United States
Environmental Protection
Agency

Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

Research and Development

EPA/600/S2-85/108 Dec. 1985

EPA

Project Summary

Destruction of PCBs—Environmental Applications of Alkali Metal Polyethylene Glycolate Complexes

Frank J. Iaconianni

This project is a follow-up on a study which focused primarily on the feasibility of chemical detoxification of PCB-contaminated soil using Franklin Research Center's (FRC's NaPEG) Reagents. The research described in the full report involves primarily a laboratory study of Sodium Polyethylene Glycol, the most effective NaPEG Reagent in terms of reactivity and stability. The study was aimed at identifying treatment conditions necessary for the most efficient decontamination in field applications. On-site and off-site field verification studies were also conducted using PCB-contaminated soil from spills in Buffalo, NY and Philadelphia, PA.

In the first phase of this study, experiments using soils contaminated in the laboratory were presumed to demonstrate that the concentration of PCBs in soil can be reduced to below 50 ppm by direct addition of the NaPEG reagent under ambient conditions typical of an *in-situ* treatment of a spill.

Laboratory tests conducted during the second phase of this project centered mainly on the treatment of PCB-contaminated soil obtained from the two spill sites mentioned above. The effects of variable reaction parameters which affect the rate of decontamination were examined in detail.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The accumulation of polychlorinated biphenyls (PCBs) and polychlorinated dibenzodioxins (PCDDs, "dioxins") in soil, sand, and living tissue is a serious problem. Although a great amount of work has been done in the area of direct chemical decomposition of these and other halogenated organics, relatively little effort has been directed toward *in situ* chemical detoxification.

The "cleanup" of a contaminated site usually involves landfilling and is not really a permanent detoxification but rather a transfer of a toxic spill from one location to another. Landfilled toxic materials are still in the environment and will persist there until they are chemically destroyed.

In the chemistry laboratory at the Franklin Research Center (FRC) during the summer of 1978, a chemical reagent was synthesized for use to dechlorinate PCB oils. Since that time a series of reagents have been developed and are now called NaPEG^{tm}* Reagents. They are essentially alkali metal polyethylene glycolates which produce rapid dehalogenation of halo-organic compounds of all types—in open air systems.

The aerobic nature of the NaPEG System immediately suggested its poten-

*Mention of trademarks or commercial products does not constitute endorsement or recommendation for use by the U S. Environmental Protection Agency.

tial for use on hazardous chemical spills. In August 1979, the U.S. Environmental Protection Agency (EPA) provided grant support to FRC to investigate the chemistry underlying the dehalogenation process, concentrating on dechlorination of PCBs. Subsequent EPA grant assistance was provided for a limited field study of the effects of a NaPEG reagent on PCB-contaminated soil. This research was described in a Project Summary entitled "Dehalogenation of PCBs Using New Reagents Prepared from Sodium Polyethylene Glycolate—Application to PCB Spills and Decontaminated Soils," August 1982.

Additional EPA grant assistance was awarded in 1982 for the detailed investigation of the effects of variable reaction parameters on the rate and extent of chemical decontamination of the substrate. This research focussed almost exclusively on the direct chemical treatment of PCB-contaminated soil. The continued laboratory investigation was aimed at identifying treatment conditions necessary for the most efficient decontamination in a direct field application. During the study an optimum reagent composition was selected based on chemical considerations. Maximum reactivity toward PCBs and other halogenated organics coupled with minimum sensitivity to reagent-deactivating side reactions was sought in selecting the best reagent formulation for further study. The full report describes the research performed and the results obtained.

Early Experiments Using Laboratory-Contaminated Soils

Laboratory experiments using simulated soil substrates spiked with PCBs confirmed that PCBs are dechlorinated by the NaPEG Reagents under mild, ambient conditions. Subsequent experiments using actual soils spiked with PCBs clearly show, however, that water in soil greatly reduces the rate of dechlorination and the effectiveness of the reagents on PCBs in real soils These adverse effects were greater than expected from the preliminary results obtained in previous studies. In addition, it was found that the most effective reagent formulation for the dechlorination of PCBs in controlled one-phase reactions and model substrates was not the most effective reagent for PCBs in soil, specifically because of its extreme sensitivity to water. The reagents described in the full report are much less sensitive to deactivation with water.

The next phase of experiments show that soil freshly contaminated with 1000 ppm of Aroclor 1260 can be decontaminated to below 50 ppm PCBs in only a few days with a direct application of Potassium Polyethylene Glycol (KPEG) 350-1. Particularly encouraging is the fact that this reagent can be used on soil containing some water and organics, and that it continues to react after several days in open air

On-Site Treatment of PCB-Contaminated Soil

The first completed on-site experiment in the application of reagent to contaminated soil was carried out by FRC personnel in Buffalo, NY, in August 1983. This experiment produced inconclusive results in contrast to those obtained under laboratory-controlled conditions.

The only known major problem which has adversely affected the results of this initial field study involves the inhibiting effect of water on the chemical degradation rate. Subsequent laboratory tests demonstrated simple techniques that may be used to minimize the adverse effects of water on the rate of decontamination.

The results of more recent, systematic laboratory investigations are much more encouraging than the preliminary on-site test. The level of PCBs in contaminated soil can be reduced from approximately 1000 ppm (highly contaminated) to below 50 ppm by direct chemical treatment under relatively mild conditions. This suggests that the direct on-site chemical treatment of PCB-contaminated soil is a promising process.

Results using PCB-contaminated soil from the Philadelphia, PA, site showed that significant dechlorination is achieved by simply air drying the soil at room temperature prior to the application of the reagent. Without this pretreatment, insignificant decontamination was observed for the relatively wet soil, even when KPEG350-1 was used.

When the soil sample was obtained from the site in May 1984, it was noticed that the treated soil was still very wet. Also, water condensation was observed under the plastic sheet that covered the plot. The sheet may keep the rain out, but it also tends to keep moisture in. This was probably not a major disadvantage, however, because without the cover, all but the soil particles closest to the surface would retain most of their excess moisture, even in extremely dry atmosphere. In light of this, thorough mixing of the soil in air, prior to reagent application, should be an essential minimum pretreatment.

Excess water, if not adsorbed, can be easily removed by exposing all of the soil to the surface, even at ambient temperatures. If such a treatment is performed on-site, especially on a warm, dry day, the promising results obtained in the laboratory tests may be verified. At this time, the various inhibiting effects of water are the only known major problems which have adversely affected the results of this initial field study. Air drying is a very important step which should greatly minimize these effects in field tests.

The on-site treatment of soils contaminated with PCBs and other halogenated aromatics looks very promising, based on the results obtained in the laboratory studies. Considerable work remains to be done in the area of process development, particularly with respect to reducing the inhibiting effect of water and optimizing conditions for soil decontamination.

Various solvent pretreatment and soil heating methods, for example, deserve additional and scaled-up investigation. Some of these techniques are currently being studied in the laboratory. Field testing must continue, however, not only to verify laboratory results, but to provide first-hand experience in real-world situations that is necessary for the development of a field process.

Conclusions

The results of the overall study show that FRC NaPEG Reagents can significantly reduce the concentration of PCBs in contaminated soils under controlled laboratory conditions. There are, however, several areas in which improvement and optimization must be achieved in order to develop a viable and economical process for chemically treating PCB-contaminated soils in the field. The most recent results of laboratory experiments suggest that:

- Application of reagent to wet soil is not as effective in reducing the concentration of PCBs. The water present in a typical reaction sample greatly dilutes the reagent. Air drying of the soil is necessary prior to treatment.
- Increased temperature is, as expected, more effective in reducing PCB concentration in soils.
- Increased temperature also eases mixing of reagent and soil; this should aid the continued reduction of PCB in soil over a period of time.
- An increase in reaction time shows continued decrease in the concentra-

tion of PCBs in the soil, particularly of the more active components

- A greater reagent to soil ratio has shown the best results. This is likely due in part to increased contact of reagent with PCBs This effect can perhaps be duplicated by a better method of mixing. In addition, increased reagent to soil ratio means less soil water contamination in the reagent. This should also increase the rate of dechlorination.
- The syringe application method, which minimizes the amount of atmospheric water coming in contact with the reagent, is sufficient; no additional advantage is realized by applying the reagent to the soil under nitrogen.
- Kerosene added to the soil as a solvent pretreatment is more effective in realizing dechlorination than toluene, or no solvent at low reaction temperatures, but not significantly more effective than no solvent pretreatment, when reactions are conducted at higher temperatures.
- The reagent diluted with kerosene or toluene prior to application to the soil is not as effective in dechlorinating the PCBs as the reagent alone applied to the soil.

Frank J. Iaconianni is with Franklin Research Center, Philadelphia, PA 19103.
***Charles J. Rogers** is the EPA Project Officer (see below).*
The complete report, entitled "Destruction of PCBs—Environmental Applications of Alkali Metal Polyethylene Glycolate Complexes," (Order No. PB 86-105 293/AS; Cost: $11.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Hazardous Waste Engineering Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

Official Business
Penalty for Private Use $300

EPA/600/S2-85/108