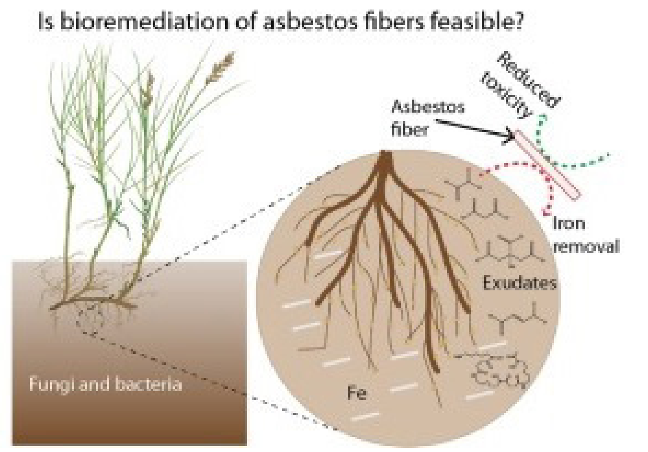
Siderophores Reduce Asbestos Toxicity in Soil

Researchers have discovered that natural compounds released from bacteria and fungi in soil, known as siderophores, can decrease the toxicity of asbestos fibers. According to the authors, their results support the feasibility of asbestos bioremediation, or using organisms such as bacteria to degrade contaminants at waste sites.

Asbestos fibers are highly toxic and have been linked to serious health conditions, including lung and stomach cancers. This toxicity is mostly attributed to the long shape of asbestos, which makes it harder for cells of the immune system to remove them from the lung.

Immune cells called macrophages generally destroy foreign materials, such as bacteria and particles like asbestos, by either engulfing the particles or producing reactive oxygen species (ROS) to destroy the material. Because asbestos fibers are often too large to be engulfed, macrophages produce excessive ROS, which can lead to inflammation and DNA damage and may eventually lead to tumor development. Previous studies have shown that the presence of iron, which is often on the outer layer of asbestos, can increase this ROS production.



This research was part of an SRP Center project led by Willenbring while at Penn. The broad goal was to determine whether alteration of asbestos particles by plants or fungi may be useful for bioremediation of asbestos-contaminated sites. (Reprinted from Journal of Hazardous Materials, 341, Mohanty et al., Siderophore-mediated iron removal from chrysotile: implications for asbestos toxicity reduction and bioremediation, 290-296, Copyright 2018, with permission from Elsevier)

Based on this connection between iron and asbestos toxicity, researchers explored whether natural soil concentrations of siderophores, which have an affinity to bind to iron, can remove iron from asbestos and thus lower its toxicity. Plants, bacteria, and fungi release siderophores to bind to iron in soil, facilitating iron uptake. The study, supported by the University of Pennsylvania Superfund Research Program (Penn SRP), was led by Jane Willenbring, Ph.D., currently at the Scripps Institution of Oceanography, University of California, San Diego, and first author Sanjay Mohanty, Ph.D., at the University of California, Los Angeles.

Iron Removal and Toxicity

The researchers measured the release of iron from asbestos fibers in the presence of natural soil concentration levels of a fungal and a bacterial siderophore and specific organic acids, which are also released by organisms to bind to iron. They treated solutions containing asbestos with siderophores or organic acids, extracted samples from those solutions at regular intervals for up to 16 days, and measured the total dissolved iron. They found that both fungal and bacterial siderophores removed iron from asbestos fibers. The organic acids, however, proved ineffective.

In collaboration with Penn SRP Center project leader Melpo Christofidou-Solomidou, Ph.D., the researchers then measured the toxicity of the treated asbestos fibers using a new method developed by the research team. They quantified ROS generated by macrophages from mice exposed to asbestos fibers with and without siderophore treatment and observed a decrease in the amount of ROS generated, and thus the toxicity of asbestos, when fibers were treated with siderophores. They also discovered that the fungal siderophores were more effective than the bacterial siderophores in reducing ROS.

Potential Site Applications

Because of its fiber strength and heat resistance, asbestos has been used in many materials produced for building or home construction, such as shingles, ceiling and floor tiles, and attic and pipe insulation, particularly if they were manufactured prior to 1980. In the U.S., nearly a thousand sites are contaminated with either asbestos-containing materials or naturally occurring asbestos minerals. The current standard for treatment of asbestos-contaminated sites is to physically remove the asbestos from the site or to cap the site with soil, both of which are expensive strategies.

According to the authors, this study indicates that siderophores in the soil environment can decrease asbestos fiber toxicity and possibly lower health risks. Removal of iron by siderophores could potentially form the basis of a low-cost bioremediation strategy, which should be explored as a viable approach for managing asbestos-contaminated sites.

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To learn more about this research, please refer to the following source:

Mohanty SK, Gonneau C, Salamatipour A, Pietrofesa RA, Casper B, Christofidou-Solomidou M, Willenbring JK. 2018. Siderophore-mediated iron removal from chrysotile: implications for asbestos toxicity reduction and bioremediation. J Hazard Mater 341:290-296. doi: 10.1016/j.jhazmat.2017.07.033 PMID: 28797944