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Divergent Weathering On Two Sides Of Plastic Fragments From Coastal Environments Around The Globe

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Abstract : Plastic debris in coastal environments undergoes a series of aging processes due to the diverse environmental conditions they are exposed to. Existing research to date lacks a thorough understanding of how these processes affect exposed and non-exposed sides of plastic fragments, leading to potentially biased conclusions on how degradation occurs. This study addresses this knowledge gap by examining surface aging characteristics on both sides (e.g., cracks, delaminations, pits, wrinkles and color residues) of 1573 plastic fragments collected from 15 coastal sites worldwide and conducting outdoor aging simulations. A clear contrast was observed between the two sides of the plastic fragments, where one of the sides often displayed more pronounced aging features. Three key indicators were introduced to quantify the aging characteristics of plastic fragments, with values ranging from 0.00 to 58.00 mm/mm2 (line density), 0.00 to 92.12% (surface loss) and 0.00 to 1.51 (texture index), respectively. Outdoor simulations revealed that sun-exposed sides of plastic sheets developed more cracks, pores, and bubbles, while the shaded sides remained smoother. The annual average solar radiation intensity of 4.47 kWh in the experimental area exacerbated the degradation of the sun-exposed side, as confirmed by a significant increase in carbonyl index, with PE rising from 0.50 to 1.70, PP from 0.18 to 1.10, and PVC from 0.45 to 1.57, indicating photoaging. These results highlight the uneven weathering patterns of plastic fragments on shorelines due to varying environmental stresses. In particular, the side facing the sun exhibited more pronounced signs of aging. Outdoor experiments confirmed that the fragments' sun-exposed sides experienced significantly higher degrees of weathering compared to the shaded sides. This study demonstrated that the divergent weathering patterns on the two sides of beach plastic fragments were primarily driven by differences in light exposure, duration, and mechanical stress.

Keywords : plastic fragments, coastal environment, surface aging features, two-sided differences
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