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Determination of Air Pollution Monitoring Stations

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ABSTRACT: Swelling urban populations and increasing number of industry and especially automobiles in and around cities have resulted in adverse effect on human health. One of the most important things regarding air pollution in these days is that the number of motor vehicles has increased, and the resulting problems of new types of air pollution on large scale need to be emphasized in large cities.The groundwork for this study is based on collected data, specific studies regarding to use passive tube sampling techniques and geo-statistic mapping tools. The low cost and easy operation of the diffusive sampling technique makes it an ideal tool for large scale air pollution surveys with a high spatial resolution. Finally, we used Kriging method to draw air pollutions maps related to NO_2 and SO_2 measurements in Shiraz city. These maps conducted us to find number of air pollution monitoring stations. Results show that we need 2 traffic, 3 urban, 1 suburban and 1 industrial station in Shiraz area.In fact, the proposed method in this study provides a useful tool that can be easily applied to other polluted cities. Meanwhile, it would become effective as well as the actual time required to implement them.

Key words: Passive samplers, Air quality monitoring, Polluted cities. Air pollution, kriging method

INTRODUCTION

Air pollution is one of the most serious issues in urban areas, due to its adverse effect on human health. In developing countries, an estimated 0.5-1.0 million people die prematurely each year as a result of exposure to urban air pollution (Kojima *et al.,* 2001).Air quality objectives and standards established for the protection of human health and environment which are being exceeded over mega- cities (Lin *et al.,* 2001). Limits and the requirements for improved critical levels for air pollutants in the European Union highlight the need for both extensive and intensive monitoring programs to determine long-term critical exposure levels for damages (Mills *et al.,* 2001) and use of new methods for air quality extensive monitoring have been developed in recent years (Harner *et al.,* 2003). The need for extensive monitoring has driven the development of passive sampling systems, which can be used in cities and remote areas as well as need no power supply. More recently, the need to verify atmospheric transport and deposition models (Simpson *et al.,* 2001) has created a demand for more intensive monitoring. The attractive alternatives are being low cost and flexibility of placement for passive sampling systems and assessing exposures at locations. Passive samplers may also be used to identify areas receiving air pollution events, that were previously unknown, and where additional infrastructure for instrumental monitoring may be required (ETI 2004).

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Passive samplers provide a way to simultaneously sample for exposure to multiple pollutants. Extensive monitoring and characterization of gaseous air-pollutant exposure of people health in populated cities will be achieved by the use of relatively inexpensive passive samplers. These should be deployed at the sampling sites, with some co-located with available continuous monitors for cross-correlation and calibration purposes (Krupa *et al.,* 2000). Deploying a large number of passive samplers can also provide data on small-scale variations in pollutant exposures. (Kickert and Krupa, 1991). This technology has progressed as one of monitoring approaches in Shiraz city. Shiraz a large and polluted city of some 1.2 million dwellers which suffers from air pollution in Iran. Its development occurred in recent years and the population has been multiplied by 3 since 1988(DOE 1996). Some industries are still located in the city or its immediate vicinity. The prevailing winds are oriented from west to east, with many days of very stable air conditions. In winter the number of days with temperature inversions is growing, as the number of rainy days is decreasing. This situation is not favorable to the quality of the atmosphere, and a growing pollution is noted. Our purpose was to have an assessment of overall pollution level in the city of Shiraz preliminary to the localization of automatic monitoring stations. The low cost and easy operation of the diffusive sampling technique makes it an ideal tool for large scale air pollution surveys with a high spatial resolution, cost- efficiency and the large area covered by passive tubes campaign made us choose this technology.We made a SO_2 and NO_2 campaign. Besides we applied also BTX tubes for a first approach of the concentration of these pollutants. The main sources of BTX in air include refueling of motor vehicles, combustion of gasoline, petrochemical industries, and various combustion processes (WHO 2000). Human exposure to BTX can have severe health effects, such as cancer and neurological diseases (Ezquerro *et al.,* 2004).

MATERIALS & METHODS

In this research we used diffusive sampler to determine of air pollution situation in Shiraz city. A diffusive sampler is a device capable of taking gas samples from the atmosphere at a rate controlled by molecular diffusion, and which does not require the active movement of air through the sampler. The diffusive sampler consists of a tube, one end containing a sorbent which fixes the pollutant. After exposure of the samplers over periods varying from a few days to a few weeks, the tubes are sealed with caps and returned to a laboratory for analysis. According to the type of device and the absorbed pollutant, analysis can be performed using different techniques, such as colorimetric, ion chromatography. Maps of the pollutant concentrations over the area can be obtained by interpolation of the diffusive sampler measurements (ETI 2002). The technique is particularly suited to determine the pollutant distribution over a large area, and to assess integrated concentration levels over long periods of time (up to two weeks). Short-term limit values can be derived from statistical data, by comparison with extended and time resolved measurement series from similar measurement locations. The proposed methodology can be used to determine areas of maximum concentration and combined with the use of a mobile laboratory. In addition it may support the optimization of monitoring network (ETI 2002).

It should be noted that the principle of molecular diffusion does not adapt to particulate matter, and that the diffuse sampling technique is therefore not applicable for PM10 or heavy metals. In urban areas, the spatial variation for primary pollutants such as NO, CO, Pb, PAH’s and benzene is mainly determined by their emissions from automotive traffic. As a result of this, one single pollutant representative of the emissions from automotive traffic may be used as indicator for the other pollutants, when determining areas of maximum concentrations. This “indicator approach” is however valid only if large industrial sources with low level emission heights are not present in the area, particularly for Pb, PAH or benzene. In this research for which an intensive measurement campaign was undertaken, it was proposed to install a number of 150 to 200 samplers. The study area is included in a rectangle of 70 by 35 km that are 2450 km^2. As the width is not constant, we consider a total surface of more than 1500 km^2 that was subsequently divided into three portions:

•20 km^2, city center

•450 km^2, rest of Shiraz

•1000 km^2, suburbs

The gridding cells will be as large as 750 m in city center, 2 km in the rest of Shiraz and 5 km in the suburbs (Table 1).

Table 1. Specification of Sampling Tubes

Location	Surface (km^2)	Cells dimension (km)	Number of tubes
City center	20	0,750 by 0,750	35
Rest of Shiraz	450	2 by 2	110
Suburbs	1000	5 by 5	40

We proposed the use of two types of tubes that are the most widespread: Radiello tubes that use an original geometry and Palmes tubes (the inventor of passive sampling tubes applied to air quality), distributed by Passam (passam 2004). We finally used only Passam tubes. Passam tubes have the following detection limits:

• 0.6 $\mu g/m^3$ for NO_2 in 14 days, or 1.2 $\mu g/m^3$ in 7 days.

• 0.4 $\mu g/m^3$ for SO_2 in 14 days, or 0.8 $\mu g/m^3$ in 7 days.

• 0.4 $\mu g/m^3$ for Benzene in 14 days, or 0.8 $\mu g/m^3$ in 7 days.

The tubes must be stocked in a cool place (fridge) and protected from the sun before analysis. The periods for installing and collecting the tubes should not be longer than 4 hours: as a consequence, many persons and vehicles are requested at the same time for these operations. For Passam ones, the tubes must be opened at installing and closed at recollecting.To reduce measuring uncertainties, 2 to 3 tubes may be installed at the same location for the same pollutant (Passam 2004). SO_2/NO_2 sites were chosen in every cell of the grid and sites were cancelled in remote cells of homogeneous zones to allow additive sampling in peak zones. Benzene tubes were applied in gas/refueling stations, explaining high levels of BTX.Only a few NO_2 tubes were analyzed locally in Shiraz University and DOE, almost all the tubes were sent back to Passam for analysis in Switzerland.Finally we used Kriging Method to draw air pollutions maps related to NO_2 and SO_2 measurements in Shiraz city.

RESULTS & DISCUSSION

During this study some data were wrong and unavailable to enter into the results. As a summary, here are statistics on the reasons why some data is not available. In Table 2, Wrong label means that the labels did not allow localizing the data on the grid. One of the major outcomes of this study was the settlement of a local air quality monitoring center in Shiraz city with some stations, a data management system that gives real time information to the Center. For industrial stations, decision should be taken according to each specific case. The passive tubes study has given an assessment of pollution over Shiraz agglomeration for $NO_2$and SO_2, Figs. 1 and 2 has shown the results of study.

During this study, we compared these maps with elements concerning emission, population density and ground occupation. As for meteorology the only information we got is that prevailing winds are west-east oriented. Now considering the two already existing automatic stations, a network for Shiraz should comprise as follow:

• 2 traffic stations: NOx, CO and PM_{10}.

The 2 traffic stations in the city center are close to the most important traffic lanes. The sampling sites represent almost the highest pollutions level exposure of a pedestrian. Traffic monitoring stations should be located some 5m away from the lane with a height of sampling between 2 and 3m.

• 3 urban stations: SO_2, O_3, NOx, PM_{10}, BTX, CO and weather parameters.

Table 2. Statistics of Tubes

Pollutant	Tubes	Analyzed locally	Lost tube	sent to Passam	No label	Wrong label	No data	Total tubes used for study	% tubes used for study
NO_2	188	10	11	165	4	11	0	150	79.79
SO_2	188	0	11	167	23	3	6	135	71.81
BTX	34	0	4	26	0	6	0	20	58.82

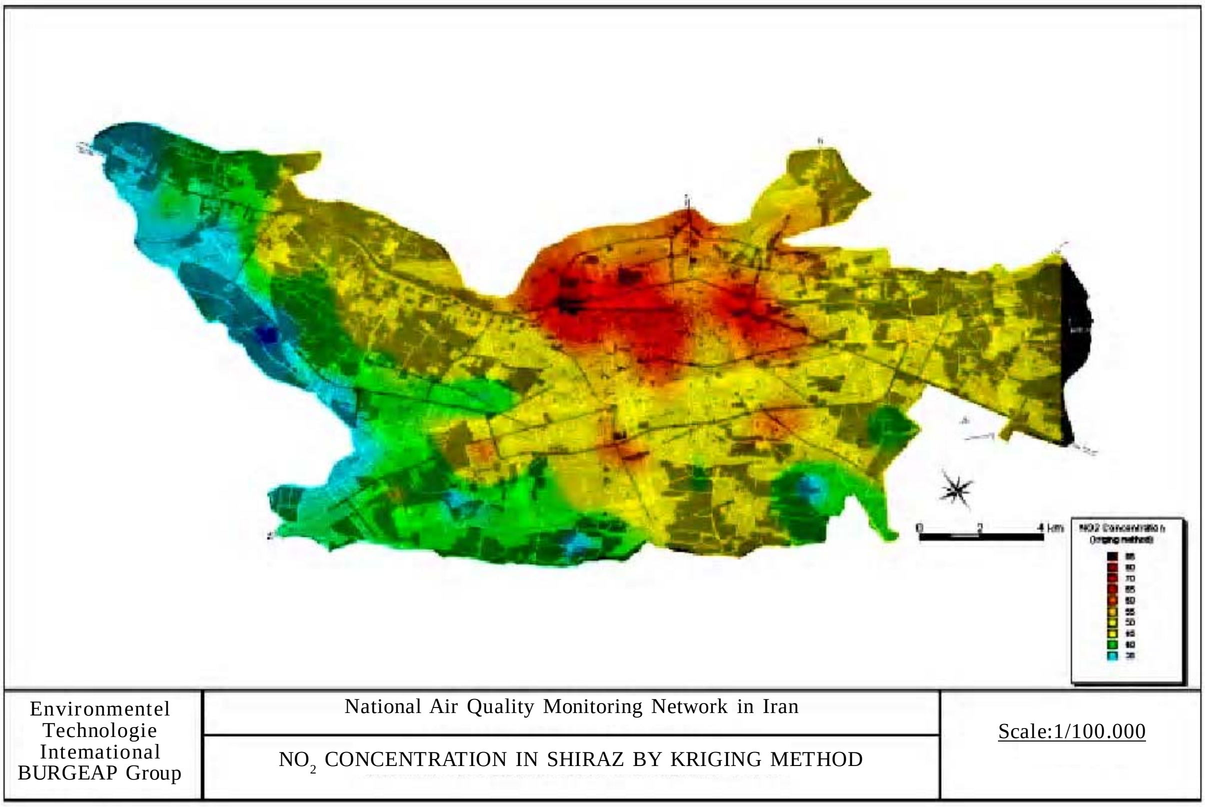

Fig. 1. NO_2 concentration in Shiraz area

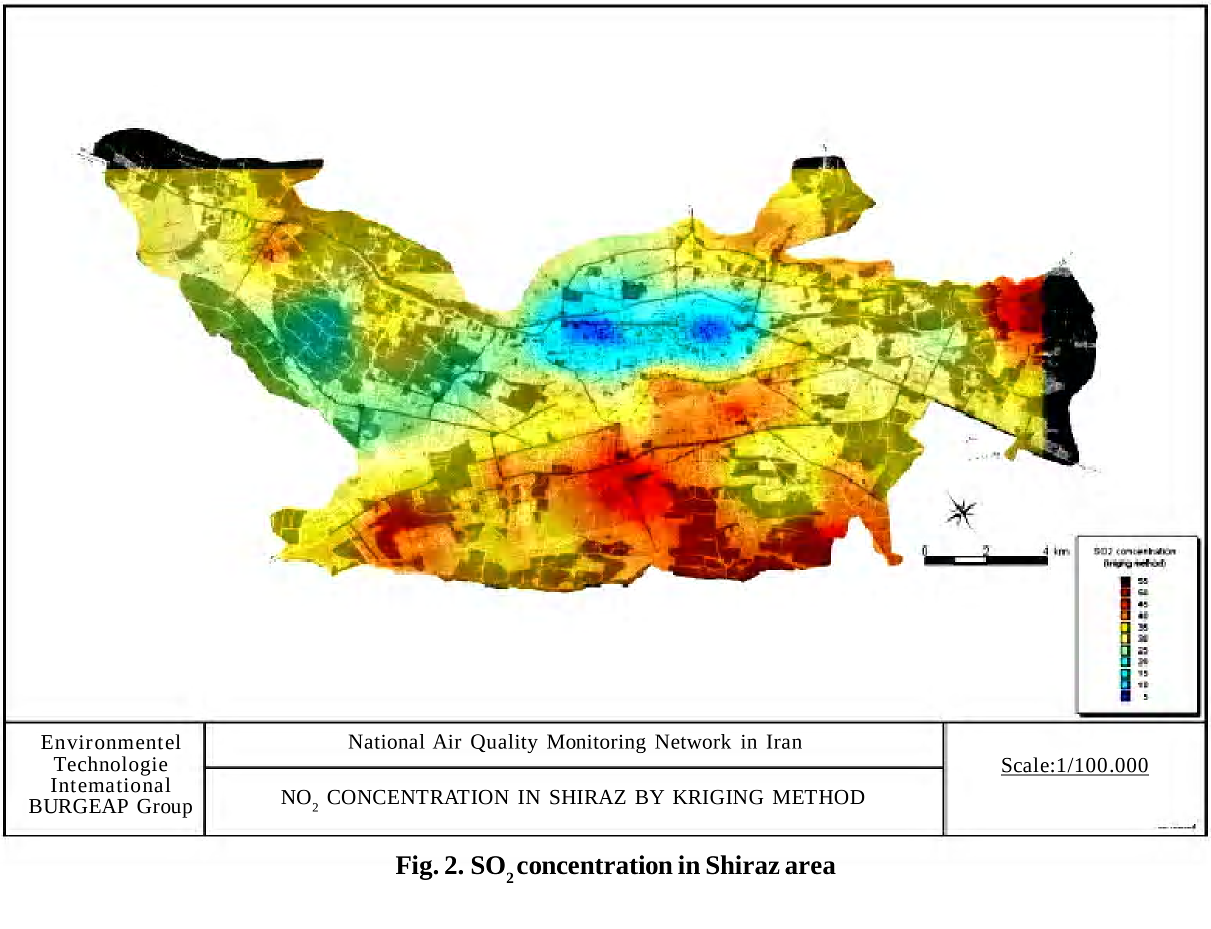

Fig. 2. SO_2 concentration in Shiraz area

- 1 industrial station: SO_2, NOx, PM_{10}, THC.

The industrial monitoring station should measure downwind frequent plume of industries. The cement plant and the petrochemical plant will receive particular attention. A mobile station would help to check that SO2 have an industrial origin by knowing NO levels.

- 1 pre-urban station: O_3, NOx and weather parameters.

The 2 traffic stations already exist. They have O3 analyzers that should be transferred to urban or pre-urban stations.The pollution levels should be representative of city center levels for urban ones and of suburban zones for suburban stations. Three urban stations and 1 suburban one seem to be relevant to allow a good monitoring of Shiraz.

CONCLUSION

On the basis of international criteria and affected population, Shiraz should have 9 monitoring stations (Table 3).Regarding executive results of our research, it has reduced to 7 stations and assists to economize the costs of air quality monitoring equipments.For every type of station, a study by mobile station would help to check the global representativeness of the station. It should also be noted that the installation of weather parameters measurements in some urban, are important and should be studied. The following map (Fig. 3) presents the zones where final locations for urban stations should be looked for. Industrial station should be in main industrial zone close to the city and pre-urban station should be some 5 to 8 km downwind (that means east) of Shiraz city center in populated zone.

Table 3. Number of automatic stations by type for an accomplished network

Inhabitants	Traffic	Industrial	Urban	Pre-urban	Rural	Total
400.000 to 1.000.000	1	To be determined	2	1	1	> 4
1.000.000 to 2.000.000	2	To be determined	3	2	2	> 9
2.000.000 to 5.000.000	3	To be determined	5	3	2	> 13
> 5.000.000	> 4	To be determined	> 7	> 3	> 3	> 16

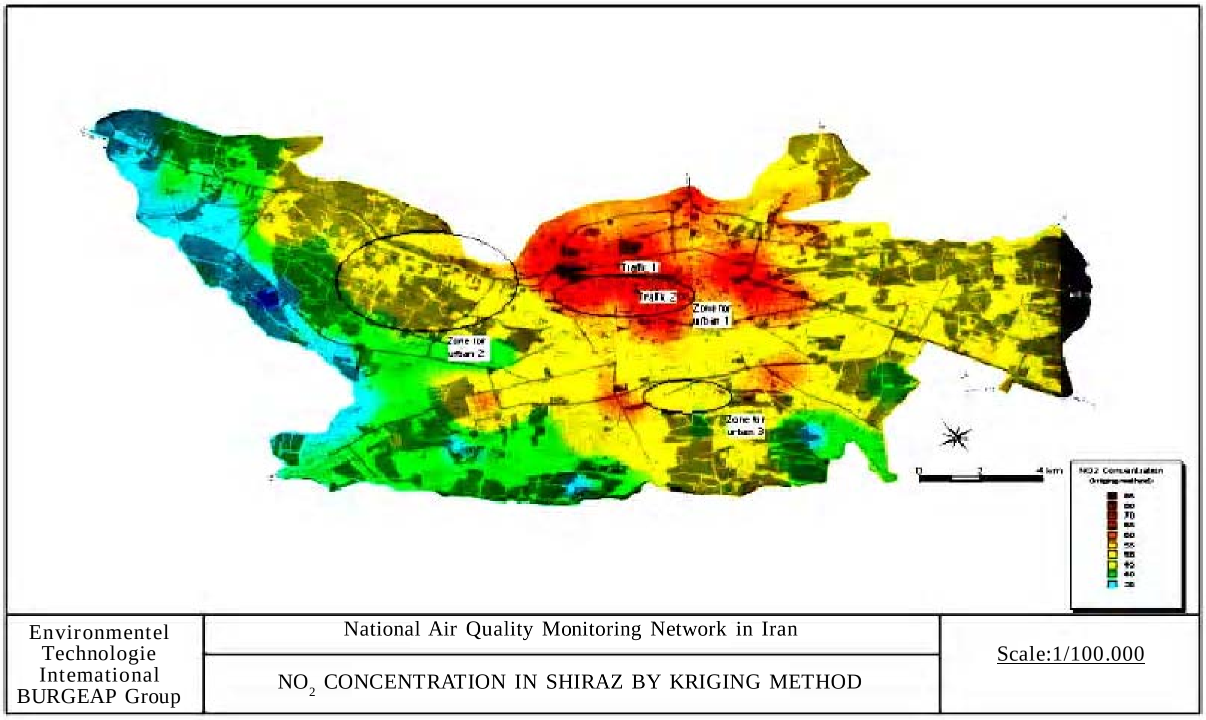

Fig. 3. Location of automatic stations under relevant correlation with population and ground occupation

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