Polychlorinated Biphenyls and Their Effects Upon Agriculture

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I. Introduction.

Polychlorinated biphenyls (PCBs) are a group of industrial chlorinated hydrocarbons that were discovered in the late 1800's and commercially manufactured in the 1930's. PCBs, a sister to DDT, are a group of chemically stable compounds and thus are not hydrolyzed by strong acids, alkalies or other corrosive chemicals. They are stable in heat and water, insoluble in aqueous media and soluble in hydrocarbon solvents. PCBs were manufactured in the United States by Monsanto Chemical Company under the trade name Aroclor up until 1972. PCBs are still manufactured in other parts of the world. The Aroclor compounds are identified on the basis of the amount of chlorine they contain i.e. Aroclor 1254 contains 54 percent chlorine.

The PCBs have chemical and physical characteristics that make them favorable for widespread industrial use. Some of the more common uses of PCBs include use in protective coatings, waterproofing, flameproofing, hydraulic fluids, heat transfer fluids, plasticizers, solvents in adhesives, printing ink, paints, pesticide carriers and electrical insulation. The PCBs are resistant to both chemical and biological degradation thus making them very persistent compounds in the environment.

It was not until 1966 that PCBs were discovered to be a contaminate of the environment and toxic to both humans and animals. The oral LD_{50} for products containing 21 to 68 percent chlorine is 4-10 grams per kilogram. Careful monitoring efforts have indicated PCBs to be present in some milk, eggs, meats, fats and oils, and cereal products. PCBs have directly and indirectly found their way into animal feeds and animal food products through water, paints, heat transfer fluids, and plastic and cardboard food-packaging materials. PCBs are fat soluble and persist and accumulate in oil and fat.

II. PCB Contamination of Silo Walls.

Farmers with poured concrete or stave silos have experienced decomposition of the silo walls. The corrosion of the walls is due to the action of the silage juices which if not repaired will completely destroy the silo over a period of time. Many materials have been utilized to resist the corrosive action of the silage juices and therefore preserve the integrity of the silo.

Wax, mineral oil, epoxy resins and other resinous material have been utilized in the coating of silos. One coating material known as Cumar[1/] contains Aroclor 1254 which is a PCB material manufactured by the Monsanto Company containing 54% chlorine. The composition is shown in Table 1. The plastic paint labeled Aroclor 1254 however was labeled for electrical use only. The Michigan Silo Company bought this material and included it in their silo sealant.

1/ Cumar silo coating contains Aroclor 1254 and should not be confused with Neville R-16-A resin which has the same name.

TABLE I. Formulation of Cumar Silo Coating

Ingredient	Amount
Paradene No. 2 (dark flaked)	40 lb.
R-16-A Neville Resin (flaked)	40 lb.
Clay	20 lb.
Parlon	25 lb.
Aroclor 5460	20 lb.
Aroclor 1254	70 lb.
Xylol	13 gal.
S.C. Solvent-100	5 gal.
S.C. Solvent-3	8 gal.

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The formulation of Cumar for the Concrete Silo Company of Bloomfield, Indiana which was a subsidary of Michigan Silo Company of Charlotte, Michigan, was for the purpose of protecting silos against organic acids produced during the ensiling process. Personnel of the Michigan Silo Co. have stated that Cumar, when used on newly constructed silos, helped retain moisture in the joint mortar during curing and gave protection of the mortar from the silage acid. Cumar has also been used to recoat the entire inner surface of silos.

When Cumar was applied to the silo wall, solvents in the coating material penetrated into the concrete thus carrying the PCBs and PCTs into the silo wall. Following the evaporation of solvents, a firm coating material was left on and in the inside walls of the silo. The transfer of the PCBs into the silage results when chips of the silo wall fall into the silage. In addition, during the ensiling process, certain organic acids are produced such as acetic and lactic acid which may dissolve some of the PCBs. Aroclor 1254 has been shown to be soluble in acetic acid. Following the dissolving of PCBs by the silage juices, they diffuse out into the silage. The silage found next to the silo wall are higher in PCBs than silage in the middle of the silo.

Animal consumption of the silage containing chips from the Cumar coated walls and dissolved PCBs results in contamination of animals with PCBs. Continual use of the silo will result in all of the coating coming off into the silage leaving no visible coating on the walls. However, the concrete still contains dissolved PCBs that have penetrated into the concrete which will continue to dissolve in the silage juices. The downward migration of juices at the base of the silo may result in the accumulation of PCBs at the base of the silo.

III. PCB Residues in Cows.

Cows may become contaminated with PCBs by eating the silage containing the coatings from the silo walls. PCB residues accumulate in the body fat of the animals and are excreted primarily by way of the milk fat. Approximately 20% of the daily intake of PCBs are excreted in the milk when cows are on a continous diet of PCBs. Once PCBs are removed from the ration, there is a rapid decline in the concentration of PCB residue in the milk fat. Work by Willett of Ohio indicates that during the first 15 days following the removal of PCBs from the ration of dairy cows that approximately 50% of the residue concentration in the milk fat was decreased. Thereafter, the residue concentration was decreased approximately 1% per day.

To date, no known treatment for increasing the excretion rate of PCBs from dairy cows is known.

IV. Treatment of PCB Contaminated Silos.

Whether to decontaminate a silo becomes an economic consideration. Research in Ohio indicates that PCB contaminated silos can be decontaminated effectively by careful cleaning of the silo wall surface and application of a barrier coating. The cost of decontamination (labor and materials) ranges from 10 to 18% of the silo replacement cost. The cost of recoating varies considerably among application companies.

Before applying a barrier coating, care must be taken to wash the surface of the silo. It has been shown that working with high pressure water (500 p.s.i.) to be effective in cleaning silo walls. The runoff must be controlled if this system is used to prevent PCB contamination of the waterways. Time must be allowed for the walls to dry prior to applying the coating. Wire brushing of the silo surface is also effective but requires a great deal of time and labor.

Should a silo still have a previous coating intact or be constructed with wax treated blocks, special preparation of the wall surface is necessary for good bonding of the barrier to occur. Sandblasting may be the best way to remove intact coating. Organic solvents should never be used in removing a coating as this method may spread the PCB contamination and leave the surface unfit for recoating. Solvents also cause problems with fire and/or toxic vapors.

Selecting a PCB Barrier

Before purchasing a silo coating, the owner should obtain a guarantee from the manufacturer stating that the product does not contain chlorinated hydrocarbons or toxic chemicals that may contaminate the silage. The barrier should be able to withstand the harsh environment of the silo and prevent acids in the silage juices from reaching the silo wall. Some of the criteria for selecting barriers include:

1. The coating must bond well to concrete.
2. It must be waterproof, non-porus, and cover completely.
3. It must be acid-resistant, as pH values as low as 3.5 are encountered.
4. Temperature ranges from below freezing to 160°F. must be withstood without failure.
5. It should be tough so that machinery, such as unloaders, don't cause it to flake off.
6. The coating should not contain chlorinated hydrocarbons or toxic chemicals.
7. The coating should meet Occupational Safety and Health Act standards to protect workers applying the material from toxic or flammable vapors. Local air pollution control regulations must be met.
8. The coating should not contain a solvent in which PCBs are readily soluble as PCBs from the silo wall may migrate into the new coating as it is applied.
9. Application of the material should be uncomplicated.
10. The cost of the coating should be low enough so that the entire recoating operation is not excessive when compared to the cost of replacing the silo.

Based on the results of research by Willett at Ohio State University, commercial coating barriers have been found to successfully form a barrier to PCB residues from the silo walls. These compounds "Thoroseal", "Acryl 60", "009", and "808-909" have been shown to effectively reduce the PCBs entering the silage. 2,3,4 Several other compounds are also being researched for effectiveness in reducing the PCBs entering the silage juices.

V. Summary.

The extensive industrial usage of polychlorinated biphenyls (PCBs) has resulted in widespread environmental contamination. Monitoring of PCBs have revealed that PCBs are found in some milk, eggs, meats, fats, oils and and cereal products. PCBs have been found in animal feeds and animal food products through water, paints, heat transfer fluids, and plastic cand cardboard food-packaging materials. PCBs are fat soluble and accumulate in oil and fat. Silo's coated with Cumar contain Aroclor 1254 and thus may contaminate the silage. Barriers against PCBs for silos have been shown to work.

2/ Thoroseal - Standard Dry Wall, Inc., Miami, Florida

3/ Acryl 60 - Standard Dry Wall, Inc., Miami, Florida

4/ 808-909 - Action Plastic, Inc., Charlotte, Michigan

5/ The use of trade names are for the purpose of identifying products and is not to be considered as an endorsement of products nor is it meant to discriminate against similar products not used.

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