Headline Story

Bacteria-based concrete offers climate benefits

Håvard Egge

Ten cubic kilometers of concrete, equivalent to the volume of Mount Everest, are used in construction projects every year, resulting in huge volumes of emissions. But a new eco-friendly cement may help to reduce our global climate footprint.

"The building industry emits huge volumes of CO_2", says SINTEF researcher Simone Balzer Le, who is part of a cross-disciplinary research team currently developing a biological cement called BioZEment. "The manufacture of cement, which is a binding agent in concrete, alone accounts for more than five per cent of global greenhouse gas emissions".

Concrete generates huge volumes of greenhouse gases. This is why researchers are looking into producing more eco-friendly forms of this important construction material. Stock photo: Shutterstock.

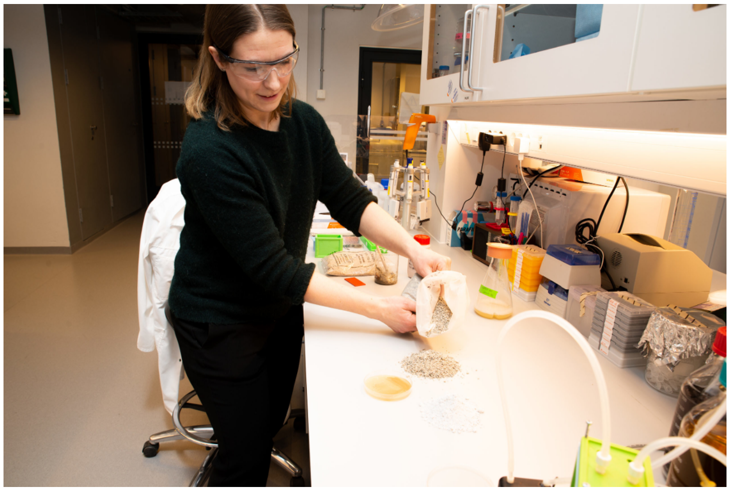
No emissions – no warming

In conventional cement production, limestone is heated to a temperature of 1450 degrees. The process is called calcination and results in the release of huge volumes of greenhouse gas (GHG) emissions in the form of CO_2.

"There are currently many ways of reducing these volumes", says Balzer Le. "Our options include capturing the CO_2gas, partially substituting the cement with another binding agent, or finding a way of making cement without heating. This is the approach we are using in the development of BioZEment", she says.

If the researchers succeed in advancing this last approach, it may have a massive influence on reducing the volumes of GHG emissions produced by the building sector.

"Our estimates indicate that using this material could reduce global emissions by up to 80 percent compared with conventional cement, although BioZEment cannot be used for all building applications in its present form. However, it will be able to contribute to the construction sector's collective efforts to reduce CO_2 emissions.



Bacteria-based concrete consists of sand, finely ground limestone and two specific bacteria, mixed with water, urea and nutrients for the bacteria. Here is Simone Balzer Le in her lab. Photo: Håvard Egge.

Bacteria instead of heating

The process starts by mixing ground limestone particles and sand in the conventional way. But instead of heating the limestone, specific bacteria are added, which the researchers have discovered close to a limestone quarry in Verdal, Norway.

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"The bacteria produce organic acids, including lactic and acetic acid", says Balzer Le. "These help to reduce the pH value of the mixture and so partially dissolve the limestone, releasing calcium ions and carbonate".

"Step two involves mixing sand with another form of bacteria in a mold and feeding this with the prepared mixture of partially dissolved limestone and urea. These bacteria produce an enzyme that splits the urea, which causes the pH to increase again. Under such conditions, calcium is formed together with calcium carbonate crystals, and it is these crystals that act as the binding agent in bacteria-based concrete", she explains.

After drying, the material in the mold becomes solid. In essence, this method is an extension of the well-known biogeochemical process known as Microbially-Induced Calcite Precipitation (MICP). Calcium carbonate precipitates as result of the interaction between natural minerals and bacterial metabolism. MICP is used, among other things, by the American company bioMASON to manufacture and stabilize subsoils.

The mixture of bacteria and sand in the mould is fed with finely ground limestone that is partially dissolved by another bacteria and a solution containing urea. Interaction of the two bacteria causes calcium carbonate crystals to precipitate, and these bind the sand grains together. After drying, a small brick of concrete is removed from the mould. Photo: Håvard Egge.

"The advantage of our approach is that both the calcium and the carbonate are derived from the limestone, which enables us to reduce the use of urea compared with another commonly applied form of MICP that obtains its carbonate solely from urea", says Balzer Le.

Start by making bricks

The researchers have been looking into a number of different ways of applying this technology. The most straightforward approach will most likely be to manufacture bacteria-based bricks, which will probably cost only about ten percent more to make than standard bricks.

"Making bricks will enable us to develop the process, but we're also looking into more commercial applications of the material that will reduce production costs", says Balzer Le. "The most realistic scenario will be to make commercially-manufactured bricks that can be transported directly from a factory to a construction site", she says.

Practical and recyclable

It is too early to say how this biological cement will perform in terms of quality.

"It will not be as strong as conventional concretes, but there are applications where its material strength will probably be more than adequate", says Balzer Le, adding that there are many potential ways of making BioZEment concretes stronger. These include a variety of types of reinforcement using either aluminum or cellulose fibers derived from timber, both of which will make the material practical for a number of different applications.

The researchers also recognize the potential to recycle BioZEment.

"This will result in less use of raw materials, making this a very exciting field of research for us", says Balzer Le.

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