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Microplastics and Marine Microbial Communities: Assessing the Effects of Plastic Type and pH on Biofilm Formation

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Abstract : Microbial communities are fundamental in shaping marine ecosystem dynamics, playing critical roles in nutrient cycling, organic matter degradation, and environmental health. Among these microbial communities, bacteria are essential in the early stages of biofouling, where they act as primary colonisers on submerged surfaces. Biofouling, characterized by the accumulation of microorganisms, algae, plants, and animals on surfaces, presents significant ecological, environmental, and economic challenges. Recently, research has focused on biofilm formation on microplastic surfaces, revealing the complex interactions that occur between microplastics and microbial communities. Biofilms—colonies of microorganisms that adhere to surfaces such as microplastics (plastic particulates <5 mm)—are integral to the fate, transport, and ecological impact of microplastics in aquatic systems. The present study builds on previous findings from the author's thesis development, and investigates the influence of different microplastic types (polyester, polyethylene, and polystyrene) and pH levels (8.2 and 7.2, representing current and predicted ocean acidification conditions, respectively) on bacterial counts and microbial diversity in the habitats of Hediste diversicolor from the Humber Estuary. Water samples were sourced from the Humber Estuary and artificial seawater was prepared to simulate different pH conditions. These water samples, both from the Humber Estuary and artificial seawater, were subjected to treatments with three different types of microplastics (polyester, polystyrene, and polyethylene), chosen based on the distribution of microplastics found in the Humber Estuary in previous studies on Hediste diversicolor and environmental water samples. Bacterial counts were measured over a 32-day period, with samples collected at Days 0, 2, 4, 8, 16, and 32. Spread plating was employed, and the treated water samples (after microplastics were removed via vacuum filtration) were cultured on agar plates. The bacterial colonies were incubated and counted at each time point. Statistical analysis revealed that microplastic type significantly influenced bacterial abundance ($p < 2e\text{-}16$), with polystyrene exhibiting the highest bacterial colonisation. Humber Estuary water samples consistently showed higher bacterial abundance compared to artificial seawater, though pH did not significantly impact bacterial abundance in the presence of microplastics. Additionally, bacterial diversity was assessed through DNA analysis, revealing specific bacterial species, such as Pseudomonas stutzeri, Bacillus cereus, and Stenotrophomonas maltophilia. Diversity indices suggested a slight decrease in bacterial diversity over time in the Humber Estuary, while artificial seawater samples exhibited more stability in bacterial diversity. Notably, there was a significant positive correlation between bacterial abundance and Hediste diversicolor feeding responses on Day 32, implying that higher bacterial counts may enhance olfactory cues and influence foraging behaviour. These findings suggest that the microplastic surfaces serve as "hotspots" for bacterial colonisation, potentially creating environments conducive to pathogenic microorganisms, which may have ecological impacts on marine organisms. The study also indicates that the microbial communities on microplastics may attract marine animals, raising concerns about the long-term ecological consequences of microplastic pollution. Future research should explore broader ecological impacts on marine species, the role of fluctuating pH conditions, and the potential transfer of pathogenic bacteria to humans.

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