

mice fed the basal P diet. Dietary P and Pb interacted to affect body weight change and feed efficiency in mice. The relative contribution of different Pb species in diet and feces was also affected by dietary P level. Differences in Pb species between diet and feces indicated that transformation of Pb species can occur during gastrointestinal tract transit. These interactions between Pb and P that alter Pb speciation may be important determinants of the bioavailability of Pb ingested in soil.

## PS 2850 Comparisons of PM<sub>2.5</sub> and BC<sub>2.5</sub> Concentrations in the Subways of Cities in the Northeastern United States

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Subways move millions a people a day across the world, bringing people to and from work and leisure. They are essential to the working economy of many cities. More are expected to be built, globally. We know that particulate matter (PM) levels on platforms are many times higher than ambient, but we know little of the origin of this pollution. No other study has investigated intercity differences in subway air quality in the Eastern United States. Here we report the PM<sub>2.5</sub> and BC<sub>2.5</sub> concentrations in the subways in Philadelphia, Boston, Washington, and in the MTA and PATH run stations in the New York City metropolitan area. We monitored real-time concentrations with a pDR 1500 and a microaethalometer on a total of 83 platforms in 74 stations across 12 lines during the morning (6:00 - 10:30 AM) and evening (3:00 - 7:00 PM) rush hours. We also collected aerosol particles on quartz and Teflon filters at the stations with the two highest measured PM<sub>2.5</sub> concentrations measured in each city; we calculated the organic carbon (OC) and elemental carbon (EC) and the PM<sub>2.5</sub> concentrations with each form of filter, respectively. Comparisons between city, time of day, on- and off- train, and train line were made. Mean real-time PM<sub>2.5</sub> concentrations in underground stations were 391.91, 250.45, 144.88, 138.70, 37.91 ug/m<sup>3</sup>, for MTA-New York, PATH-New York, Washington, Boston and Philadelphia, respectively. The average ambient PM<sub>2.5</sub> concentration across these cities was 15.91 ug/m<sup>3</sup>. Stations serviced by PATH had the highest PM<sub>2.5</sub> concentrations, as calculated by gravimetric analysis, we had observed in the world, a mean of 1204.25 ug/m<sup>3</sup>. A measurement at the Christopher Street station was valued as high as 2773.33 ug/m<sup>3</sup>. We also observed significant differences between on-train and on platform and AM and PM PM<sub>2.5</sub> concentrations. Furthermore, there was considerable variability in OC and EC concentrations between and within cities. Our results show that there is considerable variability in the PM<sub>2.5</sub> concentrations across cities in the Eastern United States. One train system, the PATH, is particularly polluted with gravimetric measurements calculated at almost 1000 times ambient levels. Means to reduce and to identify the sources of PM in these stations should be undertaken.

## PS 2851 Asbestos Exposure Risk from Ceiling and Other Building Materials

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Asbestos exposure risk was assessed from review of bulk samples collected from 27 sites from twelve states. A total of 288 bulk samples contained asbestos. Data was obtained from 18 commercial property sites and 9 residential properties. All asbestos-containing material (ACM) identified in all samples contained Chrysotile. Chrysotile content ranged from 1.25% to 70% among the various bulk samples. A total of 41 samples from popcorn or acoustical ceiling texture material were analyzed. Chrysotile content in popcorn or acoustical ceiling texture ranged from 2% to 10%. The data set contained samples from Florida, California, Colorado and other western and southeastern states. The exposure risk from textured ceiling material including popcorn and acoustical ceilings is associated with disturbance, detachment, and removal of textured surfaces. Disturbance of asbestos-containing building material may result in fiber release and mobilization of asbestos containing materials. Building materials such as duct paper contained the highest 70% ACM and roofing material exterior plaster contained the lowest 1.25% ACM. Also, caulk, wall covering, and other building materials contained asbestos. Eight personal breathing zone air samples were collected following NIOSH Method 7400 during the removal of asbestos containing textured ceiling material under negative pressure in a commercial building in Oklahoma. The personal exposures ranged from below the lab's reporting limit to 0.0201 f/cc. Area air sampling was also conducted during a large-scale (residential) asbestos removal project in Florida. A total of 400 area samples were collected during the removal of asbestos containing materials (textured ceiling, caulk, mastic and drywall) inside an active containment under negative pressure

and outside of the containment structure to approximate personal breathing zone exposures. The airborne asbestos concentration ranged from below the labs reporting limit to 0.0135 f/cc. Textured ceiling material and other ACM building materials may increase the risk of asbestos exposure in commercial and residential structures.

## PS 2852 Analysis of NIOSH Health Hazard Evaluations Featuring Lead (Pb)

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Lead (Pb) is used today in electronics, smelting, ammunition, and galvanized steel. Given this variety of possible worker exposures, evaluations summarizing occupational exposures are valuable. This analysis of 80 health hazard evaluations (HHE) with data collected by NIOSH from 1991 to 2017 found that work-related Pb exposure data has been collected in at least 32 US states. In addition, HHEs from Washington D.C., Puerto Rico, and Bolivia, were included in the analysis. Many different sectors were covered as defined by the National Occupational Research Agenda (NORA). Four (5 %) of these evaluations were from warehousing and utilities, 5 (6 %) were from public safety or healthcare, 11 (14 %) were from wholesale and retail trade, 12 (15 %) were from construction, 17 (21 %) were from manufacturing, and the majority, or 31 (39 %) were from the services sector. Given the large variety of site-specific needs and types of work covered by these NIOSH evaluations, it is not surprising that programs protecting workers from Pb were not uniformly established. Of these 80 HHE studies, 19 (24 %) reportedly had a respiratory protection program (RPP) and 16 (20 %) had a lead surveillance program (LSP). Ten (13 %) of the HHEs discussed workplaces with both a LSP and a RPP. The HHEs documented Pb exposures in regions across the United States, including Oregon, Colorado, Texas, Wisconsin, Florida, and Maine. OSHA Region 5, or the mid-western states of MN, WI, MI, IL, IN, and OH were the most represented in these HHEs. Twenty-eight percent, or 22 of 80 evaluations, were represented by Region 5 out of the ten possible OSHA regions. A wide range of exposure levels were also observed across this sample of occupational Pb exposures; air concentrations were documented in some situations as not detectable (ND), while the highest sample read 5900 ug/m<sup>3</sup>. Blood lead levels in these participants ranged from ND to 40 ug/dL. This analysis demonstrates that occupational Pb exposures are observed in workers across the United States and throughout many different types of industries. This analysis also highlights the need for future collaborations with NIOSH as employers set up respiratory protection plans, safety programs, and medical surveillance to protect the health of workers. The wide variety of settings where Pb exposures can take place demonstrates that Pb remains a priority issue in occupational health within the United States of America. *Disclaimer: The views in this abstract are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.*

## PS 2853 Occupational Biomonitoring and Interpretation of 2,4-Dichlorophenoxyacetic Acid (2,4-D) Using Field Deployable Sensors and PBPK Modeling

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Onsite rapid biomonitoring of occupational exposures supports safe working conditions and practices. Traditional quantification methods of chemicals in biofluids may have long turnaround times leading to delayed analysis and, if warranted, remedial action, highlighting the need for faster measurements and interpretation of measurements. In order to improve measurement and interpretation time of 2,4-dichlorophenoxyacetic acid (2,4-D), we developed a field deployable device for 2,4-D detection and a computational pharmacokinetic model for measurement interpretation. The antibody-based device features an optical-sensing platform that utilizes a smartphone to take measurements of colorimetric changes dependent on the presence of 2,4-D in biological samples. After optimizing conditions, the device detected 2,4-D in the linear range of 1 - 40 ug/L in biofluids. For measurement interpretation, we developed a physiologically based pharmacokinetic model (PBPK) to predict 2,4-D disposition in rats and humans and utilized a Transwell *in vitro* system to parameterize salivary transport of 2,4-D. The PBPK model predicted 2,4-D concentrations in urine (533 ug/L) of 2,4-D backpack applicators following an 8-hour workday exposed to 0.008-0.012 mg/kg/day of 2,4-D. At those same exposure conditions, the model predicted concentrations of 2,4-D in saliva at lower levels than urine (average 1.49 ug/L), but still within the linear range of the sensor. Since these expected levels are well within the detection

limits of the sensor, this device may be suitable for non-invasive and rapid onsite screenings in occupational settings. *Supported by CDC/NIOSH grant R01 OH011023.*

**PS 2854 Effects of Occupational Exposure to Low-Level Benzene on Oxidative Damage in Chinese Workers**

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Benzene is not only a common environmental pollutant, but also a common organic solvent and chemical raw material in industry and chemical production. Because of the relevant protective measures have been taken by government and enterprises, level of the occupational benzene exposure of most Chinese workers are below the occupational limit (PC-TWA 6mg/m<sup>3</sup>). The purpose of this study was to explore the effects of occupational exposure to low-level benzene on oxidative damage of workers. A total of 90 workers exposed to benzene and 85 non-exposed workers were enrolled in this study. The benzene monitoring data in workplace and the health examination data of workers were collected. Blood routine was examined, the S-phenylmercapturic acid (S-PMA), metabolite of benzene in urine, was measured by high performance liquid chromatography-mass spectrometry. The content of lipid peroxide malondialdehyde (MDA) in plasma and 8-hydroxy-2'-deoxyguanosine (8-OHdG) in urine were detected by colorimetry. The effects of benzene exposure on oxidative damage were analyzed by adjusting sex, age, BMI, smoking and alcohol consumption, and the correlation between S-PMA, 8-OHdG and MDA was analyzed. Benzene concentrations at all workplace monitoring sites were below 0.6 mg/m<sup>3</sup>. The blood routine results showed that the average red blood cell and platelet counts in the exposed group were significantly lower than those in the control group ( $p < 0.001$ ), but still located within normal limits. The results of S-PMA test showed that average concentration of S-PMA in urine of exposed workers was significantly higher than that of control group (26.54 μg/g Cr vs 7.84 μg/g Cr,  $p < 0.005$ ); average concentration of MDA in plasma and 8-OHdG in urine of exposed workers were also higher than that of control group ( $p < 0.005$ ); the urine concentration of S-PMA was positively correlated with the 8-OHdG. These results suggested that occupational exposure to low-level benzene still could increase the oxidative damage in workers and the S-PMA, metabolite of benzene had a good correlation with the oxidative damage induced by benzene. *This work was supported by the National Natural Science Foundation of China (Grants no. 81872645, 81730087).*

**PS 2855 Direct Quantification Method for S-Phenyl Cysteine Benzene: Oxide Hemoglobin Adduct**

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Benzene oxide adducts of hemoglobin have been used as biomarkers of benzene exposure in rodent models and exposed human populations using gas chromatography mass spectrometry methods. This method entails reacting dried protein with trifluoroacetic anhydride and methanesulfonic acid to yield phenyltrifluoroacetate, the ultimate product that is quantified. In this study, we developed a high performance liquid chromatography-isotope dilution mass spectrometry method for the directed quantification of S-Phenyl Cysteine (SPC), a benzene oxide adduct of hemoglobin cysteine, following acid hydrolysis of globin. The use of electron spray ionization on a triple quadrupole mass spectrometry system was employed to demonstrate a linear response in SPC concentration ranges from 200 fmol to 100 pmol with a 13.51% coefficient of variation between triplicates of samples. This new method showed a sensitivity of 20 pmol SPC g<sup>-1</sup> globin, similar to the prior gas chromatography method, but requires no derivatization. SPC remained unchanged following hydrolysis and was determined to be stable for direct quantification. Ample precision, accuracy and sensitivity shown in this method makes it ideal for environmental exposure quantification. Validation for environmental exposure is currently in progress using human samples following hurricane related exposures in Houston.

**PS 2856 Assessment of Mineralogical Composition and Ecological Risk of Potentially Toxic Metals in Surface Sediments of a Tropical Estuary**

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The bioaccumulation in excess of natural loads and potential for remobilization of sediment bound metals in aquatic ecosystems is a major environmental concern. The study assessed the degree of contamination and risk associated with ten heavy metals in forty-five surface sediments from fifteen sites in Lagos Lagoon. Metals concentrations was determined using Agilent 7500c Inductively Coupled Plasma Mass Spectrometry (ICP-MS) while mineralogical composition was examined using X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM). SEM and XRD analyses indicate that aluminosilicate and silty clay minerals influenced metals mobilization and bioavailability from sediment. The result showed that Fe with a mean concentration of 26031.96 mg/kg was the most abundant. The observed metal levels in the order; Fe > Mn > Zn > Cu > Cr > Pb > Co > Ni > As > Cd did not exceed the threshold limits for the protection of aquatic life. Estimated pollution load index (PLI), geoaccumulation index (Igeo), contamination factors and degree of contamination also indicate low to moderate environmental risks. However, the result of enrichment factor demonstrated high level of enrichment from anthropogenic sources which might still pose adverse biological effects. This calls for continuous monitoring and effective legislation in the region.

**PS 2857 Biomarker Identification for Human Exposure to Petrogenic Polycyclic Aromatic Hydrocarbons**

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On April 20, 2010, the Deepwater Horizon (DWH) oil rig explosion released approximately 4.9 million barrels of crude oil into the Gulf of Mexico. Communities that rely heavily on the Gulf for their livelihood and sustenance were deeply concerned with the long-term health effects of consuming seafood laden with crude oil. Despite extensive studies on the Aryl Hydrocarbon Receptor (AHR)-mediated toxicities of pyrogenic polycyclic aromatic hydrocarbons (PAHs) such as benzo[a]pyrene, data on the human health impacts of petrogenic PAHs found in crude oil is scarce. This study aims to identify candidate biomarkers of exposure to petrogenic PAHs that can activate AHR-mediated pathways. Plasma samples were collected longitudinally from 100 volunteers in each of four partner communities (Biloxi, Mississippi; Gulfport, Mississippi; Houma, Louisiana; and Galveston, Texas) between 2012 and 2014. Extensive survey data, health assessments, and blood and urine clinical analyses were also collected. Total plasma PAH levels were measured using Gas Chromatography-Mass Spectrometry (GC-MS) and AHR-mediated activities were quantified using a modified Chemically Activated Luciferase gene expression (CALUX) bioassay. Results show that individual total plasma PAH levels did not correspond well with AHR activation, consistent with the presence of distinct bioactive and potentially harmful PAHs in some samples. Of the 42 PAH congeners tested, the petrogenic PAH C3-Naphthalene body burden showed significant positive correlation with AHR bioactivity and may serve as a candidate biomarker. Marked differences in total PAH levels and AHR bioactivities were seen in the subjects from Biloxi and Gulfport despite residing in the same Gulf Coast region. These indicate possible influences from other factors that may be identified using the health assessment and survey data. A general increase in total plasma PAH levels across the 3 years was also observed which may be attributed to an increase in seafood consumption in the ensuing years after the DWH oil spill. This study highlights the need for long-term monitoring of human exposure to sources of crude oil contamination. Future studies include identification and validation of biomarkers of effect to petrogenic PAHs that may aid in risk assessments. *This work is supported by NIH grants R01ES026874, U19ES020676, 1P30ES06676, and T32ES007254.*

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# Preface

This issue is devoted to the abstracts of the presentations for the Continuing Education courses and Scientific Sessions of the 59th Annual Meeting of the Society of Toxicology, held at the Anaheim Convention Center, Anaheim, California, March 15–19, 2020.

An alphabetical Author Index, cross-referencing the corresponding abstract number(s), begins on page 542.

The issue also contains a Keyword Index (by subject or chemical) of all the presentations, beginning on page 580.

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