Substitution of parabens in cosmetic products: what impacts for the aquatic environment?

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Parabens used as preservatives in the formulation of most personal care products (PCPs) are found ubiquitously in surface waters worldwide. These substances are of increasing concern due to their wide utilization, and their potential negative effect on aquatic ecosystems as endocrine disruptors. Parabens have been the subject of an alert following a 2004 publication, which reported a potential link between parabens and breast cancer. Growing consumer awareness led cosmetic industry to start shifting away from parabens, by the development of increasingly popular "paraben free" or "organic" products, and by switching to alternatives substances in their formulations, processes and packaging. Key unanswered questions include to identify which products used in the formulations need to be substituted, and to avoid replacing them with other potentially harmful substances. The objectives of our study were (i) to determine which chemicals replace parabens; and (ii) to assess the impact of the substitution on the ecotoxicity of domestic greywater using bioassays.

Based on a bibliography survey, phenoxyethanol (PE), methylisothiazolinone (MIT), chlorphenesin (CPN)... were identified as frequently used methylparaben (MEP) substitutes. Importantly, this bibliography review highlighted the hypothesis that substitutes may have a potentially hazardous effect on aquatic organisms, but also underlined that little attention had been paid to their occurrence in receiving water. We then evaluated and compared their impact on the development, and survival of zebra fish larvae (until up to 8 dpf), alone or in combination. We showed that whereas PE had no effect, MEP, and its substitutes MIT and CPN, affected both the development and survival of the larvae. LD₅₀ were determined for each of the compounds. Developmental defects included oedema, weak heart beats, red blood cell aggregates, and curved tail. Furthermore, when PE was used in combination with MEP, survival was increased compared to MEP alone, and important developmental abnormalities like head malformation, deflated swimbladder unseen for MEP alone, were observed, providing evidence of synergistic effects. Finally, bioassays were applied to synthetic greywater, generated to be representative of three consumption practices: cosmetics with or without parabens, and organic cosmetics. The most frequently used PCPs were chosen: shower gel, toothpaste and skin cream for body. With respect to the daily consumption of both PCPs and that of water, raw PCPs were dissolved in a given water volume to be representative of the level found in domestic greywater. While bioassays have not shown a clear trend in function of consumption practices, our key results show that organic PCPs have also potential negative effects on aquatic organisms.

These original results clearly connect the domestic consumption practices with potential ecotoxic discharges in receiving water and raise questions about the substitution after regulation. In this context, our work highlights the need to quantify these substitution substances in wastewater and surface water.

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