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Knowledge gaps in the biological carbon pump: Does black matter? (Part 2)

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The ocean absorbs about 30% of anthropogenic CO_2 emissions, hence alleviating the increase of atmospheric CO_2 and mitigating climate change. This CO_2 uptake is driven by intertwined physical, chemical and biological processes, in which the Biological Carbon Pump (BCP) plays a pivotal role by transforming, exporting, and sequestering carbon to the deep ocean. This export of biogenic carbon from the surface ocean and its subsequent long-term storage in the deep ocean is a key component of the oceanic biogeochemical cycling responsible for maintaining a continuous drawdown of atmospheric CO_2. However, the efficiency of the BCP can be altered by several anthropogenic pressures. In particular, the impact of Black Carbon (BC), a globally emitted pollutant, yet largely neglected as an anthropogenic forcing in the BCP, remains unclear. Any combustion of biomass, biofuels and fossil fuels emits two carbonaceous 'fake twins', CO_2 (i.e. complete combustion) and BC (i.e. incomplete combustion), and while they are separated at birth and follow different pathways in the atmosphere, their fates meet again in the ocean. The atmospheric lifetime of BC ranges from a few days to one month, and BC leaves the atmosphere via dry or wet deposition onto land and ocean surfaces. In addition to direct atmospheric input of BC to the ocean, some of the BC deposited on land can reach the ocean via riverine runoff. Based on the scarce estimates of BC inputs to the ocean, the global annual flux of BC particles to the ocean is about 20 Tg C yr^{-1} (i.e. 12 Tg C yr^{-1} via direct deposition and 8 Tg C yr^{-1} via rivers). While this goes largely unnoticed, it is about 2 to 4-fold higher than the flux of plastic wastes to the ocean. Once introduced into the ocean, BC particles can interact with several components of the BCP, alter the production and remineralization of biogenic carbon, and modify the quantity and characteristics of the sinking material. Since BC may favor both remineralization and sinking, marine BC may stimulate antagonistic carbon pathways, and hence drive a positive or a negative feedback on atmospheric CO_2. Owing to its direct impact on health and climate change, atmospheric BC has been studied for decades. Surprisingly, despite massive and continuous inputs of BC to the ocean, and the potential impact of BC in marine processes and particularly on the BCP, studies on the effect of BC on marine systems are scarce, and the induced climate feedbacks unknown. Given that BC emissions is expected to increase in the coming decades due to growing energy demand, this seems an urgent topic to be addressed.