Middle-East Journal of Scientific Research 9 (4): 437-441, 2011
ISSN 1990-9233

Zonal Air Pollution Study in Yazd, Iran

Farhad Nejadkoorki and Shima Ziajahromi

Department of Environmental Engineering, Yazd University, Yazd, Iran

Abstract: Epidemiological studies generally rely on a small number of monitoring sites to represent population exposure. However, recent investigations have indicated that such a limited number of sites might not always give an adequate indication of the spatial variation in pollution levels within urban areas. Consequently, there has been a growing level of interest in methodologies to better assess the exposure levels in fine resolution when experimental measurement data are limited. This paper presented the results from an exercise in which levels of carbon monoxide (CO), carbon dioxide (CO_2), sulphur hexafluoride (SF_6) and toluene were measured and assessed in Yazd, Iran. The pollutants were measured in May 2008 using an INNOVA Multipoint Sampler and Dozer. Results revealed that there was an evenly variation of all pollutants in the studied zone, although the variation of CO and Toluene was higher than of SF_6 and toluene. The observed variability in CO is likely to be related to vehicular traffic emissions. In contrast, observed changes in other pollutant levels were most likely to be influenced by other sources.

Key words: Air pollution · Co · CO_2 · SF_6 · Toluene · Traffic emissions

INTRODUCTION

The relationship between ambient air pollution and adverse health effects including mortality has been well documented in the scientific literature, mostly via epidemiological studies [1-5]. Additionally, there has been a growing concern over the impact of urban pollution on climate change [6]. This underlines the need for pollution levels to be accurately determined and with a high level of resolution. The most common approach to pollution studies is to determine concentration levels within an area and then determine exposure in the surrounding community. This necessarily assumes that air pollution is evenly distributed within large urban areas and that the pollution levels at individual sites are well correlated [7]. However, recent studies [8]) suggested that there are greater variations than previously thought. Thus far, there has been little attention paid high resolution studies in developing countries, perhaps due to the priority and policy of local governments being directed towards more generic studies, as well as lack of relevant experimental data.

In developed countries, the majority of recent air pollution studies have focused on particulate materials (e.g. PM_{10}, $PM_{2.5}$). In general however, traditional air pollutants, such as CO and SO_2, have received more attention in developing countries. Growing interest in climate change has meant that CO_2 emission studies have become increasingly important and these have been undertaken in developing and developed countries alike. Moreover, attention has been focusing on other greenhouse gases, which although less abundant, might be highly efficient at absorbing re-radiated radiation. In this respect, the Intergovernmental Panel on Climate Change identified, SF6 as the most potent greenhouse gas that it has evaluated.

This paper assessed the levels of CO, CO_2 and SF_6, in Yazd, Iran. In addition, toluene was of concern in the city due to traffic emissions and industrial activities (including transportation and storage accidents) and this had been addressed accordingly.

MATERIALS AND METHODS

Study Area: Yazd is a desert city in central Iran with a population of 430,000. Currently, the city is expanding towards the North West (NW) and South East (SE) and there has been an increase in both the level of industrial activity in the surrounding area and in the local road traffic. The experimental area covered 6.9 km^2 (out of total city's area of 97 km^2) and is located in the Safaieh district of the SE part of Yazd (Figure 1). This part of the city is densely populated, with more road traffic and pollution levels than elsewhere, although it is relatively affluent and enjoys a pleasant climate.

Corresponding Author: Farhad Nejadkoorki, Department of Environmental Engineering, Yazd University, Yazd, Iran.

Fig. 1: Studied zone in the city

Sampling: Ten monitoring sites were carefully selected to sample the air pollutants (CO, CO_2, SF_6 and toluene). The site selection was based on a number of objective criteria to identify any spatial variability of these air pollutants. A key factor in site selection was to obtain measurements that would also be representative of areas with different population densities, land-use types and traffic densities. The sites were, placed to provide information on the entire study area and were remote from any significant local sources (e.g. school parking lots). In addition, they were far enough apart to reduce the impact of spatial autocorrelation. All location coordinates were measured with a global positioning system (Garmin eTrex Vista). The sampling campaign was carried out in the evening rush hour (1800-2000) between 6th and 25th May in 2008.

The 1303 INNOVA Multipoint Sampler and Dozer (IMSD) were used to measure the levels of CO, CO_2, SF_6 and toluene. The system has 6 inlet channels, each controlled a solenoid valve. Each sampling point was connected to the analyzing system via a tube up to 50 m in length. These connected to a manifold and a three-way valve was used to allow sequential analysis of each pollutant by the IMSD. An air-filter was included in each sampling line in order prevent particle entry into the IMSD.

The purpose of the Dozer system was to provide a dosing rate of tracer gas to ensure that the measurement system remained in calibration. The Dozer has 6 outlet channels, each with a solenoid valve and a nozzle, which reduces the internal diameter of the channel and ensures that the rate of flow of tracer gas to the dosing points is dependent only on the tracer gas supply pressure and temperature. A pressure and a temperature transducer gives information on the tracer gas supply and a filter ensures that the dosing channels are kept clean. The dosing system can deliver a continuous dose, or a discontinuous one. The Dozer system is set up for use by specifying a dosing time-out such that the 1303 will stop any current dosing procedure after a given time has elapsed without instruction from the controlling computer. This value was specified from the controlling computer. In the current study, the dozer was set to measure the pollutants at 10 minutes intervals.

In addition to the air pollutant levels, traffic volumes were recorded also at the sampling points simultaneously. The traffic fleet was regarded to consist of cars, trucks, buses, minibuses, motorbikes and bicycles and flows for each vehicle type were determined for the rush hour period (1800-2000).

Geographical Information System (GIS) Support: GIS has been utilized in air pollution studies to generate and model data and to illustrate the results. In our case, ArcGIS was implemented to develop the database, to analyze the data and to map the spatial variation of pollutant levels in the study area. The database consisting of a road map, sampling coordinates, traffic volumes and city and zone boundaries was then linked to the measurement data to give the spatial variation in pollution across the study area.

RESULTS AND DISCUSSION

The measured pollutant levels and vehicle flow rates for the sampling sites are given in Table 1. All pollutants showed a spatial variation in levels across the study area. CO_2 had a minimum and maximum concentration of 569 and 798 ppm. The corresponding figures for CO, SF_6 and toluene were 1.0 and 5.3 ppm; 0.04 and 0.06 ppm; and 4.8 and 38.1 ppm, respectively. The spatial variability of the four pollutants is shown in Figure 2. Overall, there was a significant variability in pollutant levels across the city. The highest concentrations of CO, CO_2 and toluene were in the Eastern part of the zone, while for SF6, the highest concentrations were in the NW and SE parts of the zone.

In order to examine relationship between the pollutant levels and traffic volumes for different vehicle types, a linear regression test was used. While implementing the regression test, multicollinearity (i.e. a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated) was considered. The most significant regressions are given in Table 2. Of the four pollutants, only CO appeared to be closely related to traffic sector. This suggested that the other pollutants have alternative sources and with the possible exception of CO_2, this is not entirely unexpected.

Table 1: Pollutant measurements and road traffic counts

			Air Concentration (ppm)					Traffic Flow (vehicles/ evening peak hours)					
Id	Station Name	Sampling date	CO	CO_2	SF_6	Toluene	Altitude (m)	Car	Motor-bike	Cycle	Bus	Minibus	Trucks
1	Timsarfalahi Street	06/5/08	5.3	798	0.05	9.1	1268	5401	1097	18	90	25	285
2	Daneshgah Boulevard	11/5/08	1.3	739	0.04	4.8	1298	5022	1090	24	39	42	273
3	Shahidghandi Boulevard	12/5/08	2.3	758	0.04	6.0	1277	3452	727	38	21	26	156
4	Shahidanashraf Street.	13/5/08	3.2	732	0.06	5.0	1269	2658	660	38	8	12	140
5	Edalat Street.	17/5/08	2.1	750	0.04	9.2	1284	1112	847	25	14	2	45
6	Molasadra Street	18/5/08	1.7	569	0.05	10.3	1219	1639	287	25	18	3	70
7	Khatemi Street	20/5/08	3.8	760	0.04	6.7	1254	1012	577	34	38	7	53
8	Montezarfaraj Street	21/5/08	1.0	771	0.04	8.2	1250	941	238	14	0	0	53
9	Pasdaran Street	24/5/08	1.5	750	0.06	6.9	1220	1860	1096	49	18	22	198
10	Jehad Boulevard	25/5/08	4.3	756	0.05	38.1	1283	1072	773	15	7	2	143

Table 2: Statistical relationships between pollutants and road traffic

Pollutant	n	R^2	Constant	Vehicle (regression coefficient)	*p*
CO	10	0.575	1.846	Bus (0.032)	0.082
CO_2	10	0.483	667.005	Motors (0.096)	0.157
SF_6	10	0.333	0.043	Trucks (0.00003)	0.347
Toluene	10	0.404	14.440	Minibuses (-0.285)	0.247

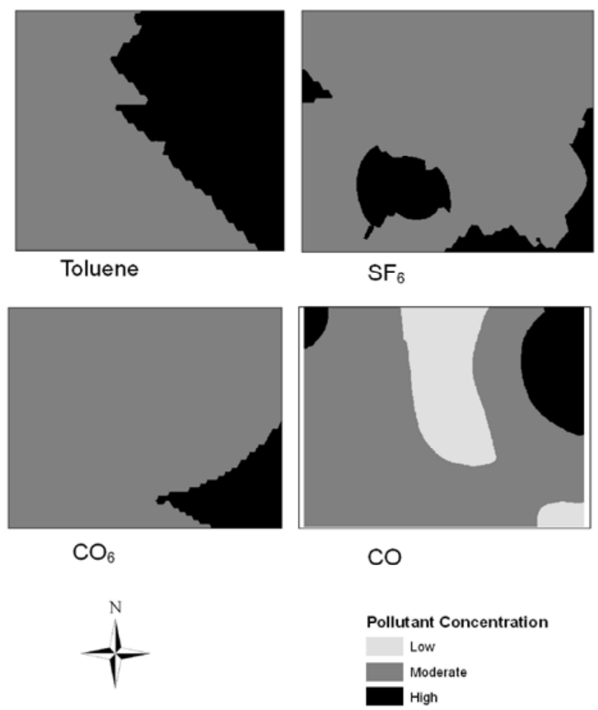

Fig. 2: Spatial distribution of pollutants

In conclusion, this study identified the large spatial variability of pollutant levels that can exist on an urban scale in Iran. As such, there is a continuing need for research into the factors that control pollution on a local scale. It is found that CO was the only pollutant identified that was correlated significantly to road traffic sources and there were no such relationships identified for CO_2, SF_6 or toluene. However, all pollutants showed quite large spatial variations within an area of 6.9 km^2 suggesting that there are likely to be physical factors affecting dispersion and/ or numerous sources of the pollutants.

Statistical and spatial modeling support local authorities to find impact of physical geography and effects of individual sources on air pollution variability at a fine resolution scale in cities. Modeling also provides decision makers and environmental researchers by examining different mitigation plans for the future air quality ambitions.

While the spatial variation in pollution levels for Yazd has been noted, the city is relatively flat. In the case of cities that are more undulating or have topographic boundaries (e.g. Tehran or Shiraz), it might be expected that this variation could be much more marked.

ACKNOWLEDGMENTS

This work was supported by the Environmental laboratory of Department of Environmental Engineering at Yazd University. The author cordially appreciates the extensive and constructive comments made by Dr. Ken Nicholson at Nicholson Environmental, UK.

REFERENCES

1. Leitte, A.M., C. Petrescu, U. Franck, M. Richter, O. Suciu, R. Ionovici, O. Herbarth and U. Schlink, 2009. Respiratory health, effects of ambient air pollution and its modification by air humidity in Drobeta-Turnu Severin, Romania. Science of the Total Environment, 407(13): 4004-4011.
2. Currie, J., M. Neidell and J.F. Schmieder, 2009. Air pollution and infant health: Lessons from New Jersey. Journal of Health Economics, 28(3): 688-703.
3. Dockery, D.W., 2009. Health Effects of Particulate Air Pollution. 2009. Annals of Epidemiol., 19(4): 257-263.
4. Saint-Georges, F., G. Garçon, F. Escande, I. Abbas, A. Verdin, P. Gosset, P. Mulliez and P. Shirali, 2009. Role of air pollution Particulate Matter ($PM_{2.5}$) in the occurrence of loss of heterozygosity in multiple critical regions of 3p chromosome in human epithelial lung cells (L132). Toxicology Letters, 187(3): 172-179.
5. Vedal, S., M.P. Hannigan, S.J. Dutton, S.L. Miller, J.B. Milford, N. Rabinovitch, S.Y. Kim and L. Sheppard, 2009. The Denver Aerosol Sources and Health (DASH) study: Overview and early findings. Atmospheric Environment, 43(9): 1666-1673.

6. Nejadkoorki, F., K. Nicholson, I. Lake and T. Davies, 2008. An approach for modeling CO_2 emissions from road traffic in urban areas. Science of the Total Environment, 406(1-2): 269-278.
7. Wilson, J.G., S. Kingham, J. Pearce and A.P. Sturman, 2005. A review of intraurban variations in particulate air pollution: Implications for epidemiological research. Atmospheric Environment, 39(34): 6444-6462.
8. Wheeler, A.J., M. Smith-Doiron, X. Xu, N.L. Gilbert and J.R. Brook, 2008. Intra-urban variability of air pollution in Windsor, Ontario--Measurement and modeling for human exposure assessment. Environ. Res., 106(1): 7-16.