Apportionment of $PM_{2.5}$ Sources across Sites and Time Periods: An Application and Update for Detroit, Michigan

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Supplemental Information

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S1. PMF background and model construction

1.1 General background

The following provides general background on PMF and receptor models. In brief, these techniques use the compositions of sources to identify and quantify the contribution of sources [1]. The chemical mass balance (CMB) model provides a solution to the apportionment problem if the source profiles are known [1,2]. This model has four assumptions: 1) compositions of sources do not change during the ambient and source sampling; 2) there is no reaction between chemical species; 3) sources of significant contributions for the receptor and their emission characteristics have been identified; 4) source profiles are linearly independent [2,3]. In the CMB model, mass concentrations of each species are considered as linear combination of emission source contributions [4]:

$$x_{ij} = \sum_{k=1}^{p} g_{ik} f_{kj} + e_{ij}$$

where, x_{ij} is the i×j dimensional data matrix of i samples and j species with uncertainties u; p denotes the number of factors; f is the number of species profile of each source; g represents the contribution of each factor to an individual sample; and e is the residual for the sample.

Another approach to solve the equation above but in the case where the source profile matrix f is unknown, uses positive matrix factorization. Again, the sample data is divided into two matrices [5]: factor contribution and factor profile. Both matrices are solved by minimizing objective function Q below:

$$Q = \sum_{i=1}^{n} \sum_{j=1}^{m} \left[\frac{x_{ij} - \sum_{k=1}^{p} g_{ik} f_{kj}}{u_{ij}} \right]^2$$

where n denotes the number of samples, m is the number of species, p is the number of sources, and x_{ij} and u_{ij} refer to the concentration and the uncertainty of each sample. Q in the formula is a critical parameter. There are two versions of Q in the PMF model provided by US EPA [6]: Q(True) and Q(robust), which differ by the approach used to calculate goodness of fit parameters, e.g., including all points or excluding points not fit by the model.

Other approaches and extensions to RM provide apportionments that can assist in locating potential source areas. The use of RM with Potential Source Contribution Function (PSCF) can indicate a potential source region contributing to a high air pollutant concentration by using trajectories of air masses over a given geographic region that contain high air pollutant concentrations as measured at a receptor [7]. The use of Concentration Weighted Trajectory (CWT) models identifies potential source areas, also using trajectory analyses to weight grid cell by the air mass residence time [8].

1.2 Model construction and application

Parameter selection and procedures for the PMF models followed recent literature. Using the signal to noise ratio (S/N), each species was characterized as 'bad', 'weak' or 'strong' for S/N<0.5, 0.5≤S/N<1, and S/N≥1, respectively [9]. For 'weak' species, uncertainties were increased 3-fold, and 'bad' species were excluded from further analysis, namely, Sb, Ba, Cd, Ce, Cs, In, Ru, Ag and Sn at all sites, additionally Co and V at DB and V at SWHS. Overall, the models used 26 species ($PM_{2.5}$, EC, OC, NH_4^+, NO_3^-, SO_4^{2-}, S, Al, Br, Ca, Cl^-, Cr, Cu, Fe, K^+, Mg, Mn, Na^+, Ni, Pb, Se, Si, Sr, Ti, Zi, and Zn). To obtain a complete dataset, missing data were replaced using the median, negative values were set to 0, and uncertainties of missing and negative values were set to four times the median concentration [10,11,12]. Values below the MDL were replaced by ½ MDL and assigned uncertainties of 5/6 MDL [9,11,12,13]. The uncertainty of values exceeding the MDL was calculated using Gaussian quadrature to propagate fixed and proportional errors, the latter assuming a fractional error of 0.1 [6,11].

Several steps were used to clean and impute data. We checked for reasonable ranges and possible outliers of each

parameter by examining the highest values. Two observations with clear outliers were removed: 2/26/19 at SWHS with greatly elevated Al levels (11.2 $\mu g/m^3$) and somewhat elevated Si but otherwise typical levels; and 7/5/20 at AP with elevated levels of Al, Ba, Mg, K, S and other species; this date was considered by the State to reflect (distant) forest fires. (Measurements at the other sites were not collected on this date.) Na^+ measurements were missing for the initial 13 months of the study period; reconstructed $PM_{2.5}$ mass (RPM) depended on these missing measurements. To impute these measurements, available Na^+ data was regressed on Na ($Na^+ \approx 3.45$ Na, R^2=0.49), and missing values were replaced with predictions. Next, FRM $PM_{2.5}$ measurements at each site were compared using scatterplots, ratios and other statistics to the RPM derived from elemental and ion measurements, which showed discrepancies for a number of observations (see the supplemental information for Figure S1, Table S1). Recognizing that relative error increases at low concentrations, several rules were used to identify and ultimately remove discordant observations: FRM<1 $\mu g/m^3$ with RPM>4 $\mu g/m^3$ or vice-versa (5 cases: 02/10/18, 09/12/20, 01/25/20 and 06/04/18 at AP; 09/10/17 at DB); FRM from 5–10 $\mu g/m^3$ with relative deviation between FRM and RPM >75% (4 cases: 12/17/19, 01/22/20, and 06/19/18 at AP; 06/17/16 at SWHS), and FRM>10 $\mu g/m^3$ with relative deviation above 50% (20 cases: 06/27/17, 12/01/18, 02/23/19, 10/17/18, 06/12/17, 01/18/19, 06/24/17, 06/30/19, 02/14/19, 09/02/19, 11/02/19 and 07/29/19 at AP; 08/11/17, 11/17/19 and 09/20/19 at SWHS; and 06/11/16, 03/07/16, 10/22/17, and 05/26/18 at DB). The PMF analyses used Na^+, K^+, and Cl^- instead of Na, K and Cl since they have a higher level of precision in analysis [15]. Species with detection frequencies below 25% of the method detection limit (MDL; [16]) were removed: As and P at all sites; Co and V at AP; and Co at SWHS. The number of daily observations in the final dataset was 693, 353 and 347 at AP, DB and SWHS, respectively.

S2. Pandemic related changes in pollutant levels, trends and apportionments.

This section extends the discussion of pandemic related effects. The discussion of the PMF profiles is limited to changes in profiles for approach 1. Approach 2A and 3 pool data across the time periods and therefore do not have experience shifts in the profiles (except between sites in approach 3). Approach 1 results are based on a smaller sample sizes, and the PMF models apply to a single year at each site. These factors limit comparability, although it is interesting to see the evolution of the profile.

At AP, decreases in annual average and median $PM_{2.5}$ levels during the pandemic appeared large (~1.5 $\mu g/m^3$), but were not statistically significant. In addition to the decrease in EC levels, statistically significant decreases occurred for Ca, Fe and Mg, possibly reflecting less entrained soil due to diminished traffic and construction. Cu also decreased significantly, although levels were low and the monthly pattern was inconsistent. PMF profiles across the two periods were similar for non-ferrous metals, road salt, secondary nitrate and secondary sulfate profiles, but difference for ferrous metals (more Cr and Ni during the pandemic), mobile sources (more Al; less Pb, Zi), and secondary sulfate (more $NH4^+$, S; less Cr, Ni, K^+). While the dominant markers for each source type, the general pattern for other species, and the three top contributors (mobile, secondary sulfate and secondary nitrate) were unchanged across pre- and pandemic periods, the PMF models show large decreases (>0.5 ug/m^3) from mobile sources and ferrous metals, and increases from salt increased.

At DB, annual average $PM_{2.5}$ levels increased during the pandemic, but medians decreased; these changes were not statistically significant. In addition to lower EC levels, statistically significant decreases occurred at DB for Sb, Ca, Cu, Mn, Ru, Sn, Ti and Zn. The monthly plots suggest that Cu, Fe, Mn, Si and Zn fell in the ~6 months of the pandemic, possibly reflecting a slowdown in ferrous and non-ferrous metals production and processing. The density plots suggest shifts in distributions to lower values during the pandemic for EC, NH4+, Sb, Pb, Sn, Ti and Zi; they also suggest (by extended right hand tails) higher peak values of $PM_{2.5}$, SO_4^{2-}, S, Na^+ and Cl^- during the pandemic. The PMF profiles showed changes for most sources, e.g., mobile sources (less Mg, S, SO_4^{2-}; more Zi, Cr, EC in the pandemic period), secondary sulfate (more Mg, Ti, Zn, K^+, NH_4^+, S, SO_4^{2-}; less Zi, Cr), secondary nitrate (more Zn, K^+), ferrous metals (more Fe, Ni; less Mn, Zn, Na^+, K^+), soil/dust (more Sr, Al, Na^+), non-ferrous metals (more Cr; less Ni, Pb Sr), and salt (more Na^+). These changes increased the apportionment of secondary nitrate and soil/dust; changes in other source contributions were small.

At SWHS, mean and median $PM_{2.5}$ levels appeared to fall during the pandemic, but again, these changes were not

significant. In addition to EC and OC, mean and/or median levels of NO_3^-, Fe, Cl^-, Mn, K+ and Zn dropped during the pandemic, while levels of Ca, Cu, Si and Sr increased. The density plots suggest pandemic-related decreases in Pb and increases in Sb. The divergence in trends at SWHW suggests the influence of multiple source types, specifically, lower contributions of soil/dust (typically containing Ca, Si, Fe) during the pandemic, and higher contributions from ferrous metals sources (Fe). This was reflected in the PMF results which showed differences in the profiles including secondary sulfate (more Zi, Br, Na^+, NH_4^+, S, SO_4^{2-}), secondary nitrate (less NH_4^+), mobile (more Si, Cr, Zi, Na^+), non-ferrous metals (less Cu, Cr; more Pb), soil/dust (more Al, Ca, Mg, Mn, Se, Ti), ferrous metals (more Fe; less Al, Ti). Despite these many changes, the only large changes in the apportionments were decreases in ferrous metals and increases in nonferrous metals.

Overall, the lower EC levels at the three sites suggested reduced traffic; the change at the SWHS site also may reflect diminished construction activity (e.g., non-road diesel sources). However, the PMF models did not show meaningful drops in mobile source levels at DB and AP. Across the three sites, sulfate and nitrate had mostly small differences, probably because these secondary pollutants arise mostly from regional sources (e.g., coal-fired power plants) that were largely unchanged during the pandemic lock-down period. Several sources with smaller contributions in the PMF models showed larger changes, as noted above and in the text,. Changes could reflect actual pandemic-induced changes, or just typical annual fluctuations due to variability in meteorology and emissions. Overall in southwest Detroit, changes in pollutant levels were small and few were statistically significant and consistent across sites.

S3. Supplemental figures and tables

Table S1. Summary statistics for reconstructed and measured $PM_{2.5}$ concentrations.
$PM_{2.5}$ measured using federal reference method 88101, and method 88502 at the three monitoring sites ($\mu g/m^3$); Allen Park from Jan 1, 2016, to May 31, 2021, Dearborn, and Southwestern High School from Jan 1, 2016, to May 28, 2021, based on 24-hour average concentrations.

Sites	Variables	N	Mean	SD	Min	25th	50th	75th	Max
Allen Park	Reconstructed	395	7.25	4.1	1.75	4.45	6.16	8.89	27.04
	88101	1303	8.74	4.65	0.2	5.5	7.8	10.9	41.9
	88502	1125	8.81	3.45	2	6	8	10	39
Dearborn	Reconstructed	200	8.83	4.82	2.04	5.52	7.84	11.05	29.9
	88101	1053	9.65	5.04	1.2	6.2	8.8	11.9	38.3
	88502	1292	9.71	3.89	3	7	9	12	39
Southwestern High School	Reconstructed	196	9.86	5.48	2.1	6.05	8.96	12.6	44.63
	88101	575	10.37	5.56	1.3	6.4	9.2	13.3	45.2

Figure S1. Scatterplots of reconstructed versus measured $PM_{2.5}$ concentrations.
FRM measurements use methods 88101 and 88502, as available.

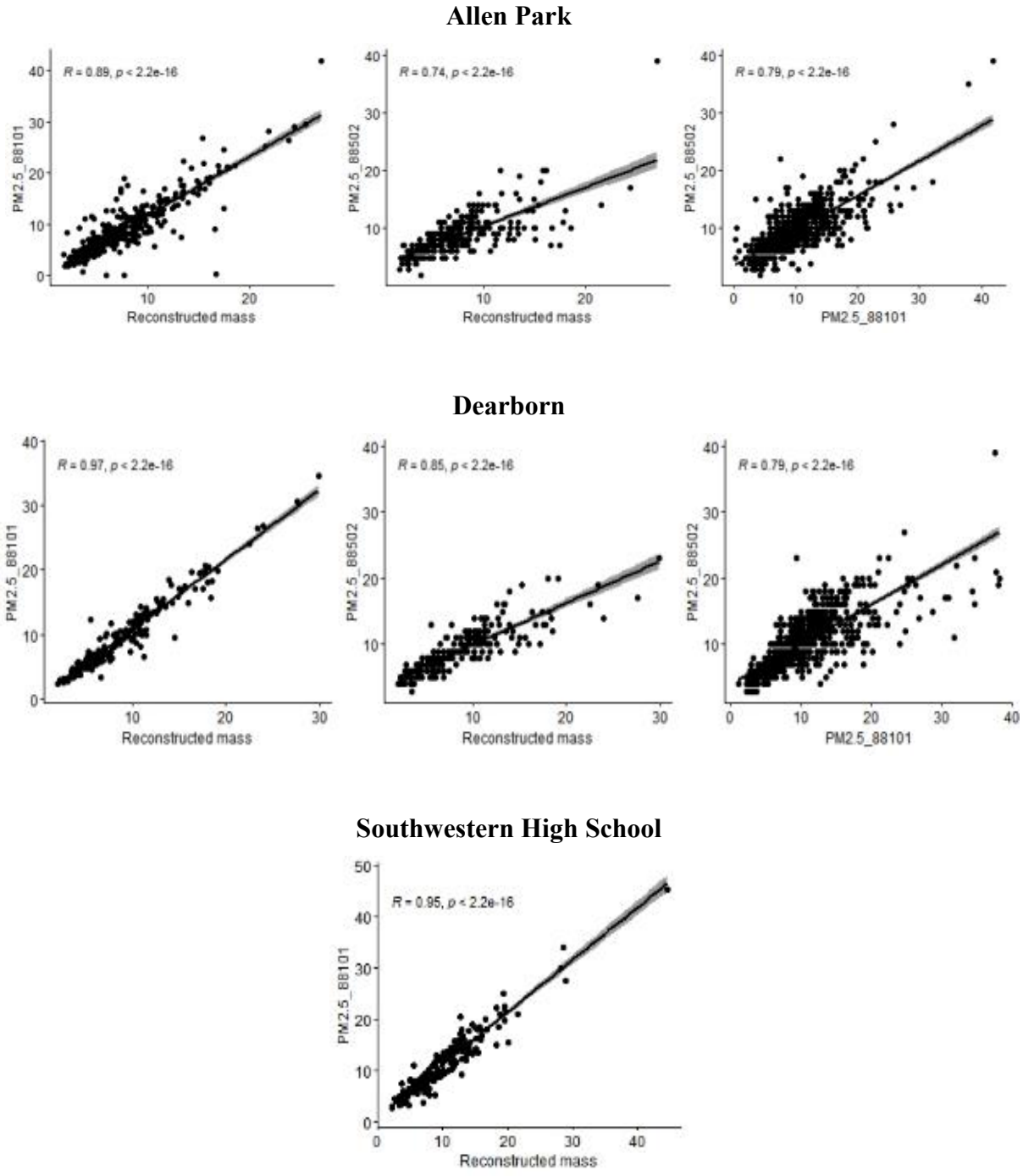


Table S2. Summary statistics of $PM_{2.5}$ and other species at the three monitoring sites ($\mu g/m^3$).
Allen Park, Dearborn, and Southwestern High School from Jan. 1, 2016, to Dec. 31, 2021. Based on 24-hour average concentrations. Excludes for species with detection frequencies below 25% (of the MDL). Continued on 2 pages.

Site	Variable	Mean	SD	Min	25th	Median	75th	Max
Allen Park (N=693)	Al	0.02	0.04	-0.05	0.00	0.02	0.04	0.45
	NH_4^+	0.51	0.61	0.00	0.12	0.30	0.66	4.17
	Sb	0.00	0.01	-0.03	-0.01	0.00	0.01	0.06
	Ba	0.01	0.03	-0.07	-0.01	0.01	0.02	0.12
	Br	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	Cd	0.00	0.01	-0.01	0.00	0.00	0.01	0.03
	Ca	0.07	0.07	0.00	0.03	0.05	0.08	0.60
	Ce	0.00	0.03	-0.07	-0.02	0.00	0.02	0.13
	Cl^-	0.08	0.19	-0.02	0.02	0.04	0.09	4.13
	Cs	0.00	0.02	-0.05	-0.01	0.00	0.02	0.09
	Cr	0.00	0.01	0.00	0.00	0.00	0.00	0.21
	Cu	0.01	0.01	-0.01	0.00	0.00	0.01	0.08
	EC	0.37	0.22	0.00	0.22	0.32	0.45	2.25
	In	0.00	0.01	-0.02	-0.01	0.00	0.01	0.05
	Fe	0.09	0.07	-0.02	0.05	0.07	0.11	0.78
	Pb	0.00	0.01	-0.01	0.00	0.00	0.01	0.03
	Mg	0.01	0.03	-0.02	0.00	0.01	0.03	0.21
	Mn	0.00	0.00	-0.01	0.00	0.00	0.00	0.01
	Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	OC	1.91	1.11	0.27	1.09	1.70	2.48	10.54
	K^+	0.04	0.07	0.00	0.01	0.02	0.04	1.39
	Ru	0.00	0.00	-0.01	0.00	0.00	0.00	0.01
	Se	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Si	0.06	0.07	-0.03	0.02	0.05	0.08	0.86
	Ag	0.00	0.01	-0.02	-0.01	0.00	0.01	0.03
	Na^+	0.04	0.11	-0.01	0.01	0.02	0.04	2.56
	Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	SO_4^{2-}	1.03	0.64	0.00	0.58	0.88	1.31	4.75
	S	0.38	0.24	0.00	0.21	0.33	0.49	1.67
	Sn	0.00	0.01	-0.03	-0.01	0.00	0.01	0.06
	Ti	0.00	0.00	0.00	0.00	0.00	0.01	0.03
	NO_3^-	1.50	1.89	-0.03	0.35	0.77	1.86	12.36
	Zn	0.02	0.01	0.00	0.01	0.01	0.02	0.15
	Zi	0.00	0.01	-0.03	-0.01	0.00	0.01	0.04
	$PM_{2.5}$	8.63	4.75	1.20	5.16	7.64	11.01	32.10
Dearborn (N=353)	Al	0.03	0.04	-0.04	0.00	0.02	0.05	0.28
	NH_4^+	0.58	0.61	0.00	0.16	0.40	0.75	4.02
	Sb	0.00	0.01	-0.03	-0.01	0.00	0.01	0.06
	Ba	0.01	0.03	-0.07	-0.01	0.00	0.03	0.12
	Br	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	Cd	0.00	0.01	-0.02	0.00	0.00	0.01	0.03
	Ca	0.13	0.15	0.00	0.05	0.09	0.14	1.48
	Ce	0.01	0.03	-0.08	-0.01	0.01	0.03	0.12
	Cl^-	0.18	0.22	-0.01	0.04	0.11	0.23	2.56
	Cs	0.00	0.02	-0.05	-0.01	0.00	0.01	0.09
	Cr	0.00	0.01	0.00	0.00	0.00	0.00	0.12
	Co	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Cu	0.02	0.02	0.00	0.01	0.01	0.02	0.10
	EC	0.51	0.30	0.00	0.30	0.46	0.65	1.72
	In	0.00	0.01	-0.03	-0.01	0.00	0.01	0.03
	Fe	0.33	0.36	0.00	0.10	0.21	0.41	3.29
	Pb	0.01	0.01	-0.01	0.00	0.00	0.01	0.12

	Mg	0.03	0.04	-0.02	0.00	0.02	0.04	0.27
	Mn	0.01	0.01	-0.01	0.00	0.01	0.01	0.05
	Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	OC	2.27	1.13	0.35	1.41	2.09	2.85	6.03
	K^+	0.05	0.06	0.00	0.02	0.03	0.06	0.74
	Ru	0.00	0.00	-0.01	0.00	0.00	0.00	0.01
	Se	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Si	0.08	0.09	-0.02	0.03	0.06	0.10	0.98
	Ag	0.00	0.01	-0.02	-0.01	0.00	0.01	0.02
	Na^+	0.05	0.06	0.00	0.02	0.03	0.07	0.31
	Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	SO_4^{2-}	1.24	0.71	0.01	0.66	1.10	1.70	3.63
	S	0.45	0.27	0.00	0.23	0.39	0.66	1.39
	Sn	0.00	0.01	-0.03	-0.01	0.00	0.01	0.06
	Ti	0.00	0.00	0.00	0.00	0.00	0.01	0.04
	NO_3^-	1.58	1.89	0.00	0.41	0.81	1.98	12.33
	V	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	Zn	0.06	0.08	0.00	0.01	0.03	0.07	0.65
	Zi	0.00	0.01	-0.03	-0.01	0.00	0.01	0.04
	$PM_{2.5}$	9.88	5.37	1.15	5.85	9.25	13.00	34.65
Southwestern High School (N=347)	Al	0.07	0.20	-0.04	0.01	0.03	0.06	2.62
	NH_4^+	0.59	0.68	0.00	0.12	0.37	0.79	4.71
	Sb	0.00	0.01	-0.03	-0.01	0.00	0.01	0.05
	Ba	0.00	0.02	-0.06	-0.01	0.00	0.02	0.11
	Br	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	Cd	0.00	0.01	-0.01	0.00	0.00	0.01	0.03
	Ca	0.16	0.22	0.00	0.05	0.09	0.18	1.87
	Ce	0.00	0.03	-0.06	-0.02	0.00	0.02	0.11
	Cl^-	0.20	0.26	-0.01	0.04	0.10	0.24	2.21
	Cs	0.00	0.02	-0.05	-0.01	0.00	0.01	0.09
	Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	Cu	0.01	0.01	0.00	0.01	0.01	0.01	0.07
	EC	0.61	0.41	0.04	0.33	0.50	0.77	3.21
	In	0.00	0.01	-0.03	-0.01	0.00	0.01	0.03
	Fe	0.17	0.16	0.01	0.08	0.11	0.21	0.89
	Pb	0.01	0.01	-0.01	0.00	0.00	0.01	0.04
	Mg	0.03	0.06	-0.02	0.00	0.01	0.04	0.88
	Mn	0.01	0.01	0.00	0.00	0.00	0.01	0.03
	Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	OC	2.42	1.23	0.36	1.49	2.19	3.10	8.41
	K^+	0.08	0.18	0.00	0.02	0.03	0.07	2.49
	Ru	0.00	0.00	-0.01	0.00	0.00	0.00	0.01
	Se	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Si	0.11	0.13	-0.01	0.04	0.07	0.14	0.92
	Ag	0.00	0.01	-0.02	-0.01	0.00	0.01	0.03
	Na^+	0.04	0.06	-0.01	0.01	0.03	0.06	0.63
	Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	SO_4^{2-}	1.31	0.83	0.00	0.69	1.11	1.81	4.06
	S	0.46	0.29	0.00	0.23	0.41	0.64	1.45
	Sn	0.00	0.01	-0.03	-0.01	0.00	0.01	0.08
	Ti	0.01	0.02	-0.01	0.00	0.00	0.01	0.31
	NO_3^-	1.62	1.91	0.03	0.45	0.85	1.92	11.98
	V	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Zn	0.03	0.04	0.00	0.01	0.02	0.03	0.46
	Zi	0.00	0.01	-0.03	-0.01	0.00	0.01	0.05
	$PM_{2.5}$	10.83	5.48	1.30	6.55	10.00	13.95	33.86

SD: standard deviation; Min: minimum; 25th: 25th percentile; 75th: 75th percentile; Max: maximum.

Table S3. Comparisons between pairs of sites for concentrations of $PM_{2.5}$ and other species.

Sites	Pollutants	Unpaired t-test		Mann-Whitney U test	
		T	p value	W	p value
Allen Park versus Dearborn	$PM_{2.5}$	-3.72	<0.01*	103499	<0.01*
	EC	-7.76	<0.01*	79609	<0.01*
	OC	-4.74	<0.01*	93280	<0.01*
	NH_4^+	-1.57	0.12	110283	0.02
	NO_3^-	-0.68	0.50	114861	0.20
	SO_4^{2-}	-4.72	<0.01*	99305	<0.01*
	S	-3.99	<0.01*	104496	<0.01*
Allen Park versus Southwestern High School	$PM_{2.5}$	-6.36	<0.01*	88194	<0.01*
	EC	-9.85	<0.01*	66265	<0.01*
	OC	-6.38	<0.01*	85211	<0.01*
	NH_4^+	-1.69	0.09	111415	0.09
	NO_3^-	-0.98	0.33	110136	0.05*
	SO_4^{2-}	-5.59	<0.01*	96016	<0.01*
	S	-4.44	<0.01*	101804	<0.01*
Dearborn versus Southwestern High School	$PM_{2.5}$	-2.28	0.02*	53329	0.01
	EC	-3.46	<0.01*	50731	<0.01*
	OC	-1.69	0.09	53746	0.10
	NH_4^+	-0.20	0.84	62224	0.67
	NO_3^-	-0.27	0.79	59400	0.53
	SO_4^{2-}	-1.21	0.23	59604	0.58
	S	-0.60	0.55	60653	0.82

*: P<=0.05, significant

Table S4. Concentrations at the three sites for one-year periods before and during the pandemic.
Sample size: 116, 61 and 58 at AP, DB, SWHS before the pandemic, respectively, and 117, 60 and 58 during the pandemic. * denotes statistical significance with P≤0.05. Highlights show increases (pink) and decreases (blue).
Continued on 3 pages.

Site	Pollutant	Mean (μg/m^3)		Median (μg/m^3)		Unpaired t-test		Mann-Whitney U test	
		Before	During	Before	During	t	p value	W	P-value
Allen Park	$PM_{2.5}$	8.275	8.105	6.850	6.710	0.26	0.80	6330.5	0.38
	EC	0.440	0.421	0.402	0.318	0.55	0.58	5668.5	**0.04***
	OC	1.768	1.863	1.568	1.577	-0.68	0.50	6678	0.92
	NH_4^+	0.526	0.580	0.300	0.295	-0.61	0.54	6908	0.73
	NO_3^-	1.571	1.643	0.845	0.735	-0.27	0.79	6690	0.94
	SO_4^{2-}	0.887	1.012	0.730	0.885	-1.62	0.11	7486.5	0.14
	S	0.323	0.357	0.273	0.301	-1.22	0.22	7173	0.45
	Al	0.021	0.020	0.018	0.016	0.25	0.80	6825	0.94
	Sb	0.001	0.003	0.001	0.003	-1.37	0.17	7537.5	0.14
	Ba	0.005	0.006	0.004	0.006	-0.29	0.77	6899	0.83
	BC	0.481	0.308	0.421	0.213	4.23	**<0.01***	3950	**<0.01***
	Br	0.000	0.001	0.000	0.000	-0.30	0.77	7291	0.15
	Cd	0.002	0.002	0.001	0.001	0.21	0.83	6714.5	0.89
	Ca	0.090	0.057	0.055	0.041	3.16	**<0.01***	5331.5	**<0.01***
	Ce	0.001	0.000	-0.003	-0.002	0.56	0.57	6663	0.81
	Cl^-	0.102	0.090	0.048	0.047	0.73	0.47	6157.5	0.22
	Cs	0.002	0.002	-0.001	0.002	-0.02	0.98	6945	0.76
	Cr	0.002	0.002	0.001	0.001	1.02	0.31	6747.5	0.94
	Cu	0.007	0.004	0.004	0.002	2.59	**0.01***	5487.5	**0.01***
	In	0.001	0.003	0.000	0.003	-1.20	0.23	7643.5	0.10
	Fe	0.097	0.067	0.080	0.058	3.88	**<0.01***	5077	**<0.01***
	Pb	0.003	0.003	0.002	0.003	-0.98	0.33	7627	0.10
	Mg	0.021	0.011	0.017	0.000	3.20	**<0.01***	4929	**<0.01***
	Mn	0.003	0.002	0.002	0.002	2.05	**0.04***	5945.5	0.10
	Ni	0.001	0.001	0.001	0.001	0.67	0.50	6681.5	0.83
	K^+	0.035	0.044	0.030	0.030	-1.14	0.26	7406	0.18
	Ru	0.000	0.000	0.000	0.000	-1.28	0.20	7440.5	0.20
	Se	0.001	0.001	0.000	0.001	0.09	0.93	6994.5	0.68
	Si	0.074	0.056	0.044	0.042	1.90	0.06	6364	0.41
	Ag	0.001	0.001	0.000	0.000	-0.27	0.79	6933	0.78
	Na^+	0.035	0.027	0.020	0.020	1.20	0.23	6361	0.46
	Sr	0.001	0.001	0.001	0.001	-1.21	0.23	7219	0.39
	Sn	0.002	0.002	0.001	0.001	-0.03	0.98	6862.5	0.88
	Ti	0.003	0.003	0.003	0.003	1.33	0.18	6398	0.45
	Zn	0.016	0.014	0.013	0.012	1.44	0.15	6165	0.23
	Zi	0.001	0.002	0.001	0.001	-0.16	0.87	6797	0.98
Dearborn	$PM_{2.5}$	8.618	9.123	7.950	7.350	-0.54	0.59	1827.5	0.76
	EC	0.572	0.497	0.502	0.432	1.41	0.16	1433	**0.05***
	OC	2.035	2.045	2.065	1.864	-0.06	0.95	1725	0.70
	NH_4^+	0.564	0.606	0.380	0.300	-0.33	0.74	1665	0.39
	NO_3^-	1.509	1.580	0.800	0.575	-0.19	0.85	1635	0.31
	SO_4^{2-}	1.073	1.168	0.920	1.000	-0.81	0.42	1881.5	0.79
	S	0.382	0.400	0.328	0.317	-0.42	0.68	1819.5	0.96

	Al	0.028	0.024	0.023	0.018	0.53	0.60	1816	0.94
	Sb	0.004	0.001	0.005	0.001	2.01	**0.05***	1431	**0.04***
	Ba	0.006	0.005	0.002	0.001	0.40	0.69	1774	0.77
	BC	0.778	0.870	0.756	0.721	-1.08	0.28	1835	0.85
	Br	0.001	0.001	0.000	0.000	-0.23	0.82	1839	0.96
	Cd	0.001	0.001	0.000	-0.001	-0.08	0.93	1820	0.96
	Ca	0.155	0.091	0.100	0.068	2.54	**0.01***	1295	**<0.01***
	Ce	0.007	0.003	0.006	0.002	0.82	0.41	1696	0.49
	Cl^-	0.226	0.174	0.149	0.107	1.01	0.31	1633	0.31
	Cs	0.001	-0.001	0.000	0.002	0.78	0.43	1698	0.50
	Cr	0.002	0.005	0.001	0.002	-1.28	0.21	1792.5	0.97
	Co	0.000	0.000	0.000	0.000	0.88	0.38	1619	0.32
	Cu	0.026	0.014	0.020	0.009	4.00	**<0.01***	974.5	**<0.01***
	In	0.002	0.000	0.001	0.000	1.51	0.13	1530.5	0.12
	Fe	0.353	0.303	0.290	0.129	0.63	0.53	1273	**<0.01***
	Pb	0.006	0.006	0.005	0.002	-0.04	0.97	1490.5	0.08
	Mg	0.034	0.023	0.019	0.016	1.35	0.18	1559.5	0.16
	Mn	0.010	0.005	0.007	0.004	3.25	**<0.01***	1280.5	**<0.01***
	Ni	0.001	0.003	0.001	0.001	-1.28	0.20	1999	0.28
	K^+	0.043	0.049	0.030	0.030	-0.73	0.47	1909.5	0.68
	Ru	0.001	0.000	0.000	0.000	2.03	**0.04***	1548.5	0.14
	Se	0.001	0.001	0.001	0.001	1.84	0.07	1541	0.13
	Si	0.091	0.064	0.056	0.050	1.68	0.10	1609.5	0.25
	Ag	0.001	0.003	0.000	0.002	-1.52	0.13	2057.5	0.24
	Na^+	0.047	0.054	0.030	0.030	-0.67	0.51	1936	0.58
	Sr	0.001	0.001	0.000	0.000	0.88	0.38	1842	0.95
	Sn	0.004	-0.001	0.003	-0.004	2.39	**0.02***	1417	**0.03***
	Ti	0.005	0.002	0.003	0.002	2.83	**0.01***	1335	**<0.01***
	V	0.000	0.001	0.000	0.000	-1.41	0.16	2010.5	0.19
	Zn	0.068	0.036	0.032	0.014	2.03	**0.04***	1195.5	**<0.01***
	Zi	0.001	0.000	0.000	-0.001	0.56	0.57	1670	0.41
	$PM_{2.5}$	10.449	9.857	9.274	8.334	0.59	0.55	1462.5	0.23
	EC	0.692	0.533	0.573	0.478	2.69	**<0.01***	1016.5	**<0.01***
	OC	2.789	2.095	2.492	1.837	3.21	**<0.01***	973	**<0.01***
	NH_4^+	0.583	0.606	0.415	0.305	-0.17	0.86	1491.5	0.29
	NO_3^-	1.653	1.503	1.065	0.570	0.40	0.69	1129.5	**<0.01***
	SO_4^{2-}	1.194	1.192	0.885	1.000	0.02	0.99	1695	0.95
	S	0.408	0.429	0.299	0.352	-0.43	0.67	1759	0.67
South-West High School	Al	0.077	0.041	0.033	0.031	1.59	0.12	1706	0.90
	Sb	0.002	0.005	0.000	0.004	-1.69	0.09	1985	0.09
	Ba	0.006	0.006	0.004	0.007	0.13	0.90	1704	0.91
	BC	0.771	0.887	0.726	0.723	-1.31	0.19	1746	0.60
	Br	0.001	0.001	0.000	0.000	0.06	0.96	1762.5	0.60
	Cd	0.002	0.002	0.000	0.000	0.03	0.97	1700	0.92
	Ca	0.102	0.213	0.072	0.093	-2.30	**0.02***	1872	0.30
	Ce	-0.002	-0.003	-0.004	0.000	0.32	0.75	1667	0.94
	Cl^-	0.237	0.178	0.128	0.075	1.21	0.23	1317	**0.04***
	Cs	0.001	0.003	0.000	0.001	-0.63	0.53	1775	0.61
	Cr	0.001	0.002	0.001	0.001	-0.96	0.34	1694	0.95

Cu	0.008	0.013	0.008	0.013	-3.18	<**0.01***	2310	<**0.01***
In	0.001	0.002	0.000	0.002	-0.36	0.72	1794.5	0.54
Fe	0.180	0.126	0.140	0.084	2.25	**0.03***	1141	<**0.01***
Pb	0.004	0.004	0.005	0.003	0.20	0.84	1568.5	0.53
Mg	0.020	0.023	0.000	0.009	-0.45	0.65	1758.5	0.67
Mn	0.005	0.004	0.004	0.003	1.33	0.18	1300	**0.03***
Ni	0.001	0.001	0.000	0.000	-0.27	0.79	1705.5	0.89
K^+	0.124	0.040	0.040	0.030	1.77	0.08	1314.5	**0.04***
Ru	0.000	0.000	0.000	0.000	0.18	0.86	1653.5	0.88
Se	0.001	0.001	0.001	0.001	0.60	0.55	1605	0.67
Si	0.080	0.135	0.059	0.071	-2.09	**0.04***	1972.5	0.11
Ag	0.001	0.001	0.000	0.000	-0.14	0.89	1693.5	0.95
Na^+	0.033	0.036	0.030	0.020	-0.39	0.70	1646	0.84
Sr	0.001	0.002	0.000	0.001	-2.32	**0.02***	2012	0.07
Sn	0.001	0.001	0.001	0.001	-0.25	0.80	1730	0.79
Ti	0.016	0.004	0.004	0.002	1.95	0.06	1372.5	0.09
V	0.001	0.000	0.000	0.000	0.71	0.48	1804.5	0.41
Zn	0.029	0.020	0.023	0.015	2.40	**0.02***	1268	**0.02***
Zi	0.001	0.001	0.000	0.000	-0.02	0.98	1707	0.89

Figure S2. Trends of monthly median levels of selected species for 1-year pre-pandemic and pandemic periods at Allen Park.

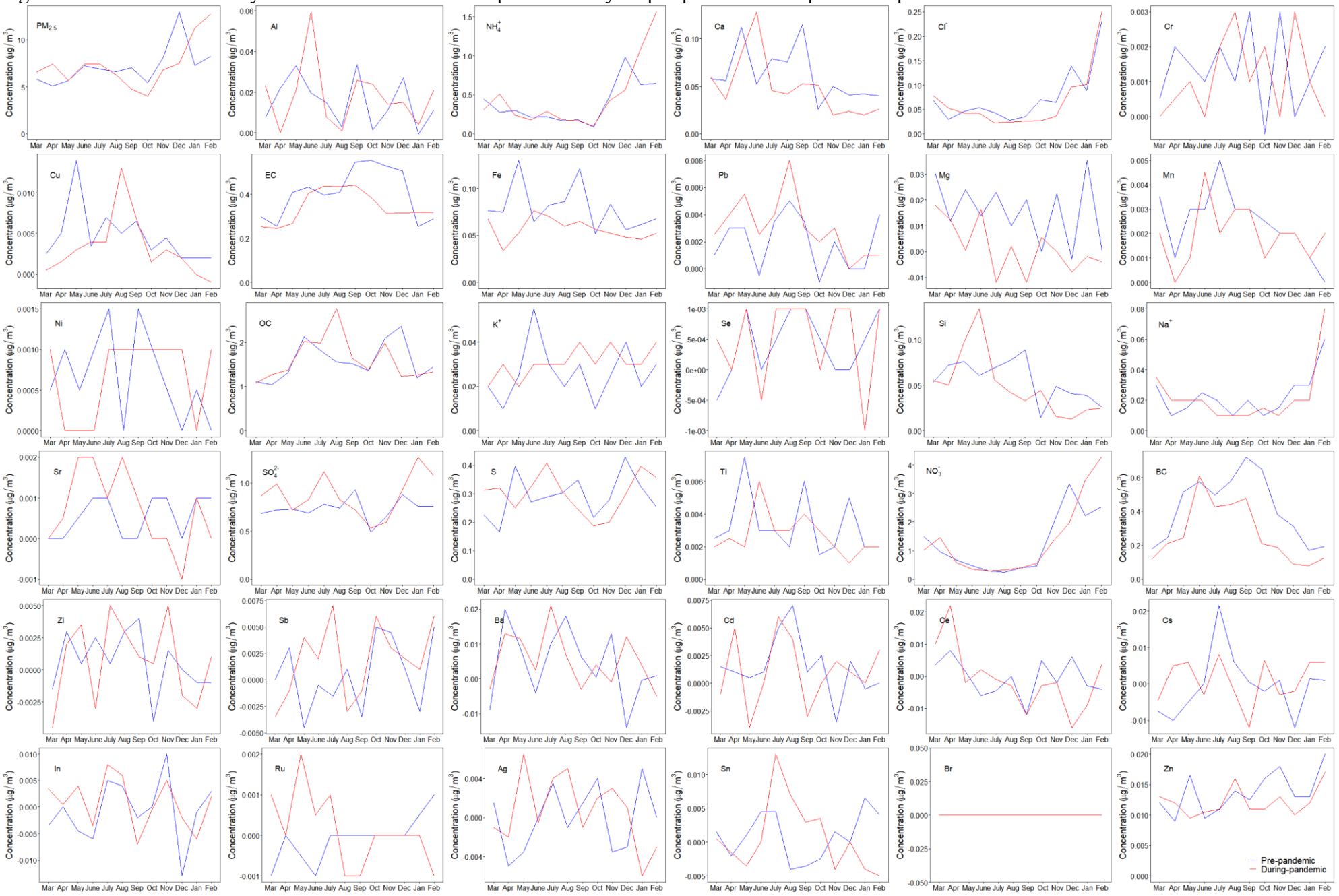


Figure S3. Trends of monthly median concentrations selected species for 1-year pre-pandemic and pandemic periods at Dearborn.

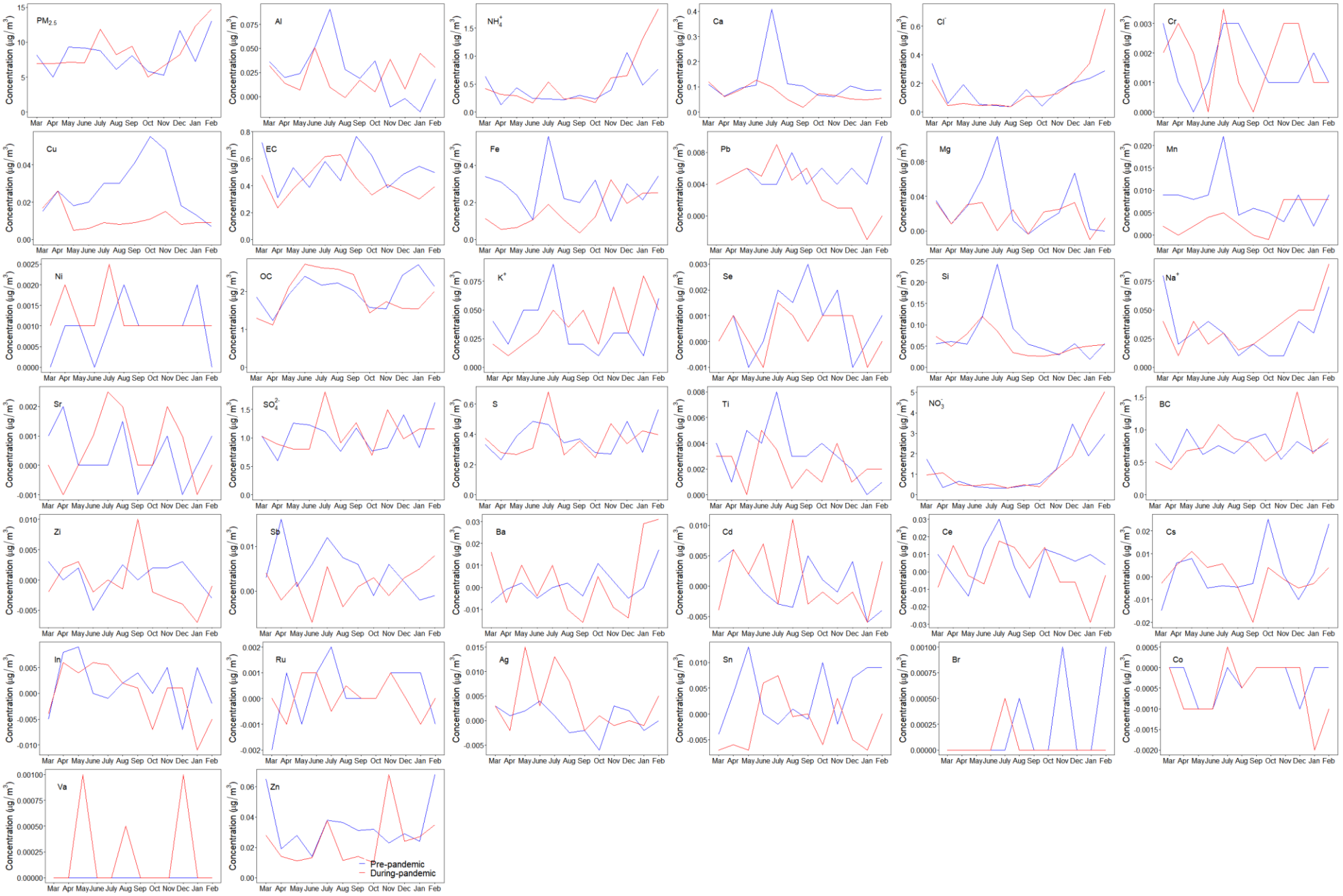


Figure S4. Trends of monthly median concentrations for selected species for 1-year pre-pandemic and pandemic periods at SWHS.

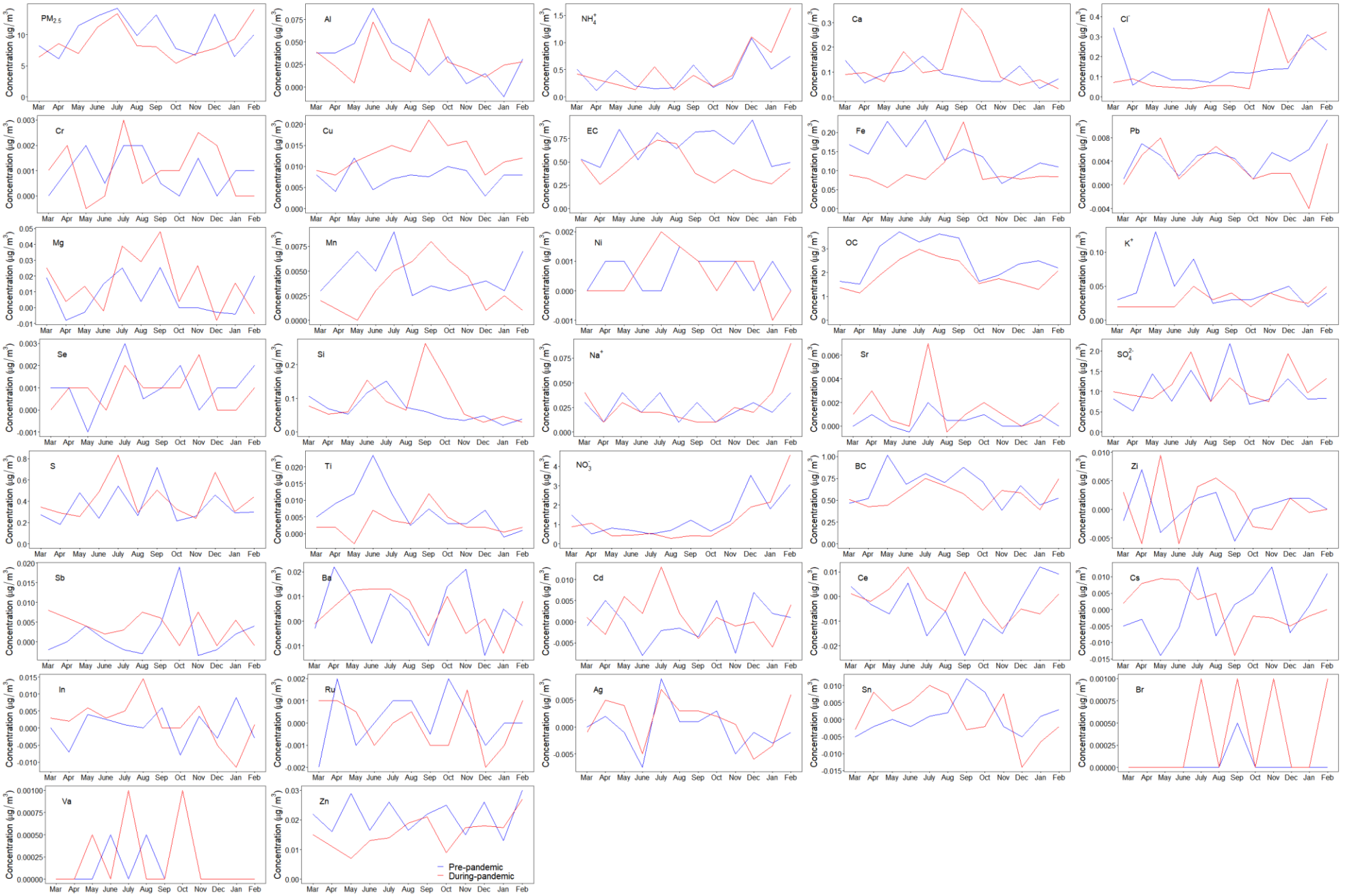
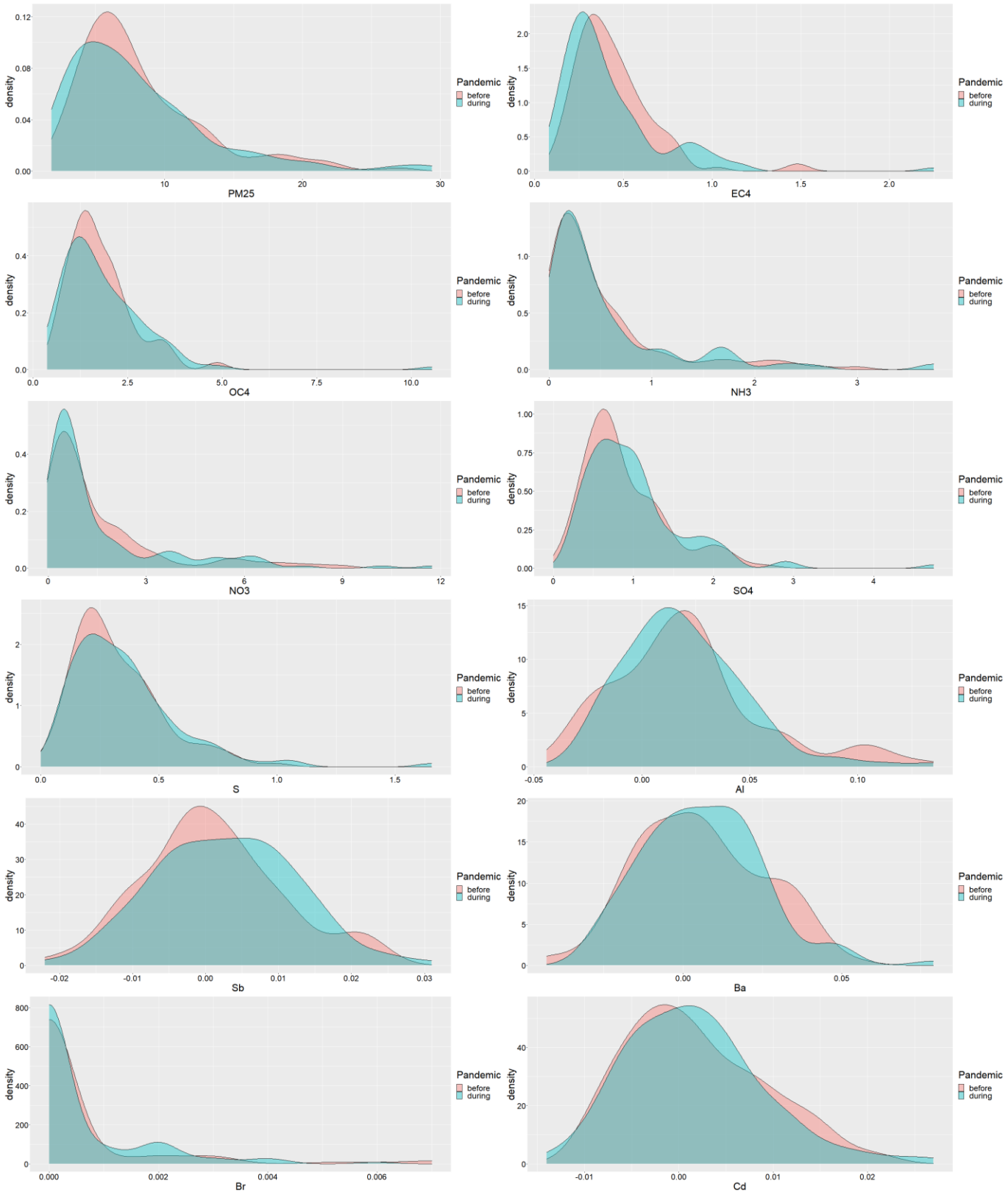
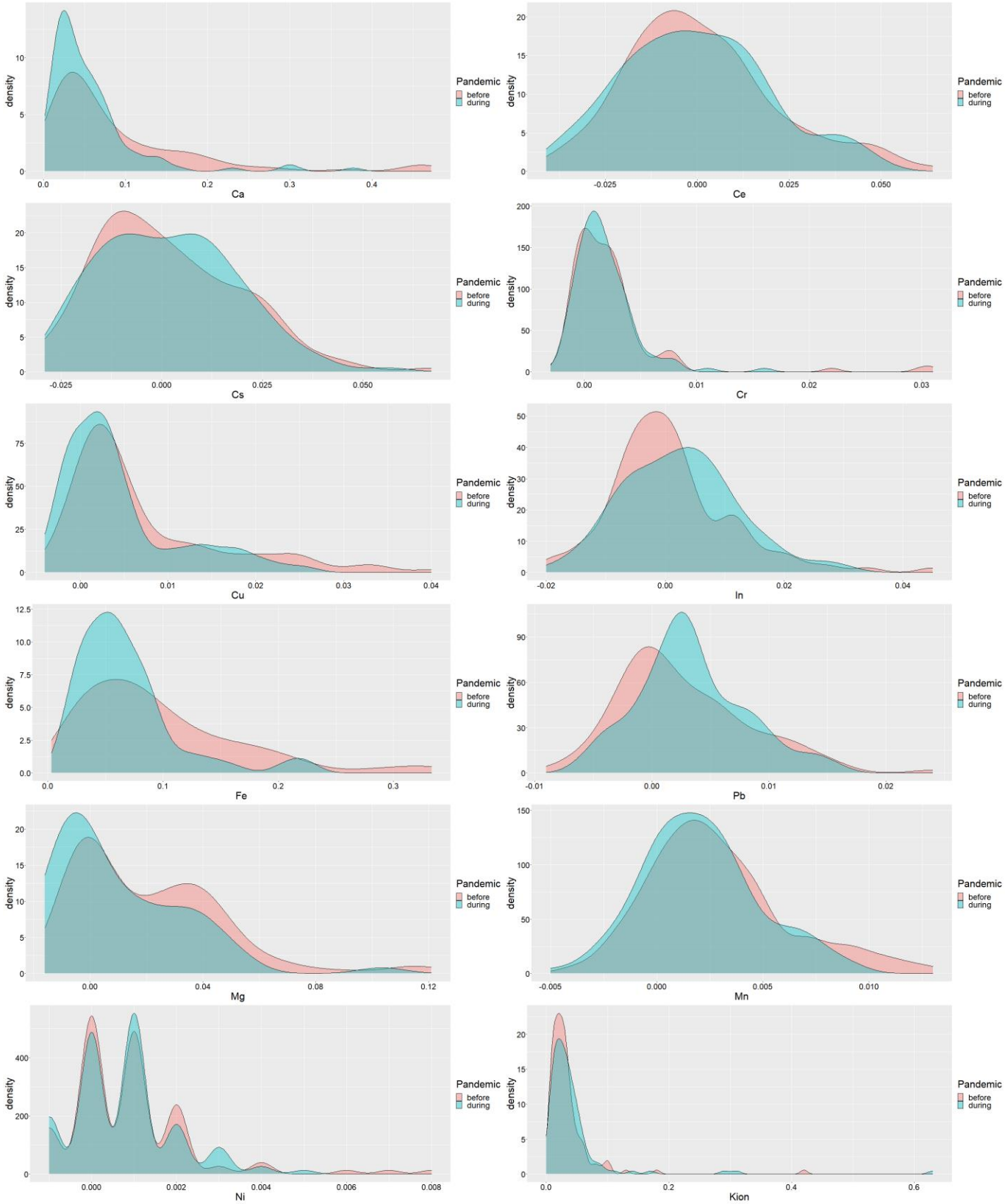


Figure S5. Density plots comparing before and during the pandemic periods for selected species at Allen Park. Continued across 3 pages.




density
Ca
Ce
Cs
Cr
Cu
In
Fe
Pb
Mg
Mn
Ni
Kion
Pandemic
before
during

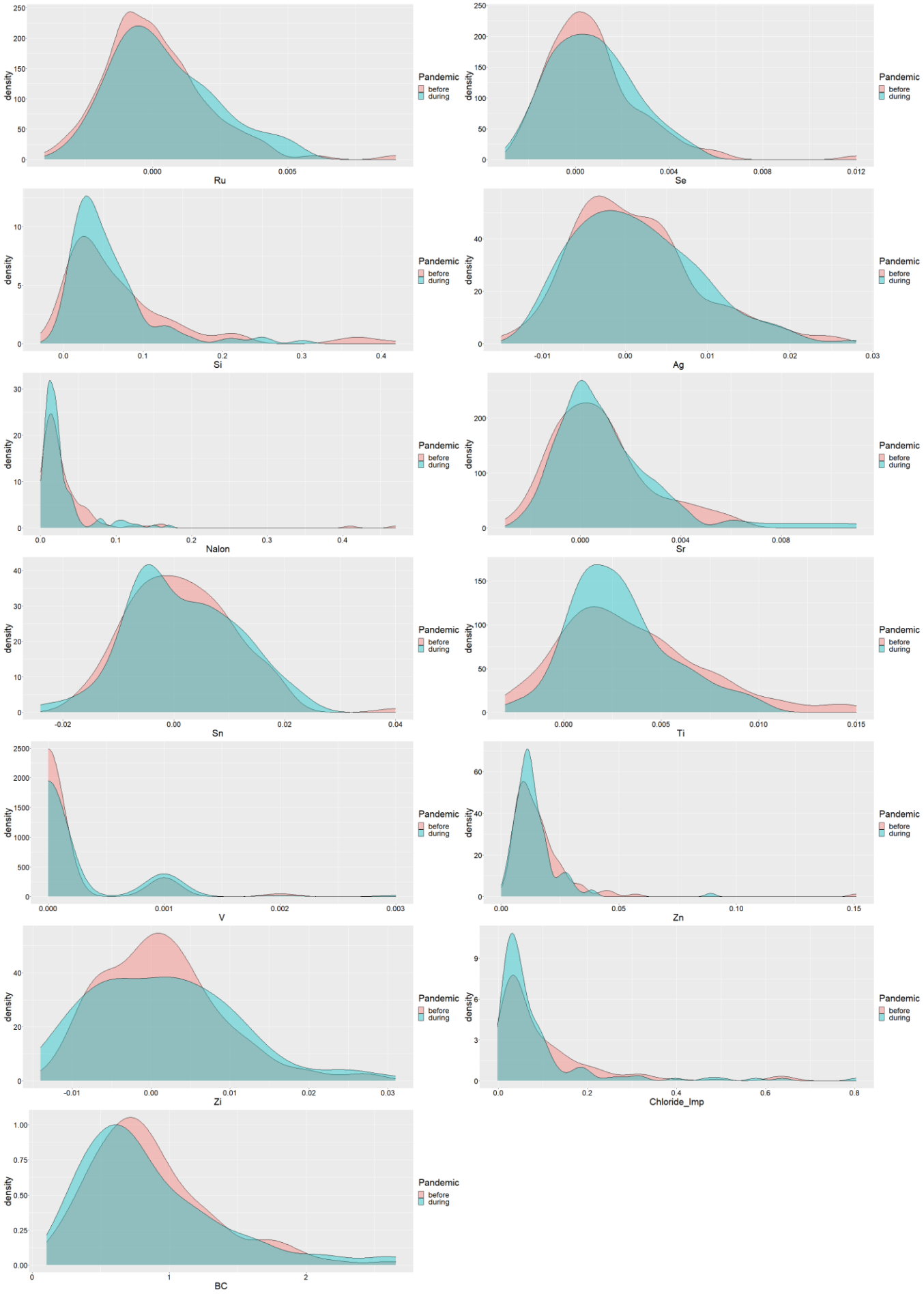
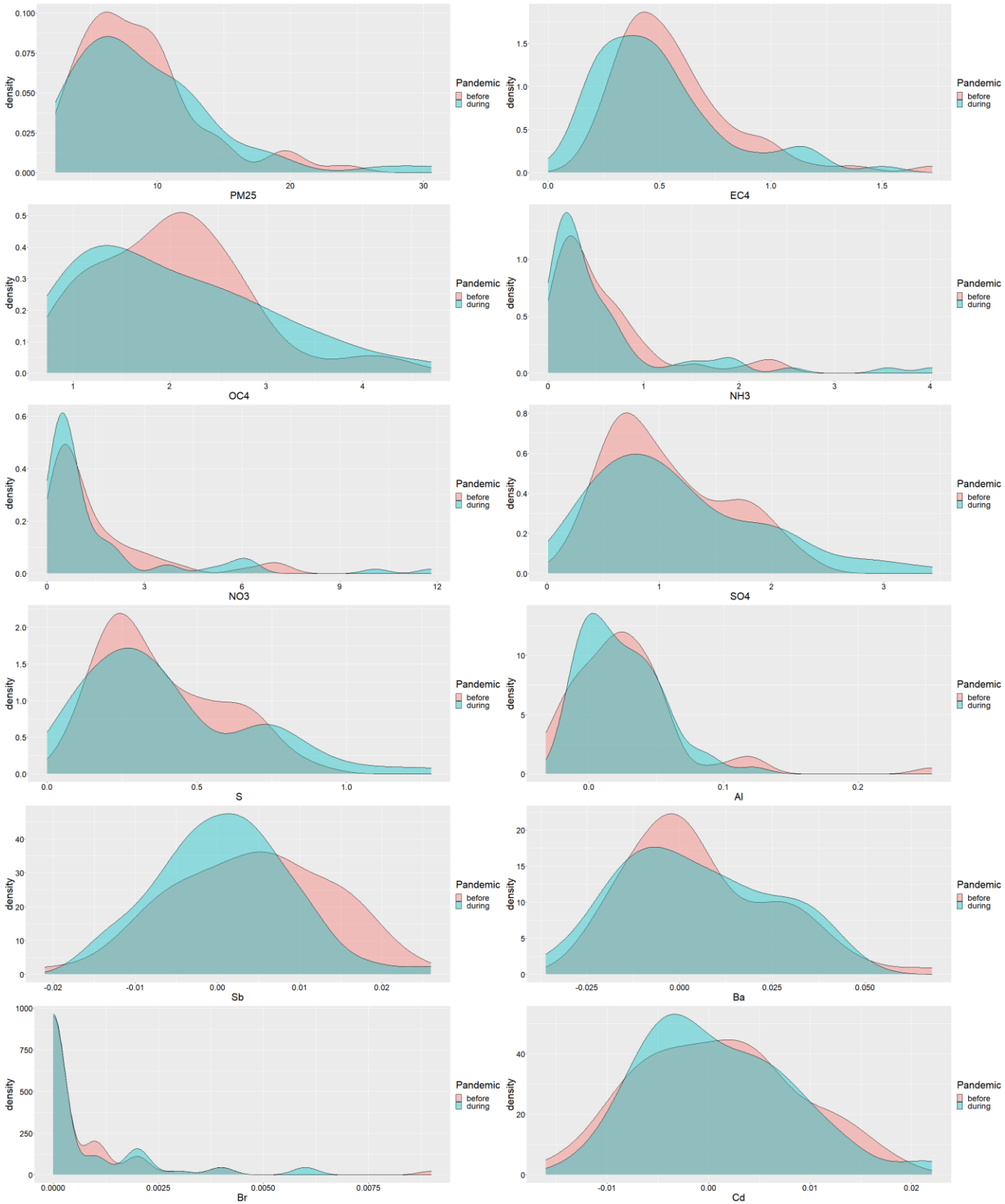
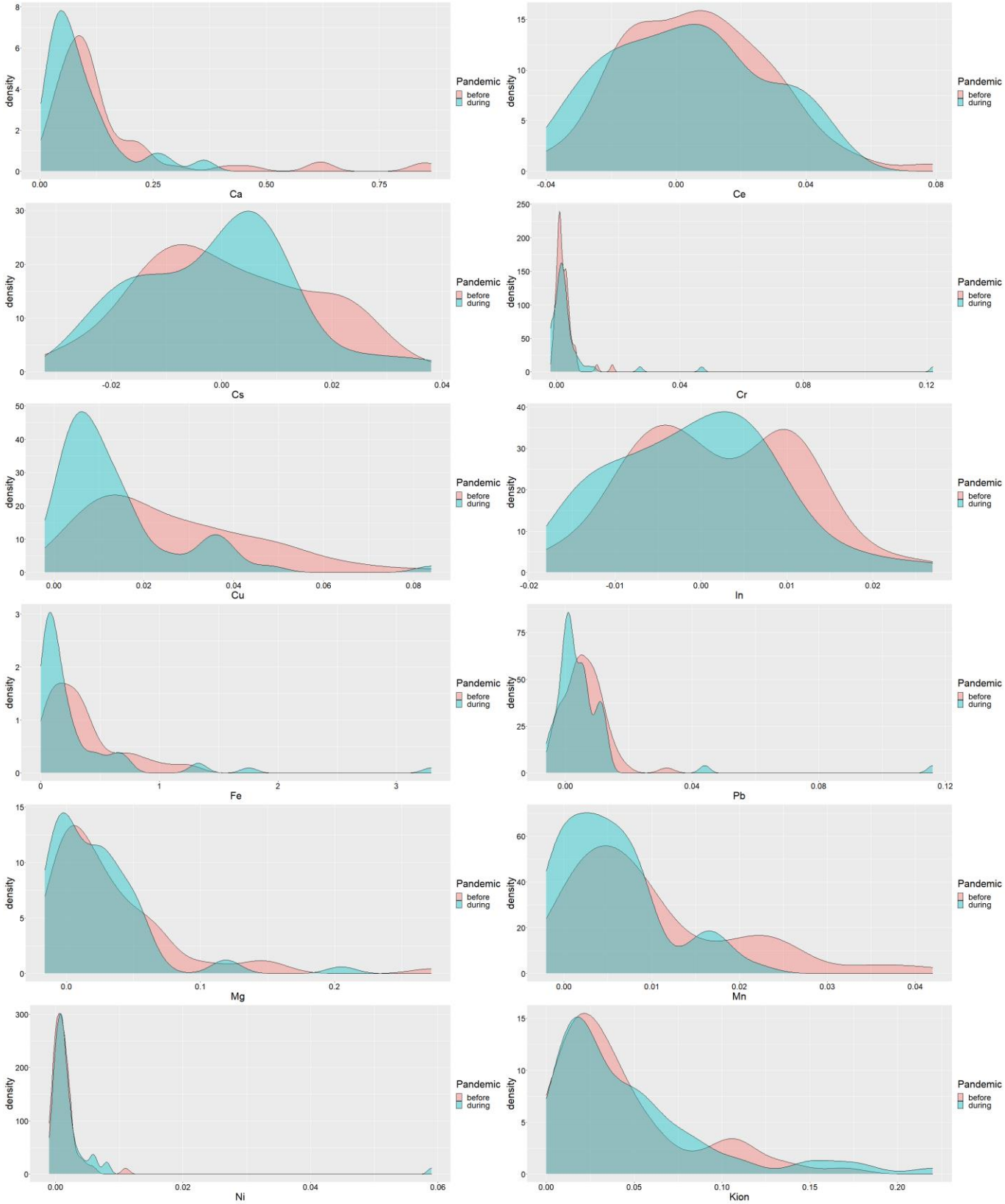

density
Ru
Se
Si
Ag
Nalon
Sr
Sn
Ti
V
Zn
Zi
Chloride_Imp
BC
Pandemic
before
during

Figure S6. Density plots comparing before and during the pandemic periods for selected species at Dearborn. Continued across 3 pages.




density
Ca
Ce
Cs
Cr
Cu
In
Fe
Pb
Mg
Mn
Ni
Kion
Pandemic
before
during

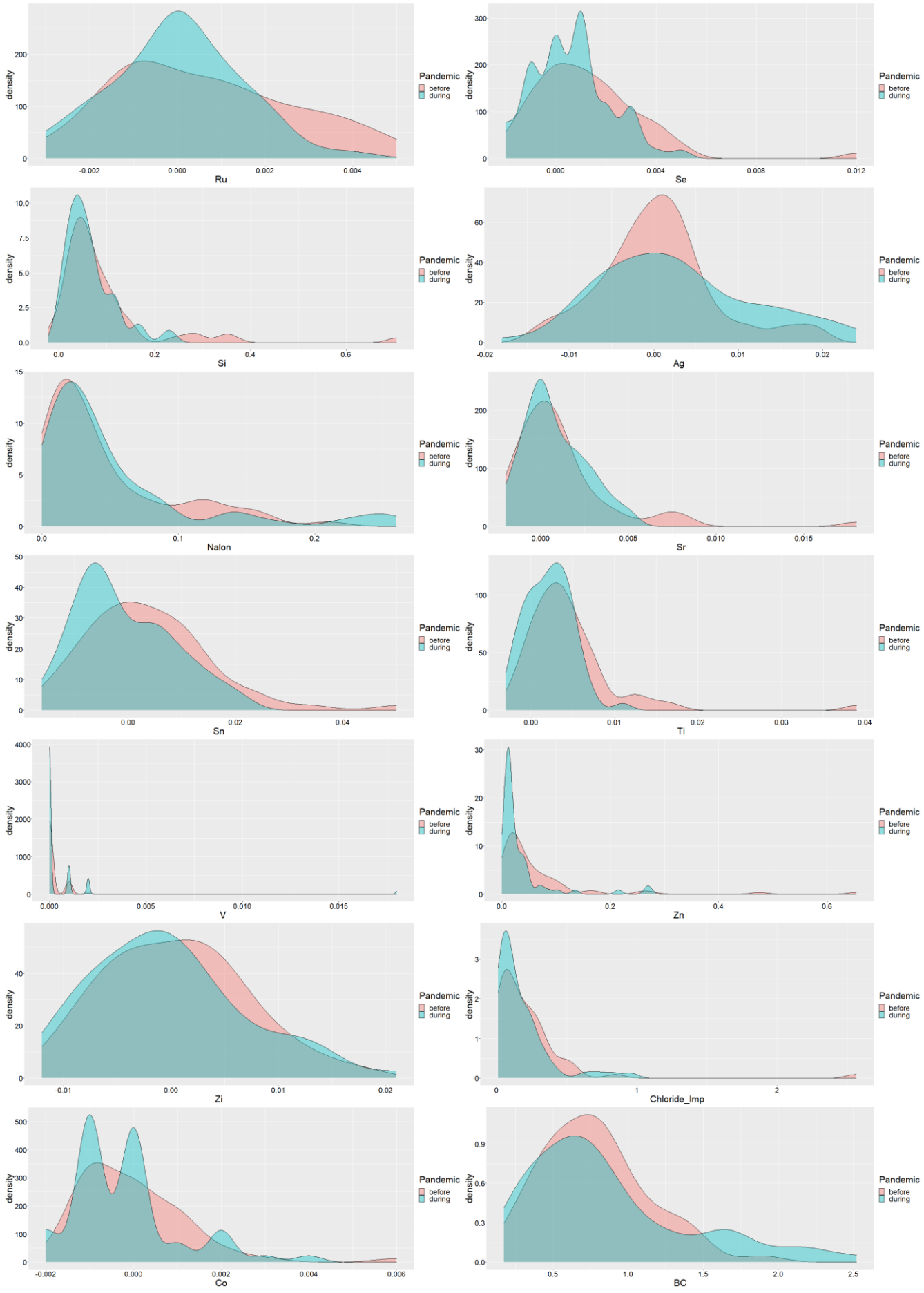
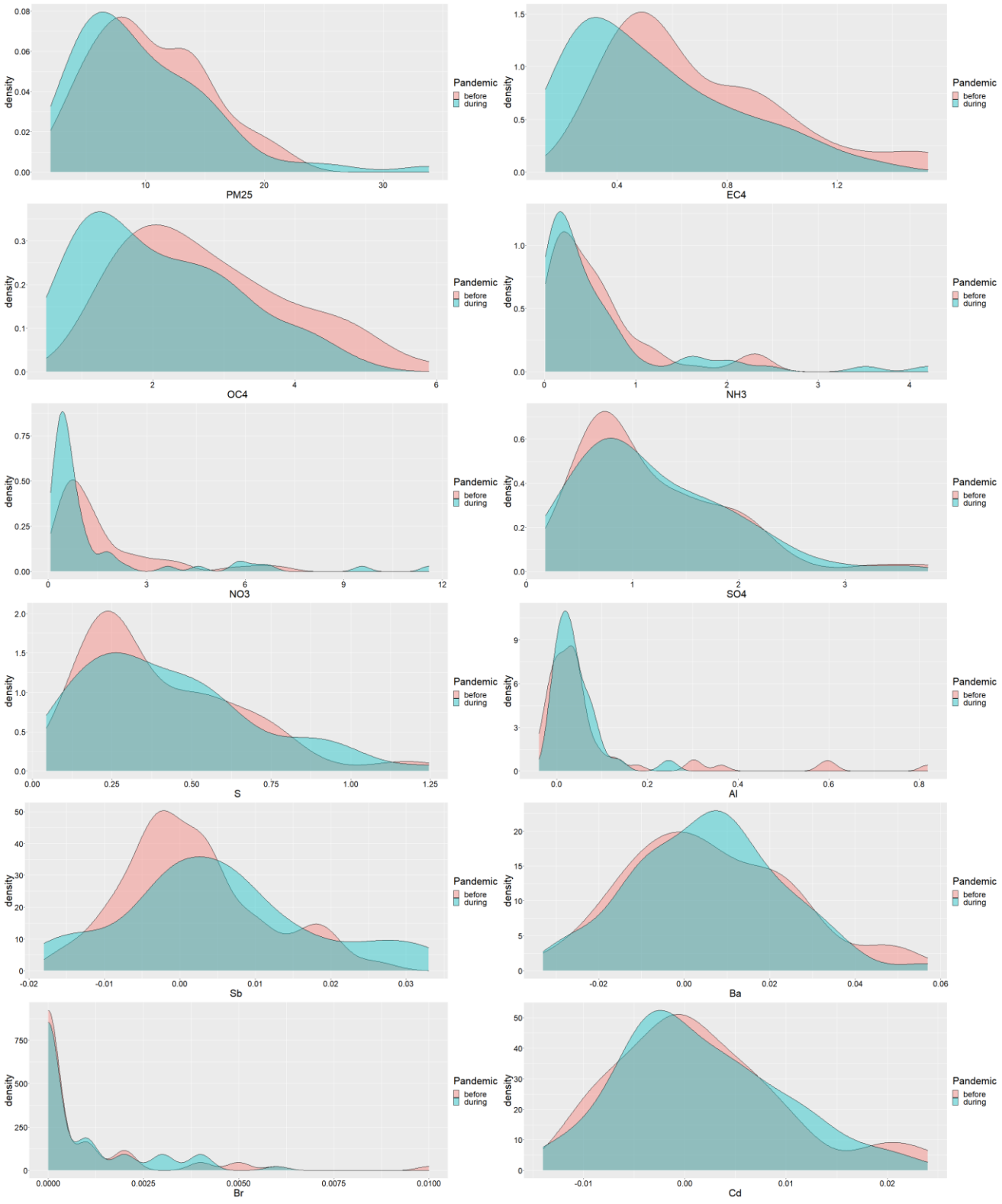
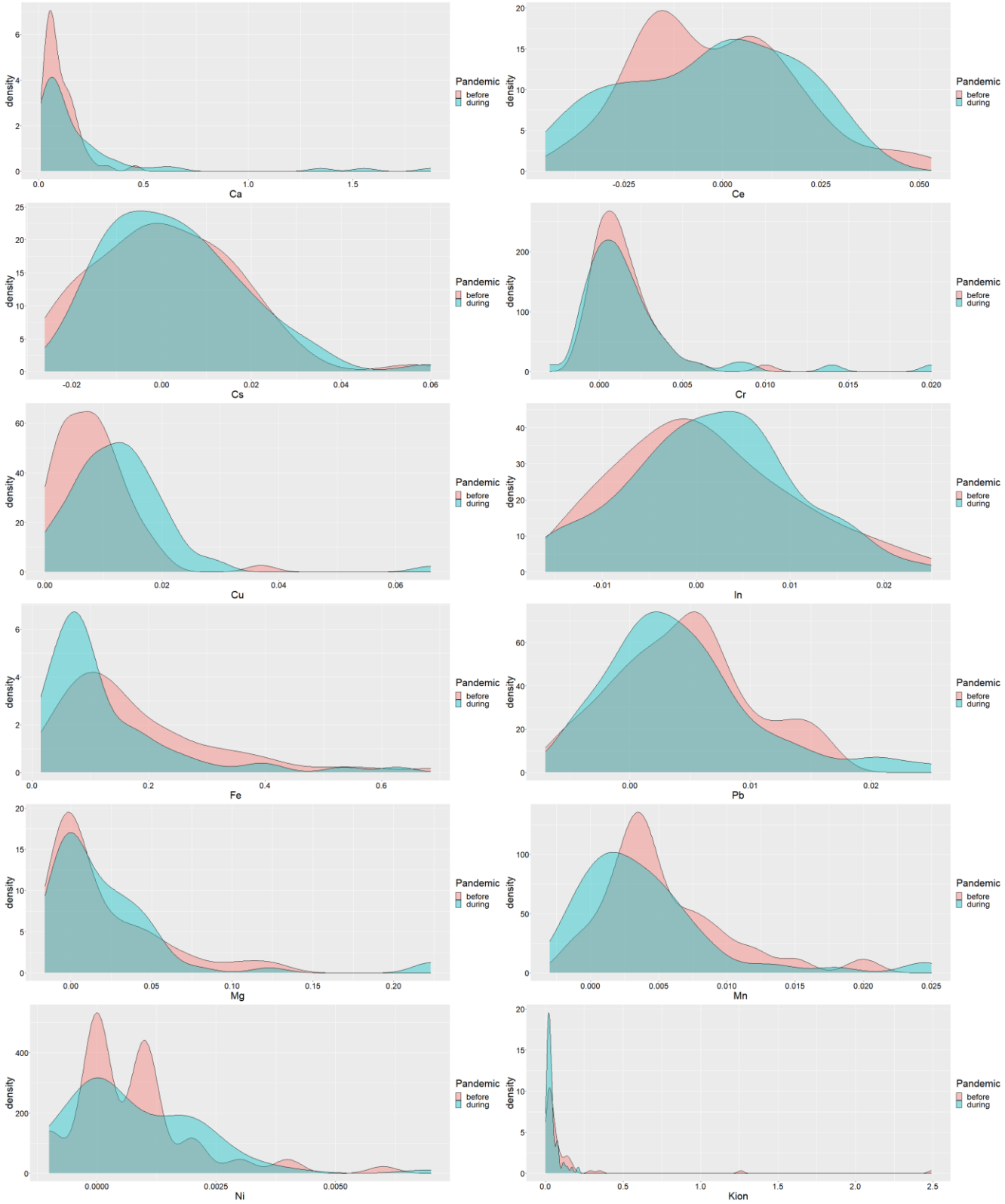

density
Ru
Se
Si
Ag
Nalon
Sr
Sn
Ti
V
Zn
Zi
Chloride_lmp
Co
BC
Pandemic
before
during

Figure S7. Density plots comparing before and during the pandemic periods for selected species at SWHS. Continued across 3 pages.




density
Ca
Ce
Cs
Cr
Cu
In
Fe
Pb
Mg
Mn
Ni
Kion
Pandemic
before
during

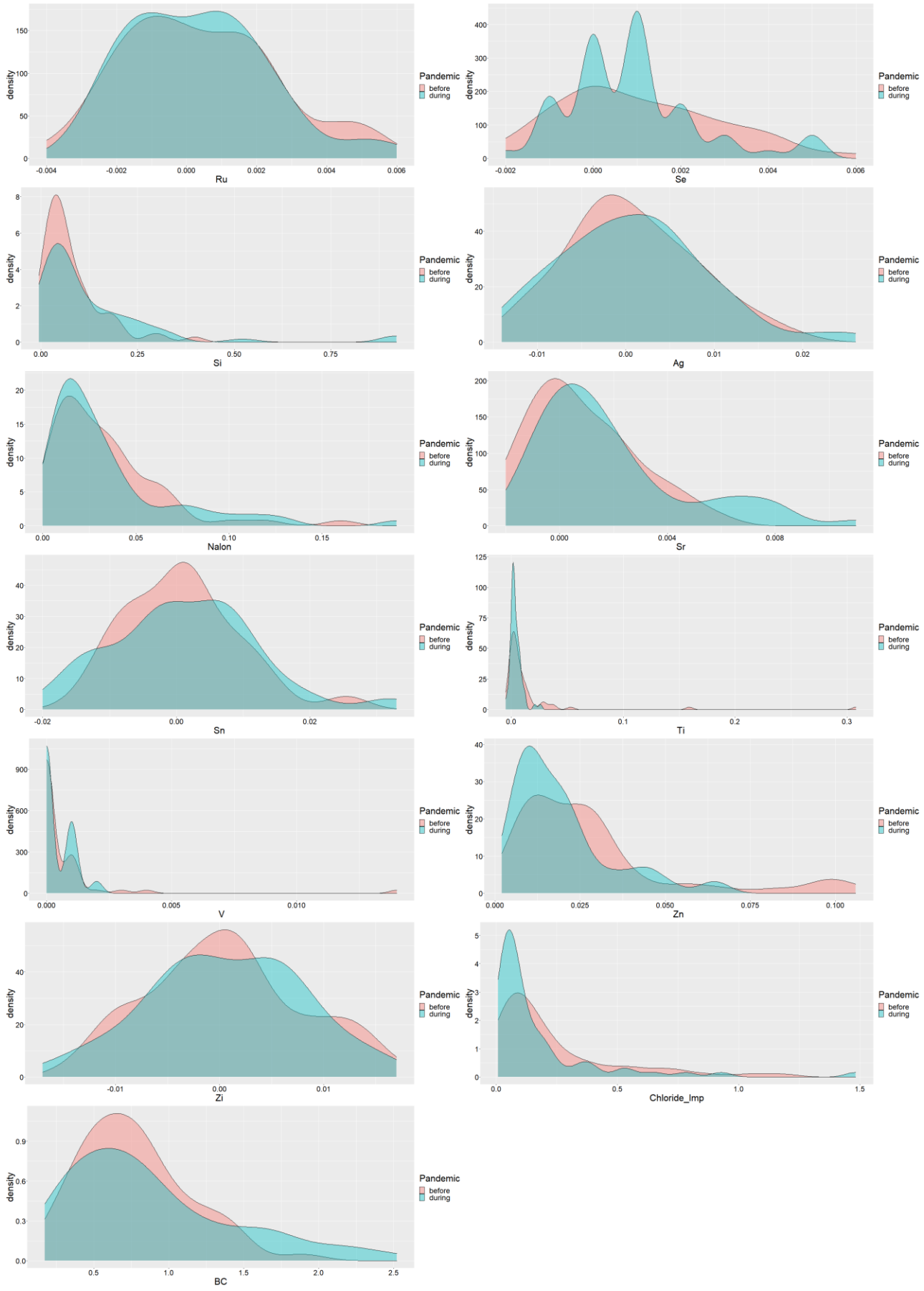

density
Ru
Se
Si
Ag
Nalon
Sr
Sn
Ti
V
Zn
Zi
Chloride_Imp
BC
Pandemic
before
during

Figure S8. Factor profiles for approach 1 for pre-pandemic and lockdown periods at Allen Park.

Figure S9. Factor profiles for approach 1 for pre-pandemic and pandemic periods at Dearborn.

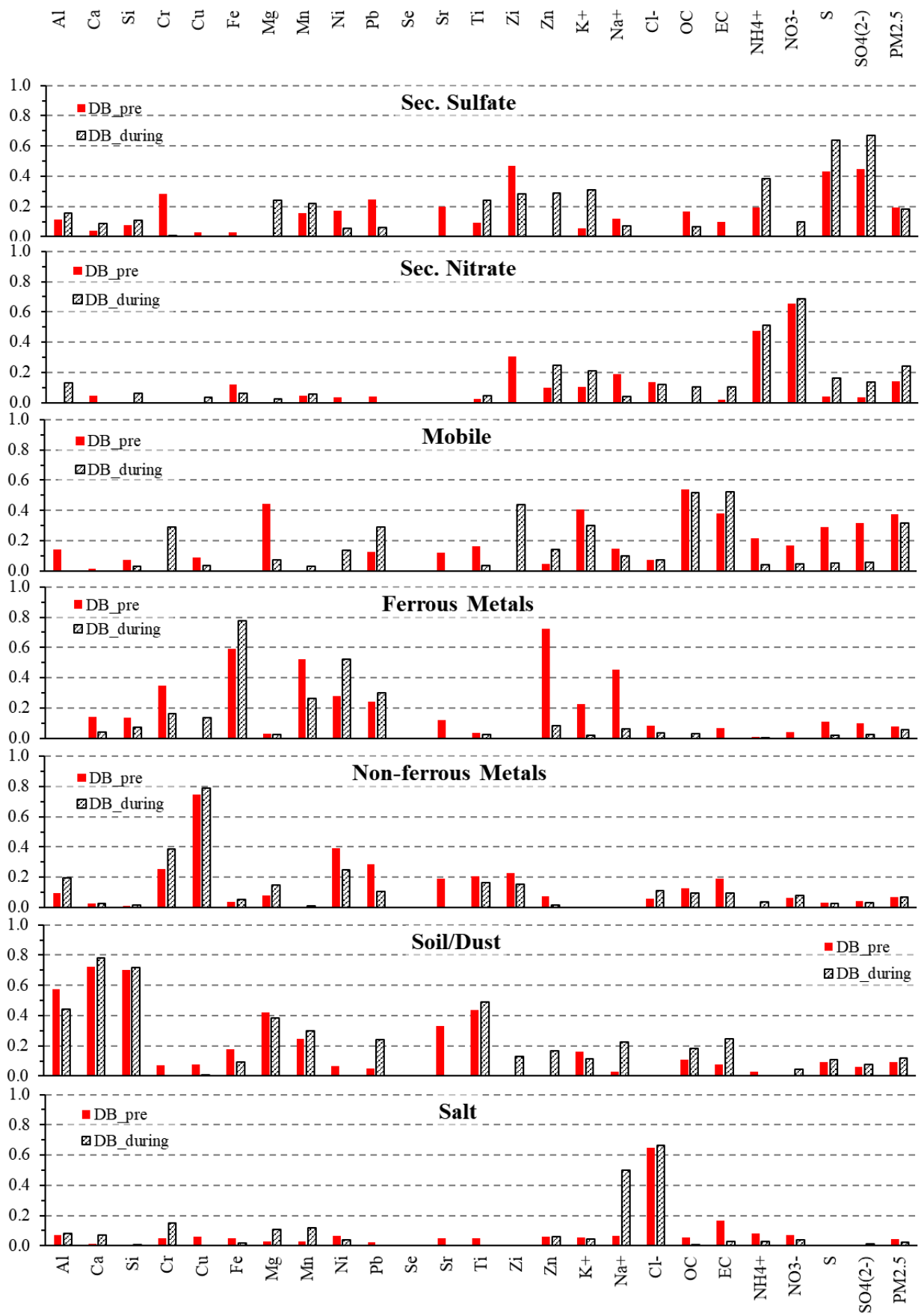


Figure S10. Factor profiles for approach 1 for pre-pandemic and pandemic periods at SWHS site.

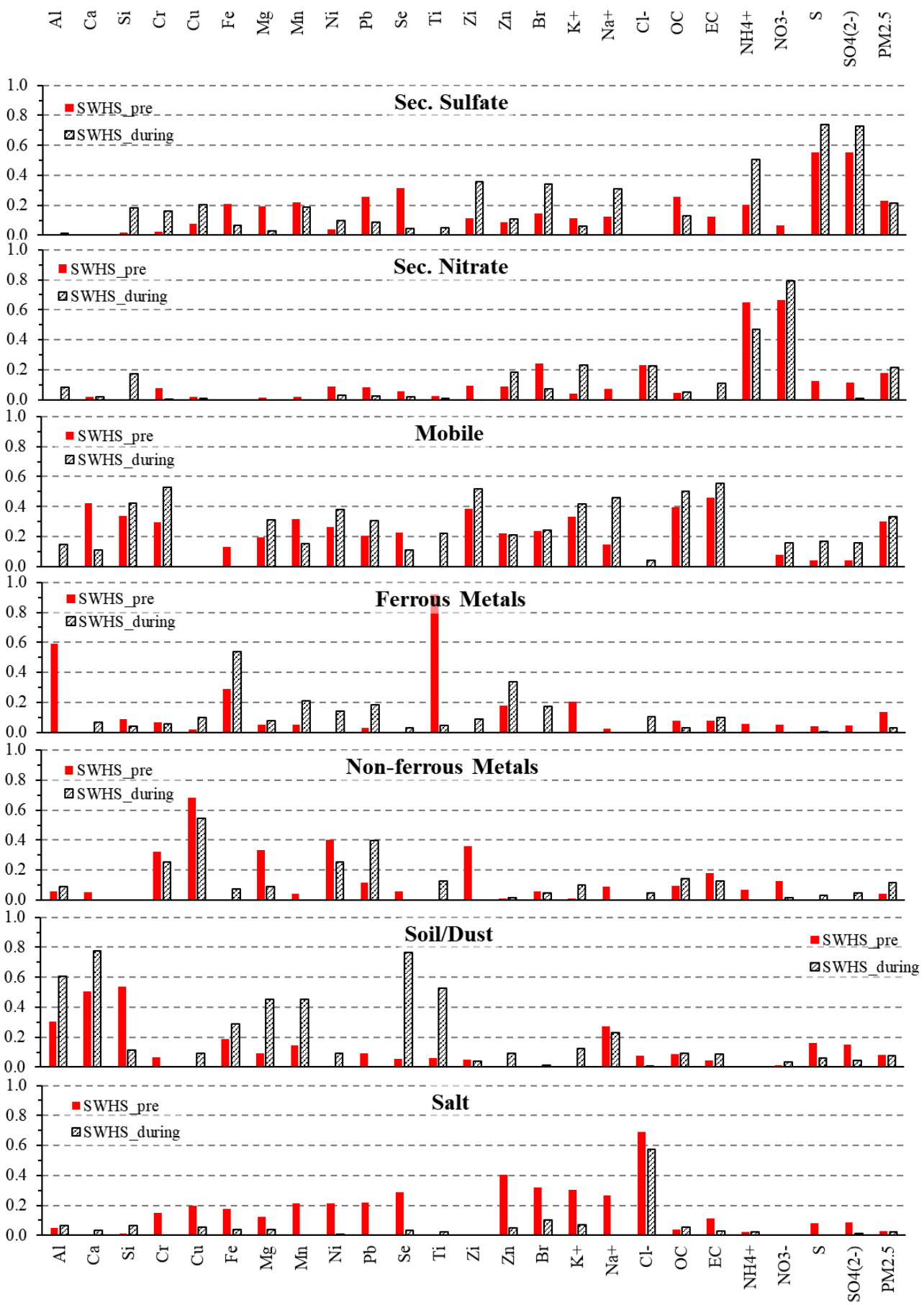


Figure S11. Factor profiles of approach 2A and 3 for pre-pandemic and pandemic periods.
Four sets of profiles are shown: Colored bars are for three individual sites using approach 3; hatched bar is profile for combined dataset using approach 2A.

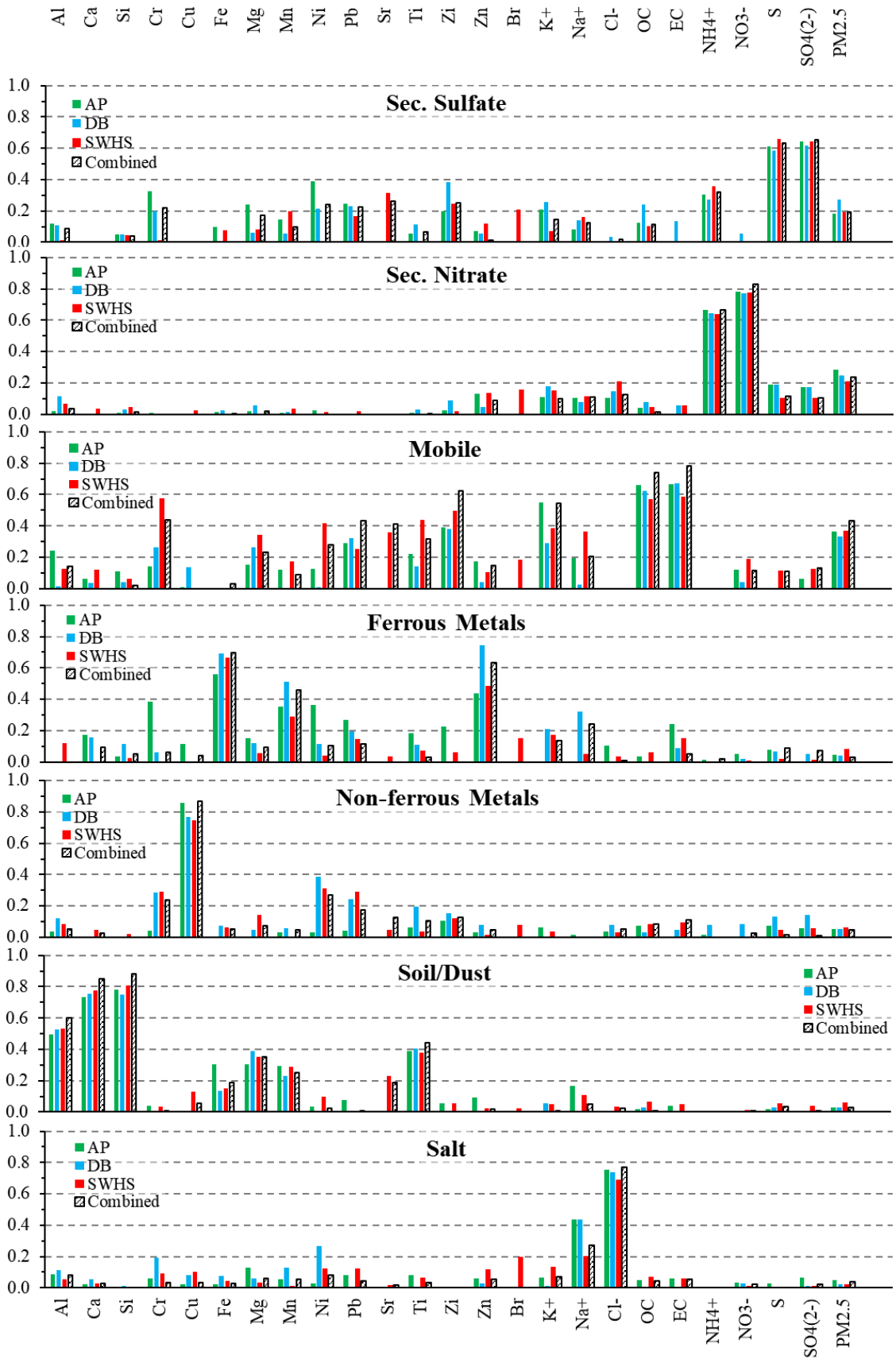
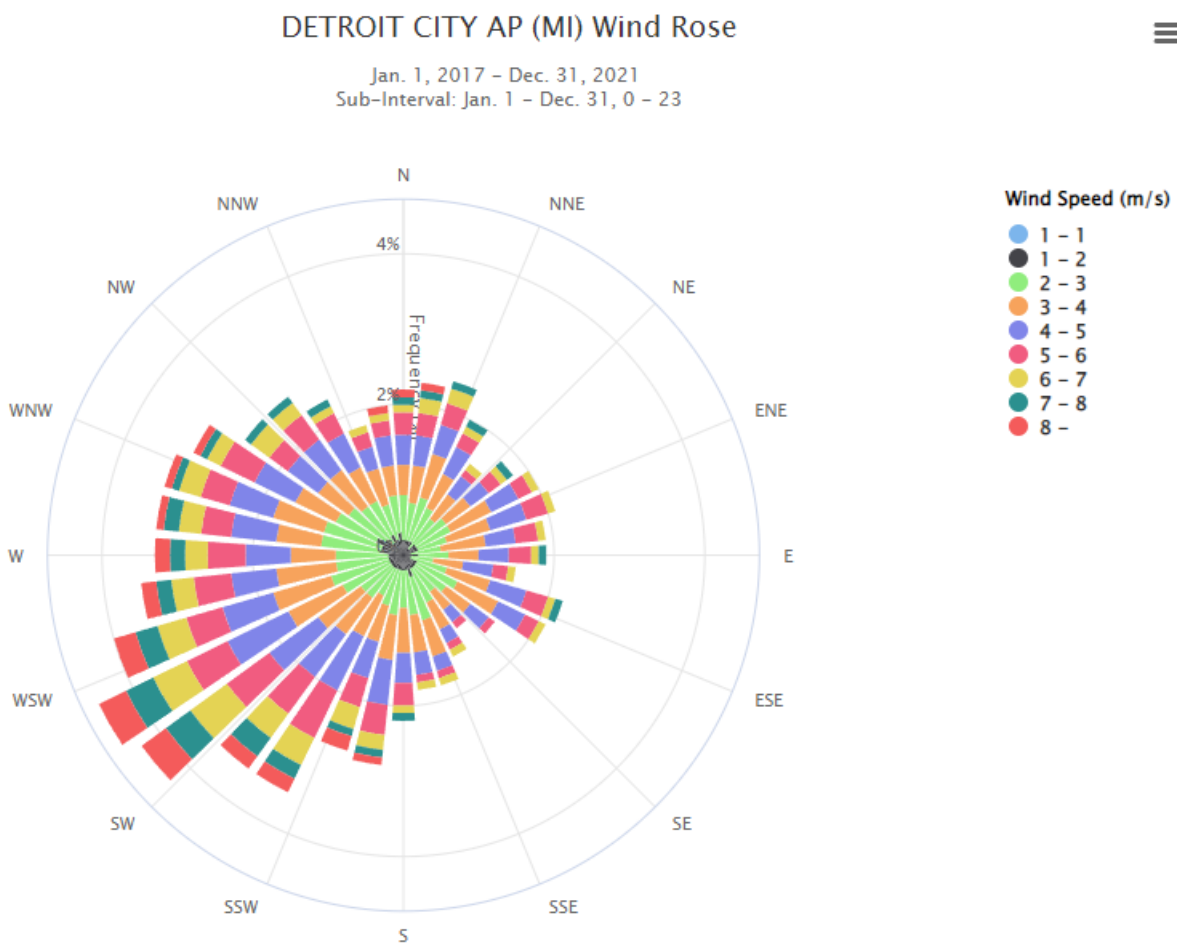


Figure S12. Annual wind rose for Detroit City Airport (Jan. 1, 2017 to Dec. 31, 2021).
Generated using Midwestern Regional Climate Center cli-MATE: MRCC Application Tools Environment (https://mrcc.purdue.edu/CLIMATE/Hourly/WindRose2.jsp)



DETROIT CITY AP (MI) - Wind Frequency Table (percentage)

Latitude : 42.4092
Longitude : -83.0100
Elevation : 625 ft.
Element : Mean Wind Speed

Start Date : Jan. 1, 2017
End Date : Dec. 31, 2021
# of Days : 1826 of 1826
obs : poss : 42945 of 43824

Sub Interval Windows

	Start	End
Date	Jan. 1	Dec. 31
Hour	0	23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	Total
1 - 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 - 2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.3	0.2	0.3	0.2	0.3	7.5
2 - 3	0.6	0.5	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.5	0.6	0.5	0.4	0.5	0.6	0.6	0.5	0.6	0.5	0.4	0.5	0.5	0.7	0.8	0.7	0.7	0.8	0.8	0.6	0.6	0.6	0.5	0.5	0.5	19.6
3 - 4	0.4	0.5	0.6	0.5	0.4	0.4	0.6	0.6	0.6	0.4	0.4	0.6	0.6	0.4	0.3	0.4	0.5	0.5	0.6	0.6	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.6	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.4	19.8
4 - 5	0.4	0.4	0.4	0.4	0.3	0.3	0.4	0.5	0.4	0.4	0.4	0.5	0.4	0.3	0.2	0.2	0.2	0.3	0.4	0.6	0.5	0.8	0.7	0.8	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.3	0.4	17.2
5 - 6	0.3	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.4	0.7	0.6	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.5	0.3	0.4	0.3	0.2	0.2	11.6
6 - 7	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.1	0.1	7.1
7 - 8	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	3.8
8 -	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	3.3
Total(%)	2.3	2.2	2.4	1.9	1.5	1.9	2.0	2.1	2.0	2.0	1.6	2.2	2.1	1.6	1.2	1.5	1.8	1.9	2.3	2.8	2.7	3.5	3.4	4.3	4.5	4.0	3.4	3.4	3.3	3.4	3.1	2.5	2.7	2.4	1.9	2.1	89.9
Calm (<1)																																					10.0
Ave Speed	4.0	3.9	3.8	3.7	3.5	3.6	3.7	3.8	3.9	4.1	4.0	4.0	3.5	3.2	3.3	3.3	3.2	3.4	3.8	4.3	4.5	4.8	4.7	5.0	4.9	4.6	4.3	4.5	4.1	4.1	3.9	4.0	3.9	3.8	3.6	3.7	3.7

Figure S13. Seasonal wind roses for Detroit City Airport.
Average wind speed in winter, spring, summer, and fall is 4.1, 4.0, 3.1, and 3.5 m/s, respectively; calms (wind speed less than 1 m/s) represent 6.6, 8.0, 13.5 and 11.6% of the time, respectively.

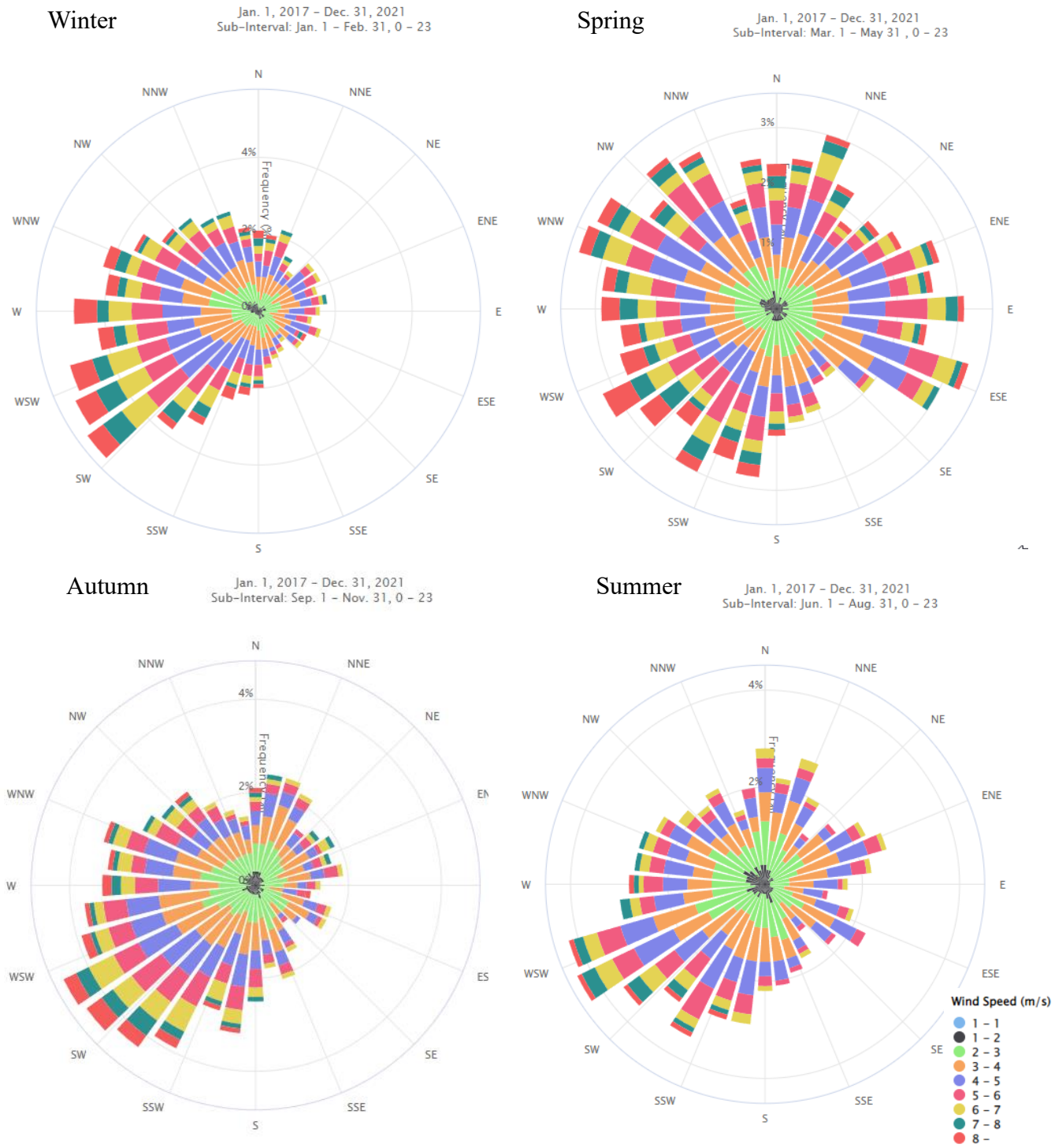


Table S5. Selected profiles from EPA Speciate database. In percent. Continued on next page.

		Profile	Ag	Al	As	Ba	Br	Ca	Cd	Cl	Cr	Cu	Fe	In	K	La	Mg	Mn	Mo	Na	Ni	P
Coal	Bituminous Combustion - Composite	91104	0.01	4.16		0.22	0.03	3.47	0.00	0.70	0.01	0.01	1.90	0.00	0.42	0.00	0.46	0.02		0.13	0.00	0.15
	Sub-Bituminous Combustion - Composite	91110		5.97		1.33	0.01	3.45		0.06	0.02	0.02	2.92		0.46			0.03	0.01		0.01	0.94
	Lignite Combustion - Composite	91125	0.00	3.79	0.00	1.07	0.00	14.52	0.00	0.09	0.01	0.07	2.77	0.01	0.43	0.00	0.99	0.03	0.01	0.19	0.01	0.28
	Residential Coal Combustion - Composit	91155	0.45	0.67	0.02	0.06	0.00	1.16	0.00	0.09	0.00	0.03	0.86	0.00	0.53	0.00	0.29	0.01		0.02	0.05	0.05
	Fly Ash - Composite	91160	0.00	5.37	0.00	0.19	0.00	20.25	0.00	0.25	0.04	0.06	4.84	0.00	0.57	0.03	1.55	0.09		0.22	0.01	0.25
Dust	Unpaved Road Dust - Composite	91100		4.45	0.00	0.07	0.00	7.01	0.00	0.13	0.02	0.01	4.13		1.59	0.02	0.67	0.12	0.00	0.04	0.00	0.05
	Construction Dust - Composite	91107	0.00	3.68	0.00	0.05	0.00	9.10	0.00	0.05	0.02	0.01	3.51	0.00	1.49			0.10	0.00		0.01	0.03
	Paved Road Dust - Composite	91108	0.00	5.36	0.00	0.09	0.00	4.65	0.00	0.22	0.03	0.02	4.18		1.64	0.01	0.69	0.09	0.00	0.26	0.01	0.08
	Sand & Gravel - Composite	91111	0.00	8.09	0.01	0.16		1.90		0.27	0.02	0.01	2.96	0.01	1.41		0.41	0.13		0.50	0.01	0.04
	Sandblast - Composite	91161		5.55	0.01		0.00	0.82	0.05	1.41	0.55	0.05	6.30		0.99			0.14	0.55	0.80	0.32	0.03
Ferrous	Open Hearth Furnace - Composite	91133				0.55	0.05	0.55	0.05	30.00	0.55	0.05	9.00		0.55				0.55		2.00	
	Sintering Furnace - Composite	91139	0.05		0.05		0.05	0.55	0.05		2.00	0.55	10.00		3.00			0.55			0.55	
	Ferromanganese Furnace - Composite	91151	0.05	0.09	0.28		0.55	0.58		17.00		2.00	6.94		20.95		0.16	0.28		13.02		
	Electric Arc Furnace - Composite	91153		1.43	0.03		0.11	1.20		0.42	0.04	0.04	2.08		7.18		2.27			2.57		0.12
	Cast Iron Cupola - Composite	91157		0.65	0.02		0.91	6.20		1.85		0.28	32.00	0.03	1.86		3.11	3.65	0.04	3.90	0.70	0.10
	Coke Calciner - Composite	91173		1.00	0.01		0.01	0.91		0.81	0.05	0.24	13.64		2.73			4.09		1.18	0.03	
	Steel Desulfurization - Composite	91179		0.05			0.00	25.78					0.06		0.04						0.03	
	Auto Body Shredding - Composite	91180	0.02	0.88			0.01	25.45	0.03	0.46	0.06	0.02	20.54	0.01	2.54			0.28	0.01		0.02	0.23
	Heat Treating - Composite	91123		0.47			0.49	0.48		0.68	0.04	0.10	5.76		0.27		0.10	0.09		0.18	0.03	
Miscellar	Charbroiling - Composite	91116	0.00	0.05	0.00	0.02	0.00	0.03	0.00	0.37		0.01	0.05	0.00	0.25	0.01	0.10			0.30	0.01	0.05
	Kraft Recovery Furnace - Composite	91119		0.09	0.00		0.07	0.62	0.00	3.06	0.00	0.01	0.07		2.49		0.02	0.00		25.83	0.00	
	Mineral Products - Avg - Composite	91120																				
	Industrial Manufacturing - Avg - Compo	91121																				
	Chemical Manufacturing - Avg - Compo	91124																				
	Cement Production - Composite	91127	0.00	1.05	0.00	0.04	0.11	16.65	0.01	3.13	0.01	0.02	0.67	0.01	6.94	0.00	0.05	0.10	0.00	2.29	0.02	
	Surface Coating - Composite	91129		3.70		1.89	0.02	3.79	0.07	0.25			0.05		0.30	2.82			0.01			
	Food & Ag - Handling - Composite	91130	0.01	0.27		0.10	0.01	0.90	0.00	0.09		0.03	0.18		0.88	0.16	0.26	0.02	0.00	0.06	0.00	0.54
	Wood Products-Sawing - Composite	91131		0.18		0.05	0.55	0.24		0.03	0.05	0.05	0.38		0.03			0.03	0.05	0.24	0.05	
	Meat Frying - Composite	91135				0.46	0.08	0.15		3.52	0.15		0.24		0.36			0.04		0.45	0.05	
	Lime Kiln - Composite	91138	0.02	0.31	0.01	0.03	0.01	8.85	0.01	1.53	0.01	0.01	0.12	0.01	1.56	0.10	0.50	0.10	0.01	27.04	0.02	0.23
	Charcoal Manufacturing - Composite	91140		7.00			0.09	9.50		5.00	0.04	0.05	6.40		7.40		1.90	0.44				
	Fiberglass Manufacturing - Composite	91142					0.05	0.05		15.00	0.05	0.05	0.55		0.55						0.05	
	Glass Furnace - Composite	91143	0.00	0.01	0.02	0.00	0.00	0.43	0.00	0.02	0.22	0.00	0.03		1.80		0.18	0.00	0.04	12.80	0.00	0.03
	Pulp & Paper Mills - Composite	91144								2.02					2.62		0.29			29.34		
	Misc. Sources - Composite	91147																				
	Asphalt Roofing - Composite	91148		0.02		0.00				0.70		0.01	0.00		0.00					0.01		
	Inorganic Chemical Manufacturing - Co	91149																				
	Food & Ag-Drying - Composite	91154					0.05	1.00		0.55	0.55	0.05	5.00		0.55			0.55			0.55	
	Asphalt Manufacturing - Composite	91159		5.95		0.22	0.00	6.02	0.00	0.04		0.01	3.28		0.72	0.23	0.21	0.06	0.00	1.24	0.00	0.11
	Ammonium Nitrate Production - Compo	91163																				
	Limestone Dust - Composite	91164		1.27	0.02	0.00	0.01	29.86	0.04	0.24	0.00	0.02	0.71		0.22		4.70	0.08		0.04	0.00	0.08
	Phosphate Manufacturing - Composite	91165	0.01	0.76	0.01	0.01	0.01	0.49	0.01	0.11	0.02	0.01	0.05	0.01	0.34		0.04	0.00	0.02	0.33	0.00	3.02
	Gypsum Manufacturing - Composite	91166					0.05	13.00	0.05	0.55	0.55	0.05	0.55		0.55			0.05	0.05		0.55	
	Urea Fertilizer - Composite	91167					0.05	0.55	0.05	11.00		0.05	0.05		0.55			0.05	0.05		0.05	
	Brick Grinding and Screening - Composi	91171	0.01	2.33	0.00		0.00	18.35		0.38	0.00	0.01	1.99		0.87		0.64	0.05		0.83	0.01	0.03
	Calcium Carbide Furnace - Composite	91172		0.58				30.00		1.05		0.02	0.54		1.25		2.40	0.04		0.92	0.02	
	Potato Deep Frying - Composite	91175																				
	Ammonium Sulfate Production - Compo	91181																				
	Inorganic Fertilizer - Composite	91182		2.11	0.00	1.53	0.01	23.79	0.01	0.31	0.16	0.02	4.66	0.05	0.59	0.49	0.09	0.18	0.01	0.12	0.04	11.15
	Boric Acid Manufacturing - Composite	91183	0.05					0.05	0.05	0.55		0.05	0.55								0.05	
Mobile	HDDV Exhaust - Composite	91106	0.01		0.00	0.03	0.00	0.06	0.00	0.02			0.03	0.00	0.00	0.03			0.00		0.00	
	Nonroad Gasoline Exhaust - Composite	91113						0.03	0.01				0.01	0.01								0.03
	Onroad Gasoline Exhaust - Composite	91122	0.01	0.15	0.00	0.06	0.01	0.29	0.01	0.08	0.00	0.02	0.40	0.00	0.02	0.03	0.05	0.00	0.00	0.11	0.01	0.17
	Brake Lining Dust - Composite	91134		0.12	0.00	3.45	0.00	1.00		0.15	0.11	1.15	11.50		0.02		11.05	0.11	0.37	0.02	0.07	
	Tire Dust - Composite	91150		0.06		0.02	0.00	0.11		0.78	0.00	0.05	0.46		0.04		0.04	0.01		0.06	0.01	0.12
	LDDV Exhaust - Composite	91162	0.01	0.02	0.00	0.02	0.00	0.03	0.00	0.02	0.00	0.00	0.09	0.00	0.00	0.01	0.01	0.00		0.04	0.00	0.03
Natural (	Natural Gas Combustion - Composite	91112																				
	Process Gas Combustion - Composite	91136		1.42	0.00	0.01	0.01	1.32	0.08	0.22	0.00	1.03	1.65		0.13	0.04	0.11	0.02	0.00	0.06	0.05	0.01
	Residential Natural Gas Combustion - C	91156		0.22			0.04	1.04		3.88	0.05		0.09		0.17			0.02		2.13	0.09	0.03
Nonferro	Aluminum Processing - Composite	91132	0.01	1.70	0.01	0.04	0.06	0.12		20.00	0.04	0.05	0.29		10.04	0.00		0.01		15.50	0.03	0.41
	Aluminum Production - Composite	91137		27.00			0.04	0.33		1.33		0.04	0.45		0.22		2.80	0.01		4.10	0.19	
	Copper Processing - Composite	91158			0.08		0.03	0.43		1.19		17.10	0.24		0.24			0.01	0.05		0.09	
	Lead Processing - Composite	91168		0.00	0.30			0.03	0.70	19.30	0.00	0.03	0.10		1.00		0.00	0.00		3.00	0.00	0.05
	Copper Production - Composite	91170	0.02				2.53		0.63		0.01	0.73	0.29	0.04	0.35			0.01	0.13		0.01	
	Lead Production - Composite	91178	0.10	0.44	2.65	0.03	0.03	1.01	0.47	0.83	0.02	0.60	1.88	0.03	0.73			0.12			0.08	0.39
Oil	Distillate Oil Combustion - Composite	91115						0.02			0.03	0.02	0.09		0.04							
	Residual Oil Combustion - Composite	91117						0.04		0.31			0.03			0.05		0.00			0.05	
	Catalytic Cracking - Composite	91141		8.08		0.01	0.00	0.13		0.01	0.04	0.02	1.16		0.08	0.54		0.02	0.01	0.00	0.15	0.03
	Petroleum Industry - Avg - Composite	91145																				
Sea Salt	Sea Salt - Composite	91176					0.20	1.40		39.92					1.40		4.79			39.92		
Soil	Agricultural Soil - Composite	91101		8.94		0.08		2.45		0.14	0.03	0.01	5.77		2.05	0.01	0.08	0.13		0.14	0.01	0.18
	Dairy Soil - Composite	91118	0.01	1.29	0.01	0.20	0.02	2.14	0.01	0.39	0.01	0.01	1.19		2.05	0.01		0.04		0.50		0.81
	Crustal Material - Composite	91169	0.00	6.79	0.00	0.05	0.00	3.81	0.00	0.05	0.01	0.01	4.38	0.00	1.88	0.00	0.72	0.10	0.00	0.32	0.01	0.07
	Industrial Soil - Composite	91174		2.80	0.00	0.06		13.69		0.36	0.06	0.02	2.56	0.01	0.73		0.60	0.25		0.29	0.00	0.15
Waste	Solid Waste Combustion - Composite	91126	0.01	1.99	0.01	0.08	0.02	2.19	0.01	13.83	0.03	0.05	2.38	0.01	2.16	0.01		0.06	0.02	0.81	0.02	0.34
	Sludge Combustion - Composite	91177		1.80		0.27	0.38	5.07	0.83	1.48	0.58	0.88	5.38		0.96		0.65	0.21		1.41		3.26
Wood	Wildfires - Composite	91102	0.00	0.06	0.01	0.00	0.04	0.39	0.00	4.15	0.00	0.00	0.04	0.00	2.94	0.00	0.03	0.00		0.57	0.00	0.01
	Agricultural Burning - Composite	91103	0.00	0.03		0.03	0.03	0.03		9.05			0.01	0.01	7.04		0.08			0.65		
	Residential Wood Combustion - Compos	91105	0.00	0.01	0.00		0.00	0.01	0.00	0.30			0.01		0.97	0.00	0.01			0.09		0.00
	Prescribed Burning - Composite	91109	0.02	0.05			0.01	0.07	0.49	0.24	0.00	0.00	0.04		0.14			0.01		0.14	0.00	0.06
	Wood Fired Boiler - Composite	91114						0.64		0.54					8.87		0.14			0.15		0.08
	Slash Burning - Composite	91146	0.03	0.10			0.03	0.15	0.03	0.51	0.01	0.01	0.04		1.31			0.02		1.73	0.01	0.09
	Wood Products - Sanding - Composite	91152						0.05					0.05									
	Wood Products - Drying - Composite	91128						0.50		4.50			0.10		4.00			0.09		3.70		

		Profile	Pb	Pd	Rb	S	SO4=	Sb	Se	Si	Sn	Sr	Ti	V	Zn	Zr	NH4+	NO3-	OC	EC
Coal	Bituminous Combustion - Composite	91104	0.00	0.01	0.00	5.64	12.67		0.33	7.98	0.02	0.11	0.20	0.01	0.03	0.01	2.82	0.21	2.63	1.70
	Sub-Bituminous Combustion - Composite	91110	0.07		0.00	2.95	10.17		0.04	9.01		0.20	0.43		0.08	0.02	0.35	0.06	3.16	4.28
	Lignite Combustion - Composite	91125	0.02	0.00	0.00	3.31	7.56	0.01	0.01	6.39	0.01	0.37	0.69	0.04	0.30	0.02	0.41	0.39	28.42	1.43
	Residential Coal Combustion - Composit	91155	0.01	0.00	0.00	1.50	3.32	0.20	0.00	0.69	0.06	0.02	0.04	0.02	0.16	0.00	1.41	0.31	44.84	23.95
	Fly Ash - Composite	91160	0.04		0.00	2.38	6.39	0.00	0.00	6.63	0.00	0.09	0.84	0.04	0.07	0.02	0.08	0.37	1.24	1.70
Dust	Unpaved Road Dust - Composite	91100	0.03	0.00	0.01	0.25	0.75	0.00		14.37		0.03	0.35	0.02	0.07	0.01	0.05	0.13	5.46	0.10
	Construction Dust - Composite	91107	0.01	0.00	0.01	0.35	1.05	0.02		11.50		0.05	0.35	0.02	0.02	0.02	0.07	0.04	4.62	
	Paved Road Dust - Composite	91108	0.07	0.00	0.01	0.51	0.65			16.91	0.00	0.04	0.37	0.02	0.13	0.01	0.07	0.04	9.74	1.04
	Sand & Gravel - Composite	91111	0.00	0.01	0.01	0.18	0.29			19.10	0.04	0.02	0.24	0.03	0.02	0.01		0.05		
	Sandblast - Composite	91161	0.05			0.88	0.55			28.22		0.04	0.40	0.01	0.33	0.28		0.05	0.50	
Ferrous	Open Hearth Furnace - Composite	91133	0.05			10.67	32.00								0.05			0.55	7.00	1.00
	Sintering Furnace - Composite	91139	0.55		0.05	13.30	40.00	0.05			0.05			0.55				0.55	20.00	
	Ferromanganese Furnace - Composite	91151	0.18		0.55	3.42	10.35		0.05	1.24		0.05			0.30	0.05			2.73	0.17
	Electric Arc Furnace - Composite	91153	0.13			1.32	4.03			5.50			0.05	0.02	0.47			5.70	5.14	10.12
	Cast Iron Cupola - Composite	91157	0.76			1.88	2.24		0.03	2.99			0.20	0.05	1.20			0.23	3.23	0.36
	Coke Calciner - Composite	91173	0.21		0.02	2.09	6.28	0.34	0.00	21.83			0.05	0.01	0.75			0.50	6.37	0.91
	Steel Desulfurization - Composite	91179	0.01			16.18	48.55					0.02	0.01	0.11	0.01					
	Auto Body Shredding - Composite	91180	0.06		0.02	2.74	8.22	0.06	0.00	1.63	0.01	0.12	0.17	0.04	0.09					
	Heat Treating - Composite	91123	0.49			0.47	0.29			0.87			0.03	0.00	2.10			0.15	7.70	0.60
Miscellar	Charbroiling - Composite	91116	0.01		0.00	0.17	0.13	0.00		0.10	0.00	0.00	0.00	0.00	0.03			0.14	67.02	4.06
	Kraft Recovery Furnace - Composite	91119			0.01	12.98	54.85	0.00		0.30		0.00	0.00	0.00	0.01		1.06	0.35	5.23	1.53
	Mineral Products - Avg - Composite	91120				4.69	14.06											0.27	5.26	1.47
	Industrial Manufacturing - Avg - Compo	91121				3.29	9.86											0.30	7.36	0.89
	Chemical Manufacturing - Avg - Compo	91124				1.04	3.13											0.35	9.18	1.83
	Cement Production - Composite	91127	0.06	0.00	0.08	6.56	17.68	0.00	0.01	4.23	0.01	0.09	0.35	0.02	0.41	0.01	2.34	4.69	12.68	2.93
	Surface Coating - Composite	91129	0.05		0.01			0.71		3.81		0.01	25.50			0.07			20.76	0.70
	Food & Ag - Handling - Composite	91130	0.01	0.01		0.36	0.36	0.02		8.14	0.01	0.01			0.01		0.11		4.05	0.18
	Wood Products-Sawing - Composite	91131	0.05			0.18	0.55			0.30	0.05		0.05		0.05			0.55	44.50	3.80
	Meat Frying - Composite	91135	0.20		0.09	0.30	0.91		0.01			0.01						2.08	57.40	
	Lime Kiln - Composite	91138	0.03	0.01	0.01	12.32	36.95	0.01	0.00	0.29	0.03	0.01	0.02	0.01	0.01	0.01		0.56	6.65	2.32
	Charcoal Manufacturing - Composite	91140	0.09			3.10	6.50			15.00			0.36	0.03	0.36			0.30	1.80	5.20
	Fiberglass Manufacturing - Composite	91142	0.05			0.18	0.55		0.05						0.05			0.55	28.00	2.00
	Glass Furnace - Composite	91143	0.20		0.01	17.60	48.90	0.00	0.01	0.32	0.02	0.00	0.00	0.01	0.02			0.02	0.71	0.06
	Pulp & Paper Mills - Composite	91144				17.42	50.56													0.10
	Misc. Sources - Composite	91147				1.84	5.51											0.16	8.77	4.41
	Asphalt Roofing - Composite	91148	0.00			0.03	0.09			0.02					0.01		0.34	0.01	60.30	0.01
	Inorganic Chemical Manufacturing - Co	91149				1.04	3.13											0.35		
	Food & Ag-Drying - Composite	91154				0.02	0.05			5.00								0.05	12.00	
	Asphalt Manufacturing - Composite	91159		0.00	0.00	0.23	0.66		0.00	14.66		0.03	0.44			0.02	0.16	0.10	4.32	5.72
	Ammonium Nitrate Production - Compo	91163															21.35	73.53		
	Limestone Dust - Composite	91164	0.14			0.57	1.71			4.45		0.04	0.06	0.00	0.05					
	Phosphate Manufacturing - Composite	91165	0.02	0.00	0.01	0.87	2.61	0.03	0.00	2.79	0.01	0.01	0.01	0.03	0.08	0.00	3.59	0.20	7.84	2.74
	Gypsum Manufacturing - Composite	91166	0.05			13.66	41.00		0.05			0.05			0.05			0.05		
	Urea Fertilizer - Composite	91167				1.30	4.00		0.05						0.05			0.55	31.00	2.00
	Brick Grinding and Screening - Composi	91171	0.01	0.01	0.00	0.59	0.98	0.01	0.00	9.92	0.01	0.05	0.14		0.02	0.01	0.04	0.22	2.42	0.06
	Calcium Carbide Furnace - Composite	91172	0.01			1.60	3.20			2.50					0.02			0.57	7.30	1.20
	Potato Deep Frying - Composite	91175																	62.70	4.00
	Ammonium Sulfate Production - Compo	91181				24.23	58.63										22.02			
	Inorganic Fertilizer - Composite	91182	0.07	0.00	0.00	1.13	2.67	0.13	0.00	3.51	0.04	0.32	0.58	0.24	0.22	0.07	0.03	0.04	2.99	1.11
	Boric Acid Manufacturing - Composite	91183				0.66	2.00								0.05			0.55		
Mobile	HDDV Exhaust - Composite	91106		0.00		0.25	0.29	0.00			0.00		0.00	0.00	0.07			0.11	17.56	77.12
	Nonroad Gasoline Exhaust - Composite	91113	0.03			0.02	0.05	0.02		0.12					0.03			0.07	47.52	12.18
	Onroad Gasoline Exhaust - Composite	91122	0.05	0.01	0.00	0.54	0.81	0.02	0.00	0.47	0.01	0.00	0.01	0.00	0.26	0.00	1.67	0.15	54.93	19.00
	Brake Lining Dust - Composite	91134	0.01		0.01	1.11	3.34		0.00	8.80	0.66	0.06	0.36	0.03	0.17		0.00	0.16	10.70	2.61
	Tire Dust - Composite	91150	0.02			1.04	3.11		0.00	0.12		0.01	0.04		0.53		0.02	0.15	47.15	22.00
	LDDV Exhaust - Composite	91162	0.02	0.00		0.47	0.86	0.01		0.30	0.00				0.06		0.73	0.23	35.53	51.41
Natural (	Natural Gas Combustion - Composite	91112				2.87	8.60											2.10	24.70	38.40
	Process Gas Combustion - Composite	91136	0.00		0.00	5.09	16.57	0.00	0.00	1.86	0.00	0.00			3.00		7.60	2.37	30.13	14.57
	Residential Natural Gas Combustion - C	91156			0.02	4.20	12.60		0.06	0.28			0.10	0.02			0.44	3.41	48.98	6.70
Nonferro	Aluminum Processing - Composite	91132	0.08		0.01	3.00	8.65	0.58	0.01	4.76	0.05	0.01	0.03	0.01	0.08	0.00		1.38	1.50	0.19
	Aluminum Production - Composite	91137	0.01			1.40	4.40			0.34			0.04	0.06	0.02			0.41	3.90	2.30
	Copper Processing - Composite	91158			0.00	0.02	0.05		0.16		0.44				2.21	0.00			1.00	0.10
	Lead Processing - Composite	91168				2.51	7.53	0.20		0.30	2.00			0.00	0.30					
	Copper Production - Composite	91170				0.05	0.15	1.51	0.64		0.42	0.00	0.01	0.00	4.56	0.01				
	Lead Production - Composite	91178	14.23	0.05		7.54	22.63	0.97	0.05	1.62	0.61	0.06	0.07		33.00					
Oil	Distillate Oil Combustion - Composite	91115				2.74	19.00			0.80					0.16				25.00	10.00
	Residual Oil Combustion - Composite	91117				12.59	44.00	0.02	0.01				0.06	0.08	0.01				1.00	1.00
	Catalytic Cracking - Composite	91141	0.01		0.00	14.28	32.69	0.07	0.00	19.82	0.00	0.01	0.67	0.26	0.02	0.01	0.33		0.01	0.07
	Petroleum Industry - Avg - Composite	91145				7.83	23.50											0.28	3.50	
Sea Salt	Sea Salt - Composite	91176				3.29	9.98													
Soil	Agricultural Soil - Composite	91101	0.01		0.01	0.15	0.11			24.44		0.03	0.52	0.03	0.02	0.01	0.06	0.06	3.08	0.02
	Dairy Soil - Composite	91118		0.01		2.61	4.46		0.01	3.99		0.02	0.05		0.03		3.33	9.26	31.83	5.16
	Crustal Material - Composite	91169	0.01	0.00	0.01	0.16	0.18	0.00		22.07	0.00	0.02	0.46	0.01	0.02	0.02	0.13	0.06	5.38	0.20
	Industrial Soil - Composite	91174	0.02		0.00	0.84	2.51			11.24		0.03	0.29	0.02	0.12	0.02	0.14	0.03	1.01	1.13
Waste	Solid Waste Combustion - Composite	91126		0.01	0.01	2.90	6.80	0.01	0.00	6.87	0.01	0.02	0.24	0.01	0.50	0.02	8.22	1.42	8.41	1.52
	Sludge Combustion - Composite	91177	2.94			6.33	19.00	0.05	0.15	4.77	1.39		0.44	0.18	0.36			1.42	8.41	1.52
Wood	Wildfires - Composite	91102	0.00		0.00	0.43	1.26	0.00	0.00	0.18	0.00	0.00	0.01	0.00	0.02	0.00	0.88	0.13	46.18	9.49
	Agricultural Burning - Composite	91103	0.00	0.01	0.01	0.65	1.65			0.02			0.00		0.01		1.80	0.35	38.82	10.90
	Residential Wood Combustion - Compos	91105	0.00		0.00	0.18	0.41			0.03	0.00				0.02		0.15	0.19	52.82	5.58
	Prescribed Burning - Composite	91109	0.01			0.14	0.33			0.01	0.02		0.07	0.00	0.23		0.34	1.07	50.19	10.93
	Wood Fired Boiler - Composite	91114				3.10	6.53			13.55									35.11	3.71
	Slash Burning - Composite	91146	0.07			0.42	1.27			0.16	0.03		0.01	0.00	0.05			0.13	52.17	4.35
	Wood Products - Sanding - Composite	91152										0.05							35.00	6.00
	Wood Products - Drying - Composite	91128				1.40	3.65			0.25					0.06			1.25	50.00	8.00

Table S6. Facility emissions of $PM_{2.5}$ and PM_{10} for 50 largest point sources in Wayne County.

			Ave	PM2.5									PM10								
Rank	Facility	SRM	Total	2000	2005	2010	2015	2016	2017	2018	2019	2020	2000	2005	2010	2015	2016	2017	2018	2019	2020
1	TRENTON CHANNEL POWER PLANT	B2811	16626	339	32	28	13	9	13	8	11	2	339	628	483	93	76	59	42	55	13
2	NATIONAL STEEL CORPORATION GREAT LAKES DIVI	A7809	15700	1122	333	83	86	87	86	87	69	29	1122	702	219	93	115	196	115	89	47
3	ROUGE STEEL COMPANY	A8640	14041	422	220	67	48	65	180	181	198	187	422	661	319	126	143	220	223	237	214
4	DETROIT EDISON RIVER ROUGE POWER PLANT	B2810	9087	67	14	7	6	3	3	1	0	0	67	56	28	23	13	12	6	2	0
5	EES COKE BATTERY L.L.C.	P0408	4502	0	0	0	22	133	125	152	152	138	0	0	0	268	139	133	161	165	146
6	DEARBORN INDUSTRIAL GENERATION, L.L.C.	N6631	1842	37	0	71	49	62	76	105	107	88	37	87	71	49	62	76	105	107	88
7	MARATHON ASHLAND PETROLEUM LLC	A9831	1566	167	0	19	68	75	85	84	59	59	167	43	83	76	83	96	92	60	68
8	RESEARCH & ENGINEERING CENTER	B6230	1413	4	3	6	5	5	3	4	5	4	4	3	6	5	5	3	4	5	4
9	GREATER DETROIT RESOURCE RECOVERY FACILITY	M4148	1339	20	0	0	0	1	1	1	0	0	20	6	5	83	50	40	22	5	0
10	MARBLEHEAD LIME COMPANY - RIVER ROUGE	B2169	977	38	11	4	7	5	11	6	11	7	60	78	52	59	60	39	44	29	30
11	DETROIT LIME, INC.	B3520	886	101	0	0	0	0	0	0	0	0	101	0	0	0	0	0	0	0	0
12	CITY OF WYANDOTTE MUNICIPAL POWER PLANT	B2132	884	331	8	3	5	3	1	1	1	2	331	35	8	8	4	1	1	1	2
13	GENERAL MOTORS CORPORATION DETROIT - HAM	M4199	821	11	0	5	1	0	0	0	1	0	11	9	11	3	4	2	2	1	0
14	JEFFERSON NORTH ASSEMBLY PLANT, DAIMLERCHR	N2155	798	16	3	43	4	29	32	2	31	2	16	3	43	4	30	33	3	33	27
15	AUTOMATIC TRANSMISSION NEW PRODUCT CENTER	M4734	789	4	10	4	3	3	3	4	2	2	4	10	4	3	3	3	4	2	2
16	FORD MOTOR CO. - ROUGE COMPLEX (ASMBLY/ENG/I	A8648	788	4	4	8	8	9	10	16	16	12	25	16	22	16	16	17	24	24	17
17	PLYMOUTH ROAD OFFICE COMPLEX	A8627	732	2	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
18	CENTRAL WAYNE ENERGY RECOVERY, L.P.	B4281	719	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
19	DETROIT WASTEWATER TREATMENT PLANT	B2103	556	153	0	0	0	10	24	21	19	18	153	20	4	4	14	35	27	24	24
20	CARLETON FARMS LANDFILL	N5986	538	5	1	1	0	0	0	0	0	2	50	53	93	33	38	9	38	35	35
21	FORD MOTOR CO. - WAYNE COMPLEX-STMP & ASMB	A8650	529	7	4	2	2	3	3	4	6	4	34	19	6	4	5	5	5	8	6
22	AUTOALLIANCE INTERNATIONAL, INC.	N0929	468	1	0	4	5	5	4	4	4	3	1	0	4	15	11	14	14	12	9
23	ROUSH INDUSTRIES	M4780	430	2	2	4	1	2	2	1	1	1	3	2	4	1	2	3	1	1	1
24	DETROIT DIESEL CORPORATION	A8638	305	81	2	3	2	1	1	1	1	1	81	2	3	2	2	1	1	1	1
25	BEACON HEATING PLANT	B2814	302	17	8	6	3	3	4	8	13	11	17	8	6	3	3	4	8	13	11
26	TRENTON FORGING	N7250	297	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
27	MISTERSKY POWER STATION	B2185	290	18	56	9	0	0	0	0	0	0	18	56	9	0	0	0	0	0	0
28	IPMC AQUISITION, L.L.C.	A7051	284	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
29	WOODLAND MEADOWS RDF	M4449	262	2	9	13	17	19	19	9	9	7	38	31	61	61	65	76	89	103	124
30	RIVERVIEW LAND PRESERVE	M4469	190	17	1	0	3	2	1	2	2	2	26	43	21	7	6	16	7	10	11
31	ATOFINA CHEMICALS, INC.	B2173	160	1	4	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0
32	CITY SAND & LANDFILL, INC.	M4510	156	6	0	0	0	0	0	0	0	0	6	3	1	0	0	0	0	0	0
33	DAIMLERCHRYSLER TRENTON ENGINE PLANT	B3350	136	2	3	1	1	1	1	1	1	1	2	3	7	6	7	6	6	7	4
34	FORD MOTOR COMPANY-ELM STREET BOILERHOUSE	M4764	120	3	5	5	5	5	4	4	4	1	3	5	5	5	5	4	4	4	1
35	DAIMLERCHRYSLER DETROIT AXLE PLANT	B3160	118	13	2	1	0	0	0	0	0	0	13	2	1	0	0	0	0	0	0
36	GM ROMULUS ENGINEERING CENTER	M4781	116	7	1	0	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0
37	NORTHVILLE COMPRESSOR STATION	N1099	111	0	0	0	2	1	2	2	3	2	0	0	0	2	1	2	2	3	2
38	SOLUTIA INC.	B2155	106	1	0	0	0	0	0	0	0	0	37	5	1	2	2	1	0	1	1
39	FEDERAL-MOGUL TECHNICAL CENTER	N6327	105	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
40	HONEYWELL	B5558	99	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
41	Sumpter Generating Plant	M4854	93	0	5	2	10	14	7	16	11	14	0	5	2	10	14	7	16	11	14
42	SEIBERT OXIDERMO INC.	N0324	91	41	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0
43	CONNERS CREEK POWER PLANT	B2812	88	4	5	0	0	0	0	0	0	0	4	5	0	0	0	0	0	0	0
44	SAUK TRAIL HILLS DEVELOPMENT, INC.	N6009	86	5	5	7	1	0	1	1	1	1	34	42	23	20	19	20	28	29	26
45	EQ-SITE #2	M4782	85	6	0	2	0	0	0	0	0	0	6	15	10	9	9	10	9	6	6
46	COMMONWEALTH INDUSTRIES	B3497	84	20	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0
47	WHITE TOWER INDUSTRIAL LAUNDRY & CLEANERS	K0291	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	FORD MOTOR COMPANY - LIVONIA TRANSMISSION I	A8645	70	2	3	9	10	9	9	26	26	19	2	3	9	10	9	9	26	26	19
49	MACK AVENUE ENGINE PLANT	M4085	66	0	1	1	1	1	1	1	0	0	0	4	1	1	1	1	1	0	0
50	VISTEON CORPORATION TECHNICAL CENTER	B7071	66	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TOTAL		79994	3105	761	420	388	565	714	753	767	620	3337	2675	1628	1104	1014	1156	1132	1111	955
	COUNTY TOTAL		83530	3506	815	494	432	612	766	804	833	686	3824	2931	1910	1294	1204	1370	1327	1358	1156

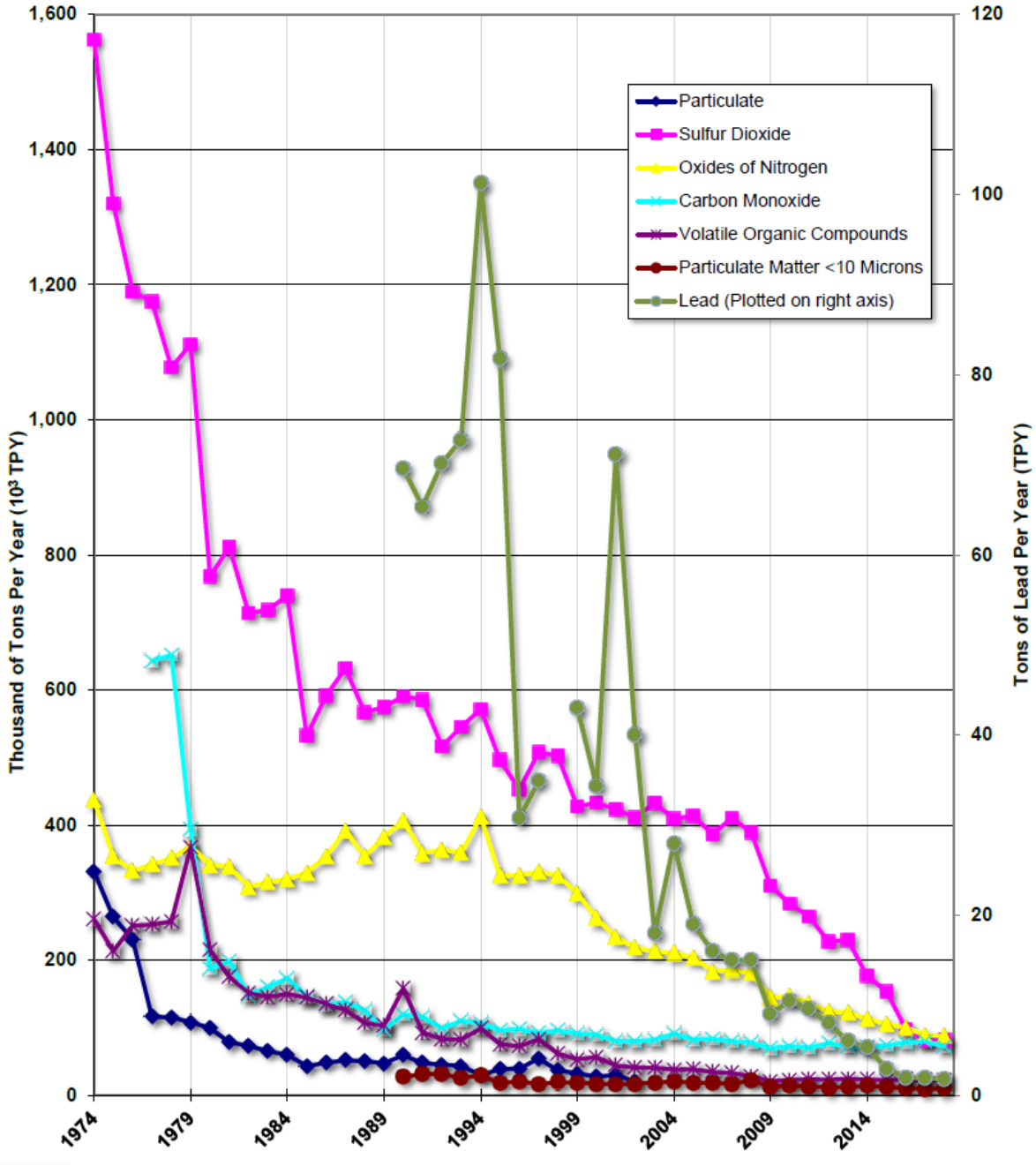
Table S7. Facility emissions of NOx and SO_2 for top 50 sources in Wayne County.

			SO2									NOx								
Rank	Facility	SRM	2000	2005	2010	2015	2016	2017	2018	2019	2020	2000	2005	2010	2015	2016	2017	2018	2019	2020
1	TRENTON CHANNEL POWER PLANT	B2811	27809	27437	23469	14456	9943	6178	3114	3754	885	7712	5775	5202	2646	1955	1812	1096	1290	267
2	NATIONAL STEEL CORPORATION GREAT LAKES DIVI	A7809	4844	4431	5845	2273	1488	1502	1483	1031	523	4063	3290	1889	1057	1333	980	1034	905	402
3	ROUGE STEEL COMPANY	A8640	98	236	651	723	689	596	572	585	446	1195	1599	611	389	358	378	413	395	241
4	DETROIT EDISON RIVER ROUGE POWER PLANT	B2810	12499	12002	14422	6395	2806	2504	2118	1556	609	6913	3940	4372	2607	1873	1519	1368	1092	362
5	EES COKE BATTERY L.L.C.	P0408	0	0	0	2452	1556	2819	3254	3193	2089	0	0	0	1135	726	1351	1379	1567	1210
6	DEARBORN INDUSTRIAL GENERATION, L.L.C.	N6631	4	756	464	746	1039	979	820	932	828	995	380	395	445	602	526	594	651	653
7	MARATHON ASHLAND PETROLEUM LLC	A9831	1467	187	104	193	215	221	168	140	134	1728	484	402	401	390	388	352	371	347
8	RESEARCH & ENGINEERING CENTER	B6230	3	3	5	4	4	3	3	4	3	55	56	90	72	69	46	51	63	40
9	GREATER DETROIT RESOURCE RECOVERY FACILITY	M4148	92	140	105	182	146	124	107	43	0	1450	887	1296	1185	1246	1212	982	189	0
10	MARBLEHEAD LIME COMPANY - RIVER ROUGE	B2169	141	155	358	700	438	446	483	248	149	415	437	442	558	565	435	471	553	332
11	DETROIT LIME, INC.	B3520	31	0	0	0	0	0	0	0	0	588	0	0	0	0	0	0	0	0
12	CITY OF WYANDOTTE MUNICIPAL POWER PLANT	B2132	1718	1529	447	19	3	0	0	0	0	879	659	1147	84	40	10	9	8	55
13	GENERAL MOTORS CORPORATION DETROIT - HAM	M4199	580	333	354	9	0	0	0	0	0	663	373	200	16	21	12	14	12	6
14	JEFFERSON NORTH ASSEMBLY PLANT, DAIMLERCHR	N2155	0	0	0	0	0	0	0	0	0	55	39	53	57	53	55	59	57	66
15	AUTOMATIC TRANSMISSION NEW PRODUCT CENTER	M4734	3	9	3	1	0	0	0	0	0	54	140	43	56	49	47	49	34	26
16	FORD MOTOR CO. - ROUGE COMPLEX (ASMBLY/ENG/I	A8648	0	0	0	0	0	0	0	0	0	61	48	52	57	60	64	69	68	53
17	PLYMOUTH ROAD OFFICE COMPLEX	A8627	1	1	0	0	0	0	0	0	0	34	26	0	0	0	0	0	0	0
18	CENTRAL WAYNE ENERGY RECOVERY, L.P.	B4281	3	0	0	0	0	0	0	0	0	495	0	0	0	0	0	0	0	0
19	DETROIT WASTEWATER TREATMENT PLANT	B2103	53	64	51	44	9	13	1	1	1	268	319	254	222	81	149	205	190	151
20	CARLETON FARMS LANDFILL	N5986	4	8	22	20	20	18	68	95	118	144	146	150	102	99	94	99	100	127
21	FORD MOTOR CO. - WAYNE COMPLEX-STMP & ASMB	A8650	9	1	3	1	1	1	0	0	0	163	105	65	47	45	57	63	73	57
22	AUTOALLIANCE INTERNATIONAL, INC.	N0929	0	0	0	0	0	0	0	0	2	4	4	45	60	55	52	47	50	50
23	ROUSH INDUSTRIES	M4780	2	1	4	1	2	2	1	1	1	68	32	63	19	36	42	18	14	15
24	DETROIT DIESEL CORPORATION	A8638	70	6	8	6	4	4	5	5	4	1132	134	158	44	35	34	88	124	89
25	BEACON HEATING PLANT	B2814	1	1	1	0	0	0	1	1	1	432	203	235	74	68	106	162	302	266
26	TRENTON FORGING	N7250	0	0	0	0	0	0	0	0	0	0	110	0	0	0	0	0	0	0
27	MISTERSKY POWER STATION	B2185	20	2	1	0	0	0	0	0	0	297	572	92	1	0	0	0	0	0
28	IPMC AQUISITION, L.L.C.	A7051	0	0	0	0	0	0	0	0	0	213	0	0	0	0	0	0	0	0
29	WOODLAND MEADOWS RDF	M4449	1	10	12	16	17	17	23	30	28	3	14	35	38	41	41	20	19	17
30	RIVERVIEW LAND PRESERVE	M4469	5	11	21	83	97	37	57	40	45	30	67	48	59	61	61	60	61	60
31	ATOFINA CHEMICALS, INC.	B2173	0	0	0	0	0	0	0	0	0	70	89	0	0	0	0	0	0	0
32	CITY SAND & LANDFILL, INC.	M4510	4	2	1	0	0	0	0	0	0	83	40	16	0	0	0	0	0	0
33	DAIMLERCHRYSLER TRENTON ENGINE PLANT	B3350	0	0	0	0	0	0	0	0	0	74	58	20	17	22	78	22	22	21
34	FORD MOTOR COMPANY-ELM STREET BOILERHOUSE	M4764	0	0	0	0	0	0	0	0	0	128	82	90	138	76	81	73	79	18
35	DAIMLERCHRYSLER DETROIT AXLE PLANT	B3160	0	0	0	0	0	0	0	0	0	16	22	16	0	0	0	0	0	0
36	GM ROMULUS ENGINEERING CENTER	M4781	6	7	0	0	0	0	0	0	0	102	49	0	0	0	0	0	0	0
37	NORTHVILLE COMPRESSOR STATION	N1099	0	0	0	0	0	0	0	0	0	71	24	20	111	80	121	104	166	147
38	SOLUTIA INC.	B2155	0	0	0	0	0	0	0	0	0	5	0	0	0	9	0	0	0	0
39	FEDERAL-MOGUL TECHNICAL CENTER	N6327	1	2	1	1	1	1	1	1	1	14	35	13	11	17	10	12	15	9
40	HONEYWELL	B5558	72	0	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0	0
41	Sumpter Generating Plant	M4854	0	0	0	1	1	0	1	1	1	0	21	8	48	72	39	89	61	74
42	SEIBERT OXIDERMO INC.	N0324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	CONNERS CREEK POWER PLANT	B2812	1	1	0	0	0	0	0	0	0	61	70	0	0	0	0	0	0	0
44	SAUK TRAIL HILLS DEVELOPMENT, INC.	N6009	5	8	2	11	7	11	10	18	15	9	15	25	16	9	13	12	14	12
45	EQ-SITE #2	M4782	1	1	1	1	1	0	0	0	0	163	117	106	38	32	26	2	2	2
46	COMMONWEALTH INDUSTRIES	B3497	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0
47	WHITE TOWER INDUSTRIAL LAUNDRY & CLEANERS	K0291	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	FORD MOTOR COMPANY - LIVONIA TRANSMISSION F	A8645	0	0	0	0	0	0	0	0	0	90	57	33	14	8	7	8	6	4
49	MACK AVENUE ENGINE PLANT	M4085	0	0	0	0	0	0	0	0	0	10	24	10	14	8	14	17	11	0
50	VISTEON CORPORATION TECHNICAL CENTER	B7071	0	0	0	0	0	0	0	0	0	6	3	0	0	0	0	0	0	0
	TOTAL		49551	47346	46357	28339	18488	15479	12293	11681	5882	31069	20543	17694	11839	10192	9859	9040	8564	5180
	COUNTY TOTAL		49680	47425	46395	28355	18508	15501	12343	11759	5970	31651	21136	18380	12200	10551	10244	9464	9007	5591

Table S8. Facility emissions of CO and VOCs of top 50 sources in Wayne County.

			CO									VOC								
Rank	Facility	SRM	2000	2005	2010	2015	2016	2017	2018	2019	2020	2000	2005	2010	2015	2016	2017	2018	2019	2020
1	TRENTON CHANNEL POWER PLANT	B2811	477	565	441	344	282	303	192	237	72	58	68	1	0	2	0	1	1	2
2	NATIONAL STEEL CORPORATION GREAT LAKES DIVI	A7809	11395	10950	9746	12124	13381	14906	12854	10775	2105	263	1225	226	51	57	52	51	44	22
3	ROUGE STEEL COMPANY	A8640	9049	9717	16260	11297	13375	16553	17048	12733	7205	53	45	40	50	52	48	48	35	26
4	DETROIT EDISON RIVER ROUGE POWER PLANT	B2810	385	385	458	385	274	176	188	181	78	39	45	2	5	4	5	4	4	4
5	EES COKE BATTERY L.L.C.	P0408	0	0	0	439	241	405	585	578	334	0	0	0	114	74	90	103	142	167
6	DEARBORN INDUSTRIAL GENERATION, L.L.C.	N6631	1318	582	402	215	340	282	305	287	265	20	5	5	5	6	15	18	9	8
7	MARATHON ASHLAND PETROLEUM LLC	A9831	487	113	99	166	145	158	127	148	178	900	453	615	366	370	343	322	366	282
8	RESEARCH & ENGINEERING CENTER	B6230	2123	2014	1536	1903	1770	558	534	571	583	80	103	64	84	77	27	27	27	26
9	GREATER DETROIT RESOURCE RECOVERY FACILITY	M4148	346	230	254	407	367	358	312	59	0	4	2	3	3	34	32	19	5	0
10	MARBLEHEAD LIME COMPANY - RIVER ROUGE	B2169	201	211	57	72	73	210	80	72	43	0	1	0	0	0	0	0	0	0
11	DETROIT LIME, INC.	B3520	167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	CITY OF WYANDOTTE MUNICIPAL POWER PLANT	B2132	358	77	364	58	35	11	10	8	22	4	6	0	3	2	1	1	1	3
13	GENERAL MOTORS CORPORATION DETROIT - HAM	M4199	306	181	87	3	0	0	0	0	5	1741	653	286	284	446	256	259	190	53
14	JEFFERSON NORTH ASSEMBLY PLANT, DAIMLERCHR	N2155	35	64	33	8	9	5	5	5	43	833	853	225	648	736	763	809	790	631
15	AUTOMATIC TRANSMISSION NEW PRODUCT CENTER	M4734	1027	1954	513	543	460	494	517	386	356	50	101	20	23	23	23	24	18	17
16	FORD MOTOR CO. - ROUGE COMPLEX (ASMBLY/ENG/I	A8648	29	55	27	14	13	14	15	15	12	456	408	691	828	837	818	830	800	514
17	PLYMOUTH ROAD OFFICE COMPLEX	A8627	521	821	0	0	0	0	0	0	0	25	31	0	0	0	0	0	0	0
18	CENTRAL WAYNE ENERGY RECOVERY, L.P.	B4281	213	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
19	DETROIT WASTEWATER TREATMENT PLANT	B2103	412	0	0	2	32	78	765	725	366	53	64	51	44	9	13	3	3	3
20	CARLETON FARMS LANDFILL	N5986	165	200	297	365	354	336	355	357	344	73	77	14	14	14	13	14	14	14
21	FORD MOTOR CO. - WAYNE COMPLEX-STMP & ASMB	A8650	113	45	16	8	10	9	9	11	9	1316	599	389	365	306	221	127	275	151
22	AUTOALLIANCE INTERNATIONAL, INC.	N0929	3	3	9	12	11	10	39	41	38	287	891	448	553	497	373	214	205	124
23	ROUSH INDUSTRIES	M4780	479	394	210	362	443	510	475	221	294	20	17	9	14	19	22	18	9	12
24	DETROIT DIESEL CORPORATION	A8638	260	40	37	26	19	19	22	22	18	79	26	14	10	13	42	24	19	16
25	BEACON HEATING PLANT	B2814	168	90	69	30	28	44	64	128	114	12	6	5	3	3	4	7	10	9
26	TRENTON FORGING	N7250	0	185	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
27	MISTERSKY POWER STATION	B2185	191	143	23	0	0	0	0	0	0	13	11	2	0	0	0	0	0	0
28	IPMC AQUISITION, L.L.C.	A7051	64	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
29	WOODLAND MEADOWS RDF	M4449	17	41	170	191	203	204	97	92	82	59	113	8	13	13	10	5	6	4
30	RIVERVIEW LAND PRESERVE	M4469	28	60	28	87	76	55	74	81	77	26	33	4	4	5	4	4	4	4
31	ATOFINA CHEMICALS, INC.	B2173	10	77	0	0	0	0	0	0	0	55	13	0	0	0	0	0	0	0
32	CITY SAND & LANDFILL, INC.	M4510	154	39	25	0	0	0	0	0	0	53	40	0	0	0	0	0	0	0
33	DAIMLERCHRYSLER TRENTON ENGINE PLANT	B3350	39	39	26	112	125	119	106	110	67	12	3	3	14	15	13	15	14	8
34	FORD MOTOR COMPANY-ELM STREET BOILERHOUSE	M4764	61	36	27	40	17	22	20	22	5	4	4	3	4	3	3	3	3	1
35	DAIMLERCHRYSLER DETROIT AXLE PLANT	B3160	13	19	14	0	0	0	0	0	0	235	1	1	0	0	0	0	0	0
36	GM ROMULUS ENGINEERING CENTER	M4781	26	19	0	0	0	0	0	0	0	8	8	0	0	0	0	0	0	0
37	NORTHVILLE COMPRESSOR STATION	N1099	10	3	2	14	10	16	13	22	19	3	1	1	5	3	5	4	6	6
38	SOLUTIA INC.	B2155	5	0	0	0	6	0	0	0	0	109	106	95	115	100	89	94	90	76
39	FEDERAL-MOGUL TECHNICAL CENTER	N6327	196	85	68	51	76	77	103	60	48	9	3	1	1	3	3	4	4	3
40	HONEYWELL	B5558	2	0	0	0	0	0	0	0	0	82	0	0	0	0	0	0	0	0
41	Sumpter Generating Plant	M4854	0	13	6	10	5	32	61	49	47	0	2	1	3	4	2	5	4	4
42	SEIBERT OXIDERMO INC.	N0324	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0
43	CONNERS CREEK POWER PLANT	B2812	71	46	0	0	0	0	0	0	0	3	4	0	0	0	0	0	0	0
44	SAUK TRAIL HILLS DEVELOPMENT, INC.	N6009	16	25	41	34	19	30	27	33	28	0	45	15	1	1	1	1	1	1
45	EQ-SITE #2	M4782	46	23	25	22	19	16	4	4	4	20	3	1	1	1	2	3	1	1
46	COMMONWEALTH INDUSTRIES	B3497	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	WHITE TOWER INDUSTRIAL LAUNDRY & CLEANERS	K0291	0	0	0	0	0	0	0	0	0	81	68	0	0	0	0	0	0	0
48	FORD MOTOR COMPANY - LIVONIA TRANSMISSION F	A8645	51	16	7	3	1	2	2	1	1	6	4	26	2	13	21	48	52	39
49	MACK AVENUE ENGINE PLANT	M4085	27	56	41	80	100	107	23	14	0	2	4	3	6	6	6	3	1	0
50	VISTEON CORPORATION TECHNICAL CENTER	B7071	109	8	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0
	TOTAL		31214	29628	31420	29426	32320	36117	35031	28048	12859	7207	6148	3269	3635	3748	3320	3112	3156	2230
	COUNTY TOTAL		31871	30265	31855	29787	32648	36538	35466	28539	13309	8865	7456	4279	4663	4730	4273	4065	4137	2986

Figure S14. Michigan state-wide stationary (point) source emission trends from 1974 to 2018. From Michigan Department of Environment, Energy and Great Lakes, 2019.



Report notes: 1) Estimating methodologies, emission factors, and data availability can vary year to year. Caution should be exercised when evaluating trends in emission estimations and should only be interpreted in a qualitative manner; 2) The criteria emissions estimate data presented here represents the data reported from the facilities and is subject to limited quality assurance efforts by EGLE to identify, verify, and correct outlier data.

Source: Michigan Air Emissions Reporting System (MAERS), Michigan Dept. of Environment, Great Lakes, and Energy - Air Quality Division Revised December 16, 2019 https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/AQD/monitoring/emission-trends-stationary-point-sources.pdf?rev=b9e63faa8d254877af2e2892d3d31935&hash=E1DD451569759D417876D7CB4BC339F8

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