Can "terra preta" be used to combat climate change?

Winner of OsterMed prize for "Climate change" competition

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ABSTRACT

Today, the world faces the imminent concern of environmental consequences brought on by poor technological and agricultural practices. Though political and scientific steps are being taken to prevent lasting impacts on worldwide populations, this article assesses the efficacy of a relatively new natural approach to the problem: terra preta. Found in the forests of the Amazon, this natural soil (also known as agrichar) possesses the chemical ability to modify ribulose-1,5-bisphosphate (RuBP) and allows the synthetic molecule to play a more definitive role in photosynthesis carbon fixation. In addition to exploring the scientific background of this solution, this article investigates its social and political implications. Bioengineering conventions, like those in Australia just starting to take form, serve as optimal champions of emphasis on agrichar production. Raising awareness about this 90% carbon-efficient soil will ensure that the environmental movement takes precedence in the public mind.

Introduction

By the end of with century, 182 million sub-Saharan Africans could die of disease "directly attributable" to climate change.[1] By 2030, more than 60 million more Africans will be exposed to malaria if temperatures rise by 2°C.[2] One-sixth of the world's population will face water shortages because of the retreating glaciers.[2] And why is that? Because the modern world has not slowed to allow the environment to overcome these serious health hurdles.

In 2008, the United States consumed 20.4 million barrels of oil per day.[3] According to the Hinkle Charitable Foundation, "Across the entire US economy, total carbon dioxide emissions per household totaled a staggering 59 tons or 118,000 pounds in 2003. When compared to the rest of the world, US households account for over six times as much carbon dioxide emissions than the remainder of the world per year, on average" [Figure 1].[4]

Year after year, despite constant awareness of the American consumer, the quantity of emissions from just fossil fuels has been increasing dramatically as the society sees more cars on the road, more environmentally dirty manufacturing plants, and more careless electric consumption. In total, 8.38 gigatons

(GtC) of carbon were released by the United States in 2006 [Figure 2].[5]

Current Approaches

The current approach to the unmitigated problem of global warming is two-pronged, political and scientific. With the world leaders taking slow steps by setting goals of lower global emissions, such as the EU mandate for limiting temperature rise to 2°C,[6] it seems that politics has found a heavy weight in environmental preservation. However, political power is not as strong as solid scientific solutions that will both change our treatment of the environment and offset the harm done. What has been emphasized today has had a peanut butter spread effect, meaning energy and money has been wasted. Instead of concentrating on a single solution, they are spread out in different areas of invention, all of which have rendered no certain success.

Perhaps the cleanest alternative source is wind power; however, the cost financially and spatially is too great compared to a lower cost-to higher output of fossil fuel. Furthermore, 20 mph winds are required for capable operation, and winds are locally intermittent. Alternative fuels like corn ethanol serve only to aggravate world poverty as food prices are driven up, and agricultural farmland is now used for energy cultivation. Another public favorite, nuclear power, has several negative impacts. Not only is the nuclear waste produced projected to be the size of the Yucca Mountain with deadly radioactive consequences, but also the high terrorist potential posed by countries with nuclear capability is frightening. Financially, uranium has become $ 40 more expensive in a span of 5 years. Lastly, the Oxford Research Group concludes, "The nuclear fuel cycle is responsible for emitting 84 to 122 grams of carbon dioxide per kWh [kilowatt hour], mostly from uranium mining, plant construction, and plant decommissioning".[7] All in all, the current methods of solving global warming and reshaping our energy economies have been unsuccessful.

The panacea

Terra preta do Indio, also known as biochar or agrichar (the global brand name) is the most plausible answer to our problems today. In short, agrichar is the antithesis of how many climate change scientists approach the global warming problem. Rather than finding a way to reform our energy economies, which could be a long process the Earth cannot afford,

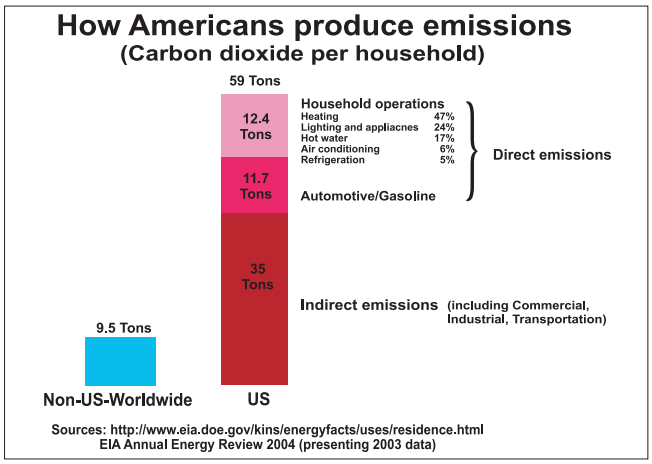

Figure 1: A diagram to show what the average American's carbon dioxide emissions come from (from http://www.eia.doe.gov/kids/energyfacts/uses/residence.html)

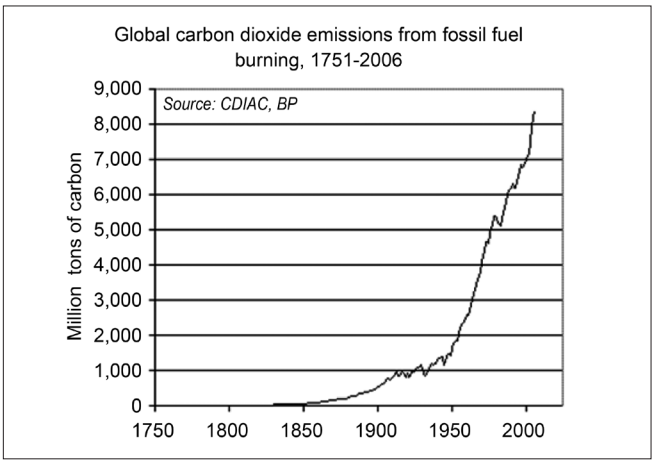

Figure 2: A graph to show how carbon dioxide emissions from fossil fuels have changed. Source: Earth Policy Institute, Eco-Economy Indicators (from http://www.earth-policy.org/index.php?/indicators/C52/)

agrichar mitigates and offsets current CO_2 levels. Through a process called carbon sequestration, agrichar creates permanent repositories for holding carbon dioxide. Geologic formations and terrestrial ecosystems are the two ways to accomplish total carbon sequestration.

The pores in many of these geologic formations have formed an impermeable membrane with overlaying layers to prevent material from leaking out; to this day, they hold large amounts of oil and gas, accumulated and held for centuries. By taking out the natural gas and oil in the rock repository at this time, carbon dioxide can be permanently injected in its place. In particular, saline formations with brine have high retention of materials, depending on the size, permeability, and heterogeneity of the particular formation in question. Not only will we be able to

store away tons of emissions, but also we can take advantage of a plethora of natural resources. At this point in time, however, permeability is still in question: the existence of carbon retention is true enough, but quantity is not clear.

One of the most successful approaches to this method of carbon sequestration in the world today was discovered mistakenly in the wet rainforests of the Amazon. Though similar in nearly every aspect to the yellow oxisol (highly weathered soil that is found primarily in the intertropical regions of the world) that surrounds these patches of dark soil, terra preta hides a truly precious ability. Unlike most soils and fertilizers used in today's gardens, terra preta do Indio has the property of which when burned, releases some carbon dioxide but retains more than 80% – an astonishing discovery that has dubbed it a carbon negative fuel. According to Jeremy Faludi (a professor of green design at Stanford University), "[With] twenty times the carbon of normal soils, terra preta is the legacy of ancient Amazonians who predate Western civilization". Amazonian Dark Earths have high carbon contents of up to 150 g C/kg (coulomb per kilogram) soil in comparison to the surrounding soils with 20–30 g C/kg soil.[8] This being said, the potential for carbon lock in this soil could offset the emissions that increase daily around the world.

Composition

Composed of pottery shards, fine charcoal bits, and waste, agrichar itself may not seem very impressive. However, the amount of effort and energy required to take normal, infertile soil in the backyard and create agrichar is not much. The pyrolyzation of farm waste at low temperatures and simple grinding of charcoal bits can recreate what the long-dead people of the Amazon had done for their very own farmyards. Pyrolyzation is the process of low temperature burning of biomass such as leaves, branches, or soil without oxygen [Figure 3]. This prevents the release of carbon dioxide. This makes bioenergy carbon-negative and improves soil health.[9]

The key ingredient is the fine charcoal. Scientists have found that the most fertile soils contained 40–90% charcoal.[10] Though this finding was counterintuitive for most soil scientists because charcoal is an inert material whose effect on the soil's productivity was assumed to be little to none, they found that charcoal in fact made the soil far more fertile due to its partnering community of bacteria. Within the charcoal

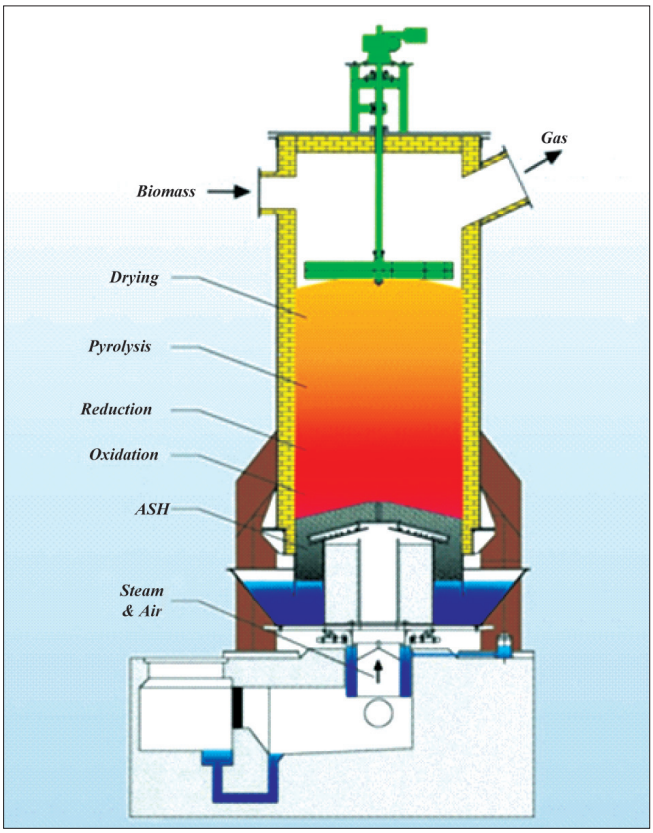

Figure 3: A gasifier (which converts carbonaceous materials, such as coal, petroleum, biofuel, or biomass, into carbon monoxide and hydrogen) in the process of pyrolyzation (from http://www.worldchanging.com/gasifier_zones.jpg)

itself, there are resins that contain nutrients, released by the bacteria's enzymes and enjoyed by the plant. These resins are nourishing because they absorb minerals from rainwater and the environment. Once a corresponding soil bacterium comes along, the nutrients are then released to the plant. Not only does the soil no longer need to sit fallow, but also the plant yield is much higher even without the use of fertilizers.

Conclusion

Terra preta offers various financial, social, economic, and environmental benefits in comparison to the current solutions to global warming. The next step has already been taken in Canada and Australia in conventions with United States bio-geochemists and Australian biofuel engineers. Lehman of Cornell University is also conducting research and studies to maximize productivity of the dark soils and prepare for mass production to truly make a worldwide impact on global warming. Although "the techniques of the Amazonians remain an enigma, their system of slash-and-smolder locked half of the carbon of burnt vegetation in a stable form like terra preta instead of

the carbon emitting process of slash-and-burn".[8] With these tips in mind, a global effort can be amassed to face off what could be an impending doom if we simply wait. Rather than take up several initiatives with little chance of success, creation of terra preta could appease our environmental concerns and provide us with a more solid future in environmental conservation.

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About the Author

Kristi Lui is 17. She is interested in public and global health. At school, she enjoys taking Advanced Placement Chemistry and Biology. She is a voracious reader of the classics and loves Shakespeare and Emily Dickinson. Kristi is a basketball and softball player as well. In her spare time, she loves to sing along with her sister's piano-playing or to play with her dog. Most of her weekends are spent at debate tournaments; last season, she was captain of the Public Forum Debate team.