



## Project Summary

# Field Evaluation of Screening Techniques for Polycyclic Aromatic Hydrocarbons, 2,4-Diphenoxyacetic Acid, and Pentachlorophenol in Air, House Dust, Soil, and Total Diet

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The objectives of this work assignment were to evaluate ELISA screening methods and determine whether these methods indicate effectively those microenvironments where high exposure to polycyclic aromatic hydrocarbons (PAH) or other semivolatiles organic compounds (SVOC) is likely.

Four commercially available assay kits for PAH, carcinogenic PAH (C-PAH), 2,4-D, and pentachlorophenol (PCP) were evaluated. The testing procedures were refined based on the evaluation results. The overall method precision and assay precision of each ELISA testing method were determined. The dust/soil samples as well as sample extracts of air and food samples collected from 13 low-income homes in the summer of 1995 were analyzed by PAH and C-PAH assays. These sample extracts were also analyzed by gas chromatography/mass spectrometry (GC/MS) to determine alkyl PAH and phthalates. The dust/soil samples from 13 low-income homes collected during the spring of 1996 were analyzed by PAH, C-PAH, 2,4-D, and PCP assays. Different aliquots of these samples were analyzed by conventional (GC/MS) methods for PAH and by GC with electron capture detection (GC/ECD) for 2,4-D and PCP. The ELISA data were compared with GC/MS data or GC/ECD data. For PAH measurements, there is no strong relationship between the ELISA

results and GC/MS results when data of similar types of samples were combined from different field studies. The ELISA data (C-PAH) and GC/MS (B2 PAH) data showed stronger relationships for dust/soil collected from 22 NHEXAS homes. The ELISA screening for PAH can indicate the likely presence of high levels of PAH in dust/soil samples. There is a positive but weak relationship between GC/ECD data and ELISA data for 2,4-D and PCP.

*This Project Summary was developed by EPA's National Exposure Research Laboratory, Research Triangle Park, NC, 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

In 1992, the National Academy of Sciences identified polycyclic aromatic hydrocarbons (PAH) and other semivolatiles organic compounds (SVOC) as among the highest priorities for exposure research, in part because these compounds are frequently constituents of fine aerosol and some of them are mutagens and probable human carcinogens. Additionally, several of the PAH and other SVOC, including phthalates, pentachlorophenol, and 2,4-D, are likely to be endocrine disruptors or have other quasi-hormonal or reproductive effects. Therefore, it is im-

perative that the identities, concentrations, and distributions of these compounds in the environment be investigated. Determining exposure to PAH and SVOC is still a new area of research. It is still largely unknown in what ways they are distributed among the vapor and particulate phases in air or the aqueous and nonaqueous phases in water. Likewise, their distributions and levels in other media, such as food or soil, are largely unknown. Because of the extensive and costly sampling and analysis efforts that are required to obtain complete information on these levels and distributions, it is desirable to apply fast, inexpensive screening methods to indicate those environments and media that are most likely to be significant sources of human or ecological exposure to PAH and SVOC.

Enzyme-linked immunosorbent assay (ELISA) techniques are currently available commercially for analysis of water and soil for PAH and for other SVOC. For example, Ohmicron Environmental Diagnostics, Inc., and the Immunosystems division of Millipore, Inc., currently market immunoassay testing kits intended for field screening applications. The test kits from Ohmicron utilize the suspended magnetic particle competition assay format, as opposed to a well-coated competition assay format from Millipore. These immunoassays are formatted to be used only for determining whether a given sample contains PAH at a concentration above or below a set threshold value.

The objectives of this work were to evaluate low-cost ELISA screening methods and determine whether application of these methods indicates effectively those microenvironments where high exposure to PAH and other SVOC is likely.

ELISA techniques were evaluated for applicability to screening of air particle sample extracts and food sample extracts generated from EPA Cooperative Agreement CR822073. Simplified and cost effective sample preparation methods for dust/soil samples were also evaluated for ELISA. Two different ELISA systems, one for total PAH and one for carcinogenic PAH (C-PAH), were included in this study. In addition, two other ELISA systems were evaluated for screening pentachlorophenol (PCP) and 2,4-dichlorophenoxyacetic acid (2,4-D) in dust/soil samples.

This work was done simultaneously with a portion of the National Human Exposure Assessment Survey (NHEXAS) Arizona pilot study, which is being conducted jointly by the University of Arizona, Battelle, and the Illinois Institute of Technology. Samples of dust/soil from 22 homes of the NHEXAS study and from 13 homes of

low-income families in North Carolina were tested by both PAH and C-PAH ELISA systems. Different aliquots of these samples were analyzed conventionally by gas chromatography/mass spectrometry for PAH. The results of the ELISA screening and conventional measurements were compared to determine the ability of the ELISA techniques to predict microenvironmental levels of PAH and other SVOC in house dust and soil.

It is desirable to know whether high PAH levels in the dust/soil are indicators of high levels of other SVOC in the same environmental media, because of the costly and extensive sampling and analysis efforts that are required to obtain complete information on the levels of pollutants in multimedia samples. We therefore re-analyzed the sampled extracts of air, dust, soil, and food generated from the EPA Cooperative Agreement (CR822073) by GC/MS for alkyl PAH and phthalates.

## Results and Conclusions

The procedures from the commercial testing kits for PAH and C-PAH assays were revised to provide adequate extraction efficiency of PAH from dust/soil. The overall precision of these revised methods expressed as percent relative standard deviation (%RSD) of triplicate real-world dust/soil samples was within  $\pm 30\%$  for PAH ELISA and  $\pm 25\%$  for C-PAH ELISA. The overall method accuracy for the PAH and C-PAH assays cannot be assessed for real-world dust/soil samples, which contain multiple components of PAH, because the spike recovery procedures are based on single component spiking: phenanthrene for PAH ELISA and benzo[a]pyrene (BaP) for C-PAH ELISA. The recoveries of phenanthrene and BaP from dust/soil samples ranged from 68 to 150% and from 110 to 130%, respectively.

The sample extracts of indoor and outdoor air samples collected from 13 low-income homes in previous studies were analyzed by GC/MS for alkyl-PAH and phthalates. Among these 13 homes there were 9 nonsmokers' homes and 4 smokers' homes. Approximately half of the homes were located in the inner city (5 nonsmokers and 2 smokers) and half of these homes were located in rural areas (4 nonsmokers and 2 smokers). Levels of 2- to 3-ring alkyl PAH in indoor air from these homes were higher than those in the corresponding outdoor air. Similar concentrations of most 4- to 6-ring alkyl PAH were observed in indoor and outdoor air for nonsmokers' households, whereas higher concentrations were in indoor air for smokers' households. Higher outdoor concentrations were observed in the in-

ner city as compared to the rural area. The sums of alkyl PAH concentrations ranged from 369 to 3,270 ng/m<sup>3</sup> in indoor air and from 49.9 to 702 ng/m<sup>3</sup> in outdoor air. With few exceptions, the relative concentrations trend for alkyl PAH found in dust/soil samples from these homes was house dust > entryway dust > pathway soil, as was also observed for their parent PAH. The sums of alkyl PAH concentrations in these samples ranged from 0.092 to 3.32 ppm. Concentrations of alkyl PAH found in the 24-h food composite samples ranged from 0.866 to 15.6 ppb.

Indoor phthalate concentrations were higher than the corresponding outdoor levels. Total target phthalate concentrations ranged from 1,160 to 5,330 ng/m<sup>3</sup> in indoor air and from 64.2 to 1,070 ng/m<sup>3</sup> in outdoor air. The general concentration trend for phthalates in dust/soil samples was similar to those of PAH and alkyl PAH. Concentrations of total target phthalates found in the 24-hr liquid and solid composite food samples ranged from 0.09 to 245 ppb.

The dust and soil samples collected from 13 low-income homes and 22 NHEXAS homes were extracted and analyzed by GC/MS for 19 target PAH. The B2 PAH (probable human carcinogens) included among the target PAH are benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]-fluoranthene, benzo[a]pyrene, indeno-[1,2,3-c,d]pyrene, and dibenz[a,h]-anthracene. The levels of the sums of these B2 PAH correlated well (correlation coefficient >0.90) with total target PAH (the sums of 19 target PAH) in dust/soil samples collected from the low-income homes and NHEXAS homes. The results from GC/MS analysis showed that levels of the sums of B2 PAH account for approximately half of the total PAH. There were positive but weak relationships of PAH among different sample media (dust, soil, and air). Stronger relationships between dust and soil samples collected from the NHEXAS homes were observed. Thus, house dust may be used as a potential indicator for other sample media for PAH exposure. More studies are needed to test this hypothesis.

Different aliquots of the above dust and soil samples were extracted and analyzed by PAH and C-PAH assays. Statistical analysis showed that PAH data in dust/soil samples generated from ELISA and GC/MS methods are significantly different. In general, PAH ELISA responses were higher than PAH GC/MS responses. The regression analyses showed that the linear relationship between ELISA and GC/MS measurements is not strong. This relationship became stronger when the data

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from each type of samples were treated separately. This finding suggested that the results of ELISA depend strongly on the sample matrices. The screening performance of ELISA was evaluated based on the frequency distribution of ELISA and GC/MS data. The results indicated that PAH and C-PAH ELISA can be used

as a screening tool, but not as a quantitative analytical method for total PAH and B2 PAH in real-world dust and soil samples.

The precision for the 2,4-D assay was better than for the PCP assay in both dust and soil matrices. The average assay precision was within 20% for the 2,4-

D assay and greater than 60% for the PCP assay. There was a positive but weak relationship between GC/ECD and the ELISA method for 2,4-D data as well as for PCP data. Positive biases for 2,4-D and PCP in most house dust samples were observed by ELISA as compared to GC/ECD.

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The complete report, entitled "Field Evaluation of Screening Techniques for  
Polycyclic Aromatic Hydrocarbons, 2,4-Diphenoxyacetic Acid, and Pentachlo-  
rophenol in Air, House Dust, Soil, and Total Diet," (Order No. PB98-103195;  
Cost: \$31.00, subject to change) will be available only from

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