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# What happens to sunscreens in swimming pools?

UV filters (UV-fs) are the active ingredient of sunscreen and personal care products such as soaps, shampoos and hair sprays to protect materials and humans from the harmful effects of sunlight radiation and conserve the integrity of the product formulation. Public concerns about secondary effects of these compounds are growing because of the contamination of the aquatic environment that may reach to potentially toxic concentration levels. Direct input of UV-f results from recreational activities when UV-fs are washed from the skin and clothes during swimming and bathing. A study in Australia showed 56% of people apply sunscreen or products containing UV-fs at least 5 days per week, and 27% of people use sunscreen infrequently on two or fewer days per week. Another study in Denmark showed 65% of the sunbathers used one or more sunscreens and 46% of them applied it all over the body. In addition to exposure to UV-fs, people are also exposed to compounds created during the oxidation of the UV-fs. For example, swimming pools receive a considerable amount of chlorine (disinfectant) daily to protect swimmers from pathogenic microorganisms. However, chlorine disinfectants are known to react with organic matter (natural and synthetic) to produce a variety of chlorinated organic compounds known as disinfection by-products (DBPs). DBPs have been associated with deleterious health effects when consumed and are suspected carcinogens. High levels of DBPs in swimming pools occur due to continuous disinfection and constant organic load from bathers and swimmers (e.g., urine, skin cells, sweat, cosmetics, and hair). The presence of DBPs along with dissolved organic matter, nitrates, chloride and bicarbonates influence the photo-degradation of UV-f in the aquatic environment. Therefore, UV-fs in exposure to chlorine in the pool may create precursors of toxic compounds. Due to increased urbanization and industrialization, many houses and apartments are using outdoor plastic swimming pools in a variety of sizes for children to swim. Despite this variety, the outdoor plastic pools have very low volume compared to larger pools. Moreover, the water in these smaller plastic swimming pools is subject to evaporation, concentrated UV-f and UV filter associated- DBPs. Thus, the concentration of UV-fs can be significantly higher in these systems compared to the larger pool systems replenished with water continuously. Based on our analysis, if a child enters the plastic swimming pool containing 8,640 USG (32,700L) designed for a family (12-people), and the pool is filled at the 90 % level, the water could contain 2.85, 1.9, 1.78 and 0.95 g/L, respectively of EHMC, OC, 4-MBC and BP3 UV-f, respectively. Therefore, UV filter presence, breakdown and associated DBPs are an important concern for children's health (Fig. 1).

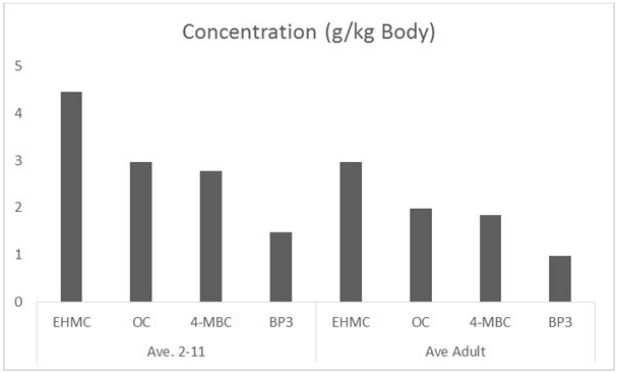


Fig. 1. A comparison of concentration of the UV Filters (EHMC, OC, 4-MBC and BP3) which could release the water from body of two different age classification.

In our analysis, it was assumed that at the pool sunscreens are applied to roughly 80% of the total body area and the average surface body of an adult male is 2 $m^2$and of an adult female is 1.82 $m^2$. If a sunscreen containing on average 88 mg/g EHMC with 85% frequency in sunscreens product compositions applied as 2 mg sunscreen/$cm^2$ of skin, the body would receive a daily exposure of sunscreen of 3 g/day for males and 2.5 g/day for females. Assuming the average adult body weights of 78 kg for males and 65 kg for females, an applied doses of EHMC may be estimated at 37 and 40 mg/kg/whole body application, respectively, for males and females. These exposures would be higher for children due to their larger surface area to body weight ratios as compared to adults.

Increased number of plastic outdoor swimming pools has considerable impacts on UV filter concentration and potential photo reactions with DBPs, which may place children at risk.

***Hamidreza Sharifan***
*Department of Civil, Environmental, and Construction Engineering, Texas Tech University, USA*

## Publication

UV filters interaction in the chlorinated swimming pool, a new challenge for urbanization, a need for community scale investigations.
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