Response to the Reviewer's Comments #1

AC: The authors appreciate comments made by reviewers that helped us substantially to improve our manuscript. We have carefully addressed the comments in the revised manuscript. Here, we provided point-by-point responses below in this document. Author comments (AC) are in **blue** and parts that were changed in the manuscript are in **red**.

General comments

RC: The manuscript describes a PM10 source apportionment study in Belgrade. The methodology is briefly described and the factor/sources are presented in detail. It is not clear why the study focuses on PM10 while it is well known that PM2.5 is a better indicator of health impacts. More effort is needed to emphasize the scientific added value of this study compared to previous work and to place it in the broader context.

AC: Thank you very much for comments about manuscript in general, methodology and factors/sources.

This study focused on comprehensive representation of PM from a wider range of sources that hasn't been identified in Belgrade Metropolitan area so far. Although the methodology used in this study is well known, the inclusion of organic tracers in source apportionment allowed us to identify two biological sources (primary biological aerosol particles and biogenic secondary organic aerosol) for the first time in the Western Balkan and wider region. PBAP source comprise a heterogeneous group of particles (bacteria, fungi, plant debris, viruses), but the most abundant fraction represent fungal spores which are usually observed in the size range 2-10 µm (Bauer et al. 2008). Other sources of interest like mineral dust and desert dust events also have coarser grain size than it is $PM_{2.5}$.

You are right, $PM_{2.5}$ is a better indicator of health impacts, but exposure to PM_{10} that consist of fine ($PM_{2.5}$) and coarse fraction ($PM_{2.5-10}$) is also recognised as a standard metric for air quality assessment and regulation while WHO recommends monitoring impact of desert dust events in PM_{10} (WHO, 2021). PM_{10} include coarse fraction which has distinct health effects beyond those attributable to $PM_{2.5}$ alone (Choi et al. 2026, Tian et al. 2020).

The importance of PM_{10} monitoring depends on the objective of the assessment:

- If the goal is to estimate long-term mortality and the overall health burden, $PM_{2.5}$ is usually sufficient and is the indicator recommended by organizations such as the World Health Organization and the European Environment Agency.

- If the goal is to assess short-term health effects, compliance with air quality standards, or the impact of coarse particles, PM_{10} monitoring remains important (WHO, 2021).

The goal of this study was to cover sources of fine and coarse particles pollutants and we monitored PM_{10}.

References:

Bauer, H., Claeys, M., Vermeylen, R., Schueller, E., Weinke, G., Berger, A., and Puxbaum, H.: Arabitol and mannitol as tracers for the quantification of airborne fungal spores. Atmos. Environ., 42, 588-593, https://doi.org/10.1016/j.atmosenv.2007.10.013, 2008.

World Health Organization: WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization, Geneva, https://iris.who.int/server/api/core/bitstreams/551b515e-2a32-4e1a-a58c-cdaecd395b19/content, 2021.

In the manuscript we also addressed reviewer's comment to more clearly explained why we focused on PM_{10} in our study:

Row 53-58

"Many studies demonstrated correlation between exposure to $PM_{2.5}$ and cardiopulmonary and lung cancer mortality, making it the world's leading environmental risk factor (McDuffie et al. 2021, Burnett et al. 2018, Pope et al. 2002). However, some authors highlight that the health effects from coarse particulate matter should not be overlooked as the adverse health effects related to this fraction distinct beyond the attributable effects of $PM_{2.5}$ alone. Therefore, the continuous monitoring of PM_{10} is necessary as it includes both coarse and fine fraction (Tian et al. 2020, Choi et al. 2026)."

Row 413 - 419

"PBAP are found mainly in the coarse fraction of PM, with a maximum in a range from 5.6 to 10 µm which can contribute to the PM mass concentration to up to 5 $\mu g/m^3$ in the summer period (Marcovecchio and Perrino, 2021). As this factor gathers the particles released into the atmosphere from living organisms, they are usually referred as bioaerosols (Fröhlich-Nowoisky et al. 2016). Dispersed in the air, bioaerosols may interact with PM which then serves as a carrier for bioaerosols. As a result, allergic sensitization and respiratory infections may occur and the incidence of these diseases is higher in areas with higher air pollution (Huang et al. 2024)."

Introduction

RC: The most appropriate citations for PMF are: Paatero P. and Tapper U.,1994 Envirometrics; Paatero P. and Hopke P., 2009 J. Chemometrics

AC: Thank you for the reminding us of these two important papers, we added these references in the introduction part where PMF model is described.

Row 104 - 108

"In light of this, the present study aimed to perform PM_{10} source apportionment in Belgrade using PMF, a multivariate receptor model capable of resolving PM mass concentration into contributions of various source types (Paatero and Hopke, 2009) by utilizing error estimates of the species from the data matrix and implements strict non-negativity constraints for the factors (Paatero and Tapper, 1994)."

RC: The objective of the study should be clearly indicated in the introduction.

AC: Thank you for this comment, we rewrote the objective that explains our aim more clearly now.

Row 112 - 115

"The objective of the study is to offer a broader perspective on PM_{10} sources by incorporating ions and, elements, and for the first time number of tracers for biogenic aerosols as well as tracers for biomass

burning together with OC and EC as input variables, and thereby quantify both natural, including biological, and anthropogenic sources at an urban background site in Belgrade."

Methodology

RC: The authors should explain more clearly in the methodological section the procedure they followed to establishing the number of factors and attributing factors to sources including the model diagnostics and the use of independent external evidence (e.g. results from other studies) used to support their choices.

AC: The followed procedure to establish final number of factors was based on recommendations of the JRC publication "European guide on air pollution source apportionment with receptor models" (Belis et al. 2019a). The model diagnostic information and references from other SA studies that we used to confirm our factors are added.

Reference:

Belis, C. A., Favez, O., Mircea, M., Diapouli, E., Manousakas M-I., Vratolis, S., Gilardoni, S., Paglione, M., Decesari, S., Mocnik, G., Mooibroek, D., Salvador, P., Takahama, S., Vecchi, R., Paatero P.: European guide on air pollution source apportionment with receptor models – Revised version 2019, EUR 29816 EN, Publications Office of the European Union, Luxembourg, https://data.europa.eu/doi/10.2760/439106, 2019a.

The extended version in the manuscript with more clear explanation and references that support our factor choices as well as model diagnostic are described:

Row 188 - 206

"To determine the optimal number of factors, solutions with a total number of factors from 3 to 9 with random seed number and no applied factor constrains were examined. The final solution was derived from 100 base runs, with robustness evaluated according to the recommendations of "European guide on air pollution source apportionment with receptor models" (Belis et al. 2019a): (1) all factors' chemical profile and temporal variability could have been interpreted, (2) Qtrue/Qexp ratio, (3) normal distribution of modelled species with more than 95% uncertainty-scaled residuals was within ±3, and (4) on displacement (DISP) and bootstrap (BS) analysis which confirmed the stability of the model.

The input data included sets of chemical tracers that allowed identification of chemical profile and temporal variability connected to certain sources based on previously conducted studies. Therefore, levoglucosan, mannosan, galactosan, K, Rb, OC and EC were tracers for biomass burning (Yttri et al. 2011, Weber et al. 2019), sugars and sugar alcohols for primary biological aerosol particles (Bozzetti et al. 2016) and 2-methyl tetrols for biogenic secondary organic aerosol from isoprene (Srivastava et al. 2018) (Table 1). As mineral dust tracers were considered Al, Ti, Sr, Ca, Mg (Moreno et al. 2006, Tursun et al. 2025), As, Cd, Ni indicated industrial emission (Querol et al. 2007) and EC, Sb, Sn, Fe, Pb for exhaust and non-exhaust emissions (Amato et al. 2009, Srivastava et al. 2018). Qtrue was 1574.62 and Qrobust 1574.66 which resulted in Qtrue/Qexp ratio of 1.03 which is less than 1.5 meaning the effect of outliers on the results was negligible (Belis et al. 2019a). In case of DISP test, no factor swaps were reported and the change in Q value remained minimal (-0.013). BS analysis based on 100 runs is showed in Table 2. All factors had > 70 out of 100 mapped factors which is considered as appropriate solution (Belis et al. 2019a). The extra model

uncertainty was 7%. The correlation between observed and modelled PM_{10} concentrations was 0.92 indicating good reconstruction of PM_{10} mass concentration.

RC: Also the way in which polar plots and backward trajectories is used should be explained in the methodological section.

AC: Thanks for this important point that we missed to add. In the methodology section of the manuscript, we added 2.7. section which addressed air mass transport modelling.

Row 211 - 230

"2.7. Air mass transport modelling

To examine and support the physical plausibility of the resolved PMF factors that they represent realistic local and transported sources influencing the monitoring site, backward trajectories and polar plots analysis were performed. To understand airmass transport to the Ada Marina station, the standard ATMO-ACCESS Research Infrastructure (https://flexpart-request.nilu.no/data-access) set-up was used for dust. Specifically, the Lagrangian particle dispersion model FLEXPART version 10.4 (Pisso et al. 2019) ran in the classic retroplume mode for 30 days backward in time for 3-hourly timesteps. The model was driven by ECMWF ERA5 reanalysis (Hersbach et al. 2019) with 0.5° spatial and hourly temporal resolution over 137 vertical levels. The resulting footprint emission sensitivity expresses the probability of potential emissions to arrive at Ada Marina, showing airmass origin, and can be converted to atmospheric concentrations at the receptor (Ada Marina) if combined with an emission dataset. For dust, emissions were first calculated using the FLEXDUST module (Groot Zwaaftink et al. 2016). FLEXDUST uses input parameters, such as soil type, vegetation/snow cover, threshold friction velocity, particle-size classes combined with surface and meteorological conditions from ECMWF ERA5 data (0.25° resolution, hourly) to calculate gridded emission fluxes for 10 size-classes of dust particles from 0.2 to 20 µm.

Beside FLEXPART, air mass transport modelling was performed also by Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) transport and dispersion model developed by the National Oceanic and Atmospheric Administration (NOAA). The 24h back-trajectories used GFS Meteorological Data and vertical velocity model and were calculated at 100 m, 200 m and 500 m above ground level.

The directional dependence and temporal behaviour of each factor was examined using polarPlot function from the openair (version 2.18-2), R package (version 4.4.2) (Carslaw, 2012)."

Results and discussion

RC: Important publications regarding the study area should be considered in the discussion of results (e.g. Almeida et al., 2020 Environmental Pollution)

AC: We agree with your comment and in revised manuscript we discussed in more details all previous SA studies performed upon data sets collected at Belgrade central zone and Belgrade Metropolitan in both introduction part as well as discussion. Also, we added Figure S1 where we marked monitoring sites of all studies performed in period of 2003-2015 and added contributions and species used for factor identification in these studies in Table S1.

Seven studies of SA were performed upon data sets collected in period 2003-2015. Paper of Almeida et al. (2020) used data set collected for period of 16 months that finished in August 2015. However, Todorović et al. (2020) took filters and results collected in one year campaign from Almeida et al. (2020) and performed additional analyses of ions. Todorović et al. (2020) performed separate SA analyses and obtain results that were partly different from Almeida et al. (2020). In the paper of Almeida et al. (2020) that was part of IAEA project in 16 cities, authors noted by themselves that combustion of oil fuel factor in Belgrade, contributing 38% to $PM_{2.5}$ mass, was overestimated. This factor did not exist as separate in the study of Todorović et al. (2020) where factor local combustion sources and ammonium nitrate accounted by 29,7 % of $PM_{2.5}$ mass. The genesis of differences between Almeida et al. (2020), Todorović et al. (2020), and our results may be explained by: time distance of campaigns (about eight years passed before WeBaSOOP campaign started); characteristics of sampling sites (Zeleno brdo vs. Ada Marina); nonidentical airborne PM fraction ($PM_{2.5}$ vs. PM_{10}); additional analysed speces used as input data for PMF analyses in Todorovic et al. (2020) and this study in comparison to study of Almeida et al. (2020).

References:

Almeida, S., M., Manousakas, M., Diapouli, E., Kertesz, Z., Samek, L., Hristova, E., Šega, K., Padilla Alvarez, R., Belis, C. A., Eleftheriadis, K., The IAEA European Region Study Group: Ambient particulate matter source apportionment using receptor modelling in European and Central Asia urban areas. Environ. Pollut. 266, 115199, https://doi.org/10.1016/j.envpol.2020.115199, 2020.

Todorović, M. N., Radenković, M. B., Onjia, A. E., and Ignjatović, L. M.: Characterization of PM2.5 sources in a Belgrade suburban area: a multi-scale receptor-oriented approach. Environ. Sci. Pollut. Res, 27, 41717-41730, https://doi.org/10.1007/s11356-020-10129-z, 2020.

Here is the revised Table S1 in the Supplementary Material:

Table S1. Overview of the source apportionment studies conducted in Belgrade for the period 2003-2015.

	PM fraction	Sampling site	Period	N	PM concentration ($\mu g/m^3$)	Chemicals analyzed	Factors resolved	Model used	Reference
1	$PM_{2.5}$, PM_{10}	1. 44°49'06.7"N 20°27'27.3"E 2. 44°47'39.8"N 20°27'56.3"E	Jun 2003 - Jul 2005	$PM_{2.5}$: 64; PM_{10}: 209	$PM_{2.5}$: 61.4 PM_{10}: 68.4	Pb, Cu, Zn, Mn, Fe, Cd, Ni, V, Al, Cr	$PM_{2.5}$: resuspended road dust (Zn, Al, Mn, Fe) (29%), traffic and oil refineries (Cr, Pb) (17.8%), oil combustion (V, Ni) (17.7%), -diesel fuel and local industry (Cu, Cd) (13.5%) PM_{10}: -road dust (Mn, Zn, Fe, Al, Ni) (26.1%), fuel oil (V, Ni) (17.4%), road traffic emission (Cu, Cd, Pb) (16.8%), traffic exhaust (Cr, Pb) (13.2%)	PCA	Rajšić et al. 2008
2	PM_{10}	1. 44°49'06.7"N 20°27'27.3"E 2. 44°47'39.8"N 20°27'56.3"E	Jul 2003 - Dec 2006	277	70.1	Al, V, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb	Fossil fuel combustion (V, Ni, Fe, Cu, Mn) (34), -traffic exhaust/regional transport from industry (Zn, Fe, Mn, Cu, Ni) (26%), traffic related particles/site specific industrial processes (Cu, Pb, Mn, Cd) (21%) , mineral/crustal matter (Al, Fe, Cu, Mn, Ni, Cd) (19%)	Unmix USEPA	Mijić et al. 2012
3	$Dp \leq 0.49\mu m$ $0.49 \leq Dp \leq 0.95$; $0.95 \leq Dp \leq 1.5$; $1.5 \leq Dp \leq 3.0$; $3.0 \leq Dp \leq 7.2$; $Dp \geq 7.2\ \mu m$	44°49'14.25"N 20°27'44.81"E	Jun - Dec 2008		$Dp \leq 0.49\mu m$: 7.9 $0.49 \leq Dp \leq 0.95$: 2.7 $0.95 \leq Dp \leq 1.5$: 1.8 $1.5 \leq Dp \leq 3.0$: 2.0 $3.0 \leq Dp \leq 7.2$: 3.3 $Dp \geq 7.2\ \mu m$: 1.3	Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-}	Ammonium sulphate (SO_4^{2-}, NH_4^+, Cl^-, Mg^{2+}) (16.4%); -marine aerosol (Na^+, Cl^-) (14.9%); construction activities (Ca^{2+}) (10%); fertilizer plant (PO_4^{3-}) (8.5%); industrial zone (Cl^-, SO_4^{2-}, NH_4^+, K^+); (8.1%) biomass burning (K^+) (8%)	PCA	Đorđević et al. 2012

4	PM_{10}	1. 44°38'42.15" N, 20°26'52.48" E 2. 44°36'11.74" N, 20°06'09.30" E 3. 44°48'03.5" N, 20°27'57.8" E	2010 – 2011		1. Summer: 31.86 Winter: 80.31 2. Summer: 26.16 Winter: 62.38 3. Summer: 44.37 Winter: 88.46	Nap, Acy, Ace, Flu, Phe, Ant, Flt, Pyr, BaA, Chry, BbF, BkF, B[a]P, Ind, DahA, BghiP	*Diesel and gasoline exhaust (traffic 1) (BbF, BkF, B[a]P, Ind, DahA, BghiP) (55.2% winter, 38.5% summer); Unburned petroleum from vehicles (traffic 2) (Nap, Ace, Phe) (13.5% winter, 17.4% summer); Stationary sources (Flt, Pyr, BaA, Chry, BkF, BbF) (31.3% winter, 43.9% summer)	USEPA PMF 3.0	Cvetković et al. 2015
5	PM_{10}	44°49'00.42"N 20°28'12.85"E	2011 – 2015	254	60.51	B[a]P, As, Cd, Cr, Mn, Ni, Pb, Cl^-, Na^+, Mg^{2+}, Ca^{2+}, K^+, NO_3^-, SO_4^{2-}, NH_4^+, OC, EC	Solid fuel burning (B[a]P, As, OC, SO_2, CO, NO_3^-) (29.8%), Industrial emissions (Cd, Pb) (21.9%), Secondary aerosols (NH_4^+, SO_4^{2-}, NO_3^-) (19.5%), vehicle derived and particle resuspension (EC, NO_x, soot) (28.7%)	Unmix USEPA	Stojic et al. 2016
6	$PM_{2.5}$	44°47'12.17"N 20°31'16.63"E	May 2014 – May 2015	133	20.8	Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, As, Ba, Pb, NH_4^+, NO_3^-, SO_4^{2-}	Biomass burning (K, Cl, S, Zn) (14.5%), -Traffic (Fe, Pb, Mn, Cu, Zn) (3.9%), secondary sulphate from regional combustion sources (S, NH_4^+) (28.8%), local combustion sources and ammonium nitrate (V, Ni, NO_3^-, NH_4^+) (29.7%), soil (Si, Ca, Ti, Fe, Mn) (5.4%) unaccounted (17.8%)	USEPA PMF 5.0	Todorovic et al. 2020
7	$PM_{2.5}$	44°47'12.17"N 20°31'16.63"E	Apr 2014 – Aug 2015	166	20.7	Al, Si, S, Cl, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Pb, Ni, P, Cr, As, Br, Ba	Soil (Al) (8%), Biomass burning (Cl, K, Zn, Pb) (15%), Traffic (Ca, Si, Fe, Ti, Mn) (3%), fuel oil combustion (V, Ni) (38%), secondary sulfate (S, Pb, Cu, Ti) (3%), unaccounted (33%)	USEPA PMF 5.0	Almeida et al. 2020
8	PM_{10}	44°47'25.4"N 20°25'02.5"E	Jun 2023 – May 2024	84	23.9	OC, EC, Na, Mg, Al, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Cd, Ba, Pb, P, Ti, Zr, Mo, Sb, Sn, Cl^-, NO_3^-, SO_4^{2-}, NH_4^+, galactosan, mannosan, levoglucosan, 2-methylerythritol, 2-methylthreitol, glucose, fructose, mannitol, arabitol, trehalose	Biomass burning (galactosan, mannosan, levoglucosan, K, Cl-, Rb, OC) (21%), Long-range transport and road-salt/local combustion (Na, NO3-, Cl-) (9%), Mineral dust (Al, Ti, Sr, Mg, Ca) (17%), Primary biological aerosol particles (glucose, fructose, trehalose, mannitol, arabitol) (10%), Biogenic secondary organic aerosol from isoprene (2-methylerythritol, 2-methylthreitol) (10%), Ammonium sulphate (SO42-, NH4+) (18%), Traffic/industry (EC, Fe, Sb, Cu, Sn, Mn, Pb, V, Cd, As) (15%)	USEPA PMF 5.0	This study

N – number of samples
*factors resolved in sampling site in urban zone of the city (Slavija)

Here is the added Figure S1 in the Supplementary Material:

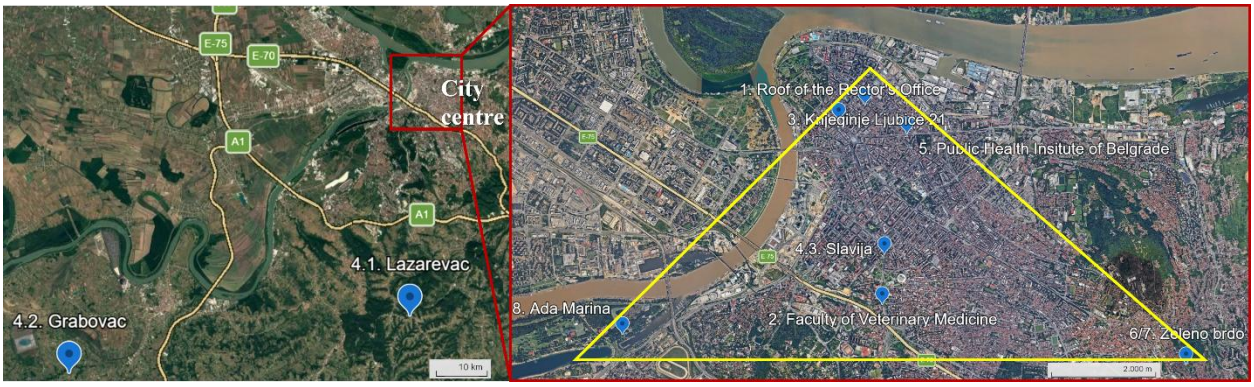

Figure S1. Map of Belgrade with monitoring sites included in the studies from the Table S1. Rajšić et al. 2008, Mijić et al. 2012: Roof of Rector's Office (1), Faculty of Veterinary Medicine (2); Đorđević et al. 2012: Knjeginje Ljubice 21 (3); Cvetković et al. 2015: Lazarevac (4.1.), Grabovac (4.2.) Slavija (4.3.), Stojić et al. 2016: Institute of Public Health Belgrade (5); Todorović et al. 2020, Almeida et al. 2020: Zeleno brdo (6, 7); this study: Ada Marina (8).

Below are the paragraphs added to the manuscript (both introduction and discussion) regarding discussion of the results:

Row 94 - 104

"In addition, sampling sites where daily (24h) filter samples were collected, were in Belgrade city area, in triangle of 20 km^2 as it is presented at Figure S1. For one of SA study, Cvetković et al. (2015), one site was in the medium of triangle and another two sites were out off triangle nearby thermal power plants in

Metropolitan area of Belgrade far away for several tens of kilometres from the city centre. Only studies of Todorović et al. (2020) and Almeida et al. (2020) overlap with the period of sampling and sampling site as filter samples were collected at the urban background area at Zeleno brdo (Figure S1). Furthermore, species used in these SA studies were different (Table S1). Some studies were performed only upon analyses of elements (Mijić et al. 2012, Rajšić at. 2008, Almeida et al. 2020), ions (Đorđević et al. 2015) or PAHs (Cvetković et al. 2015). Almeida et al. (2020) for SA study used data collected for 16 months and concentrations of elements while Todorovic et al. (2020) as input data set used one year of Almeida et al. (2020) data set and performed additional analyses of ions."

In the Section 3.2.1:

Row 329 - 335

"In the previous SA studies performed for Belgrade region and Metropolitan, biomass and/or wood burning were identified as separate or mix factor. In the study of Đorđević et al. (2012) this factor was identified as separate factor based on the dominant presence of K^+ (8%) while Cvetković et al (2015) verified it by PAHs Nap, Acy and Ace (10.4%). In the studies of Todorović er al. (2020) and Almeida et al. (2020) biomass burning was identified with Cl, K, Zn, Pb and S with contribution of about 15% in both studies. In this study biomass burning was 21% of PM_{10} mass concentration, and was identified based on OC, organic tracers (levoglucosan, mannosan and galactosan) and Rb, that is, beside K, one of the alternative tracers for this factor (Massimi et al. 2020, Pereira et al. 2025)."

In the Section 3.2.3:

Row 386 - 388

"However, factor soil, in this study titled mineral dust, was identified in the studies of Almeida et al. (2020) and Todorović et al. (2020), contributed to PM_{10} mass concentration with 8% and 5% respectively."

In the Section 3.2.6:

Row 479 - 497

"In the study of Todorović et al. (2020), factors secondary sulphate from regional combustion sources (S, NH_4^+) (28.8%) and local combustion sources and ammonium nitrate (V, Ni, NO_3^-, NH_4^+) (29.7%) accounted for around 2/3 of PM_{10} total mass concentration. For the same sampling site, Almeida et al. (2020) identified sulphate factor with contribution of 3%, which was separated from oil fuel combustion (38%). Comparing their results to ammonium sulphate contribution in our study (18%), differences may be explained by nonidentical PM fraction, SA with PM_{10} identified factors that are not only from combustion sources, the chemicals analysed and used as input data in PMF, time period when studies were conducted as well as long-term trends that indicate airborne PM decrease (de Hoogh et al. 2025). Almeida et al. (2020) analysed 19 elements (Table S1) while Todorovic et al. (2020) analysed also ions beside the 19 elements (Table S1). Furthermore, Todorovic et al. (2020) as well as Almeida et al. (2020) had sampling campaign in the period from 2014-2015. Their studies represent the last SA studies in Belgrade until

WeBaSOOP sampling campaign. In the time span of eight years, the sources in Belgrade changed due to: substantial changes in traffic routes in Belgrade central zone, industrial activities, observed reductions in PM_{10} concentrations during the 2010s. The PM_{10} decrease likely reflect the combined effects of the long-term replacement of coal- and oil-fired boiler houses with district heating supplied predominantly by natural gas, together with the gradual phase-out of small local boiler plants and other emission control measures (https://beoelektrane.co.rs/saopstenja/veliki-doprinos-beogradskih-elektrana-u-borbi-za-cistiji-vazduh-i-smanjenje-zagadenja-u-glavnom-gradu/?utm_source=chatgpt.com). Finally, Almeida et al. (2020) emphasised that in their study contributions of some tracers were not well defined which led to overestimation of oil combustion and underestimation of other factors."

Conclusions

RC: The conclusion section should be revised to match ACP guidelines for authors

AC: We appreciate indicating discrepancies between our conclusion and ACP conclusion guidelines. In the manuscript, the conclusion is improved according to the ACP guidelines, with clear and concise summary and synthesis of the obtained results, explained and summarized consistencies and inconsistencies with other SA studies performed in Belgrade are, limitations and explanation of contribution of our paper to understanding of the monitoring and mitigation measures of PM_{10}.

Row 538 - 545

"Eight SA studies were conducted in the past in Belgrade urban and Metropolitan area upon data sets collected in the period from 2003 and 2015 and WeBaSOOP year-long campaign in 2023-2024. Although WeBaSOOP study was conducted upon data set collected eight years after the last study and having different, broader range of, species used for SA, factors traffic, industry, different combustion sources, mineral/soil dust and secondary inorganic aerosol were identified in all studies in the past and ours. This indicates a continuity of these factors throughout the years on air quality in Belgrade. One study performed on data sets collected 15 years ago identified marine aerosol also but with higher contribution than in our, WeBaSOOP, study. However, in contrast to other studies, this was the first one that identified factors from biological origin (PBAP and $BSOA_{Isoprene}$)."

Row 563

"Our results showed influence of both, local (biomass burning, traffic, biogenic aerosols) and regional sources (mineral dust, salt from long-range transport) on PM_{10} concentration in this area."

Row 567 - 569

"However, further work for better understanding of PM_{10} regional and local sources in Belgrade is needed by performing SA study at least for two fractions of airborne PM represent by fine and coarse fraction as well as combination of offline and online PMF analysis and long-term measurements."

Row 570 - 580

"Mineral dust events, marine aerosol and biogenic aerosols contribute to the background concentration of PM_{10} and $PM_{2.5}$ and are largely beyond the scope of emission control measures. Although sea salt was not extracted as a separate factor in WeBaSOOP study, its contribution to PM_{10} mass may be accounted as

1-2 μg/m^3, but in case of mineral dust, contribution is estimated to be around 4 μg/m^3. In WeBaSOOP study, mineral dust represents mix of both natural and anthropogenic sources from local and long-range transport, while 1/5 of PM_{10} mass (around 5 μg/m^3) was attributed to primary and secondary airborne particulate matter of biogenic sources. As emissions from these sources are beyond controllable measures compliance with ambient air quality limit values consequently requires sufficient reductions in controllable anthropogenic emissions to offset the irreducible natural background. Where legislation permits, documented contributions from specific natural sources, such Sahara dust events and sea salt, may be excluded from compliance assessment. However, routine exclusion of biogenic aerosol contributions is generally not possible to be applied without measurements such WeBaSOOP study enabled.“