Balance calculations on the fate of cadmium and uranium from phosphate fertilizers in arable soils

HANS RUPPERT*, HENRIKE MUNIER, BENEDIKT SAUER

Geoscience Centre, University of Göttingen, 37077 Göttingen, Germany (*correspondence: hrupper@gwdg.de)

Phosphorus is an essential nutrient for plant growth and must be replenished in soils according to its extraction by plants. P-fertilizers produced from sedimentary P-deposits contain high concentrations of toxic Cd (6-92, median ~30 mg/kg) and U (39-394, median ~110 mg/kg) whose input into our soils is of toxicological relevance [1, 2]. Sedimentary phosphates are by far the most important P-source. The natural background values of German arable soils are <0.1-0.2 mg/kg Cd and <1-5 mg/kg U. Present day concentrations are 0.2-0.5 mg/kg Cd. For U no significant changes are ascertained.

Based on an average input of 17.2 kg P_2O_5 per ha and year on arable soils in Germany and a median of 65 mg Cd/kg P_2O_5 in phosphate fertilizers, the input of Cd is 1.1 g/(ha*y). The open land deposition from the air is ~0.9 g/(ha*y) (data from [3]). The export of Cd by crops is ~0.4, by seepage water ~0,3 g/(ha*y). Consequently nearly 2/3 of the Cd-input will be accumulated in the soil.

The corresponding fertilizer input for U is 4.1 g/(ha*y). Atmospheric input and U-uptake by crops in Germany are neglegible. The U concentration in seepage water of 2 µg/L [4] corresponds to an U-export of ~6 g/(ha*y), what compensates the input, but impacts the groundwater quality.

Conclusions

P-overfertilization must be prevented. A large portion of the worldwide P-application could be avoided if food losses and meat production requiring half of arable soil area would be minimized. Especially P-fertilizers produced from sedimentary deposits should be cleaned. Limiting values of <50 mg/kg P_2O_5 for both Cd or U should be established. Recycling of phosphate from waste water should be reinforced to ensure the future P-supply.

Literature

[1] Taylor et al. (2016): Trace element contaminants and radioactivity from phosphate fertilizer. In Schnug & De Kok (eds.): Phosphorus in Agriculture: 10 % Zero. P. 231-266. [2] Munier (2016): Schwermetallbelastungen in Phosphatdüngemitteln. Bachelor-Thesis, 69 pp. [3] Knappe et al. (2008): Vergleichende Auswertung von Stoffeinträgen in Böden über verschiedene Eintragspfade. UBA Texte **36**, 410 pp. [4] Dienemann & Utermann (2012): Uran in Boden und Wasser. UBA Texte **37**, 30 pp.