World Applied Sciences Journal 7 (2): 239-244, 2009
ISSN 1818-4952

Data Validity of PM_{10} Concentrations Resulting from Air Quality Monitoring Network in Tehran

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Abstract: Establishing a scientific air quality monitoring network infrastructure is corner stone in air quality management. Tehran's air quality monitoring network is not an exception from this rule. The aim of this study was to determine data validity relevant to PM_{10} concentrations announced by air quality monitoring network in mass media. An optical instrument was selected and calibrated to check data validity of PM_{10} concentration at Tehran's air quality monitoring stations. For checking PM_{10} concentration in a given time interval at each station, both case and control instruments ran simultaneously. Result showed that the validity of air quality monitoring network readings for PM_{10} is not enough valid. According to field observations, site selecting criteria for establishing monitoring stations were not qualified. In some stations, minimum, maximum and mean values of PM_{10} concentrations were the same. Weak correlation was observed between measurements of both instruments (R^2=0.19) in regression analysis. Many deficiencies such as lack of periodic calibration, ignoring maintenance and quality assurance/control may lead to invalid measurements of case instrument.

Keyword: Quality control · Monitoring station · PM_{10} concentration · Calibratio

INTRODUCTION

Establishment of Air Quality Monitoring Network (AQMN) is needed for each city. Knowing the goals of AQMN is very important to design and operate AQMN. Main objectives of a well-established AQMN include determining population exposure and assessing the effect of air pollution on human health, identifying threats to natural ecosystems, informing the public in general and providing alert systems, research information, providing data base to simulate air pollution concentration levels in no monitoring station areas by means of model, developing an efficient system to determine air quality trends and observing pollution fluctuations that is very important to determine the effectiveness of air pollution control strategies, judging compliance with national or international standards, determining representative and maximum concentrations of pollutants in urban districts, identifying and apportioning sources [1-3].

As far as we know, maintenance and operation in developing countries are too weak due to lack of knowledge relevant to imported technologies, incompatibility with conditions and many other shortcomings. In field of operating and maintenance, considering data validation, system audits, calibration, quality assurance and quality control of AQMN are in paramount of importance. Verification of measurement procedures is included in a satisfactory data validation program. In this program some techniques are used to accept, reject or qualify data in a certain purpose and consistent manner. The aim of auditing is to realize conformity of AQMN to the standard operating measures. System audits should be performed by a person who is independent of the responsible agency. Calibrations are required when instruments are first installed. Afterward, semi annual interval calibrations are recommended. Some repairs do require recalibration following the replacement of faulty components. Most repairs can be

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made in the field by a simple substitution of components. If calibration standards are not available, the instrument can be returned to the company service facility. Quality assurance has two important functions. Assessing the quality of collected data and improvement of data quality are these two distinctive functions. The first function is achieved by evaluating precision and accuracy of collected data. It is expected to show some anomalies when data quality is not qualified well. The second is obtained by optimizing strategies and correcting problematic policies. The control policies must be upgraded when data quality is unacceptable [4, 5].

"PM_{10} are particles with aerodynamic diameter 10 µm or less, or, more precisely, particles that pass through a size-selective inlet with a 50% efficiency cut-off at 10 µm aerodynamic diameters. The upper cut-off of aerodynamic diameter is about 30 µm which means that no particles greater than 30 µm enter the inlet. PM_{10} roughly corresponds to the thoracic fraction of the particles, that is, those that penetrate beyond the larynx. Most of the quantitative information available on the health effects of particulate matter come from studies in which atmospheric particles in air have been measured as PM_{10}" [6]. Health end-points which have been attributed to PM_{10} in relevant literature are fall into mortality and morbidity categories. Total mortality, cardiovascular and respiratory mortality are the main health endpoints in category of mortality which is demonstrated in long-term and short-term health effects studies. In category of morbidity, hospital admissions respiratory disease, hospital admissions cardiovascular disease, asthma attacks in children and adults have been reported [7, 8]. It should be noted that as further epidemiological studies reveal correlation between human health and air pollutants, the focus on $AQMN_S$ design for being precise and accurate will increase [9].

Tehran has 22 districts in urban area with a population of 7.8 million people. Tehran's AQMN has been provided ten monitoring stations to cover 10 districts inside the city. The aim of this study was to determine data validity of PM_{10} concentration that is measured by monitoring stations in these districts in Tehran. There is not monitoring stations in other districts and air quality is forecasted with regard to monitoring stations database by means of models.

MATERIALS AND METHODS

The study area was ten monitoring stations in Tehran city. Three of them were out of service at the time of our study and so were not considered at this study. Tehran's AQMN is classified as State and Local Air Monitoring Stations (SLAMS), with an urban/neighborhood scale focus [10] that is intended to provide a comprehensive description of air quality and its trend over time. Estimation of human exposure and determination of air pollution effects to ecosystem are other goals for establishing AQMN in Tehran.

For the period April 1, 2008, through May 1, 2008, PM_{10} concentrations were measured at monitoring stations. Entire sampling period was 90 minutes for each monitoring station. Sequencing measurements performed once every 15 minutes. A Grimm model 1.108, portable dust monitor as a control instrument was used for checking PM_{10} concentrations which is announced by air quality monitoring stations. This is an optical and direct reading instrument.

Portable dust monitor was selected for checking PM_{10} concentration values at monitoring stations because of its reliability, flexibility at handling, ease of set up, maintenance and excellent local service. It is able to measure $PM_{2.5}$ and PM_1 concentrations as well as it can determine particle size distributions. Before starting measurements, the portable dust monitor (Grimm) was calibrated (valid until 2009.12.31) and confirmed by German manufacturer (Table 1).

Gaseous pollutants such as NO_2, SO_2, O_3 and CO are also measured at Tehran's AQMN routinely. It is expected to measure more than one pollutant for performing comprehensive study and validating all pollutants data but in this study we just focused on PM_{10} measurement. Tehran's AQMN announces PM_{10} concentration once every 15 minutes, to simulate the present system schedule, we set Grimm program to measure PM_{10} concentration every 15 minutes. In one of the stations out of seven active monitoring stations, PM_{10} concentrations were measured by using True Micro Weighing Method and this parameter was measured through Beta Method Radiation in other six monitoring stations. Portable dust monitor probe were placed as close as possible to monitoring station probes, so it is assumed they are placed in one spot and conditions for both were the same. Both instruments were run simultaneously.

Table 1: Measurement values of portable dust monitor (Grimm) during calibration

Mean Value	Reference Unit	Calibrated Unit	Relative Deviation
Total Dust (0.23-20µm)	7159.8 µg/m^3	7060.1 µg/m^3	<3%
Sample Volume	0.0116 m^3		

RESULTS AND DISCUSSION

Table 2 demonstrates a summary of the all data acquired from both instruments. Difference percentage, standard deviation, minimum, maximum and average concentrations of PM_{10} were calculated during the entire sampling period for each station.

Presented data shows that standard deviation for Rose Park and Golbarg stations was zero. Therefore, in these monitoring stations minimum, maximum and arithmetic mean of PM_{10} concentration in every 15 minutes and entire sampling period were the same. It implies either improper function of monitoring station instrument or unchanged concentration of PM_{10}. It is well known that concentrations of pollutants especially particulate matters are changing in short time intervals even in indoor environments [11-15]. Standard deviations of portable dust monitor readings were not zero and they were reasonable. Although the values of standard deviation for other monitoring stations were not zero, the concentration interval between minimum, maximum and mean values were very close to each. Geophysics monitoring station was an exception. In general, the difference between minimum, maximum and mean values for Grimm readings were more considerable than monitoring station readings. Comparison of AQMN readings to those from Grimm readings showed that the validity of AQMN readings is not enough valid to be representative of the true PM_{10} concentration. Negative values in difference percentage of mean column indicate that monitoring station reading is greater than Grimm reading and vice versa for positive values.

Table 3 shows comparable PM_{10} concentration values that are measured by both instruments in Traffic park monitoring station at the same time. As it is shown, for about 1 hour (30-90min) AQMN readings were fixed on 62.26μg/m^3 while portable dust monitor (Grimm) readings were different from each other. It should be noted that AQMN readings are about 15μg/m^3 greater than Grimm readings in this station. Comparison of mean values for both instruments at all stations has shown in Figure 1.

A linear regression analysis was done on data obtained by both instruments. Figure 2 indicates the regression analysis using all directly comparable data for PM_{10}. A weak relation (R^2=0.19), with a gradient 0.23 was observed.

Table 2: Comparison of both instrument reading values at Tehran's AQMN

Station No	Station name	Instrument[a]	Min (μg/m^3)	Max (μg/m^3)	Mean (μg/m^3)	Difference Percentage of mean	SD
1	Aghdasieh	A	51.90	79.80	69.33	-43.53	10.48
		B	92.31	100.71	99.51		3.17
2	Traffic park	A	45.20	52.60	48.40	-31.43	2.90
		B	62.26	66.63	63.61		2.10
3	Geophysics	A	55.50	150.20	93.18	29.54	32.08
		B	33.18	78.38	65.66		20.21
4	Fatemi	A	71.00	85.90	77.98	-24.58	5.67
		B	93.08	98.97	97.15		2.67
5	Rose Park	A	39.60	56.10	47.07	-2.07	7.02
		B	48.04	48.04	48.04		0.00
6	Shar Ray	A	65.70	153.30	93.10	38.38	33.96
		B	56.66	58.14	57.37		0.78
7	Golbarg	A	124.40	205.80	161.33	39.27	27.39
		B	97.97	97.97	97.97		0.00

[a] A: Portable dust monitor (Grimm) reading (control); B: Air quality monitoring station reading (case)

Table 3: Comparison of both instrument reading values at Traffic Park

Station No	Control(Grimm) Reading(μg/m^3)	Case Reading (μg/m^3)	T_1(min)	T_2(min)
2	52.6	66.63	0	15
2	51.2	66.00	15	30
2	48.1	62.26	30	45
2	46.9	62.26	45	60
2	45.2	62.26	60	75
2	46.4	62.26	75	90
Mean	48.40	63.61		
SD	2.90	2.10		

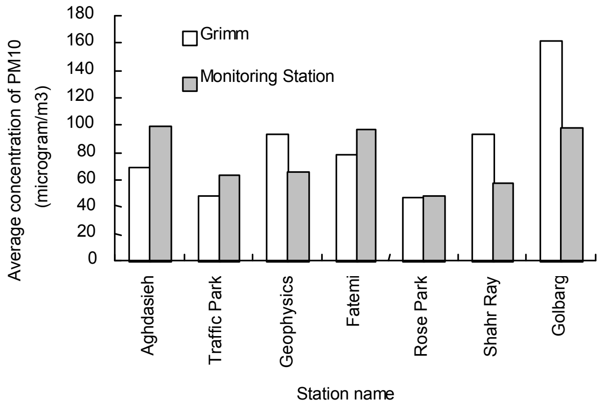

Fig. 1: Average PM_{10} concentration readings of both instruments (control and case) at different monitoring station sites

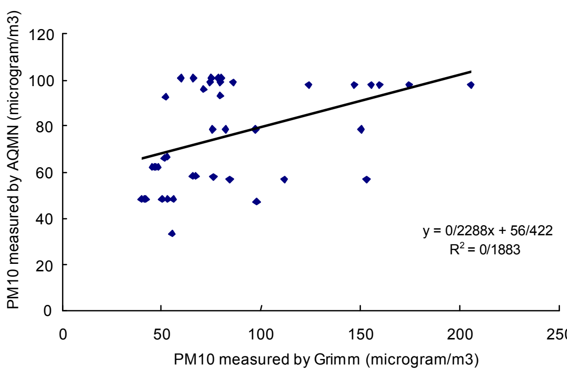

Fig. 2: Plot of Grimm measurement versus AQMN measurement for PM_{10} concentration

This study also clarified those potential deficiencies at active stations and suggested some options for correction. Field observations of Tehran's AQMN showed that majority of stations didn't meet the criteria of distance from trees and roads. A few numbers of them are located in vicinity of large buildings. The main Shortcomings fell into three categories.

- spacing from station to roadways
- spacing from station to trees and tall buildings
- obstruction on roof

All stations examined and those which are not complied with requirements have shown in last column of Table 4. All stations met the criteria of vertical probe placement. It should be noted that vertical probe placement must be 2-7 m above ground for microscale and 2-15 m above ground for other scales [10]. They also met the criteria of paving. Area should be paved or have vegetative cover [10]. Geophysics station is close to a dusty road. Soil, sand and other construction materials on road were moved by trucks while station was working.

For those stations that are near to trees first of all shut down whole instruments inside the station. Cutting trees and/or changing the place of the station are two alternatives. There is no doubt to change the place of stations which are close to roads. Shut down of instruments within these stations is also necessary until modifying or changing the place. It is needed to talk to responsible people or agencies and explain for those activities around geophysics station. Following recommendations are necessary:

- Shut down of all instruments
- Cancellation of all activities surrounding the station
- Change of the road path to prevent no longer impact on station
- Change of dusty area to paved or vegetative areas

Changing or repairing impaired electrical equipments, probe cleaning and checking electrical circuits are necessary before restarting. Furthermore, calibration, quality control flow rate verification and quality assurance flow rate audit should perform for all monitoring stations, periodically.

Quality assurance and quality control are vital parts of maintenance at monitoring station. Quality assurance comprises a wide range of activities such as site selecting, evaluating instrument performance, defining of monitoring station targets, ensuring data quality, designing the system for promotion of management and training operators. Quality control is referring to those activities related to measurement such as data management, checking site operation routinely, establishing a sequence of calibration, traceability, auditing and system

Table 4: PM10 NAMS/SLAMS site evaluation (10)

Criteria	Requirement	Stations which didn't meet criteria
obstruction on roof	≥2m from walls, parapets, penthouses, etc	fatemi
spacing from station to trees	Should be ≥20m from dripline of trees	Golbarg, traffic park and aghdasieh
	Must be ≥10m from dripline if trees are an obstruction	rose park and shahr rey
spacing from station to road	2-10m from roadway for microscale	Geophysics, fatemi, shahr rey

maintaining. Therefore, quality control is relevant to output, whereas quality assurance is concerned with input. The more is tried to correct the measurement process (input), the more is attained reliable results (output).

Based on this study, several objectives are depicted for air monitoring station in quality assurance and control. In general, obtained data should be precise, accurate, comparable, traceable and representative of ambient conditions. Achieving these objectives, it is needed to focus on the point of measurement. Monitoring stations PM_{10} readings are unacceptable because they are different from portable dust monitor readings. Mistakes or problems at the start of the measurement chain cannot be readily corrected afterwards. It should be noted that catastrophic results will occur if these measurements are considered as database by decision makers and planners. A supplementary research for gaseous pollutants can make better judgment in this regard.

Tehran's AQMN tries to add more monitoring station in near future. It is strongly recommended to consider site selecting criteria and positions of the old stations. The number, size and distribution of newly monitoring stations are determined by the requirements of local air pollution control agencies, responsible institutions and organization such as universities and department of environment (DOE). The location of these new sites should represent the right place so that reflect reliable measurements. Considering location of large industries, highways, power plants and incinerators is also essential to locate new monitoring sites. In particular, GIS-based information, dispersion modeling, study of emission densities, professional judgments, transportation patterns and economic activities is highly effective to locate the monitors. In these modern sites quality assurance and quality control activities such as instrument calibration, concentration spacing, precision/linearity checks, zero/span checks and voltage outlier should perform automatically to achieve optimum instrument efficiency. It is clear that relocation of some old monitoring sites can be effective to reach reasonable results.

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