EVALUATION OF AIR QUALITY CHANGES IN CHINESE MEGACITY OVER 2006-2021 USING $PM_{2.5}$ RECEPTOR MODELLING

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Introduction

Air quality impairment has a huge impact on human health, with atmospheric particulate matter (PM) playing a major role (WHO, 2021). Both changes in emissions and meteorological conditions might affect PM concentration trends. China experienced an increasing 2000-2013 $PM_{2.5}$ concentration trend, however after the application of restrictive measures, a sharp decrease was recorded (Geng et al., 2021). This decreasing trend was particularly evident in the city of Wuhan (Central China). This study focuses on the major $PM_{2.5}$ changes and source contributions at different urban and industrial background sites in metropolitan Wuhan from 2006 to 2021, using receptor modelling applied to experimental $PM_{2.5}$ speciation.

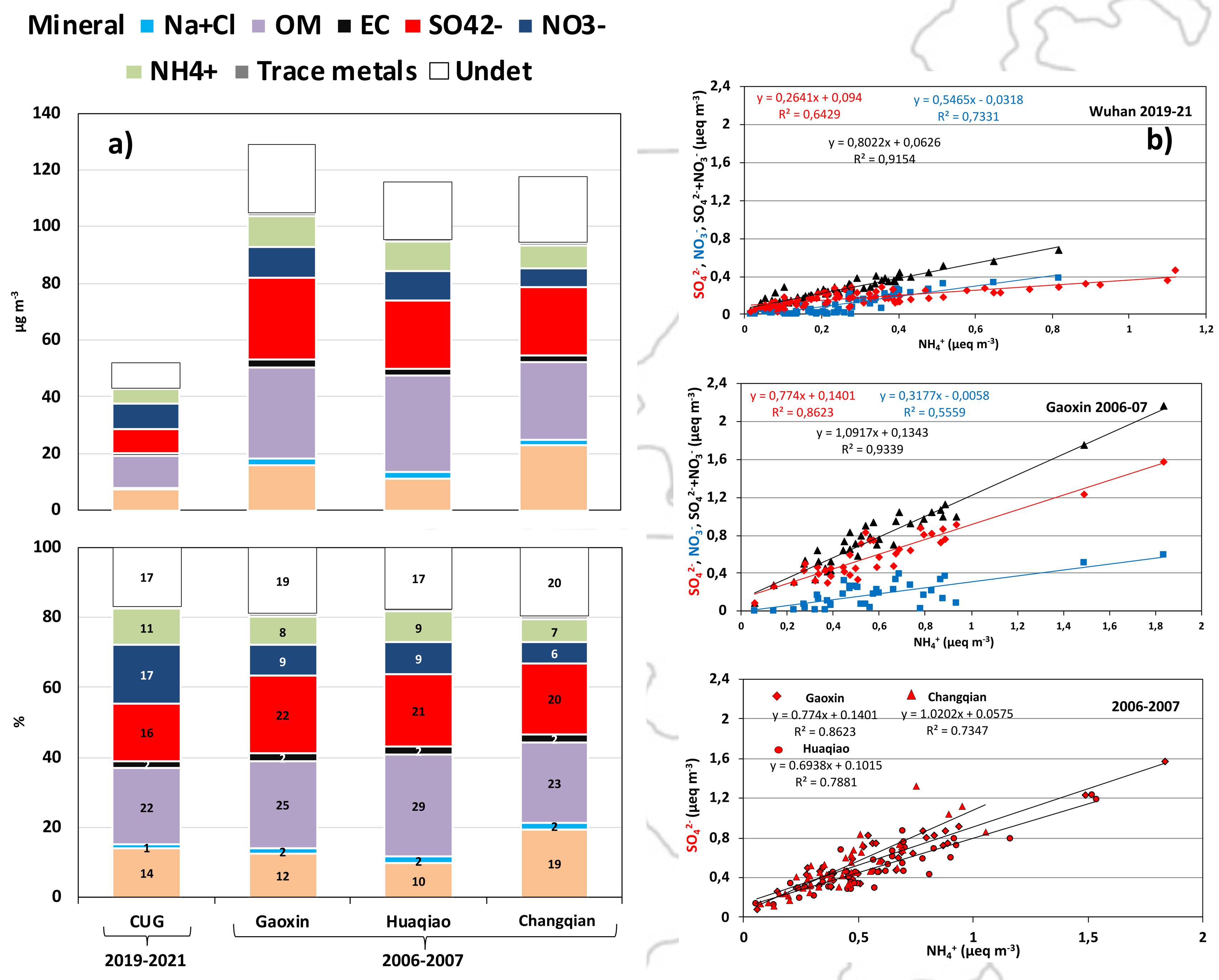

Figure 1. Column a) Levels (top) and percentage contribution (bottom) of different $PM_{2.5}$ components measured at CUG 2019-2021, and those of 2006-2007 at Gaoxin, Huaqiao and Changqian. b) Ion balance of SO_4^{2-}, NO_3^- and SO_4^{2-}+NO_3^- and NH_4^+ for CUG-2019-2021, Gaoxin 2006-2007, and SO_4^{2-} and NH_4^+ for the three sampling sites together in 2006-2007.

Methodology

Sampling was carried out in 2006-2007 at the Changqian, Huaqiao and Gaoxin urban and industrial sites (unpublished data from Lv, 2008 PhD) and at a urban site (China University of Geosciences, CUG) very close to Gaoxin, in 2019-2021.

Major and trace elements were analysed by ICP-MS and ICP-AES, water-soluble ions by HPLC and elemental and organic carbon by thermal-optical transmittance (TOT) method. Filter fractions were solvent extracted and GC-MS analysed for the determination of organic molecular tracer pollutants, in this case only in samples collected in CUG 2019-2021.

The receptor modelling analysis was done by applying the Positive Matrix Factorization model, (US-EPA-PMF5.0) to PM chemical speciation datasets.

Results and conclusions

- Average $PM_{2.5}$ levels decreased by 65% from 2006 to 2020 (*Figure 1*) due to implementation of air quality protection policies and actions.
- For SO_2 the decrease reached 88% due to the decrease of coal combustion.
- NO_2 decreased only by 25% due to the decrease induced by policy actions but the increase of traffic emissions.
- The contributions to $PM_{2.5}$ of OC, SO_4^{2-}, NH_4^+, EC and Cl^- were reduced by 48-71%, while those of NO_3^-, only 22% (*Figure 1a*). Thus, while in 2006-2007 NH_4^+ neutralised mostly SO_4^{2-} (73% of NH_4^+) and in a much lower rate NO_3^- (27%), in 2019-2021 these proportions drastically changed (48 and 52%) (*Figure 1b*).
- The changes in air quality in the urban area of Wuhan are attributable to important mitigation actions, even after correction for meteorological conditions.
- Coal combustion-related elements, mostly Pb, Ni, Ga, Rb, As, Tl, Se, Sn, Bi, K and Zn were reduced by 76-90%, while those related with road dust, traffic and construction, mostly Al, Ca, Cu, Fe, Co, were much less (reduced 54-22%).

Receptor modelling using only inorganic tracers allowed to identify 6 major sources contributing to $PM_{2.5}$ for 2006-2007 and 2019-2021 (*Figures 3a and b*):

- Regional nitrate 24 µg/m³ and 21% in 2006-2007 and 19 µg/m³ and 38% in 2019-2021.
- Regional sulphate 27 µg/m³ and 24% and 16 µg/m³ and 31%.
- Local combustion mix (coal, biomass, traffic….) 31 µg/m³ and 27% and <1 µg/m³ and <1%.
- Mineral 14 µg/m³ and 12% and 14 µg/m³ and 27%.
- Metallurgy 8 µg/m³ and 7% and 1 µg/m³ and 2%.
- Regional coal combustion 10 µg/m³ and 9% and 0.4 µg/m³ and 1%.

Accordingly, the major sources contributions reductions were: local combustion, regional coal combustion, regional sulphate, and metallurgy. Again with a lower decrease of regional nitrate and mineral.

For 2019-2021, and using both inorganic and organic tracers, seven source contributions were obtained (*Figure 3c*): regional nitrate (16 µg/m³ and 31%), regional sulphate (13 µg/m³ and 27%), biomass organic aerosols (6 µg/m³ and 11%), mineral (6 µg/m³ and 12%), regional coal combustion (5 µg/m³ and 9%), biogenic secondary organic aerosols (3 µg/m³ and 7%) and metallurgy (2 µg/m³ and 3%).

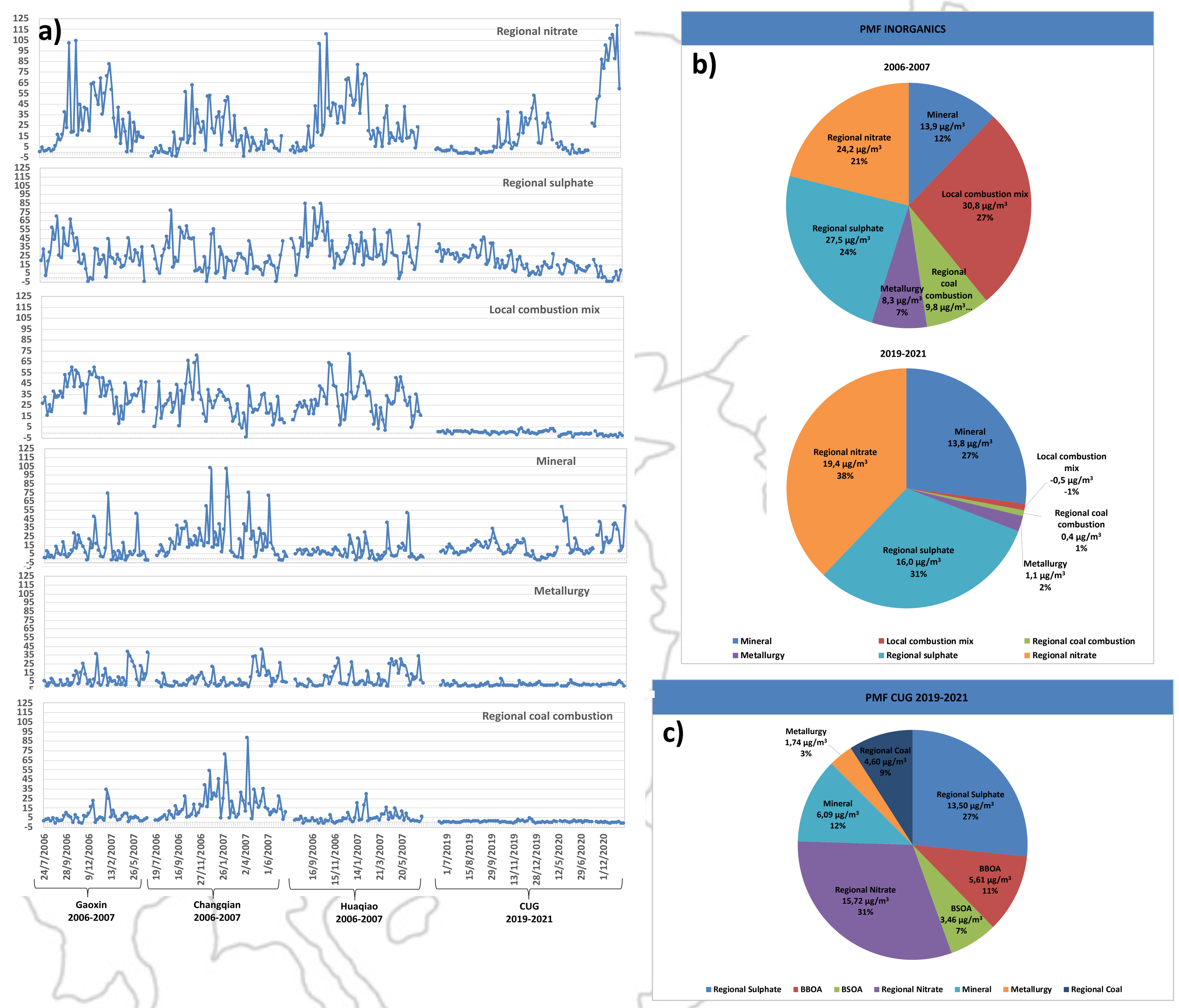

Figure 3. a) Daily source apportionment to $PM_{2.5}$ using receptor modelling EPA PMF 5.0 and only inorganic tracers for 2006-2007 (Changqian, Huaqiao and Gaoxin) and 2019-2021 (CUG): regional nitrate, regional sulphate, local combustion mix, mineral, metallurgy and regional coal combustion. b) Mean source contributions to $PM_{2.5}$ using only inorganic tracers to the 3 sites in 2006-2007 and CUG in 2019-2021. c) Idem but using both inorganic and organic tracers in CUG 2019-2021, with 7 sources identified: regional nitrate, regional sulphate, biomass burning, mineral, regional coal combustion, biogenic secondary aerosols and metallurgy.

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