Original Article

Survey of PM2.5 Concentrations in Sari's City Center in 2010

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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 PM2.5 concentrations are likely to be higher than the standards. This study was carried out to determine the level of PM2.5 at the streets' curbsides in the city center in Sari.

Materials and Methods: In this cross-sectional study the PM2.5 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 PM2.5 concentration was 83µgm-3 and it was two times more than the national one and EPA recommended 24- hour standard (35µgm-3). This study showed that mean of PM2.5 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 PM2.5 in the Sari's city centre that resulted in this study, the 24- hour PM2.5 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.

[*Mohammadyan M. Sojudi L. Survey of PM2.5 Concentrations in Sari's City Center in 2010. 2014;2(1):30-36]
http://jhs.mazums.ac.ir

***Key words*: Air** Pollution, PM2.5, 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 µm in diameter ($PM_{2.5}$) 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 ($PM_{2.5}$) cause some disorders and disease among people (2). Epidemiological studies showed that there is significant correlation between PM_{10} and $PM_{2.5}$ 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 µm 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_{10} and $PM_{2.5}$ 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 $PM_{2.5}$ 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 μgm^{-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_{10} concentrations in different areas of the Sari city (12,13,14). Also the $PM_{2.5}$ 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 $PM_{2.5}$ 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 $PM_{2.5}$ 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 Squre 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).

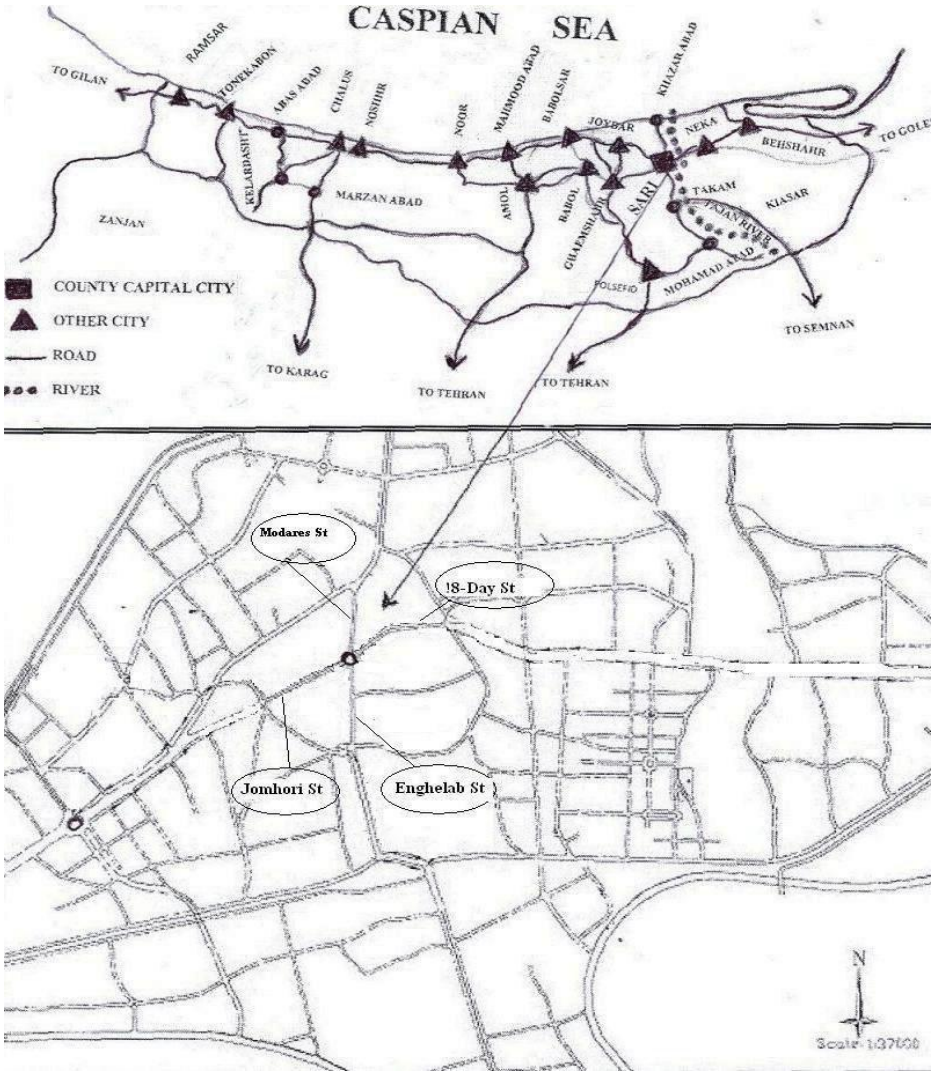

Figure 1. Map of Sari's city center and monitored streets

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 ($PM_{2.5}$) 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 PM2.5 concentrations for all monitoring sites were 83.61, 700.00, 0.00 and 51.45 µgm-3 respectively. Because of the measurement of particle concentrations in temporal 10-s periods, the minimum PM2.5 figures were probably instrument/measurement artifact, since they imply extreme cleanliness. Figures 2 and 3 demonstrate PM2.5 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 PM2.5 concentration during the high traffic flow (>2500 vehicle per hour) when monitoring was in process was considerably higher than mean PM2.5 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 PM2.5 where some heavy vehicles were passing through the street during the monitoring period was lower than the mean PM2.5 concentration during the periods while lighter vehicles were passed through the street, but the difference was not significant (Figure 3).

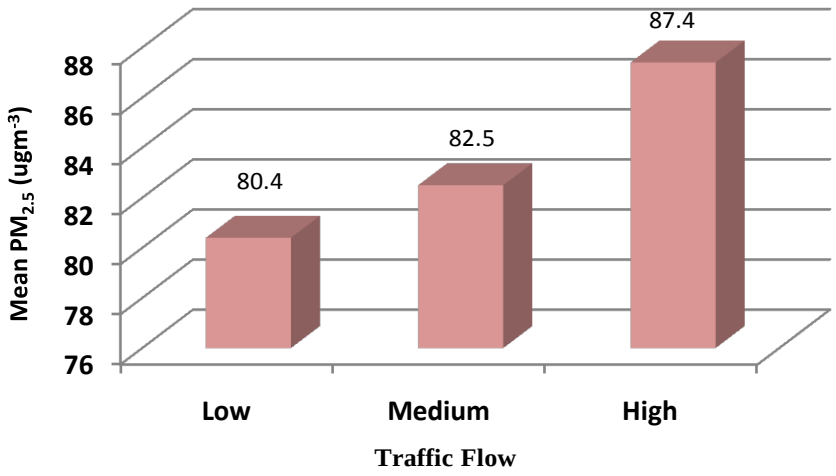

Figure 2. Mean $PM_{2.5}$ concentrations in different traffic flow condition

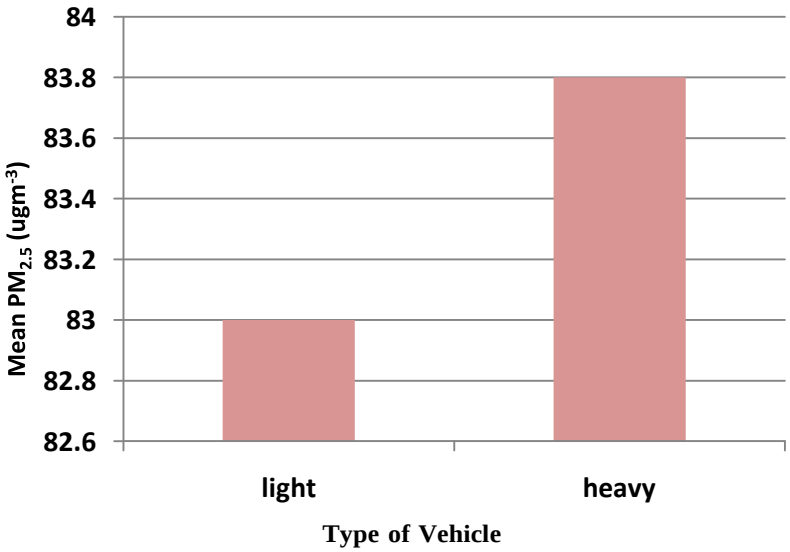

Figure 3. Mean $PM_{2.5}$ concentrations when different types of vehicle passing through

Results of the $PM_{2.5}$ monitoring in different monitoring sites demonstrated that the mean $PM_{2.5}$ concentrations for 5-minute samples in each site ranged from a minimum of 7.60 μgm^{-3} at the Jomhori Eslami Street to a maximum of 305.33 μgm^{-3} at the 18-Day Street. Descriptive statistics of $PM_{2.5}$ concentrations demonstrated in Table 1. There were significant differences between mean $PM_{2.5}$ concentrations at 3 monitored streets ($p<0.05$). However, there was no significant difference between mean $PM_{2.5}$ concentrations at 18-Day and Modarres Streets. Enghelab Street Showed the maximum average $PM_{2.5}$ concentration ($98.58\mu gm^{-3}$) and Jomhori Eslami Street resulted the minimum average $PM_{2.5}$ concentration ($71.68\ \mu gm^{-3}$).

Table 1. Descriptive statistics of $PM_{2.5}$ concentrations in 4 streets in Sari City

Street Code	No. of Sample	Mean (μgm^{-3})	SD (μgm^{-3})	Min (μgm^{-3})	Max (μgm^{-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) $PM_{2.5}$ concentrations at the Sari city centre streets was 700 μgm^{-3}. The maximum 5-minute $PM_{2.5}$ concentration in a station at the 18-Day Street was 305μgm^{-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 $PM_{2.5}$ was recorded in this site. Total mean $PM_{2.5}$ 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 $PM_{2.5}$ concentrations standards recommended for mean 24-hour and mean annual $PM_{2.5}$ 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 $PM_{2.5}$ during the current study, the mean 24-hour $PM_{2.5}$ concentrations likely to be more than standards in some days of a year. This survey also resulted that mean $PM_{2.5}$ 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 $PM_{2.5}$ 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 $PM_{2.5}$ concentrations in the Sari city center were higher than national and international standards and the $PM_{2.5}$ 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 $PM_{2.5}$ 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.

Acknowledgments

We wish to thank the Mazandarn University of Medical Sciences for all supports.

References

1. Funasaka K, Miyazaki T, Tsuruho K, Tamura K, Mizuno T, Kuroda K. Relationship between indoor and outdoor carbonaceous particulates in roadside households. Environ Pollut 2000; 110: 127-134.
2. Chunram N, Vinitketkumnuen U, Deming RL, Chantara S. Indoor and outdoor levels of $PM_{2.5}$ from selected residential and workplace building in Chiang Mai. Chiang Mai J Sci 2007; 34: 219-226.
3. Wallace L. Correlations of personal exposure to particles with outdoor air measurements: A review of recent studies. Aerosol Sci Tech 2000; 32: 15-25.
4. Mohammadyan M. Personal exposure and indoor home particulate matter: A review. Iranica J Energy & Environ 2012; 3: 246-254.
5. WHO. WHO's global air quality guidelines. Lancet 2006; 368: 1302-1302.
6. Monn CH, Fuchs A, Hogger D, Junker M, Kogelschaz D, Roth N, Wanner HU. Particulate matter less than 10 μm (PM_{10}) and fine particles less than 2.5 μm ($PM_{2.5}$): relationships between indoor, outdoor and personal concentrations. Sci Total Environ 1997; 208: 15-21.
7. Gregory CP. Personal Exposure to $PM_{2.5}$ in Minneapolis-St. Paul. Environ Bullet 2003; 1: 1-8.
8. Mönkkönen p. Observations of urban aerosols in India. 2011 [cited 2012 March 20]; Available from: URL: http://ethesis.helsinki.fi/julkaisut/mat/fysik/vk/monkkonen
9. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States. JAMA 2005; 293: 293-294.
10. Pope CA, Burnet RT, Thun MJ, Calle EE, Krewski D, Ito K, Thurston GD. Lung Cancer, Cardiopulmonary mortality, and long–term exposure to fine particulate air pollution. JAMA 2002; 287: 1132-1141.
11. Mohammadyan M, Ashmore MR. Personal Exposure and Indoor $PM_{2.5}$ Concentrations in an Urban Population. Indoor Built Environ 2005; 14:313-320.
12. Mohammadyan M, Alizadeh A, Mohamadpour RA. Personal exposure to PM_{10} among bus drivers in Sari, Iran. Indoor Built Environ 2009; 18: 83-89.
13. Mohammadyan M, Alizadeh A, Etemadinejad S. Personal exposure to PM10 among taxi drivers in Iran. Indoor Built Environ 2010; 19: 538-545.
14. Mohammadyan M, Babuyeh Darabi M, Baharfar Y. Survey of atmospheric respirable particles (PM_{10}) in Sari. In the proceeding of the 4th Conference & Exhibition on Environmental Engineering; Tehran, Iran 2010;17-18:637.
15. Mohammadyan M, Sojodi L, Etemadinejad S. survey of concentrations of PM2.5 indoor and outdoor of shops in Sari city center. J Mazand Univ Med Sci 2011; 21(84): 72-79 (Persian)
16. EPA. EPA PM Standards (online). Environmental Protection Agency. 2006 [cited 2012 Feb 17]; Available from; URL: http://www.epa.gov/air/particlepollution/standards.htm
17. Cao JJ, Lee S, Chow JC, Cheng Y, Fung K, Liu SX, Watson JG. Indoor/outdoor relationship for PM2.5 and associated carbonaceous pollutants at residential homes in Hong Kong – Case Study. Indoor Air 2005; 15: 197-204.
18. Saksen S, Uma R. Longitudinal study of indoor Particulate matter and its Relationship to outdoor concentrations in New Delhi, India. Indoor Built Environ 2008; 17: 543-551.
19. IEPA. Tehran air pollution statistics. 1st ed. Air Pollution Survey Office, Iran Environmental Protection Agency publication: 1998;1-171.