Author's response to reviews

Title: Opportunities and challenges of nanotechnology in the green economy

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Author's response to reviews: see over
Dear Editor,

thank you for the opportunity you gave us to revise our manuscript and thank you for the interesting and appropriate comments you and your reviewers made to improve the quality of our work.

Attached you’ll find two files with the revised version of the manuscript: one with marked revisions in blue (removed phrases)/red (added phrases) and another one without tracked changes. Following you’ll find a point-by-point description of the changes we made in the text according to your suggestions.

Responses to the Editor

As you requested, we tried to better integrate the first part of the manuscript, describing the use of nanotechnology in green technology, with the latter sections concerning risk assessment and management. We introduced some lines at the beginning of the section “Occupational health and safety consideration” regarding some critical safety concerns associated with specific green nanotechnology applications which may be useful to explain why occupational health considerations appear so important in this innovative field. Following you’ll find the modified version of this part of the manuscript:

“In this context according to the proposed principles for green economy, it is important that society, scientific community and industry take advantage of opportunities of nanotechnology while overcoming its practical challenges. However, not all revolutionary changes are sustainable per se and a cautious assessment of the benefits addressing economic, social and environmental implications, as well as the occupational health and safety impact is essential [95, 96]. This latter aspect, in particular, should be carefully addressed, in consideration of the expected widespread use of nanotechnology and the consequent increasing likelihood of NM exposure in both living and occupational environments. Moreover, difficulties in nano-manufacturing and handling; uncertainty concerning stability of nano-innovations under aggressive or long-term operation (i.e. in the case of supercapacitors with nano-structured electrode materials or nano-enabled construction products); the lack of information regarding the release and fate of NMs in the environment (i.e. NMs released from water and wastewater treatment devices) as well as the limited knowledge concerning the NM toxicological profile, even further support the need for a careful consideration of the health and safety risks derived from NM exposure”.

Moreover, at the beginning of the “Green nanotechnology: risk assessment, management and communication” section we introduced a brief paragraph in the attempt to explain how health and safety considerations regarding green nanotechnologies require a complex risk management plan
characterized by assessment, management and communication of emerging risks. The revised version follows:

“The newness of nano-applications in green fields, together with concerns regarding the potential impact of NMs on the health and safety of workers, urgently require scientific, technological and governmental efforts to actively manage risks for the workforce. This means to identify actual risks derived from NM exposure in workplace (risk assessment), to plan/implement control measures (risk management) and to communicate the plan. Overall, these steps, whose critical aspects will be discussed in the following sections, aim to prevent workers to be harmed and society deprived of the timely realization of all the benefits of the nanotechnology.”

Conclusions have been sharpened in order to point out in a clearer manner the advantages of nano-applications (such as opportunities to reduce pressure on raw materials trading on renewable energy, to improve power delivery systems to be more reliable, efficient and safe as well as to use unconventional water sources or nano-enabled construction products therefore providing better ecosystem and livelihood conditions) and the concerns regarding the impact that nanotechnology may have on the environment, society as well as on the health and safety of exposed workers. As regards this latter aspect, concerns are principally related to the fact that NMs may have significant, still unknown, hazardous properties related to their unique physico-chemical properties, that can pose risks for a wide range of employees potentially exposed through the overall lifecycle of NMs.

According to the “advantages/concerns” approach we have adopted along all the text for describing the current “green nanotechnology scenario”, we revised the second half of the abstract, trying to briefly and clearly point out these important topics which may be of strong interest for the reader. In the last few lines we stressed the conclusions of the review in terms of practical action strategies necessary to define an appropriate risk assessment, management and communication programs for the management of emerging risks in occupational nano-realities. We hope to have improved the abstract so that it may be intriguing for both an expert and a neophyte reader interested in this promising field.

Finally, we have introduced “*” before the Corresponding Author information, in the first page of the manuscript and also after the superscript number. We have also corrected the first heading removing “Introduction” and placing “Background”. The spelling of “Acknowledgements” has been corrected.
Responses to reviewer 1

As previously detailed, we tried to better integrate the first part of the manuscript, describing the use of nanotechnology, with the latter sections concerning risk assessment and management of nanotechnology. We introduced some lines at the beginning of the section “Occupational health and safety consideration” regarding some critical safety concerns associated with specific green nanotechnology applications which may be useful to explain why occupational health considerations are so important in this innovative field. Moreover, at the beginning of the “Green nanotechnology: risk assessment, management and communication” section we introduced a brief paragraph to explain how health and safety considerations regarding green nanotechnologies require a comprehensive risk assessment, management and communication plan obtained by scientific, technological, governmental efforts attempting to comprehensively manage emerging risks for the workforce.

Moreover, in the few lines where toxicological effects of nanomaterials have been briefly described (see the “Occupational health and safety section”), we have reported some interesting green applications of the NMs (i.e. TiO$_2$-nanoparticles and carbon-nanotubes) for which great attention of the scientific community has been paid to stress, once again the close link between technological progress and scientific research. This part has not been too much enlarged with a deep description of the hazard of the specific nanomaterials, because the review was only intended to point out some essential aspects which, surely, deserve deeper discussion in more specific settings.

The review has been, overall, shortened of about 20%, although we had the need to add some new parts to answer the reviewer 2 comments. All the sections have been shortened in some pieces, anyway, the introduction (now the “Background” section), which was very wordy, has been greatly curtailed and revised in its organization.

Minor essential revisions
- The reference “(Schulte et al. 2013b EH)”, which was in a wrong format, has been removed from the text.
- Abstract, line 17: we have substitute “report” with “review” as indicated.
- Abstract, lines 13-16: we have revised this long sentence of the abstract to more clearly detail advantages, concerns of green nanotechnology and better describe practical action strategies necessary to manage emerging occupational risks.
Responses to reviewer 2

Minor essential revisions

The phrase Page 3, 4th para “In this regard, green innovations intended to promote resource energy efficiency and to diminish environmental degradation have attracted particular technological attention” why technological only? has been removed because of the need to re-organize the introduction section, and to shorten the manuscript, particularly in its first section (now “Background”) according to the comments of reviewer 1.

Page 3 – the transition from discussion of term “green economy” to “Nanotechnology has indeed open up new frontiers….” is abrupt. Needs some introduction to the idea of nanotechnology that is introduced for the first time here…just a sentence or two would help.

We tried to express more clearly, in a brief sentence, the potential role of nanotechnology in the green economy reality according to the opportunity, offered by this innovative technology, to manipulate matter at the nano-scale obtaining materials with extremely attractive physico-chemical properties. This part of the “Introduction” section has been changed in the following manner:

“The green economy concept can indeed play a very useful role in changing the way that society manages the interaction of the environmental and economic domains. In this context, nanotechnology, which is the manipulation of matter in the dimension of 1 to 100 nm, offers the opportunity to produce new structures, materials and devices with unique physico-chemical properties (i.e. small size, large surface area to mass ratio) to be employed in energy efficient as well as economically and environmentally sustainable green innovations [8-12].”

Page 7 – “However, uncertainty remains regarding the release and fate of NMs or metal ions from the above mentioned devices in the environment, thus requiring careful control.” In the discussion of the various nano-materials this is the only example that has a comment at this point in the paper about possible environmental and health impacts. Seems out of place here (also, would be good not to start sentences with “However”…..)

This phrase has been removed from this section, anyway the concept regarding concerns on the potential nanomaterial release into the environment is still present in different parts of the manuscript.

Page 8 – “In this context according the proposed principles for green economy it is important to take advantage of opportunities of nanotechnology and overcome its practical challenges.” Better:
“In this context, according to the proposed principles for green economy, it is important to take advantage of opportunities of nanotechnology and overcome its practical challenges.” Important to whom???

This phrase has been clarified as follows “In this context according to the proposed principles for green economy, it is important that society, scientific community and industry take advantage of opportunities of nanotechnology while overcoming its practical challenges.” This appears important to underline the complex relationship between society, scientific research and industry in taking advantages as well as addressing challenges regarding the introduction of green nano-solutions.

**Discretionary Revisions**

Page 8 – perhaps, in the list of workers potentially exposed it could be clearer that the potential dangers are posed to a very wide-range of workers: lab technicians, cleaners, production workers, transportation and storage workers, retail workers, workers in disposal and waste facilities and, potentially, emergency responders who deal with spills and disasters of nano-materials. This might strengthen the health and safety section.

We agree with reviewer 2 in his suggestion to stress the concept of the emerging risks from nanomaterial exposure for a wide range of workers with the aim to strengthen the relevance of health and safety considerations in this innovative field. Therefore we introduced the proposed list of workers, potentially exposed to nanomaterials along all the lifecycle of nanomaterials, in the “Occupational health and safety considerations” section.

I was also concerned that this section, while calling for all the appropriate scientific analysis and the need for skilled and trained workers and for careful assessment and management, says nothing about the need for the political will to make sure this happens (history is littered with scientific and production innovations that we assured people had been appropriately studied and assessed and produced with good management practices and concern for worker exposures – yet led to some spectacular negative human and environmental disasters). There is no mention here of a role for government regulation or empowerment of workers (although this is referred to in the section on risk management (which in general is well presented).

According to the reviewer 2 suggestions, we modified the “Occupational health and safety considerations” section introducing, following the part that underlines the necessity for a highly skilled and trained workforce, few lines about the need for government regulation and empowerment of workers, important for the correct management of the emerging occupational risks and the adequate occupational health protection.
Revisions were made as follows:
“(…) This ambitious aim will require large scientific efforts to overcome the current lack of knowledge concerning NM hazardous properties as well as governmental engagement and empowerment of workers aimed to “assure/make sure” workforce education and regulation in order to reach suitable employee expertise, good workplace practices and adequate health protection.”

Page 13 - Risk Communication – this seems abbreviated. I think the authors could say more about the challenges of effective risk communication and the importance of making available complex technical and health information in language accessible and understandable to wide range of workers and the public. I would like to see this section a little bit more developed.

We agree with this comment and developed a little bit more this part of the text introducing the necessity of an accessible information, as well as some few lines concerning the importance of a correct and balanced information to form adequate perceptions and attitudes on nano-applications.

Following the revised version of this section:
“Risk communication, is essential for the healthy innovation and sustainable development of green nanotechnology in view of a general public transparency [126]. In this context, risk communication should become effective in terms of making available complex technical and health information in language accessible and understandable to the occupational and general population. Importantly, researchers, regulatory scientists, representatives of the workforce, industry and governmental authorities should be actively engaged in facing a dialogical pro-active communication of the potential nanotechnology risks with the aim to form adequate perceptions and attitudes. This appears extremely important to assure the spread, also promoted by mass media, of an appropriate information regarding benefits and challenges of nanotechnology, protecting public and personnel opinion from both unrealistic hopes and excessive awareness in this regard”.

The conclusion – the paper raises some very critical concerns about the impact of nano-materials, especially when integrated into a green economy. The previous pages contain a litany of wisely chosen and significant hazards presented by these materials. The conclusion could have circled back to the exciting and potentially valuable contribution that nano can make to a more sustainable economy (well said at the beginning of the paper) and said a little more about the tension between this kind of innovation and the impact on worker and environmental health – stressing the need for a full democratic discussion of the use of such materials and the potential costs and benefits to
society as a whole. This points to larger themes and reflects concerns such as those already developed (particularly in Europe) around the precautionary principle.

According to the comment of reviewer 2, we have modified the conclusion section introducing a little bit more on the exciting potential and opportunities offered by green nano-applications to reach a more sustainable economic development. Moreover, we introduced some critical points that raise concerns regarding health and safety of occupational exposed populations (i.e. the not fully known hazardous properties of nanomaterials). We stressed the need for a full democratic discussion between expertise aimed to carefully balance the benefits of green nanotechnology and the potential costs for the society, particularly in terms of environmental, public and occupational health to reach a real sustainable development of this promising field.

We hope to have improved the manuscript as expected.
We look forward for your decision,
Best regards