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# *Interactive comment on* "Carbon nanomaterials in clean and contaminated soils: environmental implications and applications" *by* M. J. Riding et al.

**M. J. Riding et al.**

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We thank the referee for their comments and well thought through constructive criticism. We have endeavoured to address each point individually, and have either modified the script accordingly or provided additional justification for an alternative response.

If you require additional information or clarification of points, we will be happy to elaborate further.

Referee #1 - The paper explored implication and application of carbon nanomateri-



als (CNMs) in clean and contaminated soils. CNMs can interact with hydrophobic organic contaminants (HOCs), and thus have an impact on the persistence, mobility and bioavailability of contaminants within soils. Overall, this review paper is well written, and the whole paper flows smoothly. It is one of the excellent papers I have read on an open-access journal. There are only several minor things that need to be addressed. Specific comments, following the order of the manuscript, are listed below.

Point 1) Authors have discussed many aspect of CNM in soils. One question would be: what will be the realistic concentration of anthropogenic CNM in the soil?

As CNMs are an emerging material, predicting a "realistic [future] concentration of anthropogenic CNMs in the soil" is exceptionally difficult. Not only are new applications for CNMs being regularly found, legislation regarding their production, use and disposal is still a rapidly evolving area of study. There are some papers which have attempted to estimate the future CNM concentration in soils, and these are all evaluated in an excellent review (Holden et al. 2014, ES&T in press DOI: 10.1021/es502440s), which has been added as a citation in the paper.

Point 2) If their concentration is extremely small, what will be the critical concentration level that can exhibit toxicity?

This is a good question, and can be addressed with reference to the review article cited in the comment above. The critical concentration at which CNMs will exhibit toxicity is extremely difficult to measure/predict for a number of reasons: (i) variations in target organism (discussed in the script in Section 5.1); (ii) variations in soil type (discussed pp. 175 L27); (iii) variations in particle characteristics (discussed throughout the script); (iv) uncertainty calculating the organism's exposure level from a particular concentration in the environment. To my knowledge, there are no papers that have consistently demonstrated toxicity results based on standard measures of toxicity (such as NOEL or LD50) for CNMs between soil/CNM types or target organisms. Based on the current level of understanding portrayed in the literature, we feel it is not possible to

either categorically state or predict the level at which toxicity will occur, nor is it possible to predict whether any potentially observed impacts will be caused by a direct result of CNMs (e.g. membrane damage by reactive oxygen species) or indirect result (sorption and reduced bioavailability/accessibility of food source). We feel that these barriers to estimating the toxicity of CNMs in the environment are sufficiently dealt with throughout the script.

3) If there is another scenario that we have to apply CNM to the soil, what is the potential application of CNM to soil?

This question lacks clarity and I am unable to understand the point it is attempting to raise. The paper concludes on pp.186 L3 that the future application of CNMs to soil should be assessed on a case-by-case basis.

4) Page 153, likely the section of "Carbon nanomaterial diversity and detection" focuses more on the diversity of CNMs, however, not on detection. If authors can summarize a table about the detection methods of CNMs in soil or other complicated matrix, it will be very helpful for readers who are interested in this topic. I have listed a few papers talking about the detection of CNMs:

(a), Detection of carbon nanotubes in environmental matrices using programmed thermal analysis K Doudrick, P Herckes, P Westerhoff - Environmental science & technology, 2012

(b) Thermogravimetry–Mass Spectrometry for Carbon Nanotube Detection in Complex Mixtures, Desirée L. Plata, Christopher M. Reddy, and Philip M. Gschwend, Environmental science & technology, 2012

(c) Characterization and Quantitative Analysis of Single-Walled Carbon Nanotubes in the Aquatic Environment Using Near-Infrared Fluorescence Spectroscopy, Ariette Schierz, Ashley N. Parks, Kathryn M. Washburn, G. Thomas Chandler, and P. Lee Ferguson, Environmental science & technology, 2012



We thank the referee for noticing this. The paper was deficient in its discussion of CNM detection methods within environmental matrices. We have fully complied with the referee's suggestion.

5) Page 160, line 28, authors have mentioned about "the physicochemical properties of pristine nC60" depends on the "method of synthesis and preparation". Please clarify how could the synthesis and preparation affect the property of nC60. Additionally, would the preparation method of nC60 affect the toxicity behaviour in soils?

We have removed the word synthesis. The impact of preparation methods is discussed at length in the sentences and paragraphs that immediately follow the sentence in question. For example, we discuss the influence of sonication and suspension media, both of which are particle preparation methods. We do not think it is possible to provide any additional information to that which is already presented. âĂČ

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Interactive comment on SOIL Discuss., 1, 151, 2014.