The Effects of Sunscreen on Marine Environments

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Coastal travel accounts for 80% of all tourism worldwide, a number that continues to grow. The number of travelers to the Mediterranean Sea alone is expected to rise to 350 million individuals per year within the next 20 years.[1] As the number of tourists visiting the world's oceans increases, the rate of sunscreen unintentionally washed into these marine environments also rises. One study estimated that approximately one-quarter of the sunscreen applied to the skin is washed off over a 20-minute period spent in the water.[2] Four of the most common sunscreen agents—benzophenone-3 (BP-3), 4-methylbenzylidene camphor (4-MBC), and the nanoparticles titanium dioxide and zinc oxide—have been considered to be risks to marine environments. As this topic has received increasing media scrutiny over the last few years, we summarize the general conclusions that can be drawn from current research and note the questions that still remain to better address patient concerns.

Benzophenone-3

Benzophenone-3, or oxybenzone, is a widely studied UV filter and its effects on marine ecosystems have received the media's attention over the last few years. Benzophenone-3 is known to cause a bleaching effect to coral, which can inhibit growth and possibly kill the organism.[3] Further, oxybenzone sunscreens can promote viral infections in coral, resulting in additional bleaching events.[2] In a recent study, exposure to BP-3 caused mobile planulae, the larval form of coral, to become clearly deformed, trapped within its own calcium carbonate skeleton.[3] The concentration of BP-3 needed to induce these physiological changes is as small as 62 parts per trillion, which is the equivalent of a single drop of water in 6.5 Olympic-sized swimming pools. Levels of BP-3 contamination in the waters off of the US Virgin Islands' beaches have been recorded as high as 1.4 parts per million, with average concentrations closer to 250 parts per billion.[3] High BP-3 concentrations have also been recorded in the waters off the Canary Islands,[4] Hawaii,[3] and South Carolina.[5]

4-Methylbenzylidene Camphor

Environmental concerns have also been raised about another common chemical UV filter: 4-MBC, or enzacamene. In laboratory studies, 4-MBC has been shown to cause oxidative stress to *Tetrahymena thermophila,* an aquatic protozoan, which results in inhibited growth. At higher concentrations, damage to the cellular membrane was seen as soon as 4 hours after exposure.[6] In embryonic zebrafish, elevated 4-MBC levels were correlated to improper nerve and muscular development, resulting in developmental defects.[7] Another study demonstrated that 4-MBC was toxic to *Mytilus galloprovincialis,* known as the Mediterranean mussel, and *Paracentrotus lividus,* a species of sea urchin.[8] Although these studies utilized highly controlled laboratory settings, further studies are needed to examine the effects of 4-MBC on these species at environmentally relevant concentrations.

Physical Sunscreens

Physical sunscreens, as compared to the chemical filters referenced above, use either zinc or titanium to protect the skin from the sun's rays. Nanoparticles, in particular, are preferred because they do not leave a white film on the skin.[9] Both titanium dioxide and zinc oxide nanoparticles have been found to inhibit the growth and photosynthesis of marine phytoplankton, the most abundant primary producers on Earth.[10,11] These metal contaminants can be transferred to organisms of higher trophic

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levels, including zooplankton,[12] and filter-feeding organisms, including marine abalone[13] and the Mediterranean mussel.[14] These nanoparticles have been shown to cause oxidative stress to these organisms, making them less fit to withstand environmental stressors. It is difficult to show their true impact, however, as it is challenging to accurately detect and quantify nanoparticle concentrations in vivo.[15]

Final Thoughts

A recent study showed that 7% of consumers (N=325) regarded environmental agencies' recommendations as an important factor in their sunscreen purchase.[16] When treating patients with these concerns, the ability to provide sound and informed advice will likely impact their sunscreen use and future sun protection behaviors. Although studies have shown the potential for sunscreen pollution to cause environmental harm, it is important to note that a portion of this research is not correlated to in vivo findings, and further work is required to determine the magnitude and importance of these studies.[15] Regardless, legislation has already been submitted in both Hawaii and the European Union calling for a ban on oxybenzone-containing sunscreens, so knowledge of the subject is prudent when counseling patients.[17] One potential solution may be to recommend sun-protective clothing during water-intensive activities to both increase skin protection and reduce the environmental impact. Furthermore, recommendations could be tailored to specific settings, such as coastal resorts and populated beaches, where these sunscreen ingredients are found in much higher concentrations. At this time, more data must be collected before making any definitive claims or recommendations, but knowledge of the current research will be an important tool in educating patients going forward.

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