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Industrial charcoal (biochar): just a dangerous technofix?

A short primer

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Purpose of this primer

Industrial charcoal, otherwise known as biochar, has recently been receiving increased attention within scientific, government and NGO forums, with suggestions that it will “allow us to address three or four critical crises at once: the climate change crisis, the energy crisis, and the food and water crises” (Tim Flannery, Australian explorer and naturalist)[1]. Some environmental groups are actively supporting the development of industrial charcoal processes, and promoting it as if it was proven, safe and useful. However, there is currently little evidence to support such claims, and even less critical assessment of biochar’s supposed benefits. The purpose of this short primer is to critically investigate the claims around industrial charcoal, or biochar, and draw attention to their serious shortfalls.

The context

While most ‘developed’ countries of the world continue to delay reducing their greenhouse gas emissions, atmospheric concentrations of carbon dioxide and other greenhouse gases are reaching increasingly dangerous levels. The impacts are being felt harder and earlier than previously thought, and as a result, leading climate scientists and NGOs have started to call not only for dramatic cuts in greenhouse gas emissions, but for the need to actively start taking carbon dioxide out of the atmosphere in order to avoid crossing the climate tipping point. Bioenergy production coupled with carbon sequestration in the form of industrial charcoal is one of the proposals for large scale climate ‘drawdown’ or sequestering of greenhouse gases already present in the atmosphere. Its large scale implementation could also substantially speed up the commercialization of second-generation agrofuels and biorefineries, making them more commercially viable.

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Why charcoal?

The incorporation of charcoal has possibly played a vital role in a number of sustainable agricultures in ancient cultures. Terra preta (Portugese for “dark earth”) is a common case study used by proponents of industrial charcoal, and refers to the very dark, fertile soil found in some areas of the Amazon Basin, one of the last traces of pre-Columbian agriculture. This type of soil has an unusually high charcoal content and because of the pottery remains found in it, is thought to have been created up to 6000 years ago by slash and char agricultural techniques developed by the local population. The exact details of how Terra preta was created are unknown, but appear to involve the incorporation of wood charcoal, diverse organic matter and nutrients in the form of manure, compost etc. Soil microbes also appear to play a vital role in its creation.[2]

Charcoal is also present in other parts of the world (Germany from Neolithic times, in the United States from circa 5,000 years ago and in Australia),[3] but very little knowledge exists about how these soils were created, nor how far they mirror Terra Preta in their properties. In the US, regular prairie fires have been suggested as one factor in their creation.

An important aspect of these charcoal-based farming systems is that the soils were created by small farmers, probably over thousands of years, incorporating many different elements and practices which resulted in increased soil fertility. In contrast, modern intensive agriculture has had catastrophic environmental impacts – species extinctions, nitrogen overloading, soil depletion, pollution, and high greenhouse gas emissions. Learning from sustainable farming practices, such as those that led to Terra Preta is vital if we want to survive as a species.

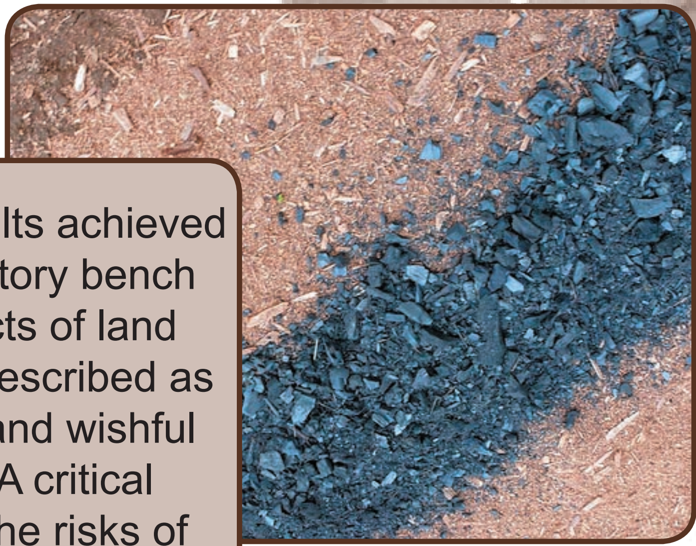
It is this concept of incorporating large amounts of charcoal into the soil that has inspired biochar, or as we call it, industrial charcoal production. However, there is little evidence that Terra Preta can simply be recreated by applying industrial charcoal to large tracts of land, especially without the incorporation of compost or manure. Without any deeper understanding of how Terra Preta is formed, companies, scientists and lobby groups are today calling for large-scale carbon funding and public subsidies for what is essentially a by-product of bio-oil and syngas production.

How does industrial charcoal production work?

Industrial charcoal (biochar) is produced as a waste product through the combustion of biomass under oxygen-limited conditions (pyrolysis)[4]. The product is similar in appearance to charcoal produced by natural burning (porous and fine grained). Depending on the kind of end product desired, the time, speed and temperature of combustion varies. With the use of certain technologies, the production of charcoal can also generate Syngas and/or bio-oil, which in turn can be used as fuel for a variety of applications. At most, 50% of the biomass carbon is contained in the charcoal (and in many systems far less), the remainder will be embodied in bioenergy and hence ultimately goes back into the atmosphere[5].

What kind of plant material does industrial charcoal production use?

Plant material (also called feedstock) used in industrial and/or research facilities include wood chips, wood pellets, tree bark, crop residues, switch grass, organic waste, sugar cane and olive waste, animal manure, sewage and paper sludge. The type of feedstock used will determine the potential commercial use and quality of the industrial charcoal product. Wood and biomass from energy crops such as short-rotation woody plants, high productivity grasses and various other herbaceous plants are best for biogas/oil



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production. Some companies (eg. the Australian company Cruciblecarbon are also proposing to incorporate up to 50% coal waste in the feedstock and are promoting this as a way of "rehabilitating and upgrading marginal land, especially degraded coal mining land".[6]

It is important to note that the proposal to continuously remove crop residues from the same land for the purpose of industrial charcoal production will inevitably lead to soil erosion and diminish soil nutrient supply.

Is all industrial charcoal production the same?

Not all industrial charcoal production is created equal. Industrial charcoal products contain different chemical, biological and physical properties, depending on feedstock (crop waste, energy crop, wood chip, municipal waste, manure, etc.) and process conditions (mainly temperature and time). As a result of these variables, industrial charcoal products will interact differently within the environment and will remain as charcoal in the soil for different lengths of time. There is currently no screening test for biochar products (eg. what feedstock is good for what purpose), nor any method to assess its long-term fate in the environment.[7]

Many research gaps

There are still many research gaps relating to the use of industrial charcoal. One of these is the interaction of types of industrial charcoal products with soil microbial communities and plants. Will the addition of various types of industrial charcoal products enhance nutrient use or will it be detrimental? Other areas of concern are an increase/decrease in water holding capacity (the jury is out) and effects on soil stability. Erosion, transport through and fate in the environment are also poorly understood. To date, only limited soil carbon modelling or total life cycle assessment has been preformed.[8]

Are there agricultural benefits?

Current results on the benefit of adding industrial charcoal products to improve crop productivity are mixed, perhaps due to the different bio-physical interactions due to geographic variations in soil type, climate, cropping and pyrolysis feedstock. The majority of the published studies are small scale (e.g. a pot) and short term. This experimental set up removes environmental fluctuation and often shows a lack of methodological consistency in nutrient management and pH control.[9] Applying results achieved at the laboratory bench to large tracts of land can only be described as unscientific and wishful thinking.

The only "biochar" field study (versus laboratory studies) published in a peer-reviewed journal in 2007, found that charcoal additions to soil made synthetic nitrogen fertilizers perform more effectively. However, yields for plants grown with char and fertilizers were still considerably lower than for plants grown solely with chicken manure. Using charcoal alone resulted in zero plant growth after two harvests.[10]

Water retention appears to be related to soil type, but any effect is probably short-lived, as the charcoal appears to physically break down into fine fractions relatively quickly. Alarmingly, "nobody knows how to incorporate biochar into the soil in a way which prevents it from eroding and, in the worst case, aggravating soil depletion."[11]

Unresolved is also the question of whether biochar should be incorporated into the soil, which will disrupt soil structures and cause soil organic carbon losses or simply be dumped on top of the soil. The latter will contribute to global warming via black carbon particulates ending up in the atmosphere.

A critical analysis of the risks of applying biochar on a large scale, assessing all issues associated with production, distribution and physical application of biochar, as well as its impacts in the soil is still totally missing. This assessment must be performed before any large scale experiments are conducted, because once added to soil it is irretrievable. Additionally, it may take 50-100 years for interactions between soil microbes and charcoal to create soils resembling Terra Preta.[12]

"Forest residues" for bioenergy and biochar?

While many promote the use of forest residues for use in bioenergy and as a future feedstock for biochar, it is known that the removal of 'forest residues' including dead wood is known to have many adverse impacts. These include lower carbon storage, increased biodiversity losses[13] as well as permanently damaging forest soils and diminishing or destroying the possibility of forest regeneration,[14] yet this practice is still promoted for use in bioenergy production and as future feedstock for biochar. Biodiversity plays an essential role in the recycling of nutrients and pollination, and hence the survival of ecosystems upon which we all depend.

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Removal of 'forest residues' will further degrade forests and erode their ability to support life.

Carbon sequestration potential?

One of the key selling points of biochar is its purported ability to sequester carbon and hence assist in climate change mitigation. Biochar proponents claim that up to 50% of the original carbon in the biomass can be permanently sequestered in soils while at the same time, increase agricultural productivity and reduce nitrous oxide and methane emissions.[15]

But the reality may be quite different. A study of black carbon remains from slash and burn agriculture in Western Kenya revealed that 72% of the carbon was lost in the first 20-30 years.[16] Evidence is emerging that due to soil microbes metabolizing carbon it is in fact being emitted back into the atmosphere rather than being sequestered.[17]

Biochar uses the same false claims used to justify other plant based energy production schemes. This creative accounting claims that any carbon emitted during pyrolsis can not only be offset by subsequent new plant growth, but that some of the carbon is also retained in the charcoal and, if put into soil, sequestered. Unfortunately, this accounting completely ignores the numerous ecological and social impacts from land use changes and is not supported by current scientific understanding of the fate of charcoal in soils.

Despite claims by biochar proponents that it will decompose very slowly and 'lock up' carbon for hundreds of years, there is currently insufficient data in the literature to confirm the short- and long-term stability of biochar under different climates and in different soils. Again, conditions during pyrolysis as well as the type of feedstock appear to influence the stability of biochar products.

The half-life of biochar, i.e. how long the carbon will stay in the soil, is presently unknown, but it is clear the answer will always depend on the circumstances, for example, the type of biomass used, production conditions, soil properties and climate.[18] If biochar is pursued on a large and/or global scale, it may be a time bomb for future generations.

Finally, biochar may play a ‘dangerous’ role in encouraging the outsourcing of emissions reductions and possibly facilitating an overall increase in greenhouse gas emissions. Its inclusion in the international climate regime through carbon offsetting and trading mechanisms will allow companies to continue burning coal and other fossil fuels while purchasing carbon credits through such schemes as the Clean Development Mechanism.

Environmental issues: is the production of industrial charcoal safe?

Different feedstocks and production conditions affect how many phytotoxic and possibly carcinogenic materials are produced during pyrolysis. Two compounds which may be released during pyrolysis, are polycyclic aromatic hydrocarbons (PAH), some of which are carcinogenic, and dioxins that have not been adequately researched[19] and may be present at dangerous levels. The charcoal will also bind any toxins contained in the feedstock, which will turn enter soil – e.g. pesticide residues, chemicals for wood treatment if ‘wood residue’ is used, etc. This means that a full environmental risk assessment is needed, which must examine possible public health impacts, as well as the potential effect on terrestrial or aquatic ecosystems.

There may also be occupational health impacts. Being a flammable solid, biochar can ignite spontaneously and the handling of large quantities requires great care and is potentially dangerous.[20] Air quality (particulates traveling into water or air), water quality (impacts on aquatic life and water treatment) and food safety (surface and systemic contamination of food products) are also potentially compromised and are all areas of further risk assessment.

Who will gain? Who will lose?

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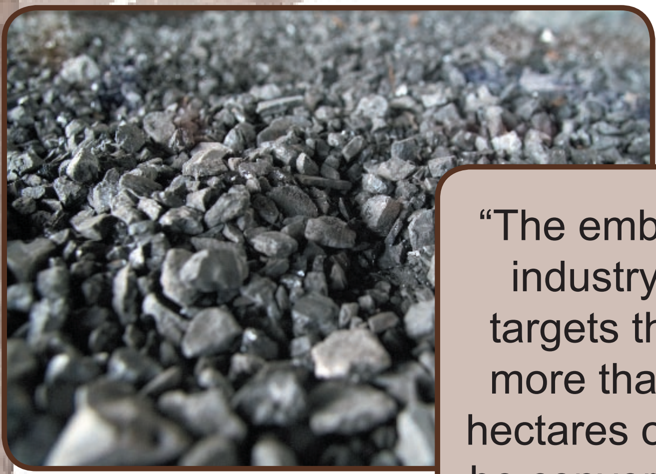
A recent CSIRO report acknowledged that the “widespread use of non-waste feedstocks for energy and biochar (or only biochar) could impact not only commodity prices but, in a manner analogous to that seen with large-scale bio-ethanol production in the USA, impact on the economics of continued energy production through feedbacks on land and input prices.”[22] As we realise the effects of large-scale ethanol production, it seems we are failing to learn from these in the pursuit of other energy and carbon draw-down technologies.

Biochar is also being promoted in the context of rural cooking stoves and to improve soil fertility. Finding clean and efficient rural cooking methods is critical. Currently open fires not only contribute to climate change, but the emissions are also a major cause of respiratory disease, with soot being a well-known human carcinogenic. While charcoal-producing cooking stoves address the latter issue, they are less efficient than other biomass stoves and require an additional 20-30% more wood or ‘residues’ to be collected.

While biochar production may potentially improve the health of rural communities, current research and development trends indicate that the major



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profiteers will be bioenergy companies, who will gain additional income from fertiliser sales associated with biochar use. Several companies hold patents or are in the process of patenting biochar-based fertilisers as well as different pyrolysis processes, depriving especially rural communities of potential affordable access to both. Because patenting is expensive, prices for various products relying on the patented process or product will increase. Potential patent infringement issues may also delay and make it impossible to develop products. Technology that has the potential to be community owned and controlled will alsso be hindered by the issuing of patents.

Another source of income from biochar production will potentially come through carbon trading, heavily promoted by biochar lobbyists. A 2006 study[23] provides an interesting insight into the types of projects that may profit from carbon trading, should biochar be included. These include an acacia plantation in Sumatra owned by a pulp and paper company, wood residue from a eucalyptus pulp and paper monoculture in Australia, and a waste incinerator turning sawdust into biochar. Clearly, pulp and paper companies, together with agribusiness firms would benefit through the establishment of 'integrated biorefineries': for example, factories that produce biofuels and biochar, based on large-scale scale industrial agriculture and industrial forestry propped up by carbon trading.[24]

The greenwash

Biochar lobbyists promote a future industry which they claim will primarily benefit small farmers and rural communities, through small pyrolysis units and charcoal-making cooking stoves. Yet the reality is that the embryonic biochar industry is calling for targets that will require more than half a billion hectares of plantations to be converted to biochar.

Politicians are listening. At the annual international climate negotiations in Poznan, Poland in December 2008, the government of Micronesia proposed that biochar should play a vital role in mitigating climate change. The governments participating in the talks agreed to include biochar into the "dialogue for the post 2012 climate regime". As a result of this political support, the Copenhagen climate talks in December 2009 could result in the rules of the Clean Development Mechanism (CDM) being extended to include projects that generate CDM credits from biochar, paving the way for this to be a key part of 'mitigation action' in the post 2012 agreement. This would provide significant financial incentive for biochar projects in the Global South and render these regions guinea pigs for an unproven technology.

How much land to cool the planet?

Biochar is closely linked to bioenergy, as bioenergy plantations are required to fuel the production of biochar. If biochar actually does work, the area of land needed to make climate mitigation a reality is staggering, involving at least 500 million hectares of dedicated bioenergy plantations. By comparison, the entire land mass of India is 329 million hectares. The proposed area is 20 to 25 times the land area currently used for agrofuel production – an already highly criticised form of energy production. Much of the land proposed for use is so-called wasteland, marginal or idle land. But these areas are often community lands that have been used by pastoralists, small-scale farmers, women excluded from land titles and Indigenous Peoples for many generations.[25] These are not 'waste' lands, but lands vital to the survival of billions of people.

What are the alternatives?

Real solutions to climate change can be found in a rapid reduction of the consumption/production growth cycle, de-industrialisation, and food and energy

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- Biofuel Watch UK

sovereignty based on truly sustainable renewable energy production. Rather than large scale and dangerous geo-engineering projects we need to learn from small farmers, indigenous peoples and other rural communities who have developed many different strategies for soil conservation and improving soil fertility. Shifting away from industrial monocultures and learning from these strategies are essential in the transition towards sustainable, just societies and for addressing climate change.

Summary: Another false climate solution

Biochar can be viewed as part of a series of false climate solutions. It is based on large-scale industrial plantations and will lead to the acquisition of large tracts of land, furthering the erosion of Indigenous Peoples' and community rights while not adequately addressing the climate crisis. The claims of biochar lobbyists of soil and climate benefits are largely unproven. However, biofuel companies would make potentially large economic gains, through the addition of biochar to industrial fertilisers and potential access to carbon credits within carbon trading schemes. Biochar, while scientifically unproven, does offer windfall profits to the industrial agriculture sector and agrofuels industry – neither of which are currently pursuing a path towards genuine sustainability.

Biochar development is a distraction from developing real and sustainable renewable energies and encourages expansion of business-as-usual for polluting industries, while unlikely to fulfill its promoters' claims of being a major profit source for small farmers and landowners.

As stated by Biofuel Watch UK, "biochar and other "climate change mitigation" strategies that depend on industrial monocultures, including those that involve industrial bioenergy production, will inevitably lead to the displacement of very large numbers of people and to the loss of food sovereignty and livelihoods... [Meanwhile, the] concept of biochar as a global soil conservation strategy disregards the many locally adapted sustainable farming and soil conservation methods which communities have developed over long periods... A 'biochar revolution' would inevitably be led by those companies who hold the patents and have access to funding, and would accelerate the industrialisation of global agriculture and forestry... [while successful] soil conservation strategies such as intercropping, permaculture, composting, the retention of crop residues, fallow periods are likely to be sacrificed for a 'one size fits all solution'."[26]

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