

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

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Received and published: 24 May 2018

GENERAL COMMENTS

By using statistical data for populations and agriculture and assuming basic equations for phosphorus recovery and agricultural phosphorus demand, the authors can give reasonable estimates for the potential of the market potential for recycled phosphorus. The results compare very well with empirically determined costs and prices.

The results of this study add important information for the discussion on phosphorus recycling and they also show issues, which have to be addressed in phosphorus recycling. For example, they show that transport costs are crucial and therefore high concentrated recycling products are needed or short distances. I recommend to ac-

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cept this manuscript for publications after the manuscript will be revised according to the comments below.

SPECIFIC COMMENTS

Sensitivity of input data: Some information about the sensitivity of the input data would help to support the discussion. Especially the influence of the P recovery efficiency could have a major effect on the result. With struvite, the authors chose a P recovery process, with a very low recovery efficiency. See e.g. Egle, L., Rechberger, H., Krampe, J. and Zessner, M. (2016) Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment of P recovery technologies. *Science of the Total Environment* 571, 522-542

Global P demand and global P recovery: It is surprising but also very interesting that the global P demand fits the global P recovery so well. It would be good if the authors could compare their data with a phosphorus balance as provided by Cordell et al. (2009), Scholz et al. (Scholz, R.W., Roy, A.H., Brand, F.S., Hellums, D.T. and Ulrich, A.E. (2014) Sustainable Phosphorus Management. A Global Transdisciplinary Roadmap, Springer, Dordrecht.) or van Dijk et al. (van Dijk, K.C., Lesschen, J.P. and Oenema, O. (2016) Phosphorus flows and balances of the European Union Member States. *Science of the Total Environment* 542, 1078-1093.). With such a comparison, the reasons for possible deviations could be identified. This discussion would be extremely helpful. One reason, which could explain the deviation could be the use of P accumulated in the soil for plant growth.

Free market: This study considers a free market for agricultural products, but in reality, this market strongly influenced by subsidies. How could this be considered?

Free struvite from Bio-P and setting of the costs for wastewater treatment: I am missing a comparison between the costs of struvite production in Bio-P wastewater treatment plants and the costs caused by struvite blockages. The authors assume that struvite recovery from wastewater is free because it off-sets the costs for removing blockages,

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but is this correct? Along these lines, it might be good to mention that P recovery from dry sanitation systems would also help to reduce environmental pollution. This is a value for society and would reduce the costs of the P fertilizer production. However, I understand that assessing this value is not easy.

Conclusions: The "Conclusions" section is rather a summary. Conclusions do not necessarily repeat the main results from study but they should rather emphasize the significance of the results.

Formulae: The formulae should be revised. I added a few remarks in the detailed comments. A formula on the production costs for compost is missing and should be added.

Language: The text contains several errors. I noted some of them in the detailed comments below. The introduction should be written more clearly. Some more hints are given in the detailed comments.

DETAILED COMMENTS

Page 1 Line 8 Sentence is unclear

Page 1 Line 9 "as well as"

Page 1 Line 11 It is unclear what the subclause "while rock phosphate products exist" means.

Page 1 Line 18 Write "Ammonium" and "Phosphate" in small letters.

Page 1 Line 22 This sentence is unclear. Could you give a reference? Much of the phosphorus used today is flushed to the sea and forms sediments. This is the first step to form sedimentary phosphate rock.

Page 1 Line 24 The estimation that peak phosphorus might occur in 2030 is based on several wrong assumptions. It is unlikely that a peak phosphorus will occur in the near future. The reserves are much larger than it was known to Cordell et al. and there are

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large resources, which still need to be explored. See Scholz, R.W. and Wellmer, F.-W. (2013) Approaching a dynamic view on the availability of mineral resources: What we may learn from the case of phosphorus? Global Environmental Change 23(1), 11-27.

Page 1 Line 26 Depletion of phosphorus is presumably not the issue but rather economic scarcity, which is mainly due to developments on the financial market. However, these developments affect not only phosphorus but also other commodities. See the reference give above.

Page 1 Line 27 "accessibility"

Notes on page 1 I suggest to include these notes in the text.

Page 2 Line 6 Delete "disproportionately", because the meaning is unclear. What would be a "proportionately large algal bloom"?

Page 2 Line 7 Replace "water based" with "aquatic".

Page 2 Line 25 "Favourable economic prospectives..." This sentence is unclear to me. You probably mean "perspectives".

Page 2 Line 30 The whole paragraph is hard to understand and should be reformulated.

Page 3 Line 10 Phosphorus-laden wastewaters and agricultural areas do not "concentrate themselves". There are locations with high concentrations are they are concentrated at certain locations.

Page 3 Line 13 What do you mean by "paying prices of varying crop sites"? The money that farmers will get for their crops?

Page 3 Line 22 Reverse the sentence: A crude, global mapping of phosphorus production sites is achieved by using..."

Page 3 Line 25 Do you mean "flow" when you write "throughput"?

Page 3 Line 23 "formula"

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Page 3 line 31 Rather use "cap" for "capita" instead of "h" for "head". "h" is usually used for "hours".

Page 3 Line 36 "phosphorus"

Page 4 Line 6 Check superscripts

Page 4 It would be helpful to explain the parameters used in equation 2 and 3 in more detail, especially, how the values for these parameters are derived.

Page 4 Line 18 Explain better, what you mean by pixel.

Page 4 line 26 "marked" instead of "stylized"

Page 4 Line 35 "sanitation"

Page 5 Line 3 The struvite process has probably the lowest P recovery efficiency of all currently known P recovery processes. See e.g. Egle, L., Rechberger, H., Krampe, J. and Zessner, M. (2016) Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment of P recovery technologies. Science of the Total Environment 571, 522-542. Ideally, the authors would also include another process with higher phosphorus recovery to show the potential of P recovery. Alternatively, a sensitivity analysis on the P recovery efficiency could be included.

Page 5 Line 13 Is there also struvite precipitation on the livestock farms?

Page 5 Line 17 90% P recovery from urine can only be achieved, if the P, which precipitates in the pipes and collection tanks is also recovered. This spontaneously precipitated P can make up 30% of the total P.

Page 5 Line 25 What do you mean by resource cost?

Page 5 Line 30 Give some more information about the literature reference of Egle. At which university was the PhD thesis conducted and when was it concluded?

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Page 5 Line 30 Why did you choose $MgCl_2$ and not MgO as magnesium source? $MgCl_2$ is more expensive. It would be good to include a sensitivity analysis on the Mg source price.

Page 5 Line 33 Does the production cost cover exactly the cost for struvite and sludge handling?

Page 5 Line 34 How do you include the additional resource cost? Is it part of BS?

Page 5 Line 35 "as follows"

Page 5 Line 4 E_{Lt} must be larger. This value corresponds to 1.6 L/100 km, which is extremely low. I would guess that it might be at least a factor 10 larger. W_{Lt} seems to be high. This might be the combined weight for truck and load.

Page 6 Equation 6 Doesn't equation 6 also have to contain transportation costs (see the term in equation 7)?

Page 6 Equation 7 Please check this equation. The units do not fit. The term $Pb \cdot EW$ results in [\$/d], while the term CF/VW has the unit [\$/km]. What is a "bunker" and what is a "handy size bulk carrier"?

Page 8 Equation 11 These equations should be adapted because it is not mathematically correct. DQ_n and SQ_i cannot stand on both sides of the equation.

Page 8 Equation 12 Does this equation mean that the population grew at the same rate at every node? What does "population density raster" mean?

Page 10 Line 1 "determine how"

Page 10 Line 7 The interpretation of the box plots is already described in the caption text. This description does not have to be repeated in the main text.

Page 10 Line 31 Delete on "pay"

Page 11 Line 8 "treatment"

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Page 11 Line 9 "variable" instead of "vary"

Page 11 Line 10 "feasibility"

Page 11 Line 16 Give the number always in the same way, e.g. in brackets.

Page 11 Line 30 "distinctly"

Page 11 Line 38 Why are the prices given in Figure 4 so much higher?

Page 11 Line 39 "Phosphorus"

Page 12 Line 30 "phosphorus"

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2018-176>, 2018.

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