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The application of sewage sludge onto agricultural lands is an economic and efficient way to restore the organic matter of soils and to fertilize them. Nevertheless, sewage sludge hasn't only beneficial contribution to the "cropped-soil ecosystem", because it contains numerous chemicals able to disturb its equilibrium.

Among these compounds appear the plant protection products, including glyphosate, diuron and nonylphenol, also known as endocrine disrupters. These compounds have been recently detected in sewage sludge applied onto soils. The impact of their application to soil through sludge is not studied yet and may present serious problems in terms of risks for environmental and human health.

Objective
Our aim is to study the fate and the impact in the soil of plant protection products (glyphosate, diuron and nonylphenol) applied through contaminated sewage sludge, in laboratory experiments.

Fate of pesticides applied to soil via sludge: Influence of the sludge amount

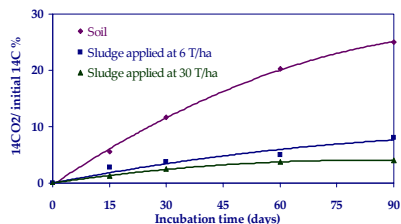
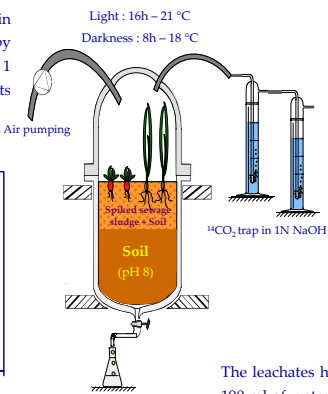
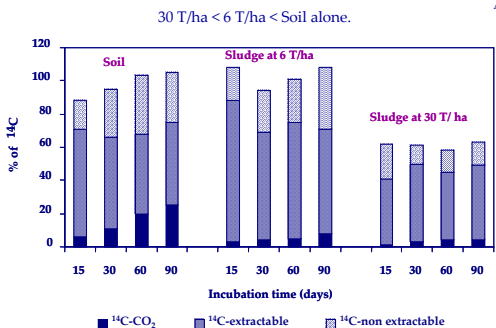
Two amounts of pelleted-dehydrated sewage sludge (6 T and 30 T d.m./ha) were spiked with ¹⁴C-compounds at the ppm level, applied to a silt-loam in microcosms and incubated for three months. During this period, we followed chemical mineralization, mobility, leachability, stabilization and uptake by higher plants. We compared these data to those obtained in the case of direct application of the chemicals onto the soil.

Ecotoxicological impact of sludge application: Influence of their rate and pesticides contents

Similar experiments were performed in bigger microcosms, but with non-labeled compounds. During the three months of incubation, we assessed the impact of sludge application on several endpoints: seed germination and plant biomass production, microorganisms growth and activity, and springtail reproduction.

Fate of pesticides applied to soil by sewage sludge

The fate of pesticides supplied to the soil via the sludge was tested in microcosm represented herein. We sowed 2 radish and 2 wheat seeds in each microcosm 15 days after sludge application. The ¹⁴C uptake by plants (< 0.01% in radish after 15 days and < 0.02% in wheat after 1 month) is negligible. The amount of chemicals transferred in both plants decreases when they are applied via sludge as follows:



The mineralization of ¹⁴C-compounds decreases when they are applied by sludge. When the sludge amount increases, the degradation of chemicals decreases, suggesting either a competition between the organic matter and the organic contaminants present in sludge, or a decreased bioavailability of the chemicals.

The leachates have been collected after 45, 60 and 90 days of incubation. 190 ml of water (20 mm rain) were applied onto the microcosms. ¹⁴C was detected in the leachates at trace levels, thus proving that pesticides can migrate through the soil and contaminate underground waters. The contamination level of percolates was as follows:

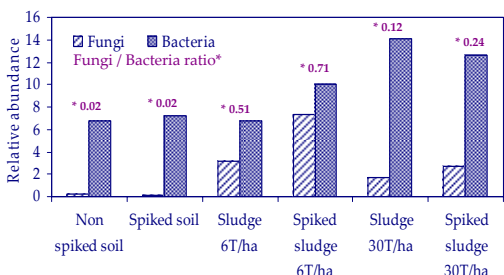
	Soil	Sludge at 6 T/ha	Sludge at 30 T/ha
45 d	0.01 %	0.01 %	0.01 %
60 d	0.03 %	0.03 %	0.02 %
90 d	0.02 %	0.02 %	0.02 %

The solvent-extractable radioactivity decreases when the organic compounds are supplied by sludge to the soil, according to a relationship with sludge amount: 30 T/ha < 6 T/ha < Soil. No transformation products of pesticides have been isolated during HPLC analysis of the extracts. The low recovery of ¹⁴C noticed in microcosm with the highest sludge amount could be due to a low efficiency of the residual ¹⁴C quantification in the soil, because of the high organic matter content.

Impact of the application of sewage sludge contaminated with pesticides

The impact of the application of sewage sludge, previously contaminated with pesticides, was investigated by considering endpoints related to several trophic levels of the soil ecosystem, in big microcosms filled with 40 kg of soil. Litterbags were installed at middle height of the sludge-soil mixture (20 kg) and kept during the 3 months of incubation. Fifteen days after sludge application, 10 wheat and 10 radish seeds were sowed. The radishes were collected after 1 month and wheat after 2 months of growth.

	Spiked Soil	Sludge 6 T/ha	Spiked Sludge 6 T/ha	Sludge 30 T/ha	Spiked Sludge 30 T/ha
Litter-bag decomposition %	39.7	59.5	63.5	48.3	40.2
Germination rate (n=10) %					
Radish (1 month)	70	80	60	0	10
Wheat (2 months)	70	100	70	0	30
Plant growth (cm)					
Radish Root	4.1 ± 1.7	4.5 ± 1.3	4.6 ± 2.1	-	4.1
Radish Stem	12.2 ± 3.3	16.6 ± 3.4	14.5 ± 3.3	-	10.6
Wheat Root	11.7 ± 2.3	8.8 ± 1.2	12.1 ± 2.5	-	7.0 ± 0.9
Wheat Stem	39.2 ± 3.1	39.4 ± 5.3	41.6 ± 8.8	-	26.1 ± 10.8
Reproduction (<i>Folsomia fimetaria</i>)					
Stimulating effect vs spiked soil %	-	88	-	90	-



The application of sewage sludge at low amounts on soil improves its activity. At high rate, the toxicity effect of sludge counterbalances its nutritive one. This has been proved by both the litterbag decomposition which increases by the low application of sludge, and the PLFA test which shows that a low rate of sludge improves the microorganisms activities of the soil, in particular, the fungi ones. The application of sludge at high rate has negative effect on the germination of the plants. On the other hand, it stimulates the reproduction of *Folsomia fimetaria*. The specific effect of pesticides supplied to soil by sludge doesn't seem to be important.

Pesticides are more persistent in soil when they are applied through sludge

- Pesticide transformation decreases when they are applied through sludge, and their stabilization in the soil increases
- Transfer of chemicals from the soil to higher plants and waters is very low
- We will study the influence of other types of sludge on pesticides persistence in soils

The application of pesticides via sludge modifies the soil activity

- An overall stimulating effect has been noticed on several endpoints at the lowest amount of sludge
- Due to fungal proliferation, the highest sludge amount decreases plant and springtail development
- It was not possible to evidence specific toxic effect of plant protection products
- The impact of pesticides contained in other types of sludge will be also assessed.