# Translocation of Polychlorinated Biphenyls into Tomatoes from Contaminated Soil

WILLIAM SWANSON and WILLIAM BERANEK, JR.
Holcomb Research Institute, Butler University, Indianapolis, Indiana 46208
and
SIDNEY BOURNE, Argonne National Laboratory, Argonne, Illinois 60439

## Introduction

In the ten years since the potential human health hazard of polychlorinated byphenyls (PCBs) was brought to public attention, the movement of PCBs through food webs has been studied extensively. In 1968 at least 1, 291 Japanese were poisoned by rice oil contaminated with PCBs, twenty-two died (1). In 1966 PCBs were first measured in fish in Swedish waters (5). Since that time PCBs have been found in almost all waters tested. In some systems, especially the Great Lakes, many species of fish are unfit for human consumption due to the high concentrations of PCBs.

Although much research has been accomplished on measurement of PCBs in various components of ecosystems and on toxicology of PCBs in animal studies, there has been little published on PCBs translocated into crops grown for direct human consumption. Interest in this question heightened recently in central Indiana as organic farmers and backyard gardeners who used PCB contaminated sludge as a humus conditioner for their soils become concerned over the possibility of PCB accumulation into their crops.

Suzuki (10) has studied the translocation of PCBs into soy beans under greenhouse conditions and Iwata (4) into carrots under field conditions. Moza (7,8) has studied the metabolism of specific PCB isomers in a salt marsh grass (*Veronica beccabunga*) and in plant-water-soil systems. Sinclair (9) has shown the reduction of photosynthesis in the green algae *Chlorella* and Keil (6) has demonstrated the reduction of nucleic acid synthesis in marine diatoms.

PCBs are lipid soluble and have been shown to biomagnify through aquatic food webs (2). PCBs are stable to chemical and biological degradation and are estimated to have a half-life of over 30 years in the environment (3). Special incinerators at temperatures above 2,000° F are required to destroy PCBs. This extraordinary stability lead to the primary use of PCBs as an insulator in capacitors and transformers used throughout the electronics industry.

U.S. production of PCBs from its beginning in 1929 until it stopped in 1977 was 1,250 million pounds. Of this total only 55 million pounds have been incinerated. There are 440 million pounds distributed throughout the environment in the air, water and soil. There are still 750 million pounds in service that have the potential of entering the environment.

This investigation was designed to measure whether or not PCBs would accumulate in the fruit of the tomato when the plant was grown in PCB contaminated soil. The plants were grown from seed in the Butler University

greenhouse between February and June 1978. The extractions and gas chromatagraphic measurements were done at Argonne National Laboratory.

## Methods

The control soil composition consisted of two parts potting soil to one part peat moss to one part sand. The contaminated soil composition consisted of three parts control soil to one part PCB contaminated sewage sludge taken from the Bloomington, Indiana sewage treatment facility.

The plants were staked and tied to keep them off the soil and spaced so as not to touch each other. As the fruit ripened it was harvested and placed into a Ball mason jar with an aluminum foil cap and frozen until extracted.

Single samples of the fruit, leaves, stems, roots and control soil were contaminated with a known quantity of Aroclor 1254 to determine the extraction efficiencies, all of which exceeded 97%.

The extraction of the soils and sludge was accomplished by placing a sample in an empty glass column (19 mm ID by 60 cm) with a glass wool plug and eluted with 20 volumes of 1:1 hexane/acetone. The extract was concentrated in a Kuderna-Danish concentrator.

The extraction of the plant samples was begun by homogenizing in 3:1 acetonitrile/water. The homogenate was then filtered and rinsed with hexane. The filtrate and rinses were diluted with three parts aqueous 1% sodium chloride solution and extracted with three portions hexane in a separatory funnel. The extract was concentrated in a Kuderna-Danish concentrator.

The plant, soil and sludge concentrates were then chromatographed on Florisil using 1% diethyl ether in hexane as the eluting solvent. After concentration, the elutant was analyzed for PCBs on a Perkin-Elmer model 3920-B gas chromatograph with an electron capture detector using a 6 foot by 2 mm ID glass column packed with 1.5% SP2250 and 1.95% SP2401 on 100/120 mesh Supelcoport.

The plants grown in the control soil (controls) were handled exactly the same way as the plants grown in the PCB contaminated soil (contaminated). A laboratory blank was a clean and empty glass beaker that followed the exact procedures as the control and contaminated samples.

## Results and Discussion

The control plants were used to measure background PCB contamination in the greenhouse and the laboratory blank was used to measure PCB contamination from the analytical laboratory. The controls had a low PCB concentration as background ranging between two and 50 parts per billion, the blank had no detectable PCB concentration. The efficiency of the extraction techniques exceeded 97%. The reporting limits of the experimental samples are based on the concentrations of Aroclors extracted from the controls and the blank (refer to Table I).

The fruit, leaves, stems, roots and control soil all had concentrations of Aroclors below 0.05 parts per million (ppm). These levels are below the

reporting limits established by this study. Above these limits there appears to be no translocation of PCBs occurring into the fruit of the tomato.

TABLE I *Concentrations of PCBs in parts per million in tomato samples*

| SAMPLE | AROCLOR 1254 | 1248 | 1242 |
|---|---|---|---|
| FRUIT | <0.01 | <0.01 | <0.01 |
| LEAVES | <0.01 | <0.01 | <0.1 |
| STEMS | <0.01 | <0.005 | <0.005 |
| ROOTS | <0.05 | <0.05 | <0.05 |
| SLUDGE | <5 | <10 | 370 (±150) |
| CONTAMINATED SOIL | <10 | <10 | 170 (± 20) |
| CONTROL SOIL | 0.2 | <0.02 | <0.02 |

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## Literature Cited

1. AYER, F. A. (ed.). 1976. National conference on polychlorinated biphenyls (November 19-21, 1975 Chicago, Illinois). 471 p.
2. GREICHUS, Y. A. 1973. Insecticides, polychlorinated biphenyls and mercury in wild comorants, pelicans, their eggs, food and environment. Bulletin of Environmental Contamination and Toxicology. **9(6)**:321-328.
3. HUNTZINGER, O., S. SAFE and V. ZITKO. 1974. The chemistry of PCBs. The Chemical Rubber Company. Cleveland, Ohio. 269 p.
4. IWATA, Y. 1976. Translocation of polychlorinated biphenyl, Aroclor 1254, from the soil into carrots in the field conditions. Archives of Environmental Contamination and Toxicology. **4(1)**:44-59.
5. JENSEN, S. 1966. Report of a new chemical hazard. New Scientist. **32**: 612.
6. KEIL, J. 1971. Polychlorinated biphenyl (Aroclor 1242): effects of the uptake and growth, nucleic acids and chlorophyll of a marine diatom. Bulletin of Environmental Contamination and Toxicology. **6(2)**:156-159.
7. MOZA, P. 1976. Contributions to ecological chemistry CXV: metabolism of 2,5,4'-trichlorobiphenyl-$C^{14}$ and 2,4,6,2,4'-pentachlorobiphenyl-$C^{14}$ in a marsh plant *Veronica beccabunga*. Bulletin of Environmental Contamination and Toxicology. **16(4)**:454-463.
8. ——, I. WEISBERGER, W. KLEIN and F. KORTE. 1974. Metabolism of 2,2'-dichlorobiphenyl-$C^{14}$ in two plant-water-soil systems. Bulletin of Environmental Contamination and Toxicology. **12(5)**:541-546.
9. SINCLAIR, J., S. GARLAND, T. ARANSON, P. HOPE and M. GRANVILLE. 1977. Polychlorinated biphenyls and their effects on photosynthesis and respiration. Canadian Journal of Botany. **55**:2679-2684.
10. SUZUKI, M., N. AIZAWA, G. OKANO and T. TAKAHASHI. 1977. Translocation of polychlorobiphenyls in soil and plants: a study by a method of soy bean sprouts. Archives of Environmental Contamination and Toxicology. **5(3)**:343-352.