PERSONAL MONITORING OF AIR POLLUTION : HOW, WHAT AND WHY?

Petro Terblanche, D.Sc
Research Institute for Environmental Diseases
Medical Research Council, Private Bag X385, Pretoria 0001

ABSTRACT:
Personal monitoring of air pollutants can provide important information regarding actual exposure to specific pollutants. The effects of air pollution on human health is dose-related. Without accurate exposure information it is difficult to evaluate the health effects caused by air pollution in a specific environment.

OPSOMMING:
Persoonlike metings van lugbesoedeling kan waardevolle inligting verskaf oor werklike blootstelling aan bepaalde besoedelstowwe. Die effek van lugbesoedeling op die mens is direk verwant aan die vlak van blootstelling. Sonder akkurate blootstellingsinligting is dit moeilik om die effekte van lugbesoedeling in 'n bepaalde omgewing te evalueer.

1. INTRODUCTION

The realization that fixed air pollution monitoring stations do not always reflect the levels of air pollution that people actually come in contact with in their daily lives, stimulated interest in measuring personal exposures to air pollution. Personal monitors are small light-weight instruments that can be carried conveniently by people as they conduct their normal daily activities.

Results of personal monitoring studies have provided invaluable information on human exposures to air pollution. Personal monitoring has become an important tool in evaluating the health effects of air pollution and for calculating risk in different environments. Personal monitoring has been used widely in occupational environments throughout the world for many years before the principle was applied to the non-occupational environment. Personal monitoring, mainly of respirable particulate matter, is being done extensively in South Africa in the mining industry, but has not been done on the general public in South Africa to date. The Vaal Triangle Air Pollution Health Study launched by the Medical Research Council has incorporated several studies on personal monitoring in its design. The results of the first study will be published soon.

The objective of this paper is to give a brief overview on the how, what and why of personal monitoring for air pollution exposure.

2. OBJECTIVES OF PERSONAL MONITORING

The importance of population exposure measurements in air pollution epidemiological studies makes it imperative that future studies include exposure estimates more representative of what people actually breathe.[1] This was already realized in the USA in 1977 at which time a call for a national effort to develop instrumentation and techniques for personal monitoring of air pollution was made.

Individuals are exposed to concentrations encountered in a variety of locations and activities. It is therefore important to determine, not only outdoor air pollution levels to predict exposure, but also to quantify the contribution of other locations (indoors, transportation) to total exposures.[2,3]

The objective of personal monitoring is to give an accurate value for total exposure to specific air pollutants for correlation with observed health effects or for risk calculation. Information on time/activity patterns of an individual carrying a monitor is of prime importance to calculate the time a person spends in different micro-environments. The relative contribution of different environments to total exposure is important information as control of air pollution is the ultimate reason for monitoring it. In evaluating the health effects of industrial air pollution the contribution of indoor and domestic air pollution must be accounted for to ensure that appropriate control standards are layed down.

3. PERSONAL MONITORING TECHNIQUES

Human exposures can be studied with direct measurements (personal monitoring) or with estimates of exposures from data obtained by fixed monitoring sites.[4] In both approaches knowledge of time/activity patterns are important.

Direct personal monitoring has become possible with the development of sampling "badges", and lightweight portable sampling systems.[4,5]

3.1 Types of personal monitors

Personal monitors can be classified into two general categories: active devices which employ a power source with a pump to pull the air across a sensor or collector and passive devices, which rely on diffusion to bring the pollutant into contact with the sensor or collector.[5]

The active samplers have the disadvantage that they usually require considerable maintenance (frequent charging of batteries, calibration and adjustment and servicing) when deployed in routine use.[4] Passive samplers have the advantages of their active counterparts, but in addition are smaller, demand little (often no) power, require less maintenance and more often less expensive. Some problems may remain, however, with boundary layer or depletion effects in stagnant air conditions. That is, the

target pollutant may be depleted and not replaced fast enough in the air immediately surrounding the badge, leading to low estimates of the concentration. These effects are often apparent at air velocities below 15 linear feet per minute measured at the face of the sampler.[5] Another disadvantage of passive samplers is the fact that the sampler has to be carried by the participant for long periods (up to one week) to get adequate concentrations for analysis. In the case of active samplers the monitoring period varies between 8 and 24 hours.

Samplers can be designed to measure pollutants on the spot (analytical or continuous devices) or collect the pollutant for later analysis in the laboratory (collection or integrated devices).[5]

3.2 Personal monitors available for specific pollutants

Personal monitors (active and/or passive) are available for the following pollutants[5]: carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM), volatile organic compounds (VOCs), nicotine, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenols (PCBs) and pesticides, ozone (O_3), sulphur dioxide (SO_2) and radon.

A summary of some of the types of personal monitors available are given in Table 1.

TABLE 1
Some personal monitors available for specific pollutants

Pollutant	Type of Monitor	Analytical methods
CO	Active/Passive	H_2SO_4 electrolyte, electrochemical.
NO_2	Passive (Palmes tubes)	Colorimetric, spectro-photometer.
Particulates	Active	Gravimetric, chemical, PIXE.
SO_2	Active	Gas chromatography, calorimetric.
O_3	Passive	Ion chromatography.
VOCs (40 different substances)	Active/Passive	Thermal/desorption/ GC/MS.
Radon	Passive	Etching, microscopic examination.
Formaldehyde	Active/Passive	GC/Chromotropic, acid.
PAHs	Passive	Room-temperature phosphorescence.

The personal monitors available on the market have provided an array of new possibilities to monitor air pollution. Continuous sampling records of personal exposure, along with time/activity data, provide the most detailed sampling information enabling researchers to determine the relative contributions of various sources to peak as well as to integrated (time-averaged) pollutant concentrations.[4] It is also possible in the case of particulate sampling to determine the chemical and elemental compositions of integrated particle samples to identify various source contributions.

4. RESEARCH RESULTS OF PERSONAL MONITORING

Results from personal sampling studies have provided information on relationships between concentrations in the ambient air and levels to which individuals are exposed.[1-5]

Several important studies reported over the past 15 years have demonstrated that personal exposures to many pollutants show little or no relationship to outdoor measurements and that personal exposures are often higher than, though poorly correlated with outdoor measurements.[4] Some of the results of personal monitoring studies are summarized here.

- Measurements of personal exposures to respirable suspended particulates (RSP) have been found to strongly correlate with indoor RSP levels and only weakly with ambient levels.[2]

- Cigarette smoking was found to be an important source of exposure to RSP and it was found that passive smoking exposure increases the mean 12 hour exposure to RSP by 20 $\mu g/m^3$.

- Studies on exposure to SO_2 have shown that personal exposure is determined more by outdoor than indoor concentrations.[4]

- CO personal exposure studies in Los Angelos have shown that high exposures occur during commuting periods and are associated with traffic.[4]

- Ambient NO_2 levels have been shown to represent indoor levels and actual personal exposures only where there are no significant indoor sources.[4]

- Exposures to O_3 occur predominantly outdoors. A study in Houston found indoor concentrations of O_3 to be negligible.[4]

CONCLUSIONS

It is evident from the literature that advances in personal monitoring have provided an array of new instruments capable of measuring human exposure to selected pollutants at levels normally found in the atmosphere. The availability of these new instruments offers a great opportunity to researchers and control agencies engaged in air pollution research studies. These new personal monitors can be used to measure human exposures to air pollution directly, rather than relying on approximate estimates of exposures derived from fixed stations or mathematical models. Personal monitoring of air pollution exposure has many applications in air pollution research, for example, it can be used to assess the representativeness of sites selected for fixed air monitoring stations in terms of actual distribution of exposures of the surrounding population. Personal monitors can also provide measurements of true individual exposure for epidemiological studies, thus freeing the epidemiologist from traditional reliance on comparisons of general geographical areas of supposed "high" and "low" exposures.[5]

Personal monitoring of air pollution exposure in the general public is currently being initiated in South Africa and will also contribute substantially to air pollution research in this country.

REFERENCES

1. Morgan M G and Morris S C. Needed: A National R & D Effort to Develop Individual Air Pollution Monitor Instrumentation. JAPCA, 27; 670 (1977).

2. Dockey W D and Spengler J D. Personal Exposure to Respirable Particulates and Sulfates. JAPCA, 31; 153 (1981).

3. Spengler J D, Treitman R D, Tosteson T D, Mage D T and Soczek M L. Personal Exposures to Respirable Particulates and Implications for Air Pollution Epidemiology. Environ Sci Technol, 19; 700 (1985).

4. Spengler J D and Soczek M L. Evidence for Improved Ambient Air Quality and the Need for Personal Exposure Research. Environ Sci Technol, 118; 268 (1984).

5. Wallace L A and Ott W R. Personal Monitors: A State-of-the-Art Survey. JAPCA, 32; 601 (1982).