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Project Summary

Interim Report on the Feasibility of Using UV Photolysis and APEG Reagent for Treatment of Dioxin Contaminated Soils

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Alkali polyethylene glycolate (APEG) was field tested at Shenandoah Stables in Moscow Mills, Missouri, to evaluate its potential to dechlorinate 2,3,7,8-tetrachlorodibenzo-p-dioxin [2,3,7,8-TCDD] under field conditions. Two tests were scheduled for early summer 1984, one inside the stable arena and the other outside, in an area known as the "slough." However, acces to the site was delayed until fall 1984 due to difficulties in obtaining the owner's approval. Because of extremely wet weather during the fall, the outside test was postponed until the summer of 1985.

An experimental design employing a Latin square was used to compare five levels of treatments. The treatments were designated: (1) APEG-treated and covered, (2) APEG-treated and uncovered, (3) not treated and covered, (4) not treated and uncovered, and (5) methoxypolyethylene glycol (MPEG) control and uncovered. In addition to the arena site, two sections of bleachers were tested with APEG to determine the ability of the chemical to decontaminate dustcovered surfaces.

An analysis of variance was performed on the sample data. It was determined that there was not a statistical difference between those plots treated with APEG and those treated with the MPEG control. The deactivation of APEG was directly attributable to the fact that APEG is moisture-sensitive. In addition to the general humidity produced by the continual rainfall during the project, high soil moisture was present inside the stable. This soil moisture was determined to be on the order of 18 to 21 percent by water weight. The APEG has since been determined to be extremely hygroscopic and capable of pulling moisture from out of the surrounding environment, resulting in its deactivation. The bleachers test showed approximately a 32-percent and a 16-percent reduction in 2,3,7,8-TCDD in the final dust samples after a single application of APEG.

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).

In 1982, numerous sites of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin, 2,3,7,8-TCDD) contamination were identified by the U.S. Environmental Protection Agency (EPA) in Eastern Missouri. The sites were contaminated in the early 1970's when waste oil containing traces of dioxin were applied to horse arenas and road surfaces to control

dust. Due to the number of sites and the volume of soil that must be handled, it is possible that in situ treatment may provide the only practical solution to the dioxin problem.

The Hazardous Waste Engineering Research Laboratory (HWERL-Ci), in conjunction with Wright State University, in Dayton, Ohio, previously established the ability of alkali polyethylene glycolates (APEGs) to destroy 2,3,7,8-TCDD in soil samples under laboratory conditions. Subsequently, EPA developed plans to evaluate the applicability of APEGs to dioxin decontamination in a controlled field test.

The objective of this study was to evaluate a selected APEG reagent and ultraviolet light (UV) under ambient conditions to determine its capability to dechlorinate and hence "destroy" 2,3,7,8-TCDD. A statistical sampling design that would facilitate the comparison of results before and after treatment was to be used. With this approach, data essential to the development of a reliable and cost-effective technique for the destruction detoxification of toxic halogenated organics such as TCDD would be obtained.

In conjunction with the Research Triangle Institute (RTI), EPA implemented the statistical design in a field study conducted in October through November 1984 at Shenandoah Stables.

The test plan involved the construction of two sites, one inside the stable arena and one outside the stable at a site referred to as the "slough."

A total of 1,060 cubic yards of TCDD contaminated soil were removed from the stable, deposited in the slough area immediately southeast of the stable, and capped with clay in the 1970s. The TCDD concentration in this area averaged 1,175 ppb. On the 25 test plots inside the arena, the TCDD concentration averaged 110 ppb.

Extremely wet weather forced the postponement of the outside UV and APEG tests until summer 1985.

The basic experimental design for the Shenandoah Stable site consisted of a 5×5 Latin square involving 25 plots (identified by row and column). The five treatments, designated by the letters A through E as shown below, were randomly assigned within the Latin square configuration:

- A = APEG treated, covered
- B = Not treated, covered
- C = APEG treated, uncovered
- D = Not treated, uncovered
- E = Methyoxypolyethylene glycol (MPEG)-treated, uncovered

Two sections of bleachers that were liberally coated with dust were identified. Each section contained two seating planks 31.5-feet long and 9.6-feet wide, and arranged in tiers. The planks were coated with dust ranging in depth from 1/16 inch to 1/8 inch. It was assumed that since all four planks had been exposed to the same environment, each would contain approximately the same levels of 2,3,7,8-TCDD. Therefore, one plank of each set could be treated with APEG.

APEG and MPEG (polyethylene glycol monomethyl ether, average molecular weight 350) were applied to designated 3-foot by 3-foot test plots. A plastic covering was then placed over the appropriate plots. To prepare the APEG reagent, the MPEG was combined with potassium hydroxide and also used alone as a reagent control.

The plots designated A and C (Figure 1) were given a single treatment of APEG. The initial treatment consisted of filling a 2-gallon steel watering can having a perforated spray cap with 7-liters of APEG. The reagent was then dispersed over the surface of a plot and allowed to fill the frame. The surface of the treated plots was then raked and stirred to a depth of approximately 3 inches with a 3-pronged garden tool in order to mix the APEG and the soil. Those plots designated as E received a similar treatment using 7 liters of MPEG. Plots designated as B and D were left untreated; however, their sur-

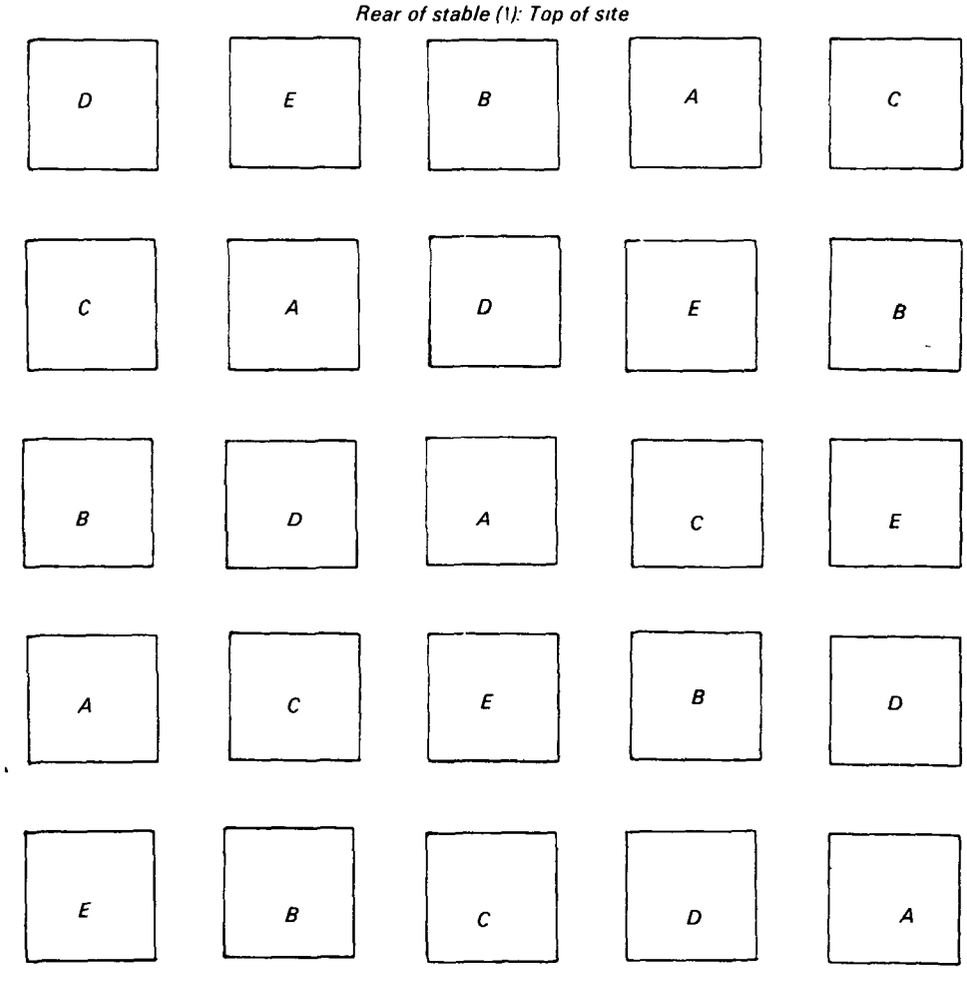

Figure 1. *Plot assignments for the arena site.*

faces were raked to simulate the mixing that had occurred in A, C, and E.

The plots designated by A and B were covered with 0.5 mm black polyethylene plastic. A 3 1/2-foot, 1-inch by 1-inch dowel was centered horizontally over the sampling frame to provide central elevation for the covering and to promote the drainage of condensate to the sides of the plot. The 5-foot by 5-foot plastic squares were then placed over the frame.

Additional treatments involved the application of a 2 to 1 toluene-APEG mixture to those sites previously treated with APEG alone. The MPEG treatments were not modified.

The previously identified bleacher sections were treated during the third visit. A standard 3-gallon hand-pressurized agricultural sprayer was used to apply the APEG. The sprayer was filled with a 2 to 1 toluene-APEG mixture and the spray nozzle was tested to see that it would emit a uniform spray.

After adjusting the spray nozzle, the can was refilled and two 31-foot by 9.6-foot (302.4 square feet) planks of bleacher were each sprayed with approximately 1 1/2 gallons of APEG reagent.

The concentration of 2,3,7,8-TCDD at Shenandoah Stables had been previously determined by EPA to have a nonuniform distribution. Consequently, the goal of the sampling protocol was to characterize each plot over time that would account for the potential variability. By compositing and analyzing a series of point samples from within each plot, a representative 2,3,7,8-TCDD concentration could be determined. The sample points were based on a regular pattern, the starting point of which was to be randomly selected for each sample.

The analyses of the soil and bleacher samples for 2,3,7,8-TCDD were performed under the auspices of the Superfund National Dioxin Study. Consequently, four contract laboratories were assigned by the Sample Management Office in Alexandria, Virginia, to perform the TCDD analyses. All analyses were performed in accordance with the established EPA TCDD analysis protocol requirements for laboratories in the study.

Duplicate measurements of dioxin concentration levels within each of the plots were made at four times: the first pair of measurements during a baseline

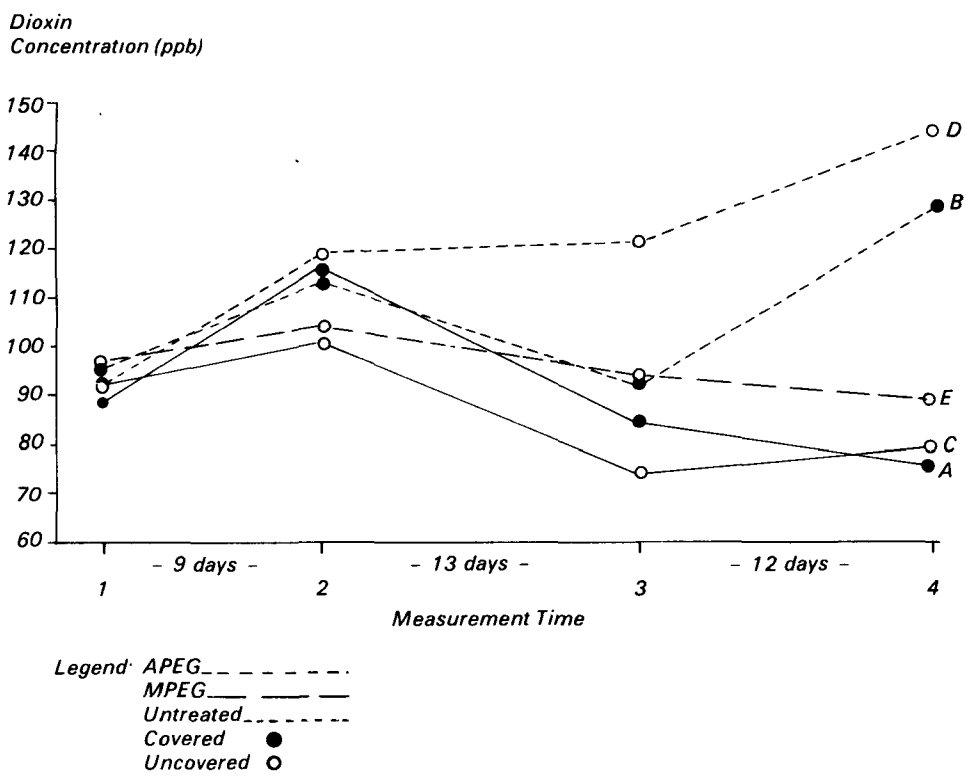

Figure 2. *Estimated mean dioxin concentrations versus measurement time.*

period (before application of any treatment), and the remaining pairs, after each of the three treatment applications. A total of 200 measurements (2 measurements per plot; 25 plots; 4 time periods) were finally taken. Due to miscommunications between the Sample Management Office and the contract laboratories, all sample results were not received. Consequently, there were 31 measurements for which the dioxin concentrations were not available for analysis. However, each of 100 cells (25 plots, 4 time periods) had at least one good dioxin determination.

A multivariate analysis of variance was performed on the sample data using the dioxin data from the four sampling visits, looking at them over time as the dependent variables, and looking at row, column, and treatment as the independent variables.

When only the initial measurement versus the final measurements are inspected (Figure 2), there is an effect for APEG versus no treatment as well as for MPEG versus no treatment. When the effects of the no treatment "treatments" are compared, both show a statistically significant increase in dioxin levels. The effects of the MPEG and APEG treatments show a decrease in dioxin levels but are not statistically significant.

The results from one application of APEG to TCDD contaminated bleachers are summarized in Table 1.

The results from field tests of APEG are not comparable to the achieved 68 percent reduction of TCDD in soil after 21 days under ambient conditions in the laboratory. A recently completed study has established that both APEG and MPEG are hygroscopic and can absorb within 9 days greater than 10 percent of its weight in moisture from the air. Moisture in excess of four percent tends to deactivate the APEG reagents and reduce their ability to destroy TCDD and other haloorganic compounds.

Soil moisture in test plots at Shenandoah Stables reached levels of 18 to 20

Table 1. *Percent Reduction of TCDD on Bleacher Surfaces*

Shenandoah Stable bleacher dust

Initial TCDD in dust (PPB)	*TCDD after 12 days of treatment*	*Percent reduction*
76.9	*64.0*	*16.8*
65.5	*44.0*	*32.8*

percent of the weight of the soil during the study. Also, the humidity remained high due to unseasonably heavy rainfall during the test period of October through November 1984; the average air temperature at the test site was 35°F. This low temperature did not contribute to drying of soil, nor could it enhance the APEG rate of TCDD destruction in the soil or on the bleacher planks.

To overcome the adverse influence of soil and air moisture on APEG, two new TCDD destruction processes are being developed and demonstrated successfully on the laboratory scale. They are heated slurry and heated in situ processes.

In the slurry process, the TCDD-contaminated soil is excavated and placed in an onsite reactor containing APEG. The soil is processed for 1 hour at 70° to 100°C to decompose the dioxin to levels below 1 ppb. The APEG is recovered and reused. In the in situ process, the soil is treated in-place by adding the reagent directly to the soil, as was done at the Shenandoah site, followed by heating the soil to 70°C with radio frequency or passive solar techniques. Both the heated slurry and heated in situ processes are scheduled to be tested in the field during fiscal years 1985-1986.

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The complete report, entitled "Interim Report on the Feasibility of Using UV Photolysis and APEG Reagent for Treatment of Dioxin Contaminated Soils," (Order No. PB 85-232 619/AS; Cost: $11.50, subject to change) will be available only from:

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