Source profile of PM10 emission sources in Western Macedonia, Greece, during 2022

S.K. Gkaras [1,2*], E.D. Triantafyllou[1], A.N. Dougali [1], Ch.N. Diamantopoulos[1], E.I. Tolis [3], A.G. Triantafyllou [1]

[1] Laboratory of Atmospheric Pollution and Environmental Physics (LAP-EP), Department of Mineral Resources Engineering, Faculty of Engineering, University of Western Macedonia, Koila, 50100, Kozani, Greece

[2] Department of Chemical Engineering, Faculty of Engineering, University of Western Macedonia, Kozani 50100, Greece

[3] Department of Mechanical Engineering, Faculty of Engineering, University of Western Macedonia, Kozani 50100, Greece

*Corresponding author:
e-mail: sgaras@uowm.gr , s.gkaras@uowm.gr

Abstract Government energy policy strategies which are intended to encourage the reduction of lignite energy production, has a negative impact on industrial activities in the region of Western Macedonia, leading to important changes of the atmospheric emission profile. Taking into consideration the current situation and the reduction of industrial contribution in PM10 emissions, we attempt to estimate the PM10 source profile and examine the similarities or the differences of specific dust sources at different sites. Each sampling site differed with respect to the location of the site and its meteorological and source characteristics. In order to accomplish that, dust samples were collected for several representative sources in the study area (e.g., unpaved roads, paved roads, vehicular emissions, soil and agricultural soil, fly ash) during 2022. The collected dust samples were resuspended to laboratory generated-dust system in order to create PM10 samples (for each emission source) which were analyzed for a series of elements by the method of Inductively coupled plasma mass spectrometry (ICP-MS). The database of PM emission profiles developed here will be used in a second stage to assist source apportionment studies for accurate quantification of the air pollution causes and enhance the evaluation of environmental authorities and policy makers to take the proper proactive measures for air quality.

Keywords: PM10, Source profiles, laboratory generated-dust system, elemental composition

1. Introduction

During the past decades, industrial and mining activities were two of the most significant emission sources in the region of Western Macedonia and had played an important role in increasing atmospheric emissions. Nowadays, current energy policy leads to a radical change of energy mix and therefore is recorded a significant reduction of industrial activities and subsequently important alteration of the atmospheric emission profile.

Analyses of the emission sources chemical profiles are important for receptor models to accurately estimate the contributions from different sources. There are just a few source apportionment studies (Samara 2005; Samara et al. 2018; Tolis et al. 2014; Gkaras et al. 2020) regarding the area of Western Macedonia (W.M.). All these studies only concern residential sites in the vicinity of lignite mining and combustion activities of the Western Macedonia Lignite Center (WMLC) or the cities of Kozani and Ptolemaida.

The current work constitutes a part of a wider research which aims to be detected (new) emission sources and be investigated their impact and the allocation to receptors within the delignification. Thus, within the framework of the above-mentioned project and taking on account the current situation, the aim of the present study was to estimate the PM10 source profiles and examine the similarities or the differences of specific dust sources at different sites. For this purpose, four sites were selected based on to the dominant emission source impacting the monitoring station location (urban, traffic, industrial, transboundary pollution, background pollution), as well the distribution /density of building (urban, suburban, rural).

2. Monitoring

2.1. Study area

Four monitoring sites with specific characteristics were chosen in order to estimate the PM10 source profile:

One within the building tissue of Kozani (SKOZ, 40.299o N, 21.799o E, 711 m above sea level, 50000 inhabitants), where urban activities and traffic density occur.

Second in the city of Grevena (SGRE, 40.082° N, 21.426° E, 526m asl, 16500 inhabitants) where wood and oil are mainly utilized for residential heating. Urban activities and traffic are also taking place.

Third in Neos Kaukasos (SNKAUK, 40.894° N, 21.472° E and 594 m asl), a sparsely populated settlement (230 inhabitants) in a rural district, which is affected by industrial transboundary pollution (Fig. 1). It is in about 500m away from the Greek – North Macedonian borders and about 15 km from the coal mining and lignite combustion activities (REK Bitola).

Fourth in a region were intense agricultural activities (use of pesticides, ploughing et.) take place. More specifically, it is located west-northwest, 200 m away from the buildings of village Velvendos (SVEL, 40.259º N, 22.064º E and 385 m asl, 3400 inhabitants) while it is surrounded by tree crops. So, this site can be considered as a rural station.

Figure 1. Map showing the Receptor sites (S). The lignite power stations (PS, only two of these are in operation, AGD - Greece and REK Bitola - North Macedonia) and the opencast lignite mines in Western Macedonia, Greece are also shown.

2.2. Emission source sampling

Particulate emission source sampling curried out during 2022. Thirty samples were totally collected from 11 corresponding sources (Table 1).

Table 1. list of emission sources

	Source	Abbreviations	No of samples
1	Paved road dust KOZANI	PRKOZ	4
2	Paved road dust GREVENA	PRGRE	4
3	Unpaved road dust VELVENTO	URVEL	4
4	Soil dust VELVENTO	SDVEL	3
5	Soil dust NEOS KAUKASOS	SDKAUK	4
6	Flying ash	FLA	2
7	Gasoline fuelled cars	GFC	2
8	Diesel fuelled cars	DFC	3
9	Oil burning	OILBUR	2
10	Wood combustion	WCOM	2
11	Pellet combustion	PCOM	2

The collected dust samples were resuspended to laboratory generated-dust system (Krestou et al. 2013) consisted of a concentration chamber connected to a glass tube, a vibration system, and a PM10 sampler (**fig.2**) - in order to create PM10 samples. More specifically, a Low Volume Sampler LVS 3.1 provided by Derenda, was used for the collection of PM10. The device is used to collect particulates in compliance with corresponding standards (EN 12341, 1998; EN 14907, 2005).
Collection of emissions from passenger (gasoline or diesel fuelled) cars was conducted in the courtyard of the university of Western Macedonia using a Low Volume Sampler Derenda LVS 3.1 during engine operation at 2000 rpm.

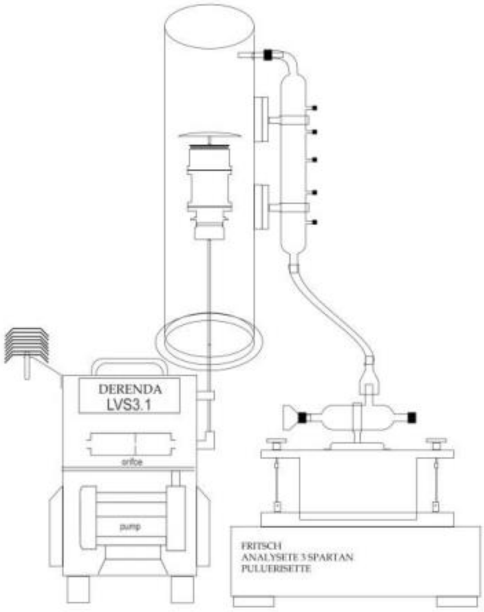

Figure 2. laboratory generated dust system.

As far as the sampling of particulate emissions from wood combustion and oil burning is concerned, it was carried out by a Low Volume Sampler installed downwind of the corresponding chimney at a distance 1.5 to 2m.
In all cases particulate emissions were collected on PTFE membrane filters (PALL teflo, 47 mm, 2um pore size).
It must be noted that the sampling goes on in order to obtain plenty of emission source profiles with a view to imprint more efficiently the current situation.

2.3. Elemental analysis

Loaded filters were digested by an Anton Paar Multiwave GO Plus microwave digestion system (Microwave – assisted Wet Acid Digestion, Method 3051A) with 6 mL mixed acid (3:1 ratio of high purity HNO_3 and HCl). All the extracts were filtered through 0.45μm membrane filter and were diluted to 25 mL with high purity water. Eventually, the resulted aqueous solutions were analyzed for the determination of Be, Na, Mg, Al, K, Ca, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Tl, Pb, Th and U using ICP-MS (Agilent 7500) according to analytical procedures reported by the instrument manufacturer.
The final elemental concentrations presented here have been properly corrected using the recovery rates and blank filters.

3. Results and discussion

Particulate emission source profiles (concentration levels of major, minor and trace metals) are presented in fig 3.

Figure 3. Source profiles

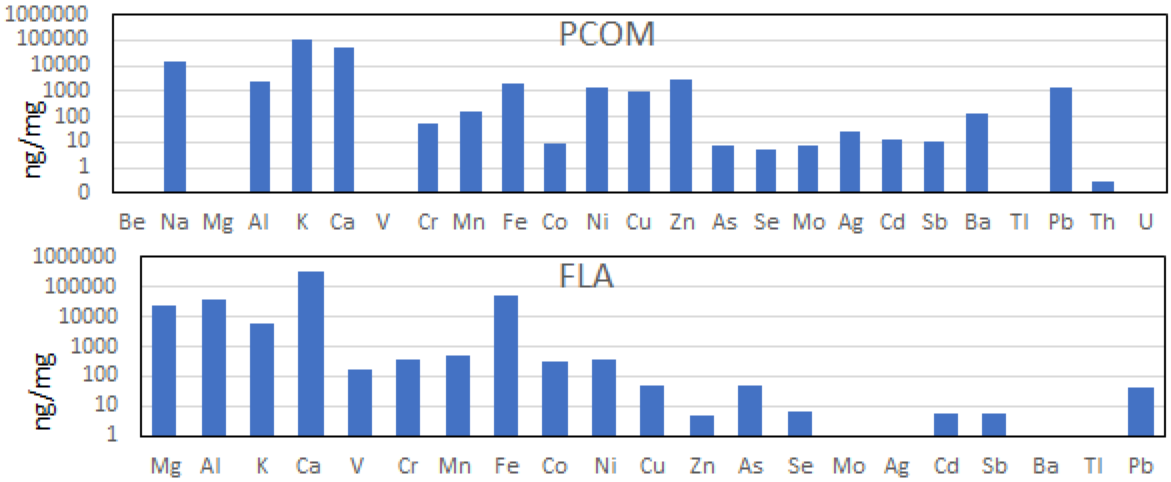

Figure 3. (Continued)

The total mass of the 25 identified elements in these profiles shows considerable variation. More specifically, this portion range between 10.6 and 24.6% in paved road dusts, 8.1 - 13.3% in unpaved road dusts, 6.8 – 9.7% in soils, 7.6 – 32.1% in vehicle exhaust, 2.5 – 19.2 in domestic heating emissions (biomass combustion or oil burning) while in the case of fly ash it approaches 41.9%. The elements Na, Mg, Al, K, Ca and Fe were the major constituents in road and soil dust samples.

In present study for the domestic heating – oil burning emissions it was found that Na and Ca were the most abundant elements (5.01 and 5.5%). K, Fe, Cu and Ni were also important (0.6 – 1.2%).

Regarding vehicle emissions, the obtained profiles showed that in diesel fuelled auto exhaust the dominant elements were Na (3.3%), Ca (6%), Fe (1.2%), Ni (0.3%), Cu (0.56%) and Pb (0.12%). Respectively, Na (5.3%), Ca (1.6%), Fe (5.12%), Ni (0.59%) dominated the gasoline profile.

In terms to biomass burning profiles K was the most abundant element (1.1% in wood and ~11% in pellet combustion).

Finally, the significand abundance of Ca (~31%) in the case of fly ash profile was characteristic.

4. Conclusions

Particulate source emissions were collected from quite a few representative sources in the wider area of WM and the corresponding PM10 samples were created. After the elemental analysis, the chemical footprint was obtained for PM10 emissions of the main sources. Therefore, the allocation of sources to receptors becomes feasible.

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