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Barrier Coatings to Prevent Polychlorinated Biphenyl (PCB) Contamination of Silage.

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Polychlorinated biphenyls or PCB's, also often called by their trade names Aroclors (Monsanto), have been recently in the news as "new" chemical contaminants found in livestock feed and subsequently in meat, eggs, poultry, fish and milk. The discovery of these compounds has caused considerable concern among those associated with animal agriculture and considerable financial loss to those who have been directly affected by this contaminant.

PCB's are a family of stable chlorinated hydrocarbons which upon analyses may appear quite similar to DDT. They, as all synthetic chlorinated hydrocarbons, are illegal contaminants of human food. PCB's are quite chemically inert and are not broken down by acids, alkalies, or corrosive chemicals. They have a high boiling point and do not readily burn - only vaporize. Thus PCB's have the necessary physical and chemical characteristics for persistance and accumulation up the food chain.

Polychlorinated biphenyls were first described in the scientific literature in 1881, and commercial production was successfully achieved in 1930. Between 1930 and 1969 the USDA listed 55 different industrial or agricultural applications of PCB compounds, many of which represented potential sources of environmental, food and feedstuff contamination. Some of the products that have contained PCB's include: electrical insulating fluids, tires, printers inks, flame retardant paints and fabrics, carbonless self-duplicating paper, some insecticides and concrete coatings. Interestingly enough, PCB's were only discovered as an environmental contaminant in 1966.

A large number of silos in Ohio and neighboring states have been coated to prevent leakage and erosion of the walls with a material that contained PCB's. The PCB found in greatest quantities in these coating materials is Aroclor 1254. This PCB material migrates from the silo coating into the silage, then is consumed by and accumulated in the livestock. Therefore, the PCB residues can ultimately be deposited in human food products produced by livestock fed the contaminated silage. If the concentration of this residue exceeds The Food and Drug Administration's "administrative guideline" the product can no longer be marketed.

The mechanism by which PCB's from Aroclor-containing coatings contaminate the silage, and in turn the livestock, was originally thought to be only mechanical by flaking off of contaminated chips. It is not uncommon for these chips to contain 5,000 to 10,000 parts per million (ppm) of Aroclor. However, recent work at the University of Kentucky has shown that the Aroclor in the coating materials is soluble in silage juices.

The replacement of contaminated silos with new ones would represent a considerable financial loss to the dairyman or cattleman. Therefore, studies are being conducted at the Ohio Agricultural Research and Development Center to determine how effective coating materials may be to prevent further PCB contamination of silage. The results of the first trial are presented in this report.

Two lines of investigation were used in this study. A silo which had been previously treated with an Aroclor 1254 containing coating was used as the major structure. The silo was divided with sheets of Masonite into test sections, the walls were wire brushed to remove loose material, and the surfaces were coated with materials (table 1) considered impervious to the PCB in the silo walls. Untreated and wire brushed test sections were left as controls. The silo was filled to the top of the experimental sections with chopped corn (32% DM). Four months later the spoilage was removed and silage samples were collected at three levels in the silo and at five distances from the silo wall. The samples were analyzed by gas-chromatography (with electron capture detector) for Aroclor 1254 in order to determine the effectiveness of the coating materials and to determine the vertical and horizontal distribution of any PCB contamination.

In other studies concrete silo blocks were painted with a coating that contained Aroclor 1254. Then the blocks were re-coated with the materials designed to prevent PCB migration. These blocks were sealed in 55 gallon barrels of chopped corn for four months. The silage was then sampled at three depths and at three distances from the blocks and analyzed for Aroclor 1254.

The results of the tests conducted in the silo are shown in figure 1. In these tests all of the coating materials reduced the amount of Aroclor 1254 that migrated into the silage when compared to the untreated control. However, only coatings I and VIII reduced the contamination level to below that of the wire brushed control surface. Statistical analyses to determine if the observed differences are significant have not yet been conducted. The reasons why coatings I and VIII provided the best barrier to the PCB are not yet thoroughly understood. It is suspected that the solvents used in the other coatings tested (II, V, IX) dissolved more Aroclor from the silo wall than did the isoprophyl alcohol and water used as solvents in coatings I and VIII respectively. When Aroclor becomes dissolved by the solvent of a new coating it can then become a component of the new surface.

In all test and control sections the majority of the contamination was detected in the silage within 30 cm (1 ft.) of the silo wall. Likewise, the concentration of Aroclor was highest at the base of the silo. For an unknown reason all samples collected one meter (about 3 ft.) from the base had low levels of Aroclor.

The levels of Aroclor 1254 in the silages from the block experiments were not as high as those observed in silage from the silo (figure 2). The major reason for this was that the Aroclor 1254 containing coating used on the blocks contained less Aroclor than the coating that was used on the silo.

All but three of the coating materials reduced the quantity of Aroclor 1254 contamination of the silage to below that of the control block. Aroclor contamination observed adjacent to coating I was higher than the control level. This cannot be readily explained since this material reduced the contamination in the silo. The solvents in coatings III and VII probably dissolved the Aroclor in the base coating and caused the increased PCB residue in the silage.

The results of this block study indicate that the thickness of the cover coating may be an important consideration when selecting a coating to cover PCB contamination. This can be readily seen by comparing coating system III vs. IV and II vs. IX. In both cases the latter coating system included both a sealer and a top coat, and the contamination was reduced. The differences in effectiveness between coatings VI and VIII, even though they are greatly different in composition, may well be the thickness of the coating. Only a thin barrier was provided by a single coating of VI, whereas a single coat of VIII was quite thick.

These studies have not yet provided enough information to recommend a particular coating or type of coating to cover the PCB contamination in silos. These trials are continuing in order to determine how long the coating will remain bonded to the silo wall and also to determine if the Aroclor will migrate through a coating when used continually. The studies have provided information about some of the necessary properties of a coating if it is to be used as an effective barrier to PCB residuos. These studies have indicated that it is not desirable to use a coating which contains a solvent in which Aroclor 1254 is very soluble. It also appears that the coating thickness influences the effectiveness of the covering.

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TABLE 1. The identifications, principle components, principle solvents and test locations of the barrier coatings tested.

Coating Numeral	Coating Type	Principle Component or Resin	Principle Solvent	Where Tested: Silo	Where Tested: Block
I	Furfuryl	Furfuryl alcohol resin	Isoprophyl alcohol	x	x
II	Vinyl	Vinyl resin	Methyl isobutyl ketone	x	x
III	Epoxy sealer	Epoxy resin	Xylene		x
IV	Epoxy sealer + Epoxy topcoat	Epoxy resin	Xylene		x
V	Epoxy sealer + Epoxy topcoat	Epoxy resin	Cellosolve	x	x
VI	Water epoxy	Epoxy resin	Water		x
VII	Thermoplastic hydrocarbon	Alkyl aeromatic hydrocarbon	Kerosene		x
VIII	Hydraulic cement	Cement	Water	x	x
IX	Vinyl sealer + Vinyl topcoat	Vinyl resin / Vinyl resin	Methyl isobutyl ketone / Methyl isobutyl ketone		x
XI	Epoxy sealer + Water epoxy	Epoxy resin + Epoxy resin	Xylene / Water	x	x

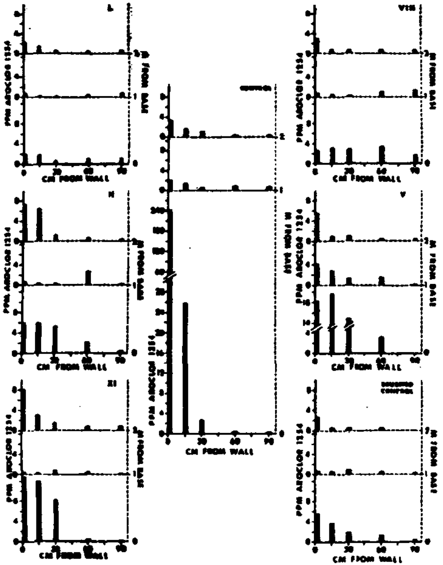

Figure 1. The parts per million (ppm) of Aroclor 1254 (dry matter basis) in corn silage from experimentally coated, wire brushed and untreated sections of PCB contaminated silo. See table 1 for a description of the coating materials used.

M	=	meter	0.30 M = 1 ft.
CM	=	centimeter	2.54 CM = 1 in.

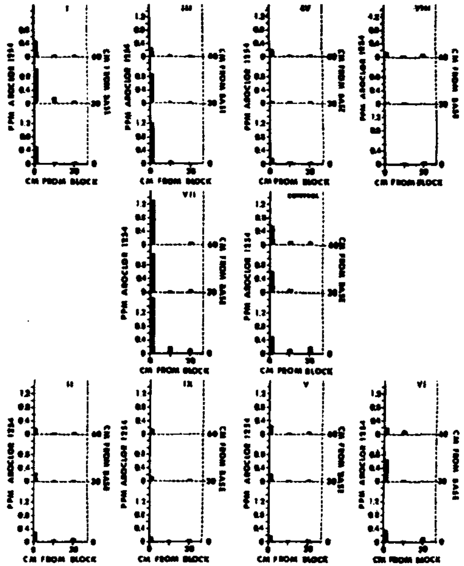

Figure 2. The parts per million (ppm) of Aroclor 1254 (dry matter basis) in corn silage from 55 gallon barrels that contained concrete silo blocks. The blocks were treated with an Aroclor 1254 containing coating then recoated with the experimental coatings. See table 1 for a description of the coating materials used.