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Filling two needs with one deed: Potentials to simultaneously improve phosphorus and nitrogen management in Austria as an example for coupled resource management systems

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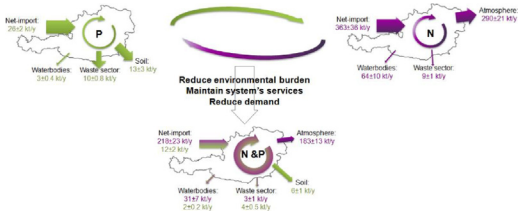
HIGHLIGHTS

- Material flows of several substances can be simultaneously analyzed in a complex system.
- Coupled Material Flow Analyses reveal co-benefits and trade-offs between substances.
- The Austrian phosphorus and nitrogen systems are closely interrelated.
- Highest efficiency gains can be achieved by a combination of different measures.
- Potentials to increase resource efficiency are higher than for emission reduction.

GRAPHICAL ABSTRACT



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ABSTRACT

The tremendous increase in resource consumption over the past century and the environmental challenges it entails has spurred discussions for a shift from a linear to a circular resource use. However, to date most resource studies are restricted to one material or a single sector or process. In this work, a coupled material flow analysis taking the national phosphorus (P) and nitrogen (N) system of Austria as an example for two closely connected resource systems is conducted. Effects of different measures aimed at reducing P and/or N-demand, increasing recycling or reducing emissions to air and water are compared to a reference state (representing the actual situation in 2015). Changes in the mineral fertilizer demand of the system, P and N losses in the waste sector, water emissions of P and N, P soil accumulation and atmospheric N emissions are analyzed. Overall positive feedbacks between measures and between different goals of one measure always outweigh negative ones, which is why the highest efficiency gains (57±4%) can be achieved by a combination of all the 16 measures studied. Potentials for the reduction of mineral fertilizer demand are larger than for emission reduction though, confirming the past priority of environmental protection over resource protection. Although coupling significantly raises model complexity it can be shown that material flows of more than one substance can be simultaneously analyzed in a rather complex system. This may reveal interrelations, co-benefits and trade-offs between different resources that might have been omitted in a mono-substance analysis and thus improve judgment of sustainability and viability of different management strategies.

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