Field Study: Screening for Toxaphene in Soil by Enzyme Immunoassay Test Kit

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INTRODUCTION

Field screening for toxaphene soil contamination using enzyme immunoassay (EIA) technology was successfully conducted in a joint project of the United States Environmental Protection Agency (USEPA) and the Navajo Environmental Protection Agency Superfund Program (NSP) at 22 sites throughout the Navajo Indian Reservation. A study by the U.S. Bureau of Indian Affairs, conducted between 1990 and 1992, identified toxaphene contamination at more than 250 dip vat sites on the Reservation. The vats, approximately 5 feet deep, 3 feet wide, and up to 50 feet long, were used from the 1930s to the late 1980s to dip sheep, goats and cattle to control parasites. The used dip solutions, mixtures of several pesticides including toxaphene and lindane, were disposed in unlined drainage channels and pits. In 1991, the NSP contacted the USEPA Region IX Emergency Response Section (ERS) in San Francisco, California, for assistance with further assessments and remediation of dip vat sites. A treatability study to test the effectiveness of *in situ* bioremediation was begun by the USEPA Emergency Response Team (ERT) in 1991.

The efficacy of using immunoassay test kits for rapid screening of soil samples for toxaphene in the field was initially studied by the ERT and Millipore Corporation in conjunction with bioremediation pilot studies at two sites in 1992 (Phase 1). Because of the excellent correlation demonstrated between the EIA field results and laboratory results in Phase 1[1], EIA test kits were used by an ERS team to assess 22 additional sites throughout the Reservation (Phase 2). Rapid assessment of the extent and magnitude of contamination at each site was necessary to determine the volume of soil to be remediated and quickly move to the bioremediation phase while weather permitted site work. Each site assessment was completed in one day by establishing a sampling grid and collecting and analyzing samples with EIA test kits. Five samples per site were submitted for laboratory analysis to confirm the EIA field results, the correlation between the field and laboratory results was found to be acceptable for Phase 2. Use of the EIA test kits for field screening of 1,130 samples in Phase 2 resulted in a cost savings for Phase 2 of 81 percent compared to the cost of laboratory analysis.

Because of the correlation between EIA and laboratory results on the Navajo project, EIA test kits were employed for field screening at another unrelated toxaphene site in Tempe, Arizona. Use of EIA test kits to screen 300 samples resulted in an 83 percent reduction in analytical costs for the project.

METHODS

Samples obtained during both phases of the Navajo project and the Tempe project required no preparation prior to extraction other than thorough mixing. Aliquots of the samples were extracted, extracts were diluted, and the diluents tested in accordance with the instructions provided with the EnviroGard™ Toxaphene in Soil test kit. [2] In Phase 1 of the Navajo project, sample extracts were run undiluted while in Phase 2 and the Tempe project samples were diluted 1:10 and 1:5, respectively. The samples were diluted so that the test detection range would be suitable to meet site-specific action levels.

All Navajo project Phase 1 samples were collected at one site, and the EIA tests were conducted in a laboratory by a trained analyst. All samples, except calibration standards, were submitted for analysis by gas chromatography (GC). During Phase 2, an average of 45 samples were collected from each of 22 different sites on separate days under a wide variety of weather conditions. The EIA test kits were used on site by a variety of field personnel. Samples submitted for GC analysis in this phase of work were from separate test kits and were selected to confirm the test kit concentration ranges. During the Tempe project, samples from one site were collected and analyzed over four days by two analysts in a climate-controlled environment. Samples submitted for confirmation analysis by GC were selected from a variety of the 20 test kits runs [3].

RESULTS AND DISCUSSION

Calibration curves were constructed from the absorbance readings for the three calibration standards in each field test kit in order to convert concentration range results into actual numerical values. For each test kit a linear regression analysis was performed to solve the equation $y = mx + b$ where x is the log of the concentration of the calibration standard and y is the percentage of the absorbance reading of the negative control for each calibration standard. The absorbance readings of the samples were converted to concentrations using the calibration curve for the test kit used. A plot of the EIA data versus validated GC data was prepared for each of the three data sets.

Excellent correlation was obtained between the EIA and GC data in Phase 1 of the Navajo project with a correlation coefficient of 0.996 for a data set of 30 samples (Figure 1). Good correlation was achieved during the Tempe project with a correlation coefficient of 0.84 for a data set of 34 samples (Figure 2).

The complete data set for Phase 2 of the Navajo project consisted of 93 samples analyzed by both EIA and GC. A correlation coefficient of 0.33 was obtained for the entire data set by linear regression. Although several variables could have contributed to this poor correlation, the effects of high contaminant concentrations, changes in weather, and different analysts were evaluated. When samples run by EIA with toxaphene concentrations more than twice that of the highest calibration standard were excluded from the data set, the correlation coefficient increased to 0.65 for a data set of 81 samples (Figure 3). The reduced sample set was further divided into a set analyzed by a variety of personnel and a set analyzed by only two people who had received training from the kit manufacturer. The correlation coefficient for the 40 samples tested by a variety of personnel was 0.531 whereas the correlation coefficient for the 41 samples tested by the two trained personnel was 0.796 (Figure 4). When the latter sample set was further divided into samples tested when ambient temperatures were above and below 65 degrees Fahrenheit, correlation coefficients of 0.928 and 0.677, respectively, were obtained (Figure 5).

Sample results for each project were evaluated for their reliability in relation to a site determined remediation action level. There were no false negatives relative to the action level for either the Navajo project Phase 1 or the Tempe project. In Phase 2 of the Navajo project the entire sample set had a 12 percent rate of false negatives relative to the action level. The sample set analyzed by trained personnel had a false negative rate of 5 percent with all of the false negative results occurring in the sample set analyzed at ambient temperatures below 65 degrees Fahrenheit.

CONCLUSIONS

Enzyme immunoassay test kits are an effective method for field screening for toxaphene in soil. The test kits are cost effective compared to laboratory analysis. On the Tempe project, use of EIA test kits resulted in a $45,000 savings in analytical costs whereas the savings during Phase 2 of the Navajo projects were $165,000.

The EIA test kit is quick and simple to use and is well suited to field conditions. Minimal analyst training or skill is required although the accuracy of the method is affected, as is that of any method, by different analysts and their techniques.

REFERENCES

1) Jonathan Matt, Titan Fan, Barbara Young, Daniel Crouse, and Harry Allen (1994). Detection of Toxaphene in Soil by the EnviroGard Toxaphene Immunoassay Test Kit. Proceedings: The Pittsburgh Conference.

2) EnviroGard™ Toxaphene Soil Test Kit Guide, Millipore, Inc.

3) Frank Milam (1995). Final Report - Sanders Aviation, Tempe, Arizona, under U.S. EPA Technical Direction Document T099410-0034A.

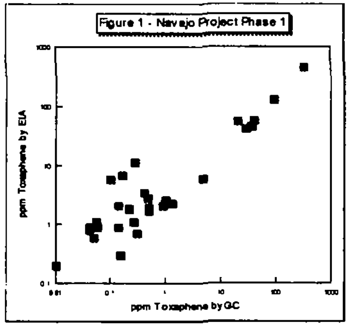

Figure 1 - Navajo Project Phase 1

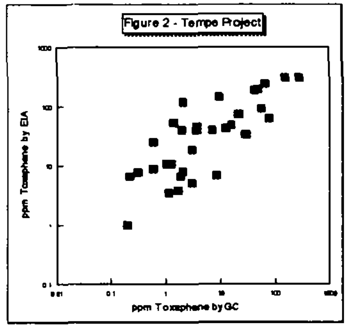

Figure 2 - Tempe Project

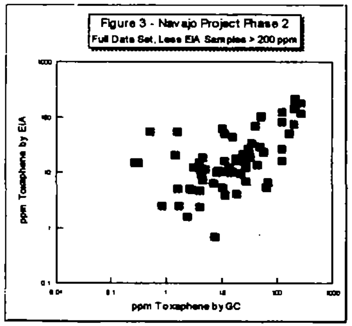

Figure 3 - Navajo Project Phase 2
Full Data Set, Less EIA Samples > 200 ppm

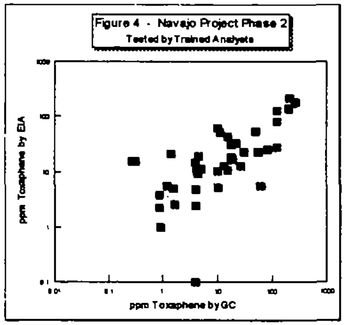

Figure 4 - Navajo Project Phase 2
Tested by Trained Analysts

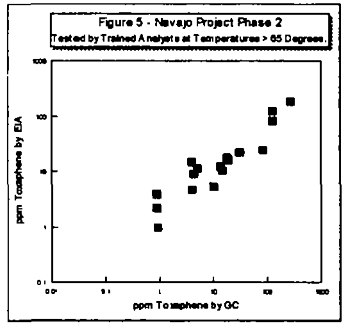

Figure 5 - Navajo Project Phase 2
Tested by Trained Analysts at Temperatures > 65 Degrees.