

## ***Interactive comment on “Global Phosphorus Recovery for Agricultural Reuse” by Dirk-Jan D. Kok et al.***

**Anonymous Referee #3**

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This manuscript analyses global potential of phosphorus recovery by developing a model which simulates phosphorus trade between supply and demand nodes. The topic is interesting for a wider audience and important in view of the fact that phosphorus is a non-renewable source and at the same crucial for agricultural production. The peak production of phosphate ore could occur already in the coming decades, which makes the assessment of recovery potential timely and relevant.

1. The authors could motivate better why there are using the minimum production costs for production nodes and maximum bid prices for demand nodes instead of average costs/optimal prices. I am wondering whether this potentially leads to an overestimation of trade because if average or maximum production costs were used, less trade would occur. The same is true if optimal or minimum bid prices of demand nodes are

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used instead of maximum prices. Could this be the reason that the model results in a misbalance of 109% total production potential to demand?

2. The graphical representation of the supply and demand curves in Figure A in Supplementary Material does not seem correct. The quantity is typically shown on an x-axis and the price on the y-axis. Moreover, the demand and supply curves are usually concave. I would refer the authors to an economics textbook (e.g. by Samuelson and Nordhaus) for an appropriate description of the supply and demand functions.

3. For countries with high and intermediate urban access to sanitation, the assumed phosphorus recovery technology is different than for countries with low urban access to sanitation. It would be helpful if the authors reported the costs of these two different technologies. They could also comment on how the technological assumptions affect the results (e.g. how would the results change if the same technology is assumed in all countries?). Related to this, how realistic is it that only source separating-, dry composting toilets are implemented in countries with low urban access to sanitation? The authors could shortly elaborate on the social acceptance of such technologies and the potential yuck factor.

4. The model description is certainly important, but I found it difficult to follow. Is it possible to describe the model more concisely and clearly?

5. I have some doubts about how realistic the model is. What certainly gives it most credibility is the relatively good approximation of the market prices. However, the justification for selecting years 2005, 2006, 2011 and 2015 is missing. Is it possible to report the model performance for all years presented in Table 4?

6. The model includes the labour wage. How are these determined or which database is used for this purpose? Do labour wages vary across countries?

7. Please explain what the ‘resource costs’ in the model stand for.

8. This study does not seem to consider the external costs of phosphorus recovery,

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such as CO<sub>2</sub> emission and energy demand (see e.g. Linderholm et al., 2012). It is recommendable to explicitly mention this and briefly discuss the implications on results. Of particular interest would be to know which of the two technologies considered in this study has higher external costs.

9. The environmentally extended world input-output tables unfortunately do not include data on phosphorus yet. Nevertheless, I was wondering if the elements of an input-output analysis or computable general equilibrium models could contribute to a more precise and realistic representation of the phosphorus supply, demand and in particular trade? Would the authors consider this as an interesting area for future research or do they not see the added value of it?

10. Two important aspects are missing in my view when explaining the far-future scenario: the prices of phosphorus are expected to be high and the new technologies (in addition to the existing ones) are likely to become available and economically feasible.

11. The literature overview with respect to phosphorus recovery could be more complete (e.g. Cornel and Schaum, 2009; Cordell et al., 2011; Molinos-Senante et al., 2011).

12. It would be useful to mention early on that the economic feasibility of P recovery varies in space because it depends on the concentration of P in wastewater, which is related to the population and livestock density. This connection was not clear to me immediately.

13. Throughout the paper I was getting confused with the term 'production', as in phosphorus production potential. Since phosphorus is produced in rock formations, do authors actually mean 'recovery' potential? I think it is important to distinguish between the terms 'production' and 'recovery' to avoid confusion.

14. Proofreading the manuscript for English language is highly recommendable.

References: Cordell, D., Rosemarin, A., Schröder, J.J., Smit, A.L. (2011). Towards

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global phosphorus security: A systems framework for phosphorus recovery and reuse options. *Chemosphere* 84: 747-758. Cornel, P., Schaum, C. (2009). Phosphorus recovery from wastewater: needs, technologies and costs. *Water Science and Technology* 59: 1069-1076. Linderholm, K., Tillman, A.-M., Mattsson, J. E. (2012). Life cycle assessment of phosphorus alternatives for Swedish agriculture. *Resources, Conservation and Recycling* 66:27-39. Molinos-Senante, M., Hernandez-Sancho, F., Sala-Garrido, R., Garrido-Baserba, M. (2011). Economic feasibility study of phosphorus recovery processes. *Ambio* 40: 408–416.

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