A43A-18

Physical Properties and Chemical Composition of Aerosols sampled in T1 site during MILAGRO Campaign

Castro T.[(1)] , Mamani-Paco R.[(1)], Saavedra Ma. I.[(1)] , García J.[(1)], Amador, O.[(1)], Carabali G.[(1)], Salcido A.[(2)], Herrera E.[(3)], Báez A.[(1)]

(1) Grupo Aerosoles Atmosféricos, Centro de Ciencias de la Atmósfera, UNAM, México. (2) Gerencia de Sistemas de Calidad, Ambiente y Seguridad, Instituto de Investigaciones Eléctricas, Morelos, México.
(3) Centro Investigación en Materiales Avanzados. Chihuahua. México (telma@servidor.unam.mx / salicido@iie.org.mx)

ABSTRACT

We present results from pollutant measurements and meteorological variables corresponding to March, 2006, during the MILAGRO campaign at site T1 (Tecamac, State of Mexico). Three 8-stage cascade impactors (MOUDI) were employed to obtain aerosol samples of different sizes. For organic compounds analysis, samples were collected with a $PM_{2.5}$ High Volume sampler. Mass and chemical composition (inorganic ions and organic compounds) were obtained with analytical techniques (gas and liquid chromatography, and atomic absorption). Particle morphology analysis was done with a TEM-EDAX System. Physical properties of aerosols were measured with a PSAP, a nephelometer and a CPC.

Meteorology sorts days with Mexico City urban influence on T1 (March 9-12) and without influence (March 14 and 15). The particle average concentration during the whole campaign was 20,000 *particles cm*$^{-3}$. For the days with and without urban influence the average concentrations were 17,500 and 8,000 *particles cm*$^{-3}$ respectively. Mornings show the highest particle concentration through the campaign in the mode d_{50}= 0.32 µm. The cumulative highest concentration of all stages was observed on March 19 followed by March 9. The average scattering and absorption coefficients obtained on T1 were 5.1x10-5 *m*$^{-1}$ and 2.54x10-5 *m*$^{-1}$, respectively, and single scattering albedo was 0.676. These values show T1 as a polluted atmosphere, just as it happens in megacities.

Particles between d_{50}= 0.18 µm and d_{50}= 1.8 µm associated with urban influence (March 9), tended to show more regular shapes through different periods of that day. These findings suggest the presence of large numbers of secondary aerosols and aged agglomerated particles. These particles are mainly associated with the influence of surrounding areas, e.g. Tizayuca Industrial Park (March 15) showed variation in morphology with size. More irregular particles were found in the smallest size, and less irregular particles were present in the largest size.

During the campaign, the ions with the highest and lowest concentration of fine particles were sulfate and magnesium, respectively. Particles analysis is considering sizes from 0.18 to 1.0 µm as fine and from 1.78 to 10 µm as coarse mode.

Several polycyclic aromatic hydrocarbons present in $PM_{2.5}$ had concentrations ranged between 0.1 to 0.5 ng m^{-3}, but naphthalene had a concentration of 2.5 ng m^{-3}.

Our results show that Tecamac population is certainly exposed to high levels of pollution from Mexico City (megacity).

CRITERIA FOR SELECTING ANALYSIS DATES (MEXICO CITY EMISSIONS INFLUENCE)

In order to select the days with influence from Mexico City on T1, we looked at two information sources. Model predictions for the campaign were reviewed [*De Foy, 2006; Fast et al, 2007*] and we consulted meteorological data for T1 site (Meteorological tower, IIE).

GASES and PHYSICAL PROPIERTIES

Method

Sampling was carried out in T1 site (Fig. 1), which is located within the Technological University of Tecamac, State of Mexico, 30 Km at north from Mexico City. Coordinates: latitude 19° 43' N and longitude 98° 58' W, at an altitude of 2,340 m above sea level.

Figure 1. T1 site

Sampling Time & Equipment: Measurements were taken continuously 24 hours a day with all the equipments.

Criteria pollutants

Gas Analyzers (CO, PM_{10}, NOx, O_3 and SO_2)

Meteorology (Fig 2)

Meteorological Tower (WSP, WDR, T, P, RH, direct and Radiation)

Suspended Particles/Aerosols (Figs. 3 and 4)

Nephelometer (Radiance Research), absorption photometer (PSAP, Radiance Research), condensation particle counter (CPC, TSI, Model 100), optical particle counter (Lasair II),

Figure 3. Neph, PSAP, CPC and Lasair

Figure 2. Met Tower

Particles captured in five increasing sizes of a MOUDI impactor (Fig. 4) were used to study their *morphology* on days with MC influence (March 9,11) and for a day with no MC influence (March 15).

Figure 4. MOUDI impactor

Results

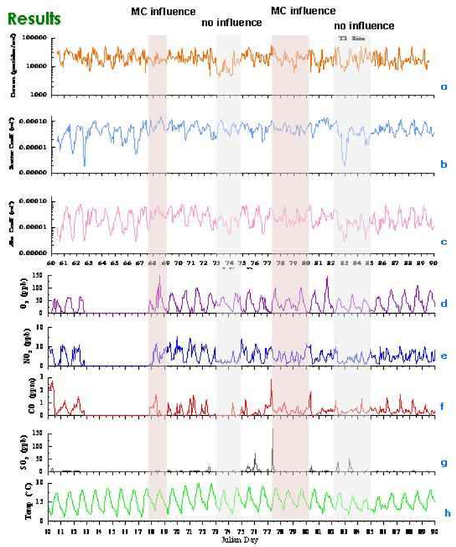

Figure 5. Aerosol physical properties and gases concentration measurement in T1.

Figure 5 shows particle physical properties (5a, b, and c) and gases concentrations (5d, e, f, and g) measured at T1 from March 1 to 30, 2006. In figure 5a, a decreasing in particle concentration can be observed on March 14 & 15 (Julian days 73 & 74). When wind was coming from the northeast (*Fast et al, 2005*) there was, no influence from the city. Mean wind speed was 4.5 m s^{-1}. Absorption coefficient also showed a decrease indicating that there was no influence from the city, but from local sources or those located northeast from T1. And gases show a similar behavior, their concentration decrease too.

From March 18 to 21 (Julian days 77 to 80) wind direction had a component from SSE which would be indicative of pollutants generated in Mexico City. Carbon monoxide (CO), nitrogen dioxide (SO_2), and ozone (O_3) increased its concentration compared with those none influenced days (March 14 & 15). On March 18, the maximum peak concentration of SO_2 on all month was observed. The preceding results indicate that pollutants were emitted mainly by none local sources.

On March 23, 24 and 25 (Julian days 82, 83 and 84) an interesting behavior of the measured parameters was observed. Figures 5d, e, f, and g show that small concentrations for CO, NO_2, and O_3 are present, but SO_2 had a maximum peak. Besides, concentration of particles diminished and the same happened with scattering and absorption coefficients. A hypothesis should be that SO_2 is originated at Tula refinery region or Tizayuca industrial park.

Morphology

Particles between d_{50}= 0.18 µm and d_{50}= 1.8 µm sampled in T1 associated with urban influence (March 9,11) showed lower variability in morphology for the considered sizes and time of the day (Figs. 6a and b). Most of the particles had compact shapes.

Particles ranging from d_{50}= 0.18 µm to d_{50}= 1.8 µm sampled in T1 and associated mainly with surrounding areas influence, eg. Tizayuca Industrial Park (March 15) showed more variation on particles morphology (Fig. 6c) compared with a day with MC influence.

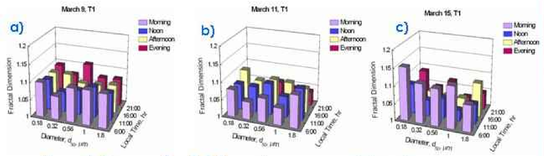

Figure 6. Average fractal dimension vs aerosol size, at Different sampling times a) and b) under MC plume, c) no MC plume, all at T1 site.

These findings suggest the presence of large numbers of secondary aerosols and aged agglomerated particles sampled in T1 during a day with MC influence.

Aerosol morphology showed some variability with size and time of the day for particles sampled during a day with little MC plume influence (Fig. 6c). During early morning conditions smaller particles (d_{50}= 1.8 µm) presented more irregular features compared with particles of larger sizes or particles sampled during other times of the day.

AEROSOL CHEMICAL COMPOSITION

Method

Aerosol particles were collected with a cascade impactor (MOUDI, MSP, Model 100) on aluminum foils. The 50% cutoff for stages 1-8 were 0.18, 0.32, 0.56, 1.0, 1.78, 3.16, 5.62 and 10 µm, aerodynamic diameter. Aerosols were sampled in two schedules (6am - 6pm and 6 pm - 6am), and inorganic ions (SO_4^{2-}, NO_3^-, Cl^-, Na^+, NH_4^+, K^+, Ca^{2+}, and Mg^{2+}) were analyzed from these samples.

A High-Vol sampler ($PM_{2.5}$) was used for 36 hr to collect particles on quartz filters and their organic compounds analyses were performed using chromatographic techniques.

Results

a) Ions

The 8 analyzed ions were present in all stages of MOUDI. Figure 7 shows that the higher ions concentrations are accumulated on the 0.32 µm mode (SO_4^{2-}, Na^+, NH_4^+, K^+).

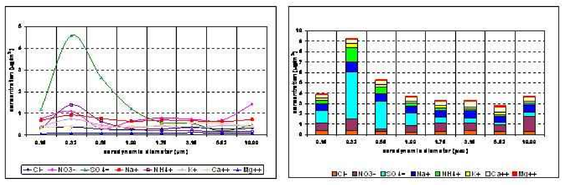

Figure 7. Average ions concentration by size distribution (24 hours)

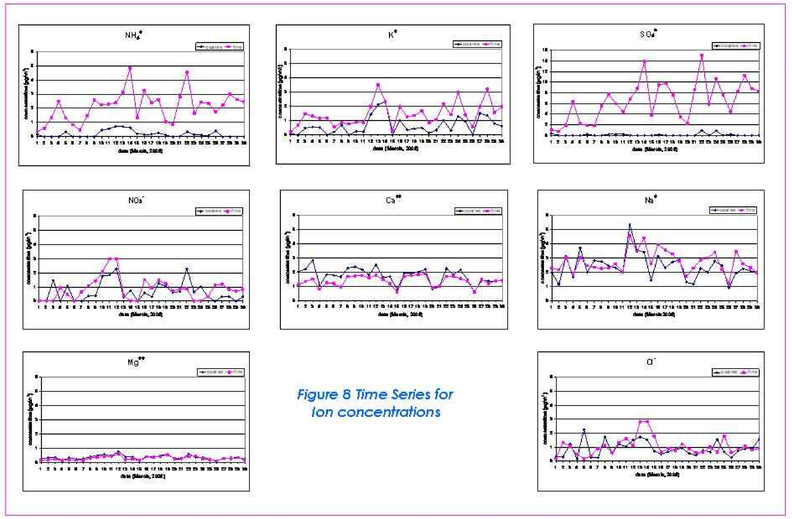

Figure 8 Time Series for Ion concentrations

Figure 8 shows the daily behavior of SO_4^{2-}, NO_3^-, Cl^-,$Na+$, NH_4^+, K^+, Ca^{2+} and Mg^{2+} concentrations. For analysis effects we made a division of particles in two modes: fine mode (0.18, 0.32, 0.56 and 1.0 µm) and coarse mode (1.78, 3.16, 5.62 and 10 µm). We suppose that coarse particles (dust, for example) are product of local effects and fine particles origin may be due to local emissions and to its interaction with pollutants transported from Mexico City.

Fine particles are formerly composed by sulfate, ammonium and potassium, not so coarse particles. Nitrate, sodium, calcium and chlorate are present in both modes, their concentrations are very similar during all days and only in some days they have little variations. Magnesium is present in both modes in very little concentration.

On March 14 and 15 (Julian days 73 & 74), all ions concentrations decrease significantly. On March 23, 24 and 25 (Julian days 82, 83 and 84) the concentration of gases present in T1, increase (figures 5 d, e, f y g). These days are not influenced by the city. The preceding results agree with the analysis of morphology and physical properties of particles.

Figure 9 shows a summary of the concentration of organic compounds (PAH) obtained on T1. Among these, naphthalene is the compound with the highest concentration. While naphthalene itself is not carcinogenic, it is the most abundant PAH in polluted urban areas (Arey et al., 1989).

b) Organic compounds

Name	AVERAGE PM2.5 MARCH, 2006 TEC-T1 ng/ m^3
Naphthalene	**2.225**
Acenaphthylene	0.097
Acenaphthene	0
Fluorene	0.41
Phenanthrene	0.35
anthracene	0.085
Fluoranthene	0.585
Pyrene	0.807
Benz(a)anthracene	0.231
Chrysene	0.262
Triphenylene	0.398
Benzo(b)fluoranthene	0.339
Benzo(k)fluoranthene	0.121
Benzo(j)fluoranthene	0.175
Benzo(e)pyrene	0.205
Benzo(a)pyrene	0.245
Perylene	0.159
Indeno(1,2,3-cd)pyrene	0.263
Benzo(ghi)perylene	0.507

Figure 9. Polycyclic aromatic hydrocarbons present in $PM_{2.5}$ (from acenaphthylene to benzo[ghi]perylene)

Acknowledgements

Thanks to MC Torres, H. Padilla and R. Gaspariano for the chromatographic analysis and R. Belmont for the atomic absorption analysis (Grupo de Química Atmosférica, Centro de Ciencias de la Atmósfera, UNAM). O. Peralta for his comments regarding the analysis of aerosol chemical composition.

REFERENCES: 1) B De Foy.. (2006) http://67.52.151.87/index.html. **2) JD, Fast, B. de Foy, F. Acevedo Rosas, E. Caetano, G. Carmichael, L. Emmons, D. McKenna, M. Mena, W. Skamarock, X. Tie, RL. Coulter, JC. Barnard, C. Wiedinmyer, and S. Madroniché.** A meteorological overview of the MILAGRO field campaigns. Atmos. Chem. Phys., 7, 2233–2257, 2007. **3) Arey, J., Atkinson, R., Zielinska, B., and McElroy, P. A.:** Diurnal concentrations of volatile polycyclic aromatic hydrocarbons and nitroarenes during a photochemical air pollution episode in Glendora, California, Environ. Sci. Technol., 23, 321–327, 1989.