microplastics appear in various colours, sizes, and morphologies in both marine and freshwater ecosystems. They undergo degradation through physical and chemical processes in these habitats. (Collard et al., 2021; Kenan & Teksoy, 2022). This degradation enhances their surface area, facilitating the adsorption of various hydrophobic organic pollutants, heavy metals, pesticides, and xenobiotic chemicals due to their hydrophobic nature (Andrady, 2011; do Sul & Monica, 2014; Horton et al., 2017; Torres et al., 2020; Collard et al., 2021). The diverse feeding habits of organisms, such as ingestion, filter feeding, suction feeding, and grazing, underscore the multifaceted negative impacts of MPs on organisms (Germanov et al., 2018; Fueser et al., 2019; Curren et al., 2024; Özsoy et al., 2024). When bioindicator species are exposed to food contaminated with MP pollution, significant threats are posed to these species (Ding et al., 2021).

Gastropods constitute an integral part of the food web due to their species diversity, abundance, and variability in size (Covich, 2010). One of the primary reasons gastropods are considered superior bioindicators is their widespread presence in diverse aquatic environments, including freshwater, marine, and even terrestrial habitats (Srivastava & Singh, 2020). This broad distribution allows for the monitoring of environmental changes across various ecosystems (Gawad, 2018). Additionally, their limited mobility or sessile nature ensures that they are directly exposed to local environmental stressors, making them reliable indicators of habitat-specific conditions (Srivasta & Singh, 2020). They play a critical role in fulfilling the nutritional requirements of various organisms, including crabs and seabirds, thereby forming an essential link in the trophic chain (Curren et al., 2024). Given their status as bioindicator species, gastropods are extensively utilized in pollution studies to evaluate anthropogenic impacts (Hall et al., 2009).

Gastropods are widely recognized as effective bioindicators in aquatic ecosystems due to their high sensitivity to environmental changes and their ecological significance. Compared to other aquatic organisms, gastropods exhibit several characteristics that make them particularly suitable for biomonitoring purposes. These include their broad geographical distribution, limited mobility, long lifespan, sensitivity to pollutants, bioaccumulation capabilities, and ease of sampling (Samsi et al., 2017; Chukaeva & Petrov, 2023).

This characteristic makes them valuable for assessing long-term pollution levels and the presence of persistent contaminants in aquatic environments (Walsh et al., 1994). Another advantage of using gastropods as bioindicators is their relatively long lifespan, which allows for the monitoring of environmental changes over extended periods. This is especially important for assessing the cumulative impacts of pollutants and for understanding long-term trends in ecosystem health (Samsi et al., 2021). Moreover, their ease of sampling and identification makes them practical for large-scale biomonitoring programs.

Gastropods possess a radula, which is a robust muscular structure located beneath the mouth with a rough-textured surface. They use this radula to bite into plant or animal tissues for feeding. (Dillon, 2000; Keeton et al., 2004). With these characteristics, gastropods have the potential to elucidate the pathways through which microplastics transfer from the environment to organisms and further into the food chain.

Potamopyrgus antipodarum (J. E. Gray, 1843), commonly known as the New Zealand mud snail, belongs to the family Tateidae within the subclass Caenogastropoda. It is recognized as one of Europe's 100 most dangerous invasive species and has triggered global concerns, leading to the implementation of management initiatives (Nentwig et al., 2018; Geist et al., 2022). *Potamopyrgus antipodarum* exhibits extensive distribution across freshwater basins in nearly all European countries, as well as in North America, Australia, and Türkiye's Aegean, Marmara, and Black Sea regions (MolluscaBase eds., 2025).

The species was first recorded in Türkiye by Bilgin (1980). With the proliferation of research on gastropods in recent years, there has been a subsequent increase in reports detailing its distribution across various regions (Odabaşı & Arslan, 2015; Odabaşı et al., 2019; Yıldırım et al., 2022). *P. antipodarum* has been recorded in 18 regions within Türkiye's freshwater basins (Tarkan et al., 2021).

The detrimental effects of MP pollution on organisms have been extensively documented in many studies (Gündoğdu, 2019; De Sá et al., 2018; Vo & Pham, 2021; Tunçer et al., 2019). However, investigations focusing on gastropod taxa, especially in freshwater species, have been comparatively limited in the context of MP pollution research relative to studies on other organisms (Imhof & Laforsch, 2016; Weber et al., 2021).

This study will be the first microplastic research conducted on the taxon *P.antipodarum* in the Kocabaş Stream. The Kocabaş Stream, distinguished by its rich ecological diversity of benthic invertebrates, is known to be subjected to domestic, industrial, and agricultural pollution (Akbulut et al., 2014; Yayıntaş et al., 2007). However, despite its significance, there is a conspicuous absence of studies focusing on MPs concerning gastropod taxa in this region. This study aims to provide evidence for the distribution of MPs in freshwater ecosystems and their transition into biota via a gastropod species.

Material and Method

The study area was determined to be the Kocabaş Stream, one of the largest and regionally significant rivers located near the Biga Bridge within the provincial borders of Çanakkale on the Biga Peninsula in the Marmara Region. Sampling was conducted in September 2024.

The Kocabaş Stream originates in the Kaz Dağı Mountains and concludes in the southern part of the Sea of Marmara (Odabaşı et al., 2019). The stream has a length of 80 km and an average discharge rate of 15-20 m^3. The highest recorded discharge was reported to be 1345 m^3

(Gündoğdu et al., 2002). The sampling station was located at the coordinates 40°16'08.8"N 27°13'09.4"E (Figure 1).

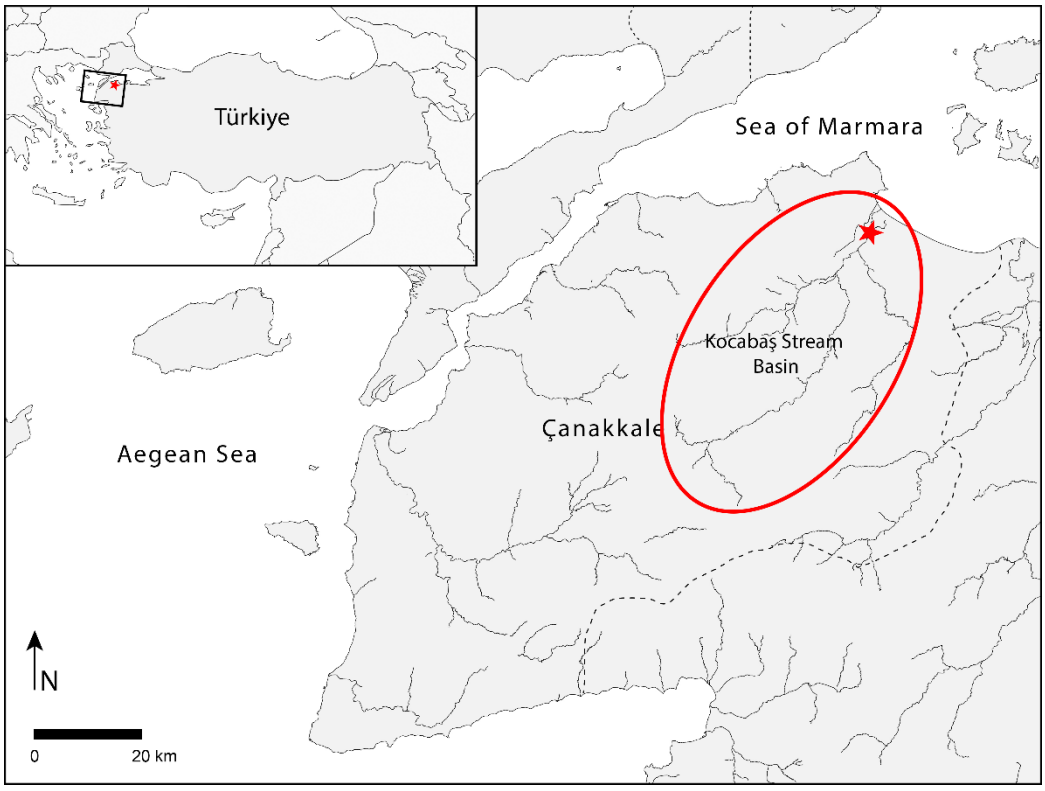

Figure 1. Study area (Legends: Red Star= sampling Point, Red Line= Kocabaş Stream Basin).

Laboratory Analysis

The study was conducted on 100 individuals of *Potamopyrgus antipodarum* that were chosen among sampled material. Specimens were selected from individuals that had reached sexual maturity and were preserved in 80% ethanol to mitigate the risk of biological damage due to storage conditions.

After sealing the tubes using tape parafilm, the material deposited into COMU-LM. The digestive tract of each sample was examined under stereo microscope in selected magnifications from 20x to 50x (Zeiss Stemi 508).

Results and Discussion

Extensive research has demonstrated that behavioral responses and reaction times are among the most significantly affected parameters when assessing the detrimental effects of microplastics (MPs) on organisms (Romero-Blanco et al., 2021). Studies indicate that MP ingestion can lead to adverse physiological and ecological consequences, including altered feeding behaviors, reduced predatory efficiency, and impaired locomotion (De Sá et al., 2015; Yin et al., 2018). Given these findings, it is reasonable to hypothesize that MPs negatively impact *Potamopyrgus antipodarum*, potentially affecting its mobility, digestive efficiency, and predator avoidance strategies**.**

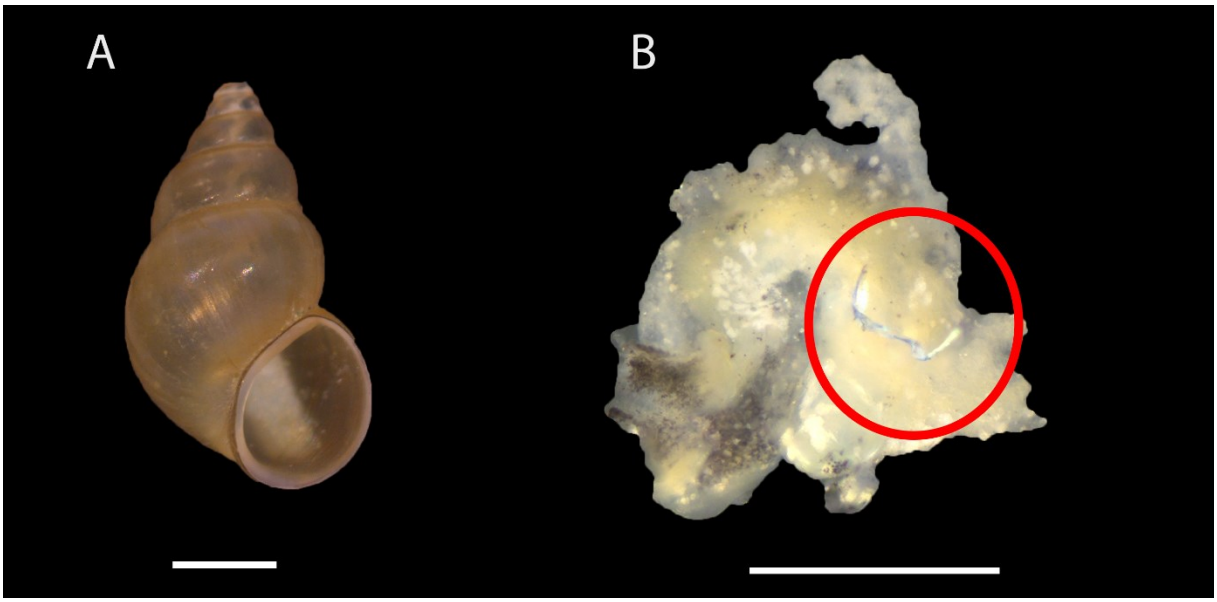

Figure 2. The images of *P. antipodarum* (A) and the microplastic observed in it's digestive tract (B). Scales= 1 mm (A: 8x, B: 25x magnifications used).

A total of 100 individuals were examined under a stereo microscope, and a plastic fibril measuring 2.5 mm in length was identified (Figure 2-B). It is hypothesized that *P. antipodarum* accidentally ingests MPs during feeding. Studies on the acute and chronic effects of MPs on *P. antipodarum* remain scarce. However, similar research on other gastropod taxa predominantly reports fiber and fragment-type MPs as the most commonly ingested forms. For instance, previous studies have documented an average of 0.25–0.88 MPs per individual in *Nerita articulata* (Zaki et al., 2021), 764.81 in *Telescopium telescopium* (Linnaeus, 1758) (Putri & Patria, 2021), 6.1 in *Bellamya aeruginosa* (Xu et al., 2020), 75.5 in *Lottia scabra* (Patria et al., 2020), 0.68 in *Littorina littorea* (Doyle et al., 2020), 26.33 in *Filopaludina mertensi* (Yasaka et al., 2022), 4.96 in *F. sumatrensis speciosa*, and 5.64 in *Pomacea canaliculata*. Studies have shown that freshwater gastropods can serve as valuable bioindicators for assessing the interaction between microplastic pollution and biota, providing insights into its potential ecological impacts.

Recent studies on MP pollution in Türkiye have revealed significant findings. However, study on freshwater gastropods is missing (Çevik et al., 2022; Aydın et al., 2023). Previous studies on microplastics in the freshwater ecosystems of Türkiye have primarily focused on their distribution, density, and types (Çullu et al., 2020; Erdoğan, 2020; Almas et al., 2022). Several studies have been conducted on water pollution in the Kocabaş Stream (Akbulut et al., 2014; Yayıntaş et al., 2007); however, no research on microplastics has been reported. Although the existing studies on the Kocabaş Stream indicate pollution in water quality, no direct correlation has been reported between the existing environmental pollution and microplastic concentrations in bioindicator species (Kutralam-Muniasamy et al., 2021; Nkosi et al., 2022). Therefore, the low occurrence of MPs in *P. antipodarum*, selected as a bioindicator in this study, does not fully reflect the extent of plastic pollution in the study area. On the other hand, differences in methodologies and their effectiveness in studies focusing on MPs have the potential to influence the observed occurrence of MPs. Moreover, no standardized method has been established for the effective quantification and identification of microplastics (Li et al., 2020).

Conclusion

Considering these findings, this study reinforces the growing concern that MP pollution poses a significant ecological threat. The need for effective plastic pollution control measures has become increasingly evident. As the first investigation of MP contamination in *P. antipodarum* in Türkiye, this study provides a crucial step in understanding the impact of MPs on freshwater gastropods.

These findings highlight the role of freshwater gastropods as bioindicators and underscore the necessity of stricter pollution monitoring and management in freshwater ecosystems. To gain a more comprehensive understanding of the extent and consequences of MP pollution, it is strongly recommended that further research be conducted across different taxa of bioindicator species and monitored over extended time periods

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Ethical review and approval were waived for this study

Informed consent
Not available

Data availability statement
The authors declare that data can be provided by corresponding author upon reasonable request.

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There is no conflict of interests for publishing this study.

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Contribution of authors

Aytuğ Zilifli, Methodology, Data analyses, Writing original draft, examination
Deniz Anıl Odabaşı, Investigation, Data analyses, Writing original draft, Examination, Editing
Serpil Odabaşı, Writing original draft, Methodology, Editing, examination

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