HOW SOIL IMPRISONS ANCIENT CARBON

Deep underground, there lies a sleeping giant that we would do well to avoid waking. The giant is a massive, dormant amount of carbon, and it’s better for us that it remains trapped in the ground rather than circulating in the atmosphere as carbon dioxide.

Many of the most crucial debates of the 21st century will involve reducing the amount of carbon dioxide being pumped into the atmosphere. The many possible solutions include trapping carbon, either in the trunks of trees or in underground vaults. The irony is that a massive amount of carbon is already locked safely away underground.

The world’s soil acts as a carbon prison and it holds more of it than the earth’s atmosphere and all of its living things combined.

Over three *trillion* tonnes of the element are incarcerated in soil and about 80% of this is found at depths of up to 3 metres. At these levels, carbon is very stable and plays no part in the carbon cycle, the process where the element is exchanged between the land, air and sea.

Now, Sebastien Fontaine and other scientists from the French National Institute for Agricultural Research have found that deep soil retains carbon so well because it lacks enough fuel for the microbes that decompose organic matter.

Going deeper

They analysed the soil of grasslands in the Massif Central in France. Two thousand years ago, the area was covered in chestnut and hornbeam trees. Through carbon-dating, we know that much of the carbon in the deep soil today comes from the decayed, sunken remains of these former landowners.

Using a suite of analytical techniques, Fontaine showed that the supply of carbon at depths of 10cm and 70cm were very different. At 10cm, where plant roots were common and microbes were plentiful, much of the carbon was younger, staying in the ground for a few hundred years before rejoining the carbon cycle.

In contrast, the soil 70cm down had far fewer roots and just a quarter of the topsoil’s microbe population. Here, carbon cycled slowly, staying in place for over 2,500 years.

The range of carbon compounds at both levels were very similar, as was the proportion of these compounds that were linked to other minerals. Neither of these factors could account for the relative stability of the deeper carbon.

Fuelling decay

Fontaine found that the key factor was the activity of bacteria, fungi and other microbes. At the surface, they are main players responsible for transferring carbon from soil to atmosphere, by decomposing organic matter. They in turn need a constant supply of fresh organic matter to work their enzymatic magic and at the surface, they get it through leaf litter.

Further down, it's a different story. Fresh organic matter is about 500 times less common, and the soil is made up of chemicals that are difficult to break down. Faced with a harder task and less fuel, the microbes struggle to make a living and their numbers are much fewer. That's why carbon at these depths is relatively secure.

Fontaine tested his theory by incubating soil the deeper 70cm layer at hot and wet conditions. This roused the bacteria in the soil but only to a small extent.

The real boost came when Fontaine added cellulose, the main component of plant litter – that spurred the microbes in the soil into action and they almost doubled in number.

In doing so, they released significant amounts of CO_2 and carbon-dating revealed that much of this came from the breakdown of very old carbon. After the cellulose had been used up, the microbes fell back to their original numbers and activity. Clearly, they're entirely capable of decaying ancient carbon stores but without a fresh organic supply, there isn't enough energy around to sustain any long-term activity.

Implications

On the whole, Fontaine's work carries a sparkle of glad tidings. They mean that the majority of carbon trapped in soil will remain untouched even if global warming raises the temperature of the surrounding soil. Even with enough heat and moisture, deep-living bacteria will do little to the carbon around them unless they get a fresh supply of carbon.

The problem is that many agricultural methods, *do* send a fresh stream of organic material into the deep soil. Drought-resistant crops, for example, have unusually extensive root systems that reach down into the depths where ancient carbon sits.

Deep ploughing, where soil is turned before planting, has a similar effect – it's like banging a large bell to wake up the sleeping giant. A preferable option would be conservation tillage, where the residues from last year's crops are used as the foundations for a new batch. It barely disturbs the underlying soil, leaving the giant to rest in peace.

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