

## Original Article

*Survey of PM<sub>2.5</sub> Concentrations in Sari's City Center in 2010*\*Mahmoud Mohammadyan<sup>1</sup> Layla Sojudi<sup>2</sup>

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**Abstract**

**Background and purpose:** Because of the high traffic flow in the city center in Sari, a walk through survey indicated that the PM<sub>2.5</sub> concentrations are likely to be higher than the standards. This study was carried out to determine the level of PM<sub>2.5</sub> at the streets' curbsides in the city center in Sari.

**Materials and Methods:** In this cross-sectional study the PM<sub>2.5</sub> concentrations were measured in 185 monitoring stations at the curbsides of four main streets in the Sari city centre. 5550 10-s samples were collected using a real time particle monitor. A questionnaire was used to record air pollution related information and data were analyzed by descriptive statistic and ANOVA tests.

**Results:** Mean of PM<sub>2.5</sub> concentration was 83µgm<sup>-3</sup> and it was two times more than the national one and EPA recommended 24- hour standard (35µgm<sup>-3</sup>). This study showed that mean of PM<sub>2.5</sub> concentration at the street during traffic rush hours in the morning and evening were higher than those measured in the afternoon.

**Conclusion:** Because of the high concentration of PM<sub>2.5</sub> in the Sari's city centre that resulted in this study, the 24- hour PM<sub>2.5</sub> concentrations are likely to be higher than standards in some days in the city centre in Sari. Therefore, monitoring and control of air pollution are recommended in this city.

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**Key words:** Air Pollution, PM<sub>2.5</sub>, Sari City, Street Pollution.

## 1. Introduction

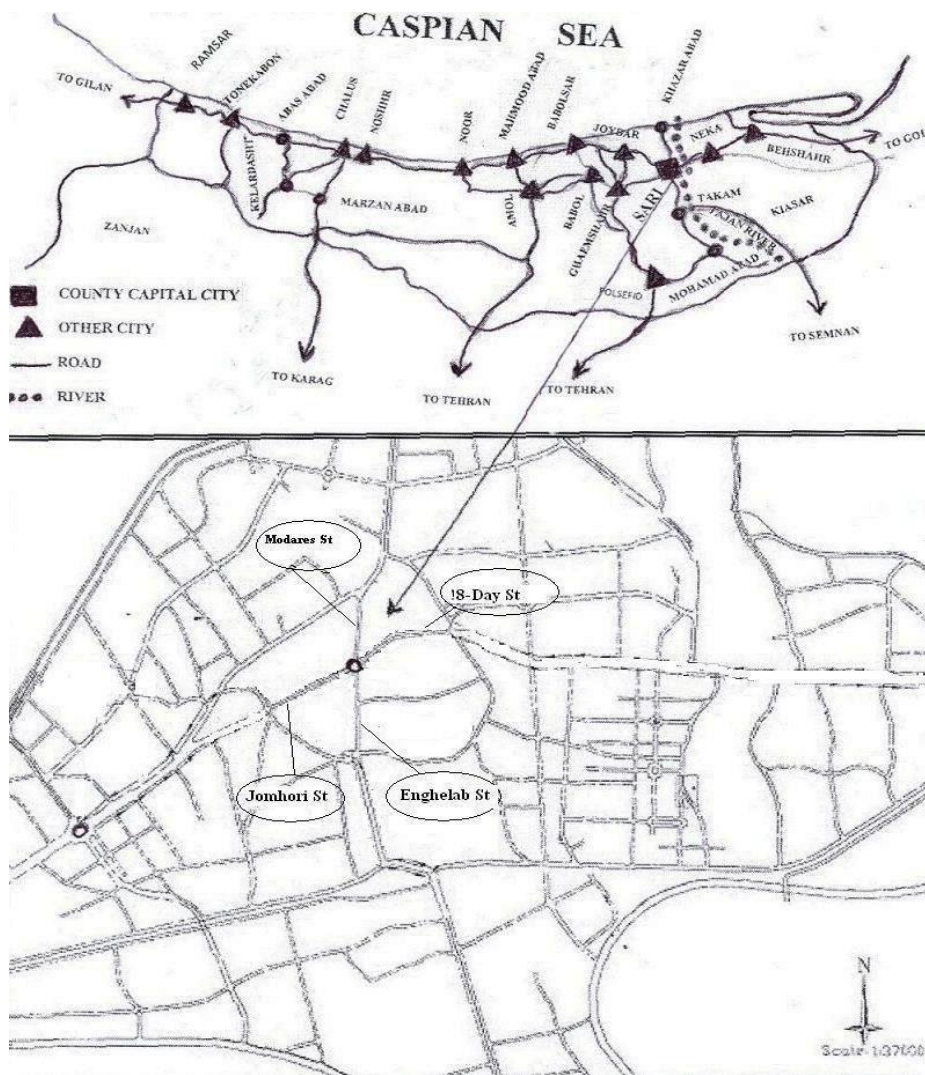
Particulate matter in the cities contains some geotoxic materials which might be inhaled by individuals both indoor and outdoor and may cause some adverse health effects among people. Particles with less than 2.5  $\mu\text{m}$  in diameter (PM<sub>2.5</sub>) are those parts of particles that may penetrate into the lower part of respiratory system. This section of particles were produced by vehicles' exhausts, industrial ventilation systems and/or combustion processes and also can produced as a secondary pollution from gas or vapor pollutants (1). Fine particles (PM<sub>2.5</sub>) cause some disorders and disease among people (2). Epidemiological studies showed that there is significant correlation between PM<sub>10</sub> and PM<sub>2.5</sub> concentrations in the ambient air and daily death rates (3,4). According to the WHO's report, 6 percent of total death is related to exposure to high concentrations of respirable particulate matters and approximately 50 percent of respirable particles are produced by vehicles (5). About 20% to 60% of inhaled respirable particles (ranges from 0.01 to 2.5  $\mu\text{m}$  in diameter) might be entered and deposited into the lungs. Thus, these types of the particles have a main effect on the lungs' tissues (6). Recently both PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are monitored by Environmental Protection Agency (EPA) as indicators for particulate air pollutants in the urban and rural areas (7). Recent studies showed that there is a more significant correlation between PM<sub>2.5</sub> concentrations and early death among people who have cardiopulmonary diseases in particular for elderly individuals (1,7,8,9). In the US

have found that Fine particulate and sulfur oxide-related pollution were associated with lung cancer and cardiopulmonary mortality. Each 10  $\mu\text{g}\text{m}^{-3}$  elevation in fine particulate air pollution was associated with approximately a 4%, 6%, and 8% increased risk of all-cause, cardiopulmonary, and lung cancer mortality, respectively. Measures of coarse particle fraction and total suspended particles were not consistently associated with mortality (10). Despite people spend more than 90% of their time indoor such as home, workplace, school and transportation, but monitoring of atmospheric pollutants in urban and rural areas are applied for air pollution reports and outcomes (11). Some studies were conducted in the Sari City to determine the drivers' exposure to respirable particles in public transportation's and to measure PM<sub>10</sub> concentrations in different areas of the Sari city (12,13,14). Also the PM<sub>2.5</sub> concentrations in indoor and outdoor shops in Sari city center concluded that the shop is the main cause of their accumulation indoor (15). There is not any air pollution monitoring station in the Sari City and on the other hand a large number of vehicles have to pass through narrow streets and corridors in the city center every day. Thus, the level of traffic flow in this city is high and traffic congestion might be often happened. According to the results of previous air pollution studies in the Sari City and other studies in similar cities, the PM<sub>2.5</sub> concentrations in the city center of Sari are likely to be higher than national and EPA's objectives. This study was carried out to determine the concentrations of PM<sub>2.5</sub> at the main streets in the center of Sari City in 2010.

**2. Materials and methods**

**2.1. Monitoring site:** In this cross-sectional study that was designed by authors based on scientific information, respirable particulate air pollution was measured in an urban area. Monitoring sites were selected at the curbsides of 4 main streets in the centre of sari city. These 4 streets were located around the Saat Square in the central point of the Sari City. There are some main taxi and bus stations at these streets and it seems that these locations are among the most

polluted areas in the Sari city. Monitoring was carried out during winter time. Monitoring sites located at the 18-Day street from Saat Square to Shohada Squire in the east, Jomhori Eslami Street from Saat Square to Darvazeh Babol Cross in the west, Modarres Street from Saat Square to Keshavarzi forked road in the north, and Enghelab Street from Saat Square to Emam Hossien Square in the south area of the Sari's City Center (Figure 1).



**Figure 1.** Map of Sari's city center and monitored streets

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**2.2. Monitoring method:** Every 10 second an air pollution data was collected and 30 data in each monitoring site (5 minutes for each site) were collected. Monitoring was carried out randomly on the main streets every day. Thus sampling was done randomly in different days of each week on different streets. All 185 sites located along 4 main streets' curbsides. The distance between 2 successive monitoring sites was less than five meters. A real time monitor (MicroDust Pro, Casella, UK) with a size selective adaptor as a monitoring probe was used to collect respirable particles (PM<sub>2.5</sub>) from ambient air. This instrument was calibrated according to the company guidelines. Instrument's monitoring probe was located on a tripod on the height of 150 cm above the curbside ground and 100 cm away from wall or other obstacles. 50 monitoring sites located at the Jumhori Eslami Street (code A), 36 monitoring sites located at the 18-Day Street (code B), 49 sites located at the Modarres Street (code c) and 50 monitoring sites located at the Enghelab Street (code D). A questionnaire was used to collect air pollution related information such as ambient condition, traffic flow condition, type of vehicles that were passing through the street during the monitoring period. Air temperature and barometric pressure were also were measured using inbuilt sensors by the sampling pump. SPSS software was used for analyzing data for descriptive and ANOVA analysis.

### 3. Results

The result of the monitoring in 185 sites at the 4 main streets in the central part of the Sari City and recorded information from questionnaire were analyzed by SPSS software. Totally mean, maximum, minimum and standard deviation of 10-s period PM<sub>2.5</sub> concentrations for all monitoring sites were 83.61, 700.00, 0.00 and 51.45 µgm<sup>-3</sup> respectively. Because of the measurement of particle concentrations in temporal 10-s periods, the minimum PM<sub>2.5</sub> figures were probably instrument/measurement artifact, since they imply extreme cleanliness. Figures 2 and 3 demonstrate PM<sub>2.5</sub> concentrations in different traffic conditions and type of vehicles which were passing through the street during the monitoring periods which analyzed by ANOVA test. As can be seen on Figure 2, mean PM<sub>2.5</sub> concentration during the high traffic flow (>2500 vehicle per hour) when monitoring was in process was considerably higher than mean PM<sub>2.5</sub> concentration during the monitoring period with low (< 1500 vehicle per hour) or medium (>1500 and <2500 vehicle per hour) traffic flow (p<0.01). Although the overall average level of PM<sub>2.5</sub> where some heavy vehicles were passing through the street during the monitoring period was lower than the mean PM<sub>2.5</sub> concentration during the periods while lighter vehicles were passed through the street, but the difference was not significant (Figure 3).

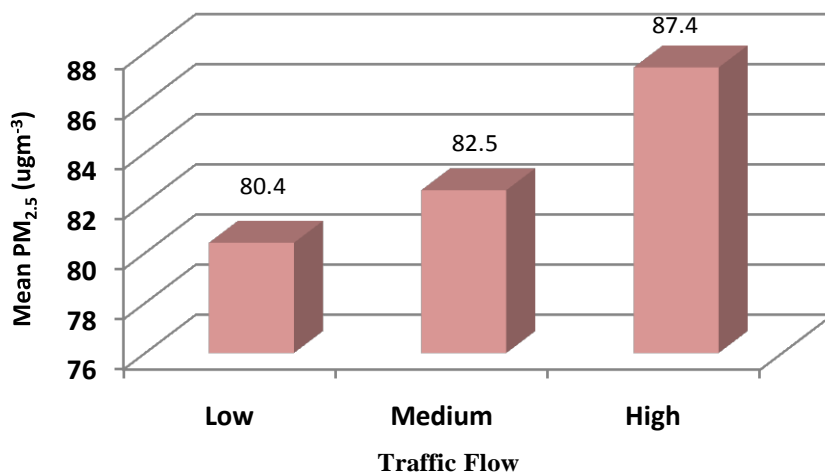


Figure 2. Mean PM<sub>2.5</sub> concentrations in different traffic flow condition

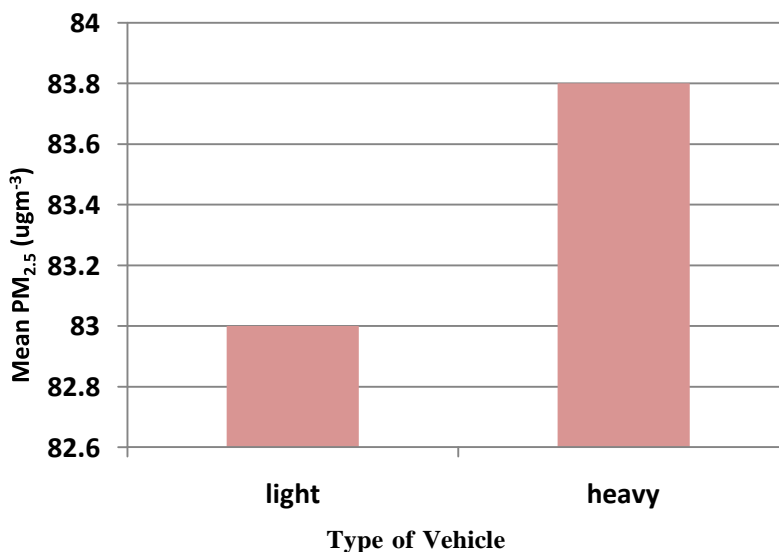


Figure 3. Mean PM<sub>2.5</sub> concentrations when different types of vehicle passing through

Results of the PM<sub>2.5</sub> monitoring in different monitoring sites demonstrated that the mean PM<sub>2.5</sub> concentrations for 5-minute samples in each site ranged from a minimum of 7.60 μgm<sup>-3</sup> at the Jomhori Eslami Street to a maximum of 305.33 μgm<sup>-3</sup> at the 18-Day Street. Descriptive statistics of PM<sub>2.5</sub> concentrations demonstrated in Table 1. There were significant differences between

mean PM<sub>2.5</sub> concentrations at 3 monitored streets (p<0.05). However, there was no significant difference between mean PM<sub>2.5</sub> concentrations at 18-Day and Modarres Streets. Enghelab Street Showed the maximum average PM<sub>2.5</sub> concentration (98.58μgm<sup>-3</sup>) and Jomhori Eslami Street resulted the minimum average PM<sub>2.5</sub> concentration (71.68 μgm<sup>-3</sup>).

**Table 1.** Descriptive statistics of PM<sub>2.5</sub> concentrations in 4 streets in Sari City

Street Code	No. of Sample	Mean ( $\mu\text{gm}^{-3}$ )	SD ( $\mu\text{gm}^{-3}$ )	Min ( $\mu\text{gm}^{-3}$ )	Max ( $\mu\text{gm}^{-3}$ )
A	1500	71.68	31.38	7.60	143.00
B	1080	80.47	45.66	30.23	305.33
C	1470	82.82	44.56	16.07	163.47
D	1500	98.58	43.33	11.27	195.53
Total	5550	83.61	42.17	7.60	305.33

#### 4. Discussion

Results of this study showed that the highest short term (10-second) PM<sub>2.5</sub> concentrations at the Sari city centre streets was 700  $\mu\text{gm}^{-3}$ . The maximum 5-minute PM<sub>2.5</sub> concentration in a station at the 18-Day Street was 305  $\mu\text{gm}^{-3}$ . This station was very close to a bus station and because of the stopping of 2 buses in the station at the same time; the highest level of PM<sub>2.5</sub> was recorded in this site. Total mean PM<sub>2.5</sub> concentration in current study was about two times more than Iranian national and US-EPA 24-hour standards (16, 19). It should be clarified that PM<sub>2.5</sub> concentrations standards recommended for mean 24-hour and mean annual PM<sub>2.5</sub> levels which are measured by fixed monitoring stations in the urban and rural areas. However, there is not any fixed air pollution monitoring station in the Sari city. This study was conducted to give us an over view of the respirable particle concentrations. Because of the high concentrations of PM<sub>2.5</sub> during the current study, the mean 24-hour PM<sub>2.5</sub> concentrations likely to be more than standards in some days of a year. This survey also resulted that mean PM<sub>2.5</sub> concentrations along the Sari's city centre streets during the high traffic flow periods (e.g. in the morning and the evening) were higher than average PM<sub>2.5</sub> levels during the times when the traffic flow was low. These

results are similar to those of other studies that carried out in different countries and concluded that proximity to street might be a factor for increasing of respirable particle concentrations (2,17,18). A study that carried out by Air Pollution Survey Office in Tehran like current study concluded that maximum concentrations of air pollutants were related to the morning before 10 am and in the evening from 17 pm to 20 pm (19). The average PM<sub>2.5</sub> concentrations in the Sari city center were higher than national and international standards and the PM<sub>2.5</sub> concentrations were higher when in high traffic flow. The authors recommend that some other studies during a long period should be applied to ensure about mean PM<sub>2.5</sub> concentrations in this city. Installation of a fixed monitoring station in the Sari city centre also recommended. Some other air pollution control methods such as changing the vehicles fuel to gas, vehicle emission control, industrial ventilation and stock emission control and sanitation of streets and corridors for solving traffic congestion in the central area of Sari city should be applied to reduce particulate air pollution.

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