Contrasting effects of Asian dust and haze on dynamics of phytoplankton growth in the Northwest Pacific and Yellow Sea

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Anthropogenic emission of air pollutants enhanced nutrient and toxic substance inputs to oceans, which affect phytoplankton growth and modulate oceanic CO_2 fixation and storage. Fertilization effects of dust aerosols on marine primary productivity (PP) has been determined in many areas of the global ocean, but the impacts of aged dust and anthropogenic aerosols, e.g., haze particles, on PP are less known. On-board microcosm experiments were conducted in different trophic-level regions including the Northwest Pacific Ocean (NWPO) and Yellow Sea (YS) during the spring cruise by *R/V Dongfanghong 2*. We found that the stimulation effect of artificially aged dust on phytoplankton growth was more pronounced in the oceans co-limited by multiple-nutrients (e.g., N and P, or N, P and Fe) than those limited by a single nutrient (e.g, N, P, or Fe). Haze particles supplied the cultures with an order of magnitude higher N than in the artificially aged dust but with similar amounts of P and Fe. However, we observed a decrease in chl a concentration at day 2 and 3 after haze particle addition to the cultures, followed by a pronounced increase (comparing with control). This is in contrast to the continuous increase in chl a concentration in cultures treated with artificially aged dust. Overall, increase in Chl a in the cultures with haze particles was lower than those with artificially aged dust (all at 2 mg L^{-1}) during the 9/10 day period cultures. These results suggest that haze particles have a potential inhibition effects on phytoplankton growth, e.g., by copper (Cu), at least in the short time scale (e.g., 2-3 days) under the specific experimental conditions in our study. Furthermore, comparing to control, the addition of artificially aged dust led to a shift in phytoplankton size towards larger (> 2 μm) cells over the duration of the experiments, while treatment with haze particles towards smaller sizes. In conclusion, fertilization effect of artificially aged dust and haze particles may be significantly different in the north-western Pacific Ocean and Yellow Sea, with potential implications for their impact on oceanic carbon storage.