Chemical characterization and source apportionment of $PM_{2.5}$ in two East-Mediterranean sites

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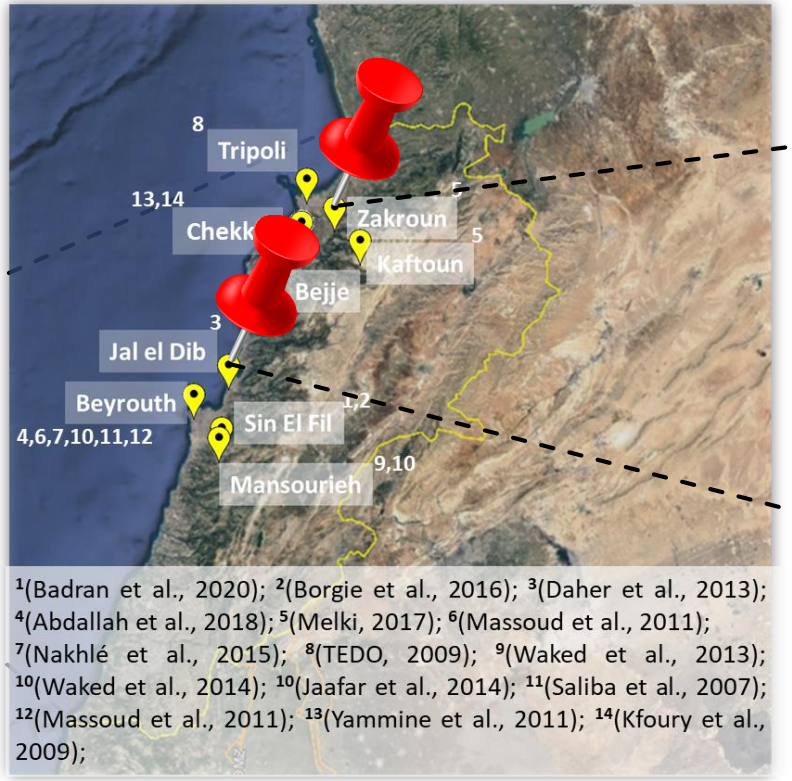
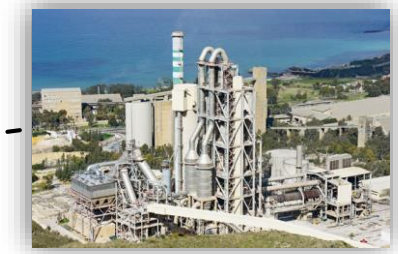
Mediterranean region

Source : Google Earth



[1](Badran et al., 2020); [2](Borgie et al., 2016); [3](Daher et al., 2013); [4](Abdallah et al., 2018); [5](Melki, 2017); [6](Massoud et al., 2011); [7](Nakhlé et al., 2015); [8](TEDO, 2009); [9](Waked et al., 2013); [10](Waked et al., 2014); [10](Jaafar et al., 2014); [11](Saliba et al., 2007); [12](Massoud et al., 2011); [13](Yammine et al., 2011); [14](Kfoury et al., 2009);



Fiaa site (FA)
Cement plants

Zouk site (ZK)

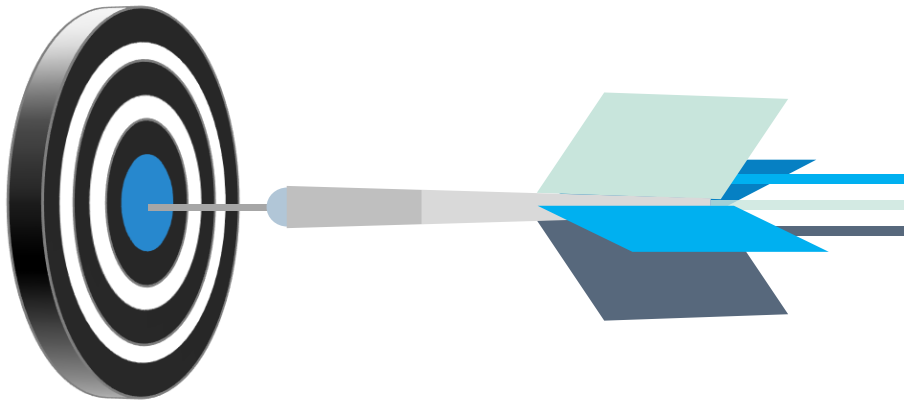
Power plant running on heavy fuel oil

Social and economic development in the region → Increased emissions of air pollution from the transport, industrial, and residential sectors → Higher concentrations of air pollutants

(Waked et al., 2012)

Objectives of the study

Identify pollution sources in two urban-industrial sites in Lebanon



Study the chemical composition of $PM_{2.5}$ collected at these sites.

Quantify the contribution of the identified sources by positive matrix factorization.

$PM_{2.5}$ sampling

Zouk site

Fiaa site

- December 2018 – October 2019
- High volume sampler operating at 30 m^3/h
- Frequency: 1 day over 3
- 24-hour basis
- Around 100 filters collected at each site

$PM_{2.5}$ chemical characterization

GC/MS

OC/EC analyzer

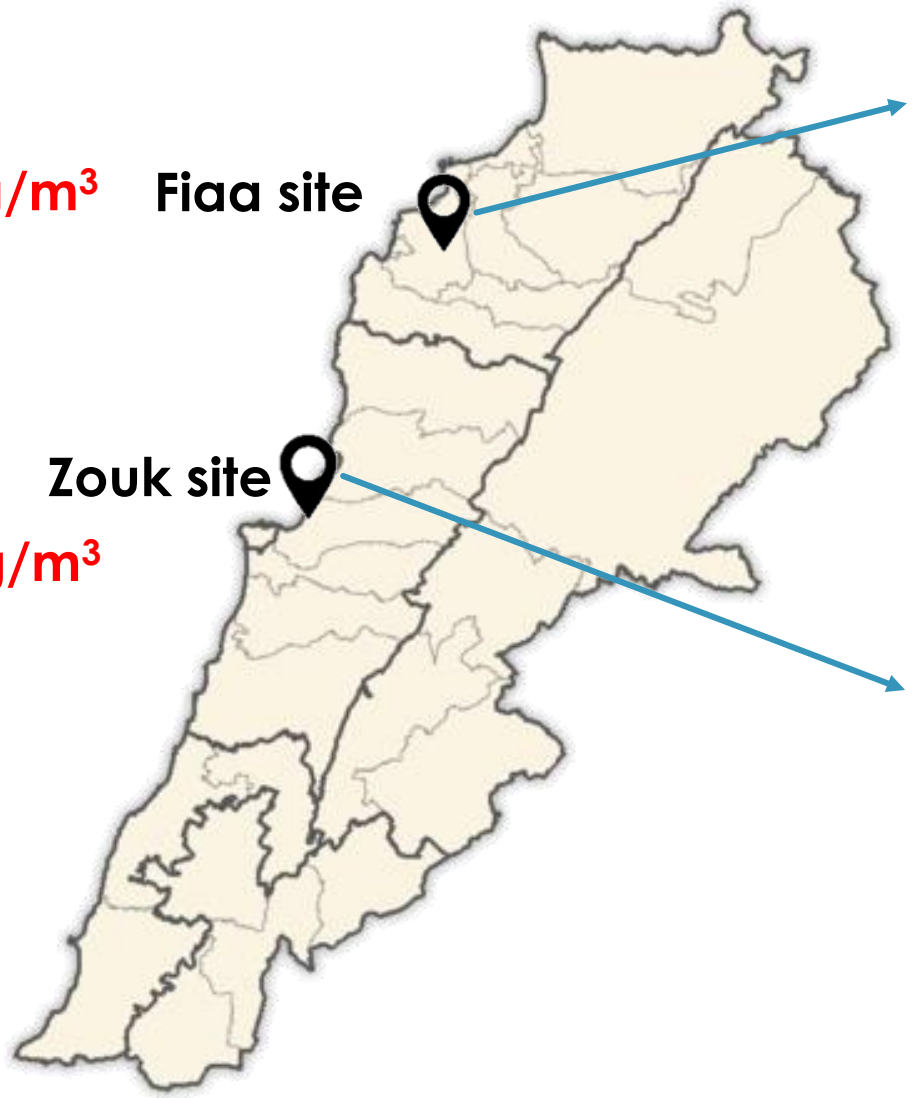
Ion chromatography

ICP / OES

ICP / MS

Organic fraction (80 species)	Carbonaceous fraction	Water-soluble ions (8 species)	Elements (30 species)
N-alkanes Polycyclic aromatic hydrocarbons Phthalates Fatty acids Hopanes	Organic carbon (OC) Elemental carbon (EC)	Anions: Cl^-, SO_4^{2-} and NO_3^- Cations: Ca^{2+}, Mg^{2+}, K^+, Na^+ and NH_4^+	Al, Mg, K, Ca, Ba, Fe, Mn, Ni, Sr, Zn, P, Sr, Ti, Zn, and Pb As, Rb, Nb, Sn, Cd, Co, Sn, Cu, Cr, Sb, V, La, Ce, Bi and Tl

Results



$PM_{2.5}$: 26.0 µg/m³ **Fiaa site**

OC: 3.1 µg/m³
EC: 0.5 µg/m³
Ions: 10.3 µg/m³
Elements: 2.6 µg/m³

OC/EC: 7.3

(Wang et al., 2020)

Zouk site

$PM_{2.5}$: 33.6 µg/m³

OC: 4.6 µg/m³
EC: 1.3 µg/m³
Ions: 11.9 µg/m³
Elements: 3.8 µg/m³

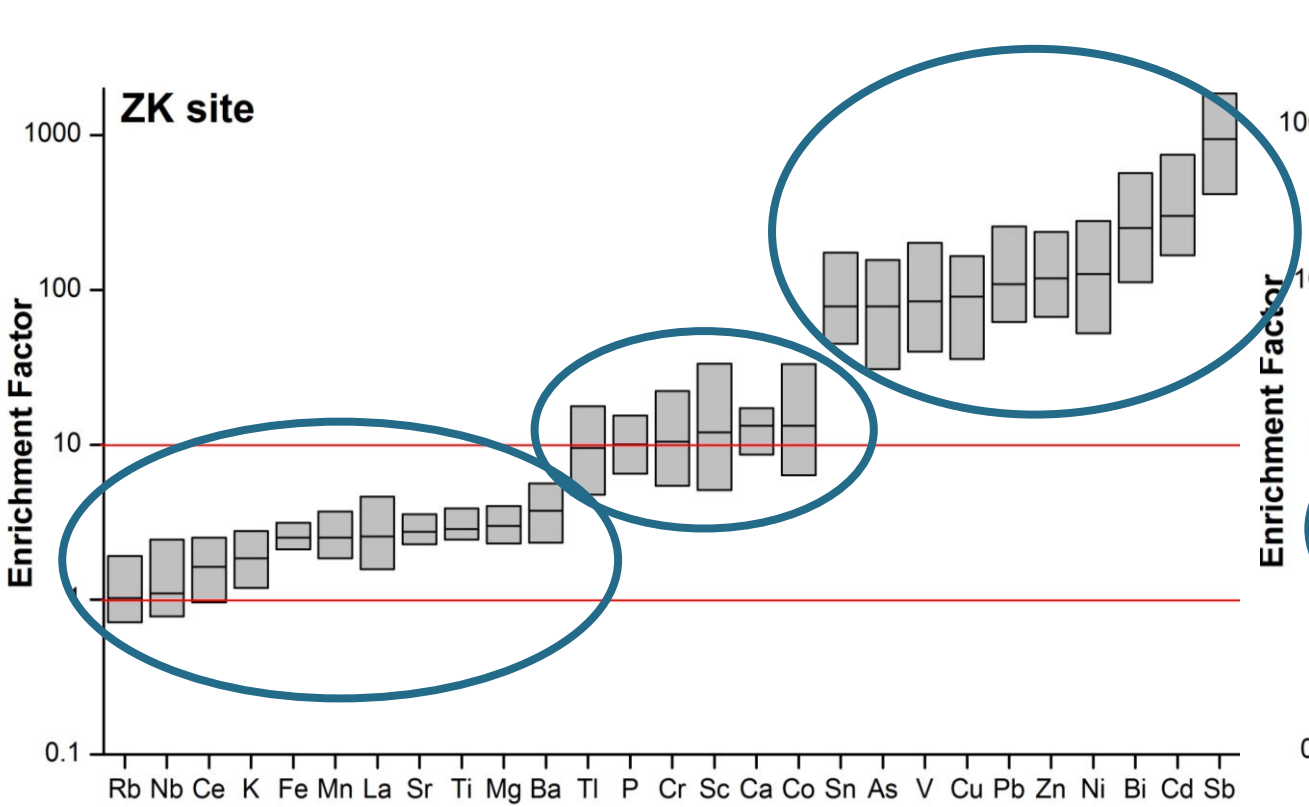
OC/EC: 3.9

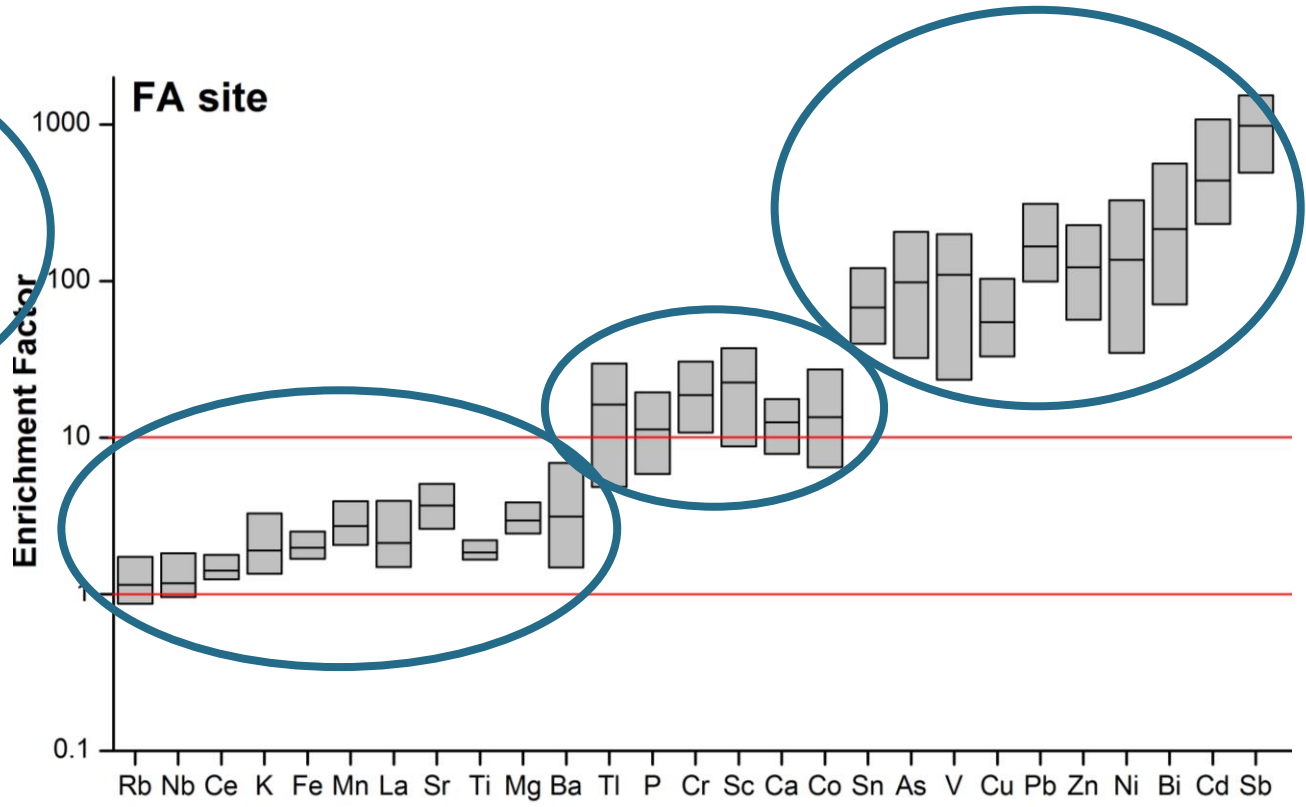
(Salameh et al., 2015)

WHO $PM_{2.5}$ annual guideline value: **5.0 µg/m³** *(WHO, 2021)*

Enrichment factors for elements

$$EF = \frac{\left(\frac{C_x}{C_{Al}}\right)_{sample}}{\left(\frac{C_x}{C_{Al}}\right)_{crustal}}$$ (Hans Wedepohl, 1995)





Rb, Nb, Ce, K, Fe, Mn, La, Sr, Ti, Mg, Ba and Tl: Crustal origins

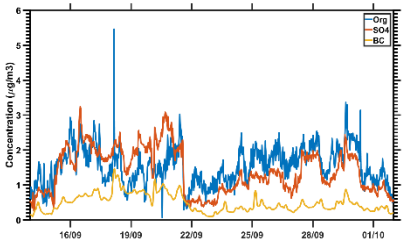
Sn, As, V, Cu, Pb, Zn, Ni, Bi, Cd and Sb: Anthropogenic origins

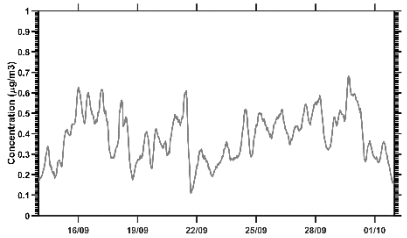
Source apportionment by PMF

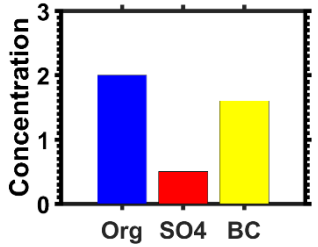
Species concentrations (ng/m^3) = Source contribution (ng/m^3) x Sources profiles (µg/µg) + Error (ng/m^3)

(Paatero and Tapper, 2012)

X = G × F + E



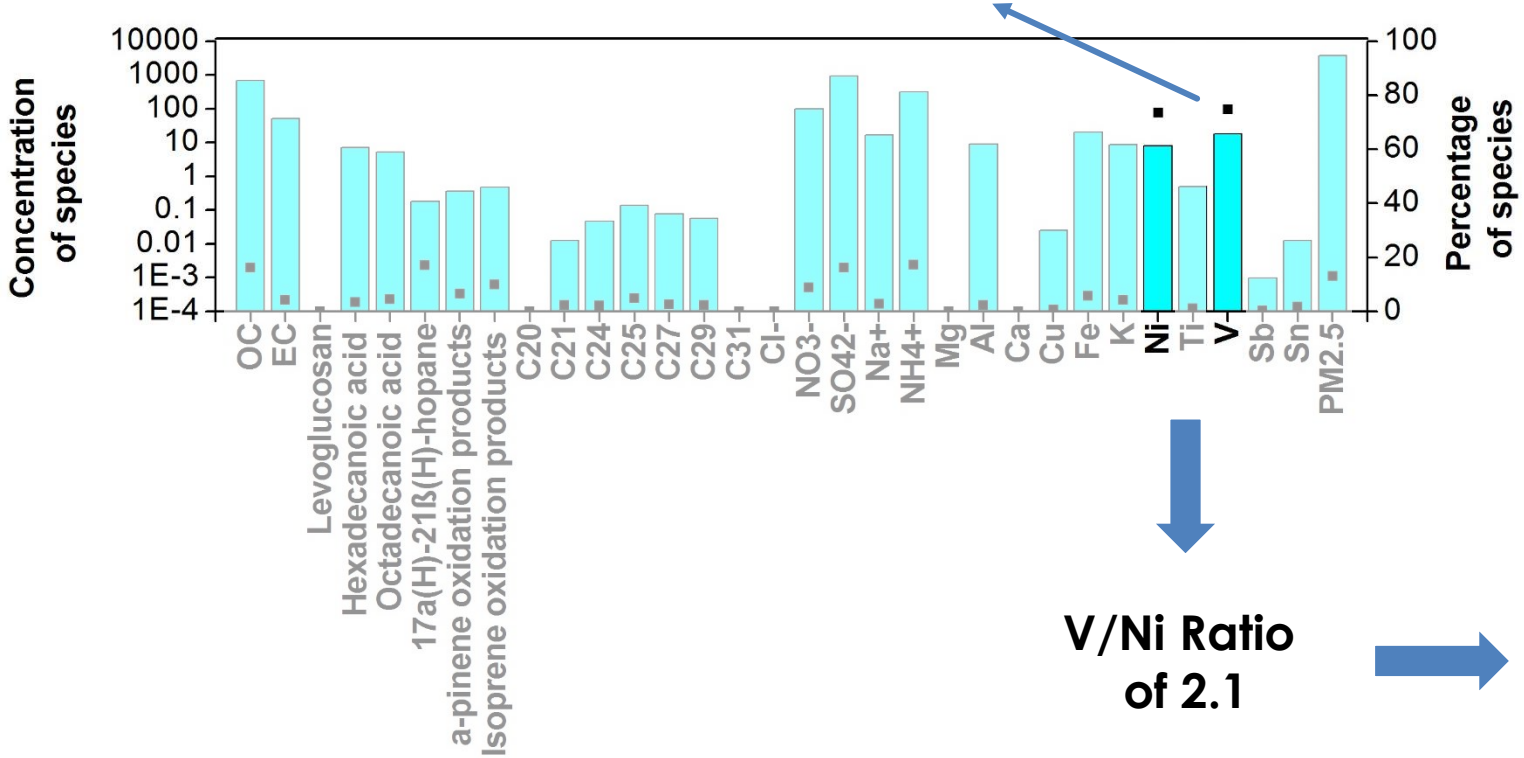




Carbonaceous fraction	Water-soluble ions	Elements	Organic compounds
EC and OC	Na^+, Cl^-, SO_4^{2-}, NO_3^- and NH_4^+	Mg, Al, Ca, Cu, Fe, K, Ni, Ti, V, Sb and Sn	levoglucosan Hexadecanoic acid Octadecanoic acid 17α(H)-21β(H)-hopane Isoprene and α-pinene oxidation products C_{20}, C_{21}, C_{24}, C_{25}, C_{27}, C_{29}, C_{31}

Focus on source profiles by PMF

V et Ni are tracers of HFO combustion(Swietlicki et Krejcj, 1996)



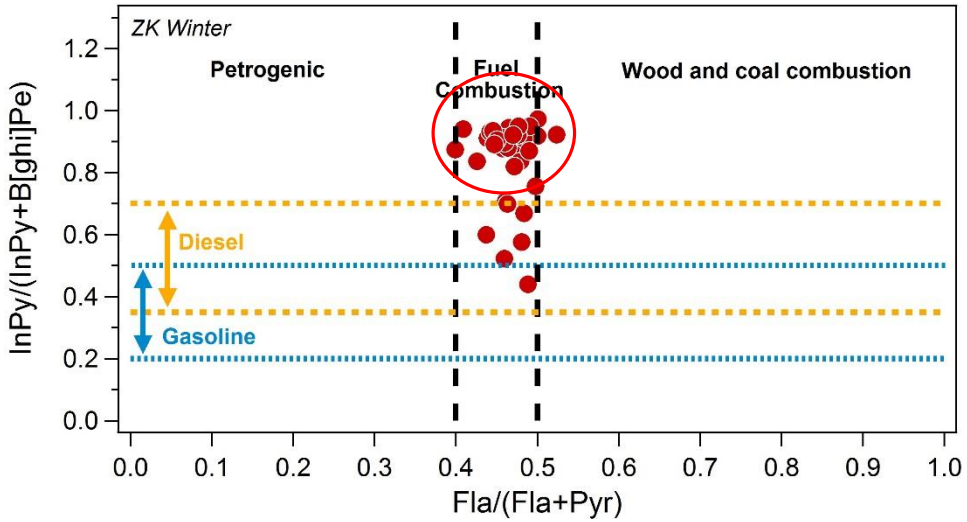
V/Ni Ratio of 2.1

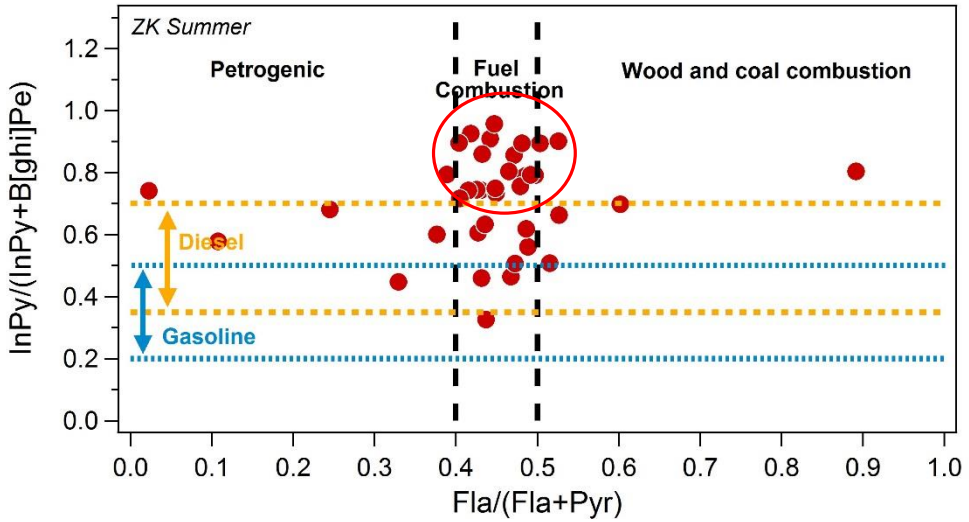
HFO combustion at the power plant at ZK and at the cement plant at FA

(Pandolfi et al.,2011)

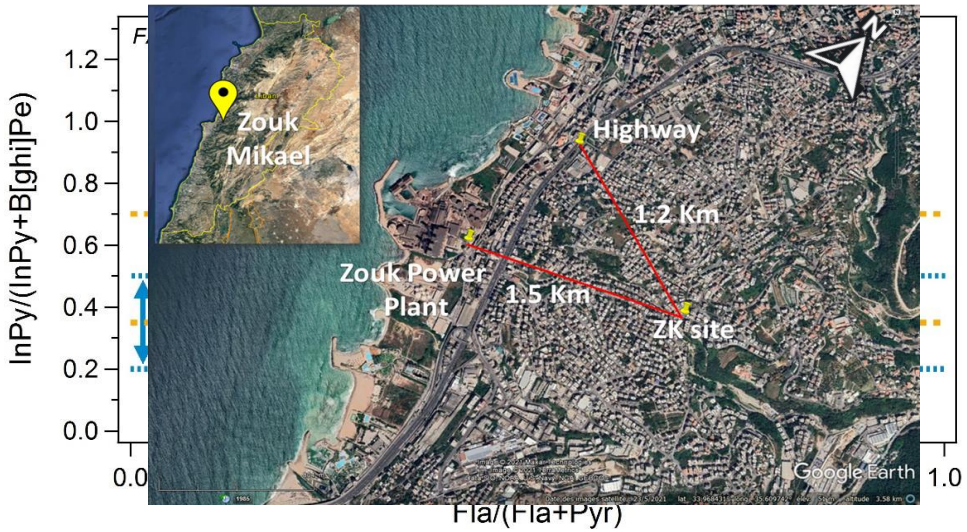
Ratio between 1.5 et 2.2 For heavy fuel combustion from power plants

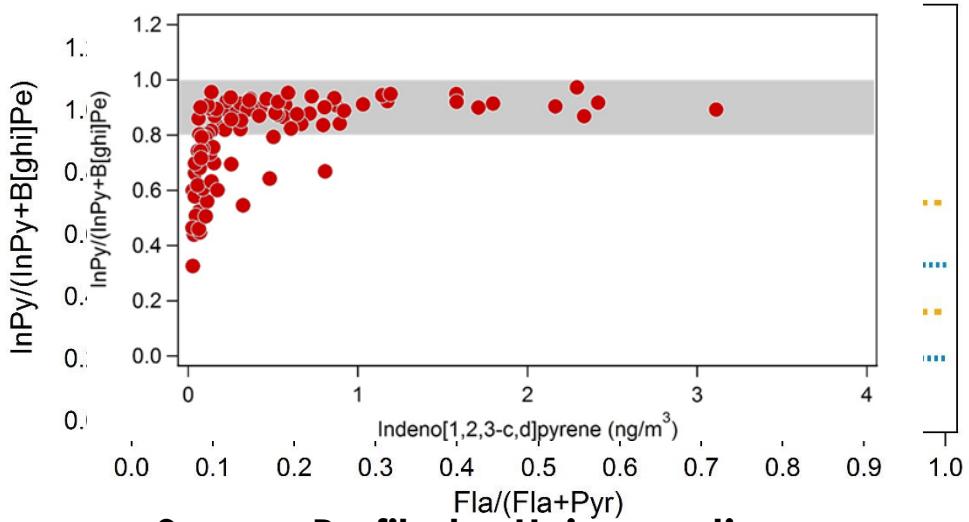
Evaluation of the ratio InPy/(InPy + B[ghi]Pe)





Ratio InPy/(InPy + B[ghi]Pe) between 0.8 and 1



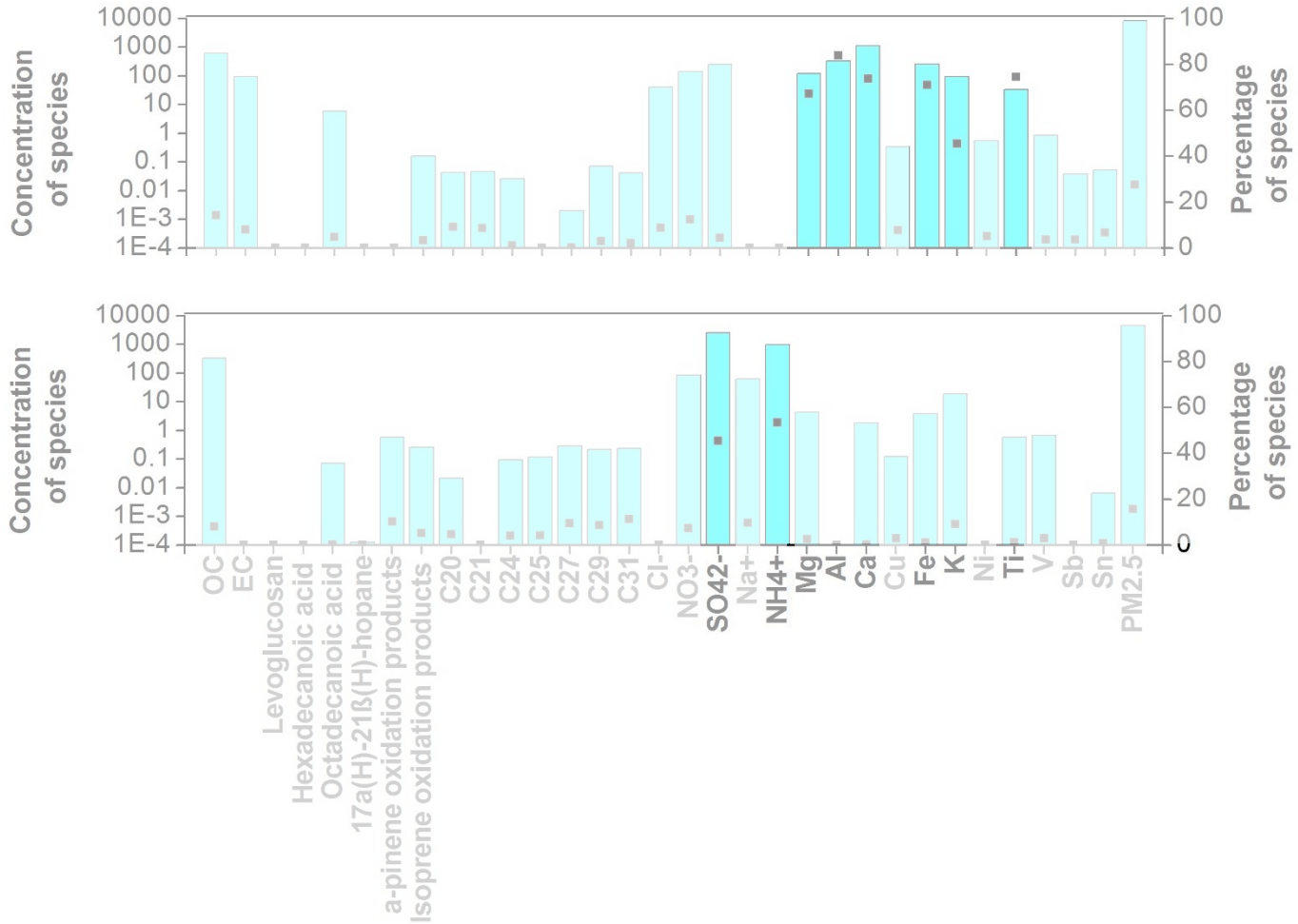


Heavy fuel oil combustion from power plant

(Fadel et al.,2021)

Source Profile by Unique ratio *(Annegarn et al., 1992)*

Focus on source profiles by PMF



Abundance of Mg, Al, Ca, Fe, Ti and K

↓

Crustal dust

Abundance of NH_4^+ et SO_4^{2-}

↓

Ammonium sulfate sources

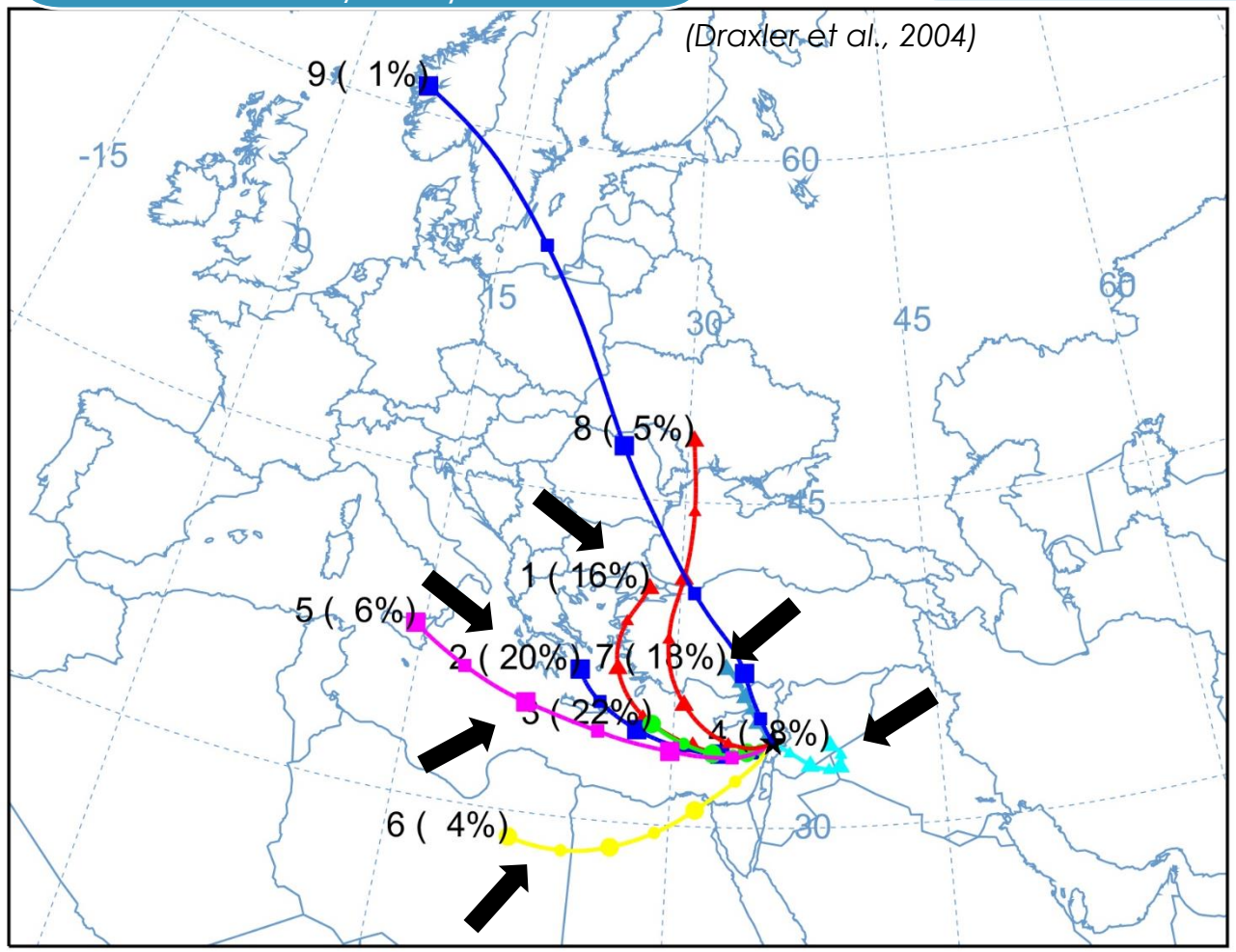
Local or long-distance origins?

Long-range transport evaluation

HYSPLIT model to calculate backward trajectories (GDAS 1, 72h every hour)

Clustering application

Attribute samples to the different clusters



Concentrations in µg/m³

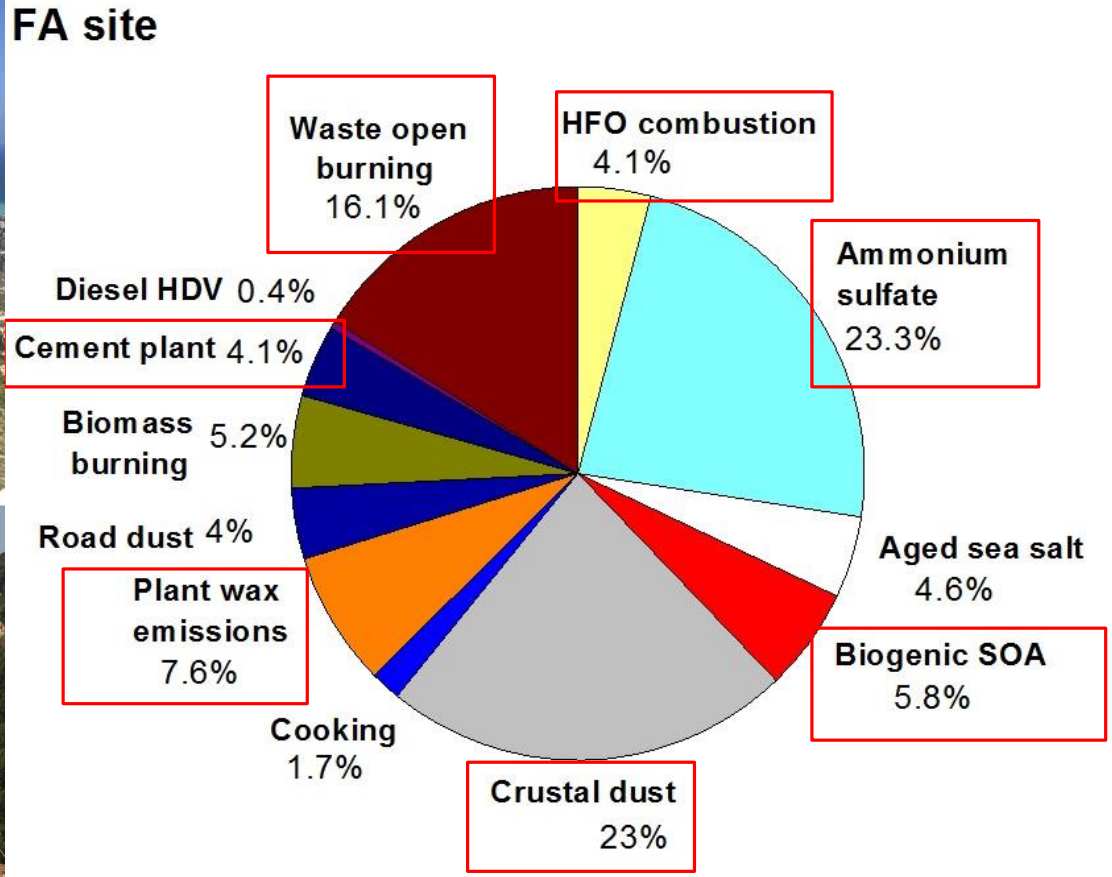
		SO_4^{2-}			
1	23.7	8.2	2.7	2.9	0.6	1.3
2	22.1	6.7	2.2	2.9	0.6	1.5
3	32.9	6.6	2.3	4.1	0.9	2.8
4	46.5	3.6	1.2	6.2	1.6	6.5
5	22.0	3.0	0.9	3.2	0.7	2.1
6	51.1	3.1	0.5	3.6	0.8	6.3
7	35.3	5.6	1.8	4.8	1.0	3.4
8	12.0	2.3	0.7	1.9	0.5	0.7
9	17.1	2.0	0.5	3.3	0.6	0.4

High levels of elements associated to crustal dust were attributed to long-range transport of air masses from the desert.

These air masses are also loaded with high levels of OC and EC mainly coming from refineries.

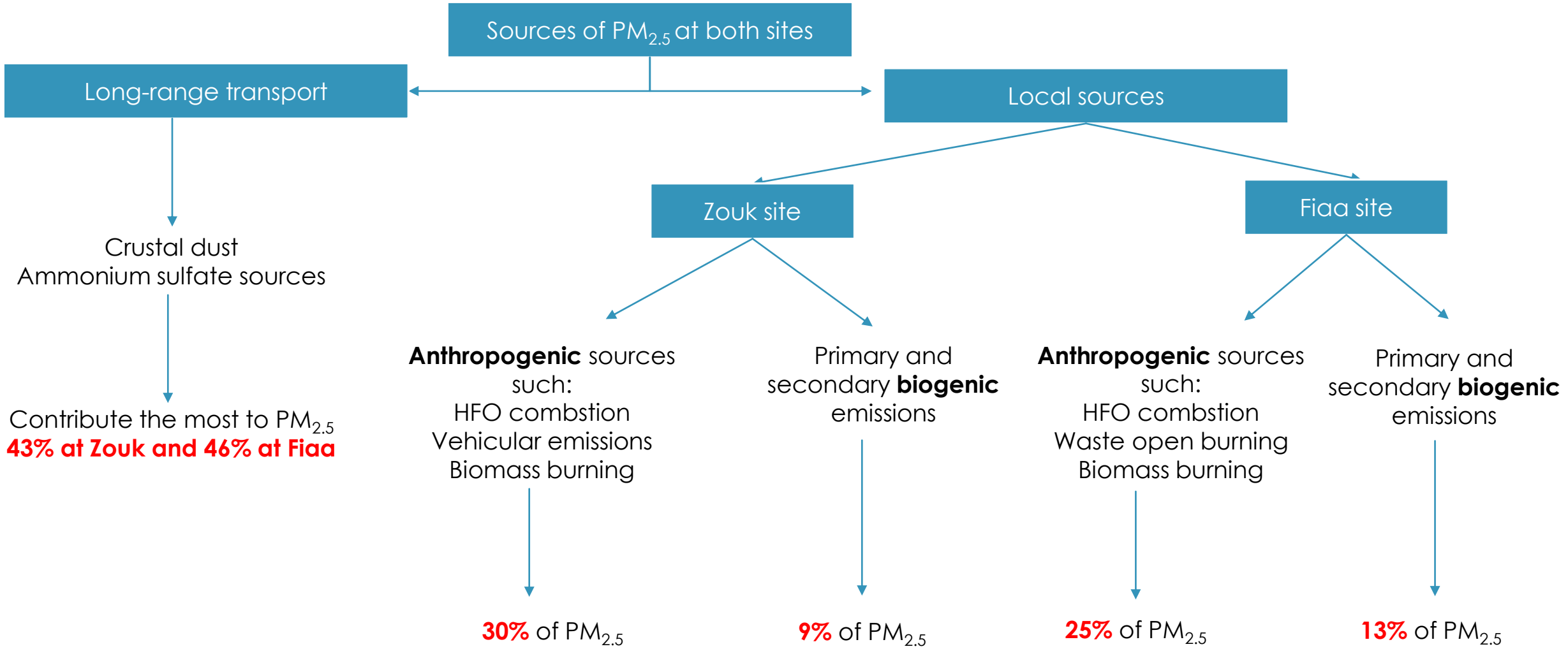
High sulfate levels originate from Eastern and Central Europe and Turkey.

Sources contribution to $PM_{2.5}$



$PM_{2.5}$: 26.0 µg/m³

Conclusions



Acknowledgment

Thank you!

Questions ?