# Correlation between the mass of $PM_{2,5}$ and the chemical composition of acid aerosols in the northwest of the metropolitan zone of Mexico City

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## Abstract

Mexico City has been considered one of the most polluted areas worldwide. Since it has a population of over 20 million, some 3 million vehicles and over 4000 industries, ambient air monitoring and respiratory and cardiovascular diseases surveillance is extremely important in order to evaluate particles' effects on human health. Acid aerosol sampling was performed with an annular denuder system and particle sampling was carried out with a low volume sampler. Sampling was 24 hours from Monday to Tuesday and Thursday to Friday. Particle and acid aerosol sampling was simultaneous. Both samplers were located in the air monitoring cabin at the Metropolitan Autonomous University, Azcapotzalco campus. The monitoring campaign lasted from January to July, 2004. During January and February sulfur dioxide concentrations were higher compared to sulfates concentrations but in June and July, sulfates concentrations were higher than concentrations of sulfur dioxide. In January and February, nitrates concentrations were the highest and nitric acid concentrations were the lowest during the whole campaign. In the correlation between Chemical Species / Mass: Nitrates / Mass; Sulfates / Mass, the highest rate was for Sulfates / Mass. Regarding mass, there were two periods of uniform concentration. In the first one, from January to March, mass concentrations were higher than they were in the period April to July. During the June–July period, meteorological conditions (high relative humidity and low wind speed) favored sulfates formation while in January and February relative humidity favored nitrates formation. Results of this correlation show that the dominant chemical species in collected particles

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were sulfates. Registered low wind speed from January to March (an average of 7.8 kph) did not favor particle dispersion so the highest mass concentrations were collected during this period.
*Keywords: $PM_{2.5}$, acid aerosols.*

# 1 Introduction

Mexico City is located at 19°03' North latitude and 99°22' West longitude and at 2200 m above sea level [1]. With over 20 million inhabitants, some 3 million vehicles and over 4000 industrial facilities, it is considered one of the most polluted cities in the world.

In order to evaluate the effect of respirable particles on health it is essential to monitor air pollutants concentrations and to carry out a survey on respiratory and cardiovascular diseases [2].

An epidemiologic study was performed in the southwest area of Mexico City during the 1993–1995 period, in which fine particle concentrations were correlated with mortality. It was detected that an increase of 10 $\mu g/m^3$ in $PM_{2,5}$ concentrations increased mortality by 1.4% [3].

Emissions of pollutants generated by vehicles deteriorate air quality and that is one of the main reasons, at a worldwide level, to improve fuel quality. In Mexico, it is considered to have reductions up to an 88% in the sulfur content of the Pemex Premium gasoline, and between 84 and 93% of the Pemex Magna gasoline which are distributed in the Metropolitan Areas (Valley of Mexico, Guadalajara and Monterrey), and 92 to 96% in the remainder of the country. The sulfur reduction in the diesel fuel will be up to 98.5%.

Presently, Pemex Premium gasoline has a sulfur content of between 250 and 300 parts per million (ppm) although the Mexican Official Standard establishes an average of 30 ppm and a maximum of 80 ppm. Diesel fuel must have one of the most important reductions, from 500 to only 15 ppm [4], because it is the main particles emitter in the metropolitan areas.

Recent studies indicate that the ionic species ($SO_4^{-2}$, $NO^{-3}$, $NH^{+4}$) contribute to particle formation in many areas. They also indicate that $SO_4^{-2}$, $NO^{-3}$, $NH^{+4}$ are the main water soluble ionic species in the $PM_{2.5}$. These three species constitute over 30% of the $PM_{2.5}$ mass in Hong Kong, and in some Korean and Swiss cities [5].

The present study was performed within the UAM-Azcapotzalco facilities, which are located in Northwest Mexico City in a neighborhood with a mixed (industrial and residential) land use.

# 2 Methodology

Acid aerosols (gases and particles) sampling was performed with a denuder system formed by a selective filters head (Teflon and nylon) for the $PM_{2,5}$ particles collection and diffusion separator tubes for the gaseous molecules collection. Gas molecules rapidly diffuse towards the separator tube walls while the fine particles are not affected in their travel through the separator tube and are finally captured on the filters [6].

Respirable $PM_{2,5}$ particles were collected with a portable low volume sampler, operated with a rechargeable battery. Particles separation was performed using a head with two impactors ($PM_{10}$ and $PM_{2,5}$) where particles were separated by size and collected on a 47 mm glass fiber filter with a 2 µm porosity.

Particles mass was gravimetrically determined. Both sampling devices (the portable low volume sampler and the denuder) were collocated at the sampling site for 24-hour periods.

# 3 Results

The monitoring campaign included the 2004 January–July period. Data on relative humidity and solar radiation were also collected since weather conditions directly affect acid aerosol formation. Wind speed information was also gathered because it is related to pollutant dispersion.

Gaseous species in the acid aerosols were sulfur dioxide and nitric acid, whether sulfates and nitrates are present as particles. Correlations were performed between chemical species collected with the denuder (particle fraction) and the aerosol total mass collected with the low-vol sampler.

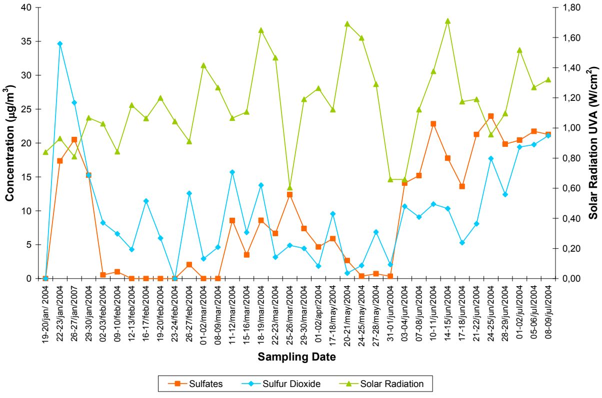


Figure 1: Ultraviolet radiation (UVR) effect on the formation of $SO_4^{-2}$ from $SO_2$.

# 4 Discussions and conclusions

## 4.1 Sulfates and sulfur dioxide

During January and February, sulfur dioxide concentrations were higher than sulfate concentrations. ZMCM meteorological conditions favored pollutants dispersion. Wind speed in February was higher than it was on January.

In Figure 1 it can be seen than sulfate concentrations were not detected during February. In March, meteorological conditions followed the previous month's trend and sulfur dioxide concentrations were higher than sulfates concentrations.

Solar radiation during March was higher than that registered during January and February. This favored sulfates formation so its concentration could be detected.

During April and May solar radiation was higher than it was during the previous months and sulfate concentrations increased perceptibly. Some days they were even higher than sulfur dioxide concentrations which can be an indication of photochemical activity during these months. Sulfate concentrations during June and July were higher than sulfur dioxide concentrations. This seems to indicate that high relative humidity and low wind speed favored sulfates formation (Figure 1).

## 4.2 Nitrates and nitric acid

During January and February the registered average relative humidity was the lowest of the whole campaign (39,5%) which favored nitrates formation. As a consequence, nitrates concentrations were higher than nitric acid concentrations. Actually, nitrates concentrations were the highest and nitric acid, the lowest, of the whole campaign. During the remainder of the campaign, relative humidity didn't show a direct influence on the nitric acid formation (Figure 2).

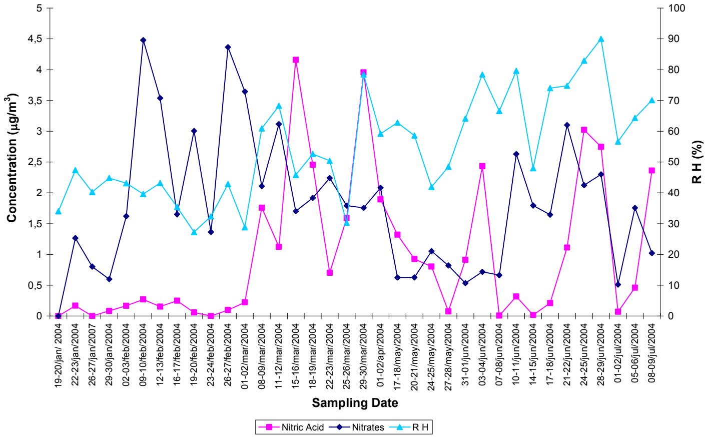


Figure 2: Relative humidity (RH) effect on the formation of $HNO_3$ from $NO_3^-$.

## 4.3 Chemical species / mass correlation

When chemical species / mass correlation results are compared it is clearly seen that the nitrates / mass correlations values are the highest, so the predominant chemical species in the collected particles is sulphate (Figure 3).

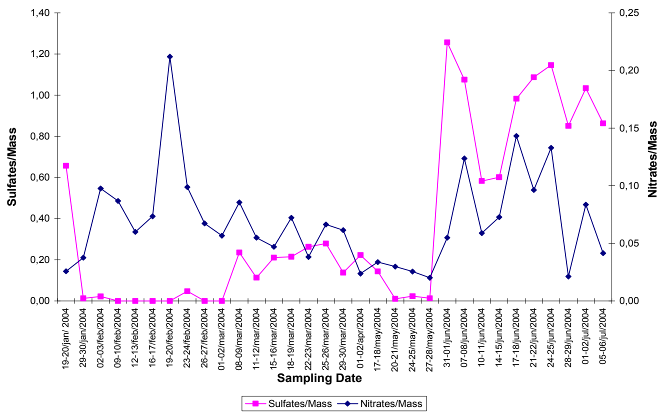


Figure 3: Correlation (chemical species/mass).

Sulfur content in fuels which are used in Mexico is very high so flue gases contain a high percentage of sulfur dioxide. This can be seen in the obtained results.

### 4.4 Mass

For mass, there were two uniform concentration periods. From January to March, collected mass was higher, which can be due to the average wind speed, of 7,8 kph. During the next period, from April to June, mass concentration decreased. Since the average wind speed was 8,6 kph it was deduced that wind speed directly affects particles dispersion which can be observed in $PM_{2,5}$ particles mass during the whole monitoring campaign (Figure 4).

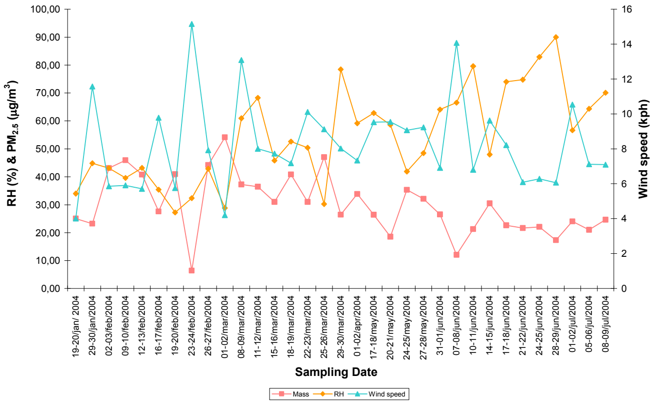


Figure 4: Relative humidity (RH) and wind speed effect on the $PM_{2,5}$ mass concentration.

The 65 µg/m$^3$ value (24 hrs average) that has been considered in the $PM_{2,5}$ Mexican Standard project was never exceeded during the whole monitoring campaign.

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