Chemical composition of PM_{10} and $PM_{2.5}$ in the Metropolitan Area of Costa Rica: Possible sources and Temporal Variations

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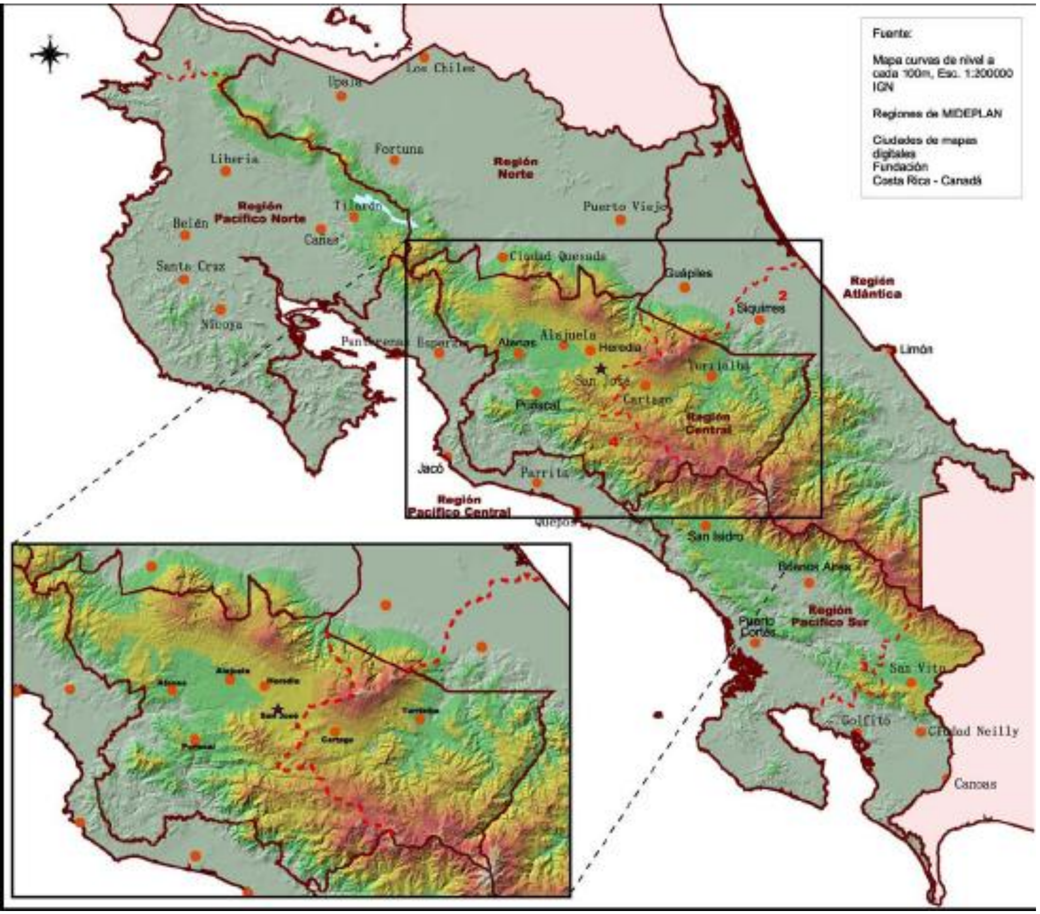
Particles PM_{10} and $PM_{2.5}$

-Particulate matter is a complex mixture of material that is directly emitted from sources and material formed by vapour nucleation/condensation mechanism, containing inorganic species as well as carbonaceous material).

-The concentration, composition, and particle size of suspended particulate matter at a given site are determined by such factors as meteorological properties of the atmosphere, topographical influences, emission sources, and by particle parameters (Koliadima et al., 1998).

-Exposure to airborne particulate matter is strongly associated with adverse health effects, affecting the respiratory and cardiovascular systems (Englert, 2004; WHO, 2005).

Metropolitan Area of Costa Rica



- Surface: 1967 km^2
- Altitude: 1300 masl
- Population: 2 493 940 habitants
- Vehicle Fleet: 745 500 units
- Includes 60% industries of Costa Rica
- Old technologies in combustion processes

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	PM_{10}	$PM_{2.5}$
Monitoring sites	3 Industrial 5 Urban 2 Residential 3 Urban Backgroud	1 Industrial 1 Residential 3 Urban background
Sampling	Each 2 days with high volumen samplers (1.13 m^3/min)	Each 2 days with low volumen samplers (5 l/min)
Parameters Analyzed	Ions (SO_4^{2-}, NO_3^-, Cl^-, NO_2^-, F^-, Br^- and PO_4^{3-}) -Metals (V, Ni, Pb, Cu, Cr, Mn, Al, Fe, Ca, Mg, Na, K) -OC and EC	Ions (SO_4^{2-}, NO_3^-, Cl^-, NO_2^-, F^-, Br^- and PO_4^{3-}) -Metals (V, Ni, Pb, Cu, Cr, Mn, Al, Fe, Ca, Mg, Na, K) -OC and EC
Quality Control	-5% of the filters were used as sampling blanks. -Analysis methods validated. -Mass reconstruction -Chemical balance	-5% of the filters were used as sampling blanks. -Analysis methods validated. -Mass reconstruction -Chemical balance

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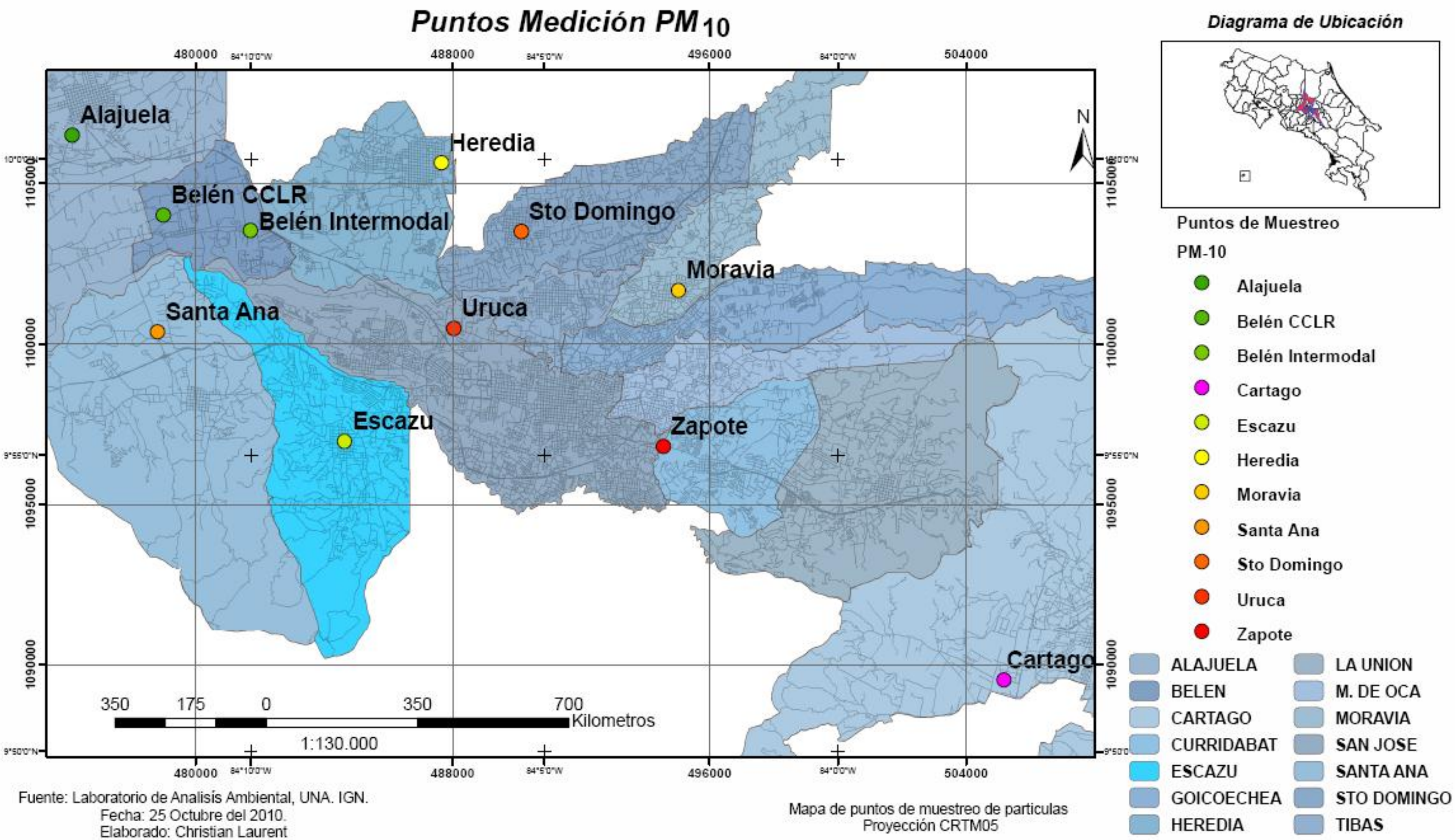
Ubicación de las Nuevas Estaciones



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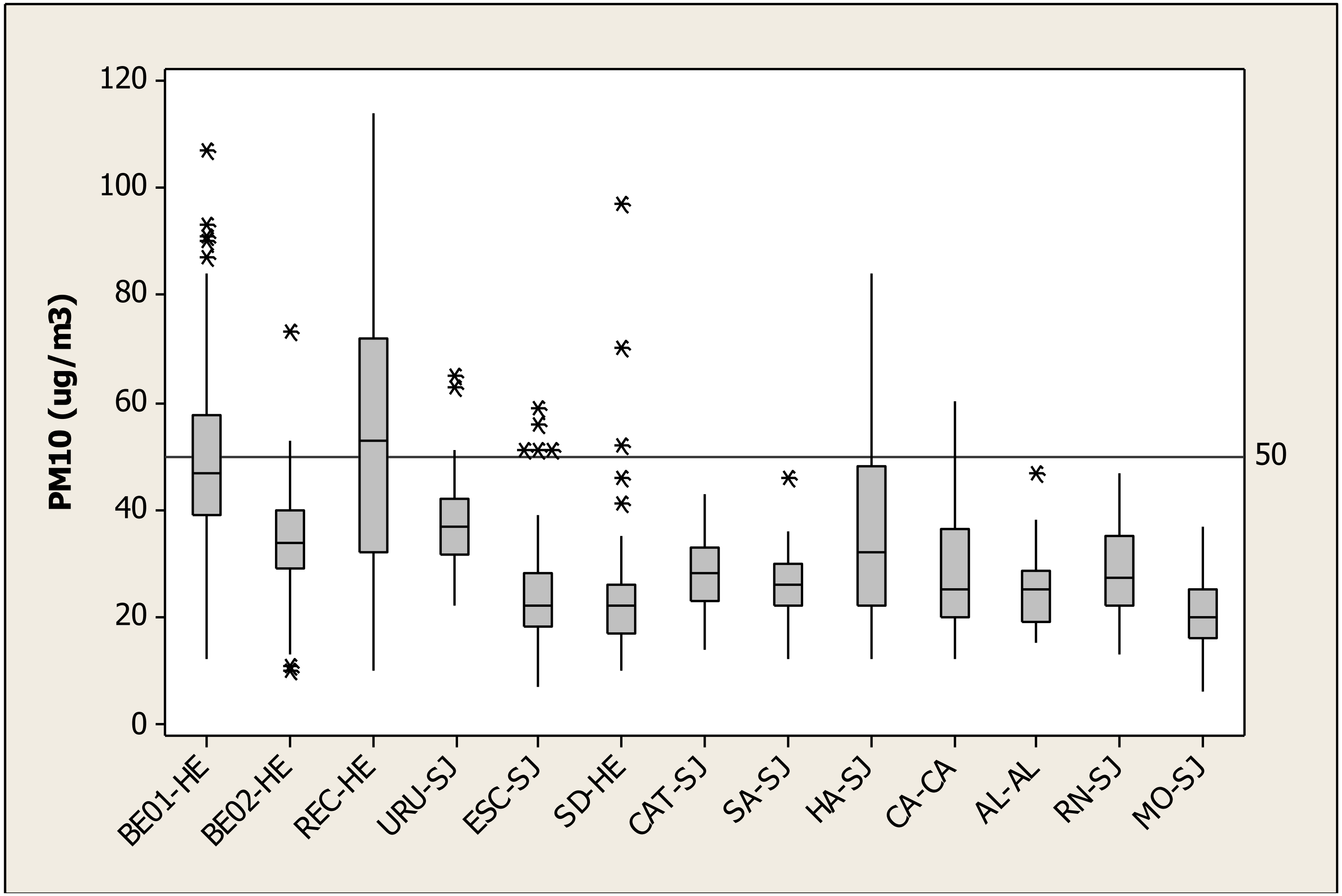

Average concentration and variation of PM_{10} in the Metropolitan Area of Costa Rica 2010

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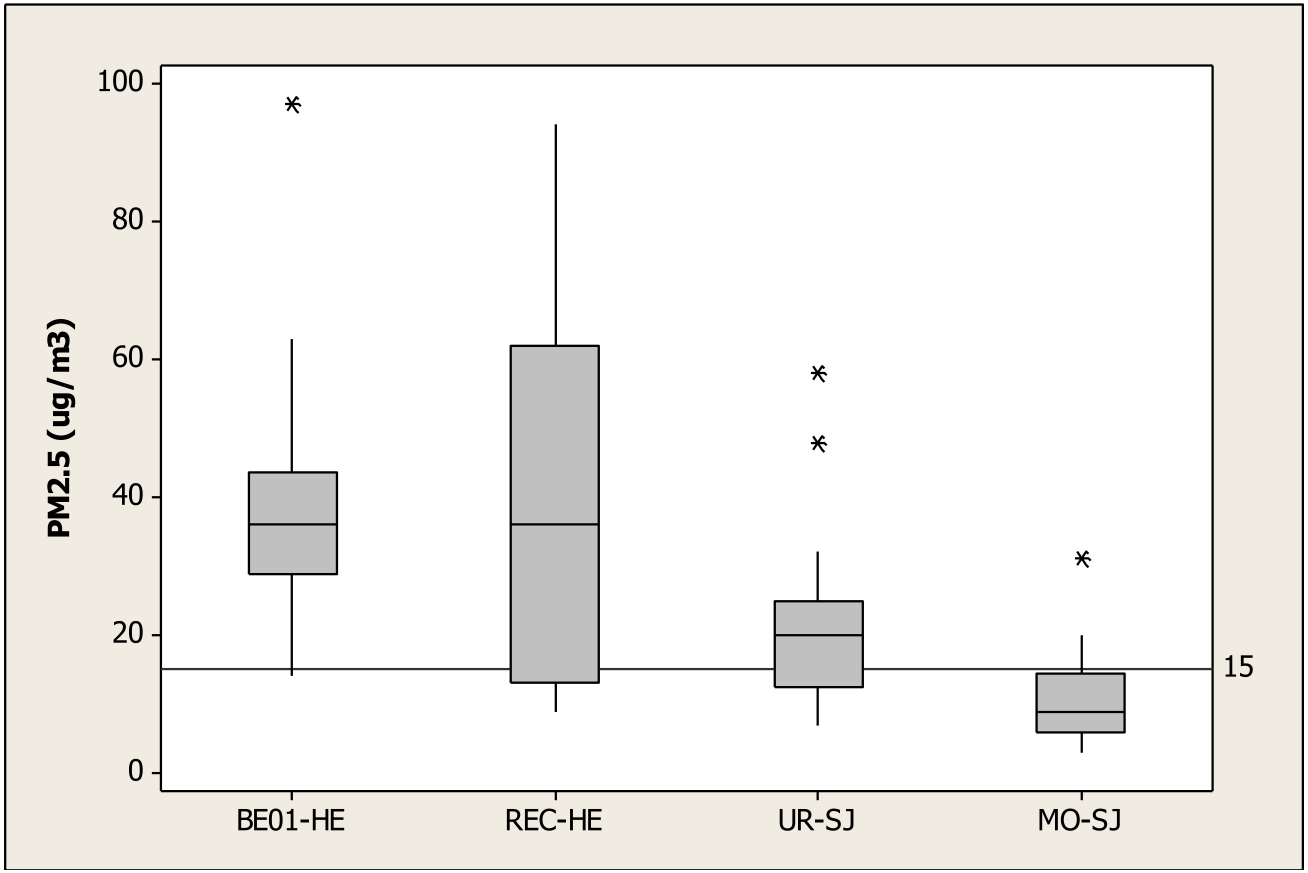

Average concentration and variation of $PM_{2.5}$ in the Metropolitan Area of Costa Rica 2010

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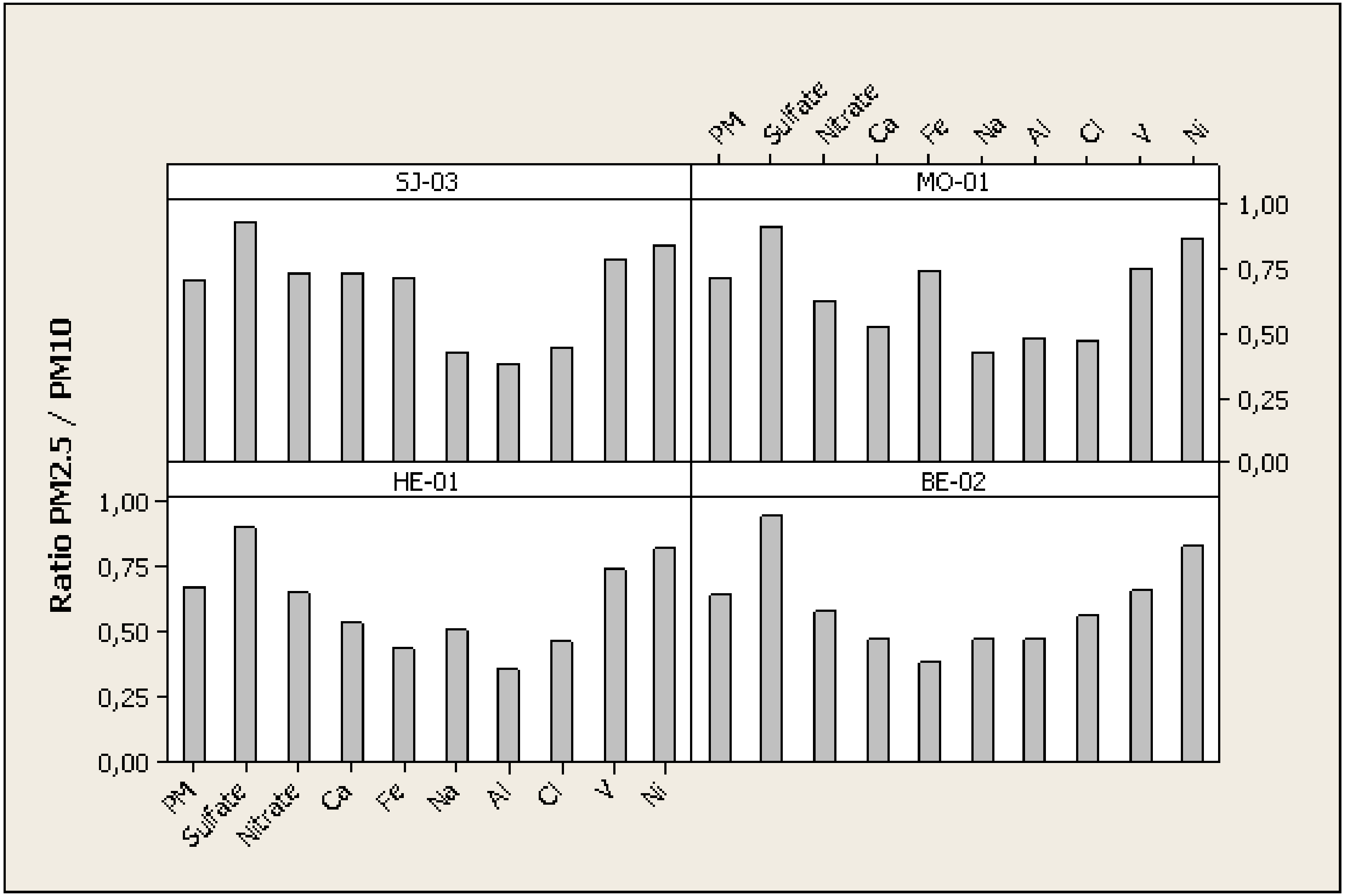

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Table 3-2. Carbon Components as a Function of Temperature and Added Oxygen

Fraction	Pyrolized Fraction	Temperature Range	Atmosphere	Reflectance vs. Initial
OC1		Ambient to 120°C	100% He	At Initial
OC2		120°C – 250°C		Under Initial
OC3		250°C – 450°C		
OC4		450°C – 550°C		
EC1	OP	Remains at 550°C	98% He 2% O_2	
				Over Initial
EC2		550°C – 700°C		
EC3		700°C – 800°C		

IMPROVE sample analysis procedures are fully documented Crocker Nuclear Laboratory SOP 276, *Optical Absorption Analysis*; SOP 301, *X-Ray Fluorescence Analysis*; and SOP 326, *PIXE and PESA Analysis*.

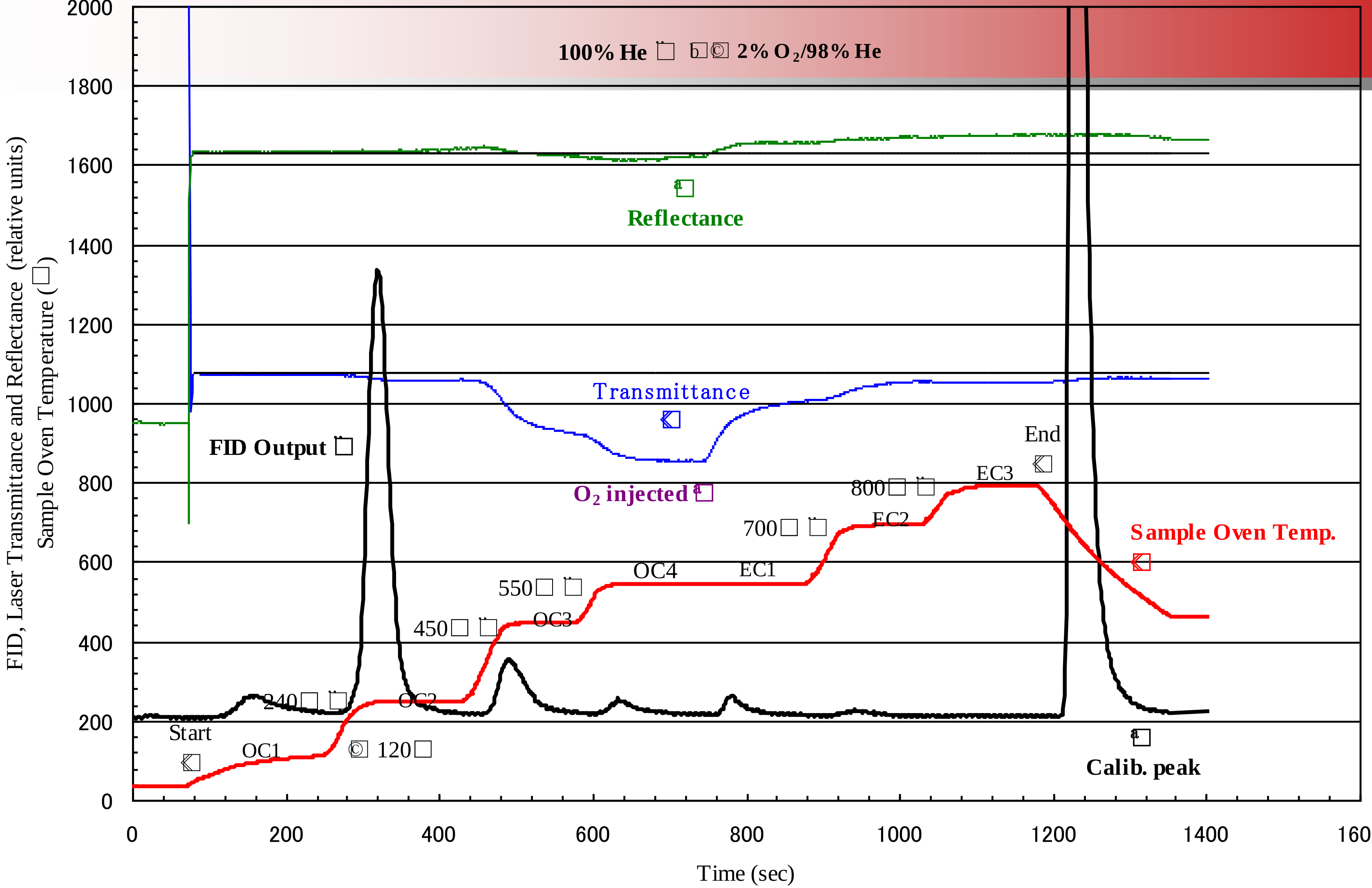

Fig. 3-1 IMPROVE protocol thermogram for the atmospheric sample measured by using the DRI Model 2001 OC/EC Carbon Analyzer.

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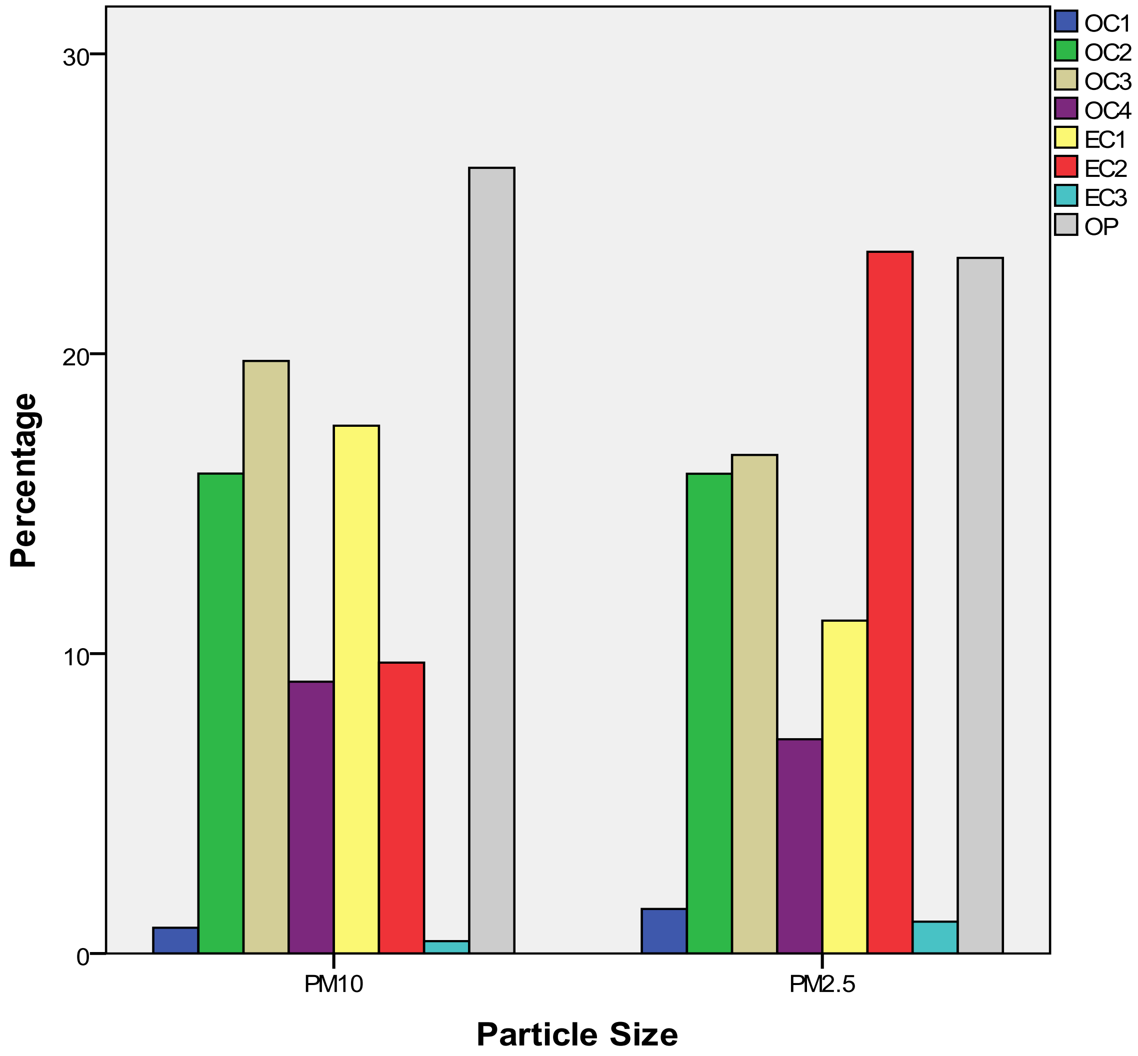
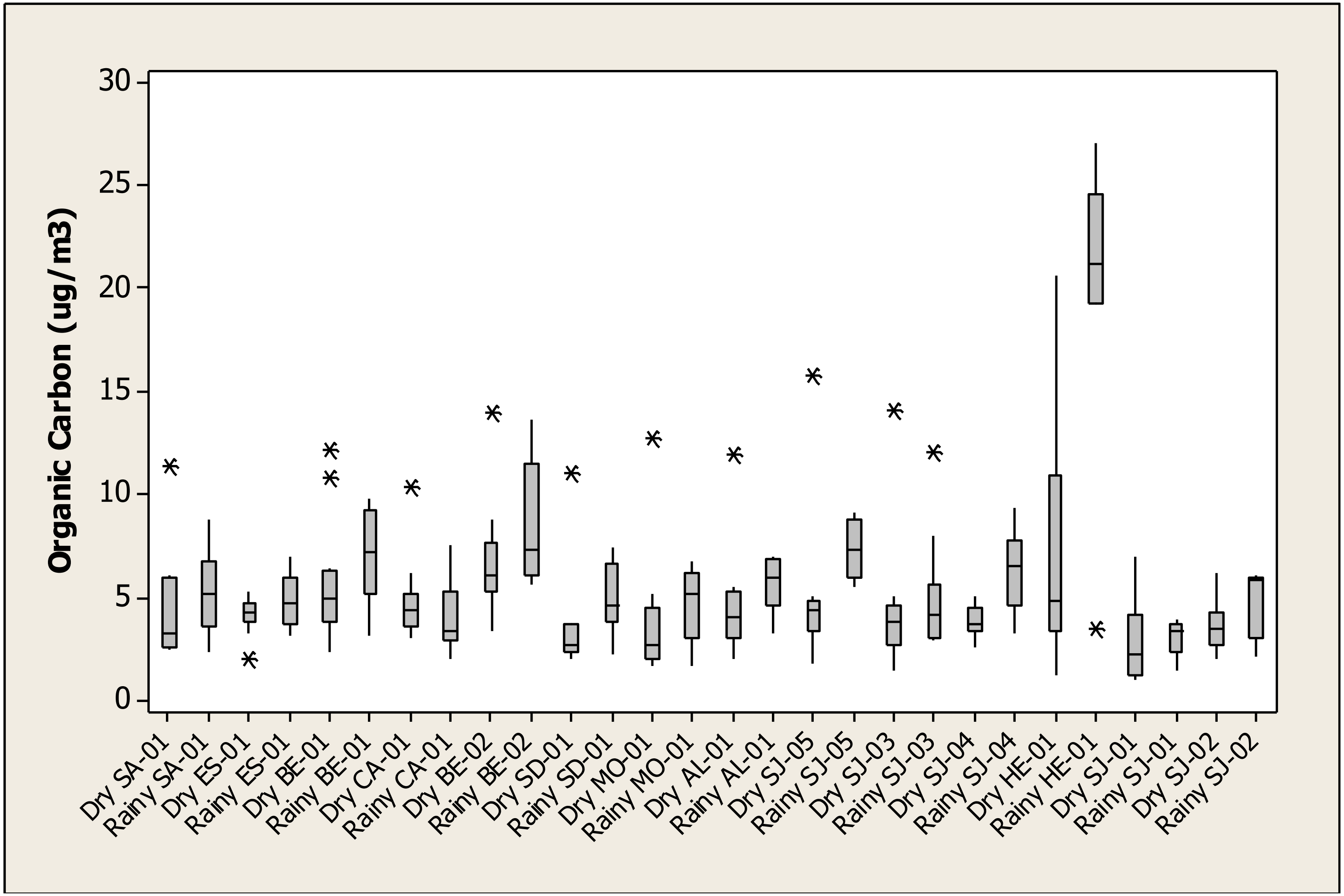
Mean composition of PM_{10} and $PM_{2.5}$



Mean composition of PM_{10} and $PM_{2.5}$



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Sampling Site	TCA (μg/m^3)	TCA/PM	SOC (μg/m^3)	POC (μg/m^3)
PM_{10}				
SJ-03	11.47	0.31	2.18	2.50
HE-01	25.06	0.45	8.49	4.96
BE-02	14.63	0.28	3.17	4.34
SA-01	9.37	0.36	1.79	3.14
AL-01	10.05	0.40	1.68	3.55
SD-01	9.11	0.41	2.54	2.15
CA-01	8.45	0.30	1.87	2.64
ES-01	8.75	0.40	1.02	3.52
$PM_{2.5}$				
SJ-03	13.67	0.55	2.31	3.42
HE-01	20.25	0.65	7.01	3.38
BE-02	16.89	0.56	3.78	5.34
MO-01	8.49	0.50	2.67	1.78

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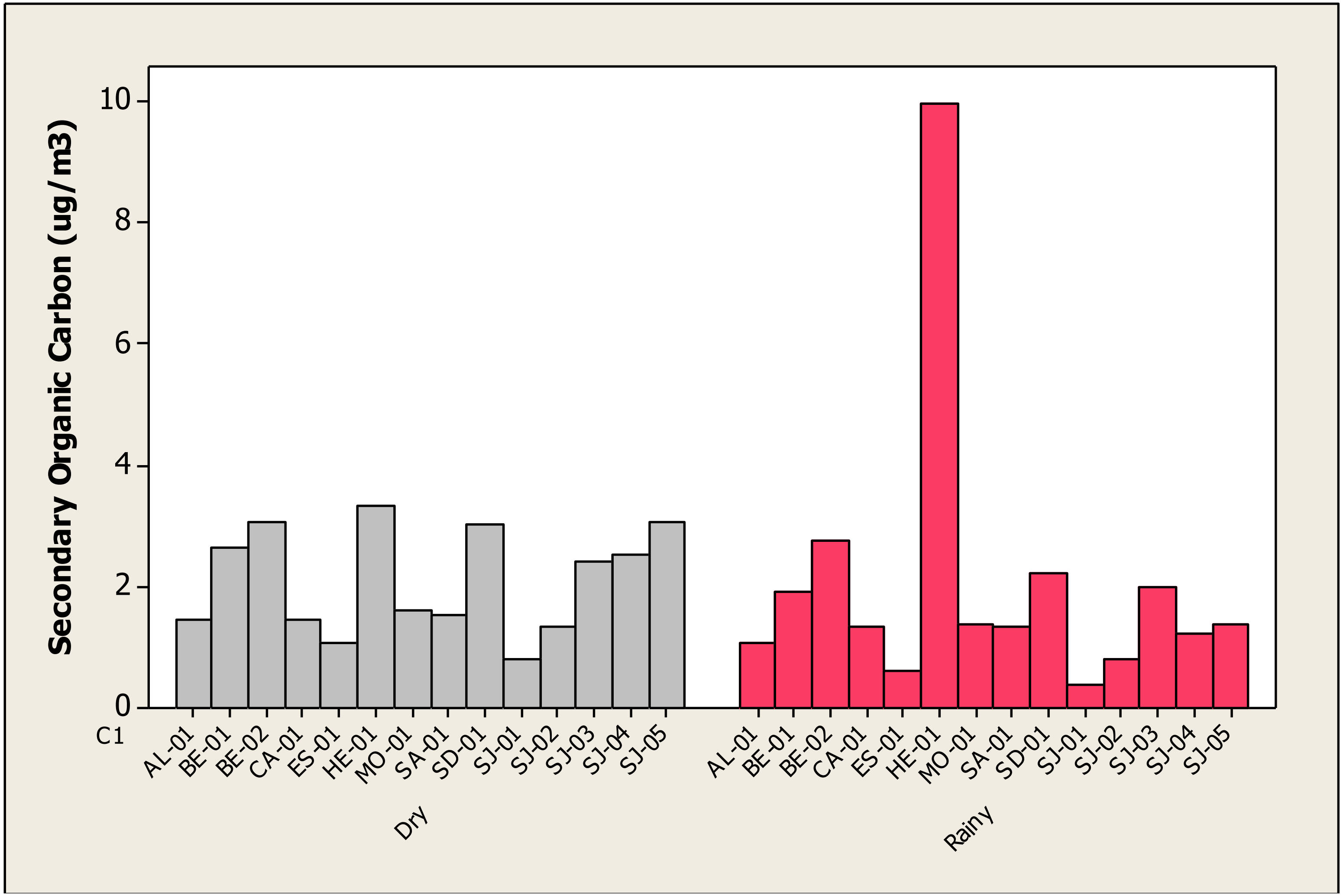

Source	Primary OC (ton/year)	%	Primary EC (ton/year)	%
Mobile Sources				
Gasoline vehicles				
Automobiles	213.4	2,62	29.51	1,17
Taxis	2.58	0,03	1.15	0,05
Diesel vehicles				
Taxi	1.45	0,02	5.07	0,20
Bus	27.91	0,34	35.49	1,41
Heavy Trucks	117.25	1,44	147.76	5,87
Light Trucks	118.69	1,46	148.94	5,91
Light Cars	20.04	0,25	57.74	2,29
Non Mobile Sources				
Airplanes	16.03	0,20	40.33	1,60
Residential Combustion	92.1	1,13	135	5,36
Commercial Combustion	0.82	0,01	0.87	0,03
Industrial Combustion	7510	92,2	1880	74,66
Agriculture Combustion	0.96	0,01	1.1	0,04
Structural Fires	1.61	0,02	0.81	0,03
On road vehicles	17.14	0,21	1.35	0,05
Cigarretes	0.026	0,00	32.9	1,31
Total	**8140**		**2518**	

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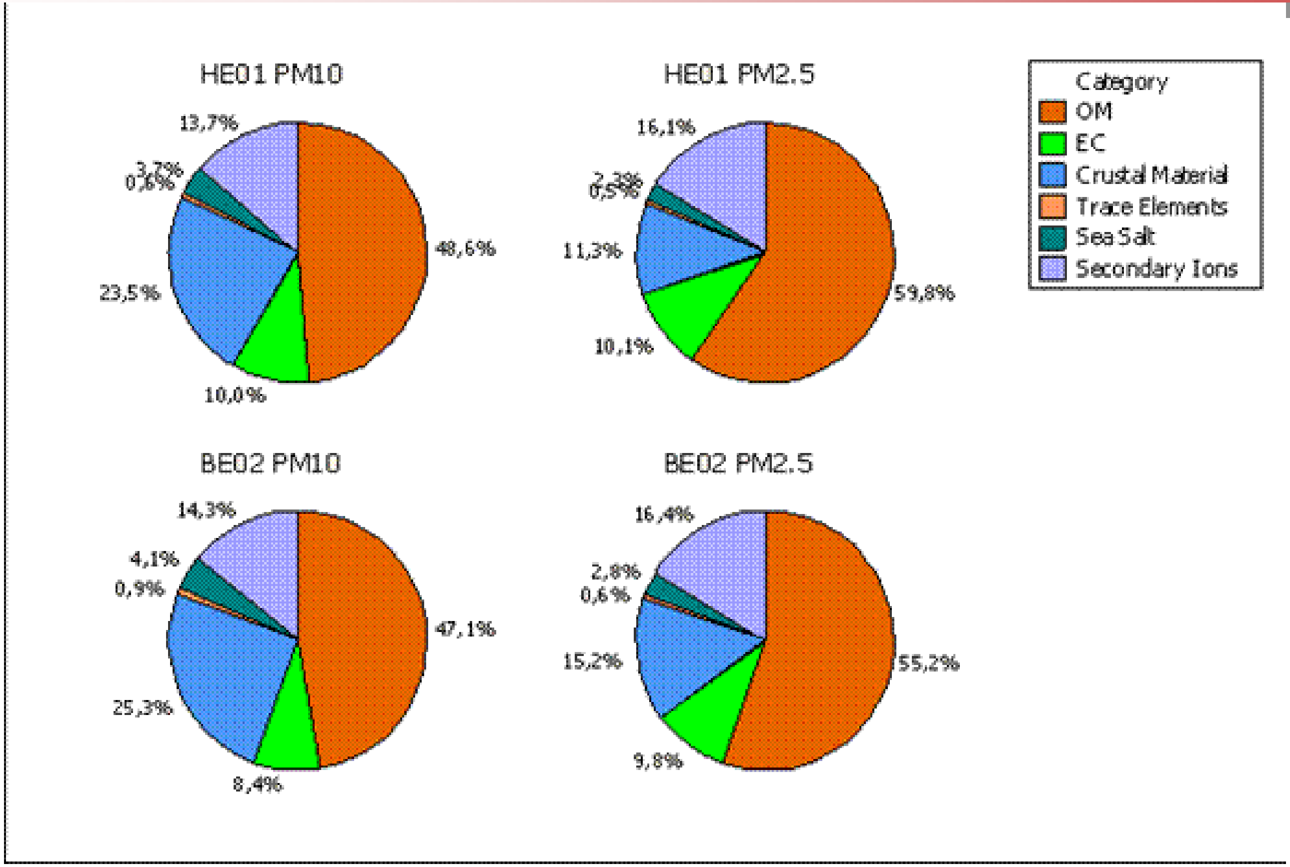

The chemical components of the PM were grouped as:

(a) crustal or mineral (sum of Al_2O_3, Ca, Fe, K, Mg and Mn)

(b) marine component (sum of Cl^- and Na^+)

(c) organic matter and elemental carbon, OM+EC

(d) secondary inorganic aerosols, SIA (sum of sulfate, nitrate and amonium).

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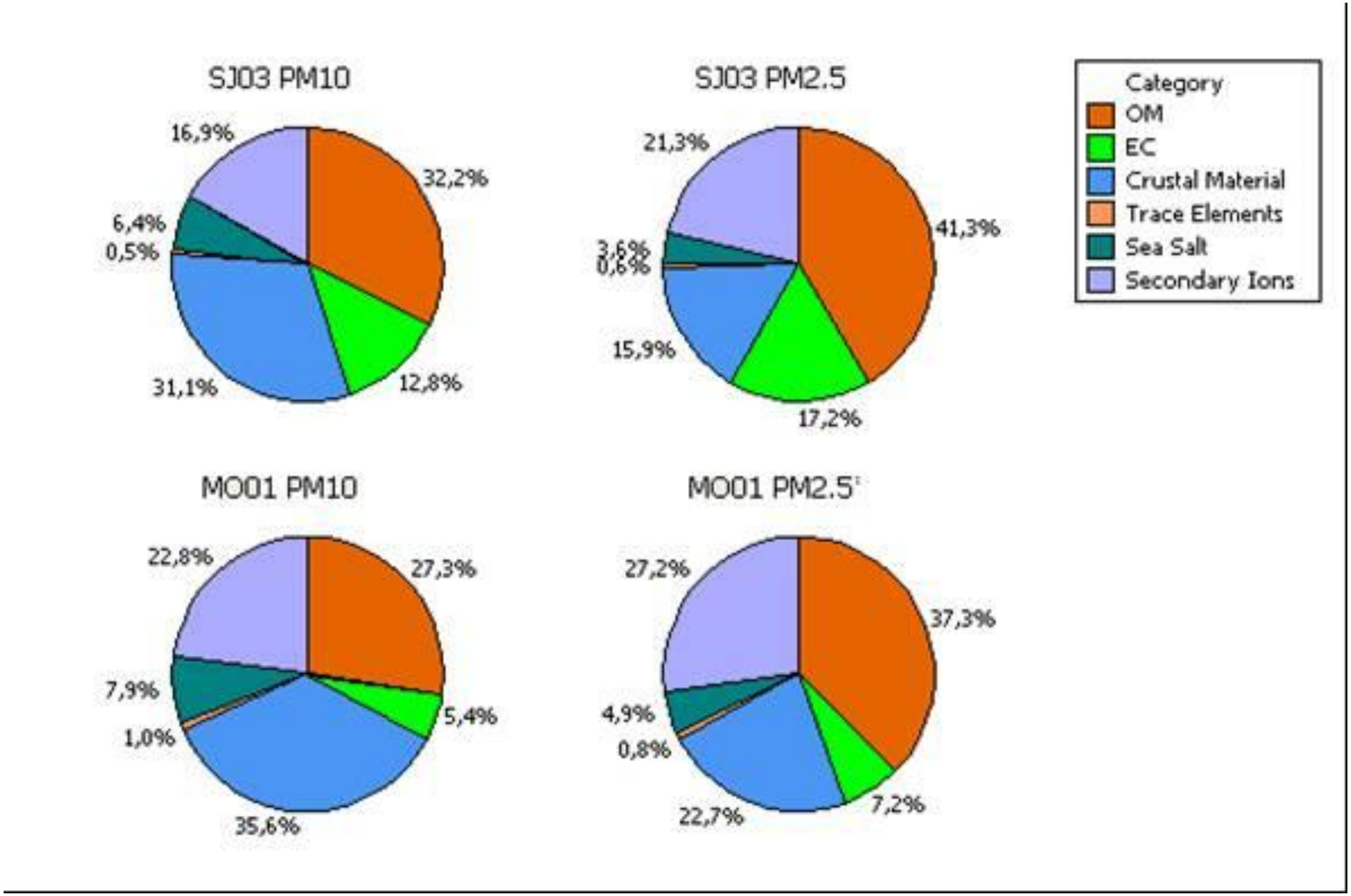

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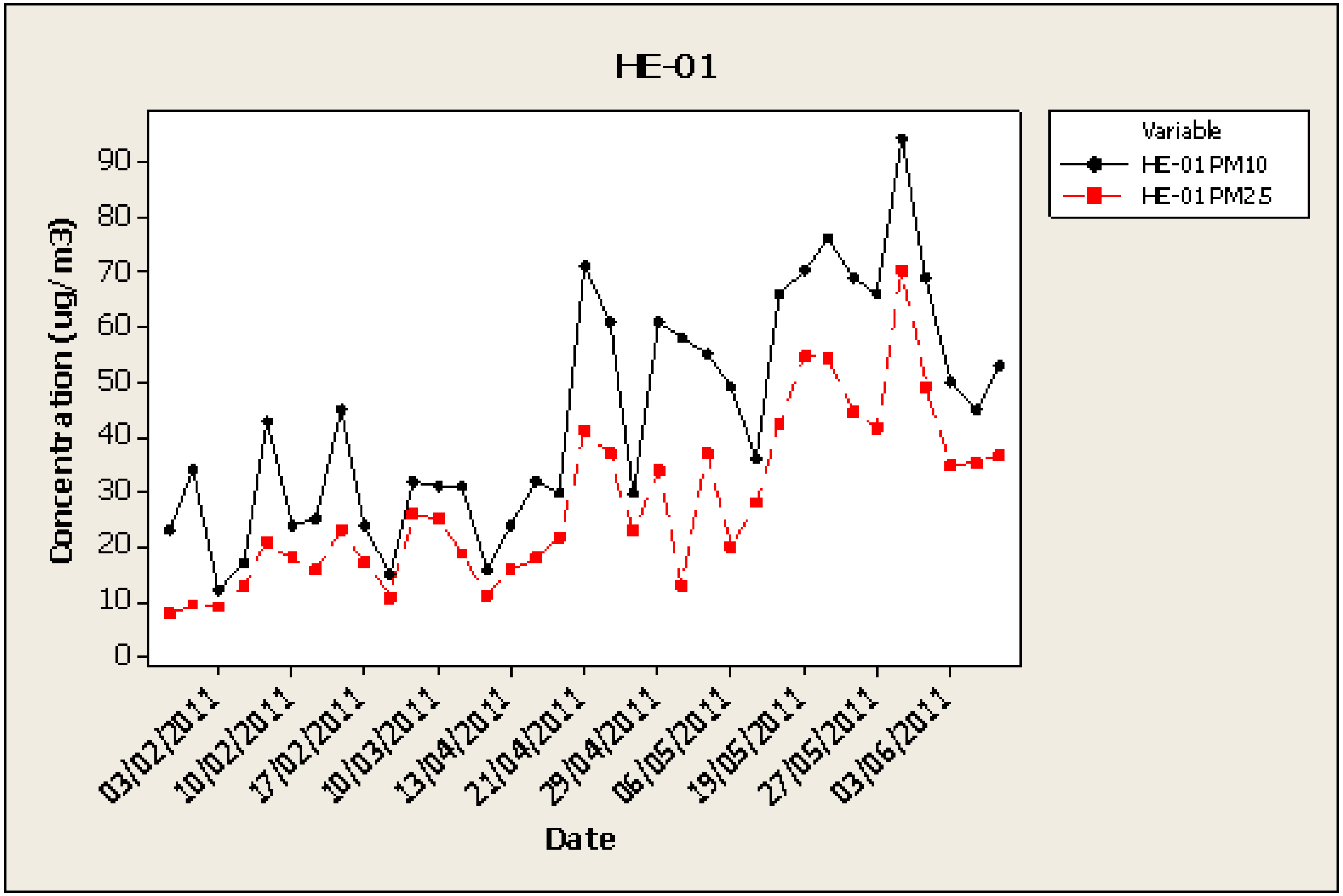
Temporal Variations



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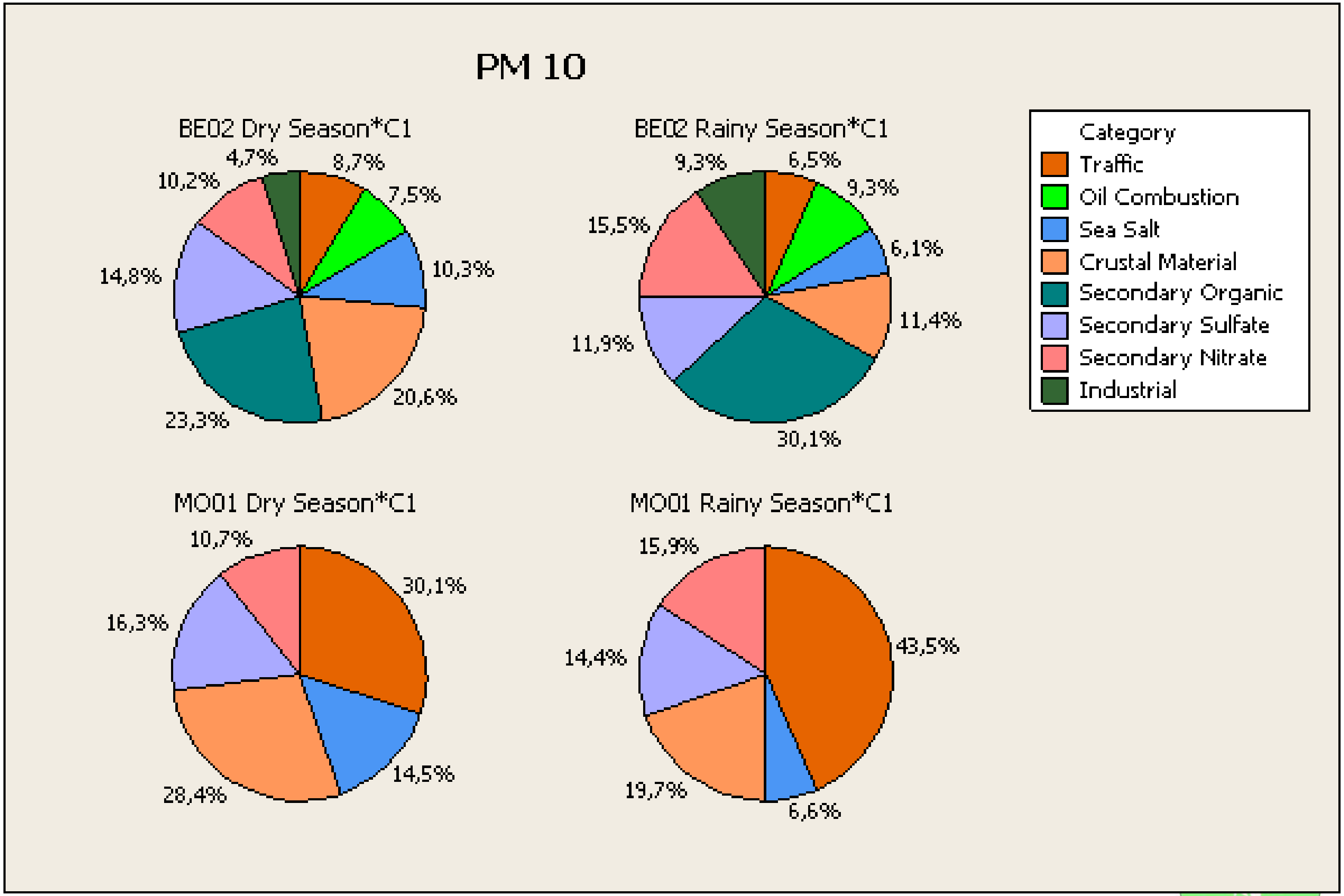
Positive Matrix Factorization: source identification

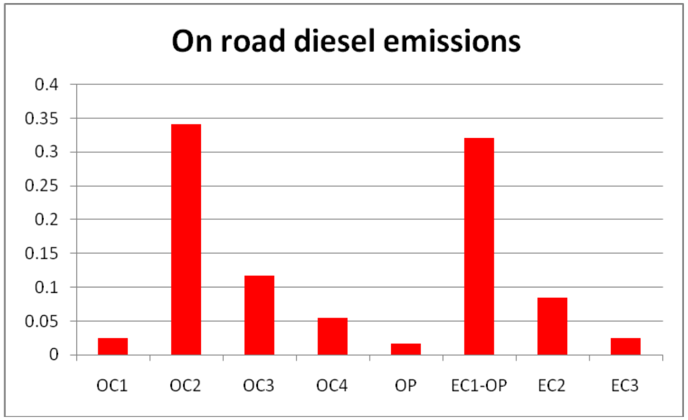
PMF is a multivariate factor analysis tool that decomposes a matrix of speciated sample data into two matrices—factor contributions and factor (Paatero and Tapper, 1994; Paatero, 1997).

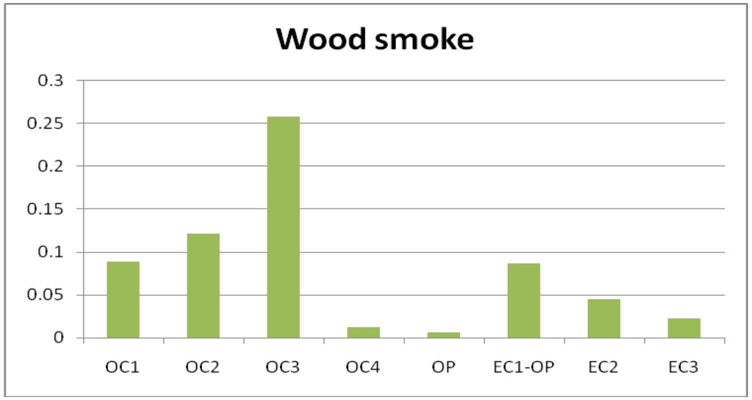
A speciated data set can be viewed as a data matrix X of *i* by *j* dimensions, in which *i* number of samples and *j* chemical species were measured. The goal of multivariate receptor modeling, for example with PMF, is to identify a number of factors *p*, the species profile *f* of each source, and the amount of mass *g* contributed by each factor to each individual sample :

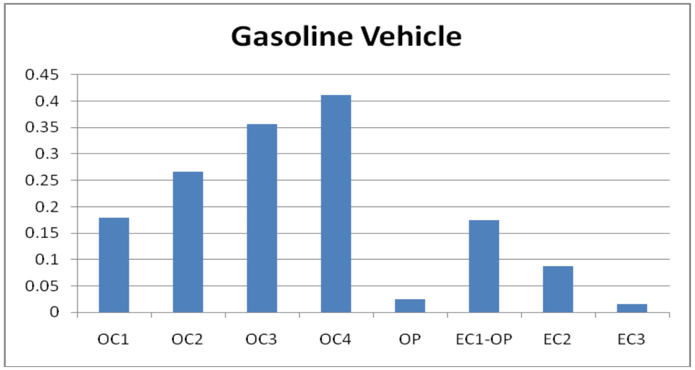
$$x_{ij} = \sum_{k=1}^{p} g_{ik} f_{kj} + e_{ij}$$

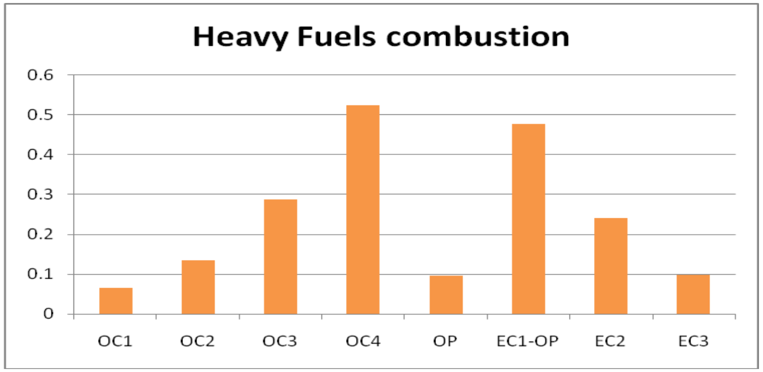
Source identificaction using PMF in PM_{10} and $PM_{2.5}$











Fractional carbon profiles in PM2.5 for combustion sources in the Metropolitan Area of Costa Rica using PMF

Conclusions

1. Some sampling sites for $PM_{2.5}$ shows average concentrations greater than USEPA annual standard of 15 $\mu g/m^3$
2. Sea salt and crustal sources have an important contribution for PM_{10}chemical composition. They are not as important as $PM_{2.5}$
3. The contribution of mobile sources (diesel and gasoline combustion) is very important for carbon concentrations in $PM_{2.5}$
4. During dry season in the metropolitan area of Costa Rica, the contribution of sea salt and crustal sources at PM10 are higher.
5. In Costa Rica, POC is more important than SOC formation in some cases

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