METHODS FOR COLLECTING SAMPLES FOR ASSESSING DIOXINS AND OTHER ENVIRONMENTAL CONTAMINANTS IN ATTIC DUST: A REVIEW

Wu Crystal D, Rosenfeld Paul E, Hesse Rob C, Clark James J
Soil / Water / Air Protection Enterprise (SWAPE), 201 Wilshire Blvd., Second Floor, Santa Monica, CA, 90401

Introduction

Dioxins and other toxic environmental contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and heavy metals are commonly transported in the environment as particulate matter in air. Airborne particles may be deposited as settled dust in areas sheltered from the environment such as in attics, where they may lie undisturbed for many years to decades. Once airborne dust infiltrates the attic, it settles and is protected from weathering, serving as a "time capsule" of contaminants associated with dust [1]. Attic dust has become increasing useful for assessing historical emissions of dioxins and other toxic environmental contaminants.

Numerous methods for collection of dust samples from interior surfaces have been reported in the literature. However, there remains to be consensus or a standard that applies widely to the many different applications of sampling techniques and conditions, including sampling of dust from attics. The American Society for Testing and Materials (ASTM) has published standards for collection of dust samples from carpeting and bare floors[2, 3, 4]. However, the specific methodology specified in the ASTM standard is not universally well-suited for collection of dust samples from all surfaces and under all conditions. In numerous recently published protocols, such as the World Trade Center (WTC) Screening Methods Study in 2005[5], U.S. EPA and other agencies have adopted a variety of non-ASTM sampling methods. In this paper we present a brief review of some commonly selected vacuum methods. We also present a sampling method developed by the authors for efficient collection of bulk dust samples from attics and other interior spaces.

Materials and Methods

The SWAPE method incorporates a common configuration using a high-volume commercial vacuum, suction hose, dust collector cartridge, and nozzle attachment (Figure 1). In practice, both handheld and backpack vacuum models with self-contained high-efficiency particulate air (HEPA) filters have been used and have worked effectively in confined space areas typically found in attics. As shown on Figure 1, a backpack vacuum (1) is fitted with a suction hose at the manifold (2). The suction hose coupling (3) is connected to the vacuum. The suction hose depicted (4) utilizes 2-inch diameter couplings on both ends. The SWAPE dust collector cartridge is forward-positioned and connected at the intake of the suction hose (5). The dust collector cartridge is assembled from basic components consisting of a Black & Decker (Model VF100H) HEPA filter (6) and the top halves of two, trimmed, 8.5-centimeter inner-diameter, polyethylene plastic bottles (7). The two polyethylene bottles are cut and fitted together around the filter media to form a solid structure. In practice, the authors have used 1-liter Aquafina purified water bottles, which are emptied, dried, and cut prior to assembly. A crevice tool (8) is connected onto the front of the filter cartridge as a nozzle. Standard duct tape is utilized to seal and fix all components. The bottle caps are retained for sealing the filter cartridge after disassembly from the vacuum hose and nozzle. The crevice tool may be discarded or reused following thorough decontamination.

Discussion

The use of vacuum methods for assessing contamination on surfaces has been reported for decades for a variety of investigations, including the assessment of radioactive particles and toxic metals such as lead. Within recent years most of the reported research has focused on indoor building surfaces, particularly carpets, bare floors, and upholstery. Several studies discussing different dust sampling methods have been reported in the literature. In 1995, U.S. EPA reported on their extensive review of dust sampling methods including a variety of wipe and vacuum sampling methods[6]. At the time of U.S. EPA's 1995 report, there was no uniform standard for sampling house dust and more than fifteen dust sampling methods were identified in the literature. The focus of the 1995 report was to explain basic concepts, summarize the house dust sampling methods described in the literature, and discuss sampling strategies and their implications for meaningful and cost-effective dust collection [6].

Standardization of methods for collection of dust from interior surfaces has been broached by various researchers and agencies; however, there remains to be consensus or a standard that applies widely to the many different applications of dust sampling techniques. Vacuum methods, which are typically used for collecting bulk samples from a variety of surfaces, are most effective for collection of dust samples from attics. ASTM has published standards for collection of dust samples from carpeting and bare floors[2, 3, 4]. However, the specific equipment called for in the ASTM standard is not universally well-suited for collection of dust samples from all surfaces, including attics and other small spaces. As a result, U.S. EPA and other agencies have adopted protocols involving a variety of adaptations of the ASTM method and/or other non-ASTM sampling methods.

There are several common vacuum sampler configurations that are suitable for collection of bulk samples of dust. All of these categories incorporate commercial vacuum cleaners, typically high-volume models. One distinct group of samplers, such as those referred to as High Volume Small Surface Sampler (HVS), consist of several nozzle designs and a cyclone dust collector attached in front of a commercial vacuum cleaner. The recent ASTM method calls for use of the HVS3 sampler[4]. Various modifications of the ASTM method have involved configurations using the HVS3 cyclone with other equipment. Another common configuration of samplers involve a dust collector consisting of a filter installed at a forward position near the vacuum hose air intake and nozzle tip. Such designs have been commonly adopted by U.S. EPA and others. The method presented by the authors in this paper also falls into this general category. The various methods and sampler configurations reviewed here present different efficiencies and capabilities when used for different applications and conditions. The various methods also present differences and limitations associated with complications of design, ease-of-use, and complications involving decontamination.

ASTM - HVS Series Methods

The HVS3 is advertised as the ASTM standard method for recovering (potentially contaminated) dust samples from surfaces for chemical analysis[7]. The HVS3 has been validated by the U.S. EPA for measuring lead, pesticides, PAHs, and PCBs in dust in carpets. The method is described in ASTM Method D5438-05 *Standard Practice for Collection of Floor Dust for Chemical Analysis* and covers a procedure for the collection of dust samples from carpets and bare floors[4]. It has been used to assess risks from lead and pesticides in house dust, but its use is limited to floors or other large flat surfaces because it cannot reach small or uneven areas, such as windows and upholstery[6].

The HVS3 (Figure 2) is a high-powered vacuum cleaner equipped with a sophisticated nozzle that can be adjusted to a specific static pressure and air flow rate. The design includes a rigid nozzle and cyclone that captures particles greater than about 5 μm. Its design involves numerous parts not made from standard materials and is therefore relatively expensive to buy compared with other methods. Its design is also cumbersome, which limits its portability and use in small or confined spaces. Operation of the HVS3 requires extensive decontamination procedures between sampling events involving the disassembly of the nozzle and cyclone. Such decontamination efforts are relatively time consuming compared with other methods reviewed here and present potential cross-contamination issues that are also a concern if sufficient cleaning is not undertaken.

The HVS3 has been modified for various studies by U.S. EPA and others, including the addition of an attachable wand or flexible tubing to allow it to sample other areas. For example, U.S. EPA modified the HVS3 method (Figure 3) for its 1997 study of lead exposures associated with residential renovation and remodeling[8]. An HVS4 model was created for small surface sampling; however, this device has not been validated, is also costly to buy, and is still bulky for small spaces such as attics.

U.S. EPA WTC Method

U.S. EPA developed a Standard Operating Procedure in 2000 for dust sampling that involves a Nilfisk GS-80 vacuum equipped with an internal HEPA filter (Figure 4). This method has been utilized by U.S. EPA at several major assessment sites and was adopted by U.S. EPA and the WTC Indoor Air Task Force Working Group for the WTC Screening Methods Study in New York City[5]. U.S. EPA has modified this method, which "may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure" [5]. The method using the Nilfisk vacuum involved collection of a sample into a dedicated sample collection bag located inside the vacuum. U.S. EPA later modified the procedure by positioning an Alsock® HEPA filter sock on the air intake end of the vacuum hose to avoid extensive decontamination of the vacuum unit. The procedure has also been modified by replacing the Nilfisk vacuum with a portable, Omega Vac® Ultivac Vacuum.

SWAPE Vacuum Method

The SWAPE method features a configuration similar to that of other common vacuum methods adopted by U.S. EPA. Many of the disadvantages of other methods such as high cost, unwieldy equipment, and time-consuming disassembly/reassembly for decontamination purposes have been avoided. The simplicity of the design, low cost, and ease-of-use of the method allows for effective collection of bulk samples of dust. The suction hose, dust collector cartridge, and nozzle configuration are durable and flexible, which facilitates collection of samples from small spaces in confined areas. The incorporation of a simple, single-use filter cartridge with a HEPA filter provides efficiency for sampling fine particles and reduces down-time and potential cross-contamination issues associated with the decontamination of dedicated parts. The method also provides for the collection of a relatively large quantity of sample material, which allows for testing of multiple chemical analytical suites, such as for dioxins/furans, PAHs, and metals, from a single unit sample of dust.

References:

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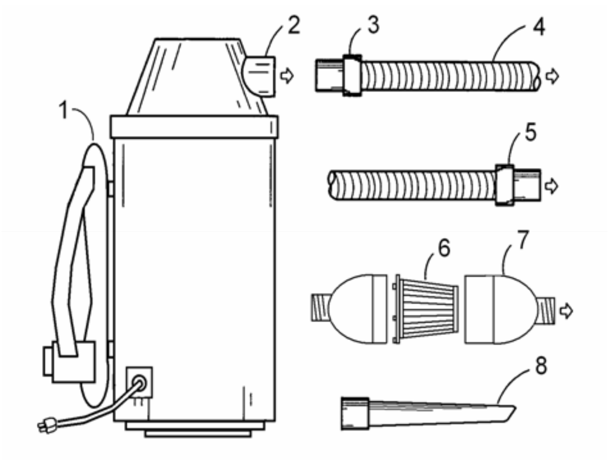

FIGURE 1: Configuration of SWAPE Dust Collector with Commercial Backpack Vacuum and Crevice Tool Nozzle

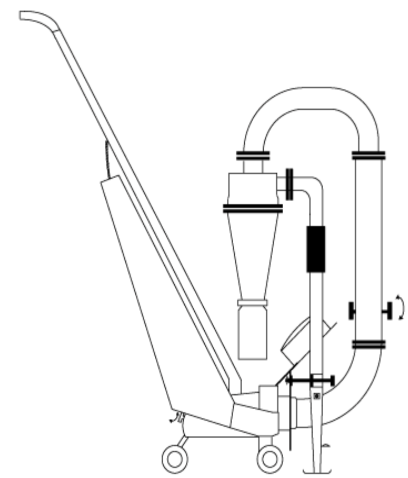

FIGURE 2: HVS3 Cyclone Dust Collector with Unspecified Commercial Vacuum[9]

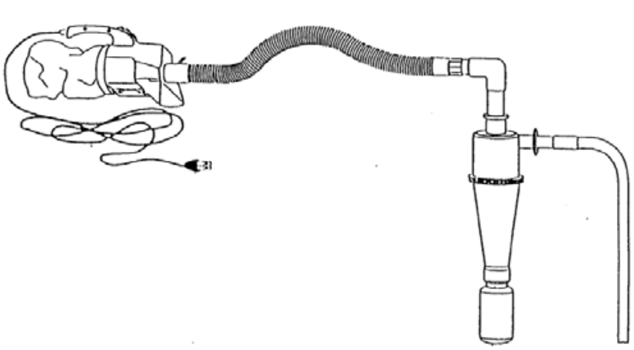

FIGURE 3: USEPA Modified HVS3 Cyclone Dust Collector with Red-Devil® Portable Vacuum[8]

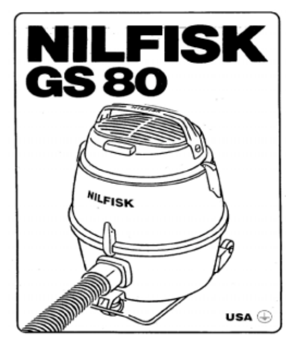

FIGURE 4: Nilfisk GS-80 Method Specified for WTC Screening Method Study[5]