Micro- and nanoplastics alter algae growth and aggregation; what are the cascading effects on marine copepods and the marine carbon flux?

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Previous research showed that marine micro-algae are sensitive to low concentrations of micro-and nanoplastics (MNPs), resulting in decreased population sizes and increased EPS production, which might have implications for marine carbon cycling. Marine snow, primarily composed of algae aggregates and faecal pellets, plays a key role in transporting carbon to the ocean floor. Changes in algae aggregates might affect how efficiently carbon sinks to deeper layers. This work investigates how MNPs affect the marine carbon flux through alterations in algae aggregation and copepod faecal pellet production. First, changes in the protein and carbohydrate content of both loosely bound (LB-EPS) and tightly bound EPS (TB-EPS) were quantified after exposure to MNPs, while changes in algae aggregate size distribution were monitored. Building further on previous work, similar particles were used: virgin PET, weathered PET, and kaolin as a natural particle control, all polydisperse and fragmented, with sizes < 5 µm. The algae, *Rhodomonas salina,* were exposed to a concentration series of 10, 100, 1000 and 10000 particles ml^{-1}. This research confirmed that decreases in algae population size are accompanied by increased EPS production. Furthermore, the protein/carbohydrate content of the TB-EPS increased upon particle exposure, suggesting greater EPS stickiness. These observations go hand-in-hand with alterations in the aggregate size distribution, as was hypothesized. The main observation was a reduced number of algae aggregates after particle exposure, however, the aggregates formed were significantly larger.

These changes in algae aggregate size and stickiness may affect how efficiently carbon in aggregates sinks to deeper layers. However, little is known about how these changes influence interactions with primary consumers like copepods. Specifically, since copepods feed on micro-algae and their feeding behaviour depends on particle size, shifts in algae aggregate size could alter grazing rates. Moreover, copepod faecal pellets contribute significantly to marine snow, and their production (both in number and size) could be impacted by changes in algal populations. To investigate these possible cascading effects, experiments were conducted with the copepod *Acartia tonsa*. *A. tonsa* species were fed with *R. salina* that were previously exposed to MNPs. During the experiment, the copepod grazing rate and faecal pellet production were monitored, alongside algae population dynamics and aggregate size distribution. By integrating these findings, we aim to adapt an NPZD model with a sinking pool to estimate the cumulative impact of MNP exposure on carbon export efficiency. This novel approach provides a comprehensive framework for understanding how pollution-driven changes in primary producers propagate through the food web, ultimately influencing global carbon cycling.

Keywords
Micro- And Nanoplastics; Micro-algae; Copepods; Aggregation; Carbon Flux