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SIZE DISTRIBUTION OF SUSPENDED PARTICULATE MATTER IN THE URBAN AREAS OF TEHRAN

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ABSTRACT

Statistical size distribution of aerosols is one of the important parameters; since methods of purification of the air depends on the size of the particulate matter which must be separated.

Our objectives were to obtain detailed measurements of aerosol size distribution in Tehran's atmosphere during the 2004 at eight sites. We used Impactor ambient sampler which is comprised of six stages that are held together. In all samples the PM is high for stage 6 (< 0.45 μ). In Enghelab station mean of PM value (< 0.45 μ) is 262 $\mu g/m^3$. The highest PM > 7.5 concentration are found 35.31 $\mu g/m^3$ at the Arjanthin square. The highest $PM_{2.5}$ were found 78 $\mu g/m^3$ at the Bahman square. This paper points out the important role that particle size distribution.

The range of particle size collected on each stage depends on the jet velocity of the stage and cutoff of the previous stage. The average percentage of particulates in the Tehran's areas are respectively 76.5 % for 7.2 μm E.C.D; 64 % for 3 μm E.C.D; 57 % for 1.5 μm E.C.D; 46.5 % for 0.95 μm E.C.D and 35 % for 0.45 μm.

Key Words: Aerosol particle; vehicle emission; PM-10; SPM, Urban pollution

1. INTRODUCTION

The lifetime of finer particles is longer than that of relatively large particles, and they are more likely to be inhaled. The fine particulate matter not only can be found from dirty diesel engine exhausts, but also can b found in petrol engine exhausts (Candle et al. 1999). In terms of the effects of PM on human health, the size of the particles and the number of the particles and their composition are very important. A persistent haze blankets the city, especially during winter the effect of suspended particles on health (statistical center of Iran, 2000).

The particulate emissions from vehicles have a great impact on human health and the environment. The small particles under PM_{10}, which remain suspended in the atmosphere for long periods of time can case changes in rain and cloud pattern. PM_{10} and < PM_{10} denotes the particulate matter with a maximum particle 10 diameter of microns (μm), and PM_{10} was initially taken as a parameter to set the unsafe level for particulate emissions in the emission standards (Gray and Cass, 1998; Bagleg et al. 1996).

As products of the engine combustion, particulate emissions can directly indicate the engine working conditions and the levels of incomplete combustion (Lammel and Novakov, 1995). Therefore the particulate emissions from vehicles are the important issues to the environment protection and the performance of the engines in the on-road vehicles.

The impact of the particulate emissions in the environment and human health , and the relationship between the particulate emissions and engine operation were briefly summarized by Gong and Waring (Gong and Waring, 1998). Airborne particulate matter (PM) originates not only directly from combustion processes, but also from, for instance , wintertime standing of streets , and from wearing of the street surfaces because of studded tyres. Re suspension has a substantial influence on both STP and PM_{10} concentrations (Johansson et al. 1999). PM_{10} denotes the PM with a maximum particle 10 diameter of micron (μm) and PM_{10} was initially taken as a parameter to set the unsafe level for particulate emissions in the emission standards (seinfeld and pandas, 1998).

As in many large cities with limited ventilation, Tehran city experience air pollution problems especially suspended particles.

Much at the northern Alborz range essentially blocks the moist and rain-bearing air from Caspian Sea from reaching the Tehran area and wash out the air pollution. Much attention has been focused on particulate phase components of exhaust fumes due to possible acute and chronic respiratory effects. Exhaust fumes are a complex mixture of particulate (Grifin et al. 2003 ; Mitranda et al. 2002).

The current set of the diesel and petrol vehicles on Tehran roads emites inordinate amounts of particulate mtter (PM). Of highest concern are the fine, respirable particles of sizes 10 and 2.5 μm (PM_{10} and $PM_{2.5}$) which are highly carcinogenic and carry toxic compound with them (Monoli et al. 2002).

The particle from engine exhausts can be much finer than 10 μm as shown by the measurement method discussed in this paper.

2. EXPERIMENTAL

The size distribution of the particulate emissions have been investigated by using impactor instruments, consisting of 5 stages with rectangular jets and a back-up filter. The equivalent aerodynamic cut-off diameters at 50 % collection efficiency for a flow rate of about 18-20 SCFM are given in table 1 (the specific gravity of the particles is assumed to be 1 g/cm^{-3}). As the collection media, whatman glass fiber filters type GF/A are used. The total volume of sampled air passed through a rotameter equipped with a photo relay. Sampling is interrupted when the flow rate decreases more than 5% as would occur in the case of reduced pumping speed due to back-up filter clogging or reduced motor efficiency.

Table 1. Sierra Hi-volume cascade impactor characteristics

stage number	Equivalent aerodynamic cut-out diameters at 50 % efficiency (μm)
1	> 7.2
2	7.2-3.0
3	3.5-1.5
4	1.5-0.95
5	0.95-0.49
6	< 0.49

A major field campaign was carried out in Tehran city through 2004. Measurements during the field program included:

- TSP measurements in 20 sites, inside and suburbs of city (Table 2) .
- Seasonal of PM concentration at 8 locations throughout the city (Figure 1) .
- PM < 7.5, PM < 0.45 (PM size distribution) at 8 sites (Tables 3) .

The Equivalent aerodynamic cut-out diameters at 50 % collection efficiency of the different impactor stages are based on the manufacturers data (Eiguren et al. 2003 ; Hays et al. 2002). Practically , the most useful information is obtained for well determined fractions in the size range below 7 μm , containing the particles penetrating the non ciliated pulmonary region (Wilson and Suh 1997 ; Brook et al. 1997). Distribution patterns have to be described in different manners to allow a valid interpretation.

In this paper, primarily the concentration Vs particle size and cumulative mass distribution representations will be used. Particulate matter (PM) was measured by 47mm fiber filter (< 0.45 μm pore size) were pre-weighed on a microbalance. The sampling pumps calibrated to a flow rate of 510 L/min. Filters were removed after sampling and allowed to equilibrate at the laboratory prior to gravimetric analysis.

3. RESULTS AND DISCUSSIONS

PM measurements in 20 sites

Table 2 shows that the highest PM concentration were observed at "Shahre-Rey" site , whereas the lowest concentrations were recorded at the "Haram-emam" Site .

Table 2. Distribution of total suspended particulate matter (μg/m^3) .

Number	Station	Mean	Maximum	Minimum
1	Tajreesh	249.44	438.57	133.78
2	Vanak	219.04	323.53	117.43
3	Arjantin	180.46	196.19	159.59
4	Tehran-pars	249.66	387.25	112.0
5	Amir-abad	535.98	820.34	217.4
6	Sadeghieh	391.25	439.02	308.77
7	Karaj-road	126.44	215.77	83.1
8	Azadi	269.71	502.57	62.11
9	Enghelab	397.19	674	96.62
10	Ferdoosi	126.99	175.96	96.62
11	Emam-hossein	195.72	250.0	140.0
12	Bahman	569.97	1127.2	308.2
13	Shoosh	425.51	2186	79.71
14	Rah-ahan	177.57	259	94.6
15	Emam-khomeini	153.99	199.28	106.89
16	Sanat	253.52	391.11	111.34
17	Baseej	233.95	395.73	150.84
18	Afsarieh	274.23	413.19	132.27
19	Shahre-rey	1627.52	2050	93.5
20	Haram-emam	141.97	213.36	69.6

PM concentrations ranged from 69.6 μg/m^3 at Haram-emam (July) to 2186 μg/m^3 at Shoosh(September).The highest PM concentration measured during the sampling period was 2186 μg/m^3 in shoosh in 26 September 2004. The Iranian standard of PM is 250 μg/m^3 which was exceeded to 9 times .

The distribution of total suspended particulate matter

As shown in table 3 , the geometric mean diameter (d_g) and geometric standard deviation (σ_g) determined. Table 3 shows the size distribution of total suspended particulate matter (μg/m^3) at 8 locations in Tehran area.

Table 3. Distribution of TSP over the Impactor stages (μg/m^3)

	Stage number							
Sampling site	1	2	3	4	5	6	d_g	σ_g
Baseej	73.21	87.10	38.74	26.79	18.16	151.68	1.54	0.131
Enghelab	115.12	77.74	35.54	31.84	38.50	260.97	0.694	0.24
Tajreesh	90.35	83.37	40.48	32.28	24.91	167.18	1.412	0.144
Arjantin	25.6	30.38	11.28	8.37	7.77	76.21	0.696	0.23
Karaj Road	15.69	29.65	17.88	11.34	6.54	45.34	1.5	0.228
Azadi	72.12	90.36	54.33	43.97	34.07	207.71	1.06	0.1558
Amir-abad	45.34	41.42	16.57	12.21	6.54	59.29	2.63	0.09
Haram-emam	24.13	20.01	12.36	8.83	11.77	76.52	0.502	0.07

*geometric mean diameter

**geometric standart deviation of PM at 84% to PM at 50%

As shown in table 3, concentration of PM<0.49 µm (fine particle mass) makes up 50-60% of PM-10, from point of view of entering of the particles in respiratory system and their staying in the lungs are more hazardous.

Seasonal measurements

Seasonal variation of PM_{10} concentration at the 8 stations selected in this study have been presented in Figure 1.

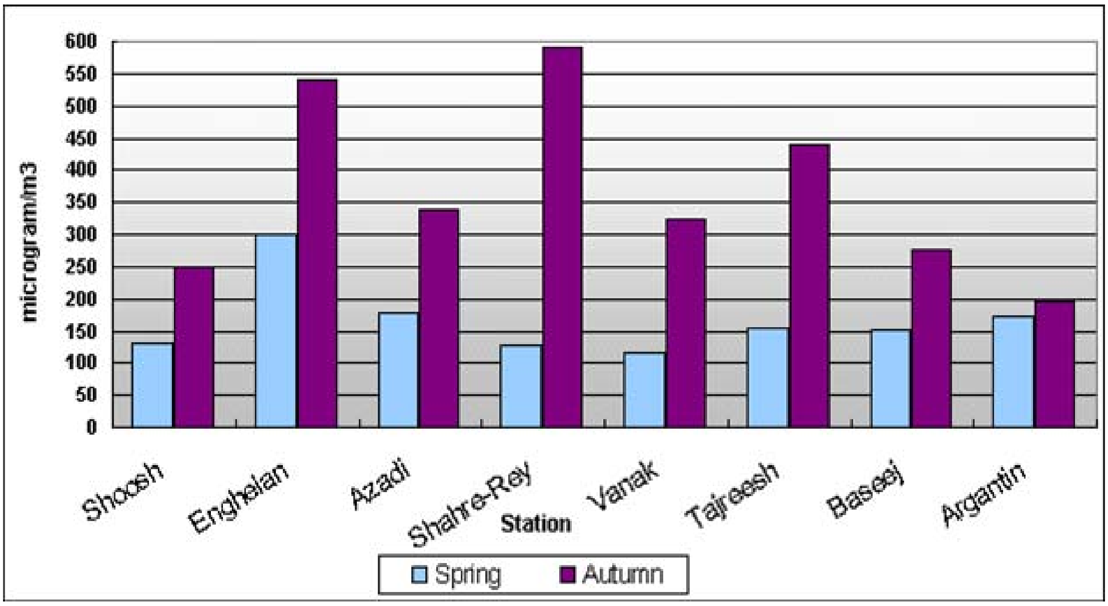

Figure 1. Seasonal concentration of PM

Diurnal variation of PM_{10} concentration at the stations Bazar, Fatemi and Aghdesieh for June month have showed in figure 2.

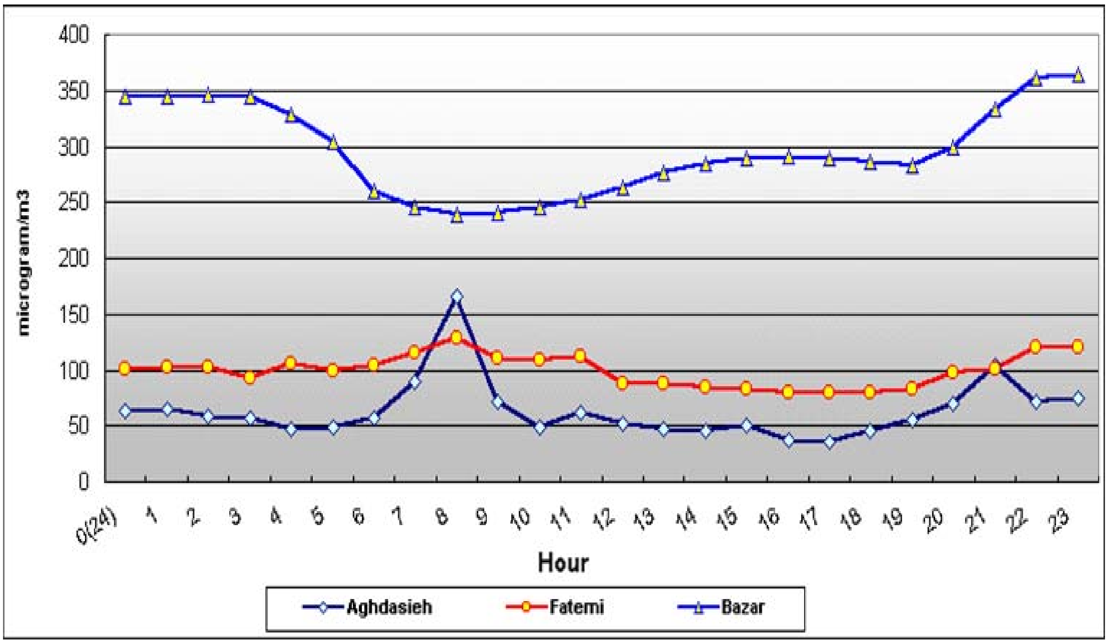

Figure 2. Concentration of PM-10 at the three sampling site (June 2004) *

* Data provided by the Air Quality Control Company (AQCC)

During the June month, the mean of PM-10 concentrations was 298.00 μg/m^3 at the Bazar site. The summer season is occasion for shopping in the Bazar in Tehran (city center).

Motor vehicles are recognized as a major source and primary direct emission of fine and ultra fine particles to the atmosphere in Tehran areas.

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