Researchers find potential use for recycled plastic in concrete

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From left, engineering faculty Adrienne Phillips, Cecily Ryan and Chelsea Heveran, along with doctorate student Seth Kane and senior Michael Espinal show samples in their lab related to a recent study about recycling microbe-treated plastic into concrete. Credit: Adrian Sanchez-Gonzalez

Millions of tons of plastic are discarded each day, and for much of it there are few options for conventional recycling. But that material could soon find a new and beneficial use thanks to microbes being harnessed by Montana State University scientists.

In a recent study, researchers in MSU's Norm Asbjornson College of

Engineering found that plastic treated with certain bacteria could be added to concrete in significant quantities without compromising the structural material's strength. The study was published in the journal *Materials*.

"This is really exciting," said study co-author Cecily Ryan, assistant professor in the Department of Mechanical and Industrial Engineering. "These initial results are very encouraging as we consider potential applications."

Typically, adding plastic or other filler material disrupts the mix of sand, aggregate and cement that gives concrete—the world's most widely used building material—its ability to bind together and support heavy loads. But the MSU team found that using bacteria to coat the plastic with a thin mineral layer allowed it to bind better with the cement. Concrete samples containing up to 5% of the bacteria-treated plastic had virtually the same strength as traditional concrete, according to the study.

"That 5% is really a big increase from what's been allowable so far," said Chelsea Heveran, assistant professor of mechanical and industrial engineering. "We were surprised by how much of an effect there was."

Because concrete is used so widely and in such high volumes, replacing even 5% of it could result in massive reuse of plastic, Heveran noted. And because concrete is so energy-intensive to make, the plastic filler could significantly reduce carbon dioxide emissions, she said. According to U.S. Environmental Protection Agency, concrete production is one of the country's largest industrial sources of the climate-altering gas.

In MSU's Center for Biofilm Engineering, the researchers immersed the plastic in a water-based solution containing the harmless bacteria Sporosarcina pasteurii, which grows on surfaces to form what's called biofilm. The microbes, left in the solution for 24-48 hours, consumed added calcium and urea—a nitrogen-based substance widely used in fertilizers—to give the plastic a thin, white coating of calcite, the hard mineral that constitutes limestone. The plastic was then mixed into small concrete cylinders that were crushed with specialized equipment to measure their strength.

Although the researchers started with chipped-up No. 1 plastic commonly found in disposable water bottles, after initial success they achieved a similar result with a mix of No. 3-7 plastic, which is used in a variety of containers but isn't accepted at most recycling facilities.

"It's really exciting that we got this result with the mixture of plastics that typically aren't recyclable," said Adrienne Phillips, associate professor in the Department of Civil Engineering, who has used the same mineral-forming bacteria to seal tiny, hard-to-reach cracks deep underground in leaking oil and gas wells.

The next step is to study the material's long-term durability as well as how the process could be scaled up so that the material could be manufactured in useable quantities, Phillips said. The researchers have partnered with Frank Kerins, associate professor in the Jake Jabs College of Business and Entrepreneurship, to begin exploring commercial applications.

The study emerged out of research during the summer of 2019 in which two high school teachers, Kendra Lunday of Capital High School in Helena and Hakan Armagan of Omaha, Nebraska, visited MSU through the National Science Foundation's Research Experience for Teachers program. The duo tested a variety of concrete filler materials, including straw and other agricultural biomass.

Armagan and Lunday were major contributors to the study, which was also "heavily driven by talented undergraduates," Heveran said. In addition to the two high school teachers, co-authors of the paper include McNair Scholar Michael Espinal, a senior majoring in mechanical engineering; engineering doctoral student Seth Kane; and Abby Thane, lab manager in the Center for Biofilm Engineering.

"What's so cool about this project," Heveran said, "is that we're using microorganisms to make just a small change to a common material, but it could have a large societal benefit."

More information: Seth Kane et al, Biomineralization of Plastic Waste to Improve the Strength of Plastic-Reinforced Cement Mortar, *Materials* (2021). DOI: 10.3390/ma14081949

Provided by Montana State University

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