Air Sampling For Volatile Organics Using an Adsorbent

Jo, W.K. and L.R. Berrafato*

Department of Environmental Health Science, Hyosung Women's University, Kyungpook, Korea,
**Department of Environmental Science, Rutgers-the State University of New Jersey and Exposure & Assessment Division, Environmental and Medicine Department, University of Medicine and Dentistry of New Jersey, New Jersey, U.S.A.*
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Abstract

To perform a long-term ambient sampling study at a residential site, an air sampler was constructed to collect 24-hour integrated air samples suitable for the volatile organic compounds (VOCs) analysis. It includes an esthetically acceptance due to proximity to homes, as well as providing the required sampling specifications. The VOCs sampler accomodates four $\frac{5}{8}$"stainless steel(SS) traps packed with adsorbent(Tenax) and is capable of four flow rates in the range of 5 to 50 cc/min. Sintered metal filters(10 micrometer) were directly connected to the inlet of the trap adapters. Additional specifications include: 1) constructed of organically inert materials, 2) weatherproof, 3) battery operated, 4) collecting of VOCs at a breathing zone level, , and 5) quiet operation with micro diaphragm pumps wrapped by the sponge. The pump/battery system was separated from the sampling shelter. Sound levels measured for this system were below permissible sound levels (NJDEP) at a residential site. The sampler has been successfully operated at both ground level in a residential area and on the roof of a one story elementary school.

KEY WORDS : VOCs, VOC Sampler, integrated air, breathing zone, permissible sound level, Tenax trap

1. INTRODUCTION

Many of the modern industrial and commercial processes involve the application of VOCs(Verschueren, 1983). Although the air levels for toxic VOCs are far below the work-place standards of the Occupational Safty and Health administration (Doull et al., 1980), the chronic effects are unknown and could be of significant public health concern.

In recent years, a concern with the health risks from exposure to outdoor VOCs has been increased(Wallace, 1982; Shah & Singh, 1988; Summerhays, 1991; Berkley et al., 1991; Hisham & Grosjean, 1991). Assessment of health risks from long-term exposures to outdoor VOCs include the construction of sampling devices that can collect air samples with minimum contamination, integrated over the desired time period, and in a form that can be transported to the analytical laboratory for analysis of specific toxic VOCs. In this study, a VOCs sampler meeting these requirements was constructed as part of the Urban Air Toxics Assessment Project(UATAP) which was conducted in Northeastern New Jersey and Staten Island, New York(Berrafato and Lioy, 1987). This sampling network is designed to provide data for a human exposure assessment to VOCs in this geographic area.

The objectives of the study were 1) to construct air sampling device to collect the selected VOCs, and 2) to apply air sampling methods (Wallace, 1982; Krost et al., 1982). Particularly, noise problem has been focused because of the use of the air sampler at a residential site.

2. METHODOLOGY

An air sampler has been constructed to collect a sample of the ambient air to meet specifications set by the Monitoring subcommittee of the UATAP to characterize air quality for selected VOCs. The air sampler was designed to have 6 feet height from the ground to consider a breathing zone. It was also designed to use two flowmeter ; 5 to 50 cc/min range rotameter at between adsorbent tube and the micro pump, and Mini-Buck calibrator at inlet of the system. It has been considered to get two duplicates at two different flow rates when needed. Wires and Cinder blocks were used to support the 6 feet height air sampler. The micro diaphragm pumps were wrapped by noise-decreasing material. Sound levels was determined for the pump running, following New Jersey (NJ) Procedures for Determination of Noise (Noise Technological Assistance, New Jersey Department of Environmental Protection). Finally, VOCs sampling procedures are summarized.

2.1. Construction of an Air Sampler*

2.1.1. Materials.**

The sampling system consisted of Stainless Steel (SS) shelter,1/4" OD SS tube, 1/4" teflon tubes, 1/4" OD tygon tube, fittings, rotameters, SS 5/8" OD adsorbent tubes, SS adsorbent tube adapters, R.S. Crum made filters, needle valves, aluminium box, micro diaphragm pumps, noise-decreasing material, 6V batteries, wire, Cinder block, and Mini-Buck calibrator.

2.1.2. Design and construction***.

The air sampling shelter was built by 1/64" thickness SS to contain adsorbent tubes and their adapters, filters, rotameters, and needle valves(see Figure 1). All connections were made of the SS tubes, the teflon tubes, fittings, and the tygon tube. The dimension of the shelter is 23" * 10" * 17" with triangle-shaped roof. One compartment was installed perpendicular to the bottom of the shelter in order to fix adsorbent tube adapters, rotameters, and needle valves to the wall of the compartment, which kept them away from outside weather. As seen in Figure 1, the filter is directly connected to the adsorbent tube adapter to avoid relatively large particles entering the adsorbent tube and to inactivate ozone. The needle valve is installed at between the adapter and the rotameter to adjust the air flow to the desired value. The rotameter, one of two flow meter, was put on the system for the double-check of the air flow volume with the Mini-Buck calibrator. Mini-Buck calibrator was temporally connected to the inlet filter immediately before the adsorbent tube to measure the air flow rate. The teflon tube made the connection between the main sampling shelter system and a small aluminium box 2 feet below the shelter which contains the batteries and micro diaphragm pumps (see Figure 2). The reason we positioned the aluminium box below 2 feet the SS shelter was to eliminate the possibility which the heat generated by the pumps could affect the desorption of collected VOCs from the adsorbent tubes. The batteries and micro pumps in the aluminium box were covered by the sponge to insulate from cold atmosphere temperature which disturbs the function of the batteries and the pumps. In addition, the pumps were totally wrapped by another sponge with an inorganic material(calcium sulfate) to decrease the noise generated from the pump running. On-off switch was put at between the battery and the pump. As seen in Figure 2, the sampling shelter was put on and connected to the supporter through the flange tightened by the screw. The 6 feet height supporter consisted of 1(1/2)" OD iron pipes, flanges and iron legs. Additional supporting materials are wire and cement blocks. The wire was directly connected to the both sides of the sampling shelter and the iron pipes through the holes made by the electric driller. The small aluminium box contained the pumps and the batteries was fixed to the iron pipes, adjusting the position easily by tightening the screws.

Table. 1. Average sound levels (dBA)[1] between 10:00 PM and 7:00 AM[2].

	Distance	from	stationary	source(ft)	
	10	20	30	35	51
Background sound level	42	43	41	42	41
Without noise-decreasing material					
total sound level	57	52	47	46	44
courected(source) sound level	57	51.4	45.8	44.2	*3
with nois-decreasing material					
total sound level	49	42	41	41	41
corrected(source) sound level	48	*	*	w	*

1. dBA: defined as the unit of sound level as measured by a sound level meter using the A-weighting.
2. Operating conditions for noise measurement
   a. weather : sunny
   b. wind speed : 6.5 mph
   c. ambient temperature : 20℃
3. * : Not distinguishable from Background: According to NJ method for noise determination, if a difference between total and background levels is 3 or less of the sound level unit, the source can not be blamed for excessive noise.

2.2. Determination of Noise from the pump running

NJ Procedures have been used for noise determination, satisfying the following conditions : testing time (between 7 : 00 AM and 10 : 00 PM, and between 10 : 00 PM to 7 : 00 AM), wind speed (below 12 miles per hour), weather (sunny), and ambient temperature (between 0℃ and 50℃). Equipments used for the noise determination were Type 2 (General Purpose) sound level meter, wind buffer sponge, wind speed meter, tape measure, flash light and thermometer. First, sound levels circling the stationary source, air sampler, were measured to consider wind effects on the sound directions. Then, background sound level was measured and sound levels from the air sampler were measured by distances with and without noise-decreasing material. The distance from the stationary source to the closest house was 51 ft. Table 1 and Table 2 shows source sound levels (dBA) from the total and background sound level between 10 : 00 PM and 7 : 00 AM, and between 7 : 00 AM and 10 : 00 PM, respectively.

2.3. Operation of Air Sampling

Two fixed site (in a residential neighborhood and on the roof of a one story elementary school) air samples were collected during the 24 hours sampling period every sixth day. Duplicate sampling was determined from the sample collection schedule. Detailed sampling procedure is described in UMDNJ-SOP(1987).

2.4. Preparation of Sampling Materials and Sampling Equipment

Wearing clean nylon gloves, clean O-rings were put

Table 2. Average sound levels (dBA)[1] between 7:00 AM and 10:00 PM[2]

	Distance	from	stationary	source(ft)	
	10	20	30	35	51
Background sound level	46	46	47	47	46
Without noise-decreasing material					
total sound level	54	49	47	46	45
courected(source) sound level	53.3	*3	*	*	*
with nois-decreasing material					
total sound level	49	46	46	46	46
corrected(source) sound level	*	*	*	w	*

1. dBA : defined as the unit of sound level as measured by a sound level meter using the A-weighting.
2. Operating conditions for noise measurement
   a. weather ; sunny
   b. wind speed : 6.5 mph
   c. ambient temperature : 20℃
3. * : Not distinguishable from Background : According to NJ method for noise determination, if a difference between total and background levels is 3 or less of the sound level unit, the source can not be blamed for excessive noise.

on the traps packed with adsorbent in the laboratory. After placing the traps in clean shipping containers, the shipping containers were placed in a clean paint can. The Chain-of-Custody(COC) and Field Sampling Sheets(FS) were prepared for all the samples. Detailed sampling material and equipments are introduced in UMDNJ-SOP(1987).

2.5. Exposure of Field Samples

The voltage of the charged battery was measured and recorded at the field to make sure if the battery works at atmospheric temperature, particularly in winter time. After turning on the micro pump using on-off switch, the flow was checked to see if it is steady through the rotameter. The Tenax traps were placed in the sampling train with recording the local time. Clean nylon gloves were used whenever the Tenax traps were handled during the sampling. With the needle valves, the air flow rates were adjusted typically to 5-10 cc/min at position #1(lefthand side in the sampling shelter) and 10-20 cc/min at position #2(righthand side). The air flow rates were measured again to record them more precisely using Mini-Buck calibrator. To measure the relative humidity, a portable psychrometer was used in the field.

2.6. Collection of Field Samples

After the exposure of the Tenax traps for approximately 24-hours, the traps were collected and the sampling informations were measured and recorded with necessary sampling equipments. The battery voltages were measured through the voltmeter and recorded to see if they have run normally during the last 24 hours. The air flows were checked visually through the rotameters to see if they are steady. The flow rates were recorded using both the rotameter setting and the Mini-Buck calibrator. Then the pumps were turned off and the time was recorded. Again with nylon gloves, the Tenax traps were removed from the sample train and placed in their corresponding shipping containers. The shipping containers were taken back to the laboratory in the clean paint can and put in the refrigerator until analyzed.

3. RESULTS and DISSCUSION

The air sampler has been tested in the laboratory prior setting it up at a field to see leaking on the system, 24-hour battery run, air flow range, steady flow, and pump running. After completion of the laboratory test, the air sampling device was installed on the roof of the four stories building. There was a big leaking somewhere on the system and the leaking was found between tygon connections tightened by a wire, possibly caused by the contracted tygon tube due to outdoor cold temperature. Hence, all connections were made using the fittings as many connections as we can do.

Since the sampling shelter was made from organically inert SS, a possible VOCs source from the shelter was eliminated. In addition, since the weatherproof was considered when the shelter was desined, there was no leaking by rain or snow. The use of battery eliminated the need of any electric power. The stability of the air sampling device was one of the big concerns when it was set up at a residential site and particularly on the roof of a one story building. The stability problem could be solved with 1/16" wires and cement blocks.

Since the noise from the pump-running at a residential site could disturb the neighborhoods, noise was another problem. The noise was also caused by the vibration of the aluminium box when the pump was running. As shown in Table 1, without noise-buffer material the source sound levels measured at 10 ft and 20 ft from the noise source between 10:00 PM and 7:00 AM were above permissible sound levels, 50 dBA (NJDEP). However, with noise-buffer material the source sound levels decreased to below permissible sound levels at the two distances. Table 2 shows that the sound levels at all distance were below the permissible sound levels. It also indicates that the use of the noise-buffer material decreased the source sound levels of 4 dBA.

Another regular sponge helped the battery function against cold outdoor weather. It was also believed that in operating the sampling, the use of clean nylon gloves, tube adapters, and clean paint can could remove some unexpected VOCs sources, such as any dust in the laboratory and the field, and/or operator's dirty finger.

4. CONCLUSION

Our air sampler has been successfully operated at both ground level in a residential site and on the roof of one story elementary school. In the later case, the main concern was security. With inorganic material (calcium sulfate) inserted into the sponge, the noise could be decreased to a certain degree enough not to disturb the neighborhoods. Since our VOCs sampler has been designed to have 6 feet height, it is thought as one of the most representative samplers in collecting the breathing zone air samples among recently developed outdoor samplers unpublished.

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흡착제를 이용한 휘발성 유기물 채취

조완근 · L.R.Berrafato*

효성여자대학교 환경보건학과, **Department of Environmental Science, Rutgers-the State University of New Jersey and Exposure & Assessment Division, Environmental and Medicine Department, University of Medicine and Dentistry of New Jersey, New Jersey, U.S.A.*

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주거지역에서 대기오염물 시료채취에 대한 장기간 연구를 수행하기 위해서 휘발성 유기화합물 분석에 적합한 24 시간동안의 종합적인 공기시료를 채취하기위해 공기시료 채취기가 제작 되었다. 이 시료 채취기는 시료채취시 요구되는 모든 특성을 포함할뿐만 아니라, 일반가정에 근접해서 설치되어야하므로 심미적 특성도 포함한다. 이 공기시료 채취기는 흡착제(티넥스)로 채워진 5/8인치 외경의 스테인레스 스틸 트랩 네개를 수용할수 있고, 분당 5 - 50 밀리리터의 범위에서 네 종류의 공기유속을 이용할수 있게 고안 되었다. 금속필터(10 마이크로미터)가 트랩 어댑터의 입구에 직접 부착되었다. 부가적인 특성은 다음과 같다 : 1) 유기물질에 불활성인 재료로 제작 되었고, 2) 날씨에 영향을 받지 않고, 3) 전지를 이용하고, 4) 사람의 호흡영역에서 공기 시료를 채취하고, 그리고 5) 방음제로 싸여진 작은 펌프를 이용하여 조용하게 작동된다. 펌프/전지 장치는 시료채취기의 본체로 부터 분리 되었다. 이 장치로 부터 야기되는 소음수준은 주거지역의 허용기준치(뉴저지주 환경보호국 기준) 보다 낮았다. 이 공기시료 채취기는 일상 주거지역과 단층의 한 국민학교 옥상에서 성공적으로 작동되었다.