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Leaching of metals from cigarettes and heated tobacco sticks in natural water

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Conventional cigarette butts are the single most collected item in annual international coastal and urban clean-ups. Once dumped, they move through sewer systems and streams into the oceans and/or accumulate in localized areas. Environmental awareness on the disposal of tobacco products (TPs) mainly focuses on the inability of discarded filters to biodegrade. There is markedly less awareness on the potential of TPs to act as point sources and leach toxicants. Indeed, the cumulative effect of many littered cigarette butts may present a significant threat to local organisms as past studies have found cigarette litter toxic to some aquatic species. At the same time, a novel 'heat-not-burn' TP was introduced that is becoming increasingly popular. However, the impact of disposing these heated tobacco sticks and exposing them to environmental water bodies is unknown. The present work aims to determine the inorganic components (Al, As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn) leached from heated tobacco sticks and conventional cigarettes in water. Two types of tobacco sticks (non-Aluminum and Aluminum versions) and one brand of conventional cigarettes were studied. TPs were operated on a routine analytical cigarette-smoking machine according to a standardized protocol and metal concentrations were determined using ICP-MS/MS. Leaching from used and unused TPs into deionized water was initially considered. The resulting dissolved concentrations were compared to the total content of each metal in used and unused solid TPs. Almost all metals were detected in leachates shortly after TP addition and almost all metal concentrations reached near-equilibrium conditions after 1 day of leaching. Arsenic was the only metal not detected in solid TPs (total concentrations) and leachates (dissolved concentrations) from used and unused TPs. Within 1 day of leaching, the dissolved concentrations of Hg and Pb were below the limits of detection of the analytical method. The highest fractions of metals leached in water were recorded for Zn, Cu and Se. The dissolved concentrations found in leachates from unused TPs were, for the majority of metals studied here, larger than those found from used TPs. The contribution of the different parts of TPs (i.e. filter, tobacco and paper) to the inorganic content of leachates was assessed for used and unused TPs. The results were compared to the dissolved and total concentrations found for TP entities. Tobacco was the major source of metals for both the dissolved and total concentrations. The effects of varying pH, salt and humic acids on the leaching behavior of metals from TPs was also studied, next to the effect of matrix where rainwater, river water and seawater were used to leach metals from used and unused TPs. All in all, discarded TPs may look like the end point of a life cycle, but there is still a way to go in addressing post-consumer waste clean-up and responsible disposal.