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Mineralization of Glyphosate in Compost-Amended Soil Under Controlled Conditions

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Glyphosate [N-(phosphonomethyl)glycine] is one of the world's most widely used herbicide. The herbicide is strongly bound to soil particles, and generally regarded as having low potential to contaminate groundwater. However, there is evidence of desorption of glyphosate from soil particles, which would result in glyphosate moving through soil and ground water (IPCS 1994; Piccolo et al. 1994; US EPA 1993). Furthermore, the herbicide is highly soluble in water (11600mg/L) at 25°C and is resistant to hydrolysis in water (Agriculture Canada 1991). Adsorption of glyphosate by clay minerals has been shown to be reduced by the presence of copper, due to the formation of glyphosate –copper complexes. Both soil type and any element in soil capable of forming complexes with glyphosate have been shown to affect the adsorption of glyphosate (Morillo et al. 1997). A study of sandy soils in Western Australia found that adsorption of glyphosate and its metabolite, aminomethyl phosphonic acid (AMPA) increased strongly with iron and aluminium content of the soils, while soil organic matter competed for adsorption sites and inhibited adsorption (Gerritse et al. 1996). Recent studies on four soils, chosen to represent the most widespread soil types in the European Union showed that soils containing higher levels of clay minerals adsorbed more glyphosate and that, the herbicide was extensively mobile in soils which could not bind with glyphosate (Piccolo and Celano 1994).

Whether glyphosate can move through the soil and contaminate both surface and ground water depends entirely on the soil conditions prevailing. Ways of enhancing the biodegradation of glyphosate in soils where it is highly adsorbed should be looked into. The present study was carried out to determine if compost made from organic solid waste could enhance the mineralization of glyphosate and hence, reduce the potential for the glyphosate contaminating surface and ground water in soils with high adsorption capacity.

MATERIALS AND METHODS

Glyphosate-phosphonomethyl-^{14}C-labeled (International Isotopes, Munich) with specific activity of 52mCi/mmol, and radiochemical purity of 99% was determined by TLC (silica gel) using butanol:water:acetic acid (60:25:15) solvent system. The commercially formulated glyphosate of isopropylamine ammonium

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salt (Roundup) with purity of >97% as determined by TLC was purchased from Monsanto Center Africa Inc. The two herbicides were used together in laboratory experiments. Quicksafe A, 2,5-diphenyloxazole (PPO) and 1,4-bis [5-phenyl-2-oxazolyl]-benzene; 2,2'p-Phenylene-bis[5-phenyloxazole] (POPOP) in toluene and Harvey Carbon-14 Cocktail (Zinsser Analytic (UK) Ltd) were used in Liquid Scintillation Counting. All solvents used were re-distilled in all-glass apparatus. The clay soil (organic content (OC) 2.07%, pH 6.08, clay content 60%, sand content 28%, silt 12%, N 0.19%, P 80ppm, Na 0.95%, K 1.85%, Ca 10.5%, Mg 4.95%, Mn 0.51%, Fe 226.96ppm, electrical conductivity (EC) of 0.62μS/cm) and compost (N 1.14%, P 0.72ppm, Cu 140ppm, Mn 2217ppm, Fe 1272ppm and Zn 755ppm) were used. Liquid Scintillation Counter (Tricarb-1000) and Biological Materials Oxidizer (OX-600 model) were used for radio-assaying.

In the incubation experiment, 50g of sieved soil samples in replicas of three were placed in biometer flasks (Bell Co. Glass Inc.) after the air-dried and homogenized soil was sieved though a 2-mm sieve. The soil was conditioned by being moistened to 75% of the field water capacity. The soil samples in biometer flasks were given different treatments before they were incubated at 30°C in the darkness under aerobic conditions. The first set of the soil samples was autoclaved at 121°C for 45 minutes at the pressure of 1.2 bars for three consecutive days. The second set of the soil samples was neither autoclaved nor received compost made from urban solid organic waste. The third set of the soil samples was spiked with compost at concentrations of 1000μg/g, 2500μg/g and 5000μg/g (compost/soil). Glyphosate solution (both labeled and non-labeled) in distilled water was added to the 50g-soil sample in each biometer flask giving an initial herbicide concentration of 100μg/g and initial radioactivity of 2μCi in soil. The soil was thoroughly mixed to ensure uniform distribution of the herbicide in soil. The side arm of each biometer flask was filled with 10ml of 0.1N NaOH to trap the $^{14}CO_2$ gas released during mineralization by soil microorganisms. The inlet of each biometer flask was filled with Ascarite to exclude carbon dioxide from entering the system. The biometer flasks were placed in an incubator to monitor the progress of mineralization. At different time intervals, the 10ml of NaOH solution from the side arm was sampled from which one ml of the solution aliquot was taken and mixed with 5ml of Quicksafe A cocktail in a 20-ml scintillation vial before it was radio-assayed. After every sampling, the side arm was refilled with fresh 0.1N NaOH solution. The experiment was run for 50 days, when maximum rate of $^{14}CO_2$ production was attained. The amount of accumulated $^{14}CO_2$ over the 50-day period was computed from the amount of $^{14}CO_2$ obtained in each sampling.

At the end of the incubation period, soil samples from the biometer flasks were removed and air-dried. A sub-sample of 20g was taken and extracted with 100ml of 0.2M KOH solution by shaking on an orbital shaker for four hours. An aliquot of 1ml of the 0.2M KOH extract was taken and mixed with 5ml of Quick safe A cocktail and radioassayed to quantify extractable residue. The readings from the Liquid Scintillation Counter were corrected by external standardization. The extracted soil samples were air-dried and 1.5g of the soil sample was combusted in a Biological Materials Oxidizer (Packard, USA). The $^{14}CO_2$ released during