Toxic Metals, PFAS and PCBs in Blood and Urine Specimens Collected from New Jersey Clinical Laboratories and Blood Banks
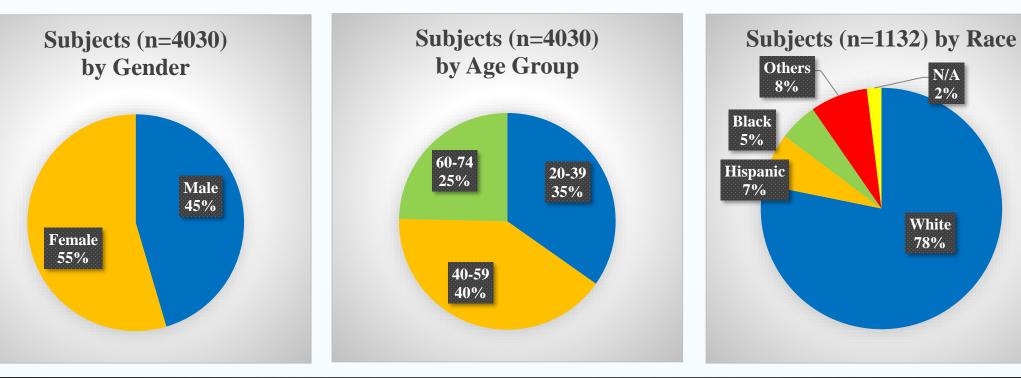
NJ Health — New Jersey Department of Health

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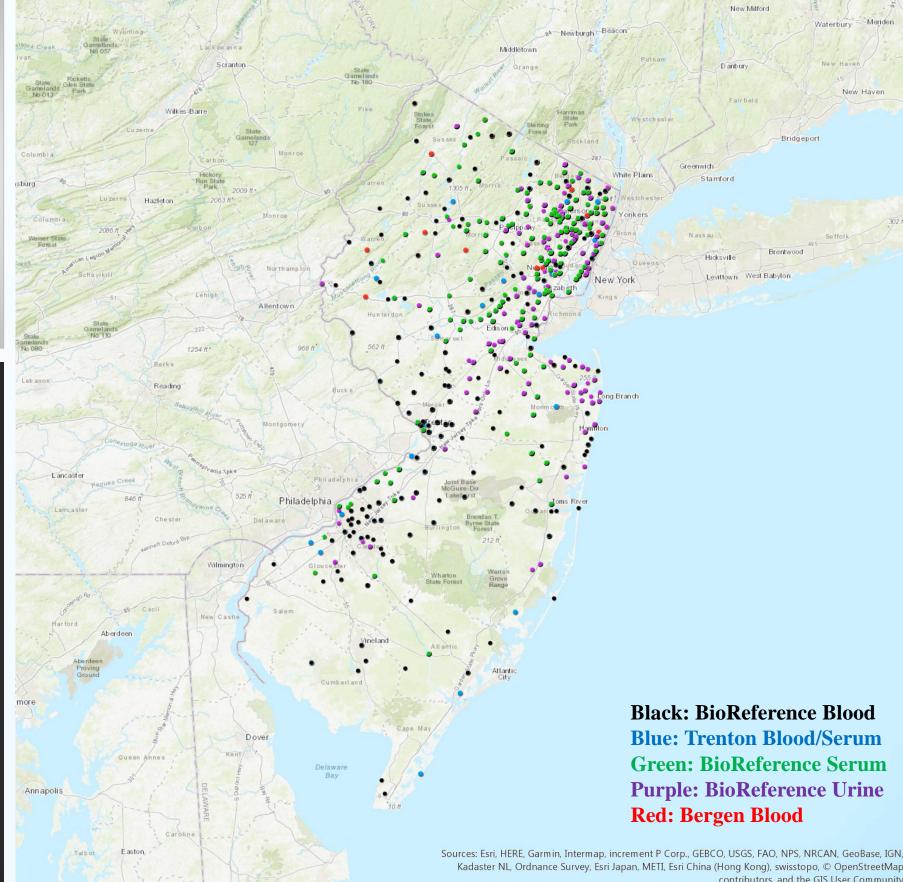
Abstract

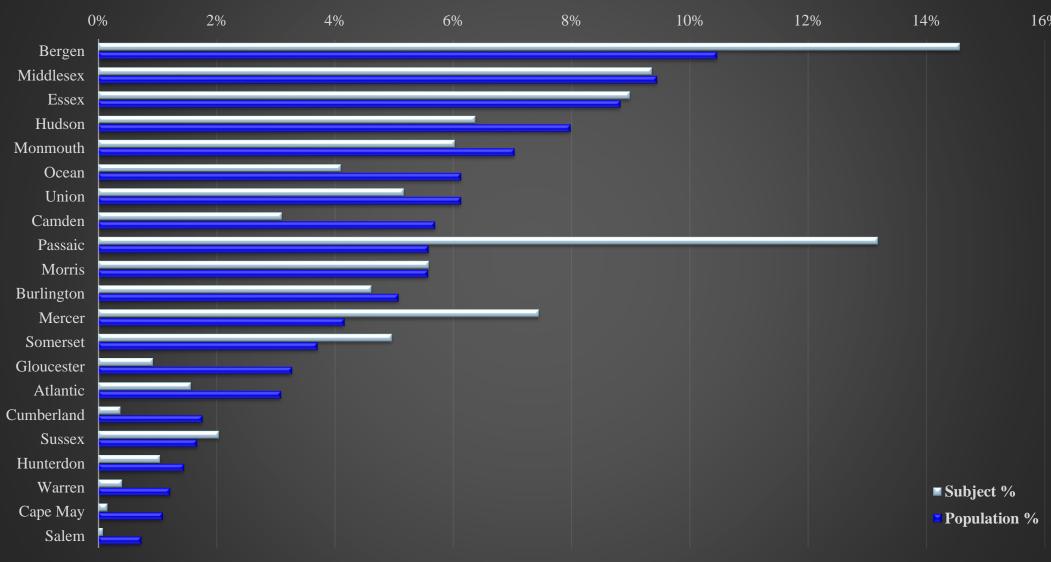New Jersey (NJ) residents are disproportionately exposed to various hazardous chemicals due to the high density of industry, traffic, and commercial sources. Statewide biomonitoring data are needed to establish a baseline of exposure and to identify potential populations at risk. However, it is costly and laborious to implement a population-based sampling, such as the approach implemented by the National Health and Nutrition Examination Survey (NHANES) for general US population. NJ Department of Health (NJDOH) conducted biomonitoring for toxic metals, polychlorinated biphenyls (PCBs), and emerging pollutants perfluoroalkyl and polyfluoroalkyl substances (PFAS) using a cost-effective alternative approach, i.e. measure target contaminants in remnant specimens collected by clinical laboratories and blood banks in NJ. This project aims to assess the distribution of toxic metals in 3000 blood and 1000 urine specimens, PCBs and PFAS in 1000 sera for NJ adults (20-74 years old). From 2015 to 2018, the study has measured 3 toxic metals in 1949 blood specimens, 7 toxic metals in 602 urine specimens, 12 PFAS in 843 sera, and 40 PCBs in 250 sera. Preliminary data showed most analytes fell within the concentration ranges reported by NHANES. However, some pollutants, such as PFNA (GM [CI]=0.75 [0.68-0.82]$_{NJ,2016-2018}$ ng/mL), are elevated compared to the US general population (GM [CI]$_{NHANES,2013-2014}$=0.69[0.63-0.75] ng/mL); some surprisingly high results were observed for blood lead (e.g. 50.4 and 26.3 µg/dL) and mercury (several in the 20-30 µg/L range and one in 128 µg/L), and several PCBs showed higher levels than national averages. In-depth analyses are being conducted to examine whether body burdens of NJ adults are significantly higher than national levels and whether there are significant differences by age, gender, race/ethnicity, and geographic location (e.g., residential ZIP codes). Through these analyses, NJDOH will identify potentially at-risk subpopulations for further exposure assessment.

Study Objectives

- Establish biomonitoring capability/capacity for emerging contaminants
  - Heavy metals in blood/urine
  - PFAS & PCBs in serum
- Monitor trends of emerging contaminants in NJ population
- Identify potential sources & hot spots in NJ

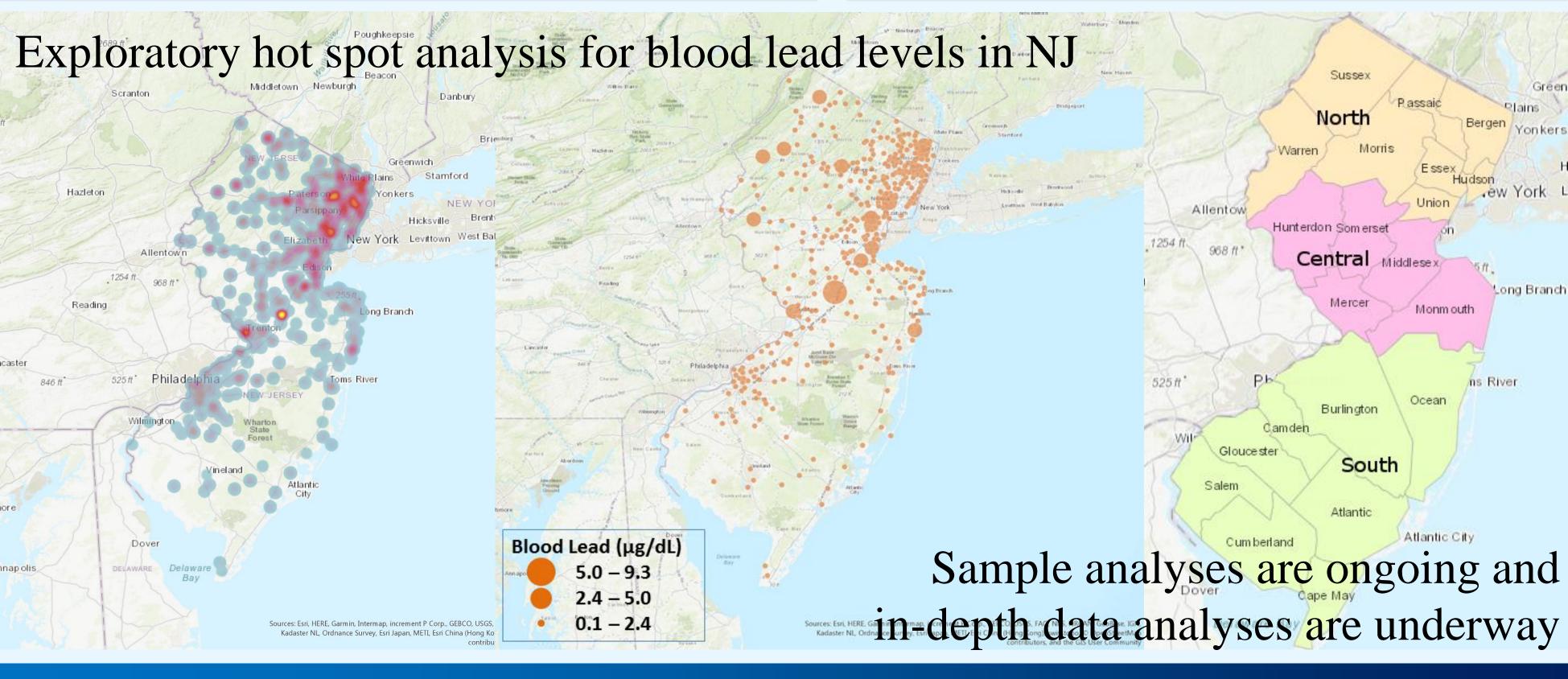## Sample Collection & Analysis

- To date, 2174 (73%) blood, 826 (83%) urine and 1030 (100%) serum specimens were collected.

Provider	Type & Collection Coverage	Blood	Urine	Serum
BioReference	Clinical Lab $ State-wide	1434 (66%)	826 (100%)	638 (62%)
Bergen	Blood bank & North NJ	349 (16%)	Not Collected	Not Collected
Trenton	Blood bank & Central NJ	391 (18%)	Not collected	392 (38%)

- Metals
  - Cd, Hg, and Pb in blood using ICP-MS (by CDC 3016.8-03)
  - As, Ba, Be, Cd, Pb, Tl, and U in urine using ICP-MS (by CDC 3018.4-02 (for 6 elements) & 3018A.3-02 (for total As))
- PFAS
  - 12 PFASs in serum using an on-line SPE and HPLC-MS/MS (by NJDOH Method modified from CDC 6304.04)
- PCBs
  - 40 PCBs in serum using an HRGC-HRMS (by CDC 6502.02)

Data Analysis

Data Preparation
- Censor low-level data (<minimum reporting limit (MRL)) and replace them with each MRL/√2.
- Assign individual weight for each subject against 2017 NJ Census data (by gender, age group, and residing county between 20-74 in NJ).
- Strata (sample provider) and cluster (sample cycle as of acquisition date) variables were added into each dataset to account for sampling design.
- Locational differences (i.e., close to sources or not) will be further explored by using ESRI's ArcGIS system with a proximity to source(s).

Data Analysis
- Descriptive statistics (GM and percentiles with 95% CIs) were calculated by using SAS's surveymeans.
- Compare GMs from this study and the latest NHANES database to examine whether NJ data are elevated than national levels.
- Differences on gender, age group, and locational differences will be examined/compared by using SAS's surveyreg and glm approaches.

Study Results

Subjects by gender, age group, race/ethnicity, and residence (zip code & county)

Subjects (n=4030) by Gender — Male 45%, Female 55%

Subjects (n=4030) by Age Group — 20-39 35%, 40-59 40%, 60-74 25%

Subjects (n=1132) by Race — White 78%, Hispanic 7%, Black 5%, Others 8%, N/A 2%

Subjects by County (n=4030 as of August 2018): Bergen, Middlesex, Essex, Hudson, Monmouth, Ocean, Union, Camden, Passaic, Morris, Burlington, Mercer, Somerset, Gloucester, Atlantic, Cumberland, Sussex, Hunterdon, Warren, Cape May, Salem — Subject %, Population %

Black: BioReference Blood
Blue: Trenton Blood/Serum
Green: BioReference Serum
Purple: BioReference Urine
Red: Bergen Blood

NJDOH biomonitoring data in 2015-2018

Metals (µg/L) in blood (n=1949) & urine (n=602)

Matrix	Analyte	MRL	>MRL	GM [95% CI]	50% [95% CI]	75% [95% CI]	90% [95% CI]	95% [95% CI]
Blood	Cadmium	0.219	60%	0.30 [0.27-0.34]	0.27 [0.24-0.31]	0.47 [0.41-0.54]	0.82 [0.68-1.00]	1.22 [0.88-1.69]
	*Lead (µg/dL)	0.250	93%	0.80 [0.67-0.95]	0.82 [0.69-0.97]	1.30 [1.09-1.56]	1.98 [1.70-2.32]	2.61 [2.25-3.01]
	Mercury	0.330	86%	1.11 [0.99-1.25]	1.11 [0.94-1.31]	2.38 [2.03-2.80]	4.42 [4.10-4.75]	6.17 [5.51-6.89]
Urine	Arsenic	1.250	94%	9.10 [7.21-11.5]	8.68 [6.61-11.4]	19.0 [13.7-26.2]	43.8 [36.2-52.9]	69.9 [41.7-117]
	Barium	0.100	96%	0.85 [0.74-0.98]	0.83 [0.69-1.01]	1.87 [1.44-2.42]	3.08 [2.31-4.12]	4.79 [3.22-7.13]
	Beryllium	0.159	0%	N/A	<MRL	<MRL	<MRL	<MRL
	Cadmium	0.056	88%	0.20 [0.13-0.31]	0.21 [0.12-0.37]	0.42 [0.29-0.62]	0.74 [0.54-1.02]	1.11 [0.82-1.50]
	Lead	0.080	83%	0.24 [0.18-0.33]	0.27 [0.18-0.40]	0.51 [0.41-0.62]	0.85 [0.52-1.39]	1.12 [0.93-1.36]
	Thallium	0.020	99%	0.17 [0.13-0.22]	0.19 [0.14-0.25]	0.29 [0.22-0.39]	0.40 [0.30-0.54]	0.53 [0.37-0.76]
	Uranium	0.003	60%	N/A	<MRL	0.01 [0.00-0.01]	0.01 [0.01-0.02]	0.02 [0.01-0.04]

PFAS (ng/mL) in serum (n=843)

Analyte	MRL	>MRL	GM [95% CI]	50% [95% CI]	75% [95% CI]	90% [95% CI]	95% [95% CI]
Et-PFOSA-AcOH	0.028	7%	N/A	<MRL [<MRL-0.04]	<MRL [<MRL-0.04]	<MRL [<MRL-0.04]	0.04 [<MRL-0.07]
Me-PFOSA-AcOH	0.027	63%	0.05 [0.04-0.05]	0.04 [<MRL-0.06]	0.08 [0.07-0.10]	0.19 [0.16-0.22]	0.31 [0.24-0.40]
PFBuS	0.043	21%	N/A	<MRL [<MRL-0.04]	<MRL [<MRL-0.04]	0.06 [0.04-0.07]	0.07 [0.06-0.09]
PFDeA	0.096	94%	0.22 [0.19-0.27]	0.22 [0.19-0.26]	0.31 [0.26-0.38]	0.46 [0.36-0.58]	0.61 [0.43-0.89]
PFDoA	0.066	57%	N/A	0.07 [<MRL-0.11]	0.12 [0.09-0.15]	0.17 [0.12-0.26]	0.22 [0.15-0.32]
PFHpA	0.055	35%	N/A	<MRL	0.06 [<MRL-0.08]	0.12 [0.10-0.14]	0.16 [0.12-0.21]
PFHxS	0.096	99%	1.02 [0.92-1.12]	1.10 [1.00-1.20]	1.76 [1.57-1.98]	3.00 [2.55-3.54]	4.15 [3.43-5.02]
PFNA	0.039	100%	0.75 [0.68-0.82]	0.75 [0.67-0.84]	1.06 [0.99-1.15]	1.45 [1.32-1.58]	1.76 [1.55-2.00]
PFOA	0.072	100%	1.92 [1.80-2.06]	1.94 [1.81-2.08]	2.86 [2.59-3.15]	3.88 [3.51-4.29]	4.89 [4.17-5.72]
PFOS	0.071	100%	2.90 [2.73-3.08]	3.00 [2.72-3.30]	4.73 [4.41-5.07]	7.09 [6.18-8.13]	9.42 [8.39-10.6]
PFOSA	0.018	15%	N/A	<MRL	<MRL	0.02 [<MRL-0.03]	0.03 [0.02-0.04]
PFUnA	0.028	90%	0.09 [0.08-0.11]	0.10 [0.08-0.12]	0.18 [0.15-0.21]	0.29 [0.24-0.34]	0.39 [0.33-0.46]

PCBs (ng/g lipid) in serum (n=250)

Analyte	MRL	>MRL%	GM [95% CI]	50% [95% CI]	75% [95% CI]	90% [95% CI]	95% [95% CI]
PCB101	0.202	100%	0.77 [0.62-0.95]	0.73 [0.54-0.98]	1.09 [0.88-1.36]	1.60 [0.56-4.55]	2.21 [N-A/N-A]
PCB105	0.113	96%	0.61 [0.50-0.74]	0.59 [0.48-0.73]	1.04 [0.82-1.32]	1.88 [0.68-5.19]	3.23 [N-A/N-A]
PCB110	0.073	100%	0.44 [0.32-0.60]	0.40 [0.28-0.57]	0.61 [0.41-0.90]	0.97 [N-A/N-A]	1.33 [0.45-3.95]
PCB114	0.135	70%	0.25 [0.17-0.36]	0.20 [0.09-0.43]	0.48 [0.19-1.24]	1.03 [0.61-1.75]	1.67 [0.94-2.99]
PCB118	0.113	100%	3.18 [2.43-4.18]	2.73 [1.81-4.12]	5.98 [3.69-9.69]	10.6 [4.15-27.1]	16.0 [N-A/N-A]
PCB123	0.143	46%	0.19 [0.17-0.20]	0.10 [0.08-0.13]	0.25 [0.19-0.34]	0.84 [0.41-1.75]	1.66 [0.83-3.33]
PCB128	0.207	22%	0.19 [0.17-0.21]	0.15 [0.07-0.29]	0.15 [0.07-0.29]	0.42 [0.22-0.80]	0.98 [0.50-1.92]
PCB138+158	0.146	100%	7.29 [4.62-11.5]	7.06 [3.31-15.1]	17.1 [8.24-35.1]	33.6 [20.8-54.3]	44.6 [24.9-79.8]
PCB146	0.212	95%	1.16 [0.65-2.09]	1.22 [0.55-2.67]	2.64 [1.25-5.58]	5.70 [2.46-13.2]	7.43 [3.62-15.2]
PCB149	0.224	39%	0.23 [0.20-0.25]	0.16 [0.12-0.21]	0.28 [0.24-0.33]	0.40 [0.26-0.60]	0.48 [0.27-0.87]
PCB151	0.182	18%	0.15 [0.14-0.16]	0.13 [0.08-0.20]	0.13 [0.08-0.20]	0.24 [0.15-0.39]	0.34 [0.14-0.80]
PCB153	0.122	100%	9.98 [5.59-17.8]	9.52 [3.84-23.6]	24.6 [8.58-70.5]	45.7 [23.4-89.0]	63.0 [N-A/N-A]
PCB156	0.143	99%	1.45 [0.75-2.83]	1.42 [0.49-4.07]	4.09 [2.02-8.29]	7.49 [4.69-11.9]	11.9 [8.23-17.1]
PCB157	0.143	77%	0.37 [0.20-0.67]	0.32 [0.10-1.01]	0.94 [0.45-1.96]	1.78 [1.09-2.90]	2.56 [N-A/N-A]
PCB167	0.191	73%	0.39 [0.24-0.66]	0.34 [0.16-0.73]	0.96 [0.34-2.18]	1.84 [0.88-3.86]	2.53 [N-A/N-A]
PCB170	0.146	100%	2.79 [1.36-5.69]	2.97 [0.97-9.16]	7.95 [2.58-24.4]	13.6 [7.28-25.6]	19.4 [11.6-32.1]
PCB172	0.241	69%	0.46 [0.26-0.81]	0.38 [0.14-1.01]	1.10 [0.41-2.98]	1.80 [0.91-3.57]	3.01 [1.27-7.15]
PCB177	0.194	74%	0.41 [0.27-0.63]	0.35 [0.10-4.84]	0.85 [0.41-1.77]	1.47 [0.93-2.32]	2.71 [N-A/N-A]
PCB178	0.170	82%	0.57 [0.28-1.19]	0.59 [0.16-2.16]	1.53 [0.55-4.24]	2.88 [1.50-5.53]	3.76 [1.70-8.29]
PCB18	0.057	99%	0.42 [0.34-0.53]	0.40 [0.35-0.45]	0.55 [0.34-0.88]	0.85 [N-A/N-A]	1.08 [N-A/N-A]
PCB180	0.122	100%	7.29 [3.41-15.6]	7.90 [2.37-26.3]	21.6 [6.51-71.6]	36.8 [20.1-67.5]	53.4 [N-A/N-A]
PCB183	0.241	84%	0.75 [0.44-1.25]	0.67 [0.33-1.36]	1.81 [0.61-5.41]	2.99 [2.37-3.77]	4.56 [2.29-9.10]
PCB187	0.202	96%	2.12 [1.01-4.45]	2.13 [0.79-5.76]	6.03 [1.60-22.8]	11.1 [4.93-24.8]	15.2 [5.73-40.5]
PCB189	0.173	54%	0.22 [0.15-0.34]	0.12 [0.06-0.25]	0.37 [0.15-0.91]	0.73 [N-A/N-A]	1.04 [0.45-2.40]
PCB194	0.116	90%	1.66 [0.74-3.72]	1.89 [0.53-6.74]	5.33 [2.78-10.2]	9.01 [6.13-13.3]	13.0 [N-A/N-A]
PCB195	0.143	73%	0.32 [0.17-0.60]	0.31 [0.10-0.96]	0.80 [0.27-2.38]	1.29 [0.89-1.85]	1.83 [0.84-4.00]
PCB196+203	0.080	100%	1.51 [0.75-3.04]	1.61 [0.54-4.79]	4.45 [1.66-12.0]	7.26 [4.40-12.0]	11.2 [5.90-22.7]
PCB199	0.173	95%	1.50 [0.65-3.44]	1.77 [0.52-5.98]	4.80 [1.77-13.0]	7.70 [4.22-14.1]	12.6 [N-A/N-A]
PCB209	0.146	83%	0.76 [0.33-1.74]	0.96 [0.19-4.78]	2.09 [1.23-3.57]	3.96 [2.48-6.34]	6.70 [N-A/N-A]
PCB28	0.057	100%	1.38 [1.25-1.54]	1.26 [1.14-1.40]	1.71 [1.47-1.99]	2.52 [1.89-3.37]	3.61 [2.60-5.02]
PCB44	0.080	100%	0.43 [0.35-0.54]	0.39 [0.33-0.47]	0.51 [0.42-0.63]	0.88 [N-A/N-A]	1.39 [N-A/N-A]
PCB49	0.057	97%	0.24 [0.19-0.31]	0.22 [0.18-0.26]	0.29 [0.21-0.42]	0.56 [0.17-1.81]	0.897 [N-A/N-A]
PCB52	0.087	100%	0.80 [0.65-0.98]	0.75 [0.60-0.85]	0.93 [0.72-1.23]	1.61 [N-A/N-A]	2.49 [N-A/N-A]
PCB66	0.113	100%	0.56 [0.48-0.65]	0.51 [0.42-0.62]	0.79 [0.61-1.03]	1.31 [0.71-2.42]	2.15 [N-A/N-A]
PCB74	0.118	100%	1.86 [1.34-2.57]	1.70 [1.08-2.67]	3.13 [1.83-5.35]	6.29 [N-A/N-A]	10.7 [N-A/N-A]
PCB87	0.135	90%	0.28 [0.21-0.38]	0.41 [0.32-0.54]	0.62 [0.30-1.28]	0.62 [0.30-1.28]	0.83 [0.53-1.30]
PCB99	0.135	99%	1.82 [1.46-2.28]	1.95 [1.50-2.54]	3.63 [2.47-5.34]	5.20 [3.60-7.50]	7.93 [N-A/N-A]

Exploratory hot spot analysis for blood lead levels in NJ

Blood Lead (µg/dL): 5.0 – 9.3; 2.4 – 5.0; 0.1 – 2.4

Sample analyses are ongoing and in-depth data analyses are underway

Study Findings & Strength/Limitation

- The study results showed some emerging contaminants (e.g., PFNA) were elevated than national levels, and identified hot spots for study analytes (e.g., blood lead) in NJ population.
- Concentrations were higher for older > younger population due to their lifetime exposures; however, gender differences varied by analyte (i.e., higher PFASs for men, but not for PCBs).
- This study approach is convenient for sample collection with less efforts; but may not truly represent NJ general population.

Acknowledgements