Airborne dust chemistry and health risk assessment in the Sistan Basin, southeast Iran

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1. Introduction

- Dust outbreaks increase PM levels in the atmosphere and are important for their impact on the ***environment, and human health*** because they can transport *toxins, viruses, and several pathogenic microorganisms.*
- Airborne dust comprises a ***variety of chemical species*** depending on the source area. Dominant constituents of dust are *carbonaceous species, crustal and marine inorganic components, secondary inorganic components, heavy metals, and trace elements.*

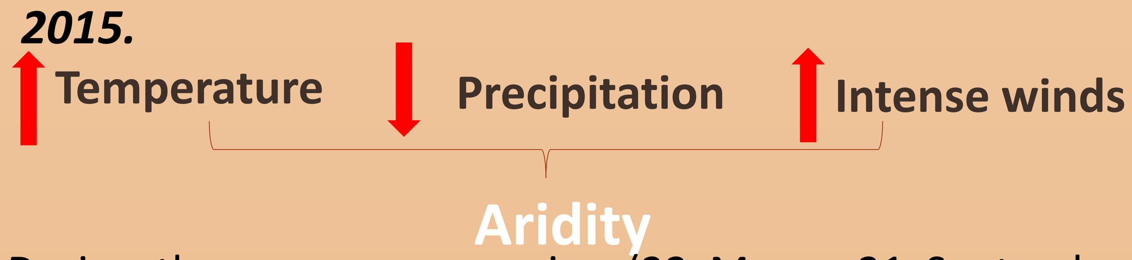
2. Motivation

This project aims to evaluate ***human health risks***, covering the lack of studies that focus on the chemical characterization of aerosol samples in Sistan. Sistan basin is one of the most challenging areas and one of the **world's dustiest environments**.

- ❑ Aerosol sampling in conjunction with the use of *standardized analytical techniques* provides us with information about the pollution of the region.
- ❑ Carbonaceous aerosol content analysis is performed for the **first time in this region**.

3. Study Region and Sampling

- Sampling was carried out in Zabol, the main city in Sistan basin. Zabol is affected by dust storms originating from the Hamoun's dried lake beds. ***Zabol was defined by WHO as the most polluted city in the world, in 2015.***



- ✓ During the summer campaign (22 May – 21 September 2021) 8-hour **PM_{10} samples** were collected on **quartz filters**, at the site of interest by using a *TCR Skypost PM FX low-volume sampler.*

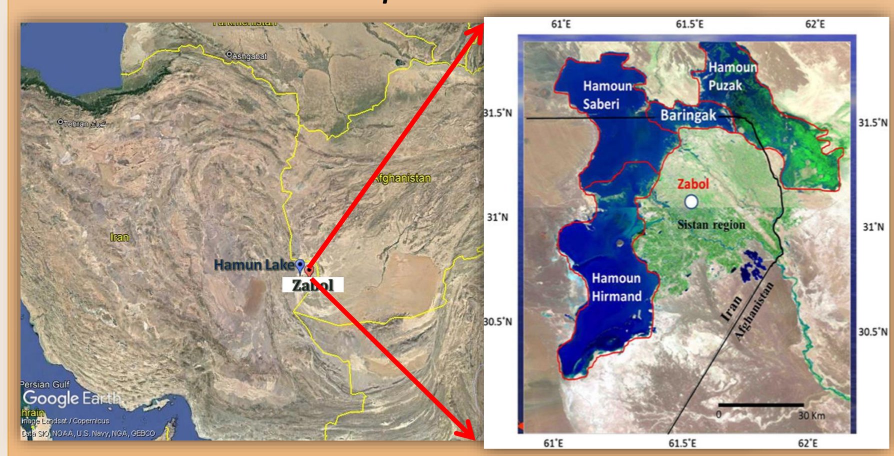
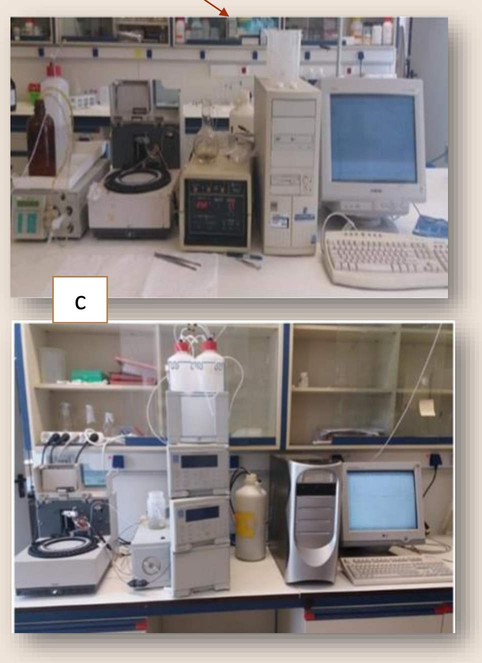


Fig.3.1. The sampling location in Zabol, Iran and the Hamoun lakes complex.

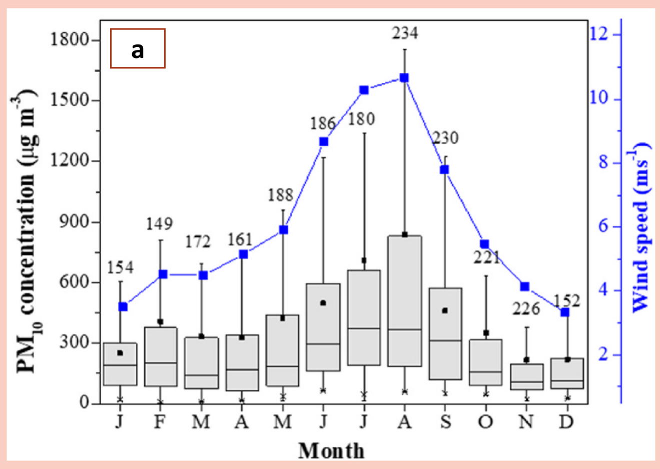
4. Methods

Part of the filters was directly analysed for ***OC and EC*** with the Thermal Optical Transmission (TOT) technique *(Birch and Cary, 1996)*, using a ***Sunset Laboratory OC/EC Analyzer (Fig. 4.a)*** .

For the ions' analysis another part of the filters was extracted in aqueous solutions with nanopure water, in an ultrasonic bath. Using an ion exchange chromatography system coupled with a conductivity detector **(Fig. 4.c)**, main ions ***(Cl^-, NO_3^-, HPO_4^{2-}, SO_4^{2-}, $C_2O_4^{2-}$, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+})*** were determined.



5. Results



Long-term analysis (2012-2020) showed that PM_{10} concentrations in Zabol maximize in summer **(693 ug/m³)** with an **annual mean** of **429 ug/m³** and a winter average at 290 ug/m³, while PM_{10} correlated well with the mean wind speed (r=0.46) *(Behrooz et al., 2022).*

Levar wind increases the uplifting of dust from the dried Hamoun lakes, mostly from morning till noon during summer *(Rashki et al., 2012).*

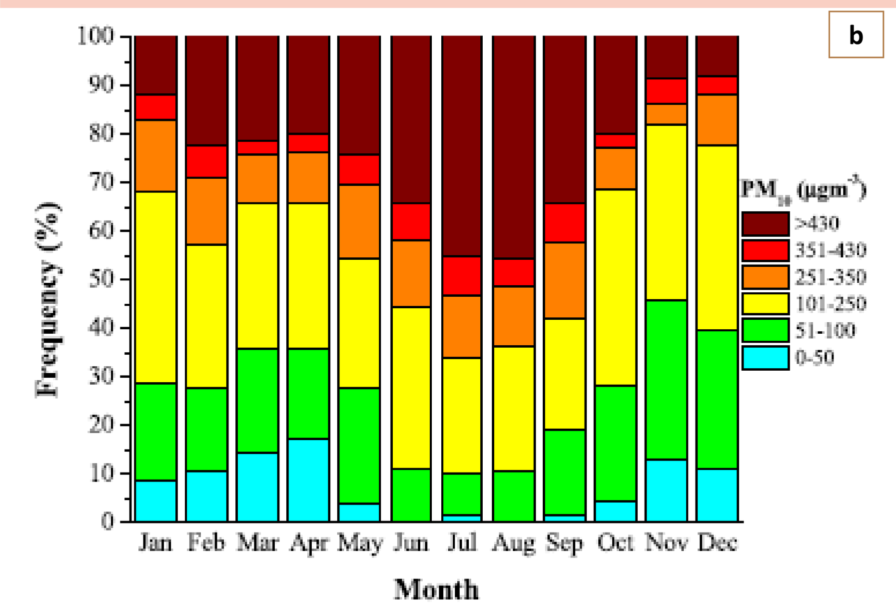


Fig. 5.a. Monthly average PM_{10} concentration with mean wind speed (period (2012-2020).

Fig. 5.b. Distribution of the monthly PM_{10} concentrations classified by the AQI categories.

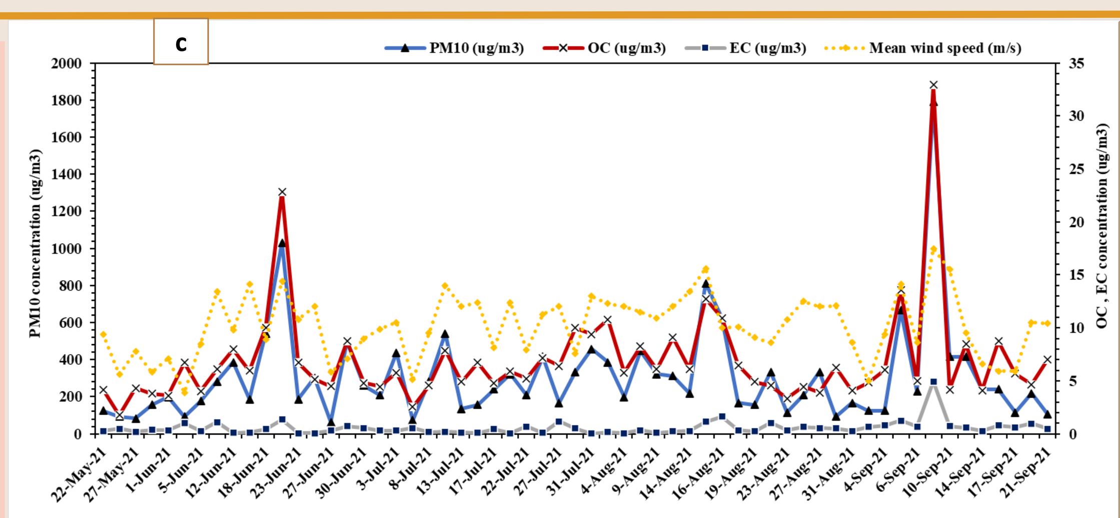
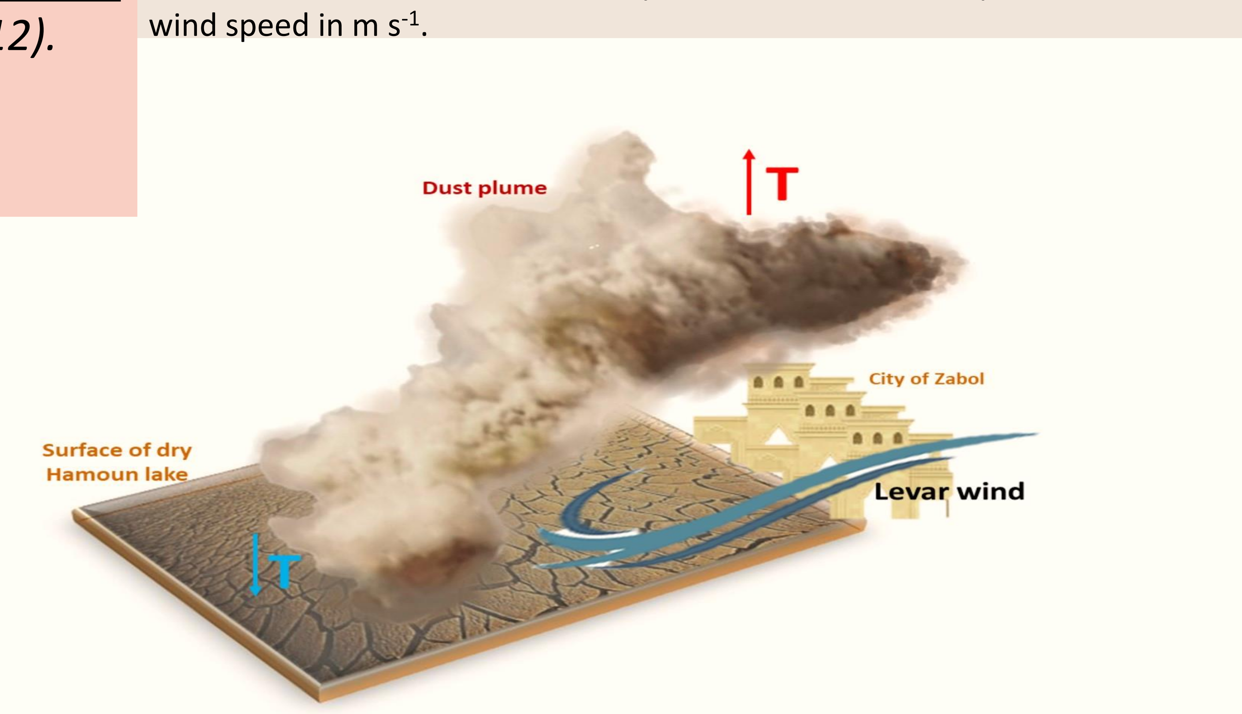


Fig. 5.c. Comparative daily diagram for the PM_{10}, OC, EC concentrations in μg m^{-3} derived from the chemical analysis of the filters. It also presents the mean wind speed in m s^{-1}.

- During the summer ***campaign of 2021***, PM_{10} concentrations were highly correlated with the mean wind speed (r=0.57) and max wind speed (r=0.59), and negatively correlated with visibility (r=-0.48), supporting the strong effect of Levar wind on dust-storm genesis ***(Fig.5.c.).***
- The vast majority of the sampling days appear **PM_{10}** levels between **200-400 ug/m³** and during intense dust outbreaks PM_{10} levels escalate above ***1000 ug/m³***.
- The carbonaceous content analysis provides a strong correlation ***between PM_{10} and OC*** fraction **(r=0.92)**, and a moderate correlation with the **EC** fraction **(r=0.75)** ***(Fig.5.c.)***, indicating that most of the PM_{10} mass originated from soil crust. **OC/EC** ratio has an average value of **32.66** emphasizing the effect of soil carbonates.



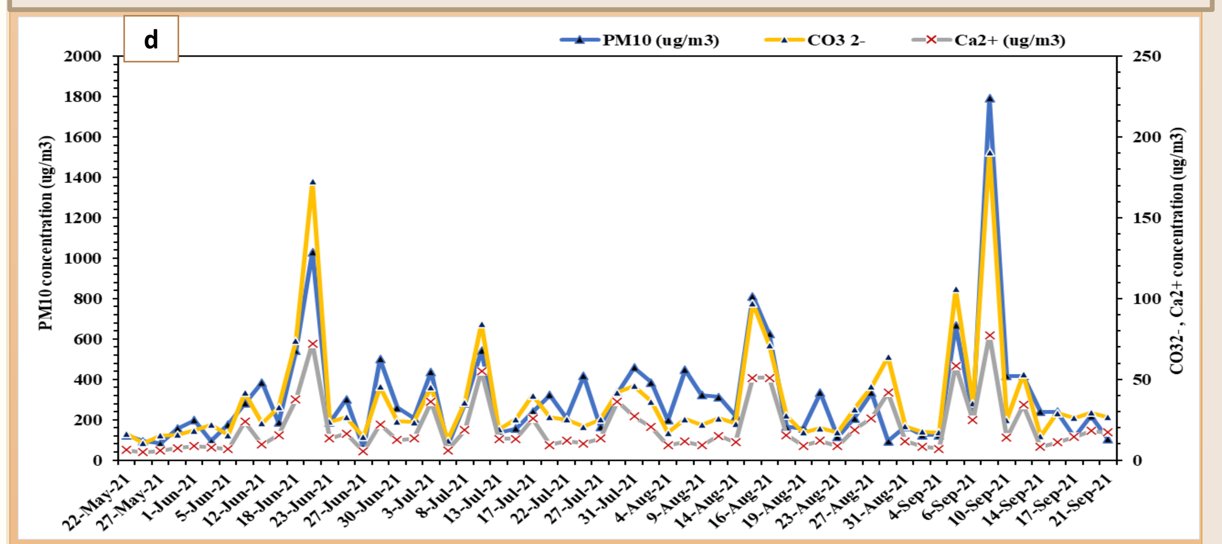


Fig. 5.d. Comparative daily diagram for the PM_{10}, Ca^{2+} and CO_3^{2-} concentrations in ug m^{-3} derived from the chemical analysis of the filters.

- **Carbonate ions (CO_3^{2-})** are strongly correlated with **Ca^{2+} ions (r=0.96)** which also highlights the fact that the dust transports soil minerals from the lake bed ***(Fig.5.d.).***

Human Health Impact

- ❑EPA air quality indices (AQI) classify the intensity of the air pollution and dust storms' impact on human health, into six classes ***(Fig.5.b.).***
- ❑ During the period 2012-2020 Zabol city presented very poor air quality according to AQI levels. Notably, only on **87 days out of 1249 days (7% of the measurements) people in Zabol could breathe clean air.**
- ❑The warm period (June to September) was characterized as **hazardous** along with the intensity of the dust storms.
- ❑**Moderate-to-good air** conditions appear only from **November to April**.
- ❑Most frequent PM_{10} class was the one that ranged from 101–250 ug/ m³, presented the lowest inter-annual variability, as well as the class 351–430 ug/ m³ *(Behrooz et al., 2022).*

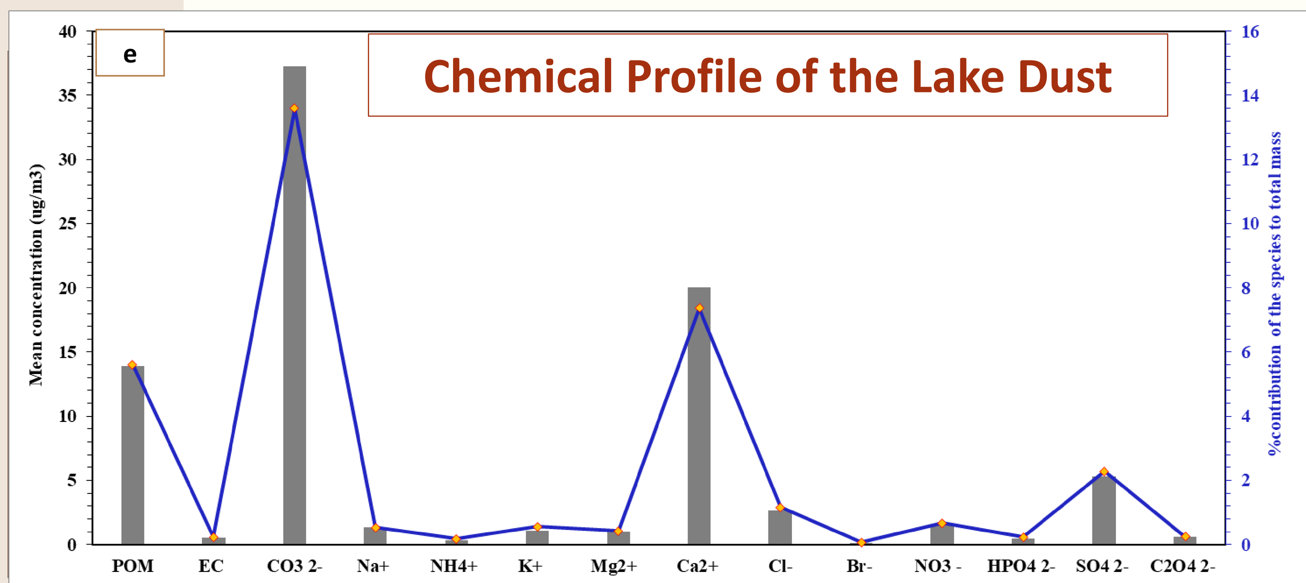


Fig. 5.e. Average concentration of each element in ug m^{-3}, along with the % contribution to the total mass.

- Regarding the ratio, $\frac{C\ every\ species}{C\ PM10}$, ***$Ca^{2+}$ and CO_3^{2-} ions are contributing the most to the total mass of PM_{10}***. This emphasizes the dominance of the natural species against the anthropogenic ones, such as HSO_4^{2-} ***(Fig.5.e.).***

6. Conclusions

✓**Mean PM_{10} levels during summer 2021 (mean value 308 ug/m³, max value ~1791 ug/m³) surpass the threshold established by the USEPA (50 ug/m³, USEPA, 2012) pointing out that Zabol has a very polluted atmospheric environment.**

✓**According to AQI, the air quality of Zabol is very poor and hazardous for human health, especially through the summer period.**

✓**The species coming from natural sources (*Ca^{2+} and CO_3^{2-}*) contribute the most to the total PM_{10} mass.**

A more detailed chemical analysis will reveal possible interactions between anthropogenic and natural aerosols and the contribution of the various sources in PM_{10}.

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