Geophysical Research Abstracts
Vol. 19, EGU2017-13683, 2017
EGU General Assembly 2017

Implications of Phosphorus Recycling from Sewage Sludge Ash for Austria's Heavy Metal Balance in Arable Soils

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Recovery of phosphorus (P) from sewage sludge ash (SSA) is a promising approach to recycle P from municipal wastewater and to significantly decrease the dependency on phosphate rock (PR) resources. Legislation to enable fertiliser production from SSA and related quality criteria to ensure their safe use in agriculture are currently discussed widely across the European Union. One remaining concern is posed by the heavy metal concentrations present in SSA, which are not or only partly removed through P recovery, depending on the applied technology. In Austrian national law, fertiliser heavy metal concentrations are primarily limited on a dry mass basis. Even if not decontaminated, SSA-based fertilisers could comply with these limits if they were to be mixed with other P-containing raw materials during the production process of mineral fertilisers. This implies that dry mass based limits are inadequate to evaluate the potential threat of recycling SSA-based fertilisers to agricultural soils.

Therefore, this work takes on an alternative approach based on heavy metal/nutrient ratios in fertilisers to determine the relevance of altered heavy metal inputs in soils if P-recycling from SSA were put into action on a nationwide scale. By using substance flow analysis (SFA), current mean heavy metal inputs to Austrian arable soils through fertilisers and atmospheric deposition are contrasted to mean outputs through plant uptake, leaching and erosion. Impacts of P recycling on this heavy metal balance are then simulated through a set of scenarios which assume the replacement of $\sim$30% of PR in fertiliser production by SSA with different degrees of decontamination from wastewater treatment plants above sizes of 50.000 PE. Lastly, changes to the status quo are evaluated: (i) in terms of relative changes of total heavy metal inputs and (ii) by contrasting yearly concentration net-increases with current and critical heavy metal concentrations in arable soils.

Results reveal that by substituting 30% of PR with non-decontaminated SSA, the soil heavy metal balance is improved for the particularly critical heavy metals Cd, V and U, with a mean decrease in inputs of -14%, -11% and -27%, respectively. Pb and Ni inputs are expected to increase by +36% and +13%, however, in mean terms, arable land is shown to be less vulnerable to these heightened inputs. Of potential concern are increases in Cu and Zn inputs of +29% and +24%. Considering their diverse role both as micronutrients and as pollutants, the need for proper management strategies for these two metals is evident. As, Cr and Hg inputs are only slightly increased and the potential for a critical enrichment in soils is generally low.

An adapted P management can therefore contribute to an improvement of Austrians mean heavy metal balance in soils on a short-term basis. However, taking the precautionary approach, adequate decontamination or source-control strategies need to be implemented to reduce the risk for individual arable soil plots and ensure a safe recycling of nutrients from SSA to agriculture.