

The influence of human activities on black carbon footprint accumulation in Marian Cove, Antarctica

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Black carbon (BC), an organic residue resulting from the incomplete combustion of organic matter, originates from both natural processes (e.g., wildfires) and anthropogenic activities (e.g., biomass burning and fossil fuel combustion). The atmospheric deposition of BC into the ocean is estimated to contribute approximately 1.8 Tg C per year, accounting for nearly 10% of the terrestrial sink for anthropogenic CO₂. This study investigates the dynamics of BC in Marian Cove, located near King Sejong Station on the Antarctic Peninsula. Dissolved black carbon concentrations ranged from 0.03 to 7.21 μM C (mean: 2.20 ± 2.14 μM C) in Marian Cove and from 1.17 to 10.2 μM C (mean: 3.97 ± 2.95 μM C) in Maxwell Bay, which was approximately 1.8 times higher than in Marian Cove. Samples were collected from 15 sites in Marian Cove in 2019 and 2023 to compare BC accumulation in sediments. The average BC concentration in sediments was 2.35 ± 0.32 mg g⁻¹ in 2019 and increased to 4.06 ± 1.19 mg g⁻¹ in 2023, representing an increase of approximately 2-fold. The average BC flux measured through small traps installed around the Sejong Station for 28 days was 0.05 g m⁻² d⁻¹, accounting for approximately 35% of the total organic carbon. In particular, the stable isotope mixing model results indicate that BC from fossil fuel sources increased 2.7-fold in 2023 compared to 2019. This rise corresponds with the resurgence of human activity, particularly tourism, on the Antarctic Peninsula in 2023 following the 2020–2021 COVID-19 pandemic, which appears to be linked to enhanced BC deposition at Marian Cove.