Bull. Environ. Contam. Toxicol. (1985) 35:564-568

Bulletin of Environmental Contamination and Toxicology

Fate of 2,4-D Entering a Freshwater Aquatic Environment

Ronald D. DeLaune and L. Miguel Salinas

Laboratory for Wetland Soils and Sediments, Center for Wetland Resources,
Louisiana State University, Baton Rouge, LA 70803-7511

The presence of synthetic organic chemicals in Louisiana's and other Gulf Coast's aquatic environment is not new. A number of toxic organics are entering aquatic environments of Louisiana and other southern states. Some are entering directly via aquatic weed control programs. Many of these compounds are toxic to aquatic life and potentially harmful to humans. Chronic, low level movement of these toxic compounds into Louisiana's streams and lakes as a result of agricultural and urban runoff and industrial discharge is a well known occurrence.

Presently large quantities of 2,4-D (2,4-dichlorophenoxyacetic acid) are being used for water hyacinth control in Louisiana. It has been determined that 2,4-D is amenable to biological degradation (Loos 1969; Ou et al. 1978; Smith 1979; Smith and Muir 1980). At present, there is insufficient scientifically based information available to determine the fate of 2,4-D which is entering the aquatic environment, as a result of its intensive use as an aquatic herbicide. Little is known on the relative degradation of 2,4-D under anaerobic as compared to aerobic conditions, when found in aquatic systems.

MATERIALS AND METHODS

A bulk sample of sediment was collected from two Louisiana shallow freshwater lakes (Lake Palourde and Lake Verret) using a Peterson dredge. Wet sediment was transferred to a 3-l., 3-neck, flat bottom flask. Sufficient surface water was added to each flask to produce a water-to-sediment ratio of 8:1. The sediment-water system was kept in suspension by continuous stirring with a magnetic stirrer. The sediment suspensions were equilibrated at 30±1°C at a controlled redox potential using a system developed by Patrick et al. (1973) with some modification. The redox potential was monitored by a platinum electrode-calomel half cell and a millivolt meter. When the desired redox potential set on the meter relay was reached the air supply was activated to pump air into the sediment suspension to prevent the redox potential from falling below the set value. Two redox potentials, one strongly reducing (-200 mV) and the other oxidizing (+500 mV), were used. Sediment maintained at -200 mV had a pH of 7. A 21-day

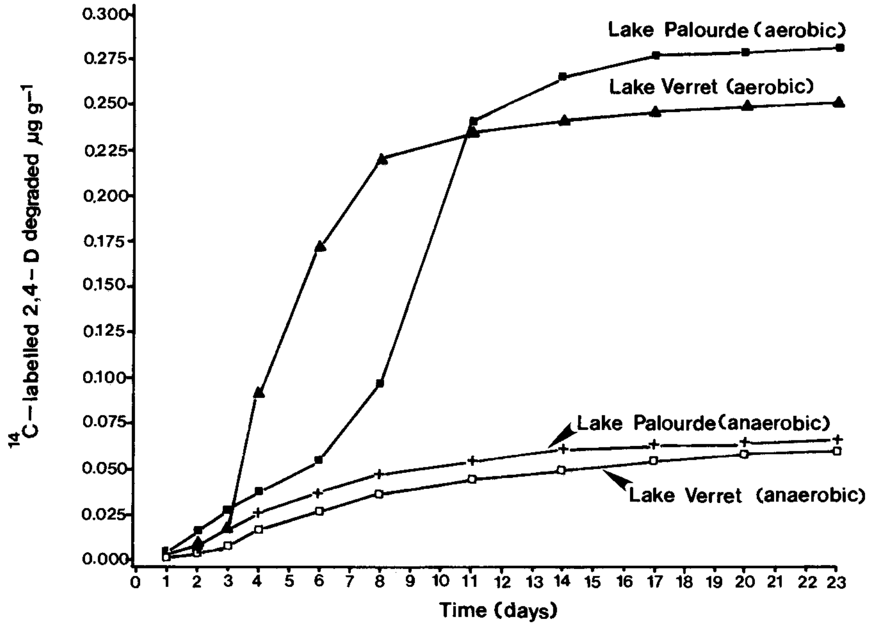

Figure 1. Degradation of 2,4-D under aerobic and anaerobic conditions in bottom sediment from Lake Verret and Lake Palourde.

preincubation period was used to allow time for equilibration of the microbial population and metabolic processes. 2,4-D at a concentration of 5 μg g^{-1} (1000 μg total) containing 1 μ Ci of side chain labelled 2,4-dichlorophenoxy[2-^{14}C]acetic acid per flask was added at the end of the preincubation. A duplicate series was set up with surface water containing no sediment for determining degradation in the water column. In addition, a series of sediment water columns were set up in which 2,4-D was added to the surface water at a rate of 5 μg ml^{-1}. The surface water was sampled periodically for determining the rate at which 2,4-D was adsorbed from the overlying water into the sediment.

RESULTS AND DISCUSSION

Pronounced differences in degradation rates of added labelled 2,4-D as affected by sediment redox potential were observed. Degradation of 2,4-D was approximately six times faster under aerobic conditions (+500 mv) as compared to anaerobic conditions (-200 mv) for sediment from each lake (Figure 1). The degradation rate in sediment under aerobic conditions was approximately .012 μg 2,4-D g^{-1} d^{-1} as compared to .002 μg 2,4-D g^{-1} d^{-1} under reducing conditions for each lake sediment. Degradation in the

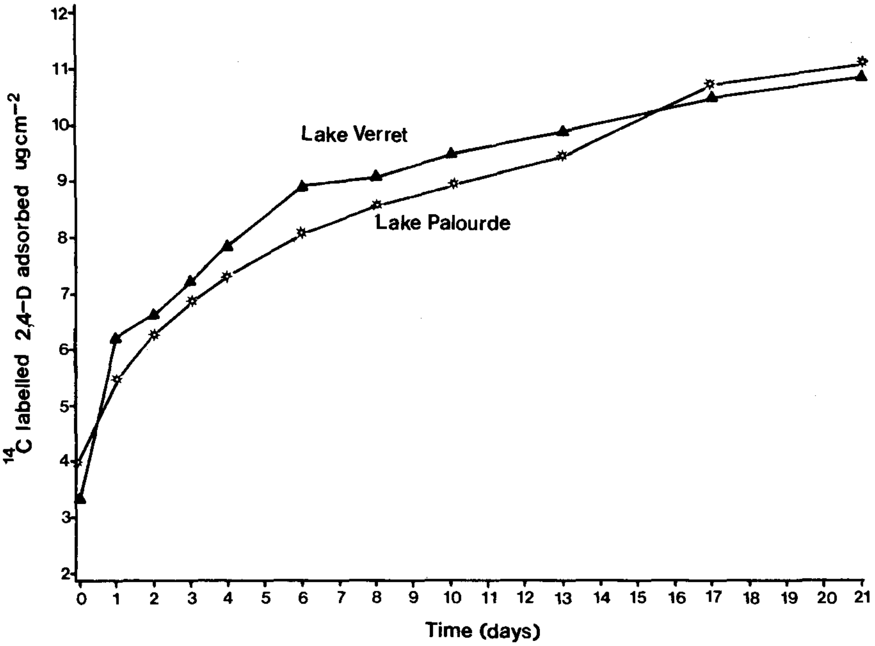

Figure 2. Amount of 2,4-D adsorbed from water column into bottom sediment.

water was several orders of magnitude slower as compared to degradation rates in the sediment with only approximately .005 ng 2,4-D ml^{-1} per day being degraded (Figure 2). This is consistent with the findings of Rubin et al. (1982) and Wang et al. (1984), who postulate that 2,4-D decomposition is dependent on type of lakewater and season of sampling.

Bottom sediment has a marked strong affinity for 2,4-D. Added labeled 2,4-D was rapidly adsorbed from the water column into the sediment (Figure 3). The adsorbtion rate was equivalent to approximately 1.78 µg cm^{-2} day^{-1}.

The data present suggest that the herbicide 2,4-D in Louisiana's aquatic environment will be microbiologically degraded at slower rates under anaerobic conditions. This leads to the conclusion that 2,4-D may be somewhat slower to degrade in anaerobic bottom sediment than that reported for aerobic upland soils. Under normal upland conditions and regular application rates (<100 µg/g), the degradation of 2,4-D is quite rapid. Degradation rates have been found to vary from having a half life of 4-11 days (Smith 1979; Smith and Muir 1980) to greater than 80% being degraded in five weeks (Wilson and Cheng 1978). The results

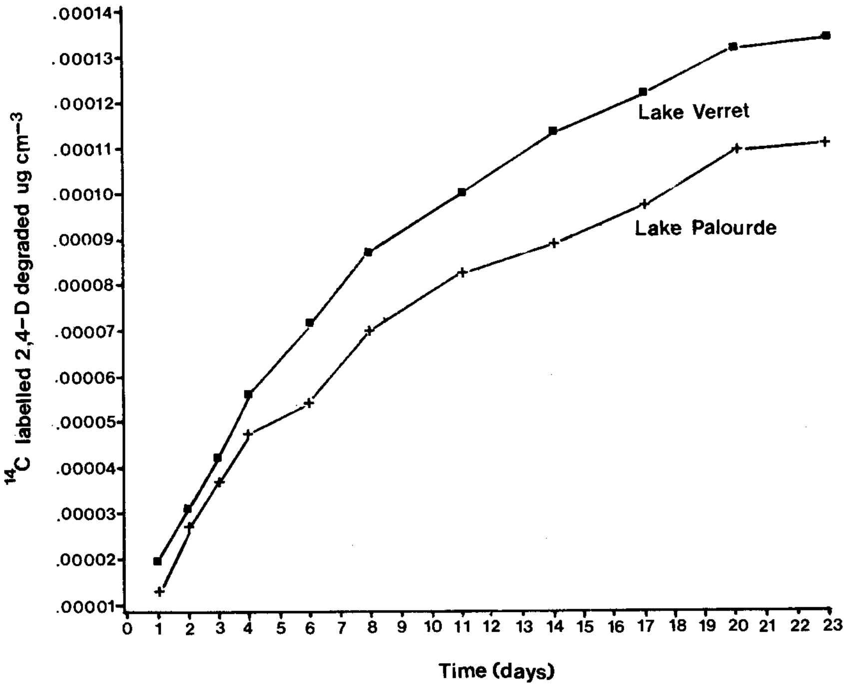

Figure 3. Degradation of 2,4-D in Surface Water from Lake Verret and Lake Palourde.

presented also show that 2,4-D entering Louisiana's aquatic environment will be rapidly adsorbed from the water column into the bottom sediment where maximum degradation is likely to occur. Little 2,4-D degradation will occur in the water column whereas maximum degradation will likely occur in the oxidized surface layer found on bottom sediment. The 2,4-D that diffuses deeper into the sediment profile, where anaerobic conditions occur, will be slower to degrade.

Acknowledgments. This work is a result of research sponsored by the Louisiana Sea Grant Program, part of the National Sea Grant Program maintained by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce and National Science Foundation.

REFERENCES

Loos MA (1980) Phenoxyaltonic acids. Ch. 1. In: Kearney PC and Kaufman DD (eds) Degradation of herbicides. Marcel Dekker, Inc., New York

Ou Li-Tse, Rothwell D, Wheeler WB, Davidson JM (1978) The effect of high 2,4-D concentrations on degradation and carbon dioxide evolution in soils. J Environ Qual 7:241

Patrick WH Jr, Williams BG, Moraghan JT (1973) A simple system for controlling redox potential and pH in soil suspensions. Soil Sci Soc Amer Proc 37:331

Rubin HE, Subba-Rao RV, Alexander M (1982) Rates of mineralization of trace concentrations of aromatic compounds in lake water and sewage samples. Appl Environ Microbiol 43:1133

Smith AE (1979) Soil persistence experiments with [^{14}C] 2,4-D in herbicidal mixtures and field persistence studies with triallate and trifluralin both singly and combined. Weed Res 19:171

Smith AE, Muir DCG (1980) Determination of extractable and non-extractable radioactivity from Prarie soils treated with carboxyl- and ring-labelled [^{14}C] 2,4-D. Weed Res 20:123

Wang YS, Subba-Rao RV, Alexander M (1984) Effect of substrate concentration and organic and inorganic compounds on the occurrence and rate of mineralization and cometabolism. Appl Environ Microbiol 47:1195

Wilson RG Jr, Cheng HH (1978) Fate of 2,4-D in a Naff silt loam soil. J Environ Qual 7:281

Received October 26, 1984; accepted January 31, 1985.