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Chemical Composition of TSP and PM_{10} and their Relations with Meteorological Parameters in the Ambient Air of Shariati Hospital District

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Abstract

Since particulate matter (total suspended particles and particulate matter with median aerodynamic diameter less than 10 μm) is one of the important pollutants in the ambient air of Tehran, the capital of Iran, organic substances, inorganic substances and lead levels in TSP and PM_{10}, correlation between TSP and PM_{10} concentrations, ratio among the two fractions and relation between TSP and PM_{10} concentrations with meteorological parameters (relative humidity and temperature) were studied. Twenty-four hour simultaneous sampling of TSP and PM_{10} has been carried out during the period of 22 December 2001 to 20 April 2002 in the ambient air of Shariati Hospital district. The results showed that inorganic substances were the most abundant component of TSP and PM_{10} (Approximately 76% and 68%, respectively); 0.21% of total mass for TSP and 0.26% of total mass for PM_{10} were lead particles; 64% of lead particles had a diameter less than 10 μm; 48% of TSP had a diameter less than 10 μm; while atmosphere relative humidity and temperature were in the range of 50% and 5-10°C respectively, specially on Saturdays in winter and more importantly in inversion conditions, the highest concentrations of TSP and PM_{10} would be expected.

Keywords: *Air pollution, Particulate matter, Lead, Organic substances, Inorganic substances*

Introduction

Particulate matter (PM) in the air includes total suspended particles (TSP), particulate matter with median aerodynamic diameter less than 10 μm (PM_{10}), particulate matter with median aerodynamic diameter less than 2.5 μm ($PM_{2.5}$), fine and ultra fine particles, diesel exhaust, coal fly-ash, mineral dusts (e.g. coal, asbestos, limestone, cement), metal dusts and fumes (e.g. zinc, copper, iron, lead), acid mists (e.g. sulphuric acid), fluoride particles, paint pigments, pesticide mists, carbon black, oil smoke and others (1). In recent years, epidemiological studies have shown association between ambient particulates matter concentration and health. Exposure to increased levels of particulate matter concentrations is related to increased mortality and a number of pulmonary effects, both acute and chronic (2, 3). In urban areas, air particle pollution is of particular interest for the possible delayed health effects associated with the continues exposure of a high-density population (4, 5). Tehran, the capital of Iran, is a great city characterized by highly dense residential and commercial premises and a vary high volume of vehicular traffic moreover; it is the most industrialized area. Many industries, including power plants, refineries, incinaerators, chemical and metallurgical factories are located in its outskirts. Thus, Suspended Particulate Matter (SPM) is a main pollutant and it may become a problem in winter because of the topography of the city and the meteorological conditions (6). Due to the particulate matter importance and its consequence especially in large cities like Tehran, it was attempted to quantify organic and inorganic substances as well as lead levels in TSP and PM_{10}, to investigate correlation between TSP and PM_{10} concentrations, to

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determine ratio among the two fractions and to analyze the influence of meteorological conditions.

Materials and Methods

Sampling Location This study was carried out in Shariati Hospital district, in Tehran. Because this district locates in the central part of the city and highly congested with traffic resulting in high air pollution, it was chosen as sampling station.

Sampling The particulate matter (TSP and PM_{10}) was collected in the sampling station at a height of about 3 m from 22 December to 20 April 2002. Two automatic High Volume Samplers with glass fiber filters (8 in 10 inches) for 24-h simultaneous sampling of TSP and PM_{10} were employed. According to EPA recommended schedule, 61 samples for TSP and 61 samples for PM_{10} were simultaneously taken during the study (7). Samples were taken every other day, at least in three days of week to cover all weekdays. During the sampling, conventional meteorological parameters (relative humidity and temperature) were regularly recorded. It should be noted that because of significantly reduction in commercial, industrial and transportation activities from 21 March to 20 April (the first month of New Year), this period was selected as control in sampling.

Analytical Techniques TSP and PM_{10} concentrations were obtained by gravimetric analysis on pre-weighed and pre-conditioned filters. Conditioning consisted of an exposure of filters for 24 h at about 25°C and constant humidity (around 50%). Before and after exposure, the filters were weighed using an analytical balance with a reading precision of ±10μg. In order to determine the organic and inorganic substances in TSP and PM_{10} a muffle furnace with 550°C was used for 15 min. The concentrations of lead in TSP and PM_{10} were determined by using nitric acid digestion method. The collected particulate matter on the filters of Hi-Vol was digested in nitric acid and then the lead concentrations were determined by Flame Atomic Adsorption (8).

Results

Statistical analysis to test the correlation was undertaken, based on linear regression. During the study the variations of 24-h simultaneous TSP and PM_{10} concentrations data were very well correlated (r=0.96) and this correlation had statistically significant at the 95% confidence (P<0.001) (Fig. 1). The maximum mean concentrations of lead in TSP and PM_{10} occurred from 22 December 2001 to 20 January 2002. The significant decreasing order of lead concentrations was due to distribution of free-lead gasoline throughout Tehran city from 21 January 2002. Quarterly mean concentrations of lead in TSP and PM_{10} (Winter 2002) were 0.64 and 0.41 μg/m3, respectively (Table 1). During the study the variation of lead concentrations in TSP comparing with that of PM_{10} was very well correlated (r=0.99) and this correlation was statistically significant at the 95% confidence (P<0.001) (Fig. 2). The variation of TSP and PM_{10} concentrations comparing with their lead concentrations was correlated (r=0.47 and 0.46, respectively) and this correlation was statistically significant at the 95% confidence (P< 0.001) (Figures3 and 4). Organic substances constituted approximately 24% of TSP and 32% of PM_{10}. On the other hand, inorganic contents of TSP and PM_{10} were 76% and 68%, respectively (Table 2). On the basis of the results when the relative humidity and temperature were in the range of 50% and 5-10°C, respectively, especially on Saturdays of winter and more importantly in inversion conditions, the highest concentrations of TSP and PM_{10} would be expected (Table 3). It is worthy to note that mortality and respiratory and cardiovascular diseases will largely increase due to the presence of the higher concentrations of chemical pollutants in air in inversion occurs along with this condition.

Table 1: Mean concentrations of TSP, PM_{10}, lead and corresponding ratios

Pollutant / Period	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	PM_{10}/TSP	Standard dev.	Lead in TSP ($\mu g/m^3$)	Lead in PM_{10} ($\mu g/m^3$)	The average ratio of lead in PM_{10} to that of TSP	Standard dev.	Lead/ TSP	Lead / PM_{10}
22 Dec to 20 Jan	263.3	128.2	0.51	0.09	1.1	0.71	0.64	0.016	0.44×10^{-2}	0.56×10^{-2}
21 Jan to 19 Feb	291.9	125.4	0.44	0.04	0.5	0.32	0.64	0.127	0.17×10^{-2}	0.25×10^{-2}
20 Feb to 20 Mar	319.9	149.5	0.47	0.05	0.31	0.19	0.64	0.097	0.096×10^{-2}	0.13×10^{-2}
21 Mar to 20 Apr	168.4	86.3	0.53	0.08	0.12	0.076	0.64	0.117	0.076×10^{-2}	0.089×10^{-2}
Winter 2002	291.7	134.4	0.46	0.07	0.64	0.41	0.63	0.088	0.25×10^{-2}	0.31×10^{-2}
Sum of 4 Months	261	122.4	0.48	0.08	0.51	0.32	0.64	0.094	0.21×10^{-2}	0.26×10^{-2}

Table 2: Mean Percentage of Organic and Inorganic Substances in TSP and PM_{10}

Pollutant / Period	TSP		PM_{10}	
	Inorganic (Percent)	Organic (Percent)	Inorganic (Percent)	Organic (Percent)
22 Dec to 20 Jan	67.3	32.7	54.4	45.6
21 Jan to 19 Feb	75.3	24.3	68.3	31.7
20 Feb to 20 Mar	78.3	21.7	73.8	26.2
21 Mar to 20 Apr	83.7	16.3	78.4	21.6
Winter 2002	74.1	25.9	65.8	34.2
Sum of 4 Months	75.7	24.3	68.1	31.9

Table 3: 24-h Concentrations of TSP and PM_{10}, in $\mu g/m^3$, according to relative humidity and temperature

Relative Humidity (Percent)	TSP		PM_{10}		Temperature (°C)	TSP		PM_{10}	
	No. of Sampling	Mean	No. of Sampling	Mean		No. of Sampling	Mean	No. of Sampling	Mean
≤50	9	362.63	9	184.25	0-5	4	209.75	4	98.25
51-60	21	292.81	21	137.81	5-10	20	303.8	20	138.2
61-70	14	254.14	14	116.79	10-15	22	246.64	22	117.09
71-80	10	188.7	10	84.5	15-23	15	248.93	15	118.13
≥81	7	176.67	17	85.5	---	---	---	---	---

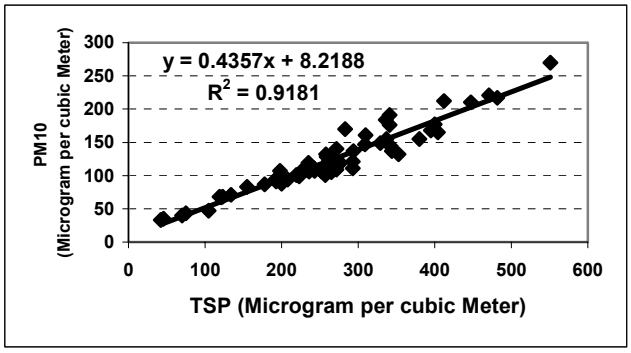

Fig. 1: Correlation of TSP and PM_{10} concentrations

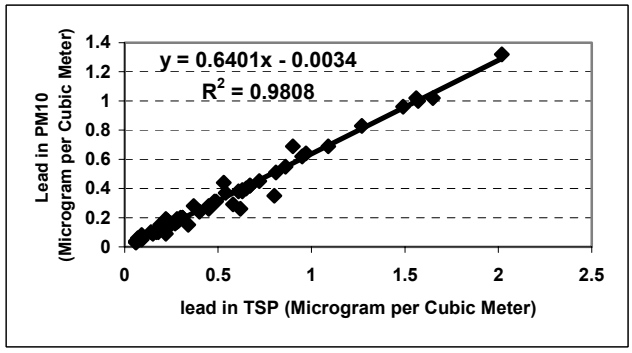

Fig. 2: Correlation of lead concentrations in TSP and lead concentrations in PM_{10}

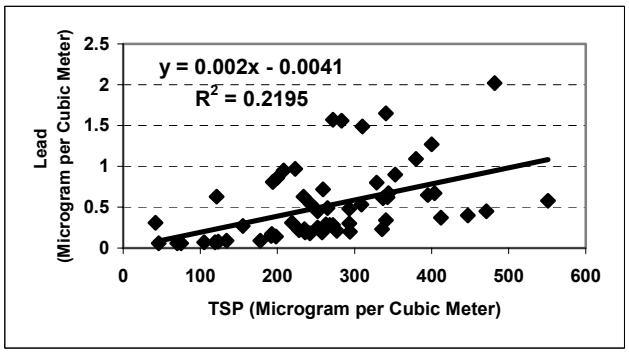

Fig. 3: Correlation of TSP concentrations and lead concentrations in TSP

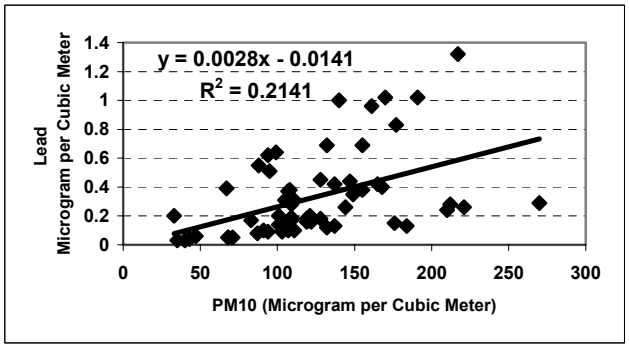

Fig .4: Correlation of PM_{10} concentrations and lead concentrations in PM_{10}

Discussion

About organic and inorganic substances in TSP and PM_{10}, it should be stated that inorganic substances are the most abundant component of TSP and PM_{10} and organic substances are more in fine particulate than coarse particulate (Table 2). Similarly, according to the research conducted in Basel, Switzerland, it was concluded that 17-17.6% of PM_{10} in rural areas and 23.6-26.1% of PM_{10} in urban areas related to organic substances (2). Investigating the Correlation between TSP and PM_{10} Concentrations Comparing with their Lead Concentrations indicated that 0.21% of total mass for TSP and 0.26% of total mass for PM_{10} were lead particles (Table 1). The average ratio of lead concentrations in PM_{10} to that of TSP was 0.64±0.094, which indicated that 64% of lead particles had a diameter less than 10 μm (Table 1). The average ratio of PM_{10} to TSP (PM_{10}/TSP) during the research was 0.48±0.08, which this indicates that 48% of TSP has diameter primarily less than 10μm (Table 1). It should be noted that ratios obtained in the different studies were 0.54-0.74, 0.87 and 0.5 in Switzerland, Italy and Mexico, respectively (4, 9, 10).

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