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Microplastic and additive release into seawater from face masks and cigarette butts: A laboratory experiment and risk estimation

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Plastic waste in the environment gradually degrades into microplastics, while organic additives within plastics can leach out during aging. Each year, approximately 5.4 trillion cigarettes are produced, leading to the disposal of 4.5 trillion cigarette butts worldwide. Similarly, mask production reached about 34.5 billion units in 2022 during the pandemic. Because 10–20% of plastic waste is inadequately managed worldwide and left uncollected or improperly released into the environment, between 0.69 and 1.04 billion masks may enter marine ecosystems each year. Yet, the environmental impact of these plastics, especially in marine ecosystems covering over 70% of Earth's surface, remains poorly understood.

In this study, cigarette butts and face masks were incubated in natural seawater under laboratory-controlled conditions for 80 days. The generation of microplastics and the leaching of toxic organic additives, including phthalates (PAEs) and organophosphate esters (OPEs), into the dissolved phase were monitored. Changes were tracked using LDIR for microplastics and GC/MS for additives, with bacterial conditions (biotic and abiotic) varied during the experiment.

Our results showed that polypropylene (98.5%) was the main polymer released from face masks, while modified cellulose acetate (91.5%) dominated in cigarette butts. We found that a single cigarette butt released about 590 ± 310 microplastic particles (n = 6) per liter, while a single face mask contributed around 1,500 ± 1,000 particles into seawater (n = 6). These microplastic debris types were composed of about 20% fibers and 80% fragments.

Our results also indicated that both cigarette butts and face masks released significant amounts of PAEs, followed by OPEs, into surrounding seawater during the first month. Di-isobutyl phthalate phthalate (DiBP) and diethyl phthalate (DEP) were the main PAEs leached from face masks, accounting for 44% and 27% of total PAEs released. In cigarette butts, diethyl phthalate (DEP) dominated at 64%, followed by Di-n-butyl phthalate (DnBP) at 14%. Tris(1-chloro-2-propyl) phosphate (TCPP) and Tri-n-butyl phosphate (TnBP) were the main OPE detected in face masks and butts accounting 40% and 35%, respectively. Finally, our results showed clear differences in degradation between biotic and abiotic conditions for both compound classes.

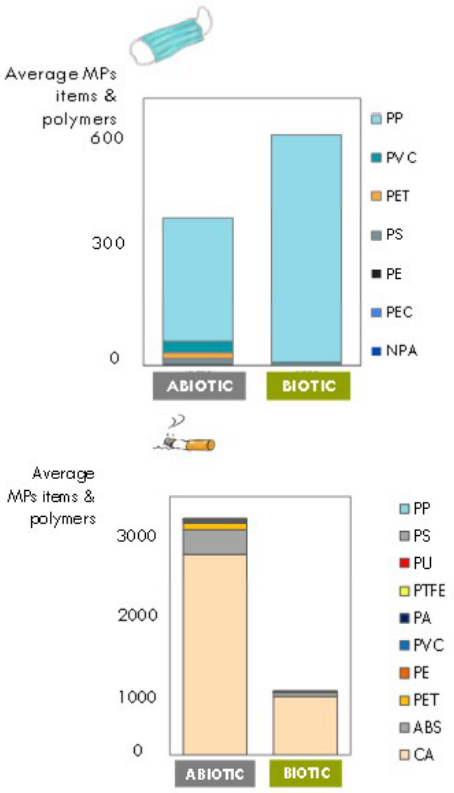


Figure 1. Average microplastic items and polymer composition for cigarette butts and face masks at the end of the biodgradation experiment