Solid Earth Discuss., 6, C666–C674, 2014
www.solid-earth-discuss.net/6/C666/2014/

Solid Earth
Discussions
Open Access

Interactive comment on "Biochar can be used to recapture essential nutrients from dairy wastewater and improve soil quality" *by* T. A. Ghezzehei et al.

T. A. Ghezzehei et al.

aaberhe@ucmerced.edu

Received and published: 12 July 2014

RESPONSE TO: Interactive comment on "**Biochar can be used to recapture essential nutrients from dairy wastewater and improve soil quality**" by **T. A. Ghezzehei et al.**

Anonymous Referee #1

Received and published: 10 May 2014

Our responses are presented in indented, bulleted, bold points under each numbered item.

This review reports on the authors' approach to solve the problem of agricultural waste disposal. This approach consists in using biochar obtained from "excess biomass" to remove "excess nutrients" in dairy wastewater. It is based on the experimental evidence of the biochar ability to remove ammonium and phosphate from dairy effluents.

The issue of agricultural waste management is relevant for the scientific community: however, the authors put under the same umbrella of "waste biomass" both plant biomass and effluents from livestock farms, which may be arguable. In fact, in my opinion, the pollution potential of these two "waste" categories is very different, and should not be given the same weight. A part from the fact that the nature of the "excess biomass" is not clearly specified, in this MS, in my opinion on the one hand it is a pity to char crop residues when it is well known the positive effect of their incorporation into soil on soil fertility (see the book "Managing crop residues" by Unger, 1994, as an example).On the other hand, when you burn or pirolyze wood to obtain energy, you cannot call the wood as "waste": it is a raw material or at least a by-product.

- **We appreciate the reviewer's comment. It was not our intention to put excess biomass and diary waste in the same category of pollutants. Even though it is common to refer to the excess biomass from some agricultural systems as 'waste' (at least in California, US), we have revised the use of this terminology to avoid confusion. Hence, we only use 'by-product' or 'excess biomass' when referring to the biomass in the revised manuscript. Furthermore, as discussed in the introduction (lines 27-30), the benefits of incorporation of biomass into soil for fertility management are not disputed. However, in some systems the amount of excess biomass produced is a lot more than what can be incorporated locally and is hence exported to other systems that do not have large amounts of excess biomass.**

The knowledge of the biochar ability to remove phosphate and ammonium from aque-

ous solutions is not new: it was already reported by *Yao et al.,* Journal of Hazardous Materials 190 (2011) 501–507; *Ying et al.*, EARTH AND ENVIRONMENT

Vol. 39, No.4, Tot No.286, 2011, Page 511-516; *Hollister,* 2011

(http://dspace.library.cornell.edu/bitstream/1813/29126/1/cch92thesisPDF.pdf) . The

authors should have cited these papers.

- **We accept the reviewer's comment and have cited these papers as suggested.**

In reading the manuscript I understand that the above mentioned authors' approach is based on two assumptions:

- The first assumption is that biochar used as soil amendment "increases soil productivity".

However, to increase soil productivity means that on a soil amended with biochar one can obtain higher crop yields. I am afraid this biochar property has not yet been fully demonstrated. In fact, given the importance of the assumption, the authors should have cited relevant references, which they did not. More precisely, they cited: Lehmann et al., 2006; Glaser, 2002. Actually, the Lehmann reference is a general review on biochar ability to sequester carbon. As far as the improvement of crop yield is concerned, Lehmann reports on a experiment on acid and infertile tropical soils: this does not seem to me a representative case of agricultural soils. Moreover, Lehmann admits that "some experiments show decreasing biomass production and crop yields at high concentrations" of biochar. Glaser studied the Terra Preta phenomenon and concluded that "black carbon can act as a significant carbon sink and is a key factor for sustainable and fertile soils, especially in the humid tropics". This has nothing to do with the experimental demonstration of increased crop productivity following soil amendments with biochar!

- **We included additional references that demonstrate improved productivity and crop yield. Specifically, we have now cited a meta-analysis of 371 independent studies culled from 114 published manuscripts, as reported by Biederman and Harpole (2013), that showed that, "despite variability introduced by soil and climate, the addition of biochar to soils resulted, on average, in increased aboveground productivity [and] crop yield."**

- The second assumption is that nutrients in dairy waste, previously entrapped in biochar, will then be released when biochar is incorporated into soil: this assumption has yet to be demonstrated experimentally, too, as the same authors admit in

Ch. 5 ("Knowledge gaps"). Instead, the same authors demonstrated that the opposite occurs (Sarkhot, D. V., Berhe, A. A., and Ghezzehei, T. A.: Impact of biochar enriched with dairy manure effluent on carbon and nitrogen dynamics, J. Environ. Qual., doi:10.2134/jeq2011.0123, 2012)

- **We have clarified this assumption and provided more evidence for how biochar has been shown to reduce leaching and gaseous losses of plant essential nutrients and increase their retention in soil, and how overtime these plant nutrients that are sorbed by biochar can become available due to changes in soil physico-chemical conditions due to the char application or decomposition of the char. The text in section 3.2 is now revised for clarity and to add more evidence from literature to support this assumption. Please note that the data on C and N retention presented in our prior paper (Sarkhot et al 2012 and 2013) is for short periods of time, doesn't account for the mechanisms listed above that determine long-term bioavailability of nutrients associated with biochar).**

The manuscript presents the authors' hypothesis to solve the problem of "agricultural

waste disposal" (chapters 1 and 2), reviews the current knowledge on biochar properties in relation to soil application (chapters 3 and 4), and estimates the potential usefulness of the author's approach for solving the above-mentioned problem (chapters 4 and 5). Within this framework, only a paragraph (4.1) is devoted to the reporting of experimental results on nutrient capture by biochar. In substance, the authors devote a large part of the manuscript to speculations based on assumptions that may not be true, whereas the reporting on the experimental part which should be the core of this MS (biochar can remove nutrients from dairy waste) is limited to a single laboratory experiment.

- **This comment likely stems from a misunderstanding of the objectives of our manuscript. As stated in the beginning of our manuscript, this paper is presenting " a review of a new approach that is showing promise for the use of biochar for nutrient capture." We provided data that strengthens the arguments for the paper that are not previously published, but this is primarily a review paper that is synthesizing knowledge from previously published works.**

No mention was made of some properties of biochar that are viewed as harmful, I mean its polycyclic aromatic hydrocarbon (PAH) content (http://pubs.acs.org/doi/abs/10.1021/jf205278v): PAH are known as carcinogenic molecules. Since this paper is a review, the concern of adding large amounts of PAH to soil could have been addressed in the "constraints" section (paragraph 3.3)

- **We appreciate the reviewer's comment and we have added a paragraph in section 5 to address this issue.**

Other comments

The title claims that "biochar improves soil quality": soil quality is a very general concept. No experimental data was given, connecting biochar enrichment and soil quality, to support this statement. "Recapture" is redundant: capture should be sufficient.

- **We accept the reviewer's comment and have changed the title of the manuscript to " Biochar can be used to capture essential nutrients from dairy wastewater and improve soil physico-chemical properties"**

Technical terms should be more accurately chosen or explained:

- confusion is made between "waste" and "by-products" (p 1102, line 24)

- **To address this comment and one above, we have revised the use of this terminology in the entire manuscript to avoid confusion. In the revised manuscript we only use 'by-product' or 'excess biomass' when referring to the biomass in the revised manuscript.**

- agricultural runoff from dairy operations (p 1103, line29): "agricultural runoff" is something larger than "dairy effluents": it may include, but is not limited to, the effluents from livestock farms

- "flushed" manure: what is it? May be you mean "slurries"? Land spreading?

- **We have revised the background (section 1) to address this point and explain what is meant by flushed manure**

- "metric tons": the International System of Units uses the notation "t"

- **'t' is now used in the revised manuscript.**

The description of Figure 1 at p.1103, lines 12-14 (a and b), does not match with the content of Fig. 1 (closed and open loop)

- **the first cross-reference to figure 1 is removed from the text to avoid confusion**

Some citations in the text body are missing in the reference section, for example: Energy information Administration, 2009 (p 1104, line8); The Manure Technology Feasibility

Assessment Panel instituted by California Air Resources Board (CARB) (p. 1106,

line 7)

- **The above references were already in the text but they formatted in a confusing way in the Copernicus reference style in endnote. We have ensured that they are listed in the same way as they are in the text in the revised manuscript.**

I think it is inappropriate to compare the results that the authors obtained in a laboratory experiment with those referring to wetlands (p 1110, line 27 and following), because the scale is not the same: how long did it take for wetlands to remove given amounts of nutrients?

References:

"Perlack, R. D., Wright, L. L., Turhollow, A. F., Graham, R. L., Stokes, B. J., and Erbach, D. C.: Biomass as Feedstock for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-Ton Annual Supply, 2005.": please specify the source of this citation.

- **This reference is available from the website of the Department of Energy's Oak Ridge National laboratory at http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf we have added the url to the reference**

I have not been able to find "Sarkhot, D. V., Ghezzehei, T. A., and Berhe, A. A.: Biochar for nutrient recapture from dairy wastewater: recovery of major nutrients, J. Environ. Qual., 42, 1545–1554, 2013). [at least, not in J.Environ. Qual.]

- **Our 2013 paper is available on the JEQ using the citation information given, alternatively see https://www.crops.org/publications/jeq/abstracts/42/5/1545**

Figure 1: the style of the lines in the figure caption does not match that in the picture

- **Figure 1 is now revised to correct the mismatch between the types of lines used in the figure and caption.**

Figure 2: coordinate axis: is it ammonium or ammonium-N? Is it phosphate or phosphate-P? The amount of added biochar should be reported in the figure caption.

- **The axis titles are correct as given, and we have added more information on the amount of biochar used in the experiment as suggested by the reviewer.**

"ppm" should be substituted with "mg L-1". The meaning of "manure dilution" is not clear: what does 100% manure dilution mean? How many replicates were done for each dilution?

- **The suggested changes were made in the caption, and the issue with dilutions and replicates was also clarified. The revised caption now reads: "Recovery of Ammonium and Phosphate by Biochar from Dairy Wastewater. Sorption experiments were done using biochar at the rate of 2g per 40 mL solution. The experiment was conducted at manure dilutions of 10-100% of the manure in 0.001M CaCl2 in order to capture the effect of nutrient concentration in manure on their recovery. Nutrient concentrations in manure can very depending on amount of water used to flush the manure, climate, and length of time the flushed manure has been stored in the lagoons (i.e. evaporative losses). The 100% concentration in this study equates to 714 mg/lt ammonium and 24 mg/lt phosphate, but higher concentrations are possible under different conditions. Error bars represent standard error where n=4 for each batch."**

We appreciate the thoughtful comments from the reviewer, Thank you!

˜ Teamrat, Deoyani, Asmeret