Sources of error and variability in particulate matter sensor network measurements

Christopher Zuidema¹, Larissa V. Stebounova², Sinan Sousan^{2,3}, Geb Thomas⁴, Kirsten Koehler⁵ and Thomas M. Peters^{2*}

¹ Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, WA, 98195

² Department of Occupational and Environmental Health, University of Iowa, Iowa City, IA

³ Department of Public Health, East Carolina University / North Carolina Agromedicine Institute, Greenville, NC

⁴ Department of Industrial and Systems Engineering, University of Iowa, Iowa City, IA

⁵ Department of Environmental Health and Engineering, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

^{*}Author to whom correspondence should be addressed.

METHODS

Metal Analysis of Gravimetric Samples

After gravimetric analysis, filter samples from the pDR1500s were analyzed for metals by field portable X-Ray Fluorescence analyzer (FP-XRF, Niton XL3t Ultra, ThermoFisher Scientific, Waltham, MA) operated in thin film ("filter") mode. One field blank from each field visit was also analyzed by the FP-XRF. The mass per filter area measured with the FP-XRF was multiplied by an area of the filter on which PM was collected (3.62 cm² as was measured using a caliper). Metal mass obtained with FP-XRF for each sample was converted to the mass concentration using corresponding sampling time and airflow rate, and an average metal blank concentration was subtracted from metal concentration detected in the sample.

RESULTS AND DISCUSSION

Metal Analysis of Gravimetric Samples

The most concentrated metals detected at the facility were iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and nickel (Ni). Metal mass fractions in the machining and welding area were nearly identical to those in personal measurements (Fe ~35%; other ~59%; Mn 6%; Ni, Zn, Cu < 1%) (Figure S2). This result is not surprising since machining and welding covered the largest area of the facility. Similar Fe (36%) and other (59%) mass fractions were observed in the cutting and shot blasting area, although slight differences were

observed in Mn (3%), Ni (1%), and Cu (1%) mass fractions. We attribute these differences to the different work processes in that area.

FIGURES





Figure S2. Average metal composition of gravimetric-equivalent mass concentration stratified by sampling location obtained by field portable XRF analysis. Central location (located within the machining and welding area) filters were not included because filter type and metal analysis methods were different.



TABLES

Table S1. Summary of sensor calibration parameters to convert voltage to photometric-equivalent mass concentration measured in the laboratory and at the central location. Laboratory slopes were determined with salt aerosol, whereas others were determined in situ with factory aerosol.

	Sensor 1			Sensor 2			Sensor 3		
	Slope, mV/(mg/m ³)	Intercept, mV	N	Slope, mV/(mg/m ³)	Intercept, mV	Ν	Slope, mV/(mg/m ³)	Intercept, mV	N
Laboratory Calibration (SE)	1054 (30)	693 (4.1)	25	1189 (20)	616 (3.1)	25	971 (20)	984 (3.1)	25
Overall Field Calibration (SE)	768 (2.4)	708 (0.3)	30,826	714 (3.7)	632 (0.4)	25,270	780 (3.4)	1024 (0.4)	26,825
Mean ± SD of Weekly Field Calibrations	742 ± 140	720 ± 29	$1,\!284\pm699$	615 ± 153	646 ± 24	$1,\!148\pm764$	735 ± 168	1039 ± 37	$1,\!277\pm570$

Notes:

SE: standard error

SD: standard deviation

	Calibrati mV/(Calibration Intercepts, mV				
	Beta	p-value	\mathbb{R}^2	Beta	p-value	\mathbb{R}^2
Time, weeks						
Sensor 1	-2.6	0.325	0.05	2.1	0.001	0.44
Sensor 2	-1.6	0.617	0.01	0.6	0.308	0.06
Sensor 3	-2.5	0.411	0.04	1.8	0.039	0.23
Mean \pm SD	-2.2 ± 0.56			1.5 ± 0.79		
Weekly pDR1000 concentration, mg/m ³						
Sensor 1	-2146.8	0.007	0.31	483.6	0.036	0.20
Sensor 2	-426.8	0.703	0.01	459.1	0.013	0.29
Sensor 3	-2367.5	0.018	0.29	686.1	0.021	0.28
Mean \pm SD	-1647.0 ± 1063			542.9 ± 124.6		

Table S2. Regression results of the relationship between calibration parameters (slope and intercept) and time and average weekly photometric-equivalent mass concentration measured by the pDR1000.