IMPROVE

Improved Phosphorus Recycling: Navigating between Constraints

PD Dr. Kurt Möller

Universität Hohenheim

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Outline

- Introduction
- Composition and assessment of the agronomical value
- Environmental impact by LCA study
- Risk assessment (potentially toxic elements)
- Evaluation of the PTE loads
- Conclusions

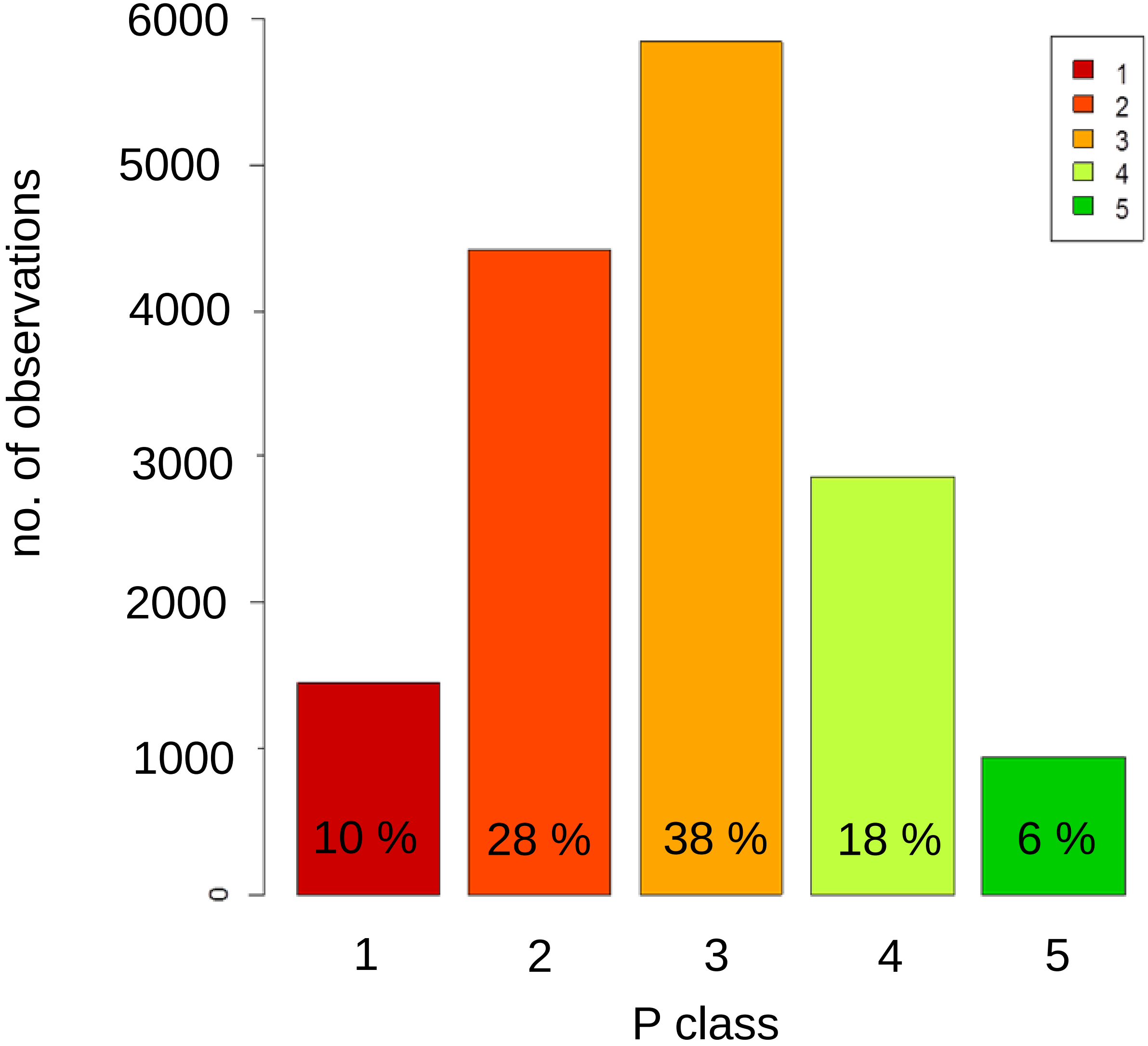
Overview IMPROVE-P

IMproved Phosphorus Resource efficiency in Organic agriculture Via recycling and Enhanced biological mobilization

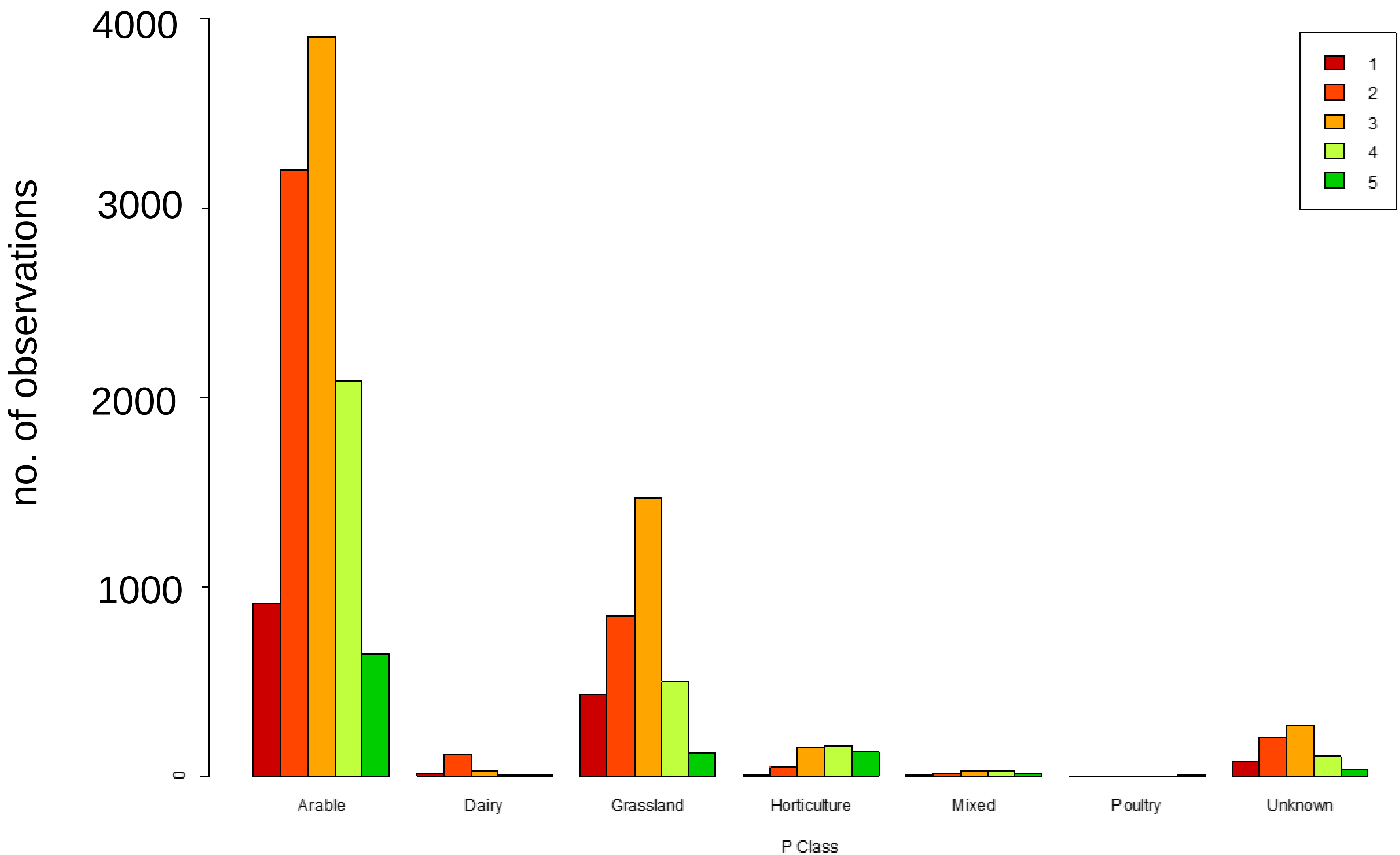
Work packages:

- Compilation of existing knowledge and synthesis on P status of organic farms
- **Evaluation of efficacy and potential environmental impacts of recycled P fertilizers**
- Improved P mobilization by adapted agronomic strategies and addition of P mobilizing Plant Growth Promoting Rhizobacteria
- Discussions with stakeholders about applicability of recycled P fertilizers

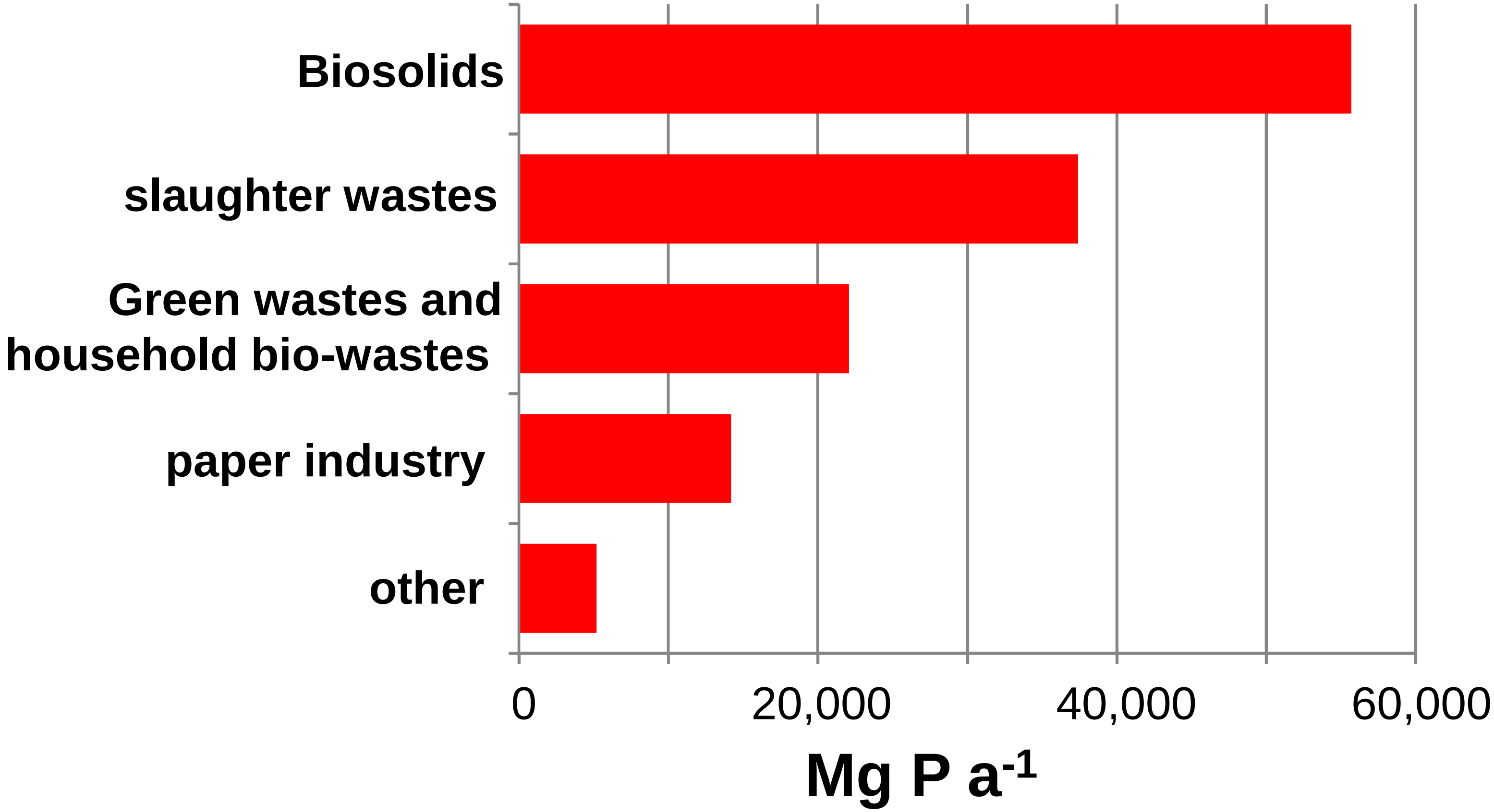
Distribution of farm scale soil extractable P values among P classes ranging from very low (P Class 1) to very high (P Class 5) (n = 15,506) (Cooper et al. 2018)



Distribution of field scale soil extractable P values among P classes ranging from very low (P Class 1) to very high (P Class 5), disaggregated by farm type. (n = 15,506) (Cooper et al. 2018)



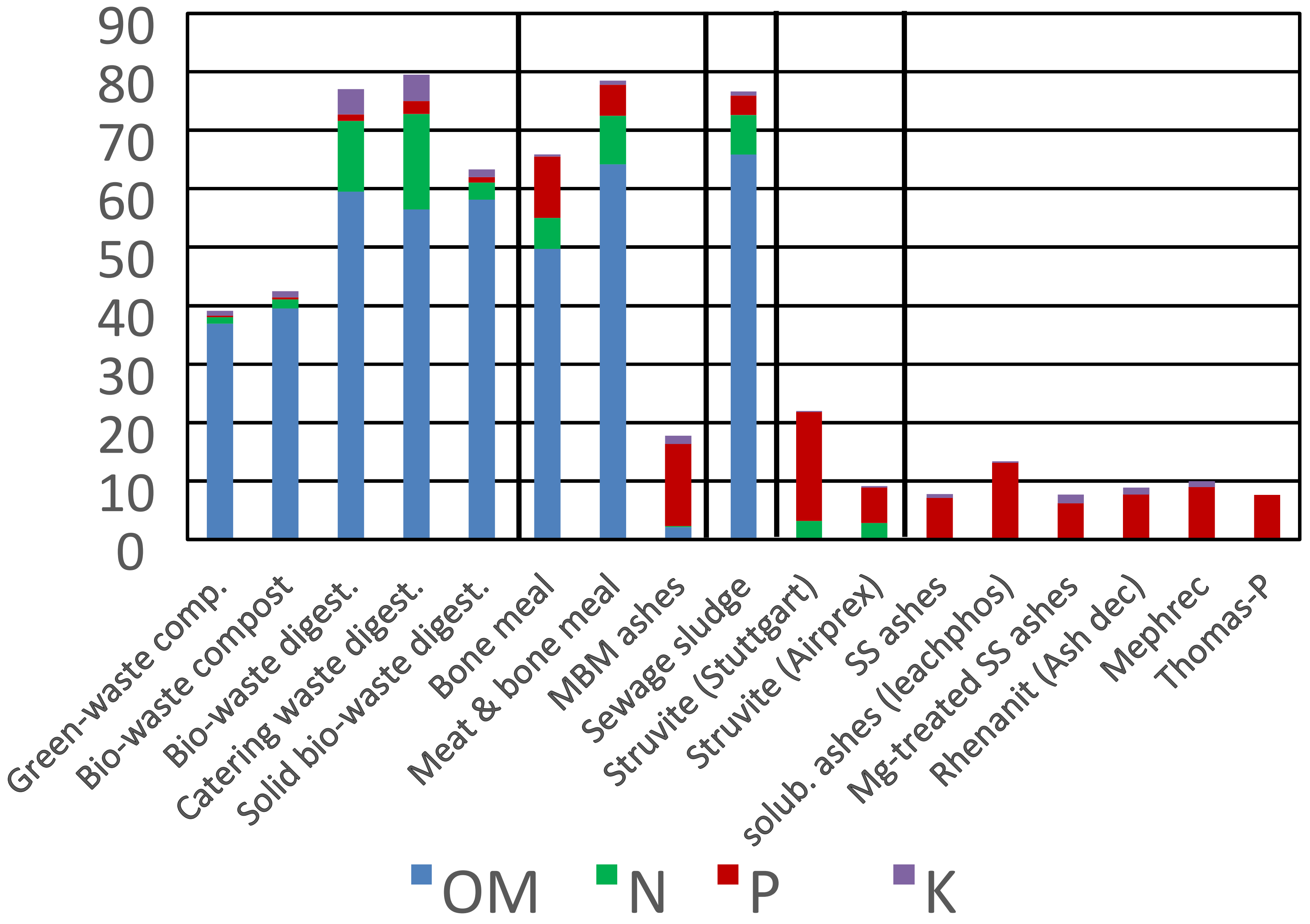
Phosphorus potentials of recycled P sources in Germany (based on data of Fricke & Bidlingmaier 2003)



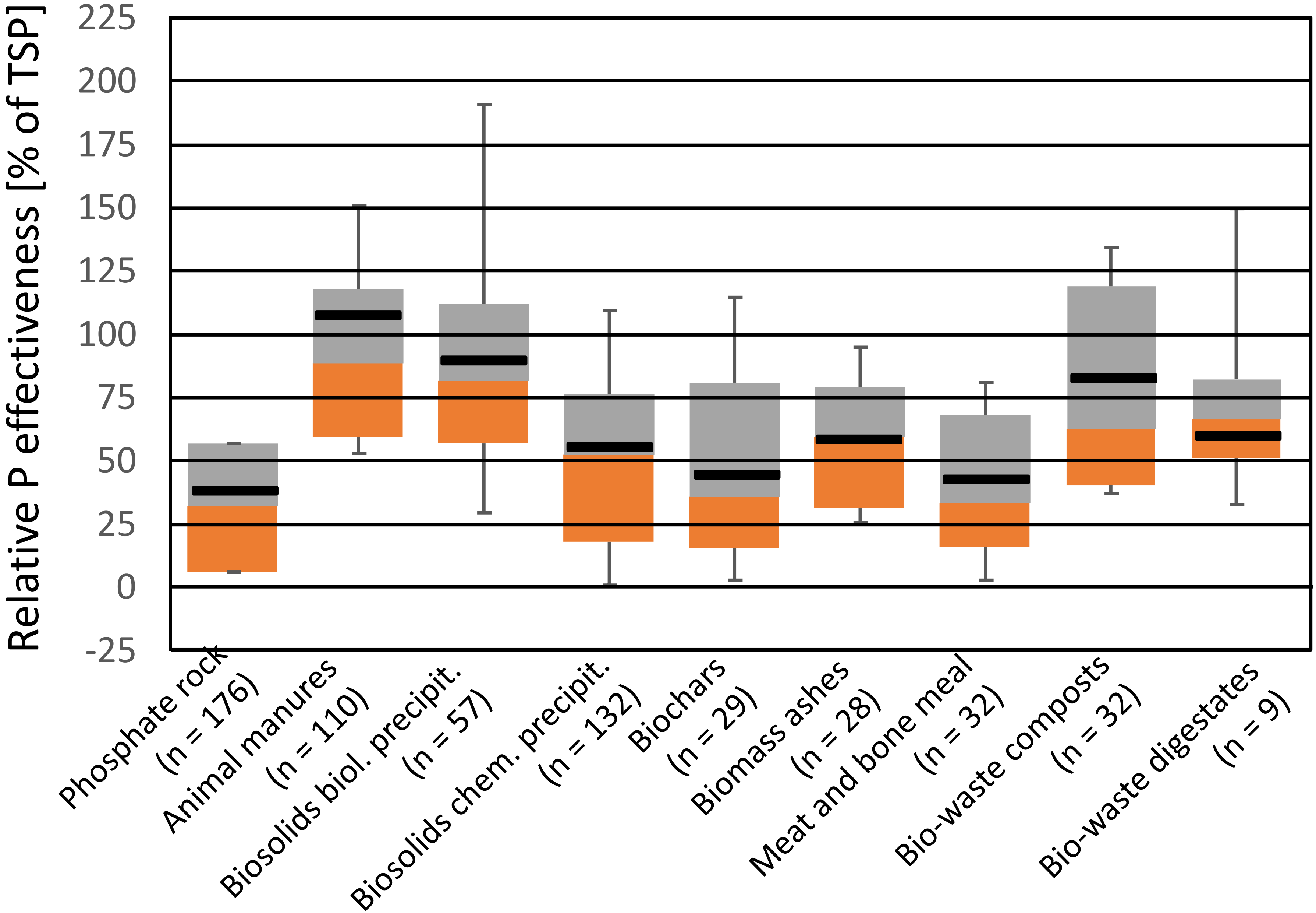
Materials and Methods

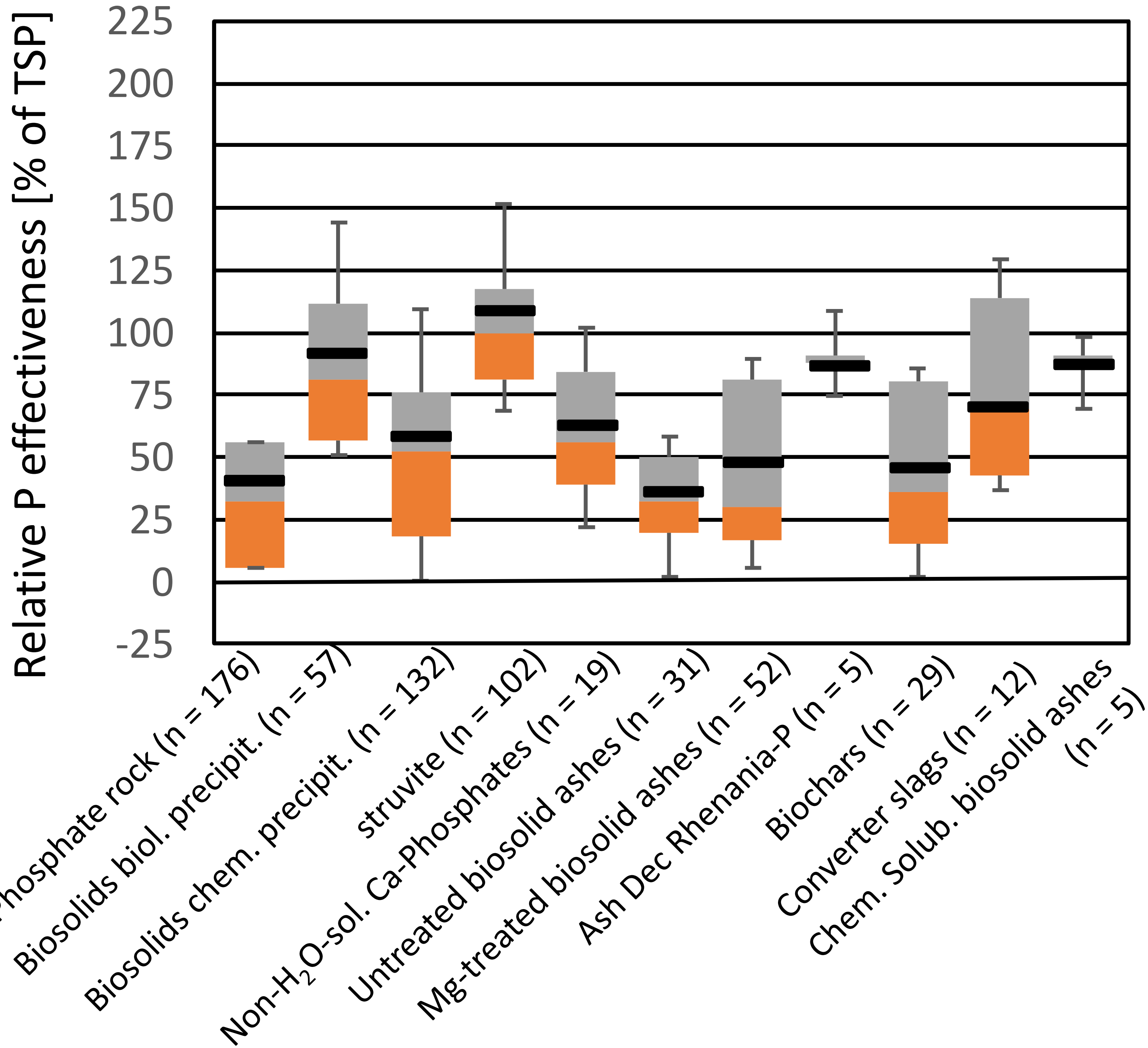
- Pot and field experiments to assess the P fertilizer value
- Compilation of the literature findings about the relative P fertilizer effectiveness of recycled P fertilizers
- LCA study (functional unit: 1 kg P)
- Risk assessment (accumulation risk for PTEs and POPs)
- SWOT analysis

Composition of recycled P fertilizers [% DM] (Möller et al. 2018)

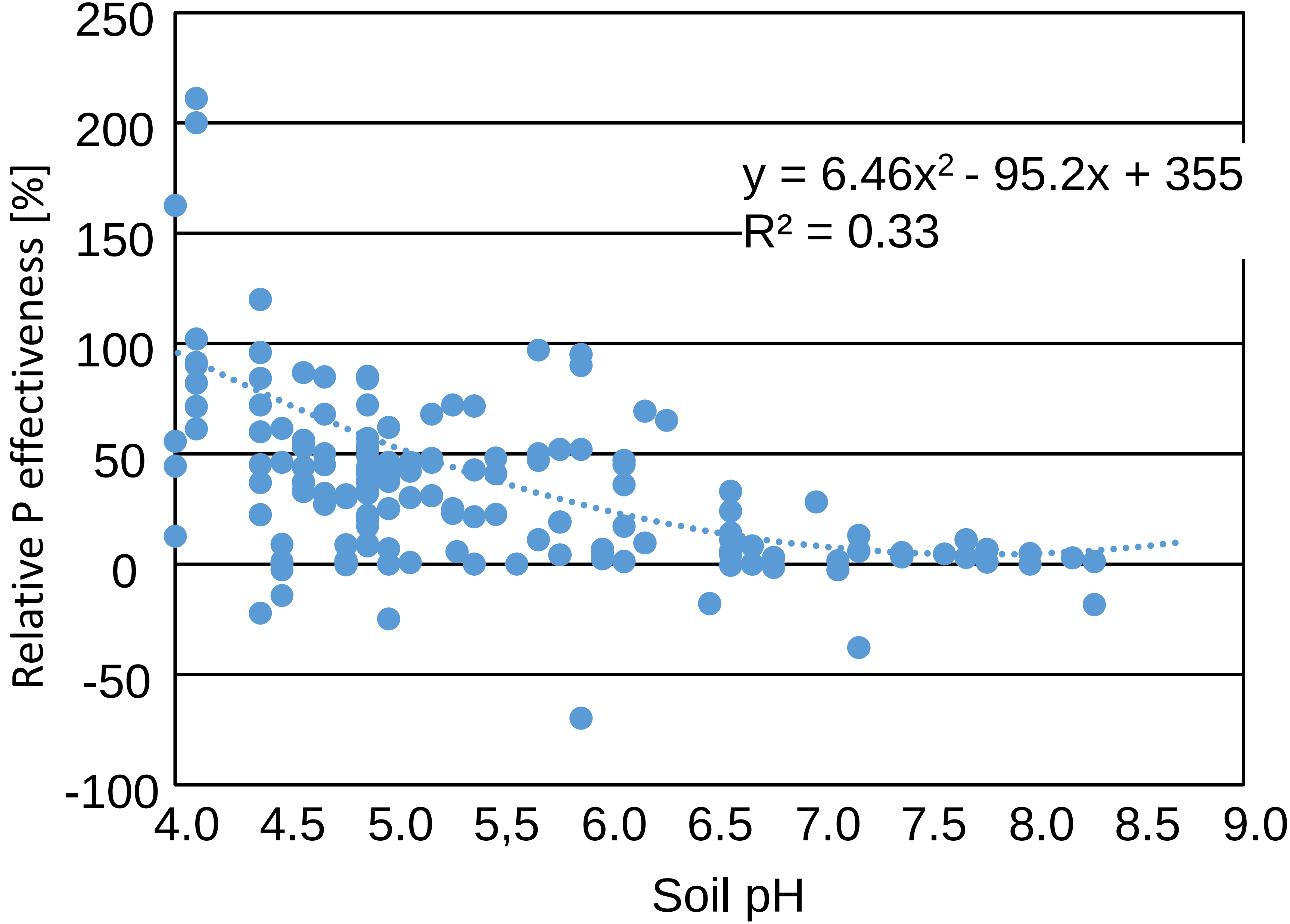


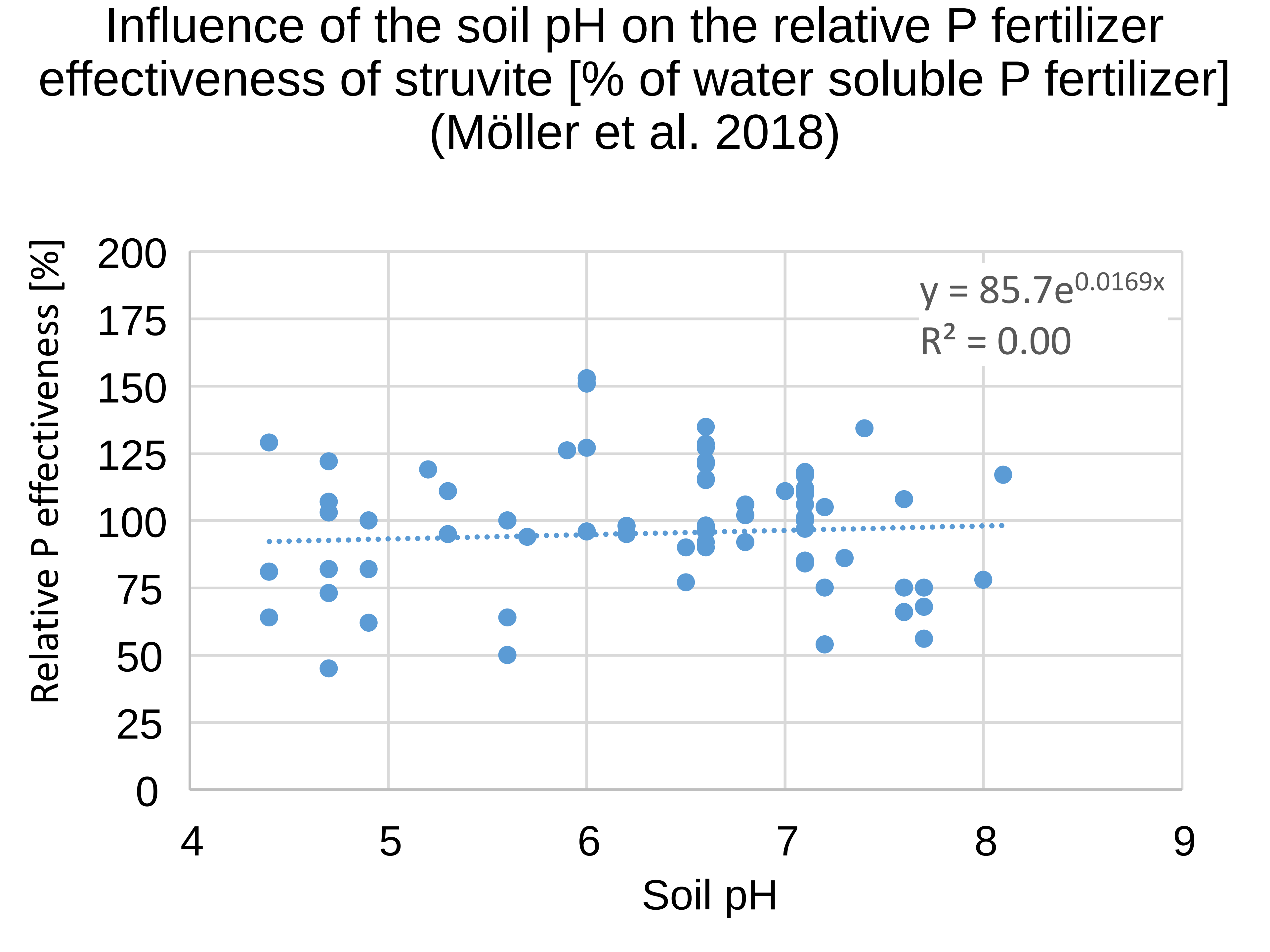
Relative fertilizer P effectiveness [% TSP] of some major P sources (adapted from Möller et al. 2018)




Relative P effectiveness [% of TSP]
225
200
175
150
125
100
75
50
25
0
-25
Phosphate rock (n = 176)
Biosolids biol. precipit. (n = 57)
Biosolids chem. precipit. (n = 132)
struvite (n = 102)
Non-H_2O-sol. Ca-Phosphates (n = 19)
Untreated biosolid ashes (n = 31)
Mg-treated biosolid ashes (n = 52)
Ash Dec Rhenania-P (n = 5)
Biochars (n = 29)
Converter slags (n = 12)
Chem. Solub. biosolid ashes (n = 5)

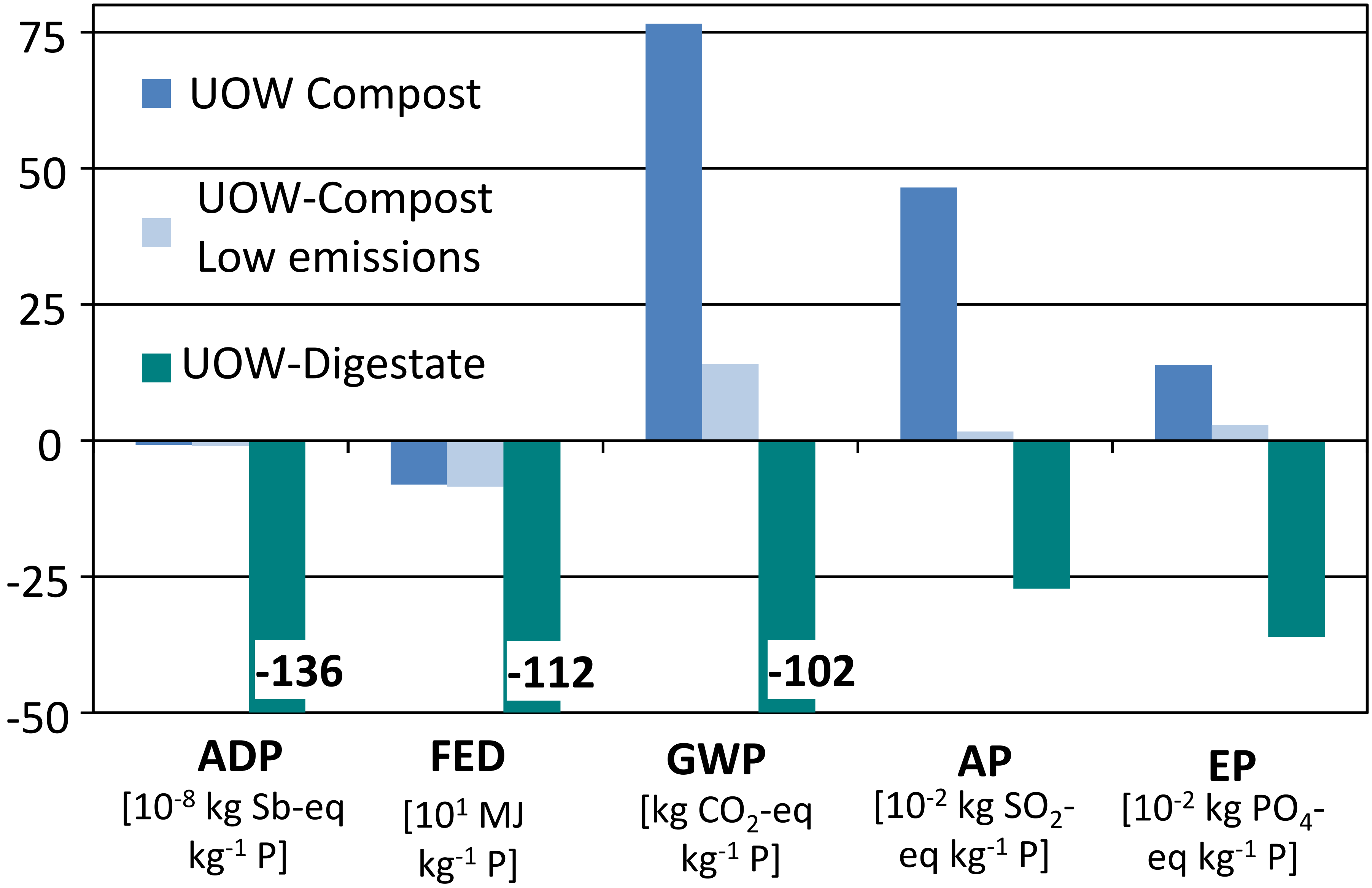
Soil pH and relative P efficiency of PR (Möller et al. 2018)



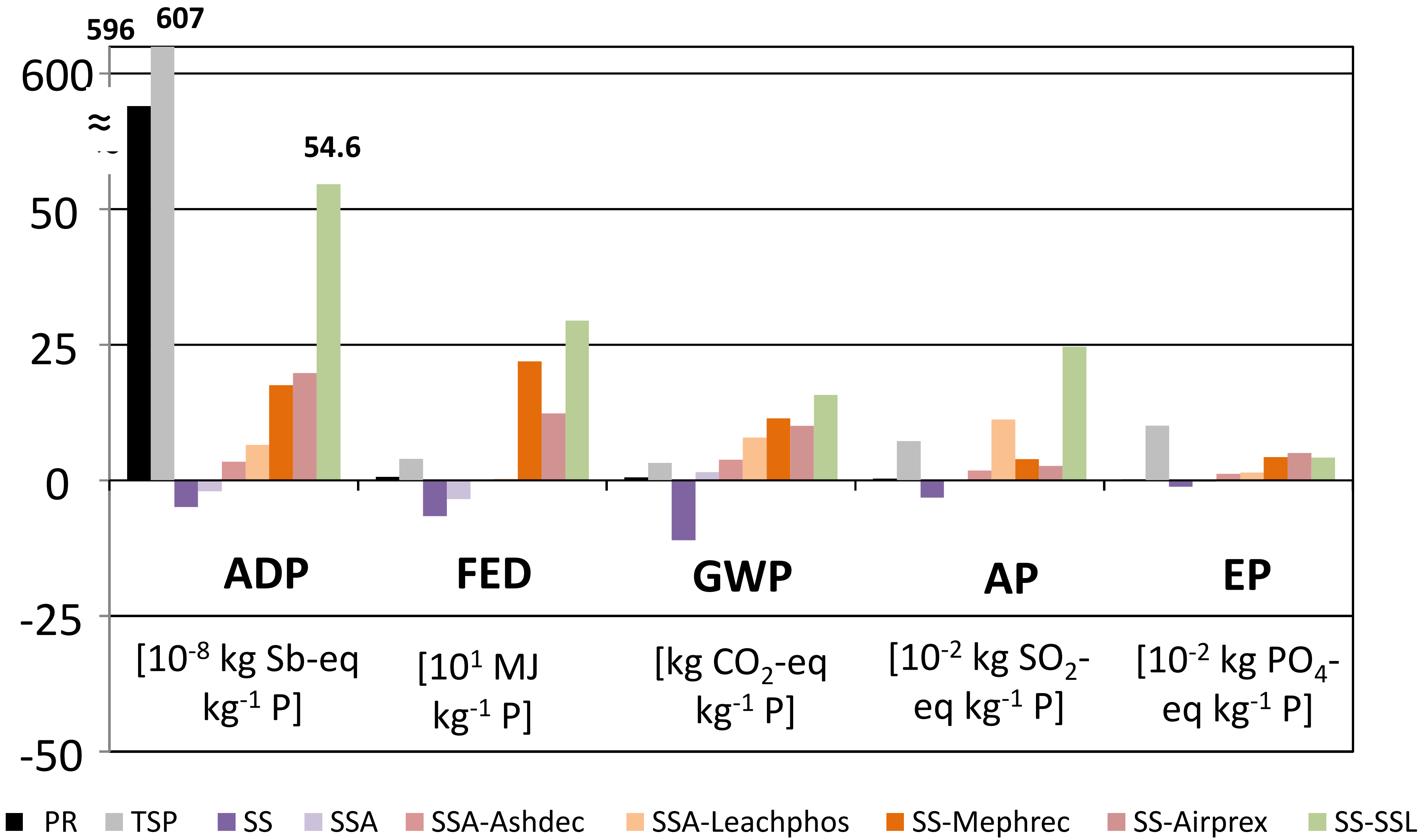


Influence of the soil pH on the relative P fertilizer effectiveness of struvite [% of water soluble P fertilizer] (Möller et al. 2018)
y = 85.7e^0.0169x
R² = 0.00
Relative P effectiveness [%]
Soil pH
0
25
50
75
100
125
150
175
200
4
5
6
7
8
9

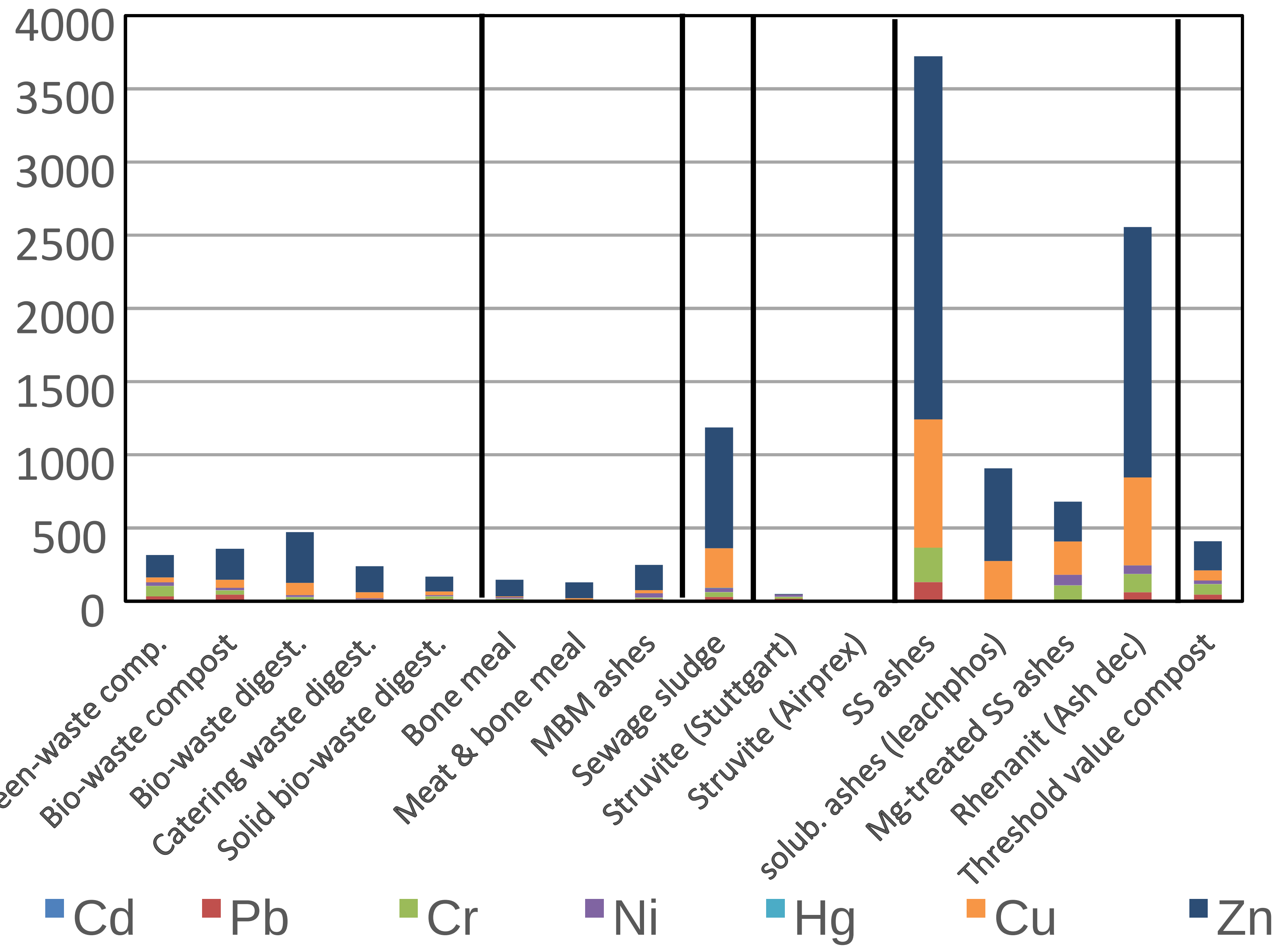
Net LCA results per kg P for urban organic household wastes (UOW), composted or digested (Hörtenhuber et al. 2018)



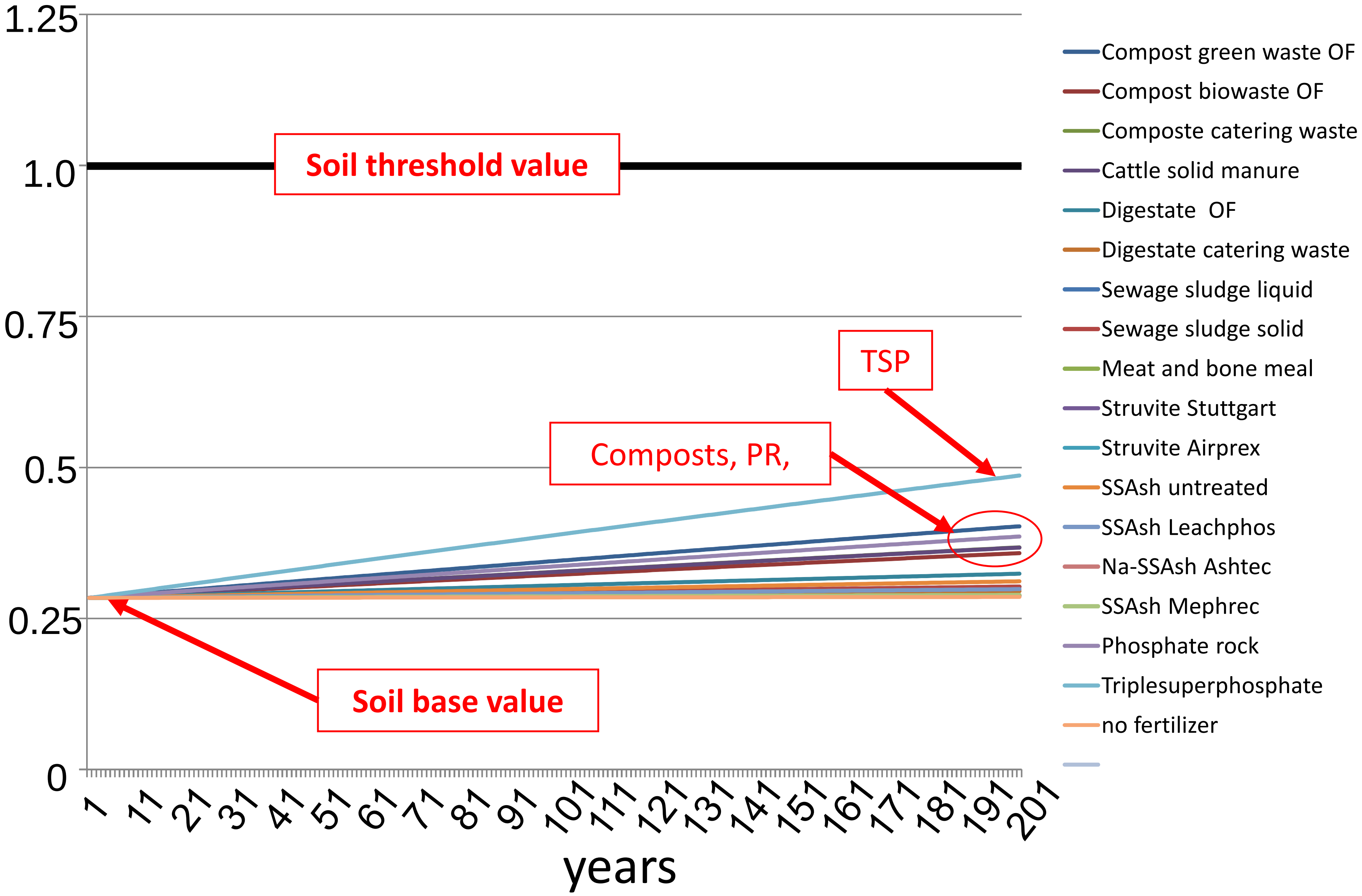
Net LCA results per kg P for sewage sludge (SS)-based recycled P-fertilizers compared to PR and TSP (Hörtenhuber et al. 2018)



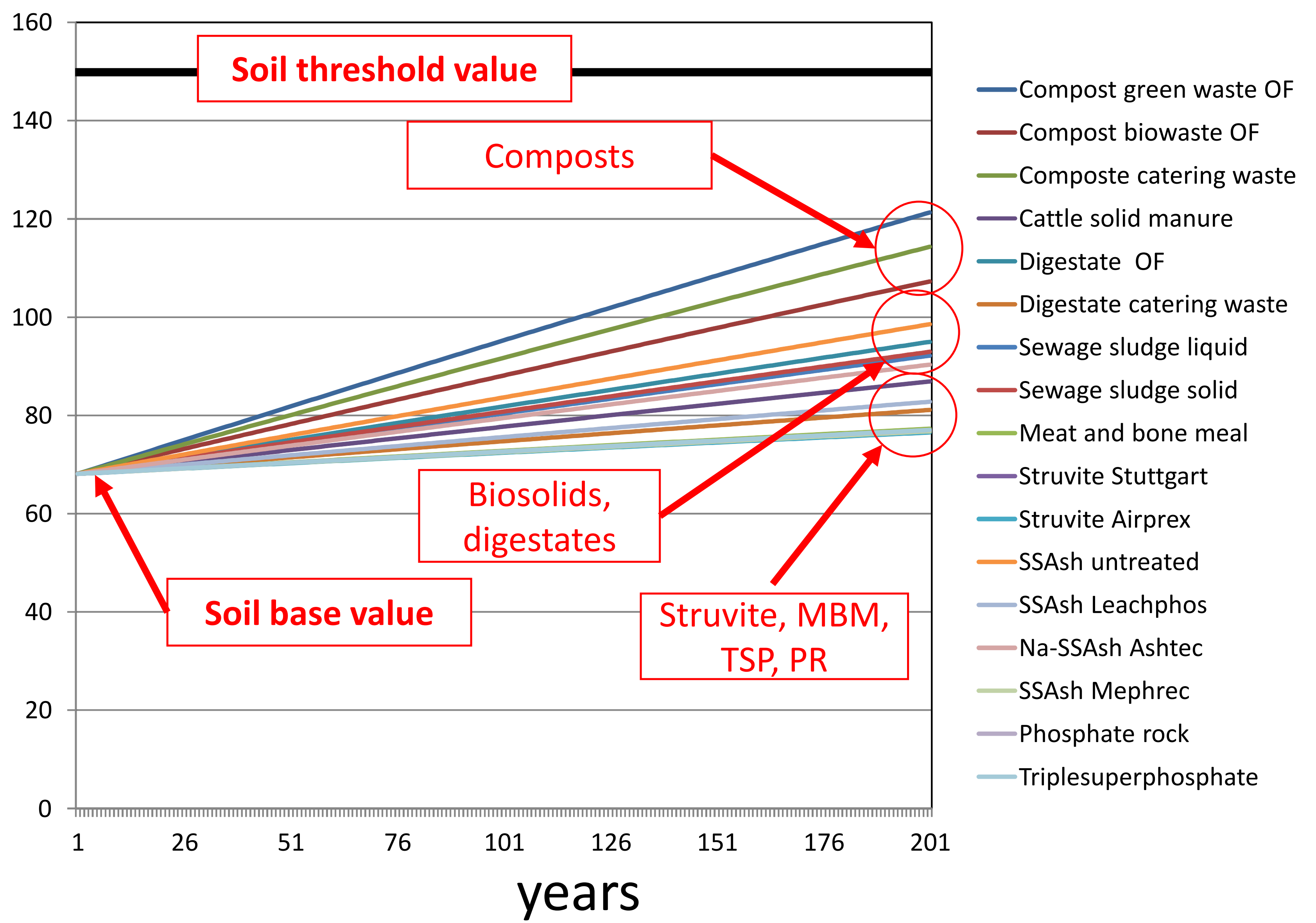
Concentration of PTEs [mg kg^{-1} DM] (Möller et al. 2018)



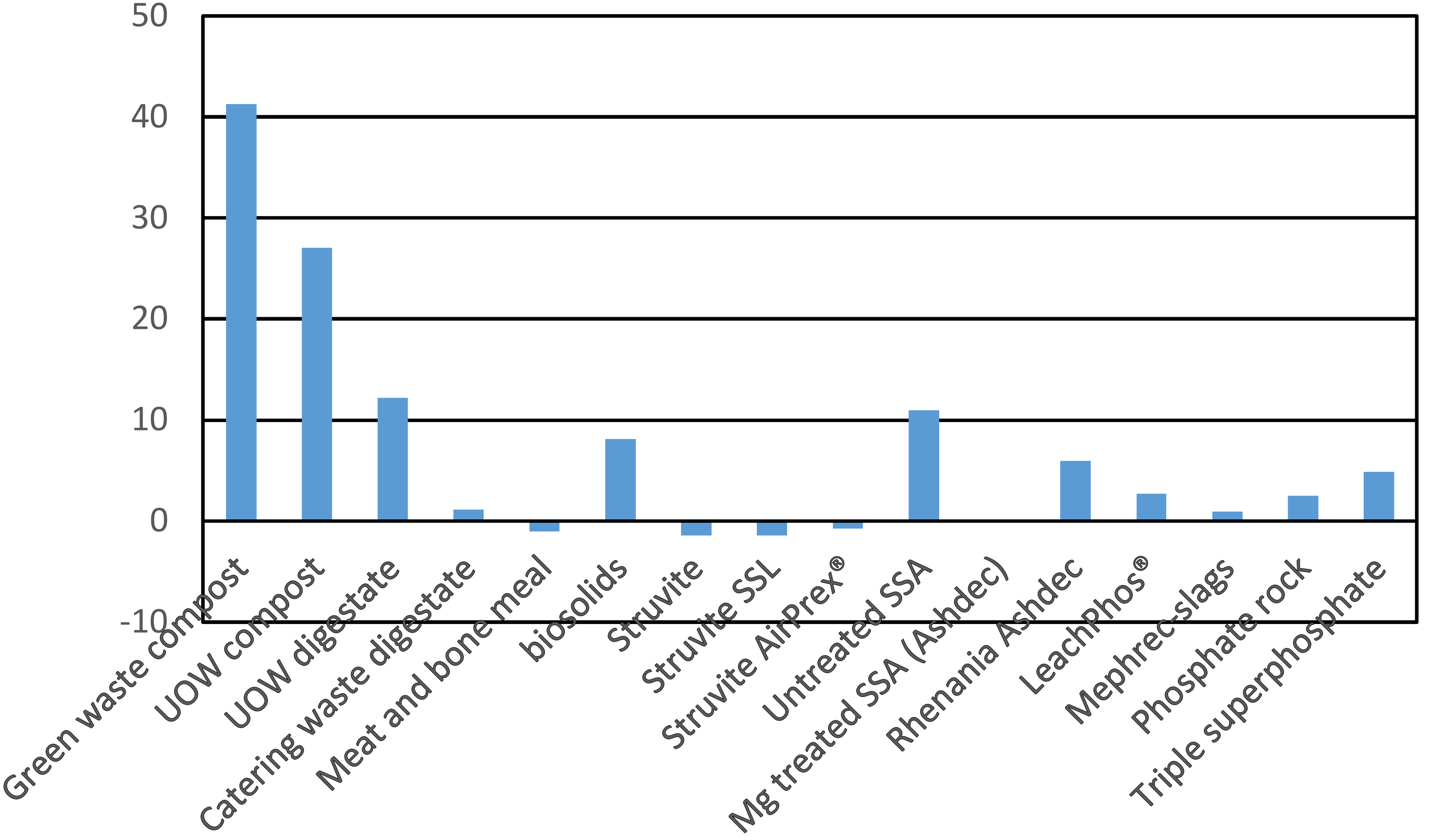
Risk Assessment: soil Cd-accumulation [mg kg^{-1} soil] with yearly application of recycled P fertilizers (equiv. 11 kg P/ha*a; soil pH: 7; water balance: 100 mm m^{-2}) (based on Weissengruber et al. (submitted))



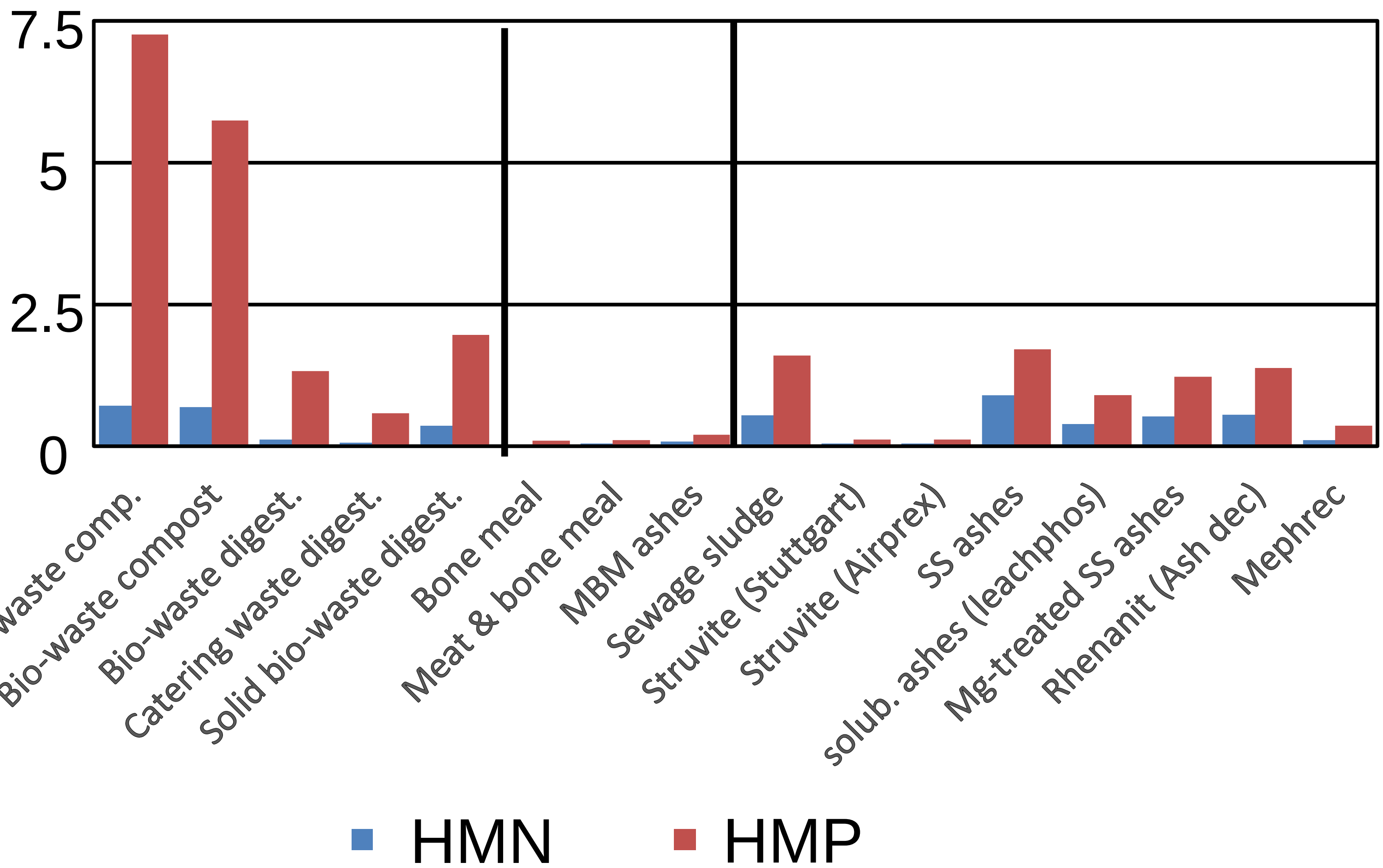
Risk Assessment: soil Zn-accumulation [mg kg^{-1} soil] with yearly application of recycled P fertilizers (equiv. 11 kg P/ha*a; soil pH: 7; water balance: 100 mm m^{-2}) (based on Weissengruber et al. (submitted))



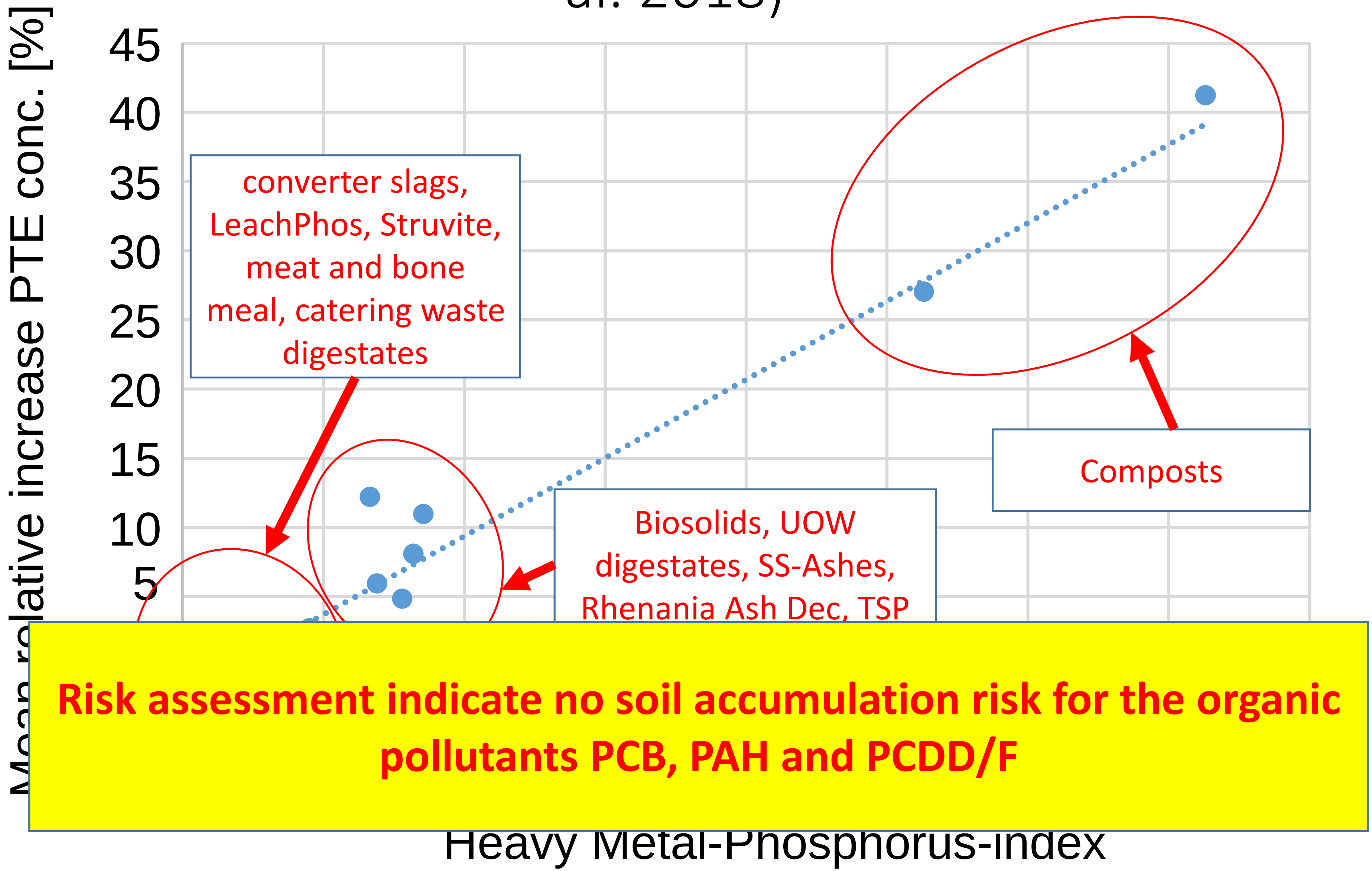
Average relative increase of the soil PTE concentration (% between base and threshold values) by continuous application of recycled P fertilizers (based on Weissengruber et al. (submitted))



Heavy metal-nutrient index and Heavy metal- P index of different recycling fertilizers (Möller et al. 2018)



Correlation between the HMP-index and the mean relative increase of soil PTE concentration (Möller et al. 2018)



Risk assessment indicate no soil accumulation risk for the organic pollutants PCB, PAH and PCDD/F

SWOT-Analysis

4
3
2
1

	P recovery	P fertilizer value	Organic matter	PTEs	Organic Pollutants	Env. impact	Overall Score
Bio-waste compost					?		
Bio-waste digestates							
Meat and bone meal							
- ashes							
Sewage sludge					?		
- Struvite (AirPrex)							
- Struvite (Stuttgart)							
- AshDec Rhenanite							

Conclusions

- Plant P availability of many recycled P fertilizers is higher than phosphate rock
- Main challenge are neutral soils:
  - untreated ashes, PR and MBM are not recommended,
  - composts, digestates, Na-Ash and struvite are more suitable.
- Many currently <u>not permitted </u>recycled P fertilizers have lower potential harmful effects and environmental impacts than permitted inputs
- PTEs are not the main constraint limiting recycling of most RPFs
- PTE flows are mainly driven by the RPF nutrient concentration → we do need a nutrient concentration related definition of threshold values

Conclusions

- For organic pollutants, pharmaceuticals etc. in RPFs and (conventional) manures uncertainties remain about risks to human health and the environment
- Approaches to reduce the risks from organic pollutants in RPFs are accompanied by several shortcomings:
  - Reduced P recovery rates
  - Increased abiotic resource depletion potential
  - Increased GHG, energy inputs, etc.
  - Lower P fertilizer value, loss of OM, N, S, etc.
- the current regulatory balance between the principle of care and the principle of ecology favors our generation at the expense of future generations.
- Presumably this balance is a result of considerations of risk mainly to our generation.

Thank you very much!

https://improve-p.uni-hohenheim.de

Financial support for this project is provided by funding bodies within the FP7 ERA-Net CORE Organic II

CORE organic II