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by

Jane C. Chuang, Ying-Liang Chou, Marcia Nishioka
Kimberlea Andrews, Mary Pollard, and Ronald Menton
Battelle
505 King Avenue
Columbus, Ohio 43201-2693

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Project Officer

Nancy K. Wilson
Human Exposure and Atmospheric Sciences Division
National Exposure Research Laboratory
Research Triangle Park, North Carolina 27711

National Exposure Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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Foreword

The mission of the National Exposure Research Laboratory (NERL) is to provide scientific understanding, information and assessment tools that will quantify and reduce the uncertainty in EPA's exposure and risk assessments for environmental stressors. These stressors include chemicals, biologicals, radiation, and changes in climate, land use, and water use. The Laboratory's primary function is to measure, characterize, and predict human and ecological exposure to pollutants. Exposure assessments are integral elements in the risk assessment process used to identify populations and ecological resources at risk. The EPA relies increasingly on the results of quantitative risk assessments to support regulations, particularly of chemicals in the environment. In addition, decisions on research priorities are influenced increasingly by comparative risk assessment analysis. The utility of the risk-based approach, however, depends on accurate exposure information. Thus, the mission of NERL is to enhance the Agency's capability for evaluating exposure of both humans and ecosystems from a holistic perspective.

The National Exposure Research Laboratory focuses on four major research areas: predictive exposure modeling, exposure assessment, monitoring methods, and environmental characterization. Underlying the entire research and technical support program of the NERL is its continuing development of state-of-the-art modeling, monitoring, and quality assurance methods to assure the conduct of defensible exposure assessments with known certainty. The research program supports its traditional clients -- Regional Offices, Regulatory Program Offices, ORD Offices, and Research Committees -- and ORD's Core Research Program in the areas of health risk assessment, ecological risk assessment, and risk reduction.

Human exposure to multimedia contaminants, including polycyclic aromatic hydrocarbons is an area of concern to EPA because of the possible mutagenicity and carcinogenicity of these compounds. These compounds originate from industrial processes and combustion and are present in a variety of micro environments. The efforts described in this report provide an important contribution to our capability to measure and evaluate human exposure to pollutants.

Gary J. Foley
Director
National Exposure Research Laboratory

Abstract

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 semivolatile 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 report was submitted in fulfillment of Work Assignment 1-04, Contract 68-D4-0023 by Battelle under the sponsorship of the United States Environmental Protection Agency. This report covers a period from May 1, 1996 to September 30, 1996, and work was completed as of September 30, 1996.

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Acknowledgment

We thank Dr. Nancy K. Wilson of the U.S. EPA for her invaluable advice and participation during this investigation.

Chapter 1
Introduction

In 1992, the National Academy of Sciences identified polycyclic aromatic hydrocarbons (PAH) and other semivolatile 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 (1). Additionally, several of the PAH and other SVOC, including phthalates, pentachlorophenol, and 2,4-D, are likely to be endocrine disrupters or have other quasi-hormonal or reproductive effects. Therefore, it is imperative 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 how 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 (2-4). 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 assignment were to evaluate low-cost ELISA screening methods and determine whether application of these methods indicates effectively those micro-environments where high exposure to PAH and other SVOC is likely.

In this work assignment, 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 assignment was carried out simultaneously with a portion of the 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 (5) and from 13 homes of low-income families in North Carolina (6,7) 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 multi-media samples. We, therefore, reanalyzed the sampled extracts of air, dust, soil, and food generated from the EPA Cooperative Agreement (CR822073) by GC/MS for alkyl PAH and phthalates.

The specific tasks that were planned to accomplish the study objectives are:

(1) Evaluate two different ELISA systems, one for total PAH and one for carcinogenic PAH, with dust and soil samples, as well as with sample extracts of air and food samples collected under CR822073.

(2) Evaluate the ELISA systems for screening PCP and 2,4-D in dust and soil samples.

(3) Analyze sample extracts of air, dust, soil and food (a total of 95 sample extracts) collected under CR822073 for alkylated PAH and phthalates.

(4) Screen extracts of dust and soil samples (a total of 102 samples) from 22 NHEXAS homes and 13 low-income homes using ELISA methods.

(5) Analyze above dust and soil samples for PAH by conventional solvent extraction and GC/MS analysis.

(6) Conduct statistical analysis of ELISA screening results and GC/MS results to determine whether the ELISA technique is an effective screening tool for total PAH exposure.

(7) Prepare a final report on the results of the study in EPA/ORD format.

This final report summarizes the work conducted for this study under Work Assignment 1-04.

Chapter 2
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 ± 30% for PAH ELISA and ± 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 benz[a]pyrene (BaP) for C-PAH ELISA. The recoveries of phenanthrene and BaP from dust/soil samples ranged from 68 to 150 percent and from 110 to 130 percent, respectively.

The sample extracts of indoor and outdoor air samples collected from 13 low-income homes in previous studies (6,7) 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 inner city as compared to the rural area. The sums of alkyl PAH concentrations ranged from 369 to 3,270 ng/m^3 in indoor air and from 49.9 to 702 ng/m^3 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^3 in indoor air and from 64.2 to 1,070 ng/m^3 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 (6,7) and 22 NHEXAS homes (5) 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 13 low-income homes and 22 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 22 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 results 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 from each type of samples were treated separately. This finding suggested that the results of ELISA depends 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 only a screening tool but not 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 those 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.

Chapter 3
Recommendations

The results of this study suggest that ELISA results are matrix dependent. The performance of ELISA screening could be improved by minimizing the matrix effect through a selective extraction method. We recommend that a study be conducted to investigate an alternative extraction method, supercritical fluid extraction (SFE) coupled with ELISA for estimating PAH in dust/soil. Various SFE conditions need to be evaluated to determine the optimal SFE condition. Different SFE conditions may be needed for different types of dust/soil samples. The dust/soil samples would be extracted by SFE under the optimal conditions and analyzed by ELISA. The ELISA results would be compared with GC/MS results to determine whether SFE coupling with ELISA can provide better estimates of PAH in dust/soil.

With the PCP and 2,4-D assays, the 60% extraction efficiency seems to limit the accuracy and precision of the method. Therefore, we recommend consideration of a solvent mixture, such as acetonitrile/phosphate buffer which can quantitatively remove 2,4-D and PCP from dust/soil. The compatibility of this solvent needs to be evaluated in the PCP and 2,4-D assays.

We also recommend that a study be conducted to investigate a cost-effective sample preparation method for air and food samples for ELISA because sample preparation is the most significant time- and cost-consuming step.

Chapter 4
Experimental Procedure

Method Evaluation of PAH and Carcinogenic PAH (C-PAH) ELISA

The PAH and carcinogenic PAH (C-PAH) assay kits were purchased from Ohmicron Environmental Diagnostics. Initially, selected pathway soil samples were assayed for screening PAH and C-PAH using the test kit procedures provided by Ohmicron Environmental Diagnostics. These procedures are described in Appendix A.

Preliminary method evaluation tests were conducted using selected house dust, entryway dust and pathway soil samples. The procedural conditions that were evaluated included the ratio of dust/soil to solvent volume, the extraction techniques, and the ELISA diluent volume. The test kit procedures involved extracting 10 g of soil with 20 mL of methanol by 1-min shaking. Because 10 g of house dust may not always be available, alternative quantities of dust mass and solvent (1 g/20 mL, 3 g/20 mL, and 9 g/20 mL) were evaluated. In these experiments, no concentration steps were performed prior to ELISA. Two extraction methods, shaking and sonication, were evaluated for removing PAH from the dust/soil sample matrices. The shaking method followed the test kit procedures (Appendix A). The sonication method consisted of two sequential 10-min extractions of the soil/dust sample by two aliquots of 10 mL of methanol. The methanol extracts were combined, filtered by quartz fiber filters and assayed for PAH and C-PAH ELISA. For the 50 fold dilution of ELISA, 25 μL of extract was diluted into 1.225 mL of diluent instead of 250 μL of extract diluted into 12.25 mL of diluent as described in the test kits. This revision provided sufficient quantities for assays and reduced the quantities of chemical wastes generated from the assays.

The procedures used for ELISA were then modified by using a smaller sample size (1 g instead of 10 g of sample), better extraction method (sonication instead of shaking), and small amounts of diluents (1.225 mL instead of 12.25 mL). The revised procedures are described in Appendix B.

Evaluation of recoveries of PAH from dust/soil samples using PAH and C-PAH ELISA was also conducted. Aliquots of selected dust/soil samples were spiked with known amounts of PAH and assayed for PAH and C-PAH by ELISA using the revised procedures (Appendix B). The spiking conditions evaluated were: phenanthrene only, benzo[a]pyrene only, phenanthrene-d_{10} only, a mixture of phenanthrene and benzo[a]pyrene, and a mixture of 16 PAH.

The air and food sample extracts from the Cooperative Agreement (CR822073) were prepared for ELISA. The air sample extracts were from 24-hr indoor and outdoor air samples, and the food sample extracts were from 24-hr liquid and solid composite samples from meals consumed by the study subjects. Aliquots of the air and food sample extracts were removed, evaporated under a gentle nitrogen stream to dryness, and redissolved into methanol. This step was required because the sample extracts were in dichloromethane which is incompatible for ELISA. The methanol extracts were then subjected to ELISA screening according to the revised procedures (Appendix B). Aliquots of the dust/soil samples from 22 NHEXAS homes and 13 low-income homes were also prepared for ELISA screening according to the revised procedures.

Sample Preparation for Conventional PAH Analysis

The house dust samples from 13 low-income families were separated into coarse and fine (< 150 μm) fractions at Battelle and only the fine fractions were used for subsequent analysis. The 150 μm cut-off point for fine dust was based on the ASTM procedure (10). The house dust samples from 22 NHEXAS homes were separated into coarse and fine (< 62 μm) fractions by the University of Arizona staff and the fine fractions were sent to Battelle for subsequent analyses. The 62 μm cut-off point for fine dust from the NHEXAS study was based on the sediments grade in the Arizona area indicating that sediments greater than 62 μm are mostly sandy. The entryway dust, pathway soil, and foundation soil samples were not separated into fine and coarse fractions prior to analysis. An aliquot (0.5 g) of each dust/soil sample was spiked with known amounts of perdeuterated PAH and extracted with two 10-mL aliquots of hexane in a sonication bath each for 20 minutes. The hexane extracts were combined, filtered, and concentrated to 1 mL for PAH analysis (8).

GC/MS Analysis Method

The sample extracts were analyzed by GC/MS using 70-eV electron ionization (EI). A Finnigan TSQ-45 GC/MS/MS instrument, operated in the GC/MS mode, was used. Data acquisition and processing are performed with an INCOS 2300 data system. The GC column was a DB-5 fused silica capillary column or equivalent, and the column outlet is located in the MS ion source. Helium is used as the GC carrier gas. Following injection, the GC column was held at 70°C for 2 min and temperature-programmed to 290°C at 8°C/min. The MS is operated in the selected ion monitoring (SIM) mode. Masses monitored are the molecular ions of the 19 target PAH and their associated characteristic fragment ions. Identification of the target compounds is based on their GC retention times of the 19 target PAH relative to those of the internal standards phenanthrene-d_{10}, 9-phenylanthracene and benzo[e]pyrene-d_{12}. Quantification of target compounds was based on comparisons of the respective integrated ion current responses of the target ions to those of the corresponding internal standards using average response factors of the target compounds generated from standard calibrations.

Quantification of the total alkylated PAH isomers is based on the average response factors of either the corresponding target alkylated PAH or their parent PAH.

Statistical Analysis

The following types of samples were collected in different field studies and analyzed by both GC/MS and ELISA:

- House dust (HD), entryway soil (ES), and pathway soil (PS) samples taken from the 13 low income homes in Raleigh/Durham, N.C. in both summer and spring field studies.
- Floor dust (FDP) equivalent to house dust, foundation soil (FSP), and yard soil (YSP) samples taken from 22 NHEXAS study (Arizona) homes.
- Air and 24-hr liquid and solid composite food sample extracts from the 13 low income homes in Raleigh/Durham, N.C. in the summer field study.

Summary statistics (Sample Size, Mean, Standard Deviation, Minimum, and Maximum) for the ELISA measurements of total PAH and C-PAH and GC/MS measurements of total PAH and B2-PAH in dust, soil, food, and air samples were determined. The total PAH measurements from GC/MS were the sums of the measured concentrations of all target parent PAH. The B2 PAH measurements were the sums of the concentrations of target PAH which are B2 PAH (probable human carcinogens). Three types of statistical analyses were performed on the data: paired t-tests, regression analysis, and Fisher's exact test. First, paired t-tests were used to determine if there are differences between the average PAH concentrations of the two analysis methods. Tests were performed on data from dust and soil samples alone and on data from all samples. Both total PAH and C-PAH measurements from ELISA and total PAH and B2 PAH measurements from GC/MS were considered. All t-tests were performed on log-transformed data.

Regression analysis was used to examine the relationships between ELISA and GC/MS for measuring PAH. The regression was performed both on raw data and on log-transformed data.

The regression analyses were conducted on all combined data, and on data from each sample medium.

To evaluate the screening performance of ELISA, we defined the performance measures of sensitivity, specificity, positive predictive value, and negative predictive value according to the results from both ELISA and GC/MS methods. The definitions of these performance measures are shown in Table 4.1. Fisher's exact test was used to test whether ELISA and GC/MS measurements are statistically independent (i.e., whether there is no predictive relationship between these measurement methods).

Table 4.1 Definitions of Performance Characteristics

		GC/MS Standard	
		Below	Above
ELISA Screening Response	Below	c	d
	Above	a	b

In the above table, the letter a represents the number of households which have an ELISA derived PAH concentration above a given value (10 ppm for PAH ELISA or 2 ppm for C-PAH ELISA) and a GC/MS derived concentration below a given value (1 ppm for total PAH or 0.5 ppm for B2 PAH). Letters b, c, and d represent similar counts. From these counts the following performance characteristics are calculated

Performance Characteristic	Definition	Calculation
Sensitivity (or True Positive Rate)	Probability of a household being above the PAH standard for the sample matrix given that there is a household with a high ELISA PAH response.	b/(a+b)
Specificity (or True Negative Rate)	Probability of a household being below the PAH standard for the sample matrix given that there is a household with a low ELISA PAH response.	c/(c+d)
Positive Predictive Value (PPV)	Probability of a household having a high ELISA PAH response given that the observed PAH level in the household is above the standard for the sample matrix.	b/(b+d)
Negative Predictive Value (NPV)	Probability of a household having a low ELISA PAH response given that the observed PAH level in the household is below the standard for the sample matrix.	c/(a+c)

Method Evaluation of 2,4-D and PCP ELISA

The 2,4-D and PCP ELISA test kits were purchased from Ohmicron Environmental Diagnostics. The assay test kits included reagents for the assay plus extraction solvents and extraction tubes. The assay test kits and extraction solvents were used as instructed; the assay test kit extraction tubes were replaced with standard 15 mL or 50 mL centrifuge tubes, for 2 and 4 mL, or 20 mL extraction volumes, respectively.

Preliminary method evaluation tests were conducted using a moist humus soil, a dry clay soil, and a house dust. The humus soil and clay soil represent two extremes of soils; the humus soil has high humic acid (organic) and water content, the clay soil has high inorganic content and little water. In general, we find equivalent extraction efficiency for 2,4-D and PCP from soil and house dust using the standard acetonitrile: phosphate buffer extraction solvent mixture, and thus it is not necessary to test all spike levels in all media (9). For this reason, evaluations of recovery from spiked humus soil were most extensive and involved measurement of recoveries using either a conventional GC/ECD analysis method or the ELISA method at 3 different spike levels. Extraction of analytes from clay soil was assessed at a single spike level only using the ELISA assay. Recovery of analytes from house dust was assessed at a single spike level with extracts analyzed by ELISA and GC/ECD.

The extraction conditions that were evaluated included: the solvent, the ratio of soil/dust to solvent volume, and the extraction technique. The ELISA extraction solvent for PCP is NaOH in 75% methanol/ 25% water and the ELISA extraction solvent for 2,4-D is 75% methanol/ 25% water. Because of the similarity of analyte properties, extraction efficiency of each analyte in each ELISA solvent was measured. The test kit procedures involved extracting 10 g of soil with 20 mL of solvent. Alternative quantities of the soil mass and extract volume were evaluated which are 1 g/2 mL, 1 g/4 mL and 1 g/20 mL. Two extraction techniques investigated were shaking (test kits procedures) and sonication in a water bath. One analytical method was used to measure both 2,4-D and PCP in sample extracts by GC/ECD. A single surrogate recovery standard, 3,4-D, was used to assess the recovery of both 2,4-D and PCP through analytical procedures. The 3,4-D showed only minor cross-reactivity (5% relative to 2,4-D) in the 2,4-D ELISA assay, and so was used as an important diagnostic tool in analyses where GC/ECD measurements were made.

Each dust sample (or soil sample) was weighed into a centrifuge tube, spiked with the designated analytes, and sonified or shaken for 10 min. The tube was then centrifuged for 10 min to settle and compact the dust. If an ELISA assay was not performed, 1.8 mL of the initial 2 mL solvent volume was removed for GC/ECD analysis. If an ELISA assay was planned, triplicate aliquots of the extract were removed first for dilution into the respective ELISA diluent; then, 1.5 mL of the initial 2 mL solvent volume was removed for the GC/ECD analysis. For the 50 fold dilution of the 2,4-D assay, 100 μL of extract was diluted into 5 mL of diluent. For the 500 fold dilution of the PCP assay, 50 μL of extract was diluted into 25 mL of diluent.

The aliquot removed for GC/ECD analysis was diluted with 20 mL of distilled/deionized water, and the pH was adjusted to 1 with concentrated HCl. The acidified extract was applied to a 500 mg C18 SPE cartridge that had been conditioned in sequence with 10 mL each of methanol, distilled/deionized water, and 1:10 acetonitrile: 0.025M phosphoric acid. After loading, the columns were air dried for 2 hours, and then eluted with two aliquots of 2 mL of 1:1 hexane:diethyl ether. The eluate was concentrated to near dryness under a stream of dry nitrogen; the internal standard (1 μg of 2,6-D) was added, and the volume was adjusted to 1 mL with 95:5 methyl-t-butyl ether: methanol.

The extracts and multi-point calibration standards were derivatized with ethereal diazomethane generated *in situ* from carbitol and diazald in KOH. After derivatization, the extracts were allowed to sit at room temperature for 30 min, and then the excess diazomethane was removed with a gentle stream of dry nitrogen.

Samples and standards were analyzed using a Hewlett-Packard 5890 GC/ECD with a 60 m DB-5 column (0.25 mm id, 0.25 μm film thickness). The GC temperature was programmed as follows: 90-180 °C at 8 °C/min; 180-210 °C at 2°C/min; 210-300 °C at 20 °C/min; final hold time of 15 min. The splitless injector was held at 250 °C. Standards were interspersed among samples in the run order. The internal standard method of quantification was used with linear regression analysis of concentration versus relative peak area.

Chapter 5
Results and Discussion

Evaluation of ELISA for Screening PAH and C-PAH

The procedures (Appendix A) provided by Ohmicron for ELISA screening of PAH and C-PAH in the soil samples were not suitable for the screening of the house dust samples. In those procedures, 10 g of sample is required for conducting ELISA. However, less than 10 g of house dust was collected from most households in both the NHEXAS study and the Cooperative Agreement study. Therefore we revised the procedures by using 1 g of dust/soil sample instead of 10 g of sample. In the original procedures, the extraction method used is hand-shaking the dust/soil with methanol for 1 min. This shaking method provided by Ohmicron may not effectively remove PAH from the dust/soil matrices. Extraction efficiency tests were conducted on three aliquots (1 g, 3 g, and 10 g) of a house dust sample with the 1-min shaking method. The results are summarized in Table 5.1. The lowest ELISA generated PAH concentrations were observed with the 10 g aliquot of the sample and the highest PAH concentrations were observed with the 1 g aliquot of the same sample. This result suggested that the 1-min shaking method cannot effectively remove all the PAH from the house dust when 10 g or 3 g of the dust sample is used. We therefore evaluated and compared two extraction methods, shaking and sonication for removing PAH from the dust and soil matrices with 1 g of sample. The comparison of 1-min shaking and sonication results is described in the following section. The amounts of diluent used for both PAH and C-PAH assays were reduced to reduce the quantities of chemical wastes generated from the assays, but the 50 fold dilution was maintained.

Table 5.1. ELISA Results for the House Dust Sample

Sample Size	Concentration, ppm[a]	
	PAH Assay	C-PAH Assay
1 g	48	4.4
3 g	29	2.4
10 g	19	1.5

[a] The reported concentrations were derived from the PAH and C-PAH ELISA responses.

It should be noted that the derived concentrations from PAH ELISA do not represent the true sum of the concentrations of all PAH, and those from C-PAH assay are not the true sum of the concentrations of all carcinogenic PAH either. This is mainly because the calibration (inhibition) curves generated from PAH and C-PAH assays were based on phenanthrene, and on benzo[a]pyrene, respectively. However, other PAH compounds also have cross activities with both assays, and the ELISA derived concentrations cannot accurately reflect the cross activities of PAH mixture in the samples.

Two extraction methods, sonication and shaking, were evaluated for the preparation of dust/soil samples for PAH and C-PAH ELISA. For this set of experiments, only a 1 g aliquot of the dust/soil sample was used for ELISA. The results are summarized in Table 5.2. For the PAH assay, there is good agreement between the sonication method and the shaking method. Using the paired t-tests with the null hypothesis that the two methods are equivalent gives: $t = 0.759$, and $p = 0.457$. However, for the C-PAH assay the sonication method results are in general slightly higher than the shaking method results. A paired t-test gives $t = 3.573$, and $p = 0.002$. The mean difference between these two methods is 1.11 ppm. This finding indicated that the sonication method is more effective in removing C-PAH from

Table 5.2. Comparison of Sonication and Shaking Extraction Methods for ELISA

	PAH Assay, ppm[a]		C-PAH Assay, ppm[a]	
Sample Code[b]	Sonication	Shaking	Sonication	Shaking
A-HD-X	84	68	6.8	5.5
B-HD-X	76	77	5.3	3.2
C-HD-X	61	54	5.2	4.0
D-HD-X	36	36	3.0	2.1
E-HD-X	33	33	3.6	2.6
F-HD-X	133	101	8.1	13
G-HD-X	29	42	3.1	2.6
H-HD-X	49	41	6.9	4.1
I-HD-X	13	14	1.9	1.6
J-HD-X	28	30	3.6	2.5
K-HD-X	56	55	5.7	3.8
L-HD-X	46	42	7.9	4.8
M-HD-X	52	47	3.9	2.8
A-ES-X	29	40	6.2	3.9
C-ES-X	15	23	2.0	2.1
E-ES-X	NA[c]	NA[c]	6.2	5.8
H-ES-X	28	21	3.4	1.8
I-ES-X	7.7	11	2.1	4.1
J-ES-X	16	19	NA[c]	NA[c]
K-ES-X	6.2	8.5	0.72	1.1
L-ES-X	7.1	10	1.2	1.5
M-ES-X	6.4	4.7	1.2	0.72
C-PS-X	NA[b]	NA[b]	1.4	1.0

[a] The reported concentrations were derived from the PAH and C-PAH ELISA responses.
[b] A, B, etc. denote household code; HD denotes house dust; ES denotes entryway dust; PS denotes pathway dust; and X denotes the field study conducted in the spring of 1996.
[c] NA denotes that data are not available in the respective assay.

the dust/soil sample matrices than the shaking method. This is probably due to the fact that most C-PAH are 5- to 6-ring, and these PAH may not be completely removed from the dust/soil by the shaking method. The revised procedures for ELISA are described in Appendix B. These procedures consisted of reducing the sample size to 1 g, extracting the dust/soil sample with the sonication method, and reducing the amount of diluent used for the ELISA.

The overall method precision for PAH and C-PAH ELISA screenings were determined. Triplicate sets of dust/soil samples were processed for ELISA screening. The precision is calculated by the percent relative standard deviation of each triplicate sample. The results are summarized in Table 5.3. The overall method precision ranged from 11.9 to 28.5% for the PAH assay and from 5.89 to 20.7% for the C-PAH assay. The precision for the C-PAH ELISA is slightly better than that for the PAH ELISA. The precision for the assays alone, not including the extraction step, was also determined by conducting ELISA in triplicate on selected dust/soil sample extracts. The results are given in Table 5.4. As we expected, the precision for the assay itself is better than the precision for the overall method because of the exclusion of the extraction step. In summary, the overall method precision was within 30% for the PAH assay and within 25% for the C-PAH assay.

Known amounts of phenanthrene were spiked into the soil samples and subsequently analyzed by PAH ELISA, and known amounts of benzo[a]pyrene were spiked into different aliquots of soil samples and analyzed by C-PAH ELISA. The recovery data are summarized in Table 5.5. Quantitative recoveries of phenanthrene and benzo[a]pyrene were obtained from PAH ELISA and C-PAH ELISA, respectively. It should be noted that when a mixture of 16 PAH was spiked into the soil samples, greater than 400% recovery of phenanthrene was observed using PAH ELISA. This is mainly because other PAH also contributed to ELISA responses. The same observation was noted for the recovery of benzo[a]pyrene using C-PAH ELISA. The recovery data of mixtures of PAH cannot be addressed, mainly due to the fact that the

Table 5.3. Overall Method Precision of ELISA Screening for PAH and C-PAH

	Precision, %[a]	
Sample Code[b]	PAH Assay	C-PAH Assay
A-HD-S	11.9	9.22
A-HD-X	24.7	20.7
K-ES-S	23.0	5.89
G-PS-S	28.5	11.1

[a] The precision is expressed as percent relative standard deviation (RSD) of the triplicate sets of dust/soil samples.

[b] A, B, etc. denote household code; HD denotes house dust; ES denotes entryway dust; PS denotes pathway soil; and S and X denote the field study conducted in the summar of 1995 and in the spring of 1996, respectively.

$$RSD,\% = \frac{standard\ deviation}{Mean} \times 100\%$$

Table 5.4. Assay Precision for the PAH and C-PAH ELISA Screening

	Precision, %[a]	
Sample Code[b]	PAH Assay	C-PAH Assay
A-HD-X	8.45	3.94
A-ES-X	13.3	7.69
C-ES-X	1.96	17.3
A-PS-X	4.40	5.24
B-PS-X	6.81	7.64
C-PS-X	6.43	10.9
FSP-54-12945	7.29	7.12

[a] The precision is expressed as percent relative standard deviation (RSD) of the triplicate sets of dust/soil sample extracts.

[b] A, B, etc. denote household code; HD denotes house dust; ES denotes entryway dust; PS denotes pathway soil; X denotes the field sampling conducted in the spring of 1996; and FSP denotes foundation soil sample.

$$RSD,\% = \frac{standard\ deviation}{Mean} \times 100\%$$

Table 5.5. Recoveries of Phenanthrene and Benzo[a]pyrene from Dust/Soil Samples

Sample Codea	Spike Level, ppm[b]	Recovery, %
PAH ELISA		
J-PS-S	5	150
J-PS-S	5	130
B-ES-X	2.5	107
B-ES-X	2.5	115
B-ES-X	0.5	68
C-PAH ELISA		
J-PS-S	0.1	130
J-PS-S	0.1	120
B-ES-S	0.2	110
B-ES-S	0.2	120

[a] A, B, etc. denote household code; ES denotes entryway dust; PS denotes pathway soil; and S and X denote the field study conducted in the summer of 1995 and in the spring of 1996, respectively.

[b] Phenanthrene was spiked into each sample for PAH ELISA and benzo[a]pyrene was spiked onto each sample for C-PAH ELISA.

calibration of PAH ELISA was based on phenanthrene, and the calibration of C-PAH ELISA was based on benzo[a]pyrene. Approximately 50% recovery of phenanthrene was observed when known amounts of phenanthrene-d_{10} were spiked onto the dust sample using PAH assay. This finding suggested that the ELISA responses of phenanthrene and phenanthrene-d_{10} are different. The overall method accuracy for both PAH and C-PAH assays cannot be addressed because neither assay can accurately determine either total PAH or carcinogenic PAH in the sample matrices containing a mixture of PAH compounds. However, PAH and C-PAH assays can still be used as screening tools for estimating PAH levels, but can not be used as a quantitative method.

The PAH ELISA quantification limit is set at 2 ppb equivalent assay concentration by the vendor. The sample extracts were spiked at 1, 0.1, and 0.05 ppb equivalent assay concentrations of phenanthrene and assayed. As expected, the results showed no increase of PAH ELISA response at these spiking levels. The C-PAH ELISA quantification limit is set at 0.2 ppb equivalent assay concentration. The sample extracts were spiked at 0.1, 0.05, 0.01, and 0.005 ppb equivalent assay concentrations of benzo[a]pyrene and assayed. The results showed no increase of C-PAH ELISA responses for all but 0.1 ppb level. At 0.1 ppb spike level, the recovery of benzo[a]pyrene was 140%. This finding suggested that C-PAH ELISA quantification limits might be lower than the specified value (0.2 ppb).

The sample extracts of air and 24-hr liquid and solid composite food samples generated from the Cooperative Agreement studies were analyzed by PAH ELISA and C-PAH ELISA. The dust/soil samples from 13 low-income families and 22 NHEXAS homes were prepared and analyzed by both assays. The ELISA derived concentrations were compared with the concentrations from conventional GC/MS analysis. These comparisons are discussed in a later section.

Alkyl PAH in Multi-Media Samples

The sample extracts of air, dust/soil, and food generated from 13 low-income families were analyzed by GC/MS for alkyl PAH (6,7). These samples were collected and prepared in the summer of 1995. The concentrations of alkyl PAH found in the indoor and outdoor air samples are summarized in Table 5.6. The alkyl PAH concentrations in indoor and outdoor air of each household are given in Appendix C. Note that households A through G are located in the inner city and households H through M are located in rural areas. These data provided values expressed in ng/m^3 for the alkyl PAH isomers and the sum of all alkyl PAH. The data reported in Table 5.6, in Appendix C, and in the following sections were corrected for the background levels in the field blank. The most abundant alkyl PAH found in air were methyl- and C2-alkyl-naphthalene isomers. The parent compound naphthalene was also the most abundant parent PAH in these air samples (6,7). The levels of 2- to 3- ring alkyl PAH found in indoor air were higher than those in the corresponding outdoor air. Similar concentrations of most 4- to 6-ring alkyl PAH were observed in both indoor and outdoor air within each nonsmoker's household. Higher concentrations of these 4- to 6-ring alkyl PAH were found in the indoor air as compared to the outdoor air within each smoker's household (households F, G, K and M). In general, higher levels of alkyl PAH were observed in inner city outdoor air as compared to the rural area outdoor air. The sum of the concentrations of alkyl PAH ranged from 369 to 3270 ng/m^3 in indoor air and from 49.9 to 702 ng/m^3 in outdoor air.

The alkyl PAH concentrations measured in the house dust, entryway dust, and pathway soil samples are summarized in Table 5.7. The alkyl PAH concentrations of each dust/soil sample are presented in Appendix D. The alkyl PAH concentrations corrected for the background levels in the field blank are expressed in units of ppm (μg/g). In general, the most abundant alkyl PAH were alkyl 3-ring PAH isomers. The sum of the concentrations of the alkyl PAH ranged from 0.584 to 3.32 ppm in house dust, from 0.218 to 1.54 ppm in entryway dust, and from 0.092 to 1.98 ppm in pathway soil. With few exceptions, the relative concentration

Table 5.6. Summary of Alkyl PAH Concentrations (ng/m^3) in Indoor and Outdoor Air Samples

	Indoor Air			Outdoor Air		
Compound	Maximum	Minimum	Average	Maximum	Minimum	Average
2-Methylnaphthalene	715	107	298	134	15.3	56.7
1-Methylnaphthalene	621	78.3	247	122	8.25	40.6
C2-alkylnaphthalene isomers	1780	145	572	374	9.31	92.3
C1-alkylphenanthrene isomers	112	12.3	40.3	30.8	2.06	9.53
C2-alkylphenanthrene isomers	174	21.2	63.2	32.6	2.95	11.0
C1-alkylpyrene isomers	49.3	1.30	7.08	3.06	0.664	1.32
C2-alkylpyrene isomers	4.64	0.395	1.36	0.895	0.201	0.405
C1-alkylchrysene isomers	2.13	0.144	0.565	1.09	0.079	0.297
C2-alkylchrysene isomers	8.63	1.41	3.83	3.70	0.716	1.62
C1-alkylbenzo[a]pyrene isomers	23.0	0.772	5.48	4.75	0.898	1.78
Sum of alkyl PAH	3270	369	1240	702	49.9	216

Table 5.7. Summary of Alkyl PAH Concentration (ppm) in House Dust, Entryway Dust, and Pathway Soil Samples

	House Dust			Entryway Dust			Pathway Soil		
Compound	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
2-Methylnaphthalene	0.046	0.012	0.023	0.028	0.005	0.011	0.009	0.001	0.003
1-Methylnaphthalene	0.025	0.008	0.015	0.022	0.003	0.008	0.006	0.001	0.002
C2-alkylnaphthalene isomers	0.301	0.034	0.106	0.082	0.019	0.040	0.021	0.004	0.009
C1-alkylphenanthrene isomers	0.875	0.088	0.359	0.239	0.024	0.102	0.240	0.006	0.049
C2-alkylphenanthrene isomers	1.89	0.131	0.499	0.341	0.067	0.193	0.967	0.029	0.167
C1-alkylpyrene isomers	0.282	0.074	0.149	0.280	0.027	0.121	0.422	0.011	0.084
C2-alkylpyrene isomers	0.156	0.039	0.082	0.104	0.013	0.051	0.103	0.006	0.028
C1-alkylchrysene isomers	0.304	0.036	0.092	0.113	0.015	0.052	0.096	0.003	0.023
C2-alkylchrysene isomers	0.286	0.025	0.099	0.029	0.013	0.019	0.113	0.005	0.018
C1-alkylbenzo[a]pyrene isomers	0.095	0.023	0.055	1.05	0.031	0.222	0.142	0.005	0.036
Sum of alkyl PAH	3.32	0.584	1.48	1.54	0.218	0.819	1.98	0.092	0.421

trend for alkyl PAH is house dust > entryway dust > pathway soil. This relative concentration trend was also observed for the parent PAH in these samples. The alkyl PAH concentrations measured in food samples are summarized in Table 5.8. Alkyl PAH concentrations are expressed in units of ppb (ng/g). The concentrations of alkyl PAH in each adult's and child's food sample are presented in Appendix E. The reported concen-trations of each food sample were corrected for the background levels in the field blank. The most abundant alkyl PAH found in the food samples are 2- to 3-ring alkyl PAH. Concentrations of alkyl PAH found in the adult's food samples were within the same order of magnitude as those in the child's food samples. The sum of alkyl PAH concentrations ranged from 0.866 to 13.9 ppb in adult food samples and from 2.10 to 15.6 ppb in child food samples.

Phthalates in Multi-Media Samples

The concentrations of target phthalates found in indoor and outdoor air samples are summarized in Table 5.9. The phthalate concentrations in individual air samples are given in Appendix F. The reported values were corrected for the background levels found in the field blank. In general, levels of phthalates found in the indoor air were higher than the corresponding outdoor air. Indoor phthalate concentrations ranged from 3.07 (di-n-octylphthalate) to 3490 (bis(2-ethylhexyl)phthalate) ng/m^3. The concentrations in outdoor air ranged from 0.475 (di-n-octylphthalate) to 594 (butylbenzylphthalate) ng/m^3.

Table 5.10 summarizes the background-corrected levels of phthalates found in house dust, entryway dust, and pathway soil samples. The phthalate concentrations of individual dust/soil samples are given in Appendix G. The general relative concentrations trend of phthalates was similar to those of PAH and alkyl PAH: house dust > entryway dust > pathway soil. The most abundant phthalates were either butylbenzylphthalate or bis(2-ethylhexyl)phthalate and the least abundant phthalate was dimethylphthalate. Note that we only measured the six target phthalate compounds because of the availability of the standards. There were other phthalates present at significant levels in the dust/soil samples which are not reported in these tables.

Table 5.8. Summary of Alkyl PAH Concentrations (ppb) in Food Samples

	Adult Subjects			Child Subjects		
Compound	Maximum	Minimum	Average	Maximum	Minimum	Average
2-Methylnaphthalene	2.36	0.009	0.524	3.21	0.011	0.555
1-Methylnaphthalene	1.67	0.049	0.326	1.95	0.013	0.344
C2-alkylnaphthalene isomers	4.32	0.235	1.74	5.03	0.419	1.86
C1-alkylphenanthrene isomers	3.98	0.118	1.80	3.49	0.505	1.44
C2-alkylphenanthrene isomers	2.53	0.136	1.23	2.74	0.549	1.08
C1-alkylpyrene isomers	2.61	0.092	1.25	2.69	0.137	0.854
C2-alkylpyrene isomers	0.294	0.024	0.148	0.918	0.061	0.182
C1-alkylchrysene isomers	0.521	0.030	0.181	0.331	0.026	0.114
C2-alkylchrysene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
C1-alkylbenzo[a]pyrene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sum of alkyl PAH	13.9	0.866	7.20	15.6	2.10	6.42

Table 5.9. Summary of Phthalates Concentrations (ng/m³) in Indoor and Outdoor Air Samples

	Indoor Air			Outdoor Air		
Compound	Maximum	Minimum	Average	Maximum	Minimum	Average
Dimethylphthalate	137	29.4	65.5	16.5	1.80	6.98
Diethylphthalate	2560	299	924	171	18.6	68.8
Di-n-butylphthalate	545	123	245	148	1.93	44.8
Butylbenzylphthalate	970	9.27	323	594	2.38	259
Bis(2-ethylhexyl)phthalate	3490	148	625	434	5.98	159
Di-n-octylphthalate	30.6	3.07	11.1	6.09	0.475	2.47
Sum of Target Phthalates	5330	1160	2060	1070	64.2	507

Table 5.10. Summary of Phthalates Concentrations (ppm) in House Dust, Entryway Dust, and Pathway Soil Samples

	House Dust			Entryway Dust			Pathway Soil		
Compound	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Dimethylphthalate	0.234	0.006	0.041	0.028	0.001	0.007	0.005	<0.001	0.001
Diethylphthalate	1.27	0.236	0.686	0.410	0.092	0.208	0.016	0.004	0.005
Di-n-butylphthalate	5.45	0.868	2.98	2.40	0.071	0.698	0.218	0.011	0.070
Butylbenzylphthalate	114	4.88	34.1	80.7	0.855	15.1	1.29	0.007	0.248
Bis(2-ethylhexyl)phthalate	131	20.6	63.2	76.5	8.57	26.0	2.59	0.018	0.477
Di-n-octylphthalate	28.2	0.526	5.3	7.07	0.084	1.88	0.061	0.004	0.020
Sum of Target Phthalates	160	28.5	77.3	109	11.5	40.8	2.68	0.039	0.822

Levels of target phthalates ranged from 0.006 to 131 ppm in house dust, from 0.001 to 80.7 ppm in entryway dust, and from <0.001 to 2.59 ppm in pathway soil.

The concentrations of phthalates found in the food samples are summarized in Table 5.11. The concentrations of the individual food samples are presented in Appendix H. The reported concentrations were corrected for the background levels found in the method blank. Note that all food containers were made of plastic materials that can contribute to the amounts of phthalates found in the food samples. The concentrations of phthalates ranged from < 0.02 to 110 ppb in adult food samples and from < 0.02 to 84.3 ppb in child food samples. In general, levels of phthalates found in the adult food samples were higher than those in the child food samples. There were also other nontarget phthalates present at significant amounts in these food samples.

PAH in Dust/Soil Samples

House dust, entryway dust, and pathway dust samples were collected from 13 low-income families during the spring of 1996 under a Cooperative Agreement study (6). Aliquots of the samples were extracted with hexane and analyzed by GC/MS for target PAH. The PAH results are summarized in Table 5.12. The PAH concentrations in individual samples are presented in Appendix I. All the reported values were corrected for the background levels found in the field blank. The sum of the concentrations of the B2 PAH ranged from 0.267 to 7.02 ppm in house dust, from 0.036 to 0.486 in entryway dust and from 0.009 to 0.701 ppm in pathway soil. With few exceptions, the sum of the concentrations of B2 PAH accounted for approximately half of the total target PAH concentrations. The concentration trend for most PAH is house dust > entryway dust > pathway soil. The finding was also observed in the dust/soil samples collected at the same households during the winter and summer seasons. House dust, foundation soil and yard soil samples collected from 22 NHEXAS homes (5) were extracted by hexane and analyzed by GC/MS for target PAH. The GC/MS results are summarized in Table 5.13. The PAH concentrations in individual samples are presented in

Table 5.11. Summary of Phthalates Concentrations (ppb) in Food Samples

Compound	Adult Subjects			Child Subjects		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Dimethylphthalate	1.92	0.012	0.447	0.414	0.028	0.128
Diethylphthalate	2.40	0.013	1.18	19.0	<0.02	1.97
Di-n-butylphthalate	9.81	0.285	3.75	4.66	<0.02	1.11
Butylbenzylphthalate	83.1	1.31	24.3	35.9	<0.02	6.48
Bis(2-ethylhexyl)phthalate	110	2.37	49.8	84.3	<0.02	10.9
Di-n-octylphthalate	54.1	<0.02	10.2	15.6	0.011	1.54
Sum of phthalates	245	11.5	89.6	114	0.09	22.1

Appendix J. The reported values were corrected for the background levels found in the laboratory method blank, since no field blank was available for this study. The sum of the concentrations of the B2 PAH ranged from 0.263 to 4.30 ppm in house dust, from 0.011 to 2.92 ppm in foundation soil and from 0.007 to 1.82 ppm in yard soil. In general, the concentrations of PAH in house dust samples were higher than those in the foundation soil and yard soil samples. Similar PAH concentrations were found in the foundation soil and yard soil samples. The sum of the concentrations of target PAH was greater than 1 ppm in 16 out of 22 house dust samples, but only in 2 foundation soil and 2 yard soil samples. The two households having greater than 1 ppm PAH levels in foundation soil also had greater than 1 ppm PAH levels in yard soil. The sum of the concentrations of B2 PAH accounted for approximately half of the total target PAH concentrations for most dust/soil samples. This finding was also observed in the dust/soil samples collected from the 13 low-income families.

Table 5.12. Summary of PAH Concentrations (ppm) House Dust, Entryway Dust, and Pathway Soil Samples

	House Dust			Entryway Dust			Pathway Soil		
Compound[a]	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Naphthalene	0.212	0.018	0.074	0.094	0.001	0.022	0.026	0.003	0.011
Biphenyl	0.516	0.020	0.117	0.215	0.004	0.037	0.011	0.001	0.005
Acenaphthylene	0.131	0.007	0.035	0.032	0.001	0.008	0.033	<0.001	0.006
Acenaphthene	0.202	0.007	0.052	0.080	0.001	0.011	0.012	0.001	0.004
Fluorene	0.814	0.015	0.110	0.191	0.003	0.022	0.015	0.002	0.006
Phenanthrene	1.32	0.063	0.321	0.223	0.019	0.070	0.156	0.007	0.054
Anthracene	0.331	0.007	0.056	0.119	0.002	0.039	0.058	0.001	0.013
Fluoranthene	2.15	0.129	0.502	0.337	0.019	0.143	0.330	0.004	0.108
Pyrene	1.57	0.087	0.359	0.251	0.016	0.110	0.264	0.004	0.082
Benz[a]anthracene*	1.47	0.041	0.255	0.067	0.004	0.026	0.100	0.001	0.029
Cyclopenta[c,d]pyrene	0.404	0.008	0.065	0.020	0.001	0.008	0.030	<0.001	0.009
Chrysene*	1.05	0.049	0.245	0.202	0.006	0.056	0.143	0.002	0.046
Benzofluoranthenes*	2.45	0.105	0.460	0.149	0.014	0.074	0.258	0.004	0.083
Benzo[e]pyrene	0.907	0.040	0.195	0.070	0.006	0.031	0.095	0.002	0.033
Benzo[a]pyrene*	0.931	0.022	0.150	0.048	0.004	0.022	0.098	0.001	0.028
Indeno[1,2,3-c,d]pyrene*	0.879	0.025	0.165	0.056	0.006	0.026	0.100	0.001	0.027
Dibenz[a,h]anthracene*	0.240	0.012	0.042	0.012	0.002	0.006	0.024	<0.001	0.007
Benzo[g,h,i]perylene	0.817	0.035	0.157	0.057	0.006	0.027	0.096	0.001	0.029
Coronene	0.283	0.016	0.062	0.028	0.000	0.011	0.030	0.001	0.011
Sum of Target PAH	15.6	0.833	3.42	1.90	0.139	0.746	1.75	0.038	0.590
Sum of B2 PAH	7.02	0.267	1.32	0.486	0.036	0.210	0.701	0.009	0.220

[a] * denotes that the target PAH are ranked as probable human carcinogens (B2) by U.S. EPA's Integrated Risk Information System.

Table 5.13. Summary of PAH Concentrations (ppm) in House Dust, Foundation Soil, and Yard Soil

	House Dust			Foundation Soil			Yard Soil		
Compound[a]	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Naphthalene	0.095	0.006	0.042	0.011	0.002	0.005	0.009	0.002	0.005
Biphenyl	0.064	0.001	0.027	0.015	0.001	0.003	0.014	0.001	0.003
Acenaphthylene	0.041	0.001	0.013	0.009	<0.001	0.002	0.004	<0.001	0.001
Acenaphthene	0.039	0.005	0.017	0.020	<0.001	0.003	0.005	<0.001	0.002
Fluorene	0.054	0.009	0.023	0.016	0.001	0.003	0.006	0.001	0.003
Phenanthrene	0.244	0.040	0.120	0.297	0.004	0.042	0.099	0.004	0.025
Anthracene	0.130	0.005	0.028	0.109	<0.001	0.012	0.012	0.001	0.003
Fluoranthene	0.746	0.047	0.199	0.780	0.004	0.090	0.330	0.005	0.040
Pyrene	0.720	0.043	0.173	0.808	0.002	0.090	0.351	0.003	0.038
Benz[a]anthracene*	0.468	0.017	0.091	0.443	0.001	0.048	0.175	0.001	0.019
Cyclopenta[c,d]pyrene	0.148	0.003	0.020	0.121	<0.001	0.014	0.053	<0.001	0.006
Chrysene*	0.685	0.048	0.149	0.564	0.001	0.075	0.319	0.001	0.036
Benzofluoranthenes*	1.58	0.075	0.314	0.932	0.002	0.126	0.590	0.002	0.062
Benzo[e]pyrene	0.578	0.031	0.134	0.341	0.001	0.051	0.221	0.001	0.024
Benzo[a]pyrene*	0.680	0.018	0.107	0.484	0.001	0.060	0.306	0.001	0.029
Indeno[1,2,3-c,d]pyrene*	0.727	0.032	0.143	0.405	0.002	0.061	0.332	0.001	0.033
Dibenz[a,h]anthracene*	0.158	0.009	0.035	0.103	0.001	0.016	0.100	<0.001	0.010
Benzo[g,h,i]perylene	0.636	0.032	0.130	0.347	0.001	0.060	0.307	0.001	0.031
Coronene	0.215	0.015	0.072	0.146	0.001	0.025	0.083	0.001	0.014
Sum of Target PAH	7.69	0.649	1.84	5.93	0.042	0.786	3.30	0.037	0.381
Sum of B2 PAH	4.30	0.263	0.840	2.92	0.011	0.387	1.82	0.007	0.188

[a] * denotes that the target PAH are ranked as probable human carcinogens (B2) by U.S. EPA's Integrated Risk Information System.

Relationship Among B2 PAH, Total Target PAH, and SVOC

As we discussed above, the sums of B2 PAH concentrations accounted for approximately half of the levels of total target PAH in most dust/soil samples. This relationship was further examined in other sample media. Table 5.14 presents Pearson correlation coefficients (r) obtained by correlating the sums of B2 PAH levels with total target PAH levels in the samples from each sample medium. The p values shown in the parentheses indicate the statistically significant level for the null hypothesis, i.e., that there are zero correlations between B2 PAH and total target PAH in each sample medium. All sample media but indoor air samples tended to give good correlations between B2 PAH and total PAH. The levels of B2 PAH correlated well ($r > 0.90$) with total target PAH in dust/soil samples. Similar but weaker relationships were observed in outdoor air ($r = 0.860$) and food ($r = 0.670$) samples. The poor correlations between B2 PAH and total target PAH in indoor air samples could be due to the high levels of 2- to 3-ring PAH found in indoor air that account for a majority of total target PAH. Strong relationships between B2 PAH and total target PAH were observed in the dust/soil samples collected from 13 low-income homes and 22 NHEXAS homes. These correlations were also observed in the combined data set from 13 low-income homes and 22 NHEXAS homes. Figures 5.1 and 5.2 display the relationships between B2 PAH and total target PAH in the dust/soil samples. Data shown in Figure 5.1 were from 78 dust/soil samples collected from 13 low-income homes during the summer and the spring seasons. Data displayed in Figure 5.2 were from 63 dust/soil samples of 22 NHEXAS homes. The data from the NHEXAS samples showed a slightly higher correlation ($r = 0.993$) than that ($r = 0.976$) from the samples from low-income homes. A similar linear relationship was also observed from the combined data set. The dust and soil samples from 13 low-income homes in the summer field study were also analyzed for alkyl PAH and phthalates. The relationship ($r=0.573$) for alkyl PAH and total target PAH in these dust/soil samples was not as strong as that for the B2 PAH and total target PAH. Similar results ($r=0.589$) were observed between total target PAH and phthalates in these samples.

Table 5.14. Correlation Coefficients (r) Between B2 PAH and Total Target PAH in Each Sample Medium

Sample Medium[a]	Correlation Coefficient, r[b]
Indoor Air (low-income homes, N=13)	-0.146 (0.6334)
Outdoor Air (low-income homes, N=13)	0.860 (0.0002)
Food (low-income homes, N=26)	0.670 (0.0002)
House Dust (low-income homes, N=26)	0.978 (0.0001)
Entryway Dust (low-income homes, N=26)	0.962 (0.0001)
Pathway Soil (low-income homes, N=26)	0.991 (0.0001)
House Dust (NHEXAS homes, N=22)	0.994 (0.0001)
Yard Soil (NHEXAS homes, N=21)	0.999 (0.0001)
Foundation Soil (NHEXAS homes, N=20)	0.997 (0.0001)
Dust/Soil (low-income homes, N=78)	0.976 (0.0001)
Dust/Soil (NHEXAS homes, N=63)	0.993 (0.0001)
Dust/Soil (combined data, N=141)	0.973 (0.0001)

[a] Data of indoor air, outdoor air, and food are from the summer field study of 13 low-income homes; data of the house dust, entryway dust, and pathway soil are from the summer and the spring field study of 13 low-income homes; and data from house dust, yard soil, and foundation soil are from NEXAS study.

[b] The corresponding P value is shown in parentheses.

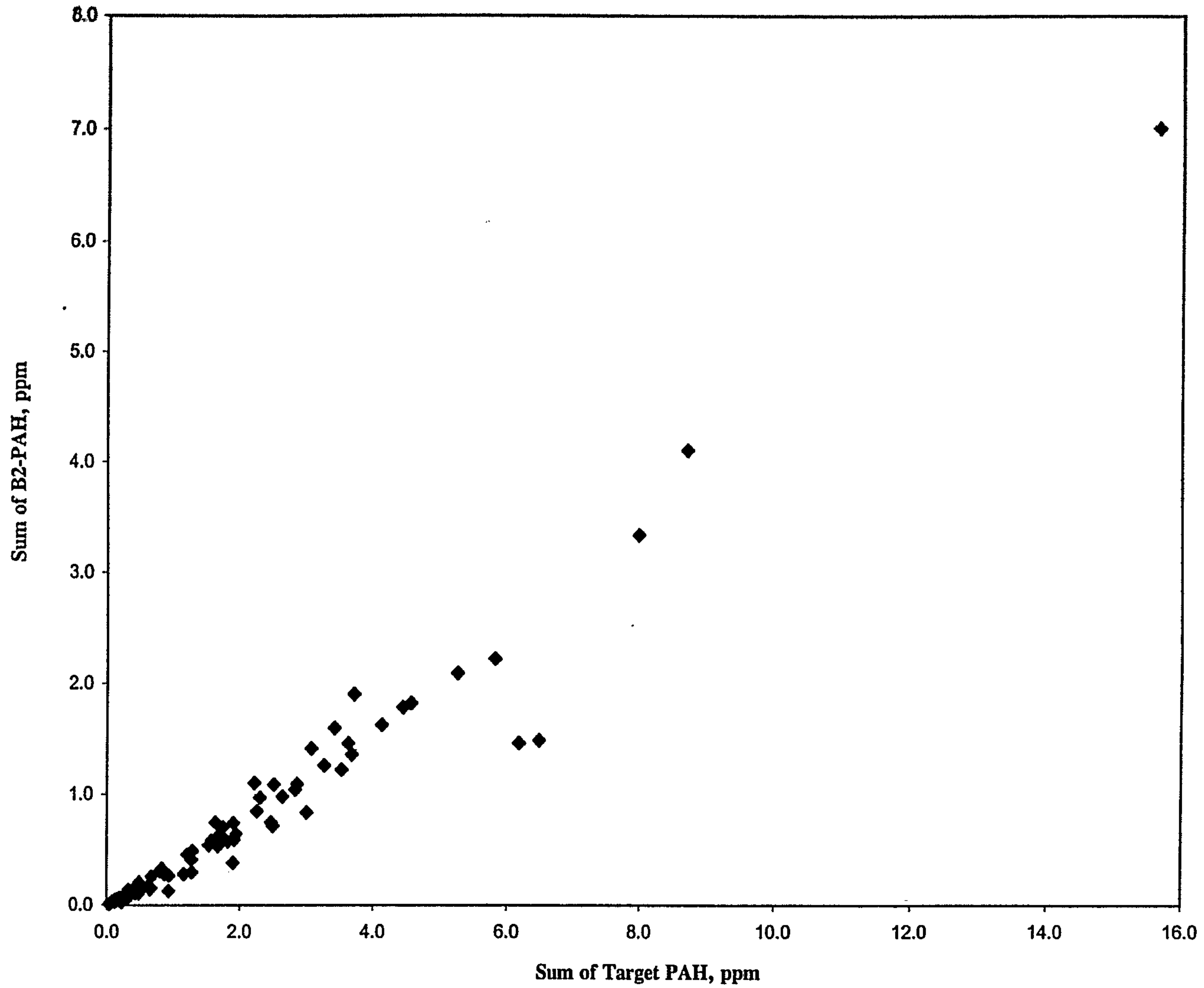


Figure 5.1 Relationship of B2 PAH and Total Target PAH in Dust/Soil Samples from 13 Low-Income Homes

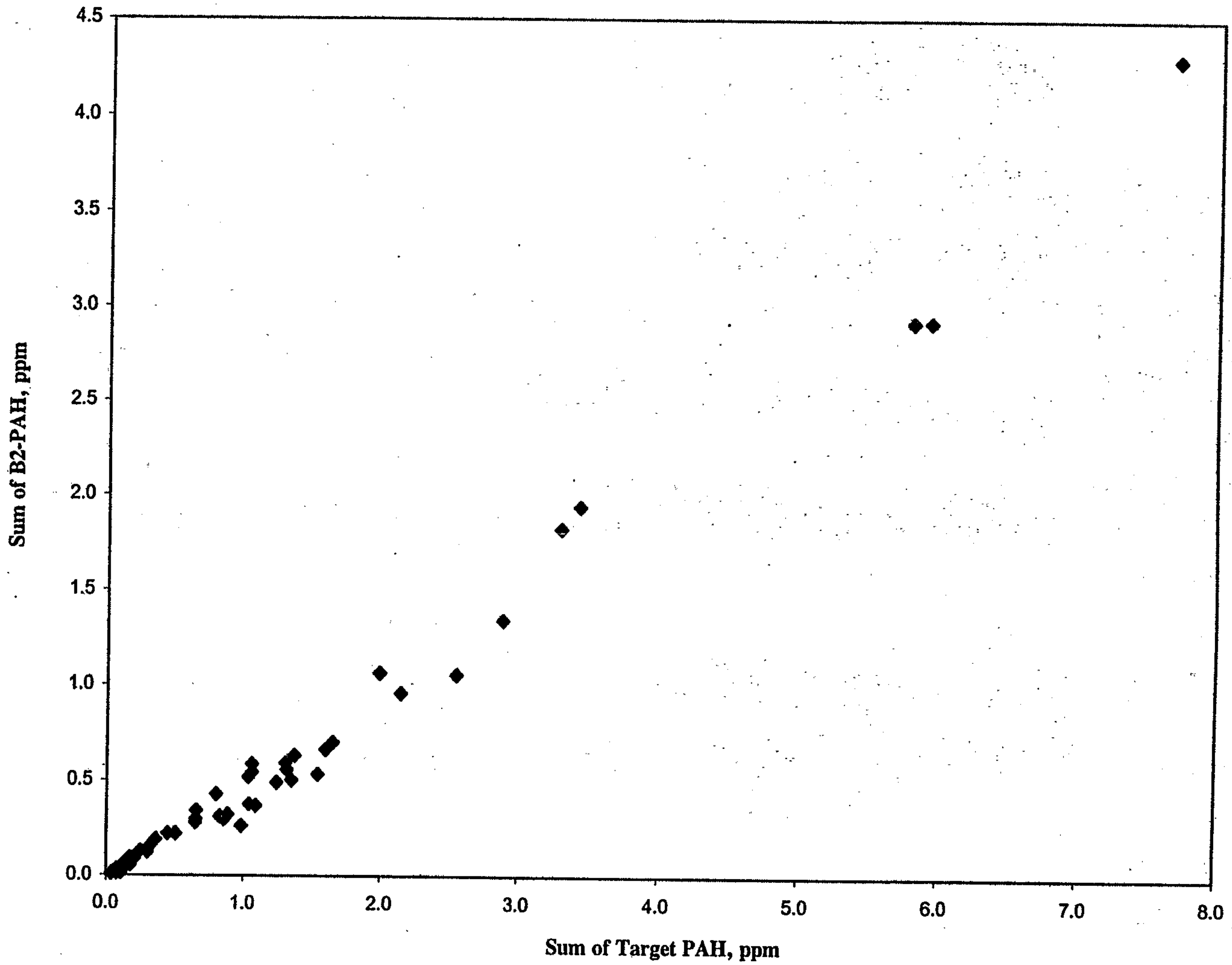


Figure 5.2 Relationship of B2 PAH and Total Target PAH in Dust/Soil Samples from 22 NHEXAS Homes

Relationships of PAH Among Different Sample Media

Multimedia samples were collected from low-income families for the Cooperative Agreement Study. It is of interest to know whether the levels of PAH in dust and soil are related to their levels in other sample media. The correlation between the measured total target PAH concentrations in different sample media was investigated. Table 5.15 presents Pearson correlation coefficients (r) for the PAH levels in one sample medium (e.g., house dust) with the PAH levels in another sample medium (e.g., entryway dust). As shown in Table 5.15, levels of total target PAH did not appear to be highly correlated in any of the different sample media. Among all sample media, the strongest relationship was observed between house dust and outdoor air samples. In general, there were positive but weak relationships for total target PAH found among dust, soil, and air samples. Similar results were also obtained for B2 PAH.

Since the food samples were the 24-hr composite solid and liquid food consumed by the subjects, as we expected there are no strong direct relationships between the food samples and other types of samples. Similar results were obtained for the sums of B2 PAH in different sample media.

The correlation between the measured PAH concentrations in house dust/yard soil/foundation soil from 22 NHEXAS homes was also investigated. Table 5.16 summarizes the correlation coefficients for total PAH and for B2 PAH among floor dust (house dust), yard soil, and foundation soil. The correlations between PAH and B2 PAH levels in house dust/yard soil and foundation soil/yard soil were higher than those obtained from the house dust/foundation soil. Similar positive relationships of PAH levels found in house dust/entryway dust and house dust/pathway soil were also observed from a previous 8-home study conducted at Columbus, Ohio (8).

Table 5.15. Correlation Coefficients (r) for Total Target PAH in Different Sample Media

	Correlation Coefficient, r[a]						
Sample Media	House Dust	Entryway Dust	Pathway Soil	Indoor Air	Outdoor Air	Adult Food	Child Food
House Dust	1.000	0.235 (0.293)	0.0114 (0.960)	0.452 (0.0349)	0.672 (0.0006)	0.250 (0.262)	0.186 (0.407)
Entryway Dust		1.000	0.367 (0.0933)	0.173 (0.442)	0.137 (0.545)	-0.063 (0.780)	0.012 (0.957)
Pathway Soil			1.000	0.023 (0.918)	0.061 (0.788)	0.173 (0.442)	-0.122 (0.587)
Indoor Air				1.000	0.434 (0.0437)	0.235 (0.292)	0.083 (0.713)
Outdoor Air					1.000	0.250 (0.263)	-0.112 (0.621)
Adult Food						1.000	0.163 (0.468)
Child Food							1.000

[a] The corresponding P value is shown in parentheses.

Table 5.16. Correlation Coefficients (r) for Total Target PAH and for B2-PAH in House Dust, Foundation Soil, and Yard Soil

Correlation Calculated Between Sample Media[a]	Correlation Coefficient, r[b]	
	Total Target PAH	B2-PAH
FDP FSP	0.326 (0.1610)	0.394 (0.0860)
FDP YSP	0.725 (0.0003)	0.776 (0.0001)
FSP YSP	0.680 (0.0014)	0.710 (0.0007)

[a] FDP denotes floor dust samples equivalent to house dust samples; FSP denotes foundation soil samples; and YSP denotes yard soil samples.
[b] The corresponding P value is shown in parentheses.

In summary, there were positive but weak relationships observed for PAH found in house dust/indoor air, house dust/outdoor air, house dust/entryway dust and house dust/pathway soil from the 13 low-income families. A positive and relatively strong relationship was observed for PAH found in house dust and yard soil from the 22 NHEXAS homes. Thus, PAH levels in house dust may be used as qualitative indicators for PAH levels found in soil or air but not food.

Comparison of PAH Data from ELISA and GC/MS

Statistical analysis was conducted on the PAH data of multimedia samples analyzed by both GC/MS and ELISA methods. Table 5.17 summarizes the number of samples analyzed for PAH by study, sample type, and analysis method. Additionally, alkylated PAH GC/MS measurements were made on dust, soil, food, and air samples from 13 low income homes in the summer field study. A listing of all data used for the statistical analysis is given in Appendix K. ELISA measurements that are not in the linear range of the calibration curves are listed along with an asterisk (*) in Appendix K. The PAH GC/MS responses are the sums of concentrations of all target parent PAH and the B2 PAH GC/MS responses are the sums of

Table 5.17 Number of Samples Analyzed by ELISA and GC/MS Methods

Study	Sample Type[a]	PAH Analysis			C-PAH/B2-PAH Analysis		
		ELISA	GC/MS	Both	ELISA	GC/MS	Both
Summer Field Study (North Carolina)	HD	9	13	9	9	13	9
	ES	9	13	9	9	13	9
	PS	13	13	13	13	13	13
	Food	18	26	18	18	26	18
	Air	18	26	18	18	26	18
Spring Field Study (North Carolina)	HD	13	13	13	13	13	13
	ES	13	13	13	13	13	13
	PS	13	13	13	13	13	13
NHEXAS Study (Arizona)	FDP	22	22	22	22	22	22
	FSP	20	20	20	20	20	20
	YSP	21	21	21	21	21	21

a: HD = house dust; ES = entryway dust; PS = pathway soil; FDP = floor dust; FSP = foundation soil; YSP = yard soil.

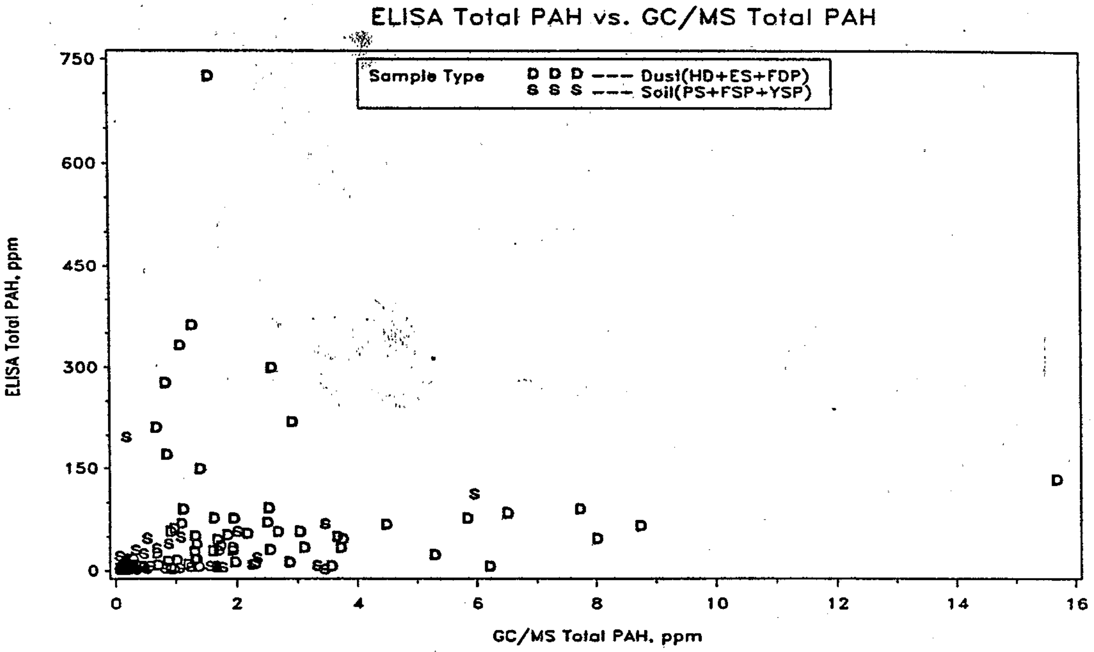
concentrations of target B2 PAH. Note that nine house dust samples (FDP) and one yard soil sample (YSP) of the NHEXAS study have very high (> 148 ppm) total PAH concentrations according to the ELISA method. The upper and lower portions of Figure 5.3 display the scatter plots of ELISA total PAH versus GC/MS total PAH in raw units and log-transformed units, respectively. Note that all log-transformed data discussed in this report referred to natural log-transformed data. Similarily, Figure 5.4 displays the scatter plots of ELISA C-PAH versus GC/MS B2-PAH. As shown in the raw data plots, most of the data are concentrated at lower PAH levels. The skewness of the data suggested performing the statistical analyses in a log scale.

To further describe the distribution of data, two-way frequency tables of ELISA total PAH versus GC/MS total PAH and ELISA C-PAH versus GC/MS B2-PAH are presented for each sample type in Appendix L. Cut-off points were chosen to best describe the spread of the data.

Summary statistics (Sample Size, Mean, Standard Deviation, Minimum, and Maximum) for the ELISA measurements of total PAH and C-PAH and GC/MC measurements of total PAH and B2-PAH in dust, soil, food and air samples are displayed in Appendix M. The dust samples include house dust (HD and FDP) and entryway dust (ES). Soil samples consist of pathway soil (PS), foundation soil (FSP), and yard soil (YSP). Note the big differences in the ranges of PAH concentrations that were obtained by the two analysis methods. For example, ELISA total PAH concentrations in FDP samples range from 5.10 to 725 ppm, whereas GC/MS total PAH concentrations range from 0.65 to 7.69 ppm. Similar differences exist in other types of samples.

Paired t-tests

In order to achieve the normality of data, the natural log-transformation was used in performing paired t-tests on dust/soil samples. Results of paired t-tests for the differences



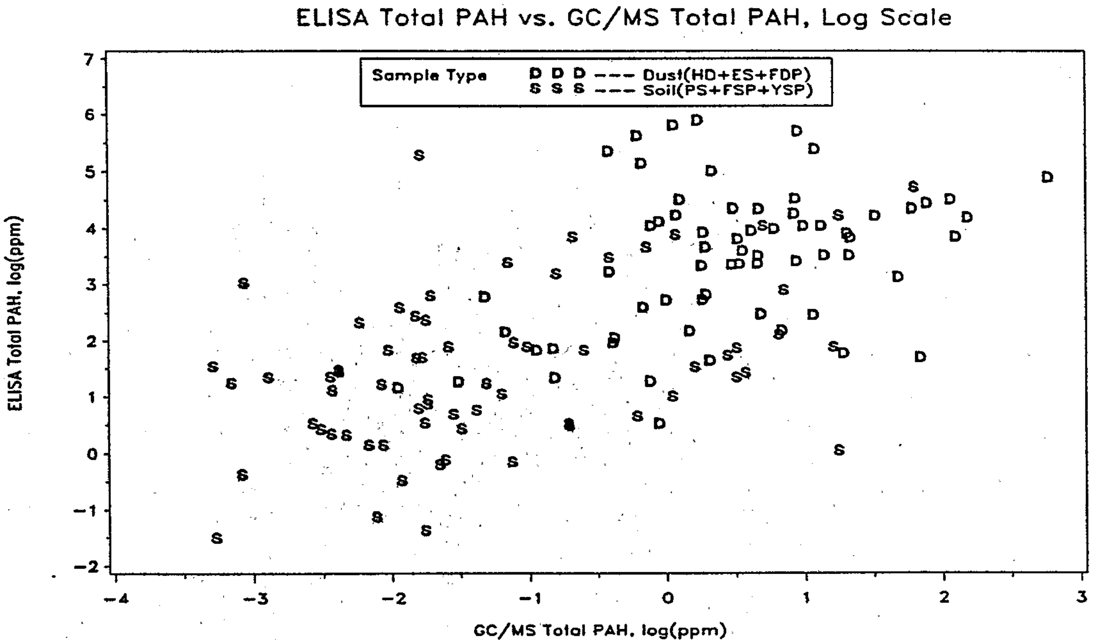


Figure 5.3. Scatter plots of ELISA total PAH versus GC/MS total target PAH.

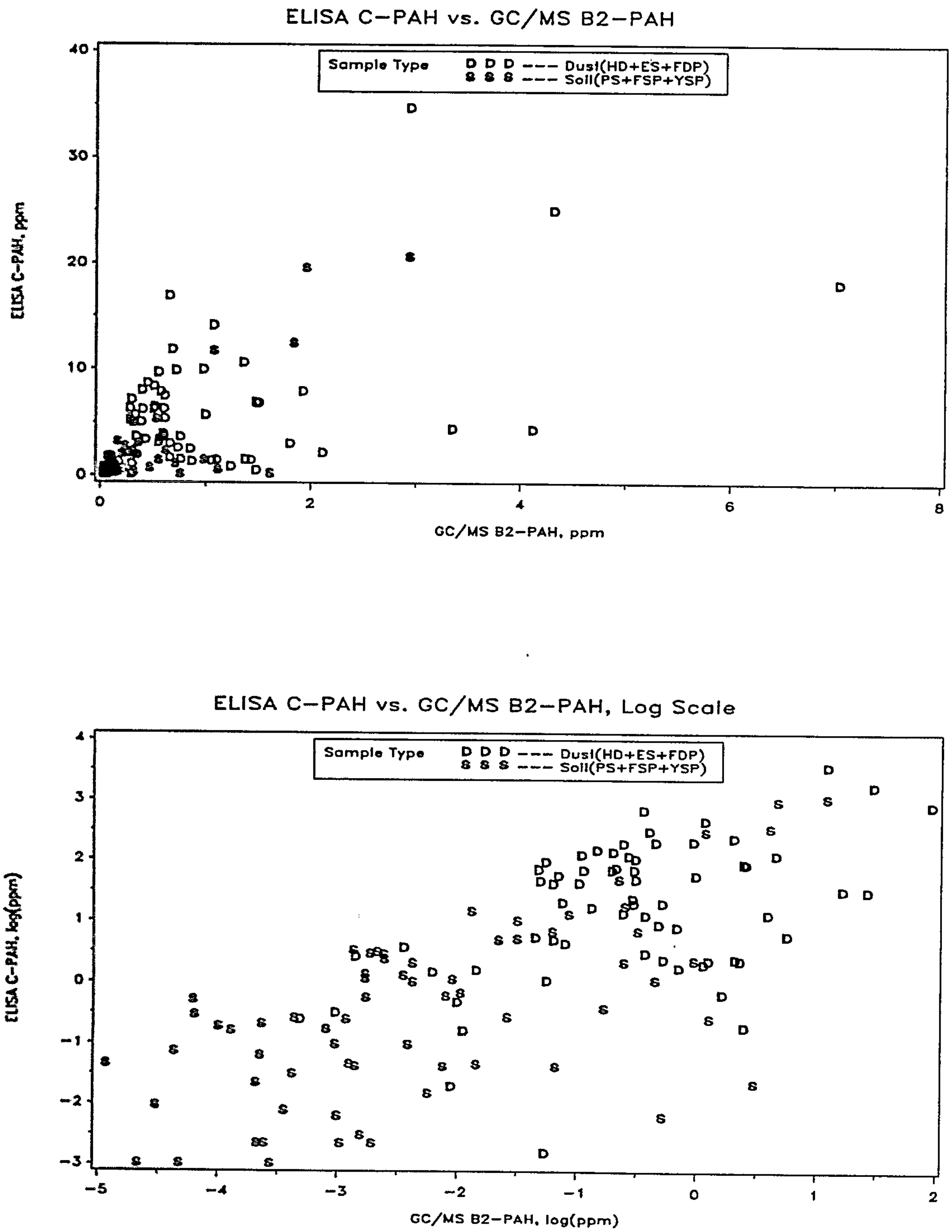


Figure 5.4. Scatter plots of ELISA C-PAH versus GC/MS B2 PAH.

between log PAH ELISA responses and log PAH GC/MS responses for dust and soil samples are displayed in Table 5.18. For example, there were 133 samples analyzed by both methods for Total PAH for the combination of dust and soil samples. The ratio of ELISA total PAH's geometric mean versus GC/MS total PAH's geometric means was 18.2. That is, the geometric mean of ELISA total PAH measurements is, on average, 18.2 times higher than the geometric mean of GC/MS total PAH measurements across all dust and soil samples. The geometric mean of data that follow a lognormal distribution is equal to the population's median. As shown in Table 5.18, all test results are significant (i.e., the differences in average PAH between ELISA and GC/MS methods are statistically significant when analyzing dust and soil samples). Generally, PAH ELISA responses are higher than PAH GC/MS responses. The ratio of geometric means between ELISA total PAH and GC/MS total PAH for dust samples and for soil samples are 20.7 and 15.8, respectively. Also the ratio of geometric means between ELISA C-PAH and GC/MS B2-PAH for the combination of dust and soil samples, dust samples, and soil samples are 5.9, 5.8, and 6.1, respectively.

Table 5.18 Results of Paired t-test for the Difference Between Log (PAH ELISA Response) and Log (PAH GC/MS Response) for Dust and Soil Samples

	ELISA Total PAH vs GC/MS Total PAH			ELISA C-PAH vs GC/MS B2-PAH		
Statistics	Comb*	Dust	Soil	Comb*	Dust	Soil
N	133	66	67	133	66	67
Ratio of Geometric Means	18.2	20.7	15.8	5.9	5.8	6.1
Geometric Std. Error	4.0	3.7	4.3	3.3	3.1	3.5
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

* Combination of Dust (HD+ES+FDP) and Soil (PS+FSP+YSP) Samples.

Regression Analyses

Initially, the regression analyses were performed on all available ELISA and GC/MS data. The results are summarized in Appendix N. There were weak relationships between ELISA and GC/MS data for various sets of samples. Note that the air and food sample extracts were the remainder of the extracts from the Cooperative Agreement study and had been spiked with perdeuterated PAH. These perdeuterated PAH had cross activities with ELISA assays and could contribute to the poor relationship between the ELISA and GC/MS data. Thus, further analyses were focused on dust and soil samples. Table 5.19 summarizes the results of the regression analyses on all the dust and soil samples from North Carolina and NHEXAS study homes. The analyses were performed using both raw data and log-transformed data. The summary includes the square of the correlation coefficient (R^2), the intercept (α), and slope (β) of the regression equation, and the p-value for the test that the slope is significantly different from zero. As shown in Table 5.19, most of the p-values are less than 0.05 and none of the R^2 values exceeds 70%. The low correlations mean that the linear relationship between ELISA and GC/MS measurements is not strong in some cases. Because ELISA derived concentrations were based on the inhibition curve of single PAH (phenanthrene for PAH assay, and benzo[a]pyrene for C-PAH assay) not a mixture of PAH, the sample matrix may have significant effects on the ELISA results. To further examine the sample matrix effects from different types of samples, we separated North Carolina study homes from NHEXAS study homes and performed regression analyses on each of the HD, ES, PS, FDP, FSP, and YSP samples. Table 5.20 shows the linear regression analysis results for the separated analyses on each sample. The linear regression model of ELISA total PAH vs. GC/MS total PAH for the FSP samples has an R^2 of 89%. This indicates that there is a significant linear relationship between the ELISA and GC/MS measurements of total PAH levels in the FSP samples. When analyzing total PAH concentrations in FSP samples from the NHEXAS study homes, 89% of the variation in GC/MS measurements can be explained by the variation in ELISA measurements. Using the regression equation of ELISA total PAH$=\alpha + \beta$ * GC/MS total

Table 5.19. Regression Analysis Results for the Dust and Soil Samples, Combination of North Carolina and NHEXAS Study Homes

	Raw Data			Log-transformed Data		
ELISA vs GC/MS	Comb*	Dust	Soil	Comb	Dust	Soil
1) TOTPAH_E*TOTPAH_G	N=133 R^2=4% α=31.48 β= 7.81 p=0.03#	N=66 R^2=1% α=71.14 β=1.02 p=0.86	N=67 R^2 = 13% α=6.81 β=10.20 p<0.01	N=133 R^2=38% α=2.79 β=0.75 p<0.01	N=66 R^2=14% α=3.24 β=0.54 p<0.01	N=67 R^2=17% α=2.09 β=0.47 p<0.01
2) CARPAH_E*B2PAH_G	N=133 R^2=39% α=1.49 β=3.49 p<0.01	N=66 R^2=26% α=3.05 β=2.60 p<0.01	N=67 R^2=68% α=0.03 β=6.01 p<0.01	N=133 R^2=50% α=1.36 β=0.71 p<0.01	N=66 R^2=23% α=1.49 β=0.53 p<0.01	N=67 R^2=40% α=0.93 β=0.62 p<0.01

* Combination of dust (HD+ES+FDP) and soil (PS+FSP+YSP) samples.

p-value: the linear regression model is statistically significant at 0.05 level if the p-value is less than 0.05.

1) Regression equation: ELISA Total PAH = α + β * GC/MS Total PAH.

2) Regression equation: ELISA C-PAH = α + β * GC/MS B2-PAH.

Table 5.20 Regression Analysis Results for the Dust and Soil Samples, Separation of North Carolina and NHEXAS Study Homes

Sample Type	ELISA Total PAH vs GC/MS Total PAH (1)	ELISA C-PAH vs GC/MS B2-PAH (2)
HD	N=22 R^2 =46% α=34.08 (p<0.01) * β=5.35 (p<0.01)	N=22 R^2 =57% α=1.85 (p=0.02) β=1.74 (p<0.01)
ES	N=22 R^2 =2% α=10.57 (p=0.01) β=0.93 (p=0.56)	N=22 R^2 =1% α=1.58 (p<0.01) β= 0.16 (p=0.81)
PS	N=26 R^2 =28% α=1.64 (p=0.07) β=2.20 (p=0.01)	N=26 R^2 =18% α=0.26 (p=0.05) β=0.56 (p=0.03)
FDP	N=22 R^2 =1% α=168.23 (p=0.01) β=-7.46 (p=0.74)	N=22 R^2 =72% α=5.01 (p<0.01) β=6.34 (p<0.01)
FSP	N=20 R^2 =89% α=7.21 (p=0.01) β=18.91 (p<0.01)	N=20 R^2 =95% α=0.56 (p=0.14) β= 7.91 (p<0.01)
YSP	N=21 R^2 =1% α=19.19 (p=0.09) β=-3.09 (p=0.82)	N=21 R^2 =97% α=0.54 (p<0.01) β=6.75 (p<0.01)

* p-value: parameter estimate is statistically significantly different from zero at 0.05 level if the p-value is less than 0.05.

1) Regression equation: ELISA Total PAH = α + β * GC/MS Total PAH.

2) Regression equation: ELISA C-PAH = α + β * GC/MS B2-PAH.

PAH, if the foundation soil's total PAH GC/MS response exceeds 1 ppm, then the predicted total PAH ELISA response would be greater than 26.2 ppm. Similarily, ELISA and GC/MS have significant linear relationships in analyzing C-PAH/B2-PAH levels in the FDP, FSP, and YSP samples from NHEXAS study homes. The R^2 values from the linear regression analyses on ELISA C-PAH versus GC/MS B2-PAH for the FDP, FSP, and YSP samples are 72%, 95%, and 97%, respectively. Using the corresponding regression equations on Table 5.20, if the floor dust, foundation soil, or yard soil's B2-PAH GC/MS response exceeds 1 ppm, then the predicted C-PAH ELISA response would be greater than 11.3 ppm, 8.5 ppm, or 7.3 ppm, respectively.

Screening Tests

Four performance measures are used to characterize the screening performance of PAH ELISA responses. They include sensitivity (or True Positive Rate), specificity (or True Negative Rate), positive predictive value (PPV), and negative predictive value (NPV). Each of the measures is defined in Table 4.1. Table 5.21 shows the frequency distribution of ELISA and GC/MS measurements on the 2 x 2 contingency tables along with Fisher's Exact test results and the four performance characteristic measurements for both ELISA total PAH versus GC/MS total PAH and ELISA C-PAH versus GC/MS B2-PAH in the combination of dust and soil samples. Tables 5.22 and Table 5.23 show the similar results in food and air samples, respectively. As shown in these tables, most performance characteristic measurements are greater than 70% and Fisher's Exact test results indicate a high degree of statistical dependence between ELISA and GC/MS responses (at 0.05 level). This finding suggested that ELISA is a good screening tool for total PAH and C-PAH. The relatively poor performance of ELISA on C-PAH in food samples (Table 5.22) may be partly due to the spiked perdeuterated PAH cross activities for ELISA assays. The possible errors associated with the estimates of the performance parameters are 10%, 30%, and 25% for the dust/soil samples, food samples, and air samples, respectively.

Table 5.21. Frequency Distribution of ELISA and GC/MS Measurements on the Combination of Dust (HD+ES+FDP) and Soil (PS+FSP+YSP) Samples

ELISA Total PAH	GC/MS Total PAH		Total
	<1 ppm	≥1 ppm	
< 10 ppm	51	14	65
≥ 10 ppm	21	47	68
Total	72	61	133

Fisher's Exact test: p* < .0001
Sensitivity (True Positive Rate): 69% (47/68)
Specificity (True Negative Rate): 78% (51/65)
Positive Predictive Value (PPV): 77% (47/61)
Negative Predictive Value (NPV): 71% (51/72)

ELISA C-PAH	GC/MS B2-PAH		Total
	< 0.5 ppm	≥ 0.5 ppm	
< 2 ppm	62	15	77
≥ 2 ppm	19	37	56
Total	81	52	133

Fisher's Exact test: p* < .0001
Sensitivity (True Positive Rate): 66% (37/56)
Specificity (True Negative Rate): 81% (62/77)
Positive Predictive Value (PPV): 71% (37/52)
Negative Predictive Value (NPV): 77% (62/81)

* p-value: two analyzing methods are not statistically independent at 0.05 level if the p-value is less than 0.05.

Table 5.22. Frequency Distribution of ELISA and GC/MS Measurements on Food Samples

ELISA Total PAH	GC/MS Total PAH < 3000 ppb	GC/MS Total PAH ≥ 3000 ppb	Total
< 16000 ppb	9	2	11
≥ 16000 ppb	2	5	7
Total	11	7	18

Fisher's Exact test: p* = .05
Sensitivity (True Positive Rate): 71% (5/7)
Specificity (True Negative Rate): 82% (9/11)
Positive Predictive Value (PPV): 71% (5/7)
Negative Predictive Value (NPV): 82% (9/11)

ELISA C-PAH	GC/MS B2-PAH < 1040 ppb	GC/MS B2-PAH ≥ 1040 ppb	Total
< 8000 ppb	6	3	9
≥ 8000 ppb	6	3	9
Total	12	6	18

Fisher's Exact test: p* = 1.00
Sensitivity (True Positive Rate): 33% (3/9)
Specificity (True Negative Rate): 67% (6/9)
Positive Predictive Value (PPV): 50% (3/6)
Negative Predictive Value (NPV): 50% (6/12)

* p-value: two analyzing methods are not statistically independent at 0.05 level if the p-value is less than 0.05.

Table 5.23. Frequency Distribution of ELISA and GC/MS Measurements on Air Samples

ELISA Total PAH	GC/MS Total PAH		
	< 50000 ng/mL	≥ 50000 ng/mL	Total
< 40000 ng/mL	8	2	10
≥ 40000 ng/mL	1	7	8
Total	9	9	18

Fisher's Exact test: p* = .02
Sensitivity (True Positive Rate): 88% (7/8)
Specificity (True Negative Rate): 80% (8/10)
Positive Predictive Value (PPV): 78% (7/9)
Negative Predictive Value (NPV): 89% (8/9)

ELISA C-PAH	GC/MS B2-PAH		
	< 1040 ng/mL	≥ 1040 ng/mL	Total
< 6000 ng/mL	5	3	8
≥ 6000 ng/mL	2	8	10
Total	7	11	18

Fisher's Exact test: p* = .015
Sensitivity (True Positive Rate): 80% (8/10)
Specificity (True Negative Rate): 63% (5/8)
Positive Predictive Value (PPV): 73% (8/11)
Negative Predictive Value (NPV): 71% (5/7)

* p-value: two analyzing methods are not statistically independent at 0.05 level if the p-value is less than 0.05.

Further investigation was done to determine whether the ELISA technique is an effective screening tool for total PAH exposure. A linear regression model of ELISA total PAH versus GC/MS total PAH was initially fitted to all paired 133 log-transformed data for the combination of dust and soil samples. A plot of residuals versus GC/MS total PAH indicated that a poor model fit and a possible lack-of-fit (11). The studentized residuals were large for 10 of the 133 samples. For these 10 samples, nine house dust samples (FDP) and one yard soil sample (YSP) from the NHEXAS study, ELISA results were all greater than 148 ppm. These high ELISA results may be from the sample matrix effect on ELISA measurements. The linear regression model was then refitted to the log-transformed data in dust and soil samples without these 10 data points. The mean square error was reduced from 7543 to 433 and the R^2 was increased from 4% to 45%. The residual plot no longer indicated a lack-of-fit. Figure 5.5 displays the regression line that was fitted to the log transformed data after removing these 10 data points in combination with reference lines at log(0.1) ppm and log(1) ppm of GC/MS total PAH, and log(2.5) ppm and log(12.1) ppm of ELISA total PAH. This linear regression model shows that GC/MS measurements of total PAH levels at 0.1 ppm and 1 ppm for the dust/soil samples, correspond to ELISA measurements of 2.5 ppm and 12.1 ppm, respectively. Note that there are very few samples in the discordant blocks (e.g., large GC/MS measurements and small ELISA measurements) but there are quite a few samples scattering from the best fit line.

In summary, PAH and C-PAH ELISA can be used as screening tool to determine PAH levels at a threshold level, but cannot provide quantitative measurements for PAH. The performance of ELISA may be improved, if a representative PAH mixture for each type of sample can be prepared and used for inhibition curves.

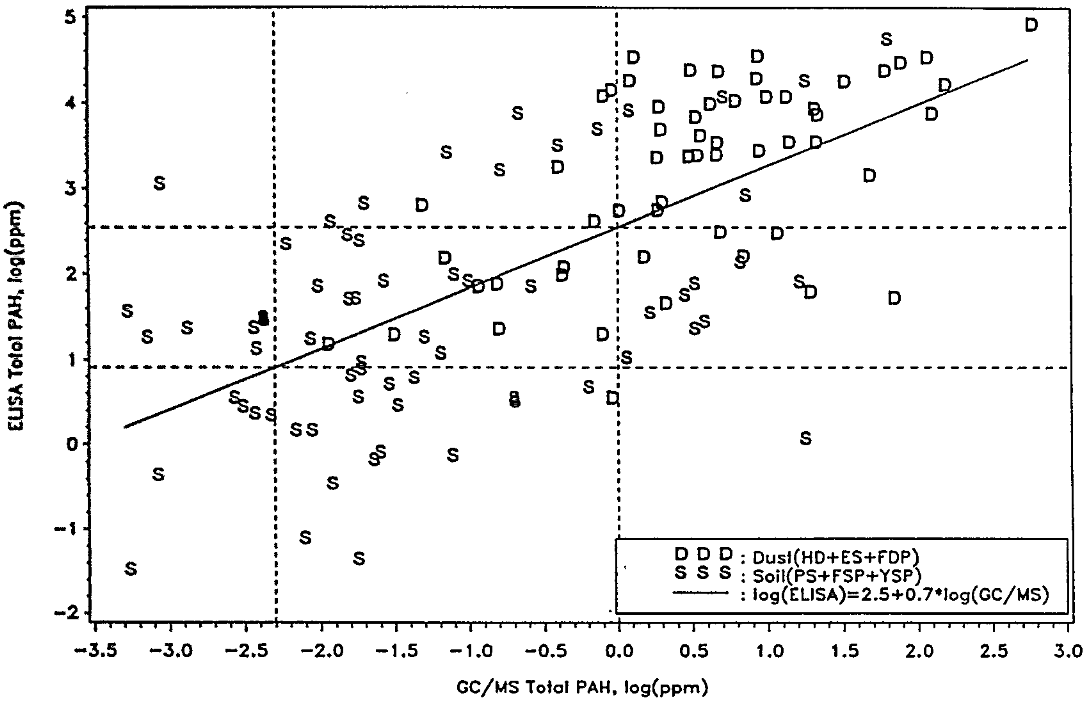


Figure 5.5. ELISA total PAH versus GC/MS total PAH, log scale.

Evaluation of ELISA for Screening 2,4-D and PCP

Recovery with 2,4-D Extraction Solvent

The results of all evaluation tests conducted with the 2,4-D extraction solvent (75% methanol in water) are given in Table 5.24. As shown there, the sonication and shaking methods appear to be equivalent in extraction efficiency; both about 60% for PCP and 85% for 2,4-D and 3,4-D at the mass:volume ratio of 1:2. For larger and smaller spike quantities of 2,4-D, the recoveries drop significantly, 58% and 26%, respectively. For the larger amount (spiked at 2.5 μg), solubility may be limited in the solvent mixture; for the smaller amount (spiked at 0.1 μg), there may be a larger percentage of the total spike tightly bound to active surface sites on the dust, thus limiting extraction efficiency. The extraction ratio of 1 g: 20 mL does not appear to significantly increase extraction efficiency; the kit-recommended ratio of 10 g: 20 mL appears to be slightly less effective than the 1 g: 2 mL ratio.

Further justification for eliminating consideration of the 1g : 20 mL extraction ratio is shown in the ELISA results for the humus soil spikes. As shown there, inconsistent results were obtained in these tests, that was probably because the concentrations of these extracts were at the low end of ELISA calibration range. With the 1 g: 2 mL extraction ratio, recoveries were reasonable (110-130 %) at spike levels equivalent to 1-2.5 μg/g levels, but predictably low with low spike quantities. Extraction from both clay soil and house dust was less than 50% with this extraction solvent. The ELISA results for the spiked house dust indicate that false positives and/or interferences or biases may occur with this matrix type.

Recovery with PCP Extraction Solvent

The same experiments described above were repeated with the NaOH-added extraction solvent and the results are given in Table 5.25. As shown there, irrespective of spike level or extraction method, the GC/ECD PCP recoveries average 60-65%, and are similar to the recoveries obtained with the 75% methanol extraction solvent by GC/ECD method. The results for 2,4-D and 3,4-D were less predictable, but appeared to indicate enhanced extraction

Table 5.24. Extraction and Recovery Efficiency Using 2,4-D Extraction Solvent (75% Methanol)

Extraction Method	Mass: Volume, g : mL	2,4-D and 3,4-D spike amount, ug	ELISA dilution factor	Recovery, ± standard deviation % n=3		
				2,4-D	3,4-D	PCP
Humus soil: GC/ECD						
sonication	1 : 2	2.5	NA[a]	58 ± 4	NT[b]	NT
sonication	1 : 2	0.1	NA	26 ±1	NT	NT
sonication	1 : 2	1.0	NA	86 ±0	84 ±0	61 ±2 (0.1 ug)[c]
shaking	1 : 2	1.0	NA	85 ±4	83 ±4	62 ±4 (0.1 ug)
sonication	1 : 20	1.0	NA	88 ±5	79 ±2	63 ±2 (0.1 ug)
sonication	10 : 20	1.0	NA	76 ±1	67 ±0	49 ±2 (0.1 ug)
Humus soil: ELISA						
sonication	1 : 2	2.5	50	108 ±30	NA	NA
sonication	1 : 2	1.0	50	132 ±80	NA	NA
sonication	1 : 2	0.1	50	31 ±30[d]	NA	NA
sonication	1 : 20	2.5	50	68 ±24	NA	NA
sonication	1 : 20	1.0	50	195 ±195[d]	NA	NA
sonication	1 : 20	0.1	50	5550±9600[e]	NA	NA
sonication	1 : 20	2.5	5	37 ±28	NA	NA
sonication	1 : 20	1.0	5	47 ±9	NA	NA
sonication	1 : 20	0.1	5	0 ±0[d]	NA	NA
Clay soil: ELISA						
sonication	1 : 2	1.0	50	46 ±10	NA	NA
House dust: GC/ECD						
sonication	1 : 2	1.0	NA	42 ± 46	NT	NT
House dust: ELISA						
sonication	1 : 2	1.0	50	257 ±229[e]	NA	NA

a) NA-not applicable
b) NT-not tested
c) Spike level for PCP
d) Analysis at low end of ELISA calibration range
e) Concentration outside of ELISA assay calibration range

Table 5.25 Extraction and Recovery efficiency Using PCP Extraction Solvent (NaOH in 75% Methanol)

Extraction Method	Mass: Volume, g : mL	PCP spike amount, ug	ELISA dilution factor	Recovery, ± standard deviation % n=3		
				PCP	3,4-D	2,4-D
Humus soil: GC/ECD						
sonication	1 : 2	7.5	NA	61 ± 1	NT	NT
sonication	1 : 2	1.0	NA	60 ± 0	NT	NT
sonication	1 : 4	0.2	NA	36 ± 6	54 ± 3	56 ± 3 (2 ug)[a]
sonication	1 : 4	0.2	NA	55 ± 2	61 ± 3	65 ± 4 (2 ug)
shaking	1 : 4	0.2	NA	65 ± 1	79 ± 2	87 ± 2 (2 ug)
sonication	1 : 20	0.2	NA	71 ± 4	94 ±13	88 ±5 (2 ug)
sonication	10 : 20	0.1	NA	59 ± 3	80 ± 4	65 ± 0 (1 ug)
Humus soil: ELISA						
sonication	1 : 2	7.5	500	105 ±10	NA	NA
sonication	1 : 2	1.0	500	126 ±100	NA	NA
sonication	1 : 2	0.1	500	227 ±393[b]	NA	NA
sonication	1 : 20	7.5	500	197 ±173	NA	NA
sonication	1 : 20	1.0	500	97 ±95[b]	NA	NA
sonication	1 : 20	0.1	500	67 ± 115[c]	NA	NA
sonication	1 : 20	7.5	50	89 ±26	NA	NA
sonication	1 : 20	1.0	50	101 ± 17	NA	NA
sonication	1 : 20	0.1	50	150 ±144[b]	NA	NA
Clay soil: ELISA						
sonication	1 : 2	1.0	500	123 ±40	NA	NA
House dust: GC/ECD						
sonication	1 : 2	1.0	NA	5 ± 2	NT	NT
House dust: ELISA						
sonication	1 : 2	1.0	500	175 ± 85	NA	NA

a Spike amount for 2,4-D
b Analysis at low-end of ELISA calibration range
c Concentration outside of ELISA calibration range

with the larger 20 mL extraction volume. The ELISA assay of spiked humus soil samples indicates reasonable recovery for spike amounts equivalent to 1-7.5 μg/g PCP levels, either with a 500 fold dilution of the 1:2 ratio extract or with a 50 fold dilution of the 1:20 ratio extract. At the lowest spike level, equivalent to 0.1 μg/g, recoveries were high and precision was low. Acceptable recovery results (123%) were obtained for the spike to the clay soil. The spikes to the house dust indicated that there may be difficulties associated with trying to apply this assay to a matrix as complex as the dust matrix. Recovery, as indicated by GC/ECD, was extremely low (5%), but ELISA results indicated a much higher recovery (175%).

Comparison of Extraction Solvents

Tables 5.26 and 5.27, respectively, compare the calculated levels of 2,4-D and PCP in house dust samples from the 13 low-income homes that are obtained with the two ELISA extraction solvents. The measure of agreement between the two extraction solvents, the relative percent difference (RPD) for the two GC/ECD measurements, ranged from 5 to 160% for 2,4-D and from <1 to 100% for PCP. As seen in these tables, 7 of 12 samples have RPD values <30% for the 2,4-D concentrations (Table 5.26) and for the PCP concentrations (Table 5.27). In most cases where the levels obtained with the two solvents are significantly different (i.e., %RPD >30%), the PCP solvent seems to extract the greater amount. These data seem to indicate a relatively consistent extraction method for either assay. However, as discussed above, the ELISA assay appears to have significant positive bias for the measurements of 2,4-D and PCP in the complex house dust matrix.

Precision of ELISA Analyses

The precision of the ELISA analyses, as indicated by the relative standard deviation (RSD) for the three aliquots removed from the extract and assayed separately, is shown in Table 5.28. As shown there, the precision of the 2,4-D assay appears superior to the PCP assay, not only

Table 5.26. Comparison of Concentration of 2,4-D in House Dust with Different Extraction Solvents

Household Code	Conc. of 2,4-D in dust with 2,4-D extraction solvent, ng/g	Conc. of 2,4-D in dust with PCP extraction solvent, ng/g	Average 2,4-D conc. in dust, ng/g	RPD (relative percent difference) between two measurements
A	41	364	203	160 (PCP>2,4D)[a]
B	4310	2320	3310	60 (2,4D>PCP)
C	1030	870	948	16
D	1980	2880	2430	37 (PCP>2,4D)
E	1230	1530	1380	22
F	233	354	294	41 (PCP>2,4D)
G	635	603	619	5
H	889	1040	965	16
I	146	112	129	26
J	647	547	597	17
K	219	513	366	80 (PCP>2,4D)
M	475	377	426	23

[a] House dust concentration of 2,4-D resulting from PCP ELISA extraction solvent is greater than the 2,4-D concentration resulting from the 2,4-D ELISA extraction solvent

Table 5.27. Comparison of Concentration of PCP in House Dust with Different Extraction Solvents

Household Code	Conc. of PCP in dust with 2,4-D extraction solvent, ng/g	Conc. of PCP in dust with PCP extraction solvent, ng/g	Average PCP conc in dust, ng/g	RPD (relative percent difference) between two measurements
A	70	214	142	100 (PCP>2,4D)[a]
B	97	53	75	57 (2,4D>PCP)
C	93	93	93	<1
D	89	156	122	55 (PCP>2,4D)
E	78	103	90	28
F	144	141	142	2
G	>450	189	NA[b]	NA
H	134	141	137	5
I	37	34	36	10
J	17	23	20	29
K	55	86	71	42 (PCP>2,4D)
M	101	93	97	8

[a] House dust concentration of PCP resulting from PCP ELISA extraction solvent is greater than the PCP concentration resulting from the 2,4-D ELISA extraction solvent

[b] NA = not applicable.

Table 5.28. Precision of Replicate ELISA Measurements of Soil and House Dust Extracts

Household Code	Relative Standard Deviation for ELISA Analyses of Sample Extract, %rsd for n=3			
	2,4-D Assay			PCP Assay
	Pathway Soil	Entryway Soil	House Dust	House Dust
A	31	22	22	100
B	37	26	8	109
C	14	18	3; 46 [a]	35
D	27	17	10	130
E	22	43	21	46
F	42	15	15	43
G	11	17	7	83
H	9	5	NT[b]	47
I	18	35	6	73
J	23	13	18	47
K	19	17	31	19
L	15	NT	23	NT
M	10	19	4	65
average	21	21	18	66

[a] The %rsd=3 from triplicate samples that exceeded the linear range of the calibration curve; samples were diluted 1:1 and reanalyzed with %rsd=46 for the triplicates

[b] NT = not tested.

in the simpler soil matrix, but also in the more complex dust matrix. The average RSD for triplicate sample extracts in the 2,4-D assay was 20%, and for the PCP assay was about 60%.

2,4-D in House Dust, Entryway Dust, and Pathway Soil

The data of 2,4-D in house dust, entryway dust, and pathway soil samples from the 13 low-income homes are given in Appendix O. From these data there appears to be a very general correlation between the GC and ELISA results. However, the RPD between matched samples were generally greater than 100%. Duplicate analyses of house dust from home M show very good agreement internally (i.e., low RPD for duplicate analyses by either GC or ELISA), and indicate that analytical errors may be negligible compared with interferences to the ELISA method. The 2,4-D levels, as indicated by the GC/ECD results, appear similar to those found in other homes (9), and thus this data set may be reasonably representative of the problems that may be encountered in applying this assay to such a complex matrix.

A significant number of the entryway dust and pathway soil samples show no appreciable levels above detection limits of either detection method. Because of the low levels, it may not be reasonable to draw conclusions about the accuracy of the ELISA method from these data. PCP was detected at substantial levels in only one entryway dust sample.

The concentrations of 2,4-D determined from GC/ECD data, presented in Appendix O, are corrected by the surrogate recovery value to provide the best estimate of the dust concentration, and account for incomplete extraction. The surrogate recoveries ranged from 51 to 110% in house dust samples, from 46 to 94% in entryway dust samples, and from 62 to 102% in pathway soil samples. These data indicated reasonable extraction efficiency and recovery through the analytical protocol. The ELISA data are not similarly corrected, so that comparing concentrations on a ng/g basis may be of limited value for samples where the surrogate recovery is low. For this reason, the more direct comparison of the GC/ECD and ELISA detection is based on a measure of the 2,4-D concentration in the extract itself on the basis of ng/mL. These concentrations are shown for the soil and house dust sample extracts in Table 5.29. The general agreement between the two techniques is most obvious in the soil samples, where both techniques indicate very low levels. However, the estimated correlation coefficient (r) between GC/ECD and ELISA methods was 0.403 ($p=0.17$), indicating a positive but weak relationship between these two methods.

PCP in House Dust

The concentration of PCP in 12 house dust samples, as determined using ELISA and GC/ECD, is shown in Appendix P. Approximately half of the matched samples show RPD <100%, indicating that ELISA may be useful for establishing trends or ranking samples by concentration. The ELISA assay still tends to show a considerable false positive bias. The analytical data appear to be adequate given that surrogate recoveries were generally >70%, and initial extraction data indicated that PCP extraction could be limited to a maximum of 60-65%. As shown in Appendix P, the 2,4-D data included therein demonstrate again the ability to simultaneously extract and analyze by GC both PCP and 2,4-D.

The direct comparison of PCP levels expressed in ng/mL in the sample extract by GC/ECD and ELISA is summarized in Table 5.30. Again, approximately half of the extracts have an RPD for a matched pair that is <100%. The estimated correlation coefficient (r) for PCP measured by GC/ECD and ELISA was only 0.311. This result indicates that there is a positive but weak relationship between GC/ECD and ELISA methods.

Quality Control Data

The levels of alkyl PAH and phthalates found in the field blanks are summarized in Table 5.31. The field blank air sample was a filter/XAD-2 module that was processed through field handling and shipping together with the field samples without sampling air. The field blanks for dust/soil and food samples were the containers used for dust/soil and food samples

Table 5.29. Comparison of 2,4-D Concentrations in Extracts using GC/ECD and ELISA

	Concentration of 2,4-D in Sample Extract, ng/mL					
	Pathway Soil		Entryway Soil		House Dust	
Home	GC/ECD	ELISA	GC/ECD	ELISA	GC/ECD	ELISA
A	<10	<35 (9)[a]	<10	44	12	217
B	<10	<35 (8)	<10	<35 (20)	1160	1250
C	<10	<35 (19)	43	<35 (26)	421	2950
D	<10	<35 (17)	<10	<35 (18)	414	77[b]
E	<10	<35 (15)	<10	41	313	345
F	<10	<35 (21)	25	<35 (23)	117	188
G	<10	<35 (16)	29	<35 (23)	280	243
H	<10	<35 (14)	NT[c]	NT	311	957[b]
I	<10	<35 (13)	19	<35 (27)	50	293
J	<10	<35 (12)	18	73	296	1350
K	<10	<35 (16)	<10	<35 (23)	66	510
L	<10	<35 (12)	29	<35 (31)	NT	NT
M	<10	<35 (26)	<10	<35 (19)	262	1630[b]

[a] Concentration is less than method detection limit; value in parentheses is the concentration measured in the assay from the non-linear portion of the calibration curve

[b] 3,4-D spiked into sample; effective concentration of 3,4-D (due to cross-reactivity) subtracted for estimated ELISA concentration

[c] NT- not tested

Table 5.30. Comparison of PCP in House Dust Extracts using GC/ECD and ELISA

	Concentration of PCP in Sample Extract, ng/mL		
Home	GC/ECD	ELISA	RPD
A	41	260	146
B	23	<35 (20)[a]	14
C	39	325	157
D	29	35	19
E	49	100	68
F	62	40	43
G	86	40	73
H	65	740	168
I	12	105	159
J	8	55	149
K	20	130	147
L	NT[b]	NT	NA[c]
M	61	260	124

a) Concentration is less than method detection limit; value in parentheses is the concentration measured in the assay from the non-linear portion of the calibration curve
b) NT- not tested
c) NA- not applicable

Table 5.31. Levels of Alkyl PAH and Phthalates Found in Field Blanks

Compound	Total amount, ng		
	Air	Dust/Soil	Food
2-Methylnaphthalene	4.89	1.35	3.51
1-Methylnaphthalene	2.92	<1	2.00
C2-alkylnaphthalene isomers	6.71	2.30	<1
C1-alkylphenanthrene isomers	12.0	1.77	<1
C2-alkylphenanthrene isomers	<1	18.7	<1
C1-alkylpyrene isomers	<1	3.14	<1
C2-alkylpyrene isomers	<1	<1	<1
C1-alkylchrysene isomers	<1	<1	<1
C2-alkylchrysene isomers	<1	<1	<1
C1-alkylbenzo[a]pyrene isomers	<1	<1	<1
Dimethylphthalate	14.9	3.20	<1
Diethylphathalate	151	17.5	14.7
Di-n-butyl phthalate	497	27.3	46.6
Butylbenzylphthalate	2400	11.2	207
Bis(2-ethylhexyl)phthalate	1370	44.7	25.3
Di-n-octylphthalate	9.26	1.80	2.34

processed through field handling and shipping. As shown in Table 5.31, trace amounts of alkyl PAH were found in the field blanks. The levels of phthalates found in the field blanks were higher than those of the alkyl PAH levels. The phthalates in the filter/XAD-2 air blank may originate partly from the XAD-2 resin and partly from the sampling cartridge. The plastic containers used for the food samples may also contribute to the phthalates found in the food field blank. Note that the reported concentrations of alkyl PAH and phthalates for multimedia samples in this report are already corrected for the levels of respective analytes found in the field blanks.

Known amounts of perdeuterated PAH were spiked onto each dust/soil sample prior to sample preparation. Table 5.32 summarizes the recovery data of the spiked PAH for each type of sample. In general, quantitative recoveries (>80 %) for the spiked PAH were obtained. These data indicated that there was no significant loss of PAH through sample preparation steps.

Respective control solutions were analyzed in conjunction with the sample extracts in every assay run and treated the same way as the sample extracts for PAH, C-PAH, 2,4-D, and PCP ELISA. A three point calibration curve was generated in every assay run. The goal for the acceptance criteria for each assay is to obtain a correlation coefficient (r) greater than 0.99. Table 5.33 summarizes the quality control data for PAH, C-PAH, 2,4-D and PCP ELISA. As shown, the correlation coefficients were greater than 0.99 for all but two of the 33 assay runs. In general, the results of the control solutions and proficiency samples were within 30 percent of the specified values.

Table 5.32. Summary of Recovery Data of Spiked Perdeuterated PAH in Dust/Soil Samples

Compound	Recovery ± Standard Deviation, %[a]					
	HD	ES	PS	FDP	FSP	YSP
Fluorene-d_{10}	92 ± 11	91± 12	86 ± 11	84 ± 15	86 ± 9.9	98 ± 9.5
Pyrene-d_{10}	96 ± 9.6	98 ± 8.1	94 ± 11	97 ± 18	89 ± 12	92 ± 15
Chrysene-d_{10}	88 ± 12	88 ± 9.5	77 ± 5.2	90 ± 14	100 ± 13	100 ± 15
Benzo[k]fluoranthene-d_{12}	90 ± 9.2	100 ± 16	83 ± 4.6	97 ± 14	100 ± 13	100 ± 8.7
Perylene-d_{12}	85 ± 16	94 ± 15	78 ± 5.1	100 ± 16	90 ± 11	93 ± 22

[a] HD: house dust samples (N=13), ES: entryway dust samples (N=13), PS: pathway soil samples (N=13), FDP: house dust samples (N=22), FSP: foundation soil samples (N=20), and YSP: yard soil samples.

Table 5.33. Summary of PAH, C-PAH, 2,4-D, and PCP ELISA Calibration Data

Assay Run	Calibration fit, r	Control Solution ng/mL (%, recovery)	Proficiency Sample, ng/mL (% recovery)		
			A	B	C
PAH Assay					
1	0.9993	25.4 (100)	6.19 (110)	22.3 (110)	43.7 (110)
2	0.9997	26.1 (100)	6.26 (110)	22.4 (99)	44.3 (110)
3	0.9991	29.1 (120)	5.38 (98)	21.1 (94)	42.0 (100)
4	0.9994	29.8 (120)	5.38 (98)	21.9 (97)	42.4 (110)
5	0.9990	23.3 (93)	5.34 (97)	10.6 (47)	44.8 (110)
6	1.0000	22.4 (90)	5.16 (94)	11.1 (50)	46.7 (120)
7	0.9993	29.6 (120)	4.78 (87)	20.4 (91)	49.6 (120)
8	0.9893	26.6 (110)	5.80 (100)	19.1 (85)	43.7 (110)
9	0.9989	26.3 (110)	4.60 (84)	19.5 (86)	42.4 (110)
10	0.9924	24.8 (99)	4.13 (75)	19.3 (86)	47.9 (120)
C-PAH Assay					
1	0.9956	2.00 (100)	0.56 (110)	1.48 (99)	3.22 (110)
2	0.9999	1.84 (92)	0.54 (110)	2.30 (150)	3.13 (100)
3	0.9977	1.65 (83)	0.57 (110)	1.58 (100)	3.52 (120)
4	0.9952	1.54 (77)	0.64 (130)	1.39 (93)	2.97 (99)
5	0.9926	1.62 (81)	0.73 (140)	1.65 (110)	2.93 (98)
6	0.9935	–[a]	0.60 (120)	1.53 (100)	2.87 (96)
7	0.9994	–	0.59 (120)	1.73 (110)	2.54 (85)
8	0.9988	3.06 (150)	0.50 (100)	1.70 (110)	3.16 (100)

Table 5.33. (Continued)

Assay Run	Calibration fit, r	Control Solution ng/mL (%, recovery)	Proficiency Sample, ng/mL (% recovery)		
			A	B	C
9	0.9979	2.08 (100)	0.67 (130)	1.72 (110)	2.91 (97)
2,4-D Assay					
1	0.9964	36.3 (100)	–	–	–
2	0.9940	25.0 (71)	–	–	–
3	0.9998	32.0 (92)	–	–	–
4	0.9984	42.8 (120)	–	–	–
5	0.9975	36.7 (100)	–	–	–
6	0.9998	38.2 (110)	–	–	–
7	0.9997	40.1 (110)	–	–	–
8	0.9909	38.0 (110)	–	–	–
PCP Assay					
1	0.9995	1.38 (140)	–	–	–
2	0.9987	2.27 (230)	–	–	–
3	0.9861	1.23 (120)	–	–	–
4	0.9904	0.96 (96)	–	–	–
5	0.9997	1.03 (100)	–	–	–
6	0.9993	1.34 (130)	–	–	–

[a] The control solution for C-PAH assay was not tested on assay run 6 and 7; the proficiency samples are not available for 2,4-D and PCP assays.

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APPENDIX A. SOIL SCREENING METHOD MEASURING PAH BY IMMUNOASSAY

1.0 Apparatus and Materials

1.1 Immunoassay test kit: RaPID Prep Soil Collection Kit, RaPID Prep PAH Sample Extraction Kit, PAH RaPID Assay Kit, and C-PAH RaPID Assay Kit (Ohmicron Environmental Diagnostics) and associated documentation.

1.2 OHAUS 300 toploading balance or an equivalent balance - used for weighing aliquots of soil samples (± 0.1 g).

1.3 Vortex Mixer - used to homogenize solutions.

1.4 Eppendorf Series 2000 Reference Adjustable Volume 100-1000 µl Pipette and Eppendorf pipette tips.

1.5 Eppendorf Repeater Pipette 4780 and Combitips 12.5 ml capacity.

1.6 Ohmicron Magnetic Separation Rack - used for separating magnetic antibody particles from solution.

1.7 RPA-I™ RaPID Photometric Analyzer - used for analyzing the PAH concentration in assayed samples.

2.0 Reagents

Note: all reagents are included in kits listed under **Apparatus and Materials**. Different testing kits are used for PAH and C-PAH assay.

2.1 PAH and C-PAH Extraction Solution - methanol with calcium chloride (2.5 mmol) as a dispersion agent.

2.2 PAH and C-PAH Extract Diluent - buffered saline solution containing preservatives and stabilizers without any detectable PAH as stated by Ohmicron Environmental Diagnostics.

2.3 PAH and C-PAH Antibody Coupled Paramagnetic Particles - PAHs and or C-PAH antibody covalently bound paramagnetic particles, which are suspended in buffered saline with preservative and stabilizers.

2.4 Lyophilized PAH and C-PAH Enzyme Conjugate - concentrated horseradish peroxidase (HRP) labeled PAH and or C-PAH analog is supplied as a lyophilized powder.

2.5 PAH and C-PAH Enzyme Conjugate Diluent - buffered saline containing preservatives and stabilizers.

2.6 PAH and C-PAH Standards - three concentrations (2.0, 10.0, 50.0 ppb) of phenanthrene (as phenanthrene analog) standards in buffered saline with preservative and stabilizers. C-PAH Standards - three concentrations (0.1, 1.0, 5.0 ppb) of benzo[a]pyrene in buffered saline with preservative and stabilizers.

2.7 Control - a known concentration of either phenanthrene (PAH assay) or benzo[a]pyrene (C-PAH assay) in buffered saline with preservative and stabilizers.

2.8 Proficiency samples - three solutions containing known amounts of either phenanthrene (PAH assay) or benzo[a]pyrene (C-PAH assay) in buffered saline with preservative and stabilizers.

2.9 Diluent/Zero Standard - buffered saline containing preservative and stabilizers without any detectable PAH.

2.10 Color Reagent - solution of hydrogen peroxide and 3, 3', 5, 5'-tetramethylbenzidine in organic base.

2.11 Stopping Solution - solution of sulfuric acid (0.5%).

2.12 PAH and C-PAH Washing Solution - preserved deionized water with detergent.

2.13 Test Tubes - polystyrene tubes for actual sample assaying

3.0 Soil Extraction Procedure

3.1 Weigh an aliquot (10 ± 0.1 g) of soil or dust sample with the Soil Sample Collection Device from the Soil Collection Kit.

3.2 Add 20 mL (entire contents) of PAH Extraction Solution to the Collection Device. Close the device with a filterless cap and shake for 1 minute. Allow the mixture to stand 5 minutes for settling.

3.3 Replace the filterless cap with a filter cap and reattach the plunger. Filter the sample extract into an Extract Collection Vial from the Sample Extraction Kit.

4.0 Extract Dilution with Diluent

4.1 For PAH assay, add 250 µl of the filtered extract to a vial of PAH Extract Diluent (12.25 mL). For C-PAH assay, add 200 µl of filtered extract to a vial of C-PAH extract diluent (9.80 mL). Cap and invert the sample vial several times.

4.2 Vortex the diluted sample extract for 1 or 2 seconds to insure complete homogenization.

5.0 PAH Immunoassay Procedure

5.1 Detach the Magnetic Separation Rack from the magnetic base and set up test tubes. Include 12 test tubes in addition to sample test tubes for duplicates of four calibration standards, control tube, and three proficiency samples.

5.2 Add 250 µl of either standards, control, proficiency samples, or diluted sample extract to test tubes by aiming the pipet tip 1/4" to 1/2" below the rim delivering liquid gently.

5.3 Prepare PAH Enzyme Conjugate for use by dissolving Lyophilized PAH Enzyme Conjugate with PAH Enzyme Conjugate Diluent. Shake well to insure thorough mixing.

5.4 Add 250 µl of PAH Enzyme Conjugate to each tube by aiming the pipet tip 1/4" to 1/2" below the tube rim without touching the rim with the pipet tip. An Eppendorf Repeater Pipette 4780 with 12.5 ml capacity Combitips is used. Air bubbles and the possibility of pipetting less volume of reagent to first tubes should be prevented by pipetting the first few aliquots of reagent back into the reagent bottle.

5.5 Gently shake PAH Antibody Coupled Paramagnetic Particles bottle until thoroughly mixed. Add 500 µl of magnetic particles to tubes with the Repeater pipette.

5.6 Vortex test tubes for 1 to 2 seconds at low speed to minimize foaming and to prevent loss of sample.

5.7 Incubate these tubes for 30 minutes at room temperature (15 - 30 degrees C).

5.8 Combine the magnetic rack securely with the magnetic base by pressing all tubes into the base. Allow 2 minutes for the magnetic particles to separate to walls of tubes.

5.9 Keep the rack attached to the magnetic base and invert the rack assembly over a waste container and pour out the solution with a smooth motion. Maintain inverted position and gently blot the test tube rims on several layers of clean paper towel.

5.10 Add 1 ml of PAH Washing Solution down inside wall of each tube with the Repeater pipette. Vortex each tube for 1 or 2 seconds and wait for 2 minutes. Invert the combined rack assembly over the waste container and gently blot test tubes on the paper towel.

5.11 Repeat step 5.10.

5.12 Remove the upper rack with tubes from the base.

5.13 Add 500 µl of Color Reagent down the inside wall of each tube. Vortex each tube for 1 or 2 seconds at low speed.

5.14 Incubate these tubes for 20 minutes at room temperature. During incubation time, add 1 ml of Washing Solution into a clean test tube for use as an instrument blank.

5.15 Add 500 µl of Stopping Solution down the inside wall of each tube.

5.16 Read results at 450nm within 15 minutes after adding Stopping Solution on RPA-I™ RaPID Photometric Analyzer programmed for PAH protocol.

Note: The procedures for the C-PAH assay are the same as the PAH assay (steps 5.1 to 5.16) except that the reagents used are from the C-PAH assay testing kit. If the PAH concentration output of a sample exceeds 50ppb (PAH assay) or 5 ppb (C-PAH assay), the sample should be diluted by a dilution factor of 10 or greater with an appropriate amount of Sample Diluent.

6.0 Reagent Storage

6.1 All reagents, with the exception of PAH sample extracts, should be stored at 2-8 degrees Celsius. Reconstituted conjugate should be used within 21 days of preparation, but if not used within that period of time, aliquots of conjugate solution may be frozen. Frozen aliquots of reconstituted conjugate may be used until the expiration date found on the kit box label.

6.2 Sample extracts should be stored at less than 0 degrees Celsius.

7.0 Quality Control

7.1 The calibration curve generated from each set of sample should have a calibration fit value (i.e., linear correlation coefficient, r) of at least 0.99. If the r value is less than 0.99, this set of samples should be reassayed. The results of the proficiency samples should also be within the ranges provided by Ohmicron Environmental Diagnostics. If the results are outside the ranges, this set of samples should be reassayed.

7.2 For each set of samples tested, a method blank or a field blank should be included. Duplicate analysis is recommended for all sample extracts.

7.3 Do not use test kits past their expiration date.

7.4 Do not use reagents designated for use with other kits.

7.5 Use the test kits within their specified storage temperature and operating temperature limits.

APPENDIX B. REVISED SOIL SCREENING METHOD MEASURING PAH BY IMMUNOASSAY

1.0 Apparatus and Materials

1.1 Immunoassay test kit: RaPID Prep Soil Collection Kit, RaPID Prep PAH Sample Extraction Kit, PAH RaPID Assay Kit, and C-PAH RaPID Assay Kit (Ohmicron Environmental Diagnostics) and associated documentation.

1.2 OHAUS 300 toploading balance or an equivalent balance - used for weighing aliquots of soil samples (± 0.1 g).

1.3 Muffled 4 dram vials with teflon lined caps - used to contain soil aliquot for extraction and storing sample extracts.

1.4 Branson Sonicator 5210 - used to thoroughly extract PAH from soil.

1.5 Muffled 1 dram vials with teflon lined caps - used to contain sample diluents.

1.6 Vortex Mixer - used to homogenize solutions.

1.7 Eppendorf Series 2000 Reference Adjustable Volume 100-1000 µl Pipette and Eppendorf pipette tips.

1.8 Eppendorf Repeater Pipette 4780 and Combitips 12.5 ml capacity.

1.9 Eppendorf Digital Pipette 4710 10-100 µl and Eppendorf pipette tips 100 µl.

1.10 Ohmicron Magnetic Separation Rack - used for separating magnetic antibody particles from solution.

1.11 "Foster Caddy" Polypropylene Vial Rack - used for holding 1 dram vial when diluting extracts with diluent.

1.12 RPA-I™ RaPID Photometric Analyzer - used for analyzing the PAH concentration in assayed samples.

1.13 Becton Dickinson Transpets Pasteur Pipettes 5 3/4" - used for transfering extract to Soil Sample Collection Device (included in RaPID Prep Soil Collection Kit).

2.0 Reagents

Note: all reagents are included in kits listed under **Apparatus and Materials.** Different testing kits are used for PAH and C-PAH assay.

2.1 PAH and C-PAH Extraction Solution - methanol with calcium chloride (2.5 mmol.) as a dispersion agent.

2.2 PAH and C-PAH Extract Diluent - buffered saline solution containing preservatives and stabilizers without any detectable PAH's as stated by Ohmicron Environmental Diagnostics.

2.3 PAH and C-PAH Antibody Coupled Paramagnetic Particles - PAH and C-PAH antibody covalently bound paramagnetic particles, which are suspended in buffered saline with preservative and stabilizers.

2.4 Lyophilized PAH and C-PAH Enzyme Conjugate - concentrated horseradish peroxidase (HRP) labeled PAH analog is supplied as a lyophilized powder.

2.5 PAH and C-PAH Enzyme Conjugate Diluent - buffered saline containing preservatives and stabilizers.

2.6 PAH and C-PAH Standards - three concentrations (2.0, 10.0, 50.0 ppb) of phenanthrene (as phenanthrene analog) standards in buffered saline with preservative and stabilizers. C-PAH Standards - three concentrations (0.1, 1.0, 5.0 ppb) of benzo[a]pyrene in buffered saline with preservative and stabilizers.

2.7 Control - a concentration of either phenanthrene (PAH assay) or benzo[a]pyrene (C-PAH assay) in buffered saline with preservative and stabilizers.

2.8 Proficiency samples - three solutions containing known amounts of either phenanthrene (PAH assay) or benzo[a]pyrene (C-PAH assay) in buffered saline with preservative and stabilizers.

2.9 Diluent/Zero Standard - buffered saline containing preservative and stabilizers without any detectable PAH.

2.10 Color Reagent - solution of hydrogen peroxide and 3, 3', 5, 5'-tetramethylbenzidine in organic base.

2.11 Stopping Solution - solution of sulfuric acid (0.5%).

2.12 PAH and C-PAH Washing Solution - preserved deionized water with detergent.

2.13 Test Tubes - polystyrene tubes for actual sample assaying.

3.0 Soil Extraction Procedure

3.1 Weigh 1 g (± 0.1 g) aliquot of a soil or dust sample and place in a clean 4 dram vial.

3.2 Transfer 10 ml of PAH Extraction Solution to the sample vial.

3.3 Cap the vial and sonicate the sample for 20 minutes. Sonicator should be filled with 1/4" of deionized water.

3.4 Remove the sample vial from the sonicator and allow it to stand and settle for 5 minutes.

3.5 Remove cap from Soil Sample Collection Device (included in Soil Collection Kit), pull back, remove, and save plunger. Transfer the sample extract from the vial to the Soil Sample Collection Device with a disposable 5 3/4" pipette, and recap the device.

3.6 Transfer 10 ml of PAH Extraction Solution again to the 4 dram sample vial and resonicate for 20 minutes. Allow vial 5 minutes to stand and settle.

3.7 Pipette the second sample extract into the same collection device.

3.8 Replace the collection device screw cap with a filter cap and reattach the plunger.

3.9 Invert the device into a clean 4 dram vial and press down on the plunger until the sample extract passes through the filter into the vial.

4.0 Extract Dilution with Diluent

4.1 Set up and label clean 1 dram vials and place the vials in "foster caddy" vial rack.

4.2 Transfer 1,225 µl of PAH Extract Diluent to each 1 dram vial and add 225 µl of the sample extract to the PAH Extract Diluent using Eppendorf Series 2000 Reference Adjustable Volume 100-1000 µl Pipette.

4.3 Vortex diluted sample extracts for 1 to 2 seconds to insure complete homogenization.

5.0 PAH Immunoassay Procedure

5.1 Detach the Magnetic Separation Rack from the magnetic base and set up test tubes. Include 12 test tubes in addition to sample test tubes for duplicates of four calibration standards, control tube, and three proficiency samples.

5.2 Add 250 μl of either standards, control, proficiency samples, or diluted sample extract to test tubes by aiming the pipet tip 1/4" to 1/2" below the rim delivering liquid gently.

5.3 Prepare PAH Enzyme Conjugate for use by dissolving Lyophilized PAH Enzyme Conjugate with PAH Enzyme Conjugate Diluent. Shake well to insure thorough mixing.

5.4 Add 250 μl of PAH Enzyme Conjugate to each tube by aiming the pipet tip 1/4" to 1/2" below the tube rim without touching the rim with the pipet tip. An Eppendorf Repeater Pipette 4780 with 12.5 ml capacity Combitips is used. Air bubbles and the possibility of pipetting less volume of reagent to first tubes should be prevented by pipetting the first few aliquots of reagent back into the reagent bottle.

5.5 Gently shake PAH Antibody Coupled Paramagnetic Particles bottle until thoroughly mixed. Add 500 μl of magnetic particles to tubes with the Repeater pipette.

5.6 Vortex test tubes for 1 to 2 seconds at low speed to minimize foaming and to prevent loss of sample.

5.7 Incubate these tubes for 30 minutes at room temperature (15 - 30 degrees C).

5.8 Combine the magnetic rack securely with the magnetic base by pressing all tubes into the base. Allow 2 minutes for the magnetic particles to separate to walls of tubes.

5.9 Keep the rack attached to the magnetic base and invert the rack assembly over a waste container and pour out the solution with a smooth motion. Maintain inverted position and gently blot the test tube rims on several layers of clean paper towel.

5.10 Add 1 ml of PAH Washing Solution down inside wall of each tube with the Repeater pipette. Vortex each tube for 1 or 2 seconds and wait for 2 minutes. Invert the combined rack assembly over the waste container and gently blot test tubes on the paper towel.

5.11 Repeat step 5.10.

5.12 Remove the upper rack with tubes from the base.

5.13 Add 500 μl of Color Reagent down the inside wall of each tube. Vortex each tube for 1 or 2 seconds at low speed.

5.14 Incubate these tubes for 20 minutes at room temperature. During incubation time, add 1 ml of Washing Solution into a clean test tube for use as an instrument blank.

5.15 Add 500 µl of Stopping Solution down the inside wall of each tube.

5.16 Read results at 450nm within 15 minutes after adding Stopping Solution on RPA-I™ RaPID Photometric Analyzer programmed for PAH protocol.

Note: The procedures for the C-PAH assay are the same as the PAH assay (Steps 5.1 to 5.16) except that the reagents used in C-PAH are from the C-PAH assay testing kit. If the PAH concentration output of a sample exceeds 50 ppb (PAH assay) or 5 ppb (C-PAH assay), the sample should be diluted by a dilution factor of 10 or greater with an appropriate amount of Sample Diluent.

6.0 Reagent Storage

6.1 All reagents, with the exception of PAH sample extracts, should be stored at 2-8 degrees Celsius. Reconstituted conjugate should be used within 21 days of preparation, but if not used within that period of time, aliquots of conjugate solution may be frozen. Frozen aliquots of reconstituted conjugate may be used until the expiration date found on the kit box label.

6.2 PAH sample extracts should be stored at less than 0 degrees Celsius.

7.0 Quality Control

7.1 The calibration curve generated from each set of sample should have a calibration fit value (i.e., linear correlation coefficient, r) of at least 0.99. If the r value is less than 0.99, this set of samples should be reassayed. The results of the proficiency samples should also be within the ranges provided by Ohmicron Environmental Diagnostics. If the results are outside the ranges, this set of samples should be reassayed.

7.2 For each set of samples tested, a method blank or a field blank should be included. Duplicate analysis is recommended for all sample extracts.

7.3 Do not use test kits past their expiration date.

7.4 Do not use reagents designated for use with other kits.

7.5 Use the test kits within their specified storage temperature and operating temperature limits.

APPENDIX C. ALKYL PAH DATA IN INDOOR AND OUTDOOR AIR SAMPLES

Compound	AI-F/XAD ng/m3	B1-F/XAD ng/m3	CI-F/XAD ng/m3	DI-F/XAD ng/m3	EI-F/XAD ng/m3	FI-F/XAD ng/m3	GI-F/XAD ng/m3	HI-F/XAD ng/m3	II-F/XAD ng/m3	JI-F/XAD ng/m3	KI-F/XAD ng/m3	LI-F/XAD ng/m3	MI-F/XAD ng/m3
2-Methylnaphthalene	254.92	228.84	626.59	254.54	190.11	355.39	715.04	191.58	135.56	180.27	307.93	107.30	324.35
1-Methylnaphthalene	240.06	117.54	620.78	215.09	128.21	254.73	352.23	103.02	108.63	100.58	570.72	78.32	323.36
C2-alkylnaphthalene isomers	594.61	334.29	1775.56	367.63	308.01	548.78	314.17	250.74	490.58	288.44	852.20	144.69	1172.66
C1-alkylphenanthrene isomers	51.91	92.09	112.33	29.31	30.04	34.23	29.19	15.14	20.60	29.55	38.53	12.28	29.02
C2-alkylphenanthrene isomers	65.48	173.91	126.94	41.16	46.48	47.83	105.96	26.13	32.06	59.24	47.37	21.22	28.24
C1-alkylpyrene isomers	3.84	10.25	5.01	2.22	2.39	4.24	49.34	1.62	1.79	2.50	4.63	1.30	2.85
C2-alkylpyrene isomers	1.05	2.52	1.30	0.49	0.47	1.50	4.64	0.39	0.55	0.55	2.26	0.43	1.56
C1-alkylchrysene isomers	0.29	1.12	0.39	0.20	0.20	0.53	0.65	0.18	0.23	0.18	2.13	0.14	1.11
C2-alkylchrysene isomers	1.41	4.00	2.03	2.09	2.59	4.38	8.63	3.96	1.41	3.24	8.15	1.59	6.35
C1-alkylbenzo[a]pyrene isomers	1.04	1.75	0.88	0.78	0.77	3.76	15.53	1.25	1.19	1.48	22.99	1.35	18.43
Sum of alkyl PAH	1214.61	966.31	3271.81	913.50	709.27	1255.37	1595.37	594.01	792.60	666.04	1856.91	368.62	1907.94

APPENDIX C. ALKYL PAH DATA IN INDOOR AND OUTDOOR AIR SAMPLES

Compound	AO-F/XAD ng/m3	BO-F/XAD ng/m3	CO-F/XAD ng/m3	DO-F/XAD ng/m3	EO-F/XAD ng/m3	FO-F/XAD ng/m3	GO-F/XAD ng/m3	HO-F/XAD ng/m3	IO-F/XAD ng/m3	JO-F/XAD ng/m3	KO-F/XAD ng/m3	LO-F/XAD ng/m3	MO-F/XAD ng/m3
2-Methylnaphthalene	99.41	50.09	75.19	42.16	63.41	134.37	83.60	15.33	45.47	50.26	25.55	32.14	20.25
1-Methylnaphthalene	54.26	29.41	71.95	21.39	54.73	122.23	65.83	8.25	29.54	29.05	13.60	17.54	10.15
C2-alkylnaphthalene isomers	69.78	59.18	338.12	24.09	87.93	373.66	89.37	20.61	53.74	39.95	15.61	18.51	9.31
C1-alkylphenanthrene isomers	10.79	15.78	16.64	5.31	6.66	30.84	8.14	5.78	5.26	7.82	4.68	4.19	2.06
C2-alkylphenanthrene isomers	11.66	18.56	18.61	6.44	6.72	32.58	10.04	7.58	5.81	9.65	6.98	5.24	2.95
C1-alkylpyrene isomers	1.61	1.48	1.96	0.76	0.92	3.06	1.61	0.68	0.66	1.96	0.76	0.69	1.02
C2-alkylpyrene isomers	0.44	0.49	0.55	0.23	0.25	0.90	0.38	0.26	0.21	0.60	0.22	0.20	0.53
C1-alkylchrysene isomers	1.09	0.23	0.20	0.27	0.12	0.39	0.29	0.12	0.12	0.26	0.08	0.08	0.61
C2-alkylchrysene isomers	3.70	2.09	1.52	2.28	0.72	1.32	0.94	1.34	1.89	1.31	1.50	1.07	1.38
C1-alkylbenzo[a]pyrene isomers	4.75	2.12	1.30	2.24	1.38	2.33	1.10	1.25	1.35	1.53	1.21	0.90	1.66
Sum of alkyl PAH	257.50	179.43	526.05	105.16	222.83	701.68	261.30	61.20	144.05	142.40	70.19	80.56	49.92

APPENDIX D. ALKYL PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-HD-S ppm	B-HD-S ppm	C-HD-S ppm	D-HD-S ppm	E-HD-S ppm	F-HD-S ppm	G-HD-S ppm	H-HD-S ppm	I-HD-S ppm	J-HD-S ppm	K-HD-S ppm	L-HD-S ppm	M-HD-S ppm
2-Methylnaphthalene	0.031	0.014	0.025	0.046	0.017	0.029	0.022	0.026	0.016	0.018	0.021	0.012	0.020
1-Methylnaphthalene	0.023	0.011	0.019	0.024	0.013	0.025	0.014	0.013	0.010	0.010	0.014	0.008	0.018
C2-alkylnaphthalene isomers	0.172	0.081	0.142	0.124	0.071	0.301	0.063	0.055	0.056	0.062	0.114	0.034	0.106
C1-alkylphenanthrene isomers	0.526	0.875	0.506	0.433	0.254	0.196	0.338	0.160	0.088	0.137	0.747	0.112	0.294
C2-alkylphenanthrene isomers	0.722	1.892	0.452	0.615	0.320	0.182	0.328	0.199	0.168	0.197	0.902	0.131	0.375
C1-alkylpyrene isomers	0.282	0.182	0.152	0.173	0.125	0.154	0.099	0.110	0.074	0.084	0.204	0.130	0.161
C2-alkylpyrene isomers	0.140	0.089	0.104	0.156	0.070	0.099	0.045	0.059	0.039	0.054	0.067	0.053	0.085
C1-alkylchrysene isomers	0.304	0.074	0.091	0.112	0.082	0.101	0.046	0.111	0.045	0.036	0.068	0.058	0.072
C2-alkylchrysene isomers	0.030	0.065	0.071	0.140	0.057	0.045	0.103	0.286	0.063	0.090	0.196	0.112	0.025
C1-alkylbenzo[a]pyrene isomers	0.061	0.036	0.075	0.071	0.058	0.039	0.058	0.054	0.024	0.055	0.071	0.023	0.095
Sum of alkyl PAH	2.290	3.320	1.638	1.893	1.067	1.170	1.117	1.072	0.584	0.742	2.403	0.675	1.253

APPENDIX D. ALKYL PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-ES-S	B-ES-S	C-ES-S	D-ES-S	E-ES-S	F-ES-S	G-ES-S	H-ES-S	I-ES-S	J-ES-S	K-ES-S	L-ES-S	M-ES-S
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
2-Methylnaphthalene	0.006	0.006	0.013	0.016	0.028	0.010	0.012	0.007	0.005	0.012	0.005	0.010	0.010
1-Methylnaphthalene	0.005	0.004	0.008	0.010	0.022	0.009	0.008	0.005	0.003	0.009	0.004	0.012	0.008
C2-alkylnaphthalene isomers	0.022	0.026	0.037	0.078	0.052	0.045	0.027	0.082	0.019	0.028	0.024	0.039	0.041
C1-alkylphenanthrene isomers	0.075	0.085	0.048	0.070	0.221	0.069	0.233	0.050	0.024	0.239	0.042	0.105	0.065
C2-alkylphenanthrene isomers	0.198	0.277	0.106	0.207	0.341	0.135	0.286	0.171	0.067	0.294	0.090	0.213	0.125
C1-alkylpyrene isomers	0.116	0.137	0.044	0.095	0.177	0.095	0.273	0.053	0.027	0.280	0.074	0.166	0.040
C2-alkylpyrene isomers	0.034	0.048	0.016	0.035	0.088	0.048	0.099	0.022	0.013	0.101	0.031	0.104	0.024
C1-alkylchrysene isomers	0.052	0.059	0.015	0.032	0.113	0.052	0.087	0.026	0.017	0.089	0.029	0.087	0.017
C2-alkylchrysene isomers	0.014	0.026	0.020	0.017	0.017	0.029	0.019	0.019	0.013	0.020	0.018	0.023	0.015
C1-alkylbenzo[a]pyrene isomers	0.063	0.342	0.069	0.039	0.064	1.046	0.381	0.119	0.031	0.391	0.080	0.175	0.084
Sum of alkyl PAH	0.584	1.010	0.376	0.599	1.123	1.536	1.425	0.553	0.218	1.463	0.396	0.934	0.429

APPENDIX D. ALKYL PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-PS-S ppm	B-PS-S ppm	C-PS-S ppm	D-PS-S ppm	E-PS-S ppm	F-PS-S ppm	G-PS-S ppm	H-PS-S ppm	I-PS-S ppm	J-PS-S ppm	K-PS-S ppm	L-PS-S ppm	M-PS-S ppm
2-Methylnaphthalene	0.003	0.003	0.009	0.003	0.004	0.004	0.005	0.003	0.003	0.002	0.002	0.002	0.001
1-Methylnaphthalene	0.002	0.002	0.005	0.002	0.002	0.002	0.006	0.002	0.001	0.001	0.001	0.001	0.001
C2-alkylnaphthalene isomers	0.008	0.009	0.019	0.005	0.011	0.010	0.021	0.007	0.006	0.004	0.005	0.004	0.007
C1-alkylphenanthrene isomers	0.039	0.049	0.064	0.011	0.145	0.019	0.240	0.015	0.006	0.013	0.012	0.011	0.015
C2-alkylphenanthrene isomers	0.254	0.067	0.175	0.058	0.296	0.070	0.967	0.067	0.040	0.064	0.052	0.037	0.029
C1-alkylpyrene isomers	0.064	0.085	0.145	0.014	0.208	0.020	0.422	0.064	0.011	0.019	0.017	0.012	0.015
C2-alkylpyrene isomers	0.018	0.021	0.077	0.010	0.051	0.008	0.103	0.021	0.025	0.008	0.013	0.008	0.006
C1-alkylchrysene isomers	0.005	0.019	0.096	0.004	0.036	0.003	0.080	0.024	0.004	0.009	0.009	0.004	0.007
C2-alkylchrysene isomers	0.016	0.008	0.113	0.011	0.012	0.006	0.022	0.008	0.007	0.009	0.009	0.005	0.011
C1-alkylbenzo[a]pyrene isomers	0.022	0.023	0.142	0.007	0.046	0.005	0.113	0.028	0.008	0.006	0.055	0.009	0.008
Sum of alkyl PAH	0.431	0.285	0.844	0.125	0.810	0.146	1.979	0.237	0.111	0.135	0.175	0.092	0.101

APPENDIX E. ALKYL PAH DATA IN THE FOOD SAMPLES

Compound	A1-S ppb	B1-S ppb	C1-S ppb	D1-S ppb	E1-S ppb	F1-S ppb	G1-S ppb	H1-S ppb	I1-S ppb	J1-S ppb	K1-S ppb	L1-S ppb	M1-S ppb
2-Methylnaphthalene	0.776	0.698	2.364	0.270	0.009	0.108	0.275	0.294	0.647	0.272	0.338	0.370	0.388
1-Methylnaphthalene	0.516	0.049	1.668	0.059	0.203	0.078	0.145	0.245	0.406	0.182	0.205	0.239	0.240
C2-alkylnaphthalene isomers	2.024	4.315	2.444	1.945	0.235	1.070	0.818	3.607	1.633	1.085	0.799	1.520	1.123
C1-alkylphenanthrene isomers	2.093	2.845	2.037	1.676	0.118	1.377	2.117	3.976	2.332	1.143	1.730	1.193	0.702
C2-alkylphenanthrene isomers	1.206	1.292	0.427	1.484	0.136	0.959	1.728	2.502	2.525	0.883	1.365	1.068	0.444
C1-alkylpyrene isomers	1.045	2.180	1.450	1.777	0.092	0.411	1.493	2.621	2.525	0.351	1.132	0.525	0.669
C2-alkylpyrene isomers	0.200	0.294	0.198	0.134	0.043	0.122	0.178	0.166	0.191	0.024	0.097	0.136	0.137
C1-alkylchrysene isomers	0.175	0.367	0.264	0.142	0.030	0.074	0.154	0.521	0.211	0.076	0.184	0.119	0.036
C2-alkylchrysene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
C1-alkylbenzo[a]pyrene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sum of alkyl PAH	8.035	12.040	10.851	7.488	0.866	4.198	6.909	13.932	10.469	4.016	5.850	5.169	3.739

APPENDIX E. ALKYL PAH DATA IN THE FOOD SAMPLES

Compound	A2-S ppb	B2-S ppb	C2-S ppb	D2-S ppb	E2-S ppb	F2-S ppb	G2-S ppb	H2-S ppb	I2-S ppb	J2-S ppb	K2-S ppb	L2-S ppb	M2-S ppb
2-Methylnaphthalene	0.313	3.207	0.011	0.218	0.100	0.509	1.248	0.654	0.247	0.060	0.089	0.492	0.070
1-Methylnaphthalene	0.187	1.945	0.203	0.157	0.060	0.318	0.638	0.377	0.139	0.013	0.057	0.299	0.073
C2-alkylnaphthalene isomers	0.754	5.029	1.231	1.374	0.419	1.358	1.779	2.267	1.638	2.481	0.926	3.006	1.870
C1-alkylphenanthrene isomers	0.836	2.207	0.839	1.266	0.505	1.349	1.801	1.925	3.491	1.208	0.667	1.883	0.703
C2-alkylphenanthrene isomers	0.606	0.990	0.699	0.849	0.732	1.476	1.769	1.077	2.743	0.845	0.572	1.161	0.549
C1-alkylpyrene isomers	0.364	1.200	0.303	0.375	0.159	1.218	1.037	1.571	2.692	1.306	0.137	0.409	0.332
C2-alkylpyrene isomers	0.102	0.918	0.104	0.126	0.061	0.159	0.104	0.128	0.152	0.199	0.069	0.138	0.102
C1-alkylchrysene isomers	0.129	0.056	0.058	0.141	0.066	0.079	0.065	0.138	0.268	0.331	0.026	0.062	0.059
C2-alkylchrysene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
C1-alkylbenzo[a]pyrene isomers	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sum of alkyl PAH	3.291	15.552	3.449	4.506	2.102	6.465	8.440	8.137	11.372	6.443	2.543	7.450	3.759

APPENDIX F. PHTHALATES DATA IN INDOOR AND OUTDOOR AIR SAMPLES

Compound	AI-F/XAD ng/m3	BI-F/XAD ng/m3	CI-F/XAD ng/m3	DI-F/XAD ng/m3	EI-F/XAD ng/m3	FI-F/XAD ng/m3	GI-F/XAD ng/m3	HI-F/XAD ng/m3	II-F/XAD ng/m3	JI-F/XAD ng/m3	KI-F/XAD ng/m3	LI-F/XAD ng/m3	MI-F/XAD ng/m3
Dimethylphthalate	108.15	137.04	49.19	56.10	37.00	33.64	29.41	43.20	69.54	41.21	93.13	32.61	121.69
Diethylphthalate	956.60	2327.94	1044.88	568.48	688.93	407.41	841.78	298.99	621.31	1299.44	956.05	386.18	628.28
Di-n-butylphthalate	264.63	493.91	291.21	223.71	122.85	162.97	298.59	158.13	183.97	245.95	241.87	197.76	246.53
Butylbenzylphthalate	564.90	717.89	211.80	215.67	158.75	182.74	969.90	468.16	123.54	9.98	80.30	356.94	9.27
Bis(2-ethylhexyl)phthalate	447.90	735.08	364.16	147.96	246.02	553.68	3165.04	227.76	258.17	284.12	532.92	177.38	383.39
Di-n-octylphthalate	10.63	30.56	13.03	3.07	3.71	7.93	22.98	6.87	5.00	7.22	14.53	4.72	13.57
Sum of phthalates	2352.81	4442.41	1974.27	1214.99	1257.25	1348.38	5327.69	1203.11	1261.52	1887.91	1918.80	1155.58	1402.74

APPENDIX F. PHTHALATES DATA IN INDOOR AND OUTDOOR AIR SAMPLES

Compound	AO-F/XAD ng/m3	BO-F/XAD ng/m3	CO-F/XAD ng/m3	DO-F/XAD ng/m3	EO-F/XAD ng/m3	FO-F/XAD ng/m3	GO-F/XAD ng/m3	HO-F/XAD ng/m3	IO-F/XAD ng/m3	JO-F/XAD ng/m3	KO-F/XAD ng/m3	LO-F/XAD ng/m3	MO-F/XAD ng/m3
Dimethylphthalate	9.21	16.50	11.38	2.45	4.14	15.05	12.59	5.08	5.53	2.72	2.15	1.80	2.16
Diethylphthalate	84.11	170.89	73.08	18.57	49.12	154.46	87.53	62.89	63.24	47.45	31.60	31.51	19.41
Di-n-butylphthalate	69.11	131.51	53.63	1.93	23.88	147.72	46.73	41.97	14.47	15.07	9.94	16.55	9.76
Butylbenzylphthalate	406.00	476.13	304.25	173.63	17.04	165.90	533.19	415.44	8.21	19.35	14.77	2.38	517.80
Bis(2-ethylhexyl)phthalate	125.45	192.62	150.93	58.46	147.42	319.73	390.29	308.95	172.07	32.96	5.98	11.46	29.66
Di-n-octylphthalate	6.09	5.65	2.14	1.02	1.05	3.66	4.34	2.15	1.89	2.46	0.55	0.47	0.64
Sum of phthalates	699.97	993.30	595.41	256.07	242.64	806.53	1074.67	836.47	265.41	120.02	64.99	64.19	579.43

APPENDIX G. PHTHALATES DATA IN HOUSE DUST,ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-HD-S ppm	B-HD-S ppm	C-HD-S ppm	D-HD-S ppm	E-HD-S ppm	F-HD-S ppm	G-HD-S ppm	H-HD-S ppm	I-HD-S ppm	J-HD-S ppm	K-HD-S ppm	L-HD-S ppm	M-HD-S ppm
Dimethylphthalate	0.019	0.006	0.007	0.092	0.024	0.018	0.026	0.039	0.010	0.024	0.023	0.009	0.234
Diethylphthalate	0.909	0.914	0.583	0.924	0.727	0.236	1.274	0.469	0.312	0.671	0.909	0.422	0.573
Di-n-butylphthalate	3.346	3.923	4.805	5.451	2.365	1.510	2.345	2.904	0.868	1.658	4.118	2.008	3.459
Butylbenzylphthalate	20.439	113.640	30.287	50.308	4.955	12.736	24.489	40.901	4.879	32.938	19.140	14.756	6.775
Bis(2-ethylhexyl)phthalate	99.774	39.745	100.009	30.935	19.470	17.142	24.132	21.502	31.407	35.778	31.304	21.788	52.484
Di-n-octylphthalate	0.526	2.119	4.221	5.815	0.989	1.017	14.087	7.060	1.833	2.784	6.162	2.524	5.723
Sum of phthalates	125.014	160.347	139.913	93.526	28.530	32.658	66.353	72.874	39.309	73.853	61.656	41.507	69.248

APPENDIX G. PHTHALATES DATA IN HOUSE DUST,ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-ES-S ppm	B-ES-S ppm	C-ES-S ppm	D-ES-S ppm	E-ES-S ppm	F-ES-S ppm	G-ES-S ppm	H-ES-S ppm	I-ES-S ppm	J-ES-S ppm	K-ES-S ppm	L-ES-S ppm	M-ES-S ppm
Dimethylphthalate	0.001	0.004	0.008	0.016	0.013	<0.001	0.007	0.015	<0.001	<0.001	<0.001	0.001	0.028
Diethylphthalate	0.206	0.256	0.200	0.205	0.335	0.111	0.344	0.410	0.108	0.092	0.147	0.097	0.194
Di-n-butylphthalate	0.071	1.216	0.243	0.773	1.262	0.569	2.400	0.936	0.227	0.151	0.357	0.439	0.429
Butylbenzylphthalate	1.487	49.721	1.809	73.398	4.008	7.228	13.768	15.337	4.876	6.921	1.159	3.681	0.855
Bis(2-ethylhexyl)phthalate	11.862	19.575	8.953	32.138	29.207	36.553	31.668	12.343	10.148	8.574	25.643	63.699	18.973
Di-n-octylphthalate	0.245	0.791	0.276	2.430	0.480	4.386	7.067	0.798	0.138	0.084	3.001	3.791	0.992
Sum of phthalates	13.871	71.563	11.488	108.959	35.304	48.846	55.254	29.839	15.496	15.822	30.307	71.708	21.472

APPENDIX G. PHTHALATES DATA IN HOUSE DUST,ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-PS-S ppm	B-PS-S ppm	C-PS-S ppm	D-PS-S ppm	E-PS-S ppm	F-PS-S ppm	G-PS-S ppm	H-PS-S ppm	I-PS-S ppm	J-PS-S ppm	K-PS-S ppm	L-PS-S ppm	M-PS-S ppm
Dimethylphthalate	0.001	0.004	0.005	0.001	0.003	0.003	0.000	0.000	0.001	<0.001	<0.001	0.000	0.000
Diethylphthalate	<0.001	0.011	0.008	<0.001	<0.001	<0.001	0.004	0.016	0.013	<0.001	<0.001	0.007	<0.001
Di-n-butylphthalate	0.086	0.074	0.104	0.026	0.072	0.052	0.218	0.064	0.087	0.035	0.034	0.048	0.011
Butylbenzylphthalate	0.048	0.034	0.471	0.076	0.043	0.059	1.288	0.037	1.041	0.031	0.073	0.014	0.007
Bis(2-ethylhexyl)phthalate	0.041	0.198	0.170	0.086	0.150	0.090	0.239	0.453	0.304	0.234	1.636	2.589	0.018
Di-n-octylphthalate	0.023	0.012	0.011	0.038	0.019	0.006	0.061	0.013	0.006	0.021	0.030	0.021	0.004
Sum of phthalates	0.198	0.333	0.770	0.227	0.287	0.210	1.811	0.582	1.453	0.321	1.773	2.680	0.039

APPENDIX H. PHTHALATES DATA IN THE FOOD SAMPLES

Compound	A1-S ppb	B1-S ppb	C1-S ppb	D1-S ppb	E1-S ppb	F1-S ppb	G1-S ppb	H1-S ppb	I1-S ppb	J1-S ppb	K1-S ppb	L1-S ppb	M1-S ppb
Dimethylphthalate	1.046	0.617	1.925	0.105	0.913	0.552	0.012	0.048	0.281	0.175	0.063	0.048	0.030
Diethylphthalate	2.401	2.288	1.590	1.679	1.063	0.389	0.059	1.318	2.266	0.660	0.789	0.013	0.864
Di-n-butylphthalate	6.933	2.096	1.161	5.064	0.285	3.156	4.770	4.012	9.805	4.071	4.604	<0.02	2.730
Butylbenzylphthalate	36.898	15.754	5.916	69.137	<0.02	3.460	1.313	38.259	83.096	3.565	52.579	<0.02	5.514
Bis(2-ethylhexyl)phthalate	69.500	100.016	39.854	3.033	9.807	21.051	66.125	110.184	95.838	74.052	42.928	12.133	2.368
Di-n-octylphthalate	14.565	23.280	3.329	0.227	0.142	0.165	16.946	17.951	54.141	1.507	0.331	0.046	<0.02
Sum of phthalates	131.344	144.051	53.775	79.246	12.209	28.772	89.224	171.773	245.428	84.030	101.295	12.240	11.506

H-1

APPENDIX H. PHTHALATES DATA IN THE FOOD SAMPLES

Compound	A2-S ppb	B2-S ppb	C2-S ppb	D2-S ppb	E2-S ppb	F2-S ppb	G2-S ppb	H2-S ppb	I2-S ppb	J2-S ppb	K2-S ppb	L2-S ppb	M2-S ppb
Dimethylphthalate	0.114	0.076	0.038	0.028	0.074	0.127	0.086	0.097	0.414	0.131	0.063	0.333	0.081
Diethylphthalate	18.968	2.302	<0.02	0.293	0.811	0.028	0.753	0.451	0.273	1.111	0.181	0.260	0.241
Di-n-butylphthalate	<0.02	4.657	<0.02	1.339	2.600	0.743	1.326	1.216	0.710	<0.02	0.235	1.079	0.471
Butylbenzylphthalate	<0.02	<0.02	<0.02	7.016	7.221	1.569	9.051	10.670	12.826	35.856	<0.02	<0.02	<0.02
Bis(2-ethylhexyl)phthalate	0.859	2.014	<0.02	1.756	3.049	1.235	3.307	3.465	84.291	34.507	2.046	2.476	2.075
Di-n-octylphthalate	0.115	1.954	0.056	0.125	0.330	0.241	0.011	0.032	15.645	0.620	0.424	0.110	0.317
Sum of phthalates	20.055	11.003	0.095	10.556	14.084	3.944	14.535	15.932	114.160	72.225	2.949	4.258	3.185

H-2

APPENDIX I. PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-HD-X ppm	B-HD-X ppm	C-HD-X ppm	D-HD-X ppm	E-HD-X ppm	F-HD-X ppm	G-HD-X ppm	H-HD-X ppm	I-HD-X ppm	J-HD-X ppm	K-HD-X ppm	L-HD-X ppm	M-HD-X ppm
Naphthalene	0.212	0.077	0.032	0.044	0.082	0.136	0.039	0.155	0.035	0.061	0.026	0.018	0.050
Biphenyl	0.516	0.035	0.045	0.042	0.086	0.279	0.097	0.130	0.020	0.052	0.054	0.072	0.098
Acenaphthylene	0.131	0.022	0.016	0.023	0.030	0.063	0.042	0.026	0.007	0.015	0.023	0.010	0.046
Acenaphthene	0.202	0.015	0.019	0.032	0.022	0.185	0.028	0.043	0.007	0.019	0.055	0.009	0.037
Fluorene	0.814	0.029	0.033	0.058	0.033	0.190	0.049	0.050	0.015	0.029	0.027	0.035	0.069
Phenanthrene	0.741	0.197	0.143	0.237	0.202	1.316	0.173	0.318	0.063	0.137	0.183	0.237	0.225
Anthracene	0.116	0.021	0.025	0.038	0.025	0.331	0.025	0.036	0.007	0.019	0.029	0.036	0.022
Fluoranthene	1.025	0.299	0.140	0.208	0.200	2.148	0.237	0.627	0.129	0.249	0.491	0.498	0.272
Pyrene	0.769	0.228	0.095	0.141	0.157	1.571	0.184	0.407	0.087	0.169	0.334	0.347	0.185
Cyclopenta[c,d]pyrene	0.100	0.020	0.008	0.018	0.036	0.404	0.025	0.065	0.013	0.026	0.045	0.061	0.022
Benz[a]anthracene*	0.360	0.087	0.041	0.117	0.144	1.465	0.117	0.323	0.064	0.090	0.187	0.209	0.108
Chrysene*	0.367	0.132	0.049	0.128	0.162	1.052	0.166	0.430	0.067	0.106	0.171	0.225	0.126
Benzofluoranthenes*	0.473	0.242	0.116	0.255	0.239	2.452	0.146	0.402	0.105	0.215	0.365	0.765	0.205
Benzo[e]pyrene	0.207	0.284	0.066	0.123	0.128	0.907	0.137	0.149	0.040	0.101	0.241	0.043	0.110
Benzo[a]pyrene*	0.138	0.037	0.022	0.063	0.073	0.931	0.040	0.126	0.030	0.062	0.090	0.293	0.044
Indeno[1,2,3-c,d]pyrene*	0.117	0.076	0.025	0.065	0.106	0.879	0.052	0.143	0.047	0.088	0.134	0.338	0.074
Dibenzo[a,h]anthracene*	0.032	0.018	0.012	0.014	0.017	0.240	0.014	0.036	0.016	0.020	0.031	0.076	0.019
Benzo[g,h,i]perylene	0.122	0.070	0.035	0.056	0.101	0.817	0.069	0.124	0.046	0.083	0.122	0.322	0.069
Coronene	0.031	0.030	0.016	0.044	0.065	0.283	0.032	0.039	0.035	0.038	0.037	0.120	0.039
Sum of B2 PAH	1.487	0.592	0.267	0.642	0.740	7.019	0.534	1.460	0.329	0.581	0.978	1.906	0.577
Sum of target PAH	6.473	1.919	0.939	1.707	1.906	15.649	1.670	3.628	0.833	1.579	2.645	3.714	1.820

APPENDIX I. PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-ES-X ppm	B-ES-X ppm	C-ES-X ppm	D-ES-X ppm	E-ES-X ppm	F-ES-X ppm	G-ES-X ppm	H-ES-X ppm	I-ES-X ppm	J-ES-X ppm	K-ES-X ppm	L-ES-X ppm	M-ES-X ppm
Naphthalene	0.067	0.008	0.094	0.017	0.006	0.010	0.008	0.013	0.014	0.004	0.001	0.041	0.001
Biphenyl	0.215	0.004	0.027	0.009	0.006	0.030	0.006	0.053	0.009	0.004	0.004	0.092	0.020
Acenaphthylene	0.032	0.001	0.018	0.006	0.005	0.007	0.004	0.016	0.003	0.002	0.002	0.003	0.002
Acenaphthene	0.080	0.002	0.009	0.002	0.004	0.010	0.007	0.009	0.005	0.001	0.003	0.006	0.002
Fluorene	0.191	0.003	0.014	0.005	0.005	0.013	0.005	0.013	0.006	0.003	0.004	0.014	0.005
Phenanthrene	0.223	0.025	0.143	0.041	0.060	0.112	0.019	0.092	0.041	0.019	0.036	0.060	0.033
Anthracene	0.029	0.062	0.114	0.062	0.014	0.018	0.002	0.012	0.005	0.005	0.004	0.059	0.119
Fluoranthene	0.337	0.024	0.264	0.045	0.327	0.176	0.019	0.252	0.135	0.042	0.085	0.097	0.055
Pyrene	0.230	0.017	0.202	0.033	0.213	0.122	0.016	0.251	0.101	0.065	0.064	0.073	0.043
Cyclopenta[c,d]pyrene	0.020	0.003	0.009	0.002	0.016	0.012	0.001	0.015	0.007	0.003	0.004	0.006	0.006
Benz[a]anthracene*	0.067	0.006	0.028	0.006	0.060	0.042	0.004	0.038	0.025	0.008	0.014	0.019	0.015
Chrysene*	0.105	0.010	0.096	0.012	0.202	0.049	0.006	0.108	0.043	0.026	0.028	0.028	0.020
Benzofluoranthenes*	0.134	0.016	0.103	0.020	0.146	0.106	0.014	0.149	0.103	0.030	0.051	0.050	0.035
Benzo[e]pyrene	0.047	0.007	0.047	0.009	0.070	0.044	0.006	0.059	0.041	0.014	0.020	0.021	0.014
Benzo[a]pyrene*	0.037	0.006	0.028	0.006	0.030	0.035	0.004	0.048	0.037	0.008	0.019	0.018	0.015
Indeno[1,2,3-c,d]pyrene*	0.033	0.007	0.034	0.009	0.038	0.038	0.006	0.056	0.040	0.011	0.017	0.029	0.018
Dibenzo[a,h]anthracene*	0.007	0.004	0.009	0.002	0.010	0.009	0.002	0.012	0.008	0.002	0.003	0.011	0.006
Benzo[g,h,i]perylene	0.036	0.007	0.041	0.011	0.049	0.033	0.006	0.057	0.039	0.011	0.017	0.028	0.017
Coronene	0.011	0.007	0.000	0.006	0.028	0.012	0.005	0.021	0.014	0.006	0.005	0.013	0.009
Sum of B2 PAH	0.383	0.048	0.299	0.057	0.486	0.278	0.036	0.410	0.256	0.085	0.133	0.156	0.108
Sum of target PAH	1.900	0.216	1.280	0.304	1.288	0.877	0.139	1.274	0.677	0.262	0.382	0.669	0.431

APPENDIX I. PAH DATA IN HOUSE DUST, ENTRYWAY DUST, AND PATHWAY SOIL SAMPLES

Compound	A-PS-X ppm	B-PS-X ppm	C-PS-X ppm	D-PS-X ppm	E-PS-X ppm	F-PS-X ppm	G-PS-X ppm	H-PS-X ppm	I-PS-X ppm	J-PS-X ppm	K-PS-X ppm	L-PS-X ppm	M-PS-X ppm
Naphthalene	0.025	0.007	0.026	0.006	0.013	0.018	0.022	0.006	0.004	0.003	0.006	0.005	0.005
Biphenyl	0.006	0.003	0.008	0.002	0.004	0.007	0.010	0.004	0.002	0.001	0.002	0.011	0.002
Acenaphthylene	0.011	0.001	0.033	0.001	0.009	0.010	0.004	0.001	0.000	0.000	0.001	0.001	0.001
Acenaphthene	0.010	0.002	0.005	0.001	0.006	0.012	0.003	0.003	0.001	0.001	0.001	0.002	0.001
Fluorene	0.015	0.005	0.006	0.003	0.008	0.014	0.007	0.006	0.002	0.002	0.002	0.004	0.002
Phenanthrene	0.147	0.038	0.125	0.017	0.095	0.156	0.031	0.028	0.007	0.008	0.017	0.019	0.012
Anthracene	0.037	0.011	0.058	0.003	0.019	0.029	0.005	0.003	0.001	0.001	0.002	0.002	0.001
Fluoranthene	0.321	0.052	0.330	0.022	0.241	0.321	0.053	0.016	0.004	0.004	0.014	0.022	0.008
Pyrene	0.264	0.041	0.213	0.017	0.180	0.235	0.051	0.011	0.005	0.004	0.017	0.017	0.012
Cyclopenta[c,d]pyrene	0.030	0.006	0.015	0.002	0.017	0.030	0.009	0.001	0.000	0.000	0.003	0.001	0.001
Benz[a]anthracene*	0.100	0.021	0.048	0.005	0.057	0.096	0.028	0.003	0.002	0.001	0.009	0.006	0.005
Chrysene*	0.122	0.023	0.143	0.011	0.087	0.125	0.033	0.005	0.003	0.002	0.015	0.015	0.015
Benzofluoranthenes*	0.208	0.043	0.236	0.020	0.178	0.258	0.073	0.011	0.005	0.004	0.015	0.023	0.007
Benzo[e]pyrene	0.081	0.016	0.086	0.007	0.076	0.095	0.032	0.005	0.002	0.002	0.007	0.008	0.004
Benzo[a]pyrene*	0.095	0.016	0.042	0.006	0.057	0.098	0.031	0.003	0.001	0.001	0.006	0.006	0.001
Indeno[1,2,3-c,d]pyrene*	0.065	0.014	0.058	0.007	0.063	0.100	0.030	0.004	0.002	0.001	0.003	0.006	0.002
Dibenzo[a,h]anthracene*	0.015	0.003	0.014	0.001	0.016	0.024	0.009	0.002	0.001	0.000	0.000	0.002	0.001
Benzo[g,h,i]perylene	0.069	0.015	0.064	0.007	0.065	0.096	0.037	0.005	0.003	0.001	0.004	0.008	0.003
Coronene	0.020	0.005	0.030	0.003	0.026	0.027	0.020	0.002	0.001	0.001	0.001	0.004	0.001
Sum of B2 PAH	0.606	0.119	0.541	0.050	0.457	0.701	0.203	0.028	0.013	0.009	0.049	0.057	0.031
Sum of target PAH	1.642	0.321	1.539	0.143	1.217	1.750	0.488	0.119	0.045	0.038	0.125	0.162	0.086

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	514125 FDP-7213218 ppm	181831 FDP7213595 ppm	314275 FDP7212912 ppm	314985 FDP7212781 ppm	318479 FDP7212925 ppm	523527 FDP7212723 ppm	313546 FDP7212648 ppm	181815 FDP7213768 ppm	312413 FDP7212794 ppm	513278 FDP-7213159 ppm	312572 FDP-7212895 ppm
Naphthalene	0.053	0.041	0.041	0.044	0.039	0.025	0.035	0.032	0.047	0.020	0.058
Biphenyl	0.032	0.018	0.026	0.032	0.012	0.022	0.052	0.001	0.027	0.012	0.045
Acenaphthylene	0.013	0.007	0.031	0.014	0.014	0.013	0.041	0.001	0.012	0.013	0.008
Acenaphthene	0.024	0.015	0.027	0.017	0.015	0.017	0.027	0.014	0.005	0.017	0.023
Fluorene	0.029	0.020	0.026	0.025	0.019	0.025	0.028	0.026	0.025	0.019	0.009
Phenanthrene	0.099	0.170	0.244	0.156	0.084	0.074	0.099	0.125	0.063	0.237	0.216
Anthracene	0.024	0.017	0.040	0.021	0.019	0.048	0.022	0.024	0.050	0.038	0.012
Fluoranthene	0.127	0.282	0.680	0.202	0.148	0.143	0.130	0.225	0.110	0.746	0.100
Pyrene	0.102	0.239	0.569	0.164	0.138	0.123	0.114	0.188	0.091	0.720	0.092
Benz[a]anthracene*	0.040	0.111	0.253	0.054	0.056	0.033	0.044	0.072	0.033	0.468	0.032
Cyclopenta[c,d]pyrene	0.010	0.024	0.071	0.012	0.011	0.008	0.011	0.013	0.011	0.148	0.007
Chrysene*	0.124	0.146	0.470	0.183	0.129	0.121	0.093	0.101	0.075	0.685	0.074
Benzofluoranthenes*	0.101	0.357	1.130	0.254	0.228	0.211	0.179	0.295	0.199	1.578	0.075
Benzo[e]pyrene	0.060	0.148	0.457	0.107	0.103	0.110	0.089	0.126	0.130	0.578	0.051
Benzo[a]pyrene*	0.042	0.143	0.421	0.067	0.069	0.063	0.059	0.072	0.060	0.680	0.023
Indeno[1,2,3-c,d]pyrene*	0.058	0.164	0.532	0.113	0.088	0.104	0.102	0.106	0.100	0.727	0.032
Dibenzo[a,h]anthracene*	0.013	0.036	0.117	0.029	0.021	0.026	0.026	0.018	0.023	0.158	0.027
Benzo[g,h,i]perylene	0.058	0.148	0.484	0.105	0.083	0.091	0.102	0.098	0.094	0.636	0.032
Coronene	0.034	0.054	0.187	0.050	0.034	0.056	0.096	0.062	0.087	0.215	0.071
Sum of target PAH	1.043	2.140	5.806	1.650	1.308	1.315	1.350	1.598	1.243	7.694	0.985
Sum of B2 PAH	0.377	0.958	2.923	0.700	0.591	0.558	0.502	0.663	0.490	4.297	0.263

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	317968 FDP7212651 ppm	323619 FDP7212736 ppm	321583 FDP7212635 ppm	315148 FDP7212693 ppm	323895 FDP7212576 ppm	315845 FDP7212879 ppm	324319 FDP7212765 ppm	513656 FDP7213146 ppm	323521 FDP7213582 ppm	181525 FDP7213494 ppm	319179 FDP7213784 ppm
Naphthalene	0.029	0.064	0.095	0.090	0.082	0.017	0.045	0.037	0.022	0.006	0.010
Biphenyl	0.014	0.064	0.040	0.055	0.033	0.009	0.023	0.016	0.042	0.007	0.010
Acenaphthylene	0.007	0.023	0.023	0.018	0.015	0.007	0.010	0.008	0.005	0.004	0.005
Acenaphthene	0.014	0.013	0.039	0.032	0.009	0.011	0.017	0.013	0.009	0.009	0.011
Fluorene	0.018	0.049	0.054	0.040	0.020	0.010	0.021	0.017	0.013	0.011	0.012
Phenanthrene	0.082	0.190	0.172	0.218	0.078	0.041	0.073	0.063	0.040	0.071	0.044
Anthracene	0.014	0.022	0.028	0.021	0.130	0.015	0.026	0.014	0.005	0.008	0.009
Fluoranthene	0.102	0.162	0.281	0.313	0.081	0.072	0.139	0.098	0.047	0.079	0.101
Pyrene	0.081	0.146	0.231	0.277	0.085	0.060	0.120	0.075	0.043	0.063	0.086
Benz[a]anthracene*	0.022	0.044	0.106	0.110	0.039	0.037	0.057	0.026	0.017	0.142	0.211
Cyclopenta[c,d]pyrene	0.003	0.012	0.023	0.027	0.018	0.004	0.015	0.006	0.005	0.003	0.008
Chrysene*	0.074	0.101	0.186	0.195	0.078	0.053	0.096	0.082	0.055	0.048	0.101
Benzofluoranthenes*	0.145	0.200	0.666	0.358	0.113	0.093	0.252	0.127	0.126	0.090	0.138
Benzo[e]pyrene	0.126	0.088	0.193	0.120	0.054	0.031	0.081	0.123	0.062	0.049	0.069
Benzo[a]pyrene*	0.018	0.063	0.112	0.131	0.035	0.051	0.067	0.020	0.021	0.093	0.040
Indeno[1,2,3-c,d]pyrene*	0.049	0.102	0.222	0.205	0.066	0.049	0.120	0.043	0.050	0.045	0.078
Dibenzo[a,h]anthracene*	0.012	0.024	0.050	0.055	0.036	0.013	0.039	0.013	0.009	0.010	0.016
Benzo[g,h,i]perylene	0.047	0.101	0.199	0.173	0.061	0.045	0.106	0.033	0.043	0.040	0.072
Coronene	0.025	0.074	0.160	0.109	0.055	0.032	0.065	0.015	0.035	0.021	0.040
Sum of target PAH	0.884	1.543	2.881	2.546	1.090	0.652	1.371	0.827	0.649	0.800	1.062
Sum of B2 PAH	0.321	0.534	1.342	1.054	0.369	0.297	0.631	0.310	0.279	0.428	0.585

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	514125 FSP5413124 ppm	181831 FSP5413531 ppm	314275 FSP5412958 ppm	314985 FSP5412916 ppm	318479 FSP5412945 ppm	523527 FSP5412583 ppm	313546 FSP5412727 ppm	181815 FSP5413717 ppm	312413 FSP5412932 ppm	513278 FSP5413137 ppm
Naphthalene	0.004	0.003	0.003	0.003	0.004	0.004	0.002	0.004	0.010	0.005
Biphenyl	0.002	0.001	0.002	0.002	0.002	0.002	0.001	0.002	0.006	0.002
Acenaphthylene	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.009	0.004
Acenaphthene	0.001	0.001	0.003	0.002	0.004	0.002	0.001	0.001	0.020	0.003
Fluorene	0.002	0.002	0.003	0.003	0.003	0.003	0.001	0.002	0.016	0.004
Phenanthrene	0.011	0.022	0.030	0.029	0.032	0.023	0.008	0.017	0.297	0.091
Anthracene	0.013	0.004	0.002	0.002	0.002	0.001	0.048	0.003	0.109	0.012
Fluoranthene	0.006	0.058	0.024	0.022	0.018	0.014	0.004	0.033	0.780	0.355
Pyrene	0.004	0.052	0.020	0.016	0.014	0.011	0.002	0.032	0.808	0.376
Benz[a]anthracene*	0.001	0.028	0.009	0.006	0.007	0.006	0.001	0.020	0.443	0.240
Cyclopenta[c,d]pyrene	0.001	0.008	0.002	0.002	0.002	0.002	0.000	0.009	0.121	0.070
Chrysene*	0.002	0.044	0.016	0.013	0.012	0.009	0.001	0.035	0.564	0.375
Benzofluoranthenes*	0.004	0.072	0.031	0.022	0.022	0.014	0.002	0.045	0.932	0.603
Benzo[e]pyrene	0.002	0.025	0.011	0.010	0.008	0.005	0.001	0.014	0.341	0.208
Benzo[a]pyrene*	0.001	0.035	0.013	0.009	0.009	0.006	0.001	0.014	0.484	0.289
Indeno[1,2,3-c,d]pyrene*	0.002	0.033	0.013	0.010	0.009	0.007	0.019	0.030	0.405	0.330
Dibenzo[a,h]anthracene*	0.001	0.009	0.004	0.003	0.003	0.003	0.001	0.007	0.095	0.103
Benzo[g,h,i]perylene	0.002	0.031	0.012	0.011	0.010	0.007	0.001	0.027	0.347	0.275
Coronene	0.016	0.015	0.005	0.005	0.005	0.005	0.001	0.014	0.146	0.088
Sum of target PAH	0.075	0.443	0.202	0.172	0.167	0.124	0.096	0.312	5.934	3.433
Sum of B2 PAH	0.011	0.221	0.085	0.064	0.062	0.045	0.025	0.151	2.924	1.940

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	312572 FSP5412828 ppm	317968 FSP5412626 ppm	321583 FSP5412684 ppm	315148 FSP5412613 ppm	315845 FSP5412929 ppm	324319 FSP-5412873 ppm	513656 FSP5413153 ppm	323521 FSP5413472 ppm	181525 FSP5413573 ppm	319179 FSP5413818 ppm
Naphthalene	0.002	0.005	0.006	0.003	0.005	0.006	0.002	0.007	0.011	0.004
Biphenyl	0.002	0.009	0.001	0.002	0.002	0.005	0.004	0.006	0.015	0.002
Acenaphthylene	0.000	0.002	0.005	0.000	0.001	0.003	0.000	0.001	0.005	0.001
Acenaphthene	0.000	0.002	0.002	0.002	0.001	0.003	0.001	0.002	0.003	0.002
Fluorene	0.001	0.003	0.002	0.002	0.003	0.004	0.001	0.002	0.005	0.002
Phenanthrene	0.004	0.034	0.050	0.018	0.022	0.050	0.011	0.026	0.037	0.022
Anthracene	0.000	0.003	0.008	0.001	0.002	0.006	0.001	0.002	0.010	0.002
Fluoranthene	0.005	0.040	0.221	0.011	0.010	0.115	0.004	0.022	0.049	0.016
Pyrene	0.006	0.032	0.228	0.009	0.008	0.108	0.003	0.014	0.052	0.010
Benz[a]anthracene*	0.002	0.018	0.095	0.003	0.006	0.049	0.002	0.006	0.023	0.003
Cyclopenta[c,d]pyrene	0.001	0.005	0.032	0.001	0.002	0.014	0.001	0.001	0.008	0.001
Chrysene*	0.003	0.024	0.207	0.005	0.006	0.118	0.006	0.019	0.041	0.006
Benzofluoranthenes*	0.005	0.042	0.363	0.010	0.006	0.197	0.005	0.023	0.102	0.012
Benzo[e]pyrene	0.002	0.018	0.141	0.004	0.003	0.080	0.002	0.010	0.122	0.006
Benzo[a]pyrene*	0.002	0.018	0.166	0.003	0.002	0.078	0.001	0.008	0.060	0.003
Indeno[1,2,3-c,d]pyrene*	0.002	0.016	0.184	0.005	0.003	0.084	0.002	0.010	0.058	0.006
Dibenzo[a,h]anthracene*	0.001	0.004	0.048	0.001	0.002	0.018	0.003	0.003	0.014	0.004
Benzo[g,h,i]perylene	0.002	0.016	0.174	0.004	0.004	0.080	0.002	0.012	0.174	0.006
Coronene	0.001	0.007	0.054	0.003	0.002	0.044	0.003	0.005	0.069	0.005
Sum of target PAH	0.042	0.298	1.987	0.085	0.091	1.062	0.055	0.178	0.858	0.113
Sum of B2 PAH	0.015	0.122	1.063	0.026	0.026	0.544	0.018	0.068	0.297	0.034

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	514125 YSP5212965 ppm	181831 YSP5213245 ppm	314275 YSP5212952 ppm	314985 YSP5212893 ppm	318479 YSP5212936 ppm	523527 YSP5212561 ppm	313546 YSP5212734 ppm	181815 YSP5214147 ppm	312413 YSP5212848 ppm	513278 YSP5213131 ppm	312572 YSP5212864 ppm
Naphthalene	0.002	0.003	0.002	0.004	0.005	0.004	0.002	0.003	0.008	0.007	0.003
Biphenyl	0.003	0.003	0.001	0.001	0.002	0.002	0.001	0.001	0.004	0.002	0.003
Acenaphthylene	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.004	0.004	0.000
Acenaphthene	0.001	0.001	0.001	0.000	0.003	0.001	0.001	0.001	0.003	0.005	0.000
Fluorene	0.002	0.001	0.001	0.001	0.003	0.003	0.001	0.001	0.005	0.005	0.002
Phenanthrene	0.010	0.013	0.008	0.005	0.030	0.025	0.013	0.012	0.042	0.099	0.004
Anthracene	0.001	0.002	0.001	0.001	0.002	0.002	0.001	0.003	0.009	0.012	0.001
Fluoranthene	0.005	0.021	0.015	0.016	0.016	0.017	0.007	0.034	0.109	0.330	0.005
Pyrene	0.003	0.017	0.014	0.014	0.012	0.014	0.005	0.032	0.103	0.351	0.006
Benz[a]anthracene*	0.001	0.009	0.007	0.008	0.004	0.008	0.003	0.027	0.053	0.175	0.002
Cyclopenta[c,d]pyrene	0.000	0.003	0.002	0.002	0.001	0.002	0.001	0.012	0.015	0.052	0.001
Chrysene*	0.002	0.014	0.013	0.017	0.012	0.014	0.006	0.040	0.092	0.319	0.001
Benzofluoranthenes*	0.002	0.025	0.021	0.033	0.021	0.024	0.012	0.055	0.185	0.590	0.002
Benzo[e]pyrene	0.001	0.010	0.008	0.013	0.009	0.010	0.004	0.017	0.074	0.221	0.001
Benzo[a]pyrene*	0.001	0.011	0.009	0.014	0.006	0.010	0.005	0.021	0.085	0.306	0.001
Indeno[1,2,3-c,d]pyrene*	0.001	0.011	0.010	0.016	0.010	0.011	0.005	0.039	0.085	0.332	0.005
Dibenzo[a,h]anthracene*	0.000	0.002	0.002	0.005	0.003	0.005	0.002	0.007	0.018	0.100	0.003
Benzo[g,h,i]perylene	0.001	0.010	0.010	0.014	0.011	0.012	0.005	0.033	0.083	0.307	0.003
Coronene	0.001	0.003	0.006	0.006	0.007	0.005	0.004	0.018	0.060	0.083	0.002
Sum of target PAH	0.037	0.160	0.130	0.170	0.159	0.170	0.080	0.358	1.037	3.299	0.046
Sum of B2 PAH	0.007	0.072	0.062	0.092	0.056	0.073	0.034	0.189	0.518	1.822	0.015

APPENDIX J. PAH DATA IN NHEXAS HOUSE DUST, FOUNDATION SOIL AND YARD SOIL SAMPLES

Compound	317968 YSP5212617 ppm	323619 YSP5212646 ppm	321583 YSP5212691 ppm	315148 YSP5212587 ppm	323895 YSP5212721 ppm	315845 YSP5212949 ppm	513656 YSP5213157 ppm	323521 YSP5213548 ppm	181525 YSP5213564 ppm	319179 YSP5214235 ppm
Naphthalene	0.003	0.005	0.006	0.008	0.007	0.006	0.006	0.005	0.009	0.005
Biphenyl	0.002	0.002	0.002	0.003	0.002	0.002	0.014	0.003	0.003	0.003
Acenaphthylene	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.004	0.001
Acenaphthene	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.002	0.002	0.002
Fluorene	0.001	0.003	0.002	0.006	0.003	0.002	0.004	0.003	0.005	0.003
Phenanthrene	0.007	0.029	0.028	0.036	0.028	0.017	0.039	0.018	0.038	0.027
Anthracene	0.001	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.012	0.002
Fluoranthene	0.019	0.017	0.072	0.019	0.011	0.011	0.013	0.020	0.063	0.012
Pyrene	0.019	0.014	0.071	0.015	0.009	0.007	0.007	0.013	0.053	0.008
Benz[a]anthracene*	0.011	0.005	0.033	0.005	0.004	0.004	0.001	0.010	0.023	0.001
Cyclopenta[c,d]pyrene	0.006	0.002	0.009	0.002	0.002	0.001	0.000	0.003	0.008	0.000
Chrysene*	0.022	0.013	0.064	0.010	0.008	0.003	0.004	0.046	0.047	0.007
Benzofluoranthenes*	0.027	0.022	0.119	0.019	0.016	0.007	0.004	0.033	0.076	0.008
Benzo[e]pyrene	0.010	0.008	0.045	0.008	0.008	0.003	0.002	0.020	0.035	0.004
Benzo[a]pyrene*	0.007	0.008	0.049	0.007	0.006	0.003	0.001	0.014	0.037	0.001
Indeno[1,2,3-c,d]pyrene*	0.019	0.010	0.060	0.009	0.009	0.004	0.002	0.021	0.030	0.002
Dibenzo[a,h]anthracene*	0.007	0.003	0.016	0.003	0.005	0.004	0.001	0.005	0.009	0.001
Benzo[g,h,i]perylene	0.020	0.011	0.055	0.008	0.010	0.004	0.002	0.022	0.030	0.002
Coronene	0.016	0.006	0.017	0.011	0.009	0.005	0.002	0.009	0.016	0.003
Sum of target PAH	0.197	0.165	0.654	0.174	0.142	0.087	0.106	0.248	0.501	0.091
Sum of B2 PAH	0.092	0.062	0.341	0.053	0.048	0.025	0.013	0.128	0.221	0.020

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Dust/Soil Samples from the Summer Field Study, ppm	A-HD-S	65.63 *	4.38	8.71	4.10	2.29
	B-HD-S	91.25 *	2.54	2.50	0.72	3.32
	C-HD-S	.	.	4.12	1.63	1.64
	D-HD-S	.	.	4.56	1.83	1.89
	E-HD-S	67.49 *	3.01	4.45	1.79	1.07
	F-HD-S	46.63	4.45	7.98	3.33	1.17
	G-HD-S	56.70 *	2.44	3.01	0.84	1.12
	H-HD-S	33.45	1.46	3.68	1.36	1.07
	I-HD-S	30.17	1.42	2.52	1.09	0.58
	J-HD-S	33.49	1.42	3.08	1.41	0.74
	K-HD-S	70.20 *	1.45	2.48	0.75	1.91
	L-HD-S	.	.	3.27	1.26	0.67
	M-HD-S	.	.	2.86	1.09	1.25
	A-ES-S	5.82	0.82	3.53	1.22	0.55
	B-ES-S	11.61	1.34	2.83	1.04	0.84
	C-ES-S	.	.	0.66	0.14	0.31
	D-ES-S	.	.	1.76	0.59	0.58
	E-ES-S	.	.	5.82	2.23	1.09
	F-ES-S	11.77	1.60	1.94	0.64	0.59
	G-ES-S	5.41 *	0.48	6.18	1.46	1.12
	H-ES-S	8.72	1.02	1.17	0.28	0.49
	I-ES-S	3.76 *	0.45	0.44	0.14	0.20
	J-ES-S	1.67 *	0.18	0.94	0.13	1.15
	K-ES-S	8.81	1.26	2.27	0.85	0.36
	L-ES-S	22.66	2.14	5.26	2.10	0.85
	M-ES-S	.	.	0.62	0.17	0.39
	A-PS-S	7.07 *	0.83 *	0.32	0.14	0.43
	B-PS-S	3.78	0.11	1.64	0.74	0.28
	C-PS-S	18.00 *	1.42 *	2.31	0.97	0.77

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Dust/Soil Samples from the Summer Field Study, ppm	D-PS-S	0.81	0.07	0.19	0.07	0.13
	E-PS-S	8.19 *	0.55	2.23	1.10	0.81
	F-PS-S	3.40	0.36	0.27	0.09	0.15
	G-PS-S	1.03	0.19	3.42	1.60	1.94
	H-PS-S	1.90	0.25	0.80	0.31	0.24
	I-PS-S	1.97	0.08	0.21	0.06	0.11
	J-PS-S	2.56	0.26	0.17	0.05	0.13
	K-PS-S	6.16 *	0.26	0.54	0.16	0.15
	L-PS-S	1.67	0.16	0.48	0.10	0.09
	M-PS-S	1.53	0.07	0.22	0.03	0.10
Dust/Soil Samples from the Spring Field Study, ppm	A-HD-X	84.24	6.80	6.47	1.49	.
	B-HD-X	76.27	5.33	1.92	0.59	.
	C-HD-X	61.00	5.19	0.94	0.27	.
	D-HD-X	36.22	2.96	1.71	0.64	.
	E-HD-X	33.29	3.61	1.91	0.74	.
	F-HD-X	133.04 *	18.08 *	15.65	7.02	.
	G-HD-X	28.54	3.07	1.67	0.53	.
	H-HD-X	49.37	6.88	3.63	1.46	.
	I-HD-X	13.28	1.87	0.83	0.33	.
	J-HD-X	28.22	3.59	1.58	0.58	.
	K-HD-X	56.49	5.67	2.64	0.98	.
	L-HD-X	45.91	7.91	3.71	1.91	.
	M-HD-X	51.90	3.88	1.82	0.58	.
	A-ES-X	28.83	6.16	1.90	0.38	.
	B-ES-X	3.50	0.60	0.22	0.05	.
	C-ES-X	15.16 *	1.98	1.28	0.30	.
	D-ES-X	8.59	1.51	0.30	0.06	.
	E-ES-X	50.27	6.19	1.29	0.49	.
	F-ES-X	3.53 *	0.06	0.88	0.28	.

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Dust/Soil Samples from the Spring Field Study, ppm	G-ES-X	3.15 *	0.54	0.14	0.04	.
	H-ES-X	27.77	3.36	1.27	0.41	.
	I-ES-X	7.68	2.06	0.68	0.26	.
	J-ES-X	16.02	1.75	0.26	0.09	.
	K-ES-X	6.18	0.72	0.38	0.13	.
	L-ES-X	7.05	1.21	0.67	0.16	.
	M-ES-X	6.37	1.17	0.43	0.11	.
	A-PS-X	6.40 *	2.28	1.64	0.61	.
	B-PS-X	0.85	0.25	0.32	0.12	.
	C-PS-X	5.60	1.38	1.54	0.54	.
	D-PS-X	0.61	0.07	0.14	0.05	.
	E-PS-X	4.55	0.65	1.22	0.46	.
	F-PS-X	4.10 *	1.03	1.75	0.70	.
	G-PS-X	1.61 *	0.56	0.49	0.20	.
	H-PS-X	0.32 *	0.05	0.12	0.03	.
	I-PS-X	0.68	0.05	0.05	0.01	.
	J-PS-X	0.22 *	0.05	0.04	0.01	.
	K-PS-X	1.14	0.11	0.13	0.05	.
	L-PS-X	2.18	0.25	0.16	0.06	.
	M-PS-X	1.39	0.12	0.09	0.03	.
Floor Dust Samples from the NHEXAS Study, ppm	FDP72-12576	89.65	5.00	1.09	0.37	.
	FDP72-12635	218.86	10.57	2.88	1.34	.
	FDP72-12648	5.10 *	6.40	1.35	0.50	.
	FDP72-12651	56.81 *	3.64	0.88	0.32	.
	FDP72-12693	299.05	14.05	2.55	1.05	.
	FDP72-12723	16.60 *	7.80	1.31	0.56	.
	FDP72-12736	725.00	9.62	1.54	0.53	.
	FDP72-12765	148.54	16.81	1.37	0.63	.
	FDP72-12781	44.80	9.80	1.65	0.70	.

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Floor Dust Samples from the NHEXAS Study, ppm	FDP72-12794	361.50 *	8.35	1.24	0.49	.
	FDP72-12879	24.90	4.95	0.65	0.30	.
	FDP72-12895	15.05 *	6.25	0.99	0.26	.
	FDP72-12912	76.67	34.64	5.81	2.92	.
	FDP72-12925	38.65	7.45	1.31	0.59	.
	FDP72-13146	169.90	5.65	0.83	0.31	.
	FDP72-13159	90.05	24.95	7.69	4.30	.
	FDP72-13218	331.92	7.95	1.04	0.38	.
	FDP72-13494	276.51	8.60	0.80	0.43	.
	FDP72-13582	210.85	7.07	0.65	0.28	.
	FDP72-13595	53.71	9.90	2.14	0.96	.
	FDP72-13768	76.90	11.79	1.60	0.66	.
	FDP72-13784	68.38 *	6.20	1.06	0.59	.
Foundation Soil Samples from the NHEXAS Study, ppm	FSP54-12583	3.34 *	0.46	0.12	0.05	.
	FSP54-12613	3.81 *	0.50	0.09	0.03	.
	FSP54-12626	2.83 *	0.79	0.30	0.12	.
	FSP54-12684	56.73	11.68	1.99	1.06	.
	FSP54-12727	1.36 *	0.07	0.10	0.03	.
	FSP54-12828	3.42 *	0.74	0.04	0.02	.
	FSP54-12873	48.36	3.44	1.06	0.54	.
	FSP54-12916	10.61	1.58	0.17	0.06	.
	FSP54-12929	4.18 *	0.30	0.09	0.03	.
	FSP54-12932	111.62	20.59	5.93	2.92	.
	FSP54-12945	5.40	0.77	0.17	0.06	.
	FSP54-12958	6.58	1.11	0.20	0.09	.
	FSP54-13124	1.67 *	0.13	0.08	0.01	.
	FSP54-13137	68.01	19.51	3.43	1.94	.
	FSP54-13153	3.78 *	0.48	0.05	0.02	.
	FSP54-13472	16.31	1.63	0.18	0.07	.

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Foundation Soil Samples from the NHEXAS Study, ppm	FSP54-13531	24.04	2.71	0.44	0.22	.
	FSP54-13573	38.88	2.27	0.86	0.30	.
	FSP54-13717	29.50	3.16	0.31	0.15	.
	FSP54-13818	1.14 *	0.55	0.11	0.03	.
Yard Soil Samples from the NHEXAS Study, ppm	YSP52-12561	1.69 *	1.45	0.17	0.07	.
	YSP52-12587	2.35 *	0.54	0.17	0.05	.
	YSP52-12617	0.88 *	1.00	0.20	0.09	.
	YSP52-12646	196.26 *	1.05	0.17	0.06	.
	YSP52-12691	32.16	3.01	0.65	0.34	.
	YSP52-12721	13.23	0.36	0.14	0.05	.
	YSP52-12734	1.51 *	0.22	0.08	0.03	.
	YSP52-12848	2.70 *	5.31	1.04	0.52	.
	YSP52-12864	20.45	0.58	0.05	0.02	.
	YSP52-12893	0.25 *	1.36	0.17	0.09	.
	YSP52-12936	11.37	1.67	0.16	0.06	.
	YSP52-12949	3.00 *	0.19	0.09	0.03	.
	YSP52-12952	6.16	1.13	0.13	0.06	.
	YSP52-12965	4.61	0.26	0.04	0.007	.
	YSP52-13131	6.52	12.43 *	3.30	1.82	.
	YSP52-13157	10.12	0.32	0.11	0.01	.
	YSP52-13245	5.35	1.56	0.16	0.07	.
	YSP52-13548	2.12 *	1.04	0.25	0.13	.
	YSP52-13564	46.58	2.02	0.50	0.22	.
	YSP52-14147	6.56	1.98	0.36	0.19	.
	YSP52-14235	4.30 *	0.45	0.09	0.02	.
Food Sample Extracts from the Summer Field Study, ppb	A1-S	27120.00	10620.00	6876.21	1126.66	466.04
	A2-S	11080.00	6680.00	2725.96	1030.58	200.77
	B1-S	19660.00	4680.00	6755.80	1076.66	553.83
	B2-S	14400.00	7060.00	2554.85	1019.11	658.10

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Food Sample Extracts from the Summer Field Study, ppb	C1-S	20560.00	9520.00	7847.89	1054.73	509.99
	C2-S	15920.00	7800.00	3134.54	1088.52	189.85
	D1-S	20720.00	8040.00	3043.76	1044.99	351.91
	D2-S	11840.00	10060.00	2704.05	1036.28	265.84
	E1-S	1080.00 *	280.00	2993.77	1028.02	150.39
	E2-S	8760.00 *	4220.00	2839.83	1026.23	134.37
	F1-S	.	.	2959.54	1024.71	235.05
	F2-S	.	.	2538.40	1013.77	238.90
	G1-S	.	.	2863.82	1032.15	428.34
	G2-S	.	.	3132.75	1021.81	494.14
	H1-S	10820.00	5180.00	3208.15	1032.38	613.01
	H2-S	15920.00	11840.00 *	2781.89	1017.29	390.55
	I1-S	23280.00	7200.00	3422.98	1085.55	481.77
	I2-S	10600.00	10780.00	2874.54	1029.40	614.06
	J1-S	19260.00	11320.00 *	2806.37	1017.31	216.71
	J2-S	7500.00 *	5580.00	2996.11	1030.64	360.79
	K1-S	.	.	2841.77	1021.17	362.71
	K2-S	.	.	2457.28	1015.16	78.60
	L1-S	22920.00	12320.00 *	2643.88	1012.40	279.15
	L2-S	11620.00	15840.00 *	2450.81	1016.85	227.51
	M1-S	.	.	2536.17	1025.09	207.39
	M2-S	.	.	2541.09	1045.81	199.75
Air Sample Extracts from the Summer Field Study, ng/mL	AIS-F/XAD	47400.00 *	6320.00	1127567.89	1062.21	37908.04
	BIS-F/XAD	69200.00 *	6400.00	54779.61	1059.31	28419.20
	CIS-F/XAD	107000.00	6760.00	116996.77	1084.34	101688.00
	DIS-F/XAD	95600.00	3840.00	80673.55	1042.29	27605.92
	EIS-F/XAD	87800.00 *	3560.00	781331.86	1043.63	21888.04
	FIS-F/XAD	.	.	47956.77	1108.71	38288.80
	GIS-F/XAD	.	.	156944.66	1808.45	49711.73

*Outside of calibration range

APPENDIX K. LISTING OF ELISA TOTAL PAH AND C-PAH RESPONSES AND GC/MS TARGET PAH, B2-PAH, AND ALKYLATED PAH RESPONSES

Sample Type	Sample ID	PAH ELISA Responses	C-PAH ELISA Responses	PAH GC/MS Responses	B2-PAH GC/MS Responses	Alkylated PAH GC/MS Responses
Air Sample Extracts from the Summer Field Study, ng/mL	HIS-F/XAD	64000.00 *	3560.00	543769.98	1051.03	17000.55
	IIS-F/XAD	24000.00 *	3040.00	198407.33	1027.06	23888.99
	JIS-F/XAD	110800.00	4080.00	349855.48	1037.69	19881.25
	KIS-F/XAD	.	.	41448.38	1148.72	57137.20
	LIS-F/XAD	10600.00 *	4120.00	35233.54	1012.57	10999.77
	MIS-F/XAD	.	.	57626.35	1095.72	60500.71
	AOS-F/XAD	24240.00	6240.00	62728.08	1089.27	7560.12
	BOS-F/XAD	25040.00	7000.00	13301.11	1040.87	5187.46
	COS-F/XAD	32560.00	6720.00	22515.27	1062.00	16176.03
	DOS-F/XAD	26560.00	7160.00	8525.27	1026.46	3200.13
	EOS-F/XAD	15920.00 *	6880.00	21783.26	1055.79	6780.62
	FOS-F/XAD	.	.	68853.47	1091.42	21001.15
	GOS-F/XAD	.	.	32026.38	1033.43	8189.00
	HOS-F/XAD	16080.00 *	5920.00	5298.32	1028.71	1711.28
	IOS-F/XAD	57280.00	13920.00	11125.29	1016.44	4377.56
	JOS-F/XAD	21120.00	6480.00	10705.63	1057.87	4251.97
	KOS-F/XAD	.	.	6063.32	1021.86	2076.09
	LOS-F/XAD	18160.00	3800.00	8427.73	1016.73	2421.54
	MOS-F/XAD	.	.	5130.81	1015.88	1506.95

*Outside of calibration range

APPENDIX L. DISTRIBUTION OF DATA FOR DUST/SOIL SAMPLES (HD+ES+PS+FDP+FSP+YSP)

C/MS Total PAH

ELISA Total PAH	0 <= ppm <0.1	0.1 <= ppm <0.5	0.5 <= ppm < 1	1 <= ppm < 2	2 <= ppm < 3	ppm >= 3	Total
0 <= ppm < 2	6	13	2	0	0	1	22
2 <= ppm < 5	7	10	1	4	0	0	22
5 <= ppm < 10	0	9	3	4	2	3	21
10 <= ppm < 50	1	8	6	12	3	6	36
50 <= ppm < 100	0	0	2	7	4	7	20
ppm >= 100	0	1	3	4	2	2	12
Total	14	41	17	31	11	19	133

GC/MS B2-PAH

ELISA C-PAH	0 <= ppm<0.05	0.05 <= ppm <0.1	0.1 <= ppm <0.2	0.2 <= ppm <0.5	0.5 <= ppm < 1	ppm >= 1	Total
0 <= ppm < 0.5	17	6	5	2	1	2	33
0.5 <= ppm < 1	6	2	3	2	0	2	15
1 <= ppm < 2	0	12	4	3	6	4	29
2 <= ppm < 5	0	0	1	8	9	4	22
5 <= ppm < 10	0	0	0	10	10	3	23
ppm >= 10	0	0	0	0	2	9	11
Total	23	20	13	25	28	24	133

APPENDIX L. DISTRIBUTION OF DATA FOR DUST SAMPLES (HD+ES+FDP)

GC/MS Total PAH

ELISA Total PAH	0 <= Ppm <0.5	0.5 <= Ppm < 1	1 <= PPM < 2	2 <= PPM < 3	PPM >= 3	Total
0 <= ppm < 2	0	1	0	0	0	1
2 <= ppm < 5	3	1	0	0	0	4
5 <= ppm < 10	3	2	2	1	2	10
10 <= ppm < 50	1	3	11	2	6	23
50 <= ppm < 100	0	2	6	4	6	18
ppm >= 100	0	3	4	2	1	10
Total	7	12	23	9	15	66

GC/MS B2-PAH

ELISA C-PAH	0 <= ppm<0.05	0.05 <=. ppm <0.1	0.1 <= ppm <0.2	0.2 <= ppm <0.5	0.5 <= ppm < 1	ppm >= 1	Total
0 <= ppm < 0.5	0	0	2	1	0	1	4
0.5 <= ppm < 1	2	0	1	0	0	1	4
1 <= ppm < 2	0	2	2	3	3	4	14
2 <= ppm < 5	0	0	0	4	7	4	15
5 <= ppm < 10	0	0	0	10	9	3	22
ppm >= 10	0	0	0	0	2	5	7
Total	2	2	5	18	21	18	66

APPENDIX L. DISTRIBUTION OF DATA FOR SOIL SAMPLES (PS+FSP+YSP)

GC/MS Total PAH

ELISA Total PAH	0 <= ppm <0.1	0.1 <= ppm <0.5	0.5 <= ppm < 1	1 <= ppm < 2	2 <= ppm < 3	ppm >= 3	Total
0 <= ppm < 2	6	13	1	0	0	1	21
2 <= ppm < 5	7	7	0	4	0	0	18
5 <= ppm < 10	0	6	1	2	1	1	11
10 <= ppm < 50	1	7	3	1	1	0	13
50 <= ppm < 100	0	0	0	1	0	1	2
ppm >= 100	0	1	0	0	0	1	2
Total	14	34	5	8	2	4	67

GC/MS B2-PAH

ELISA C-PAH	0 <= ppm<0.05	0.05 <= ppm <0.1	0.1 <= ppm <0.2	0.2 <= ppm <0.5	0.5 <= ppm < 1	ppm >= 1	Total
0 <= ppm < 0.5	17	6	3	1	1	1	29
0.5 <= ppm < 1	4	2	2	2	0	1	11
1 <= ppm < 2	0	10	2	0	3	0	15
2 <= ppm < 5	0	0	1	4	2	0	7
5 <= ppm < 10	0	0	0	0	1	0	1
ppm >= 10	0	0	0	0	0	4	4
Total	21	18	8	7	7	6	67

APPENDIX L. DISTRIBUTION OF DATA FOR FOOD SAMPLES

GC/MS Total PAH

ELISA Total PAH	0 <= ppb < 2500	2500 <= ppb < 3000	3000 <= ppb < 3500	ppb >= 3500	Total
0 <= ppb < 10000	0	3	0	0	3
10000 <= ppb < 16000	1	5	2	0	8
16000 <= ppb < 20000	0	1	0	1	2
ppb >= 20000	0	1	2	2	5
Total	1	10	4	3	18

GC/MS B2-PAH

ELISA C-PAH	0 <= ppb < 1020	1020 <= ppb < 1040	1040 <= ppb < 1060	ppb >= 1060	Total
0 <= ppb < 6000	0	4	0	1	5
6000 <= ppb < 8000	1	1	0	2	4
8000 <= ppb < 10000	0	0	2	0	2
ppb >= 10000	4	2	0	1	7
Total	5	7	2	4	18

APPENDIX L. DISTRIBUTION OF DATA FOR AIR SAMPLES

GC/MS Total PAH

ELISA Total PAH	0 <= ng/mL < 10000	10000 <= ng/mL < 50000	50000 <= ng/mL < 100000	ng/mL >= 100000	Total
0 <= ng/mL < 2000	2	2	0	0	4
20000 <= ng/mL < 30000	1	2	1	1	5
30000 <= ng/mL < 40000	0	1	0	0	1
ng/mL >= 40000	0	1	2	5	8
Total	3	6	3	6	18

GC/MS B2-PAH

ELISA C-PAH	0 <= ng/mL < 1020	1020 <= ng/mL < 1040	1040 <= ng/mL < 1060	ng/mL >= 1060	Total
0 <= ng/mL < 4000	1	1	3	0	5
4000 <= ng/mL < 6000	1	2	0	0	3
6000 <= ng/mL < 7000	0	0	3	4	7
ng/mL >= 7000	1	1	1	0	3
Total	3	4	7	4	18

APPENDIX M. Summary Statistics of ELISA and GC/MS PAH Reponses for Various Dust and Soil Sample Types

Sample Type		ELISA Total PAH	ELISA C-PAH	GC/MS Total PAH	GC/MS B2-PAH
Comb. (HD+ES+PS+FDP+FSP-+YSP), ppm	N	133	133	141	141
	MEAN	43.34	3.63	1.60	0.64
	STD	88.09	5.30	2.13	0.95
	MIN	0.22	0.05	0.04	0.01
	MAX	725.00	34.64	15.65	7.02
Dust (HD+ES+FDP), ppm	N	66	66	74	74
	MEAN	73.58	5.48	2.45	0.95
	STD	114.17	5.90	2.47	1.12
	MIN	1.67	0.06	0.14	0.04
	MAX	725.00	34.64	15.65	7.02
Soil (PS+FSP+YSP), ppm	N	67	67	67	67
	MEAN	13.54	1.82	0.66	0.30
	STD	29.46	3.87	1.06	0.53
	MIN	0.22	0.05	0.04	0.01
	MAX	196.26	20.59	5.93	2.92
HD, ppm	N	22	22	26	26
	MEAN	54.22	4.43	3.76	1.47
	STD	26.69	3.59	3.10	1.43
	MIN	13.28	1.42	0.83	0.27
	MAX	133.04	18.08	15.65	7.02
ES, ppm	N	22	22	26	26
	MEAN	12.02	1.66	1.66	0.53
	STD	11.46	1.65	1.73	0.61
	MIN	1.67	0.06	0.14	0.04
	MAX	50.27	6.19	6.18	2.23
PS, ppm	N	26	26	26	26
	MEAN	3.37	0.44	0.79	0.32
	STD	3.75	0.55	0.90	0.41
	MIN	0.22	0.05	0.04	0.01
	MAX	18.00	2.28	3.42	1.60
FDP, ppm	N	22	22	22	22
	MEAN	154.52	10.34	1.84	0.84
	STD	168.15	7.15	1.71	0.96
	MIN	5.10	3.64	0.65	0.26
	MAX	725.00	34.64	7.69	4.30
FSP, ppm	N	20	20	20	20
	MEAN	22.08	3.62	0.79	0.39
	STD	29.37	6.16	1.47	0.76
	MIN	1.14	0.07	0.04	0.01
	MAX	111.62	20.59	5.93	2.92
YSP, ppm	N	21	21	21	21
	MEAN	18.01	1.81	0.38	0.19
	STD	42.40	2.70	0.71	0.39
	MIN	0.25	0.19	0.04	0.01
	MAX	196.26	12.43	3.30	1.82

APPENDIX M. Summary Statistics of ELISA and GC/MS PAH Reponses for Food and Air Samples

Sample Type		ELISA Total PAH	ELISA C-PAH	GC/MS Total PAH	GC/MS B2-PAH
Food, ppb	N	18	18	26	26
	MEAN	15170.00	8278.89	3328.16	1037.43
	STD	6623.35	3659.54	1442.05	27.82
	MIN	1080.00	280.00	2450.81	1012.40
	MAX	27120.00	15840.00	7847.89	1126.66
Air, ng/mL	N	18	18	26	26
	MEAN	47408.89	5877.78	148810.62	1082.25
	STD	33855.90	2480.81	270652.63	151.81
	MIN	10600.00	3040.00	5130.81	1012.57
	MAX	110800.00	13920.00	1127567.89	1808.45

APPENDIX N. The Square of Correlation Coefficients for all Possible Combination of Data

ELISA vs GC/MS	Raw Data					Log-transformed Data				
	Comb*	Dust	Soil	Food	Air	Comb*	Dust	Soil	Food	Air
1) TOTPAH_E*TOTPAH_G	R^2 =4%	R^2 =.1%	R^2 =13%	R^2 =25%	R^2 =13%	R^2 =38%	R^2 =14%	R^2 =17%	R^2 =10%	R^2 =37%
2) CARPAH_E*B2PAH_G	R^2 =39%	R^2 =26%	R^2 =68%	R^2 =1%	R^2 =.1%	R^2 =50%	R^2 =23%	R^2 =40%	R^2 =0.2%	R^2 =3%
3) TOTPAH_2*TOTPAH_G	R^2 =2%	R^2 =.3%	R^2 =44%	R^2 =43%	R^2 =57%	R^2 =32%	R^2 =6%	R^2 =17%	R^2 =45%	R^2 =61%
4) CARPAH_2*B2PAH_G	R^2 =38%	R^2 =21%	R^2 =67%	R^2 =12%	R^2 =0.1%	R^2 =48%	R^2 =20%	R^2 =36%	R^2 =8%	R^2 =3%
5) TOTPAH_E*TOTALK_G	R^2 =3%	R^2 =.1%	R^2 =9%	R^2 =26%	R^2 =16%	R^2 =35%	R^2 =10%	R^2 =15%	R^2 =13%	R^2 =41%
6) TOTPAH_2*TOTALK_G	R^2 =1%	R^2 =1%	R^2 =31%	R^2 =28%	R^2 =72%	R^2 =26%	R^2 =4%	R^2 =11%	R^2 =27%	R^2 =66%

* Combination of Dust (HD+ES+FDP) and Soil (PS+FSP+YSP) samples.
1) ELISA total PAH of all data vs. GC/MS target PAH.
2) ELISA C-PAH of all data vs. GC/MS B2-PAH.
3) ELISA total PAH within calibration range vs. GC/MS target PAH.
4) ELISA C-PAH within calibration range vs. GC/MS B2-PAH.
5) ELISA total PAH of all data vs. GC/MS target PAH + alkylated PAH.
6) ELISA total PAH within calibration range vs. GC/MS target PAH + alkylated PAH.

APPENDIX O. CONCENTRATION OF 2,4-D IN HOUSE DUST

	Concentration of 2,4-D in House Dust					Other analytes by GC/ECD	
	GC/ECD	ELISA[a]				PCP[b]	SRS[c]
Household Code	ng/g	ng/g		RPD[d]		ng/g	recovery, %
	replicate #1	#1	#2	#1	#2		
A	41	197	433	131	165	70	60
B	4310	3038	2410	35	57	97	54
C	1030	27500	5908	186	141	93	81
D	1980	522	NT[e]	117	NA[f]	89	102
E	1230	176	669	150	59	78	51
F	233	292	368	22	45	144	98
G	635	708	480	11	28	>450[g]	86
H	889	1970	NT	76	NA	134	70
I	146	593	569	121	118	37	69
J	647	2140	2650	107	122	17	89
K	219	641	1020	98	129	55	61
L	NT	NT	NT	NA	NA	NT	NT
M	475	3350	NT	150	NA	101	110
M duplicate	624	3650	NT	142	NA	100	105
RPD for duplicates	27	9	NA	NA	NA	1	NA
solvent blank	<20	58[h]	NT	NA	NA	<1	103

a) Duplicate dust samples extracted; first sample (replicate #1) analyzed using both ELISA and GC/ECD; second sample (replicate #2) analyzed using only ELISA

b) PCP-pentachlorophenol

c) SRS- surrogate recovery standard; 1 μg spike of 3,4-D in replicate #1 samples only

d) RPD between GC/ECD and replicate #1 ELISA value; RPD between GC/ECD and replicate #2 ELISA value

e) NT- not tested

f) NA- not applicable

g) Saturated signal

h) Evidence of 6% cross-reactivity for 3,4-D in the 2,4-D ELISA assay

APPENDIX O. CONCENTRATION OF 2,4-D IN ENTRYWAY SOIL

	Concentration of 2,4-D in Entryway Soil			Other analytes by GC/ECD	
	GC/ECD	ELISA		PCP[a]	SRS[b]
Household Code	ng/g[c]	ng/g[d]	RPD[e]	ng/g[f]	recovery, %
A	<20	85	158	359	65
B	<20	<70 (39)[g]	118	<1	78
C	171	<70 (51)	108	2	50
D	<20	<70 (36)	113	33	46
E	<20	81	156	3	62
F	54	<70 (45)	18	<1	92
G	69	<70 (45)	35	2	82
H	NT[h]	NT	NA[i]	NT	NT
I	41	<70 (54)	27	<1	95
J	38	141	115	<1	92
K	<20	<70 (44)	126	4	84
L	92	<70 (62)	39	<1	64
M	<20	<70 (37)	115	<1	94
solvent spike	97% [j]	120% [j]		76%[j]	94

a) PCP-pentachlorophenol
b) SRS-surrogate recovery standard; 1 μg spike of 3,4-D
c) Method detection limit- 20 ng/g
d) Method detection limit- 70 ng/g
e) RPD- relative percent difference between GC/ECD and ELISA measurements; 50% of MDL used to calculate RPD when analyte not detected
f) Method detection limit- 1 ng/g
g) Concentration is less than method detection limit; value in parentheses is the concentration measured in the assay from the non-linear portion of the calibration curve
h) NT- not tested
i) NA- not applicable
j) Percent recovery of spike; 1 μg spike of 2,4-D and 0.1 μg spike of PCP

APPENDIX O. CONCENTRATION OF 2,4-D IN PATHWAY SOIL

	Concentration of 2,4-D in Pathway Soil			Other analytes by GC/ECD	
	GC/ECD	ELISA		PCP[a]	SRS[b]
Household Code	ng/g[c]	ng/g[d]	RPD[e]	ng/g[f]	recovery, %
A	<20	<70 (18)[g]	14	1	89
B	<20	<70 (16)	25	<1	70
C	<20	<70 (39)	118	4	84
D	<20	<70 (33)	107	<1	70
E	<20	<70 (29)	97	<1	62
F	<20	<70 (42)	123	<1	99
G	<20	<70 (31)	102	<1	89
H	<20	<70 (25)	86	<1	82
I	<20	<70 (26)	89	<1	102
J	<20	<70 (24)	82	<1	91
K	<20	<70 (31)	102	<1	86
L	<20	<70 (23)	79	<1	78
M	<20	<70 (52)	135	<1	86
solvent spike	90% [h]	175%[h]		66%[h]	86

a) PCP-pentachlorophenol
b) SRS-surrogate recovery standard; 1 μg spike of 3,4-D
c) Method detection limit- 20 ng/g
d) Method detection limit- 70 ng/g
e) RPD- relative percent difference between GC/ECD and ELISA measurements; 50% of MDL used to calculate RPD when analyte not detected
f) Method detection limit- 1 ng/g
g) Concentration is less than method detection limit; value in parentheses is the concentration measured in the assay from the non-linear portion of the calibration curve
h) Percent recovery of spike; 1 μg spike of 2,4-D and 0.1 μg spike of PCP

APPENDIX P. CONCENTRATION OF PENTACHLOROPHENOL (PCP) IN HOUSE DUST

	Concentration of PCP in House Dust			Other analytes by GC/ECD	
	GC/ECD	ELISA		2,4-D	SRS[a]
Home	ng/g	ng/g[b]	RPD[c]	ng/g	recovery, %
A	214	520	83	364	38
B	53	<70 (39)[d]	30	2320	85
C	93	622	148	870	81
D	156	167	7	2880	91
E	103	197	63	1530	93
F	141	80	55	354	88
G	189	83	78	603	90
H	141	1450	165	1040	90
I	34	203	143	112	71
J	23	106	129	547	71
K	86	256	99	513	45
L	NT	NT[e]	NA[f]	NT	NT
M	93	520	139	377	132

a) SRS-surrogate recovery standard; 1 μg spike of 3,4-D
b) Method detection limit- 70 ng/g
c) RPD- relative percent difference between GC/ECD and ELISA measurements; 50% of MDL used to calculate RPD when analyte not detected
d) Concentration is less than method detection limit; value in parentheses is the concentration measured in the assay from the non-linear portion of the calibration curve
e) NT- not tested
f) NA- not applicable

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