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Biochar turns a negative positive

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Charcoal – it's great for barbequing hamburgers and hot dogs over a long weekend. But can it help save humanity?

Dozens of scientists who gathered in Australia three weeks ago for the first annual International Agrichar Initiative conference say that making "char" and burying it in soil – a process called "sequestration" – could prove a valuable approach to managing climate change.

It seems an odd suggestion, but early research shows that "agrichar" or "biochar" sequestration not only keeps carbon dioxide from reaching the atmosphere, it can actually extract it and contribute to the goal of reducing atmospheric concentrations. Instead of being "carbon neutral," the storage of biochar in soil is being dubbed as "carbon negative."

"Our calculations suggest that emissions reductions can be 12 to 84 per cent greater if biochar is put back into the soil instead of being burned to offset fossil-fuel use," Johannes Lehmann, an associate professor of crops and soil sciences at Cornell University, wrote in the latest issue of the scientific journal *Nature*.

Lehmann, a co-chair of the Australian conference and one of the leading experts on biochar sequestration, said the potential could be huge but more study is necessary. In fact, a keynote speaker at the conference was scientist Tim Flannery, author of the top-selling book on global warming, *The Weather Makers*, who has become a vocal supporter.

To better understand the concept of biochar sequestration, it's important to distinguish between an approach that's carbon "neutral" and one that's "negative."

Simply burning biomass, such as wood waste, or ethanol made out of corn is generally considered *carbon neutral* because it's assumed that the CO{-2} released will be reabsorbed in the corn and trees that will eventually grow to replace the original material. It's a closed system,

where CO{-2} is released and captured through the lifecycle of plant growth. Theoretically there's no net increase and no net decrease of the greenhouse gas, at least if we ignore the effects of deforestation and global soil depletion.

Biochar sequestration, by comparison, is considered *carbon negative* because it results in a net decrease in atmospheric CO{-2}. The idea behind it is that part of the biomass, instead of being completely burned, is turned into carbon-rich char through a process called pyrolysis, which essentially bakes the biomass in the absence of oxygen.

In fact, pyrolysis turns material such as wood chips and crop waste into three main components: gas (methane and hydrogen), a renewable "bio-oil" that can be used as a fuel or for "green" chemical production, and a char that contains roughly 60 per cent of the carbon contained in the biomass.

Everything from chicken droppings to municipal organic waste could be partially converted into these components through pyrolysis.

Canadian companies such as Dynamotive Energy Systems, Agri-THERM, and Advanced Biorefinery are experts in the pyrolysis field, but the char has held little value to them. They use the gas and bio-oil as replacements for fossil fuels and they burn the char to help power the pyrolysis process – though all are carbon neutral uses.

What Lehmann and his colleagues are suggesting is that the char, considered highly stable and resistant to chemical breakdown over hundreds of years, be mixed with topsoil. This permanently removes that carbon from the plant lifecycle and, as a result, achieves a net reduction of atmospheric carbon – that is, it's carbon negative.

"In every cycle, you store some of the carbon in the soil in the form of biochar," says Marco Rondon, a scientist with the International Development Research Centre in Ottawa.

He says the use of biochar in soil goes back hundreds of years to the Amazon Basin, where original inhabitants are thought to have purposely created low-temperature, smouldering fires using crop and food waste. Some of the biomass burned, but much of it was carbonized through natural pyrolysis. The result over time was the creation of a rich, black soil known today as *terra preta*.

Study of biochar is not new. Researchers have long believed the char, an inert and highly porous material, plays a key role in helping soil retain water and nutrients and in sustaining microbes that maintain and improve soil fertility.

"For most of the people working on this, we started not thinking of the carbon sequestration option. The main focus was how to improve plant productivity in areas where soils are depleted," says Rondon.

But the focus is shifting as public concern over global warming grows and, with it, the pressure on governments to take action to reduce the greenhouse gases that are causing climate change. "Three years ago (biochar) was not considered (for sequestration), but now people are starting to. It's gaining momentum," he says.

Malcolm Fowles, a professor of technology management at the U.K.-based Open University, says the biochar also reduces the soil's requirement for irrigation and fertilizer, both of which emit CO{-2}, and it reduces emissions that result from natural decay processes in the soil.

"Biochar has been observed to reduce nitrous oxide emissions from cultivated soil by 40 per cent," says Fowles.

And as Rondon points out, if forest and agriculture waste is merely left on the land to decompose, it will release methane – a greenhouse gas that's 21 times more potent than CO{-2}. It may be better to harvest some of that waste and turn it into char than let it rot, at least from an emissions-reduction perspective.

Still, it's early days, and all involved concede that much more research is necessary to get a better sense of the full potential of biochar sequestration. Should it, for example, be included under the Kyoto protocol as an accepted form of carbon storage and therefore qualifying for carbon credits? After all, it's certainly easy to measure, unlike abstract concepts like planting trees.

And can it be done on a large enough scale to really make a difference?

"The biophysical benefits are now clearly spelled out and far enough advanced that economists can help to find opportunities to make it work," Lehmann told the *Star* in a recent interview.

The technology is already here, he points out. No major scientific advances are necessary. In his *Nature* commentary, he wrote that biochar sequestration combined with the biofuel energy that also comes from the pyrolysis process becomes economically attractive when the market value of CO{-2} reduction reaches $37 (U.S.) per tonne.

By comparison, it's been estimated that the technology required to capture CO{-2} from a coal plant and sequester it in deep geological storage is above $40 per tonne. And not all the CO{-2} is actually captured, so the approach can't even qualify as being carbon neutral.

Still, it's unclear what the appropriate model would be for large-scale

deployment of biochar sequestration. Should small pyrolysis machines be scattered on farms around the world, where residue from crops is partially converted to char and then put directly back into the soil? Should systems be considered as part of municipal waste strategies?

Is it best to focus on developing countries trying to revive depleted lands? At what point does the transportation required to seek out and harvest the raw biomass become uneconomical and too carbon intensive itself?

Clearly, every region and every industry will have to do its own research to determine whether sequestering biochar, and getting all the benefits associated with pyrolysis and soil improvement makes political and economic sense.

David Layzell, an expert on bioenergy and plant sciences at Queen's University, says there are a lot of questions that need to be answered.

"That's the kind of research we need to figure out what's the optimal use of this," he says, at the same time lamenting the lack of research funding flowing into this area in Canada. "They're pouring money into geological sequestration, which is great, because it needs to be done. But we're going to need all of these approaches."

It's something to think about the next time you throw a steak on the charcoal barbecue.

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