Impact of urban emissions on regional air quality in Fez city area, Morocco

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ABSTRACT

An intensive field campaign was conducted to investigate the chemical composition of particles simultaneously at the remote Mohammed V observatory (AMV) and urban city of Fez in the Middle Atlas region of Morocco. The aim of this study was to assess the regional air quality and health impact exposure to PM_{10}. Aerosol sampling was carried out using a particle collector PM_{10}. Various laboratory analysis was performed including particle mass, OC/EC, inorganic ions, trace metals, and a wide range of organic species. The results show that the PM mass has a similar trend at both sites, however, the mass concentration was twice as high at the Fez urban site (62 µg m^{-3}) than at AMV (35 µg m^{-3}). Anthropogenic metals which were dominated by Cr, Cu, and Ni increased by about 62%. at the urban site of Fez. PAHs at Fez were two times higher with high contributions of Fluorene, Retene, Phenanthrene and benz(a)anthracene, resulting mainly from vehicle emission, typical for industrial emission, waste incineration, and other combustion processes.

KEYWORDS: particulate matter, air pollution, Fez city, PAHs, anthropogenic metals.

1 INTRODUCTION

The World Health Organization has estimated that ambient air pollution is responsible for seven million premature deaths per year worldwide (WHO, 2021). Some field studies in African cities have reported annual average PM_{10} concentrations that exceed permissible levels (Najdja et al. 2018). But there is still a real need for air quality monitoring facilities to assess the risk to human health to improve air quality and control emissions. Most particulate matter in urban areas in Africa comes from road traffic, biomass burning of municipal waste, and heavy industry, such as cement plants (Najdja et al. 2018). Previous studies in Morocco show a high contribution from local biomass combustion rather than long-distance transport (Benchrif et al. 2018). Other study reports that ozone concentration reached alarming levels and PM_{10} levels exceeded threshold limits during the summer and spring (Inchaouh et al. 2017). However, in most cases, air quality is only quantified using a combination of monitored and modeled data without taking in consideration the health impact assessment. Thus, studies investigating the chemical composition of particles are needed in Morocco. Thus, the acquisition of new knowledge and reduction of uncertainty regarding the effect of aerosols on health and atmospheric composition related to air

pollution. This study aims to collect information on PM levels and their chemical composition. It also aims to identify the different sources of PM emissions that contribute to the deterioration of air quality in Morocco and their health impact, which will allow the development of abatement strategies to improve local air quality.

2 METHODS

Aerosol sampling was carried out simultaneously during an intensive campaign at two sites in the Middle Atlas region of Morocco: The Atlas Mohammed V Observatory (AMV), a newly established research station located at high altitude (2100 m.a.s.l) in the Atlas Mountains, and an urban site located in the city center of Fez. Particulate matter (PM_{10}) filter samples were collected at both sites using a high-volume (HV) collector during an intensive measurement campaign from the 15th September to 15th October 2019. The chemical composition of the samples was analyzed for PM mass, trace metals, water-soluble ions, organic carbon (OC/EC), and polycyclic aromatic hydrocarbon (PAH) contents.

3 RESULTS AND DISCUSSION

3.1 PM_{10} mass variation

The daily average amount of PM_{10} at the study site was 62.2 µg m^{-3}, ranging from 37.5 µg m^{-3} (02/10/2019) to 107 µg m^{-3} (30/09/2019), as shown in Figure 1. The average PM_{10} concentration at Fez was twice as high as the regional background concentration (35.9 µg m^{-3}), and about 81% of the samples exceeded the World Health Organization (WHO) guideline values which recommends a concentration limit of 45 µg/m^3 in 24h (WHO, 2021).

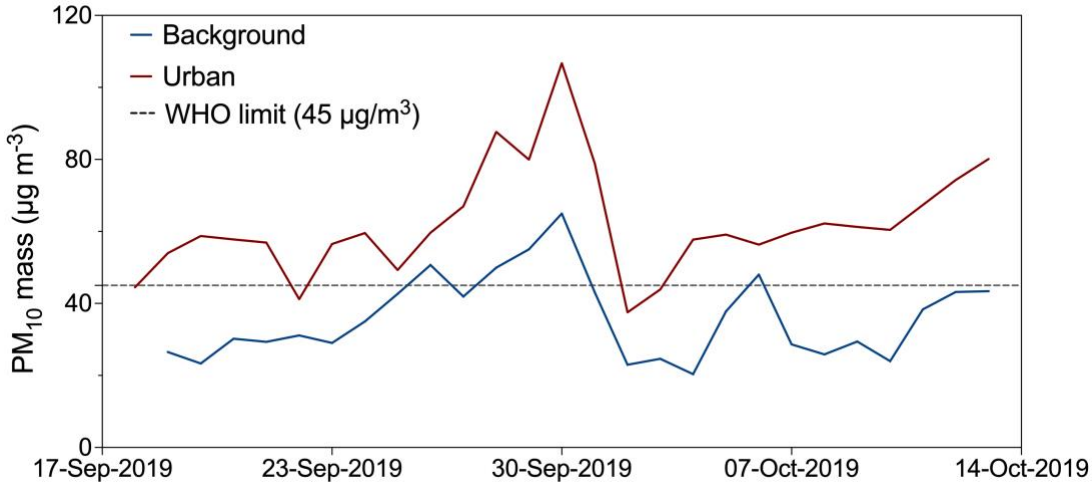

Figure 1: Temporal variation of PM_{10} levels at the background and urban sites in Morocco.

The average PM_{10} concentration found in the city of Fez is comparable with studies done at other Moroccan sites, such as Marrakech, Meknes and Agadir, which are exposed to high urban emissions, with PM_{10} concentrations between 50 and 110 µg m^{-3} (Inchaouh et al. 2017; Tahri et al., 2013, 2017).

3.2 Chemical composition

Table 1: Summary of the chemical composition at the background and urban sites. Concentrations are given in units of μg m^{-3}.

Chemical component	Background (AMV)	Urban (Fez City)
Mass	35.9	62.5
OC	1.6	7.2
EC	0.29	2.6
Cl^-	0.06	0.44
NO_3^-	1.1	2.9
SO_4^{2-}	1.1	2.5
$C_2O_4^{2-}$	0.10	0.18
Na^+	0.19	0.77
NH_4^+	0.40	0.71
K^+	0.06	0.55
Mg^{2+}	0.06	0.15
Ca^{2+}	0.81	2.23

The chemical composition of PM_{10} including OC/EC and major inorganic elements is presented in Table 1. The concentration of OC reached at the remote site of AMV 1.6 μg m^{-3}, which is mainly due to biogenic emissions. Moreover, the OC concentration was 5 times higher in Fez (7.2 μg m^{-3}) indicating the strong contribution of other potentially anthropogenic sources to biogenic emissions. The low concentration of EC at AMV (0.29 μg m^{-3}) indicates that the local anthropogenic influence is minimal, whereas the average EC concentration recorded at Fez (2.6 μg m^{-3}) was 10 times higher. The average concentration of sulfate and nitrate recorded at AMV which is about 1.1 μg m^{-3} was 2 times higher than that at Fez. Comparable ammonium concentrations were found at both sites with a higher concentration at AMV during specific periods.

3.3 Impact of air pollution

Levels of some trace metals and PAHs at Fez were significantly higher than those reported at the WHO limit values, as indicated in Figure 2. For instance, The AMV site was used as a reference site to highlight the impact of air pollution at Fez. Therefore, Cr, Cu, and Ni values were 2-5 higher than those found at AMV. While PAHs which are dominated by Fluorene, Retene and Phenanthrene are on average 2-4 times higher. This indicates that the city of Fez is exposed to high levels of pollution most likely from waste incineration and traffic emissions. Health risk assessment were performed using health index such as Hazards Quotient (HQ) and carcinogenic (ELCR) index for both receptor (adult and child). Description of health index The calculated values of Hazards Quotient (HQ) were found higher for all metals specially Ni, Mn, and Cr which has adverse health effects. It was observed that high traffic intensity may have been responsible for the high contribution of trace metals. The highest value of ELCR was found for lead, the trend of the average value of carcinogenic risk factor was found to be ~ 2-4 times higher than the prescribed limit.

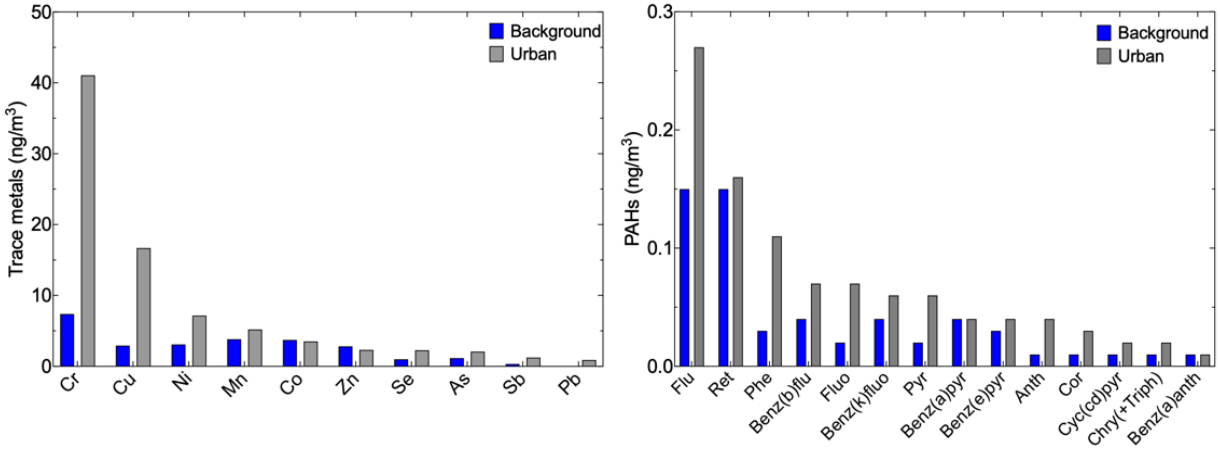

Figure 2: Variation of anthropogenic metals and PAHs at background and urban sites.

4 CONCLUSION

The urban city of Fez is exposed to high levels of particulate pollution from combustion processes and vehicle emissions which can have a drastic impact on the health of the population. These findings are of interest to managing air quality as they highlight the critical emission sources on which local authorities should focus their abatement efforts.

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