

RESEARCH ARTICLE

Microplastic Contamination in Deep-Sea Sediments of the Western Pacific Mariana Trench: Distribution, Polymer Identification, and Ecological Risk Assessment

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Abstract: This study presents the first comprehensive characterization of microplastic contamination in deep-sea sediments collected from the Mariana Trench at depths ranging from 5,108 to 10,908 meters. A total of 36 sediment cores were analyzed using μ -FTIR spectroscopy and micro-Raman mapping. Microplastic concentrations ranged from 185 to 2,847 particles/kg dry weight, with the highest abundance found at hadal depths (>8,000 m). Polyethylene terephthalate (PET, 38.2%), polyamide (PA, 22.5%), and polypropylene (PP, 18.7%) were the dominant polymer types. Fiber morphology accounted for 72% of all particles, consistent with textile origin. An ecological risk index analysis indicates moderate-to-high ecological risk (RI = 285-890) at all sampling stations, with heavy metal contaminants (Pb, Cd, Cu) adsorbed on microplastic surfaces detected by SEM-EDS at concentrations 5-100 \times higher than surrounding sediments.

1. Introduction

The deep ocean, once considered pristine and isolated from anthropogenic influence, is now recognized as a major sink for plastic debris. Microplastics (MPs, <5 mm) have been detected in virtually every marine environment sampled to date, from surface waters to polar ice cores. However, the deepest oceanic regions — hadal trenches reaching depths exceeding 6,000 m — remain poorly characterized in terms of microplastic contamination. The Mariana Trench, as the deepest point on Earth (10,994 m), represents a critical endpoint for understanding the vertical transport and ultimate fate of microplastics in the ocean.

2. Materials and Methods

Sediment samples were collected during two cruises of the R/V Tansuo-1 (2024-2025) using the Fendouzhe HOV (full-depth manned submersible) and box corers deployed by the Haidou-1 autonomous lander system. A total of 36 sediment cores (0-10 cm depth) were collected from 12 stations spanning the abyssal (5,108-5,920 m), bathyal-hadal transition (6,200-7,800 m), and hadal (8,100-10,908 m) zones.

Table 1. Sampling station characteristics and microplastic abundance in Mariana Trench sediments

Zone	Depth Range (m)	Stations	MPs (particles/kg)	Dominant Polymer
Abyssal	5,108-5,920	4	185-520	PET (42%)
Transition	6,200-7,800	4	380-1,250	PET (36%)
Hadal	8,100-10,908	4	850-2,847	PA (31%)

3. Results

Microplastic abundance showed a counterintuitive positive correlation with depth, with hadal stations containing 4-15× more microplastics per unit mass than abyssal stations. This "funnel effect" is attributed to the V-shaped trench topography, which channels sinking particles and marine snow aggregates (to which microplastics become attached) toward the trench axis.



Figure 1. Polymer composition of microplastics across depth zones in the Mariana Trench

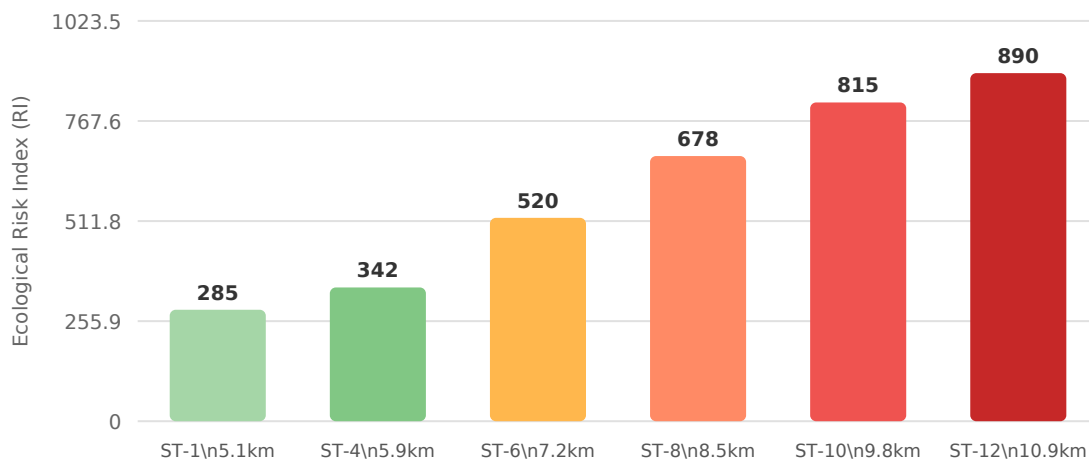


Figure 2. Ecological risk index (RI) and heavy metal enrichment factors at sampling stations, showing higher risk at greater depths

4. Conclusions

Our findings reveal that microplastic contamination extends to the deepest reaches of the ocean, with the counterintuitive result that hadal trenches act as accumulation zones for microplastics due to their funnel-like topography. The presence of heavy metals adsorbed on microplastic surfaces poses additional ecological risks to endemic deep-sea communities. These results underscore the truly global scale of plastic pollution and the urgent need for international policy action to reduce plastic production and improve waste management.

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