The Fate of PCDD/F in Sewage Sludge Applied to an Agricultural Soil

Schwarz, K., McLachlan, M.S.
Chair of Ecological Chemistry and Geochemistry, University of Bayreuth, 95440 Bayreuth, Germany

Abstract

The fate of PCDD/F in sewage sludge following agricultural application was investigated. Two sludge concentrations were employed. In one case a typical municipal sewage sludge was applied. In the second case the same sludge was spiked to increase the Cl_8DD concentration by a factor of 1000. The sludges were applied to a soil and exposed to environmental conditions for 6 weeks in late summer. No significant changes in the PCDD/F concentrations over time were observed. This indicates that neither photodegradation nor volatilization are important loss mechanisms for PCDD/F following the agricultural application of sewage sludge.

Introduction

The environmental fate of polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) in sewage sludge and on soil surfaces has been the subject of several studies. McLachlan and Reissinger[1] found deviations between the PCDD/F homologue patterns in sewage sludge and in soil that had been treated with sewage sludge and suggested that this might be attributable to photodegradation and/or volatilization of the PCDD/F in the applied sludge. Tysklind and Rappe[2] reported photolytic transformation of PCDD/F sorbed to fly ash. A photolytic dechlorination of Cl_8DD on soils was reported by Miller et al.[3] and Kieatiwong et al.[4] Tysklind et al.[5] observed photodechlorination of PCDD/F on soil samples and suggested that photochemical degradation of Cl_8DD in sewage sludge should be further investigated.

In this work the fate of PCDD/F in sewage sludge was studied in an experiment designed to simulate the application of sewage sludge to a plowed field.

TRANS

Experimental

Soil and sewage sludge. An agricultural soil containing 2% organic matter, 67% sand, 12% silt and 21% clay was employed in this experiment. The sewage sludge was from the wastewater treatment plant in Bayreuth. One portion of the sewage sludge was spiked with Cl_8DD to increase the concentration by a factor of 1000.

Pretreatment of the samples. The soil of the experimental plot was sieved to a depth of 10cm with a 2mm sieve. For each sample 300g (dry weight) of this soil was put into a 16x16 cm basket of aluminum mesh. 150g (10g dry weight) of sewage sludge was applied to the soil. This application rate reflects the German sewage sludge regulation which permits the application of 5 tonnes of dry sludge per hectare once in 3 years. Half of the baskets were treated with spiked and half with unspiked sludge. The baskets were imbedded in the soil surface to minimize disturbance of the soil parameters (moisture, temperature, density, texture).

Sample exposure. Three different exposure scenarios were employed. One set of samples was placed under a sheet of glass that transmitted no UV-B light (transmission <0.001%). The second set of samples was placed under a sheet of glass that transmitted UV-B light (25% at 300 nm, 50% at 320 nm, 70% at 340 nm). The third set of samples was not covered by glass but was equipped with a sliding roof which closed over the samples during precipitation events.

The experiment began on September 7, 1992 and ended on October 20, 1992. During this period the maximum midday radiation over the 295-385 nm wavelength band varied between 3 and 12 W/m^2. Samples were collected from each sludge and exposure variant on days 4, 8, 14, 29 and 43 after beginning exposure. The samples were packed in aluminum and frozen.

Analysis. The samples were freeze dried, spiked with 12 ^{13}C-labeled PCDD/F and Soxhlet extracted for 16 hours in toluene. The extracts were cleaned up using a modified version of the method in the German sewage sludge regulation. The HRGC/HRMS analysis was performed on a VG-Autospec Ultima at a resolution of 10,000.

Results and Discussion

No significant changes in the PCDD/F concentrations were observed for any of the exposure scenarios. The Cl_8DD and Cl_7DD concentrations of the unsheltered spiked samples are plotted in Figure 1. Although the Cl_8DD concentrations were a factor of 500 higher, no increase in the Cl_7DD level was observed. It was concluded that a measurable photodechlorination of Cl_8DD did not occur.

Although the UV-B radiation may under some environmental conditions be higher than in this experiment, the exposure period was much longer than usual. In Germany sewage sludge is commonly plowed under one to three days after application. The absence of any change in the PCDD/F concentrations in sewage sludge following 43 days of exposure leads to the conclusion that neither photodegradation nor volatilization are important mechanisms in the fate of PCDD/F in sewage sludge following agricultural application.

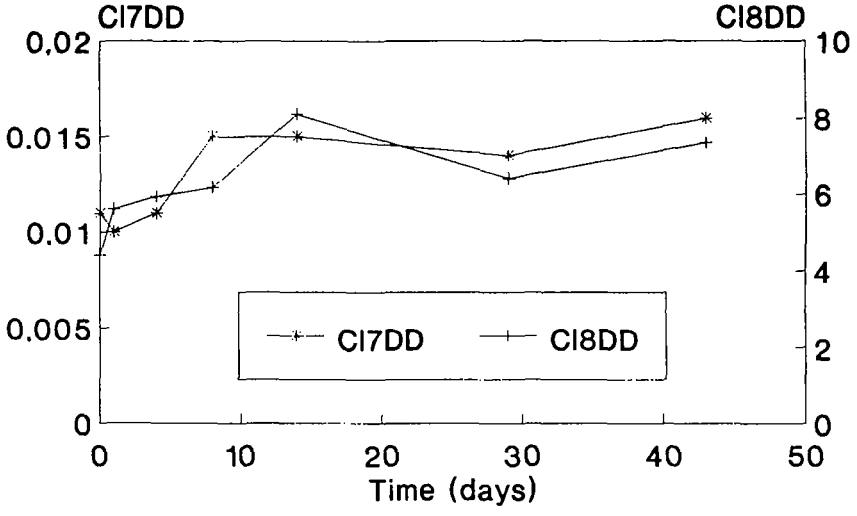

Figure 1

Concentrations of Cl_8DD and Cl_7DD in mg/kg DW normalized to the amount of sludge applied in the unsheltered exposure variant with spiked sludge

References

1 McLachlan MS, Reissinger M. Der Einfluß der Klärschlammdüngung auf die Konzentrationen organischer Schadstoffe in Böden. *VDI Berichte* 1990;837:475-488.
2 Tysklind M, Rappe C. Photolytic transformation of polychlorinated dioxins and dibenzofurans in fly ash. *Chemosphere* 1991;23:1365-1375.
3 Miller GC, Herbert VR, Miille MJ, Mitzel R, Zepp RG. Photolysis of octachlorodibenzo-p-dioxin on soils: production of 2,3,7,8-TCDD. *Chemosphere* 1989;18:1265-1274.
4 Kieatiwong S, Nguyen LV, Herbert VR, Hackett M, Miller GC. Photolysis of dioxins in organic solvents and on soils. *Environ. Sci. Technol.* 1990;24:1575-1580.
5 Tysklind M, Carey AE, Rappe C, Miller GC. Photolysis of OCDF and OCDD on soil. *Organohalogen Compounds* 1992;8:293-296.