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SOIL
Manuscript Revision soil-2015-46

Dear Dr Estela Nadal Romero,

Please find enclosed our revised manuscript entitled:
"Quantification of the inevitable: The influence of soil macrofauna on soil water movement in rehabilitated open-cut mine land."
We have considered all of your comments and those of the two reviewers, and carefully itemised our responses in the following pages.

Thank you for your consideration and do not hesitate to contact me should you have any further questions or concerns.

Best regards,

Sven

On behalf of

Elizabeth Williams

Response to Reviewer 1

We would like to thank the anonymous referee for this review and the constructive and positive comments. We have addressed his/her comments as follows (suggested changes are highlighted):

Comments: However, it is missing some practical examples or sufficient evidence confirming that this is an actual problem affecting the environment. It brings a novel approach, but at this stage the problem, the authors are searching solutions for, isn't supported by clear evidence.

Response: While the manuscript included the reference to an actual example of macrofauna affecting the performance of waste rock cover facilities (Taylor et al., 2003), we recognise that this needs to be more explicit and would like to add the following sentence: "For example, in their report about the deterioration in performance of a waste rock cover facility in tropical Australia, Taylor et al. (2003) concluded that, amongst the formation of shrinkage cracks and macropores associated with root channels, the formation of termite galleries played a critical role."

Comment: The title contains the expression "soil macrofauna", but the authors are only talking about ants, with termites being mentioned once but their impact is not discussed further. Earthworms should be mentioned as well, when talking about soil macrofauna, as they are burying soil macrofauna and can affect soil hydrology (Joschko et al., 1989, Joschko et al., 1992, Edwards et al.1990, Blanchart et al., 2004), or an expression soil macroarthropods or a different formulation should be used.

Response: We acknowledge the effect of soil macrofauna other than ants and would like to add some discussion points about earthworms as suggested by both reviewers. For example: "Likewise, burrowing macrofauna such as earthworms affect the soil structure and profile characteristics in a similar manner by modifying the pore and aggregate size distribution, the soil bulk density, and soil organic matter, eventually affecting the soil water holding capacity and infiltration rates (Blouin et al., 2013; Jouquet et al., 2014; Frouz and Kuraz, 2013)."

Comment: Authors point out that further research on this topic is needed, which is supported by their conclusions. However, the idea of testing effect of ants and termites on soil hydrology in mesocosm experiments seems very ambitious and would also be very expensive, as both ants and termites form complicated underground galleries. The authors make this suggestion without discussing it with relevant literature that would suggest that experiments like that are viable. I would recommend to focus on field trials in post mining areas, where there are spoil heaps being colonized with soil macrofauna and this problem could occur. The hydrological and chemical parameters can be measured in field as well (e.g. Wang et al., 1995, Cammeraat et al. 2002).

Response: We agree with the reviewer about the challenges involved with laboratory and glasshouse experiments. Likewise, we encourage field trials and promote open-cut mining lands as ideal environments. This is summarised in the manuscript at page 7, lines 16-32 and Table 3. We recognise the lack of references though and will add them as suggested by the reviewer:

“We suggest two alternative approaches to collect empirical data (Table 1) that can be used to initially quantify these interactions and eventually to reduce uncertainty in modelled hydrological variables such as deep drainage, infiltration, or plant available water (Léonard et al., 2004). For example, manipulative experiments under controlled conditions are effective means to assess the impact of early colonisers on the soil water dynamics. A soil chamber or column (Joschko et al., 1989; Joschko et al., 1992) can be used as a formicarium (Wang et al., 1995), where an ant nest is transplanted (including queen and workers) and food, water and nesting resources provided. Predefined water regimes could then be administered to simulate rainfall events, while the temporal dynamics of soil water potential and content are monitored across the soil profile. Similarly, these small scale experiments are suitable for assessing the colonisation rates and environmental conditions (e.g., pH, temperature, humidity, soil water content) required to colonise soils by ants. At a larger investigative scale (Table 1), field trials in combination with untreated control or reference sites are effective means to assess the impact of macrofauna on soil structure and inter-specific fauna interactions (feedbacks) in relation to soil biodiversity and soil development (Cammeraat et al., 2002). In this regard, open-cut mining lands may provide ideal environments, because the physical properties of re-constructed soils are fundamentally different (and less complex) from those of degraded but physically intact soils.”

Finally, we would like to stress that, in remote areas, considerable costs are involved in field trials to cover augering and maintenance requirements. In this regard, laboratory and glasshouse experiments potentially provide a more efficient alternative to field trials and should produce critical knowledge to optimise field trial designs.

Comment: The references are appropriate and there is a sufficient number of references.However, authors have missed some papers that bring important knowledge about the effect of soil macrofauna on soil hydrological properties.

Response: We thank the reviewer for providing us invaluable references and will add them accordingly.

Response to Reviewer 2

We would like to thank the anonymous referee for this review and the constructive comments. We have addressed his/her comments as follows (any changes are highlighted):

Comment: However there are other similar summarizing text that should be consulted namely book chapter Frouz J Kuráž V 2014 Soil Fauna and Soil Physical Properties. In Frouz J. (ed) Soil biota and ecosystem development in post mining sites, CRC press, Boca Raton, 265-278 pp. which specifically address this issue.

Response: We thank the reviewer for this invaluable reference, which explores the effect of soil macrofauna on physical properties of post-mining soils and interactions of soil fauna activity with technical processes used during mine site rehabilitation. In this regard, we will add the reference to the manuscript accordingly. However, we would also like to stress that our short communication paper goes beyond the review of effects of macrofauna on general soil formation, but also presents a specific case as an example of the role termites play in the deterioration in performance of waste rock facilities (Chapter 2). We elucidate the role numerical modelled can play to better understand and eventually predict the performance of engineered cover systems (Chapter 3). Furthermore, we suggest two alternative approaches to collect empirical data that can be used to initially quantify these interactions and eventually to reduce uncertainty in modelled hydrological variables such as deep drainage, infiltration, or plant available water (Chapter 4).

Comment: Secondly the text is focuses on role of ants and termites but neglect role of earthworm and other macro-fauna in this process which is quite fundemental also in mining soil. I realized that the proportion of individual fauna group vary in various countries and the authors are from Australia, where ants and termites play major role but e.g. termites play negligible role in most of Europe. So the authors should either made clear that this text is focused only on Australia, them more regional journal would be more appropriated or consider role of earthworms in larger extent. There are many studies available in European post mining soil to illustrate earthworm effect (here references in above mentioned review can be helpful).

Response: We agree about the critical role earthworms play in the formation of soils in post-mining lands and regret that this important point was missed out. We intend to add the following sentence: "Later during ecosystem rehabilitation, burrowing macrofauna such as earthworms affect the soil structure and profile characteristics in a similar manner by modifying the pore and aggregate size distribution, the soil bulk density, and soil organic matter, eventually affecting the soil water holding capacity and infiltration rates (Blouin et al., 2013; Jouquet et al., 2014; Frouz and Kuraz, 2013)."

We would like to emphasise though that ants and termites, rather than earthworms, are amongst the first colonisers at post-mining sites "due to their rapid recolonisation, particularly by generalist taxa that have long-distance (relative to macrofauna) dispersal strategies." (page 4, lines 19-21). "Within weeks after topsoil establishment, the first colonisers such as soil-nesting ants (e.g., *Iridomyrmex* species in Australia) build underground galleries, thereby initiating changes in soil properties (Lee and Foster,

1991).” (page 5, lines 16-19) Therefore, we believe the manuscript, submitted as short communication paper, should predominantly focus on the impact of ants and termites on soils.

Comment: Finally I have some concern about organization of the article. The importance of mining and restoration is evident but the review should be about physic and biota so I would limit the note about socioeconomic impact and definitely do not put them in to name of the chapter instead I would underline advantages and limitation of post mining sites from research perspective and most importantly try to more conceptualize fauna effect.

Response: At the Editor’s discretion, we consider the current manuscript structure to be most appropriate to present a short communication paper (Reviewer #1: “The presentation is well structured…”). Chapter 2 discusses the impact of mining on social communities and ecosystems and the opportunities of post-mining land rehabilitation. More importantly, a specific environmental problem of open-cut mining is presented as an example to demonstrate the effect of macrofauna on waste rock cover facilities. The latter is briefly presented as a conceptual scheme in Fig. 2.

Comment: I particularly missing effect of soil fauna on SOM distribution in soil profile which affect water field capacity and wilting points of post mining soil, again larger consideration of saprophagous macrofauna is highly needed. Also fauna effect will likely affect hydrology in several spatiotemporal scales, level of aggregates was already mentioned, then architecture of burrows wall and burrows itself, will be important, maintenance and development after abandonment many be another level of complexity and finally interaction of these processes on level of soil profile, those are just some key processes to consider. I believe that presentation of some schematic diagram or table that would summaries these processes and will be expanded in the text in the way what impact they may heave and how we should study them would substantially improve quality of the ms.

Response: We thank the reviewer for pointing out the effect macrofauna can have on the formation of SOM and the effect on the field capacity of soils, and will add this aspect to the following sentence: “These macrofauna alter the local soil structure and profile characteristics (Jones et al., 1994; De Bruyn and Conacher, 1994), influence soil aggregate stability (Cammeraat and Risch, 2008; Lavelle et al., 2006), water infiltration and mechanical strength (Eldridge, 1994; Frouz and Kuraz, 2013), and increase the field capacity through the formation of holo-organic and organo-mineral aggregates (Frouz and Kuraz, 2013)”.

Adding another figure about the processes influenced by macrofauna is beyond the scope of the manuscript and beyond the format of a short communication paper. Instead, we would like to point out that the manuscript already includes references that reviewed and presented those processes (e.g., Lavelle et al., 2006 and Jones et al., 1994).