

Sampling of PM_{2.5} respirable particles in the northwest of the metropolitan zone of Mexico City during 2006

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Abstract

The Metropolitan Zone of Mexico City is one of the most polluted areas in the world. PM_{2.5} respirable particles are a health risk for the population. They can induce chemical reactions in the atmosphere, increasing the possibility of acid rain formation and they are a factor for reducing visibility. They could also reduce solar radiation, thus increasing the changes in the environmental temperature and altering biological rates of plant growth. The sampling site was located at the facilities of the Metropolitan University Campus Azcapotzalco. This site is located Northwest of Mexico City, and it is a zone with urban and industrial developments. Sampling of PM_{2.5} respirable particles was done using a Minivol Portable Sampler Airmetrics and the mass of particles was determined by gravimetry. Particles samples were collected for 24 hours from Monday to Tuesday and from Thursday to Friday, for 11 months from January to November 2006. A total of 36 samples were collected. The particles mass data were correlated with the wind velocity for the sampling days. The average concentration of PM_{2.5} was 27.93 µg/m³ with a wind velocity of 5.17 m/s. There are two maximum values for PM_{2.5} that coincide with the values of minimum wind velocity during the monitoring period: for the sample of February 9th there was a PM_{2.5} concentration of 43.12 µg/m³ with a wind velocity of 3.76 m/s. For November 16th there was a PM_{2.5} concentration of 49.17 µg/m³ and a wind velocity of 3.62 m/s. The minimum concentration obtained on February 23rd was 13.29 µg/m³ with a wind velocity of 4.95 m/s, and for June 1st the concentration



was $13.01 \mu\text{g}/\text{m}^3$ with a wind velocity of 4.97 m/s. During this sampling campaign the average of $65\mu\text{g}/\text{m}^3$ $\text{PM}_{2.5}$ for 24 h, given as a permitted ambient air quality, was never surpassed.

Keywords: air pollution, respirable particles.

1 Introduction

Cities located in valleys or in mountainous regions are especially prone to experiencing dangerous levels of air pollution due to a series of unfavourable factors, both meteorological and geographical, which prevent good ventilation in the region [1].

Air pollution in Mexico City has increased with the city's population and industry growth and with the time and length increase of the inhabitants' trips. One of the main agents that determine air quality is Total Suspended Particles (TSPs). This term refers to a great diversity of air suspended materials that exist as solid or liquid particles in a wide size interval (from $0.005 \mu\text{m}$ to $100 \mu\text{m}$) [2].

Particles are generated in a great variety of sources, both anthropogenic and natural. They can either be directly emitted to the atmosphere (primary particles) or formed there through gaseous emission transformations (secondary particles) [2].

Particles increase chemical reactions in the atmosphere; they reduce visibility, increase the acid rain fall possibility, fog and cloud formation: they reduce solar radiation, thus reducing ambient temperature and biological plant growth rates.

Particle size is the most important physical characteristic for their toxicity determination. Particles' toxicity is determined by their chemical and physical characteristics. Size, measured in terms of their aerodynamic diameter, is an important parameter for their behaviour characterization, since penetration ability and retention in the diverse region of the respiratory system depend on size [2].

Recent studies report that seasonal variations affect atmospheric particle composition, residence time and the concentration to which population is exposed [3]. In Mexico City air pollution increases during winter because of thermal inversions.

Particles measuring less than 10 micrometers (PM_{10}) can be inhaled and accumulated in the upper tract of the respiratory system. Particles less than 2.5 micrometers, respiratory fraction ($\text{PM}_{2.5}$), can penetrate all defences and reach the bronchial tubes and the alveoli [4].

Once particles have been deposited in the respiratory system their irritating action depends on their chemical composition and their toxicity, as well as on the ease with which they adsorb or to absorb other substances on their surface, producing a synergistic effect that increases their aggressiveness.

Other reported health effects are respiratory disease increase, asthma attacks and cardiopathies, such as heart attacks and arrhythmias. Respirable fraction particle risk increases with the possibility of the association with acid or with basic substances, such as nitrogen oxides, sulphur dioxide and ammonia, synergizing the potential harmful effects. Particles can also contain heavy metals



(chromium, arsenic, beryllium, cadmium, mercury), polycyclic aromatic hydrocarbons and volatile organic compounds.

In Mexico City it has been observed that for a $10 \mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ concentrations (over the maximum allowed value for $\text{PM}_{2.5}$ particles, which is as an average for 24 hr, $65 \mu\text{g}/\text{m}^3$), there is a 1.6% increase in the daily death rate of the elderly (over 65 years) and of 6.9% in children (less than one year old) [2].

$\text{PM}_{2.5}$ mainly originate in combustion processes and in coal, gasoline and wood burning. Only a few originate in the earth's crust as finely pulverized dust [5].

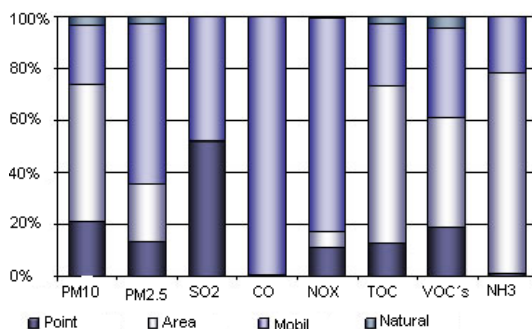
Data published by the Air Quality and Emissions Inventory Direction of the Environment Secretariat show that mobile sources are the main $\text{PM}_{2.5}$ emitters, with a reported value of 3,835 ton/year in 2006, see Table 1 [6].

In figure 1 it can be seen that mobile sources contribute 61.9% of the total $\text{PM}_{2.5}$. Out of this percentage, 38% is emitted by diesel powered vehicles, that is, buses and trucks [6].

Table 1: ZMVM emissions inventory, 2006.

	Emissions															
	PM_{10}		$\text{PM}_{2.5}$		SO_2		CO		NO_x		TOC		VOC's		NH_3	
Sector	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]	[ton/year]	[%]
Point Sources	4,869	21	826	13	3,555	51	6,637	0,3	21,255	11	112,21	13	106,39	19	204	1
Area Sources	12,133	53	1,366	22	34	0,5	7,37	0,4	12,645	6,5	537,03	61	238,29	42	15,381	77
Mobil Sources	5,248	23	3,835	62	3,324	48	1,376,739	39	159,54	82	208,84	24	193,29	34	4,351	22
Vegetation and Soil	803	3,5	164	2,6	N/A	N/A	N/A	N/A	1,248	0,6	27,481	3,1	27,481	4,3	N/A	N/A
Total	23,05	100	6,191	100	6,913	100	1,990,806	100	194,7	100	885,6	100	566,1	100	19,34	100

Source http://www.sma.df.gob.mx/inventario_emisiones/index.php?op=cc



Source http://www.sma.df.gob.mx/inventario_emisiones/index.php?op=cc

Figure 1: Criteria pollutants by source ratio.

Presently, many experts explain that people's health can be damaged by $PM_{2.5}$ particles, which include carcinogenic agents [7]. In Mexico, only in 2005 were environmental health standards modified in order to include and establish the maximum allowed value for $PM_{2.5}$ particles, which is, as an average for 24 hr, $65 \mu\text{g}/\text{m}^3$.

2 Methodology

Particles were collected using a low volume sampler (Minivol.) Each sampling time was 24 hours, Monday to Tuesday and Thursday to Friday. The $PM_{2.5}$ sampling campaign included the January to November period. The mass gravimetric determination was made with the support of the Atmospheric Monitoring Network of the Federal District Government.

Particles dispersion is related to wind speed. Wind speed data were obtained from the *Observatorio Meteorológico de Tacubaya* from the *Sistema Meteorológico Nacional de la Comisión Nacional del Agua*.

Sampling site was located at the Universidad Autónoma Metropolitana, Unidad Azcapotzalco (UAM-A) campus. The UAM-A is located in the *Delegación Azcapotzalco*, northern Mexico City. "Its geographical coordinates are $19^\circ 30' 16.99''$ North Latitude and $99^\circ 11' 19.96''$ West length at 2127 msnm.

The area weather is temperate and sub humid, with rains during July, August and September. Total annual fall is estimated between 600 and 1200 cubic centimetres. Average temperature oscillates between 12°C and 16°C (sometimes even 20°C). The *Delegación* occupies a surface of 33.86 km^2 (the 2.23% of Mexico City). In this area there are small communities, quarters, neighbourhoods and industrial zones. The University is located in a mixed land use area, that is, residential and industrial. Norwest is the Vallejo Industrial Zone and east, the Reynosa Sport Center and the *Alameda Norte* (a park, which is an ecological recovery area). South and southeast, there are several middle income residential areas with a high population density. West and northwest there are also middle and low income residential areas with a high population density ("El Rosario", "CTM", Xochinahuac and "CROC"). The big subway station "El Rosario" is located southwest.

3 Results and conclusions

The $PM_{2.5}$ sampling campaign period went from January to November, 2006 during which 36 samples were obtained.

Particles mass concentration was correlated to wind speed (Figure 2). During the monitoring campaign an average concentration of $27.93 \mu\text{g}/\text{m}^3$ was obtained with an average wind speed of 5.17 m/s .

$PM_{2.5}$ concentrations present two highest values which coincide with the lowest wind speed values registered during the monitoring campaign. The February 9th $PM_{2.5}$ sample concentration was $43.12 \mu\text{g}/\text{m}^3$ with a wind speed of 3.76 m/s and the obtained concentration for the November 16th sample was $49.17 \mu\text{g}/\text{m}^3$ with a wind speed of 3.62 m/s .



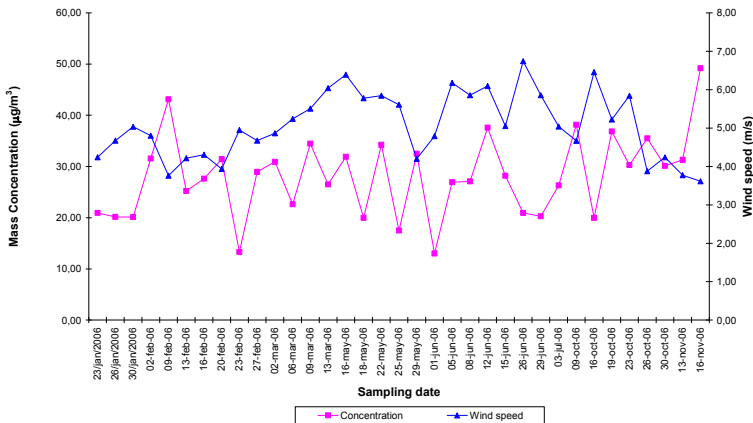


Figure 2: $PM_{2.5}$ mass concentration and wind speed correlation during 2006.

Table 2: $PM_{2.5}$ concentration at the ZMVM, 2006.

Location	Monitoring Station	$PM_{2.5}$ [$\mu\text{g}/\text{m}^3$]
Northwest	TLA	33
Northeast	XAL	40
	SAG	27
Centre	MER	27
Southwest	PED	30
	COY	31
Southeast	UIZ	35

Source: http://www.sma.df.gob.mx/simat/tablas_xls/indicadores/PM25m.xls

Also, $PM_{2.5}$ concentrations present two lowest values on the February 23rd and on the June 1st sample ($13.29 \mu\text{g}/\text{m}^3$ and $13.01 \mu\text{g}/\text{m}^3$) with wind speeds of 4.95 m/s and 4.97 m/s, respectively.

The Air Monitoring System (SIMAT) has 49 monitoring stations, 36 of which are distributed in the Valley of Mexico Metropolitan Zone (ZMVM) and 13 are in the State of Mexico, Figure 3. $PM_{2.5}$ concentrations are monitored in seven stations of the ZMVM, Northwest of Tlalnepantla Station (TLA), Northeast of Xalostoc (XAL) and San Agustín (SAG), Center of Merced Station (MER), Southwest of Pedregal Station (PED) and Coyoacán Station (COY), Southwest of the UAM- Iztapalapa Station (UIZ) [8].

SIMAT reported values as percentile 90 for 2006 suggest that the spatial variation of $PM_{2.5}$ concentrations at the ZMVM is minimum, Table 2.

From the obtained data it can be concluded that $PM_{2.5}$ concentrations which have been reported by SIMAT monitoring stations, as well as the ones obtained from the monitoring campaign, don't exceed the 24 hours average value of $65 \mu\text{g}/\text{m}^3$ set by the Mexican Authority.

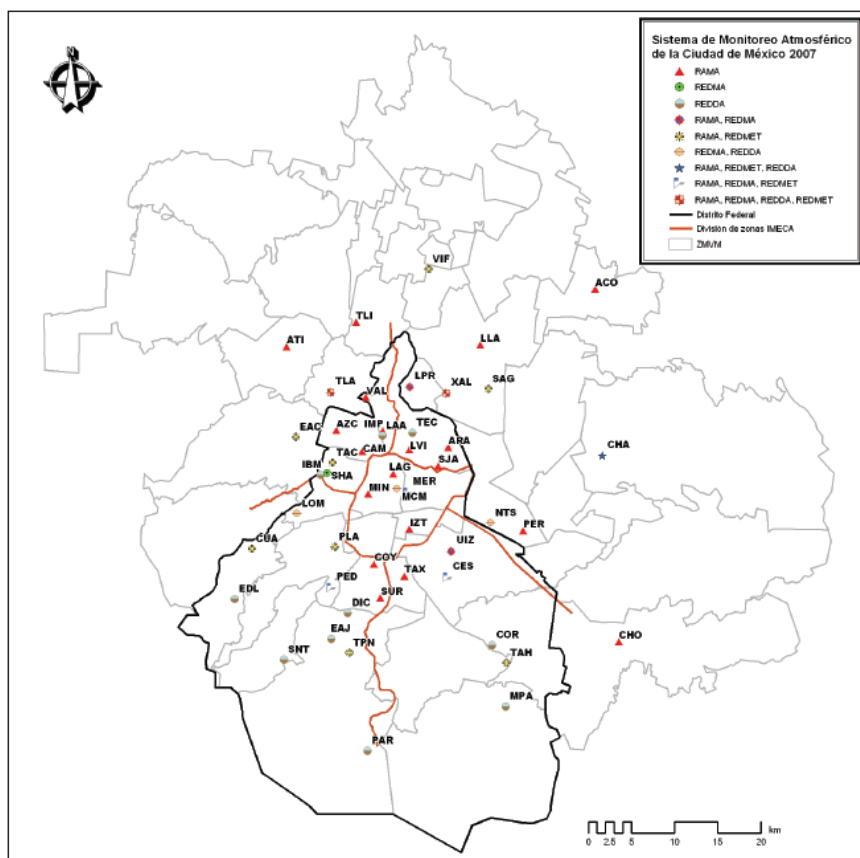


Figure 3: Distribution of the SIMAT monitoring stations, 2006.

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