RESEARCH ARTICLE

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Comparative Analysis of Measured PM Concentrations with AQI and Iranian Clean Air Standard (Case Study: Sari, Iran) 2010-2015

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Background & Aims of the Study: Among different kinds of air pollutants, Particle matters due to their proved destructive impacts on human health and their various sources like transportation attract wide attention. The objective of this work is determining the real value of particle matters in one of the important and busy roads in Iran (Sari- Qaemshahr road).

Materials & Methods: In this study, measurement and field analysis of particle matter (PM) pollution of Sari-Qaemshahr road (Iran), with high load of traffic, has been done during a 6 years period (2010-2015) and the results have been investigated by means of AQI and Iranian clean air standard indexes. Furthermore, the effect of pollutants on human health is discussed.

Results: The results showed that particle matter pollution in study stations has an increasing upward trend. Comparison of measured particles with clean air standard expresses that the amount of particles is under the clean air standard limitation and it could not considered as a danger. However, comparison of PM with AQI index showed that the amount of the PM, except 2010, is in the range of very unhealthy and it shows a very poor condition. Considering its effects on human health, the increasing trend of these particles could become a concern for the society.

Conclusions: This research reveals that the Iranian clean air standard needs a meticulous review in order to administer the emission of PM, using the results which are obtained from this study.

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Background

The PM_{10} particles are so small that they can easily travel to the lower part of respiratory system and could have different detrimental health impacts with themselves. PM_{10} consists of small particles (solid or liquid) of various atmospheric mixtures (1). $PM_{2.5}$ are very small particles which transfer to air from different sources including diesel vehicles, power plants, burning foods and some industrial activities. Coarse particles are included of air dust of dirt roads and dust created by crushers and metal rubbing process. According to numerous studies which have been done around the world, transportation and traffic are the main sources of dust emissions and production (2). Particle pollutant has a considerable impact on growth of mortality and hospitalization among respiratory and cardiac patients. This air pollution can also affect the frequency of Chronic Obstructive Pulmonary disease. A

study which has been done in Ahvaz (Iran) from 2009 to 2013 showed that the annual frequency of COPD during this period had a direct relation with PM concentration (3). Daily changes of mortality and the number of hospitalized people are related to the variations of air pollutant particles (1,4). Studies show that every 10 $\mu g/m^3$ augmentation of PM_{10} concentration, daily fatality increases within 0.5 to 1.6 percent (1,5-6). Several studies have been done in Iran to express the effect of PM concentration on human health (7-10). In addition, recent studies which have been conducted in the United States suggested that $PM_{2.5}$ daily and annual federal standard (65 $\mu g/m^3$ and 15 $\mu g/m^3$ respectively) and PM_{10} daily and annual federal standard (150 $\mu g/m^3$ and 50 $\mu g/m^3$ respectively) secure human health should be lessened (11).

In addition, California made standards more strict for particles in 2002; so, the average of annual standard for $PM_{2.5}$ and PM_{10} were considered equal to 12 and 20 $\mu g/m^3$, respectively (12). A study which was done on the lives of children in south California showed that children with asthmatic disease who live in highly polluted areas (specially particles, NO_2 and acidic vapors) are more vulnerable to symptoms of bronchitis (13,14). Several studies which have been done recently around the world have shown the relation between air pollution (particularly particles and CO), fatality of the infants, birth weight loss and preterm birth (13). In this regard, there is not a certain estimation of the contribution of fine particles and coarse particles and it is under investigation (13). The health effects of the fine particles looks more significant in the west coast of the United States, and in other areas, the impact of coarse particles is more remarkable (13-15). Among various issues in this regard, pollution caused by road traffic due to their deteriorating effects on air quality of near cities has gained special attention. $PM_{2.5}$ and $PM_{10-2.5}$ composition close to an interstate highway in Detroit, Michigan, USA which is well-known for its high traffic load in the USA was studied by Oakes (16). In this study, different sources including traffic and regional industries were considered. This study revealed that augmentation of $PM_{2.5}$ and $PM_{10-2.5}$ near roadway areas could have destructive health impacts. Another study in this regard performed a field study in order to study the relationship of different commuting ways in China with personal exposure to $PM_{2.5}$ and CO (17). In this study, exposures to $PM_{2.5}$ and CO were considered simultaneously during trip to consider a different inhalation rate and trip duration. The result of this study showed that commuting modes have determining effect on $PM_{2.5}$ and CO exposure. An important outcome of this investigation was that cycling is not a preferable commuting way in highly air polluted areas. In another study the effect of main roads on PM_{10} concentration in London city was investigated (18). PM_{10} concentration data were from 10 monitoring sites and an ANN model was developed to predict the impacts of these roads on PM_{10} concentration in London. This study showed that road traffic has between 24% and 62% contribution in hourly average roadside PM_{10} concentration. In another study, the spatial distribution of ultra-fine and $PM_{2.5}$ particles alongside noise near two major freeways in Los Angeles had been investigated (19). The result of this study suggested that exposure of ultra-fine particles and $PM_{2.5}$ is higher in downwind of freeways.

Treatment of respiratory disease by air pollutants is possible with some mechanisms. Particles and gases with high solubility in water are absorbed through the epithelial layer which masking the respiratory system, and are entered into the blood which flows into that area (20,21). As researches show, the particle matters (PM) have numerous negative effects on human health including reduced lung function, lung diseases and respiratory tract symptoms (22). One of the effective actions is to quantify the amount of particle pollutants and applying air quality index (AQI) along with

national air quality standard to represent the impacts of different air pollution levels on resident's health. Then, after identifying and analysis of these particles, serious attention should be paid to reduce them.

Aims of the study:

The objective of this study was determining the real value of particle matters emitted from one of important and busy roads in Iran (Sari-Qaemshahr road) by 6 years measurement of these pollutants in two points along the road and comparing these values with AQI and clean air standard of Iran in order to express the health impacts regarding different levels of pollution and observe pollution variations.

Materials & Methods

In this study, the Sari-Qaemshahr road (Mazandaran-Iran) was selected as a pilot; because it is one of the roads with the highest traffic in Iran. Due to the presence of excessive pollution caused by automobile traffic, this road is considered environmentally critical. This road is located in Iran, Mazandaran province, Sari city. Since the pick hours of road traffic are at 12 to 13 pm, all of the experiments were done during this period. By regarding the criteria and selected pilot, the experiments and particle matter assessment were done finally during a 6-years period from 2010 to 2015 on the Sari-Qaemshahr road. The particles were sampled at two points along the road and were measured in the field by means of dust track (BABUK-A) which is a light-scattering laser photometer. With respect to meteorological parameters variations, in each year and in each season, assessments were done, separately. In this regard, particle matters were measured for every season in each year and for every month of each season. Then, an average is taken from values which were obtained from ambient particle experiments in each year, so that the value of each year is the average of obtained numbers of particles test in that year. Data were processed by Excel to compute seasonal mean, maximum, minimum and standard deviation. These experiments were performed for 6 consecutive years (from 2010 to 2015) and the results are presented in graphs. The obtained results were compared by two indexes of AQI and clean air standard of Iran to examine the trends of changes. Calculation of AQI was done by considering the average of three samples in each season (23). AQI as an indicator is applicable to report daily air conditions (24,25). Air quality index (AQI) is classified for various pollutants with attention to the concentrations of pollutants and in each case recommends specific health and safety measures which are shown in table 1 with specific colors (26).

Table 1) AQI index in 6 separate categories with different levels

Air quality index	Level of health care	Colors
0 – 50	Good	Green
51 – 100	Medium	Yellow
101 – 150	Unhealthy for sensitive groups	Orange
151 – 200	Unhealthy	Red
201 – 300	Very unhealthy	Violet
301 – 500	Dangerous	Amethystine

Results

The results show an increasing trend of PM concentration over 6 years of the study. In addition to this increase, PM concentration is still not higher than the Iranian clean air standard in every season. Comparison of the results with AQI index showed that in all years except 2010, very unhealthy condition is dominated.

- **Comparison of Measured Particles with Clean Air Standard of Iran**

Fig. 1 shows the results of experiments which were done in the spring season of each year. The process of experiments is for every season of each year; three values of seasonal maximum, minimum and average are considered and the graph is drawn according to these three values in order to better show of variations.

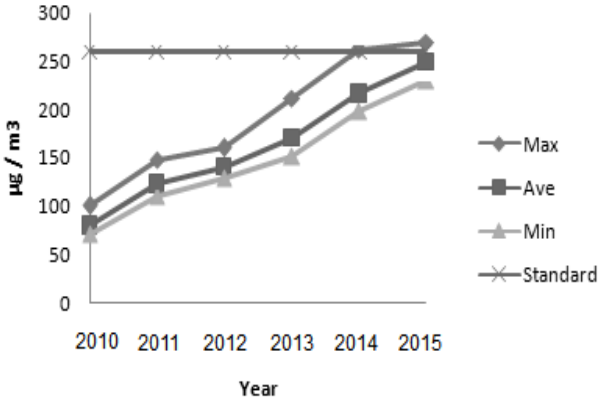

Figure 1) Comparison of particle matter concentration in spring season of each year with Iranian clean air standard

In Fig. 2 measured particles in the summer of each year are shown which are compared according to clean air standard.

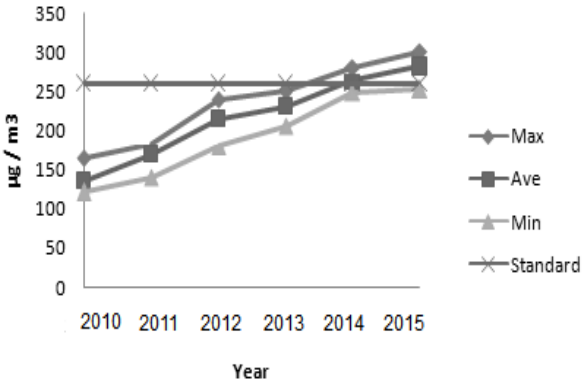

Figure 2) Comparison of particle matter concentration in summer season of each year with Iranian clean air standard

The values of measured particles in autumn and winter of each year are presented in Fig 3 and 4.

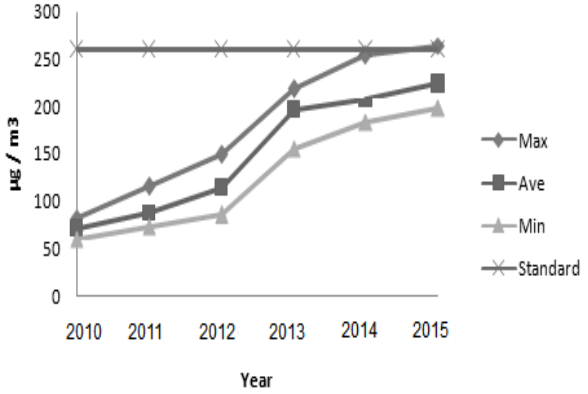

Figure 3) Comparison of particle matter concentration in autumn season of each year with Iranian clean air standard

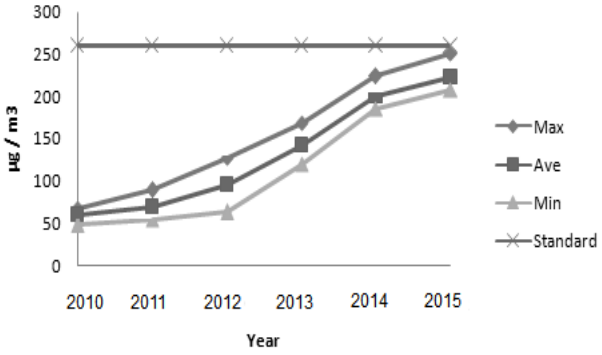

Figure 4) Comparison of particle matter concentration in winter season of each year with Iranian clean air standard

Generally, the amount of particle matters (PM) which were measured during these years and in various seasons have been studied by clean air standard. The amount and increasing rate of these particles, which represent an increase of particles in ambient, is very high, but in comparison with clean air standard, this situation seems acceptable.

- **Comparison of Measured Particles with AQI**

After comparison of measured particles with the clean air standard of Iran, comparison of ambient particle has been done with AQI index which is presented in table 2.

Table 2) AQI of particles from different years on the Sari-Qaemshahr road

Level of health care	AQI	Ave PM±SD ($\mu g/m^3$)	Road Name	Year
Unhealthy	151 – 200	90±16	Sari-Qaemshahr	2010
Very unhealthy	201 – 300	145±28	Sari-Qaemshahr	2011
Very unhealthy	201 – 300	162±36	Sari-Qaemshahr	2012
Very unhealthy	201 – 300	190±24	Sari-Qaemshahr	2013
Very unhealthy	201 – 300	229±42	Sari-Qaemshahr	2014
Very unhealthy	201 – 300	243±48	Sari-Qaemshahr	2015

Discussion

As in Fig 1 is observed, particle matter in the spring has an increasing trend during 6 years. In this graph, standard value equals to 260 according to clean air standard, and measured particles are compared with this value (27,28). Fig. 1 shows that all points on the curve are below the standard line and only maximum value of 2014 and 2015 is upper than standard value and it is dangerous.

According to Fig 1, particle matter in the summer has an increasing trend, during 6 years. In Fig 2, it is clear that the amount of particle matter in the summer is more than spring and several factors contribute to this issue. In the summer, as school closures and favorable weather, travel and traffic rate are much higher than other seasons and since the Sari-Qaemshahr road is considered as the most crowded road of the country, the amount of environmental particles produced in this way is more than other places. Other reasons such as heat and low rainfall in this season, lead to increase of particle matter in the summer (29,30). By looking at the chart, we see that all points on the curve are below the standard line and only maximum value of 2013, 2014 and 2015 which are upper than standard value; they are dangerous and at the rest of the points, the amount of particles is less than standard value.

Fig 3 and 4 show that the amount of these particles in these two seasons, except maximum value of 2015 which is more than standard value, are below and less than standard value.

As can be seen in table 2, the measured particle matters from 2010 to 2015 are compared with AQI index.

According to table 2, it can be concluded that none of these 6 years studies show the favorable conditions. According to six classifications and purple color of the table 1, regardless of 2010 (which is a reminder of unhealthy condition), the rest of the years from 2013 to 2015 were expressed very unhealthy and very harmful conditions.

According to graphs of parts (1-2), these values in comparison with the clean air standard show the favorable conditions, while AQI index shows that the amounts of particle matters which are obtained during these 6 years are very high and dangerous, and have a very unhealthy condition (purple color, according to table 1).

Conclusion

Results of investigation and analysis show that particle matter pollution at selected stations between 2010 to 2015 has an increasing trend. Evaluation of these data, by clean air standard and AQI, well defined the health risk of these pollutants for human health. This study shows that particle matters (PM) concentrations between 2010 to 2015 are in an acceptable situation compared with the clean air standard. However, when it compared with AQI index,

sanitary conditions are not favorable and it shows unhealthy condition (red color) for 2015; for the rest of the years, it shows very unhealthy condition (Violet color). Analysis of this research has shown that clean air standard needs a serious review and the value of its standard must be modified according to the current situation in order to represent the correct results. Moreover, in order to control of particles and air pollution, we need to have accurate data to manage the traffic and prevent further growth of these particles in the environment. By regarding the daily growth of industry and traffic, in the absence of management, measuring and controling of pollutants and their sources, particle matter concentration could increase more and would have irreversible hazard to human life.

By looking at the obtained results and a notable increase of air pollution in the Sari-Qaemshahr road, some suggestions are presented here in order to control and reduce the particle matter resulted from traffic, which are as follows:

- Use of public transportation vehicles and reduce of private vehicles movement.
- Use of gas fuels in various industries and vehicles and reducing the use of fossil fuels and gasoline.
- Need for air pollution control systems.
- Optimal management of urban air pollution systems to control the air pollution.
- Improvement of public transportation and use of cars based on the capacity to carry passenger and cargo.
- Improvement of urban and inter-urban traffic system.
- Preparing of allowable technical centers for control and continuous adjustment of vehicle's engine.
- No deployment of major industries which contribute to air pollution within the cities and acceptance of industries locating regulations.
- Making of green space around the road for removal of contaminants by trees which are considered as absorbents of pollutants.

Footnotes

Conflict of Interest:

The authors declared no conflict of interest.

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