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A PILOT STUDY TO OBTAIN 24-HOUR AIR POLLUTION EXPOSURE PROFILES

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Abstract

A pilot study was conducted using workers from a semiconductor plant. This paper describes the methods used to acquire and evaluate air pollution exposure data for significant environments (including workplace, in-transit, and residence) to which workers are exposed throughout a typical 24-hour day. Summer and Winter measurements were made on products of combustion, radon, respirable particulates, and a variety of organic compounds.

Introduction

Over the past decade, considerable efforts have been directed at (1) controlling emissions of air pollutants from stationary and mobile sources, and (2) reducing exposure to pollutants in the workplace. However, little consideration has been given to pollutants generated in the indoor environment. Epidemiological studies of air pollution effects assume that both the indoor and outdoor exposures are identical or at least comparable to environmental levels estimated from outdoor sampling sites. The human population certainly has access to the ambient atmosphere; however, most of our time is spent inside buildings in which air quality can be markedly different from that of the outdoors. Most people are indoors at least 80 percent of the time and those most susceptible to the health effects of pollution (the old, the infirm, and the very young) spend essentially full time indoors.

NIOSH and EPA guidelines set acceptable dose levels that will not produce adverse effects in different environments. However, workers exposed to a given hazardous agent in the home as well as the workplace would continue to increase their total daily dosage. In addition, an exposure to a given agent in one environment may have an additive or synergistic effect with a different agent encountered in another environment. That is, the effect from a given dosage of an agent may vary upon exposure to other agents with similar effects. Consequently, the dose of a hazardous agent received from one environment may not adequately characterize an individual's total exposure. Moreover, levels considered safe for exposure in one environment may not protect an individual when his exposure is increased via another environment. Generally, the extent and magnitude of the nonoccupational exposure contributing to the worker's total dosage of the agent has not been adequately investigated. In addition, the contribution

to the total daily dosage may vary depending on the industry, the agent, and the nonoccupational environment. Agents present in the occupational environment may be specific only to that environment and not occur in nonoccupational environments, may be carried from the work environment to the nonoccupational environment, or may be present in both environments as a result of emission sources in both. Therefore, in determining a total exposure profile of an individual it is necessary to evaluate the occupational and nonoccupational environments.

The total exposure profile of an individual or population should be considered in establishing occupational and outdoor ambient exposure standards and in recommending measures for controlling exposures. The primary missing component in existing exposure estimates is the nonworkplace indoor environment. It has become increasingly apparent that this is an important component part of the individual's total exposure. Thus, EPA's interest in total exposure is in determining if there is a need for the agency to engage in a reserch effort to develop technology to control exposure to pollutants encountered in indoor environments other than the workplace.

The purpose of this study was to develop a data collection methodology to allow (1) assessing the exposure levels in three environments (workplace, in-transit, residence) during typical 24-hour periods, (2) characterizing activity patterns of workers and physical surroundings that affect pollution levels and exposures, and (3) estimating "typical" 24-hour air pollution exposure profiles.

Experimental Design and Methodology

The participants for this study were hand-picked from a semiconductor plant located in the northeastern United States. The criteria for selecting the nine test subjects included:

- Willingness to participate
- Type of residence
- Type of cooking
- Smokers versus nonsmokers
- Job classification.

Pollutants of Interest

Table 1 summarizes the pollutants sampled, sampling duration and measurement method for the three locations: residence, in-transit, and workplace. Except for the organics, all data for the "other" location under residence are for ambient conditions 10 to 30 feet from the house.

Residence

Data Obtained. Indoor measurements included the concentration levels of NO_x, O_3, B(a)P, HCHO, Rn, CO, total hydrocarbons and RSP, and other selected organics. Concentrations of NO_x, O_3, SO_2, CO, total hydrocarbons, and RSP were also measured outside the residence.

Data Collection Process. Residential air pollutant concentration measurements were collected with air samplers for 4 days in each home.

Table 1. Pollutants Sampled.

Pollutant	Residence		In Transit[3]		Workplace	
	Method	Times Measured	Method	Times Measured	Method	Times Measured
NO	Chemiluminescence[1]	4 days	Chemiluminescence	2 days	Chemiluminescence	2 days
NO_2	Chemiluminescence[1]	4 days	-	-	-	-
NO_X	Chemiluminescence[1]	4 days	Chemiluminescence	2 days	Chemiluminescence	2 days
O_3	Chemiluminescence[1]	4 days			Chemiluminescence	2 days
SO_2	Flame Photometry/[1] Pulsed Fluorescence	4 days			Flame Photometry/ Pulsed Fluorescence	2 days
CO	NDIR[1]	4 days	CO Monitor	2 days	CO Monitor	2 days
THC	FID[1]	4 days	-	-	-	-
Radon	Eberline-MGM-2[2]	4 days	-	-	Track Etch Badge	1 month
RSP	Filter	4 days	Filter	2 days	Filter	1 day[4]
ORGANICS	Tenax Columns		Tenax Column	2 days	-	-
	Dosimeter Badge	1 day[5]			Dosimeter badge	1 4-day accum. 2 1-day accum.
BaP	Filter	2 days[5]			Filter	2 days[6]
HCHO	Molecular Sieve	4 days[7]			Column	1 day[7]

1. All measurements recorded by the APPLE Computer are 5 min. averages (2 min. washout periods) for 4 days, covering the hours from about 6 p.m. to 8 a.m.

2. Radon was measured each minute. Track etch badges were also placed in the homes of selected participants for 1 month.

3. All in transit grab samples were measured for the duration of time the participant spent going from home to work and then work to home. There were 2 periods measured each day for 2 days.

4. RSP Filters were taken in the residence in both the kitchen (4 5-hour grab samples) and the central living area (4 12-hour grab samples). At work 1 8-hour grab sample was collected.

5. The Organics at the residence were measured by 1 12-hour badge worn by the participant and 2 12-hour Tenax columns, in the central living area only. At work 1 4-day accumulative Tenax column sample and 2 1-day accumulative samples were collected.

6. The BaP is measured by 2 1-day accumulative grab samples in the residence in both the kitchen and central living areas. The workplace BaP was measured by 2 1-day accumulative samples.

7. HCHO was measured by 30 min. grab samples for 4 days at the residence in the central living area and by a 1 hour grab sample collected on 1 day at the workplace.

Continuous monitoring equipment was housed in a small trailer located adjacent to the residence as shown in Figure 1. The temperature-controlled trailer contained an Apple II® computer for automated sampling as shown in Figure 2. A CSI Model 1700 Gas Phase Titration Calibrator was employed for multipoint calibration of ozone, oxides of nitrogen, and sulfur dioxide analyzers.

Indoor and ambient outdoor exposure measurements were obtained from at least two sampling points in the residence (the kitchen and a central location) and one point outdoors. Teflon sampling lines were run from the trailer to the sampling points through a temporary plywood window. Sampling points selected depended upon the home construction, type of heating system, and family activity patterns.

In addition to the residential pollution measurement, air infiltration measurements were also made using SF_6 techniques. Depending upon the size of the house 15 to 25 cc of SF_6 was injected throughout each room by the means of a hypodermic syringe. Every 20 minutes a sample was taken by a gas chromatograph from the sampling manifold in the trailer.

In-Transit

Data Obtained. In-transit monitoring was limited to carbon monoxide, nitrogen oxides, respirable particulates, and selected organic compounds. The limitation was due to logistic problems in relocating analytical and sampling equipment. In addition, some pollutants (for example, BaP) were expected to occur in concentrations below the detection limits of the analytical methods due to the short sampling periods.

Data Collection Process. In-transit data were collected on 2 of the 4 days of residential sampling. Air-sampling equipment with self-contained power units was placed in the worker's vehicle during the commute to and from work. A field representative operated the sampling equipment and recorded the findings as well as data describing physical conditions such as make of the vehicle, presence of smokers, and other information that may affect air quality in the vehicle.

Workplace

Data Obtained. The same pollutants, except for total hydrocarbons, were investigated in the workplace. In addition, other specific pollutants identified for a particular work environment were sampled.

Data-Collection Process. Both area and personal monitors were employed. Area sampling was conducted near the workers principal work station for 8 hours or for the appropriate time dictated by the worker's schedule. Each worker was monitored in the workplace on 2 of the 4 days when his in-residence sampling was in progress.

Worker Location Diary

A "Work Log" recorded the worker's location and activities during his work shift by time of day. The worker's location during the

24-hour period was also noted to appropriately weight exposure. Separate forms were used for the worker and for use in data analysis.

Results

The data base obtained for this study is large; however, some of the findings are summarized in this brief paper. Table 2 indicates an average exposure level to the pollutants as measured with continuous instrumentation during the winter season for eight of the participants. This table shows that the average SO_2 level for Subject 8 (74.85 PPB) was well above the criteria level of 30 PPB. The NO_x levels were extremely high for a majority of the test subjects, especially Subject 1 (485 PPB). Most of these high levels were associated with homes utilizing gas cooking stoves (Workers 1, 2, 3, 6 and 7). Radon levels varied from 3.32 to 14.94 Pico Curries/liter (piC./1). These values are above the only nonoccupational federal standard for indoor radiation. This standard of 3 piC/1 is for structures built in contaminated areas around inactive uranium mill tailing sites. The carbon monoxide and ozone levels were well below the federal standards.

Other results indicate: (1) residential air infiltration rates varied from 0.07 to 7.58 air changes per hour; (2) RSP levels were extremely high and varied between 37 and 2,462 mg/m^3; (3) highest RSP values were found in-transit mode--about 14 times that found in the residence; and (4) the most abundant organic compound found in the home or in-transit was methylene chloride.

Table 2. Average Exposure Level for the 24-Hr Profile During Winter.

Worker	SO_2 PPB	NO_x PPB	CO PPM	O_3 PPB	Radon PiC./1
1	7.5	485.1	2.7	0.7	4.1
2	0.4	74.9	1.5	1.9	4.9
3	4.1	39.4	2.4	1.2	7.4
4	1.1	40.1	2.6	3.6	10.7
5	13.5	88.9	4.8	12.8	5.1
6	0.8	85.7	2.4	1.7	14.9
7	1.5	86.2	1.8	13.3	3.3
8	74.9	22.5	3.5	0.4	7.7

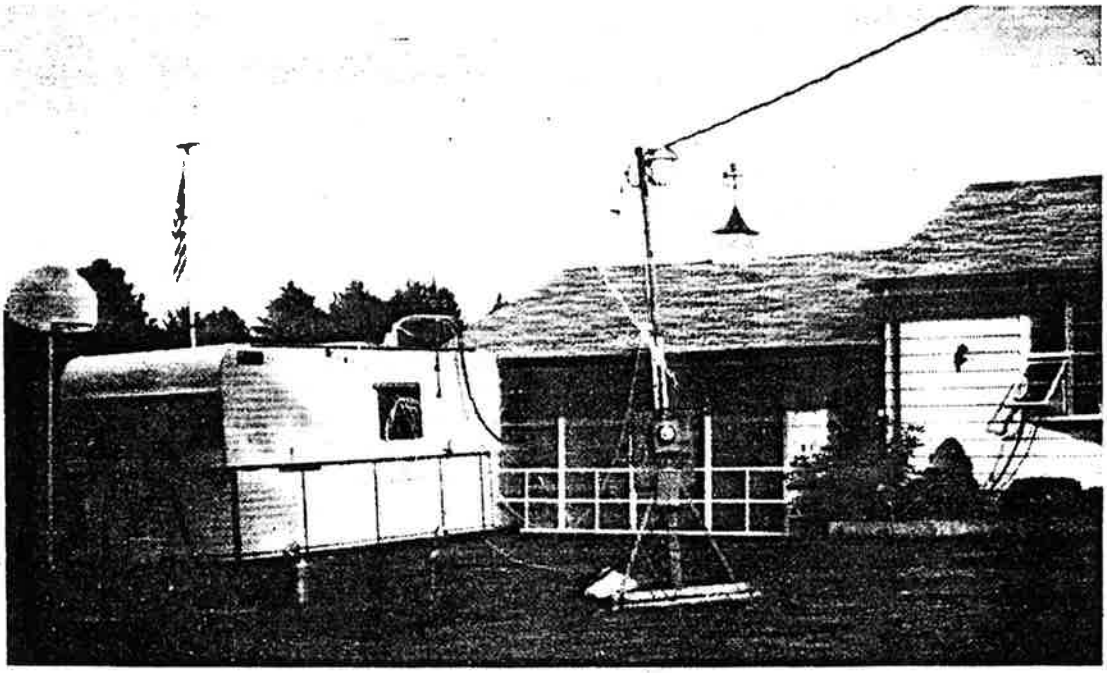

FIGURE 1. RESIDENTIAL MONITORING TRAILER

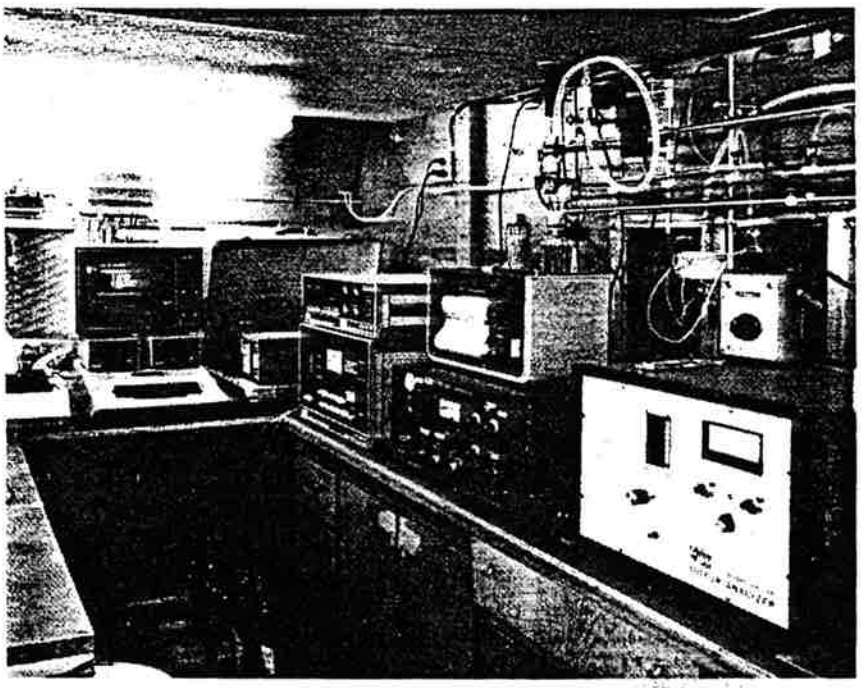

FIGURE 2. INTERNAL VIEW OF TRAILER