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Black carbon and $PM_{2.5}$ concentrations in two Bulgarian cities

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1. Outline

1. Particulate matter and Black carbon – brief intro
2. Motivation and Goal
3. Sampling sites location, equipment and analysis
4. Results
5. Conclusions

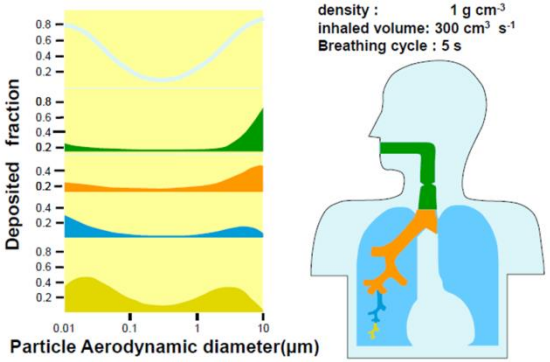
What are the aerosols (Particulate Matter, PM)?

An assembly of **liquid or solid particles suspended** in a gaseous medium

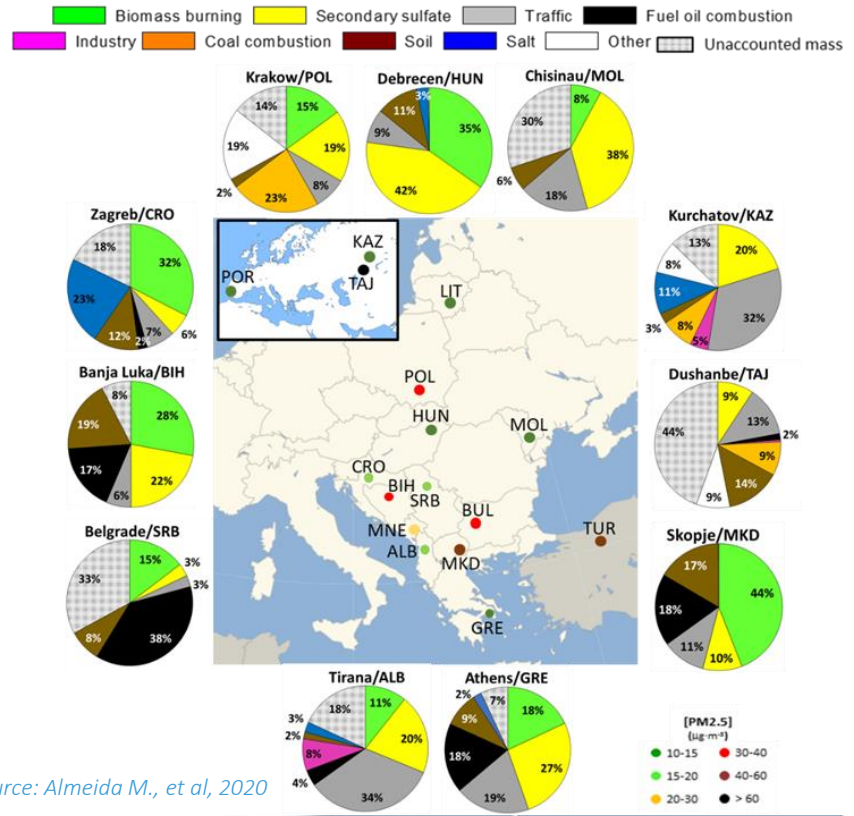
- **Dust:** solid particles formed by mechanical disintegration of a parent material
- **Smoke:** a visible aerosol resulting from incomplete combustion
- **Fog or mist:** liquid particle formed by condensation or atomisation

PM are characterized by their size

- TSP Total suspended particulate matter (up to ~35 µm)
- PM_{10} Particulate matter smaller than 10 µm
- Coarse PM Particles larger than 2.5 µm
- Fine $PM/PM_{2.5}$ Particles smaller than 2.5 µm
- Ultrafine PM Particles smaller than about 100 nm
- Nuclei mode Particles in the range 5–100 nm
- Accumulation mode Particles in the range 100 nm - 2 µm



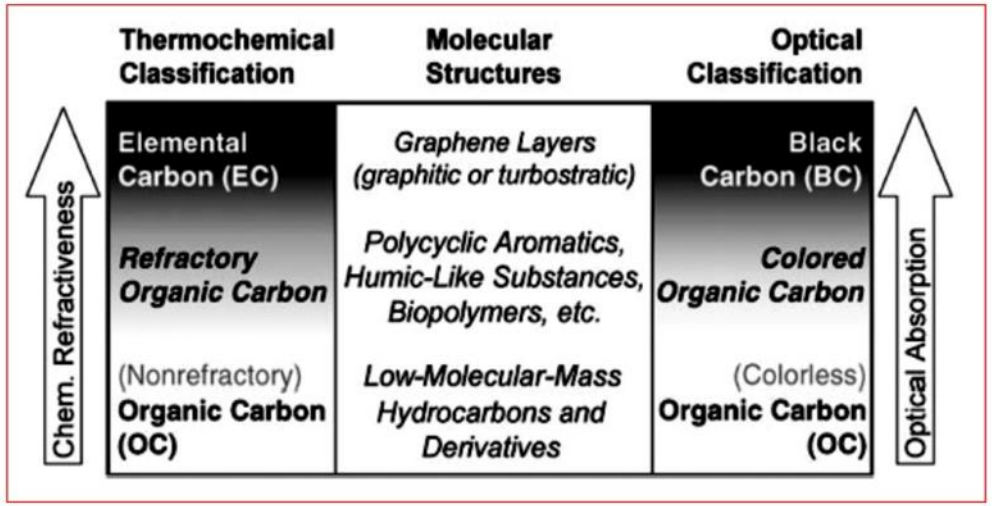
Source: Manauskas M., 2019



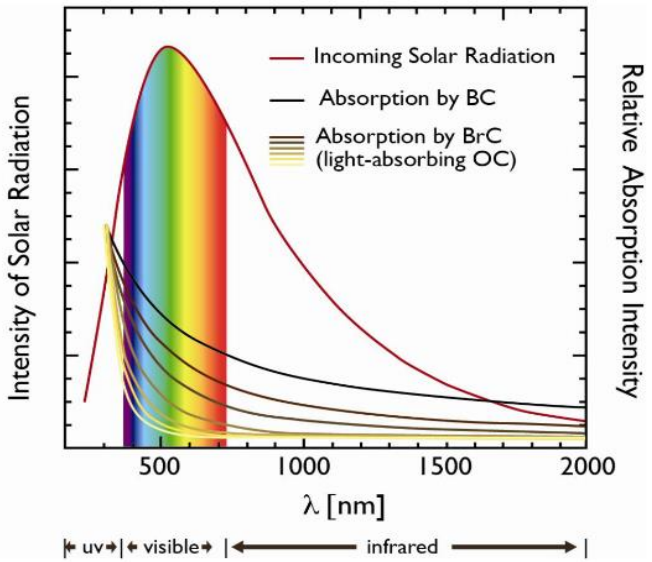
Source: Almeida M., et al, 2020

What is a Black carbon?

- A particulate of **soot** emitted by the incomplete combustion of fossil fuels and biomass
- Black carbon (BC) and brown carbon (BrC) are carbonaceous aerosols



Source: U. Poschl, AC, 2005



Source: J. Yuan, 2017

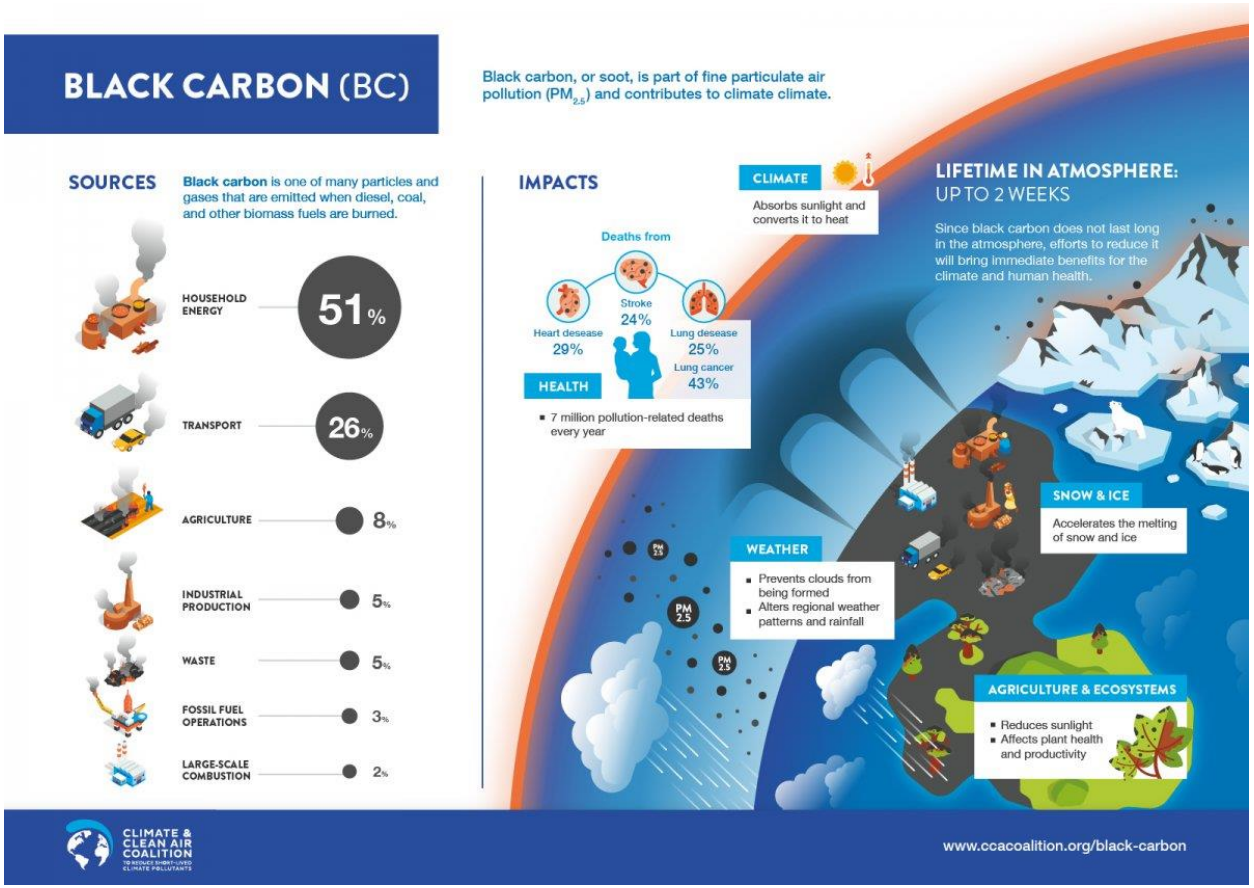
- BC
  - strongly absorbs visible and near- IR light
  - Predominately released by high-temperature combustion of fossil fuels
- BrC
  - absorbs light primarily at the low visible wavelengths and the near ultraviolet range of the spectrum
  - emitted by biomass combustion

2. Motivation and goal

Why Black carbon?

- **A significant proportion of fine particle aerosol composition is comprised of black carbon (BC)**
- **BC impacts**
  - Human health
  - Climate
  - Weather
  - Snow & ice
  - Agriculture & ecosystems

Lack of observations **in Bulgaria.**



The objective – to estimate BC concentration in urban fine particulate matter ($PM_{2.5}$) **in two Bulgarian cities.**

3. Sampling sites location and equipment

Sofia

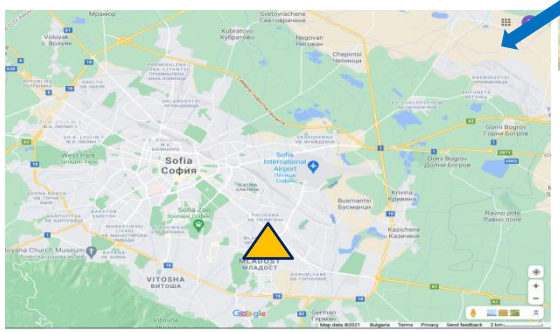
Central Meteorological Observatory (CMO) at NIMH

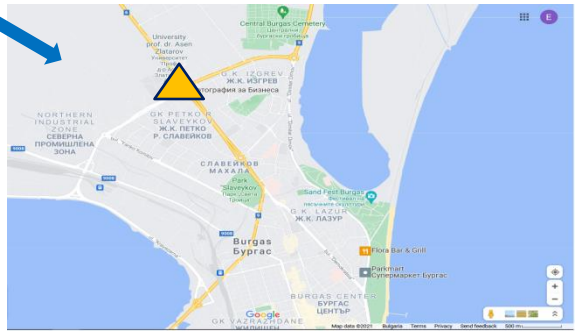
42.66 N, 23.38 E, 586 m a.s.l.

Burgas

University "Prof. Dr Assen Zlatarov"

42.3141N, 27.2647E, at 30 m a.s.l.





Study period: summer (18 June-2 July) and in the autumn (29 Sep – 6 Nov) on 2020

Sampling duration - 24h.

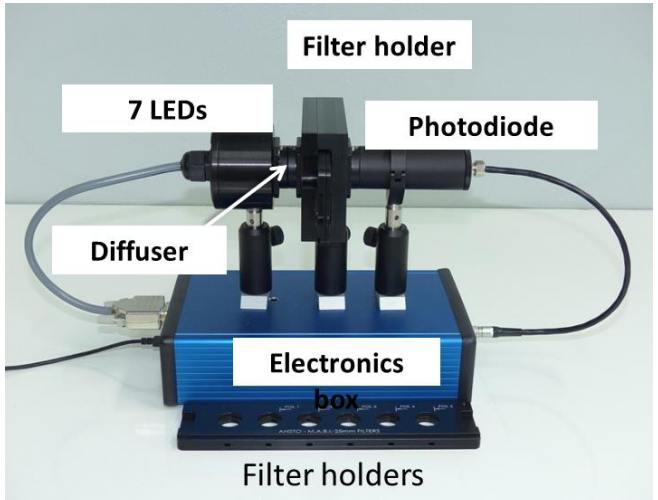
Filters type: Teflon - PTFE PP Ring Supported

EN-12341 standard

Filters conditioned for 48h before and after sampling (T= 20±2°C, RH=50±5%),

4. Equipment and analysis of BC

- Multi-wavelength Absorption Black instrument (MABI) developed at Australian Nuclear Science and Technology Organisation
- Light absorption (I_o and I) at seven different wavelengths (405nm, 465nm, 525nm, 639nm, 870nm, 940nm and 1050nm)
- Differentiate the contributions from sources - biomass burning (BrC) and motor vehicles-traffic (BC)



Filter holders

Atanacio A. J., Cohen D. D., Button D., Paneras N., Garton D., Multi-wavelength Absorption Black Carbon Instrument (MABI) Manual, Australian Nuclear Science and Technology Organisation, Australia.

Determination of black carbon light absorption coefficient:

$$b_{abs} = 10^2 \left[\frac{A}{V}\right] ln\left[\frac{I_o}{I}\right]$$

A - filter collection area in cm^2
V - volume of air sampled through the filter in m^3
I_o - measured light transmission through blank (unexposed) filter
I - measured light transmission through exposed filter

Mass absorption coefficient (ε): $\varepsilon = a\lambda^b$

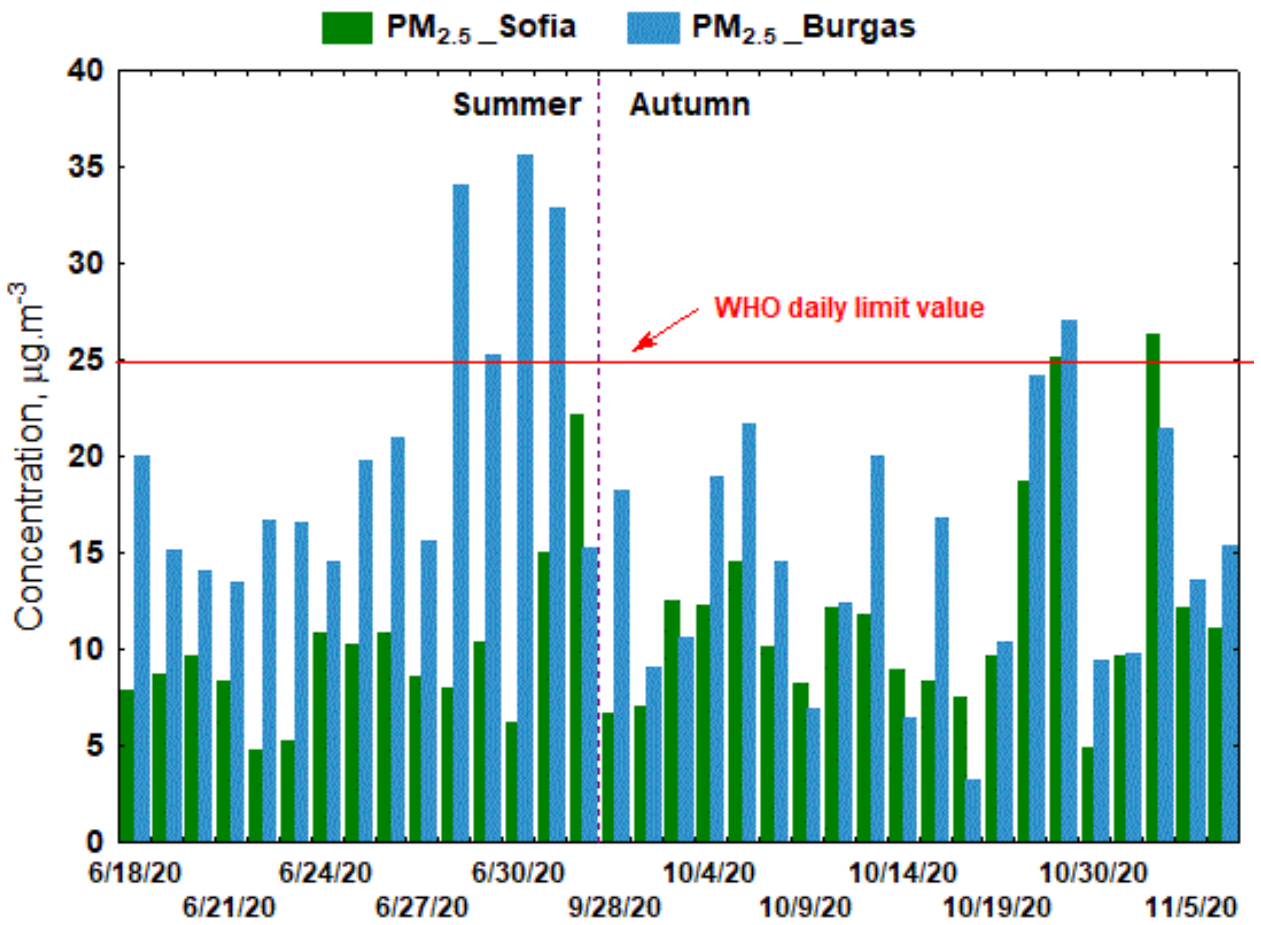
Determination of BC concentration:

$$BC\left(ngm^{-3}\right) = \frac{10^5\left[A\left(cm^2\right)\right]}{\left[\varepsilon\left(m^2g^{-1}\right)\right]\left[V\left(m^3\right)\right]} ln\left[\frac{I_0}{I}\right]$$

The BrC concentration is derived from the differences between BC (405 nm) and BC (1050 nm) as suggested by Coenh et all. 2000

5. Results

$PM_{2.5}$ mass concentrations in Sofia and Burgas

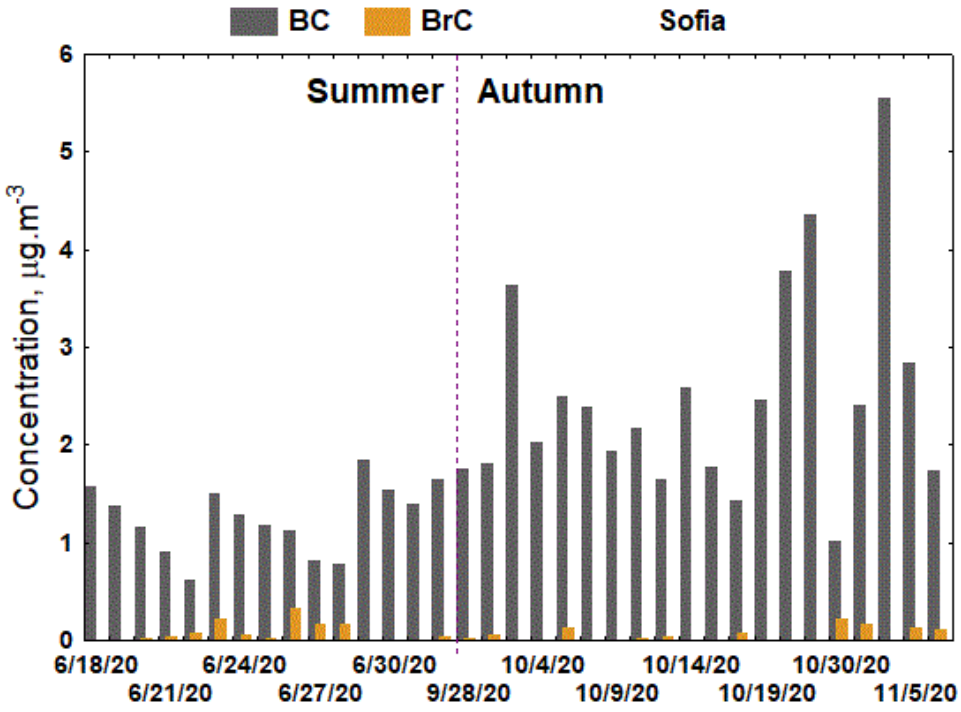


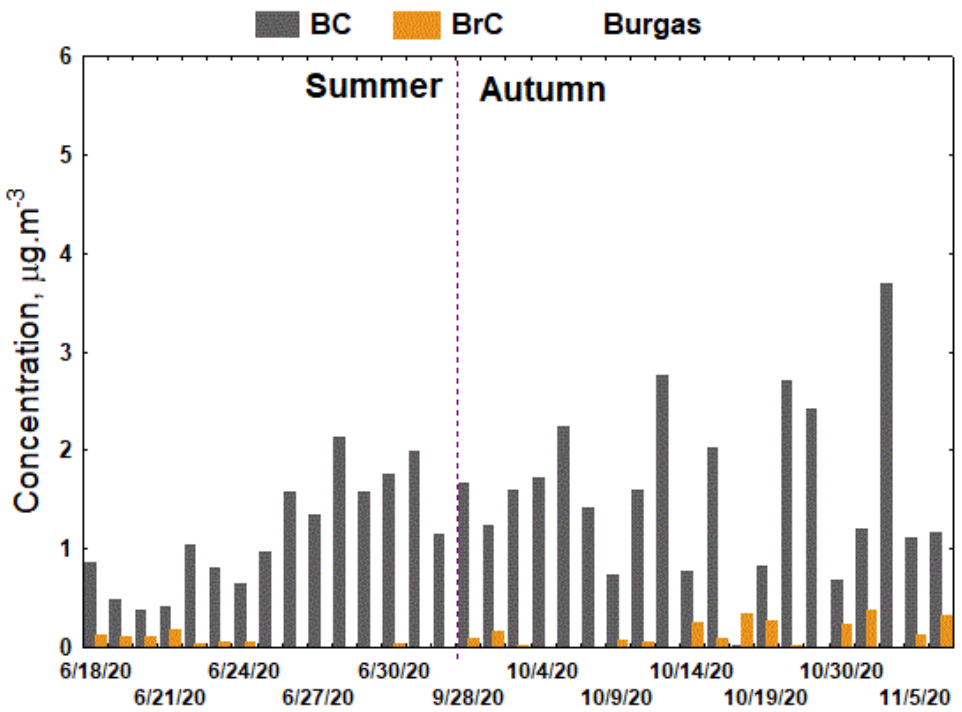
Range of mass $PM_{2.5}$ concentrations:

- Sofia: **4.8 - 26.4** μgm^{-3}
- Burgas: **3.3 - 35.6** μgm^{-3}

5. Results

Black carbon (BC) and Brown carbon (BrC)

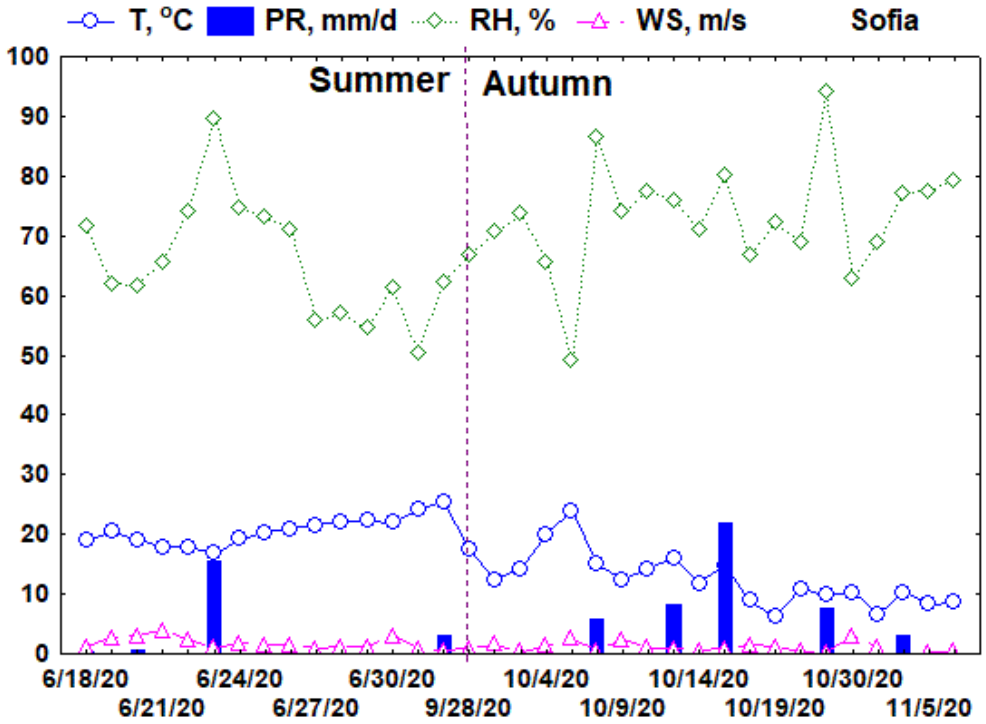




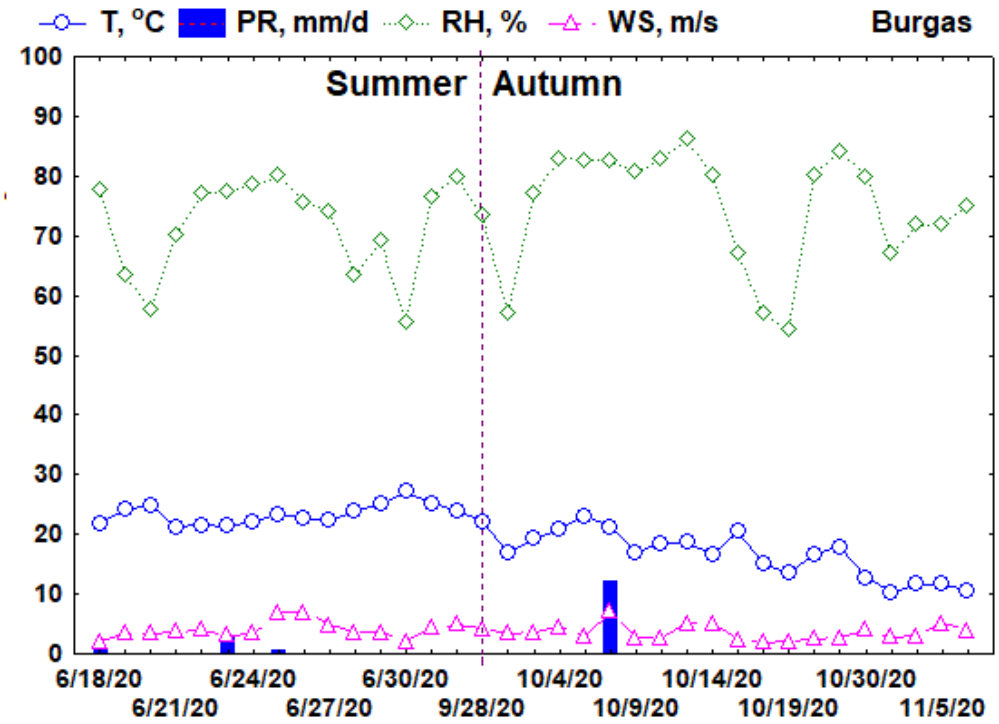
Mean concentration, µgm^{-3}	Sofia	Burgas
Black carbon	1.96	1.39
Brown carbon,	0.10	0.14

5. Results

Time series of temperature (T), precipitation rate (PR), relative humidity (RH), and wind speed (WS)



	T	PR	RH	WS
$PM_{2.5}$	-0.06	-0.22	0.14	**-0.46**
BC	**-0.49**	-0.10	**0.39**	**-0.55**



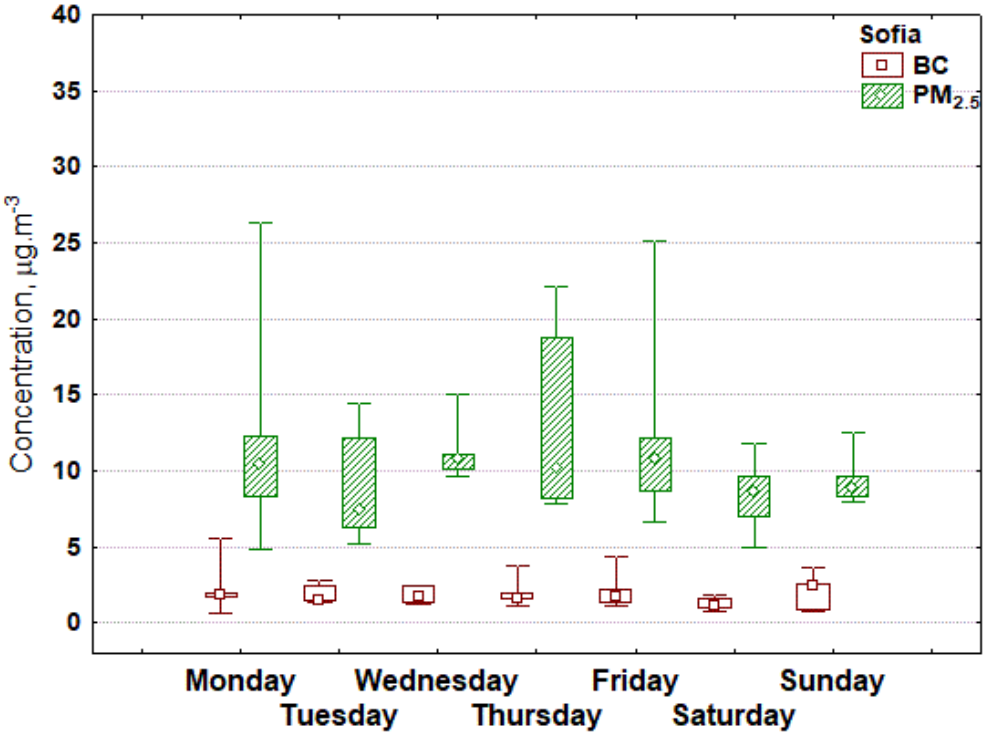
	T	RH	WS
$PM_{2.5}$	**0.52**	0.04	0.01
BC	-0.03	**0.29**	-0.02

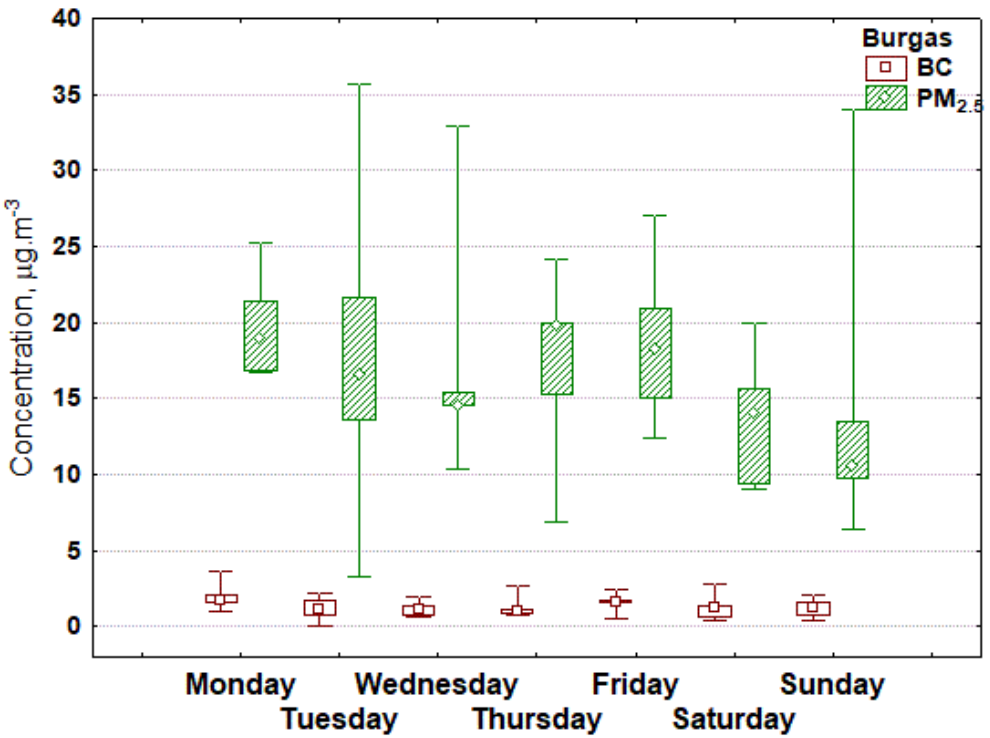
Statistically significant correlation coefficients ($p < 0.05$) are bolded

5. Results

Box-whiskers plot of BC and $PM_{2.5}$ concentrations for different weekdays and weekend

Median; Box: 25%-75%; Whisker: Min-Max





8. Conclusions

- This study aimed to determine one of the most significant components in urban fine particle matter, **Black Carbon.**
- Using MABI we were able to differentiate the contributions from sources as biomass burning (BrC) and motor vehicles-traffic (BC)
- Results show
  - **Sofia - 18%** of the $PM_{2.5}$ mass consists of BC and only **1.3 %** is BrC
  - **Burgas - 10%** of the $PM_{2.5}$ mass is BC and **1.6%** is BrC
  - Correlation between $PM_{2.5}$ and BC for both sampling site (Sofia - 0.74 and Burgas - 0.61) suggest the **domination of fossil fuel combustion** contribution to $PM_{2.5}$ concentration.
  - The $PM_{2.5}$ concentrations in Burgas are higher than those in Sofia.
  - The derived BC values for Sofia are higher than those for Burgas reflecting the higher traffic intensity in Sofia.
- Our study helps to better understanding $PM_{2.5}$ composition and its sources
- The acquired new knowledge for carbon concentrations (BC / BrC) in the $PM_{2.5}$ is vital for this European region where there is a lack of such data.
- Because of the significant role of BC in urban air quality and human health more studies on BC sources are needed.

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Thank you!

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CARBOAEROSOL

Study of black CARBOn and some important hydrocarbons in the atmospheric AEROSOL in an urban environment