Literally "dark earth," Amazonian terra preta has un-pretty names like biochar and agrichar—but by

The Good Black Magic That Could Save the Earth

Terra Preta

By KELPIE WILSON

MAGIC DUST *You don't have to be a scientist to be excited by this way to sequester carbon in the earth, make soil more fertile, produce usable energy—and lower greenhouse gases.*

any name this ancient, mysterious substance is an exciting and powerful tool to reduce greenhouse gases.

Sometimes it seems that the more you examine a problem like global warming, the more you learn how deep and disturbing it really is. In the case of global warming, scientists have identified a number of what they call "positive feedback loops." Such reactions are not called positive because they are beneficial, but because they feed on themselves and amplify the problem at hand.

One example is the problem of Arctic sea ice. As the Arctic Ocean warms, the highly reflective ice melts. As ice disappears, more dark water is exposed to sunlight, and the ocean heats up even faster. Another one is the fact that the warmer the climate gets, the more soils release carbon dioxide, a major component in greenhouse gases. Spend much time thinking about that and you're likely to go into a tailspin of despair.

Wouldn't it be wonderful to discover a positive feedback loop on global warming that works for us instead of against us? Or how about some magic dust we could just sprinkle around that would solve a lot of problems all at once? Sit tight, you're about to hear some very good news.

BEST ENERGIES TESTED GROW POWER *The Australian company Best Energies makes biochar for soil scientists to test. The company also has its own small biochar test plot. The biggest, healthiest plants in the left front corner are grown with both a complete fertilizer and a biochar soil amendment.*

Recently, a group of scientists and agricultural researchers have discovered something almost like a magic dust: an ancient soil amendment based on charcoal, called biochar, that establishes a positive feedback loop for pumping carbon out of the air and into the soil. That's exactly what we need to clear the earth's atmosphere of excessive greenhouse gases that are trapping heat and contributing to global climate change.

Wow. Some field trials have shown crop yields 800 percent above soils that lack the biochar booster.

Plants are part of nature's carbon cycle. They remove carbon dioxide from the atmosphere as they grow and leave carbon in the soil when they die. Soil microorganisms decompose this soil organic carbon, making nutrients available to new plants, but at the same time, they release carbon dioxide back into the atmosphere. That is why soil organic matter, while important for plant growth, is not eligible for carbon sequestration credits under the Kyoto protocol.

Black carbon in the form of biochar is, however, a different story. Charcoal has the potential to stay in soil for many thousands of years. And while it is nicely staying out of the atmosphere, it is also lending an astounding fertility to soil. Some field trials have shown crop yields 800 percent or more above soils without biochar. Now we have a positive loop going our way, because more plant material means you can make more biochar and have even more black carbon to bury in soil.

But wait—as the late night TV commercial would say—that's not all! Charcoal is made by a process called pyrolysis that bakes wood, straw, or any biomass in a kiln or other oven in the absence of oxygen; this heat-without-burning drives off bio-oils and volatile gases. The oils and gases can be collected and burned as fuel, helping out with our energy crisis. There are even more benefits from this black magic dust, but we'll come back to those later.

DRAWING ON ANCIENT WISDOM

The exceptional properties of biochar were first noticed in the Amazon where there are thousands of hectares of what is called "terra preta," which is Portuguese for "dark earth." These dark earths can be several feet deep and contain up to 9 percent carbon. Nearby soils typically have only about half of one percent. But this is no natural phenomenon. The terra preta soils were deliberately created by a lost Amazonian civilization.

Sadly, the civilization itself was wiped out by European diseases that spread ahead of the conquistadors. As the jungle grew over these lost cities, every trace of the civilization was obscured until very recently when a highly fertile black earth full of ancient pottery shards began turning up for sale as potting soil in Brazilian markets. These soils had to be at least 500 years old.

A group of researchers led by Johannes Lehmann of Cornell University has been studying the terra preta soils in Brazil. Lehmann has been concerned with dating the terra preta soils because he wants to verify that they can indeed store carbon safely away from the atmosphere for very long periods. Recently he has discovered man-made soils that are more than 7,000 years old. While he found no pottery shards in the oldest layers, he did find stone tools. The terra preta soils are an ancient wisdom indeed.

Many cultures have noticed that adding cinders and ash to soils helps their fertility. Japan has a long tradition of using biochar; it is a major ingredient in bonsai potting mixes. Japanese scientists today have many ongoing research projects looking at the activity of charcoal in soil and at integrated systems to produce energy, charcoal, and food.

MULTI-DISCIPLINARY EXCITEMENT

Although organized research into biochar is very new, it is growing rapidly, and because it addresses so many urgent problems, from global warming to soil fertility to energy, it is attracting interest from a wide variety of people. Johannes Lehmann

Kelpie Wilson is Truthout.org's *environmental columnist and regularly writes for* Yoga +.

Garden photo by BEST Energies; Group photo provided by Robert Flanagan; Previous pages: Sprout in soil: © White Packert / Getty Images; Test tube soil: © Dan Saelinger / Getty Images

FLANAGAN'S STOVE
With such a stove, village farm families can turn biomass into cooking gas and soil-enriching biochar.

Exploring the Double Promise of Terra Preta

Soil science researcher Janice Thies is a colleague of Johannes Lehmann's at Cornell University. She chaired a panel at the conference in Australia, and afterwards talked with *Yoga +* about her research. She described to me the excitement she felt when her department interviewed Lehmann for a faculty position. "It was his work on terra preta," she said, "that got my vote for him to join us."

Thies is now deeply involved with the terra preta research herself, trying to understand what makes it so fertile. One question is whether the effect is primarily chemical or primarily biological. Charcoal is a highly porous material that is very good at holding nutrients like nitrogen and phosphorus and making them available to plant roots. It also aerates soil, while at the same time it helps retain water—a very important trait for drought-ridden areas around the world.

Charcoal's pores also make excellent habitat for a variety of soil microorganisms and fungi. Think of a coral reef that provides structure and habitat for a bewildering variety of marine species. Charcoal is like a reef on a micro-scale.

Where Bio-piracy Left Its Mark

Thies tried to bring soil samples back from Brazil to analyze them in her lab at Cornell, but Brazil's bio-piracy laws, a legacy of the pharmaceutical companies and their pillage of Amazonian medicinal plants, prevented her from doing that. And so Thies began teaching Brazilians how to do the DNA analysis. "As a result, we got Brazilian people excited about these soils and learning something about them," she said. The Brazilian researchers are beginning to confirm that the terra preta soils have a profusion of diverse soil microorganisms living in them.

INTERNATIONAL COOPERATION *Robert Flanagan, Janice Thies, with associates on a biochar project in China.*

Clearly the magic is not simply adding charcoal. In fact, researchers have learned that adding char alone to extremely deficient soils can be worse than doing nothing at all, because charcoal will chemically bind the few nutrients that are in the soil. The best results come when charcoal and a complete fertilizer are used.

Janice Thies and her associates now have research projects going all over the world. These international projects are in the early stages and Thies still seeks definite answers to most of her questions, but so far the results continue to confirm the promise of biochar for its role in improving soil fertility.

—*K. W.*

and others decided it was time to start a dedicated scientific society and hold a conference. "We need to get the engineers together with the environmental scientists, with the economists and the policy analysts," Lehmann said. "Get them together into one pot and stir heavily."

On assignment from *Yoga +*, I was able to attend the International Agrichar Initiative conference in Australia in May of this year and found it seething with the kind of chemical energy that comes from combining many active ingredients.

Scientists were there to discuss how they're probing the mysteries of biochar, for it still isn't known exactly how this dark earth works. Engineers were there to discuss different pyrolysis techniques: how changing the temperature and airflow produces charcoal with different properties and different amounts of fuel by-product. Farmers were there looking for miracles to rescue the poor, tired soil on their farms. Industrial managers came to see if there was a use for the huge piles of waste that their timber mills, pulp mills, and food-processing plants produce.

Development workers came because half the world uses charcoal for cooking fuel and they are searching for a better way for the world's poor to cook their meals. Primitive, inefficient charcoal kilns presently in use gobble up forests and pollute the air.

Climate change analysts came for the promise of carbon sequestration, and investors came to seize a rare opportunity to make money while doing good. Joe Herbertson, director of an energy consulting company called Crucible Carbon, said, "When I heard about this technology, the hairs went up on the back of my neck."

It was a very interesting gathering.

BIOCHAR CAN HELP THE POOR

More good news about biochar is that it can help with many problems that plague the poorer parts of the world. Much effort over the years has gone toward developing better cookstoves for people

{ BIOCHAR POTTING SOIL }
Yes, you can try this at home

The recipe below is for a special potting mix that Cornell University soil researcher Janice Thies devised for home use.

8 parts peat moss
1 part vermicompost or leaf compost (aged)
1 part perlite

Per quart of the above mix, add the following:

⅛ cup bone meal
⅛ cup blood meal (substitute ¼ cup chicken manure for the blood and bone meal if you prefer)
¼ cup charcoal (use horticultural charcoal from the garden store, or if you have it, substitute used charcoal from an aquarium filter)
1 Tbsp. organic liquid fertilizer

HOUSEPLANTS GONE WILD
Janice Thies developed and tested her biochar-enriched potting mix at home. As you can see, results were spectacular.

who have no gas or electricity. Charcoal is a traditional cooking fuel, but making charcoal in traditional kilns is a wasteful and polluting process compared to a modern pyrolysis unit.

Robert Flanagan, an entrepreneur working in China, has come up with a low-cost wood-baking stove that makes charcoal while providing a cooking flame at the same time. He demonstrated the stove at the conference one evening.

He loaded the fuel box with about 1.5 kg of wood, started it with a small amount of charcoal, and turned on the unit's draft control fan. As the wood heated up, it gave off gases that burned in a colorless flame in the burner ring. Flanagan and his wife, Naomi, passed out tiny marshmallows and wooden skewers and we all had a go at toasting them over the glowing coals. After about an hour, the stove cooled down and Flanagan dumped a small pile of charcoal out of the fuel box. This could go into a potting soil or directly in a field.

Flanagan has also been working on giving Jatropha plants a better start by using biochar in the potting soil for seedlings. Jatropha is an oil seed tree that is being grown on degraded land in Africa, India, and elsewhere to produce bio-oil for fuel. He found that plants started with biochar grew much more vigorously than plants without.

Etelvino Novotny, a soil scientist at the University of Sao Paolo, is trying to recreate terra preta by making a char that is fortified with fertilizing organic oils. Terra preta has organic oils in it that are not found in plain charcoal. Novotny hopes that his work will help save the Amazon rainforest. He said, "It's wonderful that we can use the cultural knowledge from the Amazon for our benefit rather than exploit its physical resources. This can help farmers. Everywhere small farmers could use the terra preta technology and improve the fertility of their soils."

BURN IT OR BURY IT?

Some conference participants suggested that energy, rather than soil health and carbon sequestration, would be the key driver for adopting biochar. There is a trade-off between producing energy or charcoal, because the pyrolysis process can be optimized either way. Desmond Radlein of Dynamotive Energy Systems said, "It is wishful thinking that people will switch to renewable fuels unless it is cheaper." Because money is needed for transport and labor to put biochar into soil, he's one who sees a path forward in maximizing energy production first.

Robert Flanagan put forth a different view. There are 700 million farmers in China, he pointed out. China could quickly deploy a small, village-level pyrolysis unit he is developing, and because labor is cheap, spreading the biochar on fields would be affordable even without a large energy harvest.

Others at the conference felt that an expanding market for carbon credits under the Kyoto protocol would be the force that drives the adoption of biochar. Mike Mason, director of the U.K. biomass energy company, Biojoule, said the impact of biochar on nitrous oxide emissions alone would be enough incentive to fund the effort to put biochar in fields.

Nitrous oxide is 270 times more potent than carbon dioxide as a greenhouse gas, and it lasts for 150 years in the atmosphere. Use of nitrogen fertilizers is a major source of the gas, and a difficult one to mitigate. But biochar applied to fields seems to have a significant damping effect on nitrous oxide emissions. Dr. Lukas Van Zwieten, who is measuring nitrous oxide emissions from biochar-amended fields at the New South Wales Department of Primary Industries, said, "The more I look into this, the more excited I get."

OK, WHAT'S THE DOWNSIDE?

Because of our social conditioning, people have the unfortunate potential to abuse a gift like biochar by focusing too closely on those aspects which seem most beneficial to us and neglecting the things that don't fit into our system of economic rewards. If that happens, we will not create the positive feedback loop that puts carbon into the soil and cools the planet.

Some conference participants were interested in using the charcoal itself for energy rather than as a soil amendment. They called it "green coal." If biochar is mostly burned to continue powering our unsustainable industrial growth society, it will cause the same problems seen with the palm oil industry, which is rapidly deforesting the habitat of orangutans in Indonesia, for instance, or the American corn ethanol industry, which is impover-

Photo by BEST Energies

ishing U.S. soils and driving up food prices.

Janice Thies, one of the Cornell researchers, said that she hopes that biochar will first be used to take care of the earth. "There's an old Chinese saying that soil is the mother of all things. I hope we don't take the process all the way to everything going to produce energy, but that we hold back and give back to the earth some of this carbon. I know the economics don't lean toward that, but this is an integrated system of activities that is helping to slowly siphon CO_2 back into long-term stabilized carbon in the soil."

How do you turn good black magic into bad black magic? By letting short-sighted greed rule. Economic theory today relies on short-sighted greed to power the engines of economic growth, but optimizing an industry for its most immediate benefits does not always produce the greatest good. Biochar technology requires a more expansive thinking that values the long-term health of essential earth processes as much as products and profits.

Biojoule's Mike Mason shared his idea for creating and maintaining the beneficial feedback loop that will fully realize the promise of biochar. He said that timing is the key. First, we must take the 4 billion tons of agricultural waste products generated every year and turn as much of that as possible into biochar and then bury it in soils to increase soil fertility. After a few years, as the productivity of our fields rises, we can begin optimizing biomass pyrolysis for energy production to help replace dirty coal and vanishing stocks of oil and gas. Eventually, as civilization moves more and more to rely on the clean energies of solar, wind, and ocean power, we can shift biomass utilization back to char again and keep sequestering more carbon to get atmospheric levels back to pre-industrial levels.

BEST ENERGIES' BIOMASS BAKER *Pyrolysis can be fine-tuned to maximize the yield of either usable gas as an energy source or charcoal for agriculture. Yet by not optimizing the baking process to favor either at the expense of the other, well-balanced pyrolysis can do more for the health of the earth.*

A dream scheme for terra preta is to turn agricultural waste into biochar to boost soil fertility. Then in a few years, biomass pyrolysis can favor more energy production to supplant dirty coal.

TRADING IN CARBON CREDITS

Biochar researchers have thrown a few numbers around about how much impact it could have on global warming. Johannes Lehmann of Cornell says that by 2100, biochar could be sequestering all of the CO_2 that humans produce. He says that the process will become economically viable as soon as the value of avoided carbon dioxide emissions reaches $37 per ton, about nine times higher than the current price.

Clearly, it is essential that the carbon trading market matures to the point where it can provide the money to do this job. Getting the United States to join with other nations in the carbon market is the most important job ahead. It is essential that all of us as citizens stay focused and pressure our governments to shift the system of economic rewards so that it acts to preserve the planet, not plunder it. This is both a moral and a practical issue.

Meanwhile, our understanding of terra preta must increase. Senator Ken Salazar, a Democrat from Colorado, is working on a bill to fund biochar research and field trials. And many organic farmers, gardeners, and permaculture enthusiasts have discovered biochar and are doing their own trials in fields, orchards, and pots. See our sidebar *(far left)* for a potting soil recipe and directions for doing your own trials so you can see for yourself how biochar works.

The beautiful thing about nature's positive feedback loops is that if you get the right one going, it feeds on itself, and all it takes from us is some care and attention. Biochar provides us with a way to work with nature rather than against it. We don't have to hold up the sky all by ourselves; in fact, it would be impossible.

There is something that everyone can do to reinforce this positive whirlwind of change. Whether that is writing letters to politicians, planting a seed in a pot, or sowing an entire field, the power is in getting the process started. Then all we have to do is let it go. +