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2021

Chemistry and the Environment Division Award



Division President Hemda Garelick

40 posters under evaluation for

- Overall Aesthetics
- Scientific Merit
- Relevance to IUPAC Division VI research topics
- Country of origin

11 judges from Division VI

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2021

Chemistry and the Environment Division Award

1st place (\$300 Award):

Nansi Fahkri (Lebanon)

Title of presentation:

PM2.5 sources in the Eastern
Mediterranean capital Beirut: chemical
characterization and contribution to
ambient concentrations

Co-Authors:

Marc Fadela, Michael Pikridas, Minas Iakovides,
Cyril Karam, Charbel Abdallah, Melek Keleş, Fatma
Öztürk, Jean Sciare, Patrick L. Hayes, Charbel Afif

PM_{2.5} sources in the Eastern Mediterranean capital Beirut: chemical characterization and contribution to ambient concentrations

Nansi Fakhri^{a,b}, Marc Fadel^a, Michael Pikridas^c, Minas Iakovides^c, Cyril Karam^a, Charbel Abdallah^a, Melek Keleş^d, Fatma Öztürk^d, Jean Sciare^d, Patrick L. Hayes^b, Charbel Afif^{* a,d}

^aEMMA Research Group, Centre d'Analyses et de Recherche, Faculty of Sciences, Université Saint-Joseph, Beirut, Lebanon
^bDepartment of Chemistry, Faculty of Sciences, Université de Montréal, Montréal, Québec, Canada
^cClimate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Nicosia, Cyprus
^dEnvironmental Engineering Department, Faculty of Engineering, Bilkent University, Ankara, Turkey



ABSTRACT

- In this work, the chemical composition of fine (PM_{2.5}) particles at two sites (urban and semi-urban) in the Greater Beirut Area in Lebanon, with a population of one million inhabitants, was investigated in order to identify the main sources that lead to poor air quality in the capital and its surrounding, particularly during the hot season.
- Measurements of the composition of PM_{2.5} comprised a large suite of organic markers and carbonaceous (EC and OC) species in addition to elemental components and ions.
- This work is for the first time such measurements have been performed in Lebanon over an extended period (5 months).
- Average PM_{2.5} concentration during our study exceeded, at both sites, the WHO guideline of 5 µg/m³ by a factor of six.
- Source apportionment was performed using simultaneously organic and inorganic species by means of the positive matrix factorization (USEPA PMF 5.0).
- The results identify the main sources of PM_{2.5} in Beirut during the hot season with greater specificity than previously possible given the inclusion of organic tracer measurements.
- The PMF model using organic markers was able to identify 5 more sources given the integration of the organic markers: biomass burning, secondary organic aerosol, vegetation, vehicular and cooking emissions, which are usually not resolved by typical PMF analysis using only inorganics, while the usual trace elements identified 4 sources.
- This study gives a better understanding of the main PM_{2.5} sources in Greater Beirut. The results of this study can be useful for policy-makers in formulating effective local PM control strategies.

INTRODUCTION

- PM_{2.5} is a critical air pollutant owing to its detrimental effect on human health, contribution to visibility reduction and impact on climate.
- PM originate from both natural and anthropogenic sources.
- Outdoor air pollution led to 4.2 million deaths worldwide per year according to the World Health Organization.
- The Eastern Mediterranean region is facing serious air pollution problem and Lebanon represents one case study of this region.
- Lebanon is a Middle Eastern Mediterranean country bordered by the Mediterranean Sea to the west.
- Few studies have examined the concentration of PM_{2.5} in Lebanon and they reported that the average PM_{2.5} concentrations were three to five times higher than the WHO yearly target value, which is 5 µg/m³.

- The first step to achieve our goal, which is to determine the sources of PM_{2.5} in Lebanon consists of collecting PM_{2.5} samples from the locations in Beirut.
- Samples were collected at 2 sites in Beirut: **Hersh** which is an urban site and **USJ** a suburban site.
- The urban sampling site Hersh (33°52'15" N, 35°30'36" E) was located at Hersh Beirut Park. This site, as shown in Figure 1, is characterized by a high density of residential and commercial premises and surrounded by a small forested pine area.
- The USJ site (33°51'55" N, 35°33'51" E) was located in the near suburbs of Beirut on the roof of a building (12 m) at the Science and Technology Campus (200 m above sea level). The Mansourieh residential area is located 1 km southeast of the site while forested pine areas are located northeast and south of the site.
- The approximate distance between the two sites was 5 km.



Figure 1: Map showing the location of the two measurement sites in the capital Beirut and surrounding region (Google Earth®).

CHEMICAL ANALYSIS

- A total of approximately 160 filters were collected at both sites on a 24h basis using a high-volume samplers during the hot season from May to September 2014.
- PM_{2.5} mass concentration was determined gravimetrically by weighing the filters before and after the sampling.
- Elemental and organic carbon were analyzed using the thermo-optical transmission method on a sunset laboratory analyzer.
- Soluble anions and cations were analyzed by ion chromatography.
- Major elements and trace metals were analyzed by ICP-MS.
- For the first time in the Middle East and the East Mediterranean, a large suit of organic tracers which were analyzed by GC-MS were included in a source apportionment study.

RESULTS

- Average PM_{2.5} concentrations:
 - Hersh: 30±16 µg/m³
 - USJ: 32±14 µg/m³
- The concentration of PM_{2.5} exceeded the daily standard set by the World Health Organization (WHO) (15 µg/m³) (WHO, 2021) in all samples collected from Hersh and USJ.

- The temporal variation of PM_{2.5} concentrations for the sampling period at Hersh site is presented in Figure 2: unusually high PM_{2.5} concentrations were recorded between the 3rd and 6th of May where the concentration of fine particles reached 130 µg/m³.
- The average Si, Al and Fe concentrations during this event were approximately ten times higher than those detected during the non-event days.
- These elements are of crustal origin and signature of a dust storm. Indeed, Lebanon experiences dust storms two to three times per year originating either from the Middle East or North Africa in the fall and spring seasons.

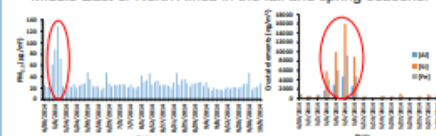


Figure 2: The temporal variation of PM_{2.5} concentrations and crustal elements for the sampling period at Hersh site.

- FLEXPART, which stands for FLEXible PARTICle dispersion model, was used to simulate air parcel trajectories. Back trajectories using FLEXPART showed that the air mass of this event is originating from North Africa.

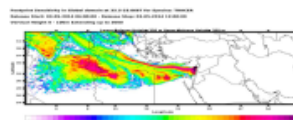


Figure 3: Example of footprint PES map obtained by backwards trajectory analysis.

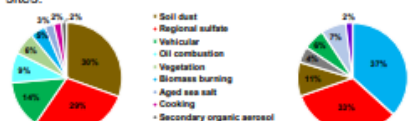
PMF preliminary results:

7 sources were identified at the USJ site:

Identified sources	Main compounds
Soil dust	Ca, Fe, Ti, Al, Mg
Regional sulfate	Ammonium and sulfate
Oil combustion	V and Ni
Sea salt	Na and Cl
Biomass burning	Levoglucosan
Vehicular	Hopane
Secondary organic aerosol	Dicarboxylic acids

- +2 sources were identified at the Hersh site:**
 - Vegetation:** *o*-pinene oxidation products, isoprene oxidation products, β -caryophyllene oxidation product
 - Cooking:** Fatty acids

- The contributions of the main sources at Hersh and USJ sites:



- Secondary particles:** the two sites presented a comparable contribution of ~30% of the total PM_{2.5}. In the Eastern coast of the Mediterranean Sea, sulfate is known to originate in summer from long-range transport of air masses originating from Eastern and Central Europe resulting in enriching the air with SO₂. However, the local scale emission could not be neglected.
- Soil dust:** Hersh site levels were higher by a factor of three. Results of the urban site Hersh evidenced the relevance of vehicular emissions, and important apportionments of crustal matter could be associated to road traffic. Non-exhaust emissions from road traffic are a significant source of elements in the atmosphere. These emissions originate from diverse sources including the wear of vehicle parts, such as tires and brakes, and the resuspension of dust.
- Biomass burning:** the very high contribution of biomass burning at the USJ site was mainly from local sources. Huge bush fire in Baabda village occurred during this period, which is 4 km away from the USJ site.

CONCLUSIONS

- Identification and quantification of the main sources that lead to deteriorated air quality in the capital, particularly in the hot season.
- This source apportionment study of PM_{2.5} using PMF is the first in Lebanon and the Middle East that used simultaneously organic and inorganic species.
- This study pointed that non-exhaust emissions from road traffic are an important source of PM_{2.5} in Beirut, which might be the case in other urban areas of the East Mediterranean.
- Forest fires had an important impact on the air quality.

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ACKNOWLEDGEMENTS

This publication has been produced within the framework of the EMME-CARE project, which has received funding from the European Union Horizon 2020 Research and Innovation Program (under grant agreement no. 856 612) and the Cyprus Government. This project was also funded by the Research Council and the Faculty of Sciences of Saint Joseph University of Beirut –Lebanon. PLH and NF acknowledge support from the Natural Science and Engineering Research Council of Canada (NSERC) Discovery Grant Program (RGPIN/05002-0214). NF also acknowledges a scholarship from the Centre de recherche en écotoxicologie du Québec (EcotoQ), a strategic cluster funded by the Fonds de recherche du Québec – Nature et technologies.

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2021

Chemistry and the Environment Division Award

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2nd place (\$200 Award): Mahshid Keramatnejad (Canada)

P

Title of presentation: The Impact of Air Pollutants on the Biophysical properties of A Model of Tear Film Lipid Layer

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Co-Authors: C. DeWolf

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2021

Chemistry and the Environment Division Award

A

3rd place (\$100 Award):

Andrés Villamil Hernández (Colombia)

P

Title of presentation:

An Experience for Soil Recovery and Fortification from Vermicompost

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Co-Authors:

Jessica Loaiza-Loaiza, Andrés Camilo Villamil Hernández, Luis García-Sánchez

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INTRODUCTION

Depletion of soil nutrients, mainly due to inappropriate agricultural practices, leads to a decrease in pH. The implementation of organic amendments such as vermicomposting and the addition of lime are methods that have shown positive effects, favoring the production and quality of the crops. This study evaluates the effect that the application of these amendments has on the quality and productivity of the corn crop in a soil, with a pH equal to 4.7. It is located in the rural property "La Primavera" (3.7739497,-75.1370426,14), Vereda Chenche Medialuna, municipality of Coyaima, Tolima Department, Colombia, South America.



Colombia is located in the northwest of South America



Tolima is one of the Colombian central departments



Eisenia Fétida as an alternative to household waste disposal



Vermicompost drying process



Treated vermicompost



pH-4.5 soil to improve



A. Soil without amendment. B. Amendment leached. C. Amendment lime D. Amendment Lime-Humus. E. Amendment Humus



A. Fruits amendment leached. B. Fruits amendment lime. C. Fruits amendment Lime-Humus D. Fruits Amendment Humus.

#	Amendment Lime-Humus	Amendment Humus
1	8.19	8.03
2	8.32	8.25
3	8.18	8.15
4	7.91	8.03
5	7.68	8.09
6	8.11	8.16
7	7.79	7.70
Average	8.02	8.05

Average weight of 50 grains of corn in the humic amendments

FRUITS PER AMENDMENT



The experiments began in the last months of 2020, harvesting the fruits in February 2021. Five soils are tested. No treatment, treatment with vermicomposting leachate, lime treatment, treatment with lime-vermicomposting and only vermicomposting humus. The variables evaluated are the germination capacity of the corn seeds in each treatment, the growth and development of the crop, taking as a reference the height and diameter of the stems, the length and diameter of the fruits, the number of rows, total grains and the weight of them. The results obtained show that growth and fruit production in the five treatments was higher in the humic amendments, especially in the lime-vermicomposting amendment, with a highly significant difference with respect to the soil without treatment.

IN SUMMARY

The soil, chosen for the study, has been intensively cultivated in the past. In the same way, chemical compounds were applied to increase the crops. Now, the products, at the end of the harvest, showed that the application of vermicompost serves to recover infertile soils.

Humic amendments are the best option to improve soil quality and agricultural production of corn. They could replace inorganic fertilizers avoiding, this way, soil deterioration

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