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ARTICLES

1. Jeffery, S., Abalos, D., Prodana, M., Bastos, A., van Groenigen, J. W., Hungate, B., & Verheijen, F.
   Biochar boosts tropical but not temperate crop yields. (meta-analysis)
   (2017) Environmental Research Letters, 12 (5)
   Applying biochar to soil is thought to have multiple benefits, from helping mitigate climate change to managing waste to conserving soil. Biochar is also widely assumed to boost crop yield [5, 6], but there is controversy regarding the extent and cause of any yield benefit. Here we use a global-scale meta-analysis to show that biochar has, on average, no effect on crop yield in temperate latitudes, yet elicits a 25%

average increase in yield in the tropics. In the tropics, biochar increased yield through liming and fertilization, consistent with the low soil pH, low fertility, and low fertilizer inputs typical of arable tropical soils. We also found that, in tropical soils, high-nutrient biochar inputs stimulated yield substantially more than low-nutrient biochar, further supporting the role of nutrient fertilization in the observed yield stimulation. In contrast, arable soils in temperate regions are moderate in pH, higher in fertility, and generally receive higher fertilizer inputs, leaving little room for additional benefits from biochar. Our findings demonstrate that the yield-stimulating effects of biochar are not universal, but may especially benefit agriculture in low-nutrient, acidic soils in the tropics. Biochar management in temperate zones should focus on potential non-yield benefits such as lime and fertilizer cost savings, greenhouse gas emissions control, and other ecosystem services.

2. Novak, J.M.a , Ippolito, J.A.b , Lentz, R.D.b , Spokas, K.A.c , Bolster, C.H.d , Sistani, K.d , Trippe, K.M.e , Phillips, C.L.e , Johnson, M.G.f
   Soil Health, Crop Productivity, Microbial Transport, and Mine Spoil Response to Biochars
   (2016) Bioenergy Research, 9 (2), pp. 454-464

   Biochars vary widely in pH, surface area, nutrient concentration, porosity, and metal binding capacity due to the assortment of feedstock materials and thermal conversion conditions under which it is formed. The wide variety of chemical and physical characteristics have resulted in biochar being used as an amendment to rebuild soil health, improve crop yields, increase soil water storage, and restore soils/spoils impacted by mining. Meta-analysis of the biochar literature has shown mixed results when using biochar as a soil amendment to improve crop productivity. For example, in one meta-analysis, biochar increased crop yield by approximately 10 %, while in another, approximately 50 % of the studies reported minimal to no crop yield increases. In spite of the mixed crop yield reports, biochars have properties that can improve soil health characteristics, by increasing carbon (C) sequestration and nutrient and water retention. Biochars also have the ability to bind enteric microbes and enhance metal binding in soils impacted by mining. In this review, we present examples of both effective and ineffective uses of biochar to improve soil health for agricultural functions and reclamation of degraded mine spoils. Biochars are expensive to manufacture and cannot be purged from soil after application, so for efficient use, they should be targeted for specific uses in agricultural and environmental sectors. Thus, we introduce the designer biochar concept as an alternate paradigm stating that biochars should be designed with properties that are tailored to specific soil deficiencies or problems. We then demonstrate how careful selection of biochars can increase their effectiveness as a soil amendment.

3. Ahmed, M.B., Zhou, J.L., Ngo, H.H., Guo, W.
   Insight into biochar properties and its cost analysis
   (2016) Biomass and Bioenergy, 84, pp. 76-86

4. Ok, Y.S.a , Chang, S.X.b , Gao, B.c , Chung, H.-J.d
   SMART biochar technology-A shifting paradigm towards advanced materials and healthcare research
   (2015) Environmental Technology and Innovation, 4, pp. 206-209.

5. van Laer, T.a , de Smedt, P.a , Ronsse, F.b , Ruysschaert, G.c , Boeckx, P.d , Verstraete, W.e , Buysse, J.f , Lavrysen, L.J.a
   Legal constraints and opportunities for biochar: A case analysis of EU law
   (2015) GCB Bioenergy, 7 (1), pp. 14-24.

   This article addresses biochar from a legal point of view. It analyses different policies and regulations from a European (Flemish) point of view and provides a first and general insight in what potential legal constraints the development of a biochar industry might face and what opportunities lie ahead. This is due to the fact that biochar is a recent product and a lot of scientific uncertainty still exists regarding the consequences of its application. From the analysis it appears a multitude of policies and legislative measures influence the development of the biochar industry. Hence, it is important that all these policies and legislative measures are analyzed in an appropriate manner. Moreover, considerable lobbying, negotiating and cooperation between different disciplines (legal, scientific, economical, etc.) will be required so as to develop a feasible and safe biochar framework.

6. Cayuela, M.L.a , van Zwieten, L.b , Singh, B.P.b , Jeffery, S.c , Roig, A.a , Sánchez-Monedero, M.A.a
   Biochar's role in mitigating soil nitrous oxide emissions: A review and meta-analysis
   (2014) Agriculture, Ecosystems and Environment, 191, pp. 5-16.
   The results of a meta-analysis show that addition of biochar decreased N.sub.2O emissions from soils by an average of 54%. acents Factors for mitigation (biochar C/N, pyrolysis conditions, application rate, N fertilizer, soil texture and pH) were identified and discussed.

7. Githinji, L.
   Effect of biochar application rate on soil physical and hydraulic properties of a sandy loam
   (2014) Archives of Agronomy and Soil Science, 60 (4), pp. 457-470.
   Biochar is used as a soil amendment for improving soil quality and enhancing carbon sequestration. In this study, a loamy sand soil was amended at different rates (0%, 25%, 50%, 75%, and 100% v/v) of biochar, and its physical and hydraulic properties were analyzed, including particle density, bulk density, porosity, infiltration, saturated hydraulic conductivity, and volumetric water content. The wilting rate of tomato (Solanum lycopersicum) grown in soil amended with various levels of biochar was evaluated on a scale of 0-10. Statistical analyses were conducted using linear regression. The results showed that bulk density decreased linearly (R2 = 0.997) from 1.325 to 0.363 g cm-3 while the particle density decreased (R2 = 0.915) from 2.65 to 1.60 g cm-3 with increased biochar amendment, with porosity increasing (R2 = 0.994) from 0.500 to 0.773 cm3 cm-3. The mean volumetric water content ranged from 3.90 to 14.00 cm3 cm-3, while the wilting rate of tomato ranged from 4.67 to 9.50, respectively, for the non-amended soil and 100% biochar-amended soil. These results strongly suggest positive improvement of soil physical and hydraulic properties following addition of biochar amendment.

8. Lorenz, K.a b , Lal, R.b
   Biochar application to soil for climate change mitigation by soil organic carbon sequestration
   (2014) Journal of Plant Nutrition and Soil Science, 177 (5), pp. 651-670.
   Pyrogenic carbon (C) is produced by incomplete combustion of fuels including organic matter (OM). Certain ranges in the combustion continuum are termed 'black carbon' (BC). Because of its assumed persistence, surface soils in large parts of the world contain BC with up to 80% of surface soil organic C (SOC) stocks and up to 32% of subsoil SOC in agricultural soils consisting of BC. High SOC stocks and high levels of soil fertility in some ancient soils containing charcoal (e.g., terra preta de Índio) have recently been used as strategies for soil applications of biochar, an engineered BC material similar to charcoal but with the purposeful use as a soil conditioner (1) to mitigate increases in atmospheric carbon dioxide (CO2) by SOC sequestration and (2) to enhance soil fertility. However, effects of biochar on soils and crop productivity cannot be generalized as they are biochar-, plant- and site-specific. For example, the largest potential increases in crop yields were reported in areas with highly weathered soils, such as those characterizing much of the humid tropics. Soils of high inherent fertility, characterizing much of the world's important agricultural areas, appear to be less likely to benefit from biochar. It has been hypothesized that both liming and aggregating/moistening effects of biochar improved crop productivity. Meta-analyses of biochar effects on SOC sequestration have not yet been reported. To effectively mitigate climate change by SOC sequestration, a net removal of C and storage in soil relative to atmospheric CO2

must occur and persist for several hundred years to a few millennia. At deeper soil depths, SOC is characterized by long turnover times, enhanced stabilization, and less vulnerability to loss by decomposition and erosion. In fact, some studies have reported preferential long-term accumulation of BC at deeper depths. Thus, it is hypothesized that surface applied biochar-C (1) must be translocated to subsoil layers and (2) result in deepening of SOC distribution for a notable contribution to climate change mitigation. Detailed studies are needed to understand how surface-applied biochar can move to deeper soil depths, and how its application affects organic C input to deeper soil depths. Based on this knowledge, biochar systems for climate change mitigation through SOC sequestration can be designed. It is critically important to identify mechanisms underlying the sometimes observed negative effects of biochar application on biomass, yield and SOC as biochar may persist in soils for long periods of time as well as the impacts on downstream environments and the net climate impact when biochar particles become airborne.

9. Singh, B.a , MacDonald, L.M.b , Kookana, R.S.b , Van Zwieten, L.c , Butler, G.d , Joseph, S.e f , Weatherley, A.g , Kaudal, B.B.g , Regan, A.h , Cattle, J.i , Dijkstra, F.a , Boersma, M.j , Kimber, Sc, Keith, A.a , Esfandbod, M.k
Opportunities and constraints for biochar technology in Australian agriculture: Looking beyond carbon sequestration
(2014) Soil Research, 52 (8), pp. 739-750.

10. Mukherjee, A., Lal, R.
The biochar dilemma
(2014) Soil Research, 52 (3), pp. 217-230.

11. Scott, H.L.a , Ponsonby, D.b , Atkinson, C.J.a
Biochar: An improver of nutrient and soil water availability - What is the evidence?
(2014) CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 9, art. no. 19

Biochar has consistently been proposed for improving soil fertility by increasing nutrient and soil water availability. We critically reviewed the recent literature, focussing particularly on these agronomic aspects. We clarify the differences between biochar made from plant (plant-derived biochar, PDB) and animal feedstock (animal-derived biochar, ADB) and show how the pyrolysis temperature affects biochar properties. We also tabulate crop yield data against production variables using recent field and greenhouse studies. We found evidence to suggest that ADB supplies many more nutrients than PDB and that, in general, biochar can improve nutrient availability indirectly through changes in pH, CEC, soil structure, improved fertilizer efficiency, decreased nutrient leaching and may affect nutrient availability by changing nitrogenous gas release and the soil microbial community, which, under some circumstances translates into short-term, increased crop yield. Few studies however show complete nutrient budgets particularly for N and do not elaborate on the underlying mechanisms of interaction, especially with regards to microbial-induced changes. Also the longevity of the different beneficial effects is questionable as most studies are less than a year long. A synopsis of the literature concludes that biochar application promotes soil water-holding capacity, particularly in soils that are degraded or of low quality. Despite this conclusion, it is hard to find studies that have adopted methodologies which are fully appropriate to support an increase in available water, such as available water capacity and how this changes in response to crop uptake and soil drying. We conclude that the variability in biochar, due to the variable feedstock and pyrolysis process, as well as particle size and application method necessitates and also enables production of specific purpose-driven biochars to benefit particular aspects of crop production.

12. Herath, H.M.S.K.a b , Camps-Arbestain, M.a , Hedley, M.a
Effect of biochar on soil physical properties in two contrasting soils: An Alfisol and an Andisol
(2013) Geoderma, 209-210, pp. 188-197.

13. Ameloot, N.a , Graber, E.R.b , Verheijen, F.G.A.c , De Neve, S.a
Interactions between biochar stability and soil organisms: Review and research needs
(2013) European Journal of Soil Science, 64 (4), pp. 379-390.
The stability of biochar in soils is the cornerstone of the burgeoning worldwide interest in the potential of the pyrolysis/biochar platform for carbon (C) sequestration. While biochar is more recalcitrant in soil than the original organic feedstock, an increasing number of studies report greater C-mineralization in soils amended with biochar than in unamended soils. Soil organisms are believed to play a central role in this process. In this review, the variety of interactions that occur between soil micro-, meso- and macroorganisms and biochar stability are assessed. In addition, different factors reported to influence biochar stability, such as biochar physico-chemical characteristics, soil type, soil organic carbon (SOC) content and agricultural management practices are evaluated. A meta-analysis of data in the literature revealed that biochar-C mineralization rates decreased with increasing pyrolysis temperature, biochar-C content and time. Enhanced release of CO2 after biochar addition to soil may result from (i) priming of native SOC pools, (ii) biodegradation of biochar components from direct or indirect stimulation of soil organisms by biochar or (iii) abiotic release of biochar-C (from carbonates or chemi-sorbed CO2). Observed biphasic mineralization rates suggest rapid mineralization of labile biochar compounds by microorganisms, with stable aromatic components decomposed at a slower rate. Comparatively little information is available on the impact of soil fauna on biochar stability in soil, although they may decrease biochar particle size and enhance its dispersion in the soil. Elucidating the impacts of soil fauna directly and indirectly on biochar stability is a top research priority.

14. Abel, S., Peters, A., Trinks, S., Schonsky, H., Facklam, M., Wessolek, G.
Impact of biochar and hydrochar addition on water retention and water repellency of sandy soil
(2013) Geoderma, 202-203, pp. 183-191.
Application of biochar (BC) and hydrochar (HTC) in soils is being increasingly discussed as a means to sequestrate carbon and improve chemical and physical properties for plant growth. Especially the impact on physical properties is not well investigated so far. Addition of biochar leads to a decrease in bulk density, an increase in total pore volume as well as an increase in water content at the permanent wilting point. An increase in AWC could be observed for all sandy substrates used, except for the highly humic sand. Notable differences in the effects on the AWC could be measured among the three chars used. Particle size distribution of the chars as well as their consistency had different impacts on the pore size distribution of the soil matrix.

15. Vassilev, N.a b , Martos, E.b , Mendes, G.c , Martos, V.b d , Vassileva, M.a
Biochar of animal origin: A sustainable solution to the global problem of high-grade rock phosphate scarcity?
(2013) Journal of the Science of Food and Agriculture, 93 (8), pp. 1799-1804
Phosphorus (P) is an essential element for all living organisms. However, in soil-plant systems, this nutrient is the most limiting, leading to frequent applications of soluble P fertilisers. Their excessive use provokes alterations in the natural P cycle, soil biodiversity and ecological equilibrium and is the main reason for the eutrophication of water, with consequences on food safety. Biotechnology offers a number of sustainable solutions that can mitigate these problems by using various waste materials as a source of P on the other htheir solubilisation by selected micro-organisms. This review present results on the solubilisation of animal bone char with high phosphate content by micro-organisms to produce organic acids such as lactic acid, citric acid and itaconic acid. All experiments were performed under conditions of

liquid submerged and solid state fermentation processes. Freely suspended and immobilised cells of the corresponding microbial cultures were employed using substrates characterised by low cost and abundance. Other alternative technologies are discussed as well in order to stimulate further studies in this field, bearing in mind the progressive increase in P fertiliser prices based on high global P consumption and the scarcity of rock phosphate reserves.

16. Mccormack, S.A.a b , Ostle, N.c , Bardgett, R.D.b , Hopkins, D.W.d , Vanbergen, A.J.a
Biochar in bioenergy cropping systems: Impacts on soil faunal communities and linked ecosystem processes
(2013) GCB Bioenergy, 5 (2), pp. 81-95.
Biochar amendment of soil and bioenergy cropping are two eco-engineering strategies at the forefront of attempts to offset anthropogenic carbon dioxide (CO_2) emissions. Both utilize the ability of plants to assimilate atmospheric CO_2, and are thus intrinsically linked with soil processes. Research to date has shown that biochar and bioenergy cropping change both aboveground and belowground carbon cycling and soil fertility. Little is known, however, about the form and function of soil food webs in these altered ecosystems, or of the consequences of biodiversity changes at higher trophic levels for soil carbon sequestration. Hitherto studies on this topic have been chiefly observational, and often report contrasting results, thus adding little mechanistic understanding of biochar and bioenergy cropping impacts on soil organisms and linked ecosystem processes. This means it is difficult to predict, or control for, changes in biotic carbon cycling arising from biochar and bioenergy cropping. In this study we explore the potential mechanisms by which soil communities might be affected by biochar, particularly in soils which support bioenergy cropping. We outline the abiotic (soil quality-mediated) and biotic (plant- and microbe-mediated) shifts in the soil environment, and implications for the abundance, diversity, and composition of soil faunal communities. We offer recommendations for promoting biologically diverse, fertile soil via biochar use in bioenergy crop systems, accompanied by specific future research priorities.

17. Biederman, L.A., Stanley Harpole, W.
Biochar and its effects on plant productivity and nutrient cycling: A meta-analysis
(2013) GCB Bioenergy, 5 (2), pp. 202-214
Biochar is a carbon-rich coproduct resulting from pyrolyzing biomass. When applied to the soil it resists decomposition, effectively sequestering the applied carbon and mitigating anthropogenic CO_2 emissions. Other promoted benefits of biochar application to soil include increased plant productivity and reduced nutrient leaching. However, the effects of biochar are variable and it remains unclear if recent enthusiasm can be justified. We evaluate ecosystem responses to biochar application with a meta-analysis of 371 independent studies culled from 114 published manuscripts. We find that despite variability introduced by soil and climate, the addition of biochar to soils resulted, on average, in increased aboveground productivity, crop yield, soil microbial biomass, rhizobia nodulation, plant K tissue concentration, soil phosphorus (P), soil potassium (K), total soil nitrogen (N), and total soil carbon (C) compared with control conditions. Soil pH also tended to increase, becoming less acidic, following the addition of biochar. Variables that showed no significant mean response to biochar included belowground productivity, the ratio of aboveground: belowground biomass, mycorrhizal colonization of roots, plant tissue N, and soil P concentration, and soil inorganic N. Additional analyses found no detectable relationship between the amount of biochar added and aboveground productivity. Our results provide the first quantitative review of the effects of biochar on multiple ecosystem functions and the central tendencies suggest that biochar holds promise in being a win-win-win solution to energy, carbon storage, and ecosystem function. However, biochar's impacts on a fourth component, the downstream nontarget environments, remain unknown and present a critical research gap.

18. Ronsse, F., van Hecke, S., Dickinson, D., Prins, W.
Production and characterization of slow pyrolysis biochar: Influence of feedstock type and pyrolysis conditions
(2013) GCB Bioenergy, 5 (2), pp. 104-115

Biochar was produced by fixed-bed slow pyrolysis from various feedstock biomasses under a range of process conditions. Feedstocks used were pine wood, wheat straw, green waste and dried algae. Process conditions varied were the highest treatment temperature (HTT) and residence time. The produced chars were characterized by proximate analysis, CHN-elemental analysis, pH in solution, bomb calorimetry for higher heating value, N2 adsorption for BET surface area and two biological degradation assays (oxygen demand, carbon mineralization in soil). In proximate analysis, it was found that the fixed carbon content (expressed in wt% of dry and ash-free biochar) in the biochar samples strongly depended on the intensity of the thermal treatment (i.e. higher temperatures and longer residence times in the pyrolysis process). The actual yield in fixed carbon (i.e. the biochar fixed carbon content expressed as wt% of the dry and ash-free original feedstock biomass weight) was practically insensitive to the highest treatment temperature or residence time. The pH in solution, higher heating value and BET surface positively correlated with pyrolysis temperature. Finally, soil incubation tests showed that the addition of biochar to the soil initially marginally reduced the C-mineralization rate compared against the control soil samples, for which a possible explanation could be that the soil microbial community needs to adapt to the new conditions. This effect was more pronounced when adding chars with high fixed carbon content (resulting from more severe thermal treatment), as chars with low fixed carbon content (produced through mild thermal treatment) had a larger amount of volatile, more easily biodegradable, carbon compounds.

19. Mukherjee, A.a b , Zimmerman, A.R.a
Organic carbon and nutrient release from a range of laboratory-produced biochars and biochar-soil mixtures
(2013) Geoderma, 193-194, pp. 122-130.

Biochar has shown promise as a soil amendment that increases carbon sequestration and fertility, but its effects on dissolved organic carbon (DOC), nitrogen (N) and phosphorus (P) cycling and loss is not well understood. Here, nutrient release from a variety of new and aged biochars, pure and mixed with soils, is examined using batch extraction and column leaching. In successive batch extractions of biochar, cumulative losses were about 0.1-2, 0.5-8 and 5-100% of the total C, N and P initially present, respectively, with greater releases from biochars made at lower temperature and from grass. Ammonium was usually the most abundant N form in leachates but nitrate was also abundant in some biochars, while organic N and P represented as much as 61% and 93% of the total N and P lost, respectively. Release of DOC, N and P into water was correlated with biochar volatile matter content and acid functional group density. However, P release via Mehlich-1 extraction was more strongly related to ash content, suggesting a mineral-associated P fraction. Columns with soil/biochar mixtures showed evidence of both soil nutrient sorption by biochar and biochar nutrient sorption by soil, depending upon biochar and soil type. This study demonstrates that biochars contain a range of nutrient forms with different release rates, explaining biochar's variable effect on soil fertility with soil and crop type and over time.

20. Ameloot, N.a , De Neve, S.a , Jegajeevagan, K.a , Yildiz, G.b , Buchan, D.a , Funkuin, Y.N.a , Prins, W.b , Bouckaert, L.a , Sleutel, S.a
Short-term CO2 and N2O emissions and microbial properties of biochar amended sandy loam soils
(2013) Soil Biology and Biochemistry, 57, pp. 401-410.

LIVRES

Bruges, J. and D. Friese-Greene (2009). The biochar debate: charcoal's potential to reverse climate change and build soil fertility. White River Junction, Vt, Chelsea Green Pub.

Guo, M., et al. (2016). Agricultural and environmental applications of biochar: advances and barriers. Madison, Wisconsin, Soil Science Society of America.

Discover the mechanisms and processes of biochar amendment for achieving stunning agricultural and environmental benefits. Agricultural and environmental communities are looking to biochar for enhancing soil carbon sequestration and crop productivity, but practical applications are elusive. Accomplished international researchers present a whole picture of biochar in improving soil quality, reducing soil greenhouse gas emissions, and decontaminating stormwater and mine sites. Composition and characteristics of biochar, its interactions with contaminants and soil constituents, and its transformation in the environment are addressed. Readers will appreciate the comprehensive review of the latest biochar research and applications and gain critical guidance in best biochar generation and use.

Lee, J. W. (2013). Advanced biofuels and bioproducts. New York, Springer.

Designed as a text not only for students and researchers, but anyone interested in green technology, Advanced Biofuels and Bioproducts offers the reader a vast overview of the state-of-the-art in renewable energies. The typical chapter sets out to explain the fundamentals of a new technology as well as providing its context in the greater field. With contributions from nearly 100 leading researchers across the globe, the text serves as an important and timely look into this rapidly expanding field. The 40 chapters that comprise Advanced Biofuels and Bioproducts are handily organized into the following 8 sections: * Introduction and Brazil's biofuel success * Smokeless biomass pyrolysis for advanced biofuels production and global biochar carbon sequestration * Cellulosic Biofuels * Photobiological production of advanced biofuels with synthetic biology * Lipids-based biodiesels * Life-cycle energy and economics analysis * High-value algal products and biomethane * Electrofuels

Lehmann, J. D. and S. Joseph (2009). Biochar for environmental management: science and technology. London, Earthscan.

Biochar is the carbon-rich product when biomass (such as wood, manure or crop residues) is heated in a closed container with little or no available air. It can be used to improve agriculture and the environment in several ways, and its stability in soil and superior nutrient-retention properties make it an ideal soil amendment to increase crop yields. In addition to this, biochar sequestration, in combination with sustainable biomass production, can be carbon-negative and therefore used to actively remove carbon dioxide from the atmosphere, with major implications for mitigation of climate change. Biochar production can also be combined with bioenergy production through the use of the gases that are given off in the pyrolysis process. This book is the first to synthesize the expanding research literature on this topic. The book's interdisciplinary approach, which covers engineering, environmental sciences, agricultural sciences, economics and policy, is a vital tool at this stage of biochar technology development. This comprehensive overview of current knowledge will be of interest to advanced students, researchers and professionals in a wide range of disciplines.

Major, J. and b. Centre québécois de valorisation des (2011). Le biochar: outil pour la gestion des résidus de biomasse et la fertilité des sols. Québec, CQVB.

Ok, Y. n.-s., et al. (2015). Biochar: production, characterization, and applications. Boca Raton, Florida, CRC Press, Taylor & Francis Group.

Encompassing high priority research areas such as bioenergy production, global warming mitigation, and sustainable agriculture, biochar has received increased worldwide interest in the past decade. Biochar: Production, Characterization, and Applications covers the fundamentals of biochar including its concept, production technology, and characterization. The book builds on this foundation by providing examples of state-of-the-art biochar application technology in agronomy and environmental sciences, along with detailed case studies. Edited by a group of well-known biochar experts and including chapters written by a group of international experts in their field, this valuable resource can be used both as a textbook for graduate courses or as a handbook for policy makers and practitioners in the field.

Taylor, P. (2010). The biochar revolution: transforming agriculture & environment. Victoria, Global Publishing Group.