Uranium, a new villain among the dirty dozen in soil protection

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INTRODUCTION

Agriculture is a main contributor to environmental loads of nearly all elements of the periodic system, for instance by applying waste-based fertilizer materials such as sewage sludge, and mineral fertilizers. Particularly mineral P fertilizers contain significant amounts of elements which affect the quality of the environment and food plants.

The Institute for Crop and Soil Science of the Julius Kühn-Institute (JKI) estimates annual average loads of some trace elements such as As, Cu, Pb and Zn to agricultural land in Germany exclusively through the application of P- fertilizers for the time span from 1950/51 to 2016/17 (Table 2). U is not only radioactive but also toxic. The chemical toxicity of U is estimated to be substantially higher than the radiological hazard. The chemical toxicity of U ranges between that of Hg and Ni, and it is enhanced synergistically by Cd.

MAIN RESULTS

Soil and drinking water resources pollution with U derived from mineral P-fertilizer

According to the amount of P_2O_5 consumption data provided by FAO, about 707 tons U per year are added to agricultural soils in European countries through the application of mineral P-fertilizers (Figure 1).

The mean transfer factor for U in soils to crop plants is 0.05 and thus comparable to that of As, Co, Hg and Pb. The by far greatest contribution to the daily intake of U by humans has U in drinking water. Fertilizer-derived U is a primary a risk for the quality of groundwater and drinking water (Table 1).

At an annual application rate of 9 $g \cdot ha^{-1}$ U applied with 22 $kg \cdot ha^{-1}$ P a steady state concentration of 22 $\mu g \cdot L^{-1}$ U is expected in the percolating water.

Uranium – the hidden treasure in rock phosphates

The U in rock phosphates has a high commercial value in context of increasing electricity demand. As in Table 1 shown, 167 t U were spend with mineral P-fertilizers on an average in Germany alone every year. 167 t U contain enough energy to supply 2,350,000 average sized German households and equals the energy of firewood harvested from 5,600,000 ha forest. From 10 g U (corresponding to a P-fertilization of 22 $kg \cdot ha^{-1}$ P according to GAP) 500 kW of energy can be produced. Compared to the same amount of energy derived from coal this saves a total of 500 kg CO_2.

CONCLUSION

Proposed action to protect soils and water bodies from fertilizer-derived uranium

Retrieval of U from mineral P- fertilizers protects not only soils and waters from this toxic element, but is also an unconventional contribution of agriculture to climate protection. In recent years new processes for the extraction of U from rock phosphate or phosphoric acid have also been improved .

Because of increasing demand and decreasing supply stock market prices for U can be expected to be increasing. This implies that investments in technology for the extraction of U from rock phosphates will not yield higher fertilizer prices.

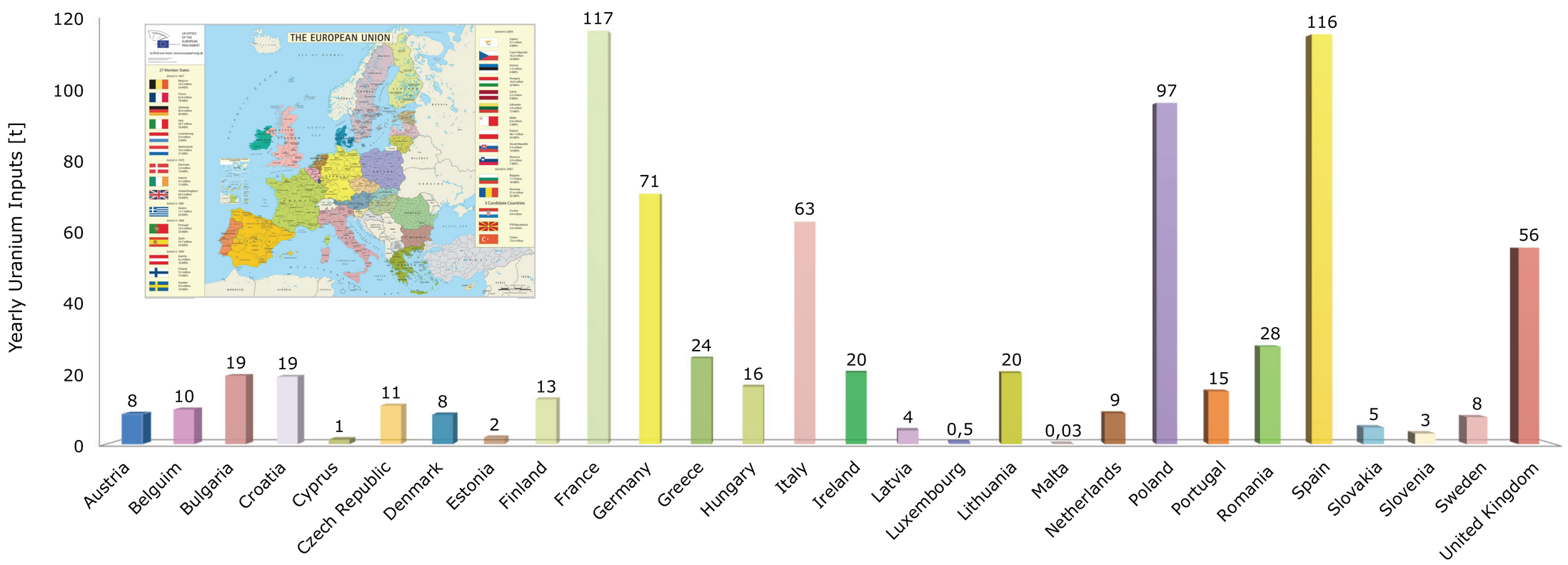

Figure 1: Estimated annual U input to agricultural soils with mineral P fertilizers in the European Union (based on FAO data 2002-2013)

Location	Well Type	U [$\mu g \cdot L^{-1}$]	NO_3 [$mg \cdot L^{-1}$]
Straubing	Shallow	2.8	40
	Deep	<0.2	2.8
Rehlingen	Shallow	10	22
	Deep	1.6	8.2

Table 1: Evidence for fertilizer-derived U in groundwater - U and nitrate concentrations in neighboring shallow (7–9m) and deep (70–90 m) wells of two waterworks in southern Germany (data from 2008).

Element	As	B	Cu	Ni	Mo	Pb	U	Zn
[$t \cdot a^{-1}$]	38	1575	170	71	50	14	**167**	604

Table 2: Annual average loads of the Elements from 1950/51 to 2016/17

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