A Proposed Method to Conduct Indoor Dust Sampling

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1.0 INTRODUCTION

Current data gaps for the assessment of exposure *via* the above pathways include concentrations of COCs in indoor air (including particulate matter less than 10 um, in size), and in settled dust on indoor surfaces. The relationships between metal concentrations in outdoor and indoor air have been previously examined, and it is possible to calculate indoor air concentrations from outdoor air concentrations when no significant indoor sources for the COCs exist. In the case of the Flin Flon Soils Study there are no significant indoor sources of the COCs which are all metals or metalloids. It would be reasonable and conservative to assume that indoor air and outdoor air concentration are equivalent. Therefore, the focus of the indoor air quality measurements should be on indoor dust for the purpose of this HHRA.

Outdoor soil is the primary source of indoor dust, and as such, there is a relationship between the concentrations of chemicals in the two. Hwang *et al*. (1997) and Calabrese (unpublished) undertook comprehensive studies in Anaconda, Montana which included an examination of the relationship between contaminant levels in the interior surface dust of 25 homes, and outdoor soil concentrations. The average reported soil and interior dust concentrations were very different between the two studies; however, the relationships (indoor dust:outdoor soil) were very similar (0.391 and 0.389 for the Hwang *et al*. and Calabrese studies, respectively.

2.0 INDOOR DUST SAMPLING METHODOLOGIES

The U.S. EPA (1997) defines house dust as "a complex mixture of biologically derived material (animal dander, fungal spores, *etc*.), particulate matter deposited from the indoor aerosol, and soil particles brought in by foot traffic". The focus of this study is the portion of household dust originating from outdoor soil-borne sources (sometimes referred to as settled dust). Settled dust on hard surfaces is often sampled using a swipe method; however, this method is particularly suited for the measurement of COC loading rather than COC concentrations in dust (Lanphear *et al*., 1998). Concentration data are required for the risk assessment; therefore it is preferable to collect indoor dust data using soft- and hard-surface vacuum sampling.

A number of studies have examined the relationship between different methods used for sampling of indoor dust. Lioy *et al*. (1992) found that while loadings were substantially greater with wipe sampling, metal concentrations within the dust samples were similar for both methods of sampling. It must be noted that most indoor dust sampling methods (*i.e.*, both wipe and vacuum methods) are designed to measure loadings as the amount of toxicant per unit area (*i.e.,* ug/m^2). This information is very difficult to utilize within the context of an exposure/risk assessment. Preferable when using the data to estimate exposure is the expression of toxicant concentration on a mass basis (*i.e.*, ug/kg dust). This type of data can be collected though the use of vacuum sampling, where vacuum contents are analyzed to determine the concentration of specific toxicants. Vacuum cleaner sampling has its own series of problems, most notably the variability in design and efficiency. That said, residential vacuum cleaner bag samples are commonly used to collect dust samples (Lioy *et al.*, 2002) and have been used to collect dust during residential sampling in a number of recent studies (Colt *et al.*, 1998, 2000; Hysong *et al.*, 2003; Hinwood *et al.*, 2004). However, this method (referred to as household vacuum cleaners-bag/dust collection method) lacks the precision of systematic designed vacuum sampling methods, and likely will not retain particles below 10 um (Morawska and Salthammer, 2004). Ideally, a sampler specifically designed to collect house dust, such as the HVS3 (high-volume small surface sampler), should be used to undertake a study of this nature. Coupled with a HEPA filter, the HVS3 can be used for the collection of dust samples of particles smaller than 5 um. This preferred method also allows for the collection of the dust sample directly into a wide-mouth 250 ml HDPE (high-density polyethylene) sample bottle making it a simple but effective method for determining gross contaminant levels in indoor dust.

Zhipeng *et al.* (2003) also considered several different methods for the collection of indoor dust samples for a study conducted in New Jersey. Zhipeng *et al.* (2003) looked at five methods of sampling lead-contaminated dust on carpets. The methods considered were (i) wipe; (ii) adhesive label; (iii) C18 sheet; (iv) vacuum; and, (v) hand rinse. The wipe and vacuum methods showed the best reproducibility and correlation with other methods. The authors concluded that surface wipe sampling was the best method to measure accessible lead from carpets for exposure assessment, while vacuum sampling was most effective for providing information on total lead accumulation (long-term concentrations).

In a study conducted in Ottawa, designed to compare metal levels in outdoor (exterior) dust and soil with metal levels in indoor (household) dust, Rasmussen *et al.* (2001) utilized a vacuum method for collection of indoor samples. The sampling protocol involved sample collection by the residents with their personal vacuum cleaners. New bags were supplied and participants were instructed how to carryout the sampling. The protocol involved a short questionnaire with questions about the following confounding variables:

- age of dwelling
- primary source of heating
- size of house
- construction characteristics
- renovation/redecoration history
- distance from road
- number of adult occupants, children and pets
- lifestyle factors including occupation and smoking habits

Rasmussen *et al.* (2001) found that it was difficult to predict indoor dust concentrations based on outdoor soil in Ottawa, as the lack of heavy industry led to a predominance of indoor contaminant sources.

Hwang *et al.* (1997) collected indoor dust using a method developed by Que-Hee *et al*. (1985). The Que-Hee *et al.* (1985) method involves the use of stainless steel sampling tubes connected to a portable sampling pump (1.2 to 2.5 liters/min) and three sampling passes for surface dust; and three wipes with handwipes. Hwang collected samples from three locations within each house: (i) an area adjacent to the main entrance; (ii) a floor area in the room utilized most by the subject children; and, (iii) a floor area in the subject child's bedroom. Hwang *et al.* (1997) found a good correlation between indoor dust and outdoor soils, as previously discussed.

Two recent studies (Hinwood *et al.*, 2003, 2004; Hysong *et al.*, 2003) collected indoor dust samples by collecting the bag from household vacuum cleaners and/or emptying the contents of these vacuum cleaners (household vacuum cleaners-bag/dust collection). By collecting vacuum bags/dust previously collected through normal household cleaning activities, a study of this type provides an averaged concentration of household dust level collected throughout the house. As such, sampling of this type does not suffer from sampling bias where samples are collected from inaccessible areas of the house (*e.g.*, attic); does not require special training for residents; and, does not require any special equipment.

This method was found to provide a cost effective sampling option that provided good information regarding metal levels (concentrations) in indoor dust. Hinwood *et al.*, (2003, 2004) sieved the samples to remove fractions larger than 63 um, while Hysong *et al.* (2003) separated their samples into the following size fractions: coarse (≥ 2 mm); medium (> 2 and ≤ 62.5 um); and, fine (< 62.5 um).

Two recent studies have been conducted in Canada, one in Port Colborne, Ontario, and the other in Trail, British Columbia. While these studies go beyond the objective of this study (see Section 3.0 below), detailed information is provided to help place some context around the nature of these types of studies that have recently been conducted in Canada.

2.1 Rodney Street Community, Port Colborne

As part of the Soil Investigation and Human Health Risk Assessment for the Rodney Street Community (RSC) in Port Colborne, Ontario, Jacques Whitford (JWEL) conducted a study to measure the concentrations and loading of COCs in indoor air and dust for use in the HHRA. The protocol for this study is summarized below.

Sample Selection:
The overall study area was divided into three zones, based on the maximum soil concentrations in the top 5 cm of the general area, which had been determined in an earlier investigation. The high, moderate and low zones had measured nickel concentrations of >5,000 ppm, 200 to 5,000 ppm, and <200 ppm respectively. Statistically, 6 to 8 indoor air samples from each zone are needed to fulfill the study objectives; however, as the distribution of concentrations of COCs in air is unknown, a larger sample size of ten per zone was selected. No data were available to indicate how many dust samples were needed for statistical significance, therefore dust samples were taken at all locations for indoor air sampling.

Preliminary Study:
A preliminary indoor airborne dust study was conducted to determine the appropriate analytical method, minimum flow rate for air pumps, duration of sampling, laboratory sample preparation, and any potential sampling problems. Samples were collected over 24 and 48 hour sampling periods and analyzed for metals by ICP-MS.

Co-location Study:
TSP and PM_{10} sampling equipment were calibrated against the MOE's outdoor air sampling equipment. Four or five duplicate samples were taken with each of the PM_{10} and TSP samplers running adjacent to the MOE samplers for 24 hour periods.

Renovation Study:
A small study was conducted to assess the potential for exposure to COCs during renovation (defined as the removal or walls and/or ceilings, or extensive attic renovations) of 50 year old or older homes. 3 to 5 houses undergoing renovations were selected for the study. Indoor air and hard-surface samples were collected prior to and during the most destructive phase of the renovations. Indoor air samples were taken in an area where a major renovation activity was conducted, and in an area away from the renovations that is still available for general use. Hard-surface dust samples were

collected within the renovation area only. Sampling, preparation and analysis protocols were similar to those for the main indoor dust study.

Sampling:
Sampling was scheduled for a day when the house would be occupied for 6 to 8 hours during the day (not necessarily consecutive) in addition to time spent sleeping in the house. Residents were asked not to vacuum during sampling or the 7 days prior to sampling, and to maintain normal activity in the house during sampling. The residents were asked to keep a diary of time spent and general activities in the house during air sampling, and a questionnaire was administered by the field technician at the time of sampling. The questionnaire covered the number of people residing in the house and their ages, activities/hobbies undertaken in the house, use of the attic space, *etc*. To account for environmental and other conditions around the house being sampled, a house in each zone was sampled concurrently and observed conditions were recorded by the field technician. Each sampling location was photographed and recorded by the field technician

<u>Indoor Air</u>:
Air sampling was carried out in the principal main room on the ground floor of the house where residents spend the largest part of their time and which receives the most traffic. Both PM_{10} and TSP were sampled. PM_{10} and $PM_{2.5}$ fractions are both expected to contribute to inhalation and cancer risk, but as $PM_{2.5}$ is included in PM_{10}, only PM_{10} was sampled. TSP was sampled for added conservatism. PM_{10} represents the inhalable fraction, but an inhalation cancer risk slop factor was developed by the U.S. EPA for TSP in order to make conservative estimates.

PM_{10} samples were recovered using a URG-2000-30ENB Cyclone with a 47 mm diameter, 0.8 µm pore size mixed cellule ester (MCE) filter. TSP samples were recovered using a URG-2000-30ENB air pump (without the cyclone head) with a 37 mm, 0.8 µm pore size MCE filter. The sampling duration was 24 hours. MCE was selected as the filter medium for three reasons:

- low COC concentrations;
- low variability in the COC concentrations, particularly nickel; and,
- its ability to embed particulate matter within its matrix, minimizing negative error from particulate loss during transport and transfer of the filter.

<u>Settled Dust – Soft Surfaces</u>:
All sampling for settled dust was performed after PM_{10} and TSP sampling was completed. Up to 5 dust samples were taken from fabric surfaces (*i.e.* carpet/rug and upholstered furniture) in each house. Every effort was made to take the same number of samples from each house, with additional furniture samples replacing carpet samples, or even additional hard-surface samples replacing soft-surface samples, as necessary. Carpet (or rug if necessary) was sampled at the following locations:

- the centre of the most frequently used play area for children under 6 years;
- the main entrance/exit to the house;
- the secondary entrance to the house; and,
- the main hallway of the house, or route of high traffic flow in the house.

The upholstered furniture sample was taken from:

- a regularly used chesterfield; or,
- an easy chair.

Samples of settled dust from soft surfaces were taken by drawing the nozzle, held at a 45° angle, of a Personal Air Sampling Pump over a known template area. The pump operated at 2.5 litres/minute and deposited the sample on 0.8 µm pore sized MCE filter. The Department of Environmental Health, University of Cincinnati Medical Center Tygon Tube Sampling Technique Procedures, which have been standardized by the U.S. EPA Office of Pollution Prevention & Toxics (U.S. EPA, 2000a; 2000b) and the ASTM (1999), were used.

<u>Settled Dust – Hard Surfaces</u>:
2 dust samples from hard surfaces were collected in each house from:

- a commonly contacted portion of kitchen tiled floor; and,
- the sill of a window, commonly accessed and most likely to be contacted by a child.

U.S. Department of Housing and Urban Development procedures for wipe sampling of lead in house dust were used along with supporting protocols (U.S HUD, 1990; ASTM, 2002a; 2002b; and NIOSH, 1996). A single commercial wipe was used for each sample. The wipe was drawn in an overlapping fashion over a defined template area, and then folded to reveal a clean area for second and third passes over the area.

<u>Settled Dust – Attic</u>:
One composite, bulk sample of dust was taken from each accessible and unsealed attic. Approximate measurements of width, depth and ceiling height sufficient to estimate the attic's volume were also taken. Samples were collected in plastic bags from the side of the attic where disturbance is minimal.

<u>Soil</u>:
For those houses where soil sampling had not been conducted previously, nine 20 cm deep soil cores were taken from each of the front and back yards. Each core was divided into three depth intervals (0-5 cm, 5-10 cm and 10-20 cm). Samples from the same depth were composited for each yard (6 composites in total) and analysed for 21 metals and metalloids by ICP-MS.

Sample Preparation and Analysis:
PM_{10}, TSP and surface dust samples were analyzed to determine COC content and loading.

Indoor Air:
The mass of the particulate sample was taken as the mass of the filter after sampling less the mass before sampling. Filters were digested according to U.S. EPA method IO-3.5 (modified to used nitric acid instead of aqua regia (nitric and hydrochloric acids)). A full analytical scan for 21 metals and metalloids was performed by ICP-MS using U.S. EPA Method IO-3.5 (modified for no duplicate samples since the entire filter was digested at once).

Settled Dust:
Samples of settled dust were digested in aqua regia and then analyzed for metals and metalloids by ICP-MS. For soft-surface samples where a filter was used, the mass of the particulate sample was taken as the mass of the filter after sampling less the mass before sampling.

Quality Control:
Statistical analysis of data was performed to identify outliers. Travel and sample blanks were collected. Standard reference materials for air filters and soil samples were analysed. Spikes and method blanks were analyzed.

2.2 Trail, B.C.

For the lead exposure assessment portion of the HHRA conducted in Trail, British Columbia, indoor dust samples were taken in 20 homes, 7 from East Trail, 8 from West Trail and 5 from Tadanac. House dust was collected from soft surfaces using the HVS3 sampler, with the pressure drop and flow rate set according to the HVS3 manual. Samples were collected directly into wide-mouth 250 mL HDPE sample bottles.

The main sampling objective was to obtain a sufficient mass of dust for analysis (preferably > 1 g), since only contaminant concentrations, and not loadings were being measured. Therefore, it was not critical to accurately measure the area sampled (the area sampled was approximately 1.2 m by 1.8 m).

Three sub-samples were taken from the target areas in each home:

1. a carpeted floor area in front of the main family T.V.;
2. a carpeted floor area in a child's bedroom (or an adult's bedroom, if no children reside in the house); and,
3. if sample 1 is from the living room, then a carpeted floor area in a children's play room or family rec. room, otherwise, a carpeted floor area in the living room.

If any of the three target areas were not present in the home, or if they were not carpeted, then additional sub-sample(s) were collected from one of the other areas, so that the composite always consisted of three sub-samples from carpeted areas.

For quality control purposes, two blind samples of certified reference material (200 g of NIST 1648 Urban Particulate), three blind duplicates (co-located HVS3 samples) and three blanks were collected and/or analyzed with the house dust samples.

3.0 OBJECTIVES OF THE STUDY

The team's past experience with the collection of indoor dust samples has been that these data can be difficult to collect in a scientifically valid, non-biased, manner and even more difficult to interpret within the context of a human health risk assessment. Lead contamination is an exception, due to specific techniques and measures designed to evaluate lead dust in homes (HUD, 1995; EPA 1995); however the primary COCs for the HHRA include mercury and arsenic and as such the methods specially designed for lead are of little utility for these COCs. The original proposal to address this issue was to use literature derived ratios such as those calculated by Hwang *et al*. (1997) and Calabrese (unpublished) to predict indoor dust concentrations. However, discussions with the TC and their scientific advisor yielded a consensus that a validation scale indoor dust study should be conducted to ensure that indoor dust:outdoor soil ratios derived in other studies are appropriate for use. The primary purpose of this study is to validate those literature ratios using Flin Flon specific data. The preferred method for the collection of indoor data, and the accompanying SOP (standard operating procedure) is predicated by this objective. The proposed method (HVS3 sampler and HDPE sample bottles), will provide a good indication of indoor dust concentrations in living spaces, which can easily be used for risk assessment purposes and can be related back to previously collected outdoor soil levels in an effort to predict indoor dust levels in living spaces throughout the Flin Flon area.

The objectives of this study are two-fold:

(i) to validate literature based indoor dust:outdoor soil ratios using Flin Flon specific data in an effort to predict indoor dust levels in living spaces; and,

(ii) to generate data that can easily be used for risk assessment purposes and assist in the evaluation of indoor exposure levels spaces throughout the greater Flin Flon area.

4.0 PROPOSED METHODOLOGY

4.1 Selection of Sampling Locations

USE SAME HOMES AS PREVIOUSLY

4.2 Preferred Sampling Method

As previously discussed, many methods are used for the collection of indoor dust samples. As the focus of this study is to measure metal concentrations in indoor dust, not overall loadings, a vacuum based method is preferred. Additionally, since this study is intended as a validation scale study, it is important to maximize the precision of the results. The use of high volume surface sampler vacuum cleaner is deemed most appropriate as it will eliminate the uncertainty of vacuum bag dust collection from residential vacuum cleaners with different designs and different particle collection and retention systems. This method (referred to as HVS3 method) uses cyclonic action and a HEPA filter to collect dust particles smaller than 5 um and therefore, is an effective method for determining a range of toxicants and toxicant levels in indoor dust (Lioy *et al*., 2002). By using a trained field team to collect vacuum samples directly into sample bottles, handling of the samples will be reduced and an averaged concentration of household dust level will be collected from the busiest areas of the house. As such, sampling of this type does not suffer from sampling bias where samples are collected from inaccessible areas of the house (*e.g.*, attic) and does not require special training for residents.

4.3 Confounding Variables/Sampling Questionnaire

A number of confounding variables can impact the relationship between indoor dust and outdoor soil. In an effort to understand and evaluation these variables, it is recommended that a short questionnaire be completed as part of the sample collection procedure. The following information will be collected as part of the questionnaire:

- age of dwelling
- primary source of heating (*i.e.*, gas, oil, electric)
- construction characteristics
- renovation/redecoration history
- number of adult occupants, children and pets
- lifestyle factors including occupation and smoking habits
- fireplace/wood stove use
- vacuuming behaviour (*e.g.*, how often, last time)
- type of vacuum cleaner

4.4 Data and Results

The study as described above will provide indoor dust concentration data, expressed on a ug COC/g dust basis. This indoor dust concentration data will be paired with outdoor soil data collected at the same residential location. The intention will be to examine the relationship between indoor dust and outdoor soil (the indoor dust:outdoor soil ratio). The impact of confounding variables will also be examined. The ratio, assuming a statistically valid regression relationship can be established, will be used to validate similar ratios available in the published literature with a goal of predicting indoor dust concentrations at locations throughout the Flin Flon area.

With the exception of lead, no screening criteria exist for indoor dust. As such, the data collected in this study will be used solely for the purpose of the HHRA and the validation indoor dust:outdoor soil ratios.

5.0 STANDARD OPERATING PROCEDURE

As part of the Human Health Risk Assessment (HHRA) being conducted for the Flin Flon area, additional indoor dust samples will be collected from residential homes. The dust collection will provide site-specific information on the level of exposure to several metals within a residential home relative to the level of exposure from other sources.

5.1 SOP Objectives

The objective of this Standard Operating Procedure (SOP) is to provide guidance on the collection of indoor dust samples and outdoor soil samples, and specifically on the operation and sanitization of the High Volume Small Surface Sampler vacuum (HVS3).

It should be noted that the following procedures for indoor dust sample collection were based on the ASTM Standard Practice for Collection of Floor Dust for Chemical Analysis (Designation: D 5438-00) (ASTM, 2004). Guidance on the operation of the HVS3 Sampler was provided by CS3, Inc., in the High Volume Small Surface Sampler HVS3 Operation Manual (1998).

5.2 METHODS FOR INDOOR DUST COLLECTION

5.2.1 Indoor Dust Collection

1. Prior to each appointment, ensure you have the following:
   For dust sample collection:
   - Data collection package (includes permission form, questionnaire and sample data sheet)
   - Dust sample bottle with labels attached (with a few extra sample bottles in case they are needed)
   - 2 Metre sticks
   - Gloves
   - A marking pen
   - Cleaning products (including Kimwipes, cleaning brushes, methanol wash bottle, waste methanol bucket with lid, clean tub with lid, alcohol wipes, garbage container with lid)
   - Manila envelope or cardboard for leak check
   - Vice grips for nozzle adjustment
   - Tape

2. Upon arrival at the home, any questions that the primary resident may have regarding the study should be answered. The participant must then provide informed consent by completing 2 copies of the permission form. One copy of the permission form is left with the resident of the home for their records, while the other is kept with the survey and data sheet, which becomes part of the field team's documentation.

3. One of the field team members will complete the questionnaire with the primary resident. If the questionnaire cannot be completed during the sampling appointment, one of the field team members will follow up with the primary resident at a later date to complete the questionnaire by telephone.

5.2.2 Pre-Sampling Preparation

Prior to each sampling event, the HVS3 (Figure 1) should be checked for leaks. To check the HVS3 for leaks, hold a manila envelope or thick piece of paper or cardboard over the nozzle to seal it off from any air intake. Turn the vacuum on and ensure that the flow Magnehelic gauge reads between 0 and 0.02 inches of H_20.

If the gauge reads greater than 0.02 inches of H_20, ensure that all the connections of the gauge tubing are correct. If the gauge tubing connections are correct and the flow still exceeds 0.02 inches of H_20, it is then necessary to check all gaskets, clamps, the catch bottle and the nozzle, to ensure that there are no damaged parts.

Each sample bottle should be free of contamination by ensuring that it is acid washed, left to air dry and then labeled with a tare weight (with the lid on) prior to being used to collect a sample.

5.2.3 Selection of Indoor Dust Samples

The dust sample for each household will comprise a composite made up of three or more sub-samples collected from the following areas of the home:

1. a carpeted floor area in front of the main family television;

2. a carpeted floor area in a child’s bedroom (or in an adult’s bedroom, if no children reside at the house);

3. (if sample 1 is from the living room) a carpeted floor area in a children’s play room or family recreation room.

NOTE:
If more than one of the 3 sub-sample locations are in the same room, or if one of the sub-sample areas does not exist in the home, an additional sub-sample should be collected from a carpeted area in the main room (not directly side by side, if possible). The sub-sample should be located where children typically sit on the floor to play or in a high-traffic area of the room.

Following the collection of dust from 3 sub-sample areas, the collection bottle should be examined to determine if enough dust has been collected. If the amount of dust in the collection bottle DOES NOT completely cover the entire bottom surface of the bottle, an additional sample area (s) (1 m^2) should be vacuumed until enough dust has been collected in the sample bottle.

5.2.4 Marking the Sample Area

Once a sub-sample area has been selected, a $1m^2$ area should be measured using the 2 metre sticks and should be marked on 2 sides with long strips of tape on the carpet or area rug. It is recommended the sub-sample area be located at least one meter from any outside door.

5.2.5 Setting the Nozzle Flow and Pressure Drop

1. Make sure the correct information is recorded on the sample bottle label including house sample ID number, tare weight (in grams), date and time of sample, and sampler's initials. Attach the sample bottle securely to the cyclone.

2. Clean the nozzle and the wheels with a Kimwipe immediately prior to sampling.

3. Place the HVS3 on the bottom left hand corner of the sample quadrat. Adjust the HVS3 sampler for the height and type of carpet being sampled prior to turning the power on. The height of the nozzle is adjusted using the height control knob (A) at the back of the vacuum, between the rear wheels. The nozzle level adjustment (B) (a dial located at the front of the vacuum) can also be used to position the nozzle.

4. Turn the power on.

5. The flow rate and the pressure drop are the 2 most important factors affecting the efficiency of the HVS3 sampler.

    - The pressure drop at the nozzle is a direct function of the flow rate and the distance between the sample surface and the nozzle flange. The flow rate is controlled by a butterfly valve (D) located on the outside of the downstream side of the control tube.

    - The flow is measured by the pressure drop across the cyclone (C); the higher the flow rate, the higher the pressure drop. The nozzle position is controlled by the height control knob (A) on the back of the HVS3 (between the rear wheels) and the nozzle level adjustment (B) by the level

(E) on the front side of the nozzle. The nozzle height and therefore, pressure drop, must be adjusted to regulate the complete system.

6. When adjusting the nozzle to the correct height and flow rate, first centre the level on the front of the nozzle by using the height control knob (A) between the rear wheels. If the HVS3 is close to position but the level is not set, use the leveling knob (B) on the nozzle. Once the level is set, turn the power on and adjust the flow rate using the butterfly valve (D) on the downstream control tube and the Magnehelic gauge.

7. Tip the nozzle forward for a few seconds to seal the nozzle to the carpet. The Magnehelic gauge should be adjusted according to the following specifications:

Carpet Type	Flow Rate (inches of H_20)	Nozzle Pressure Drop (inches of H_20)
Plush	8	9
Level Loop	5	10

8. Setting the flow rate may adjust the pressure drop and vice-versa. Continue to make small adjustments to the nozzle height, leveling knob and flow rate dial until the correct readings are on the Magnehelic gauges.

9. If the correct pressure drop cannot be achieved or the nozzle cannot be leveled to the type of carpet being sampled, the position of the nozzle may need to be adjusted by loosening the flex joint and re-positioning the nozzle to the desired angle.

5.2.6 Collecting the Sample

1. Begin sampling by moving the nozzle forwards, in a straight line from one end of the sub-sample area to the other. Once the first pass of the sub-sample area is complete, pull the sampler directly backwards, passing over the same strip of carpet/rug. For the next forward pass, angle the nozzle slightly to the right to the adjacent section of un-sampled carpet and repeat the motion forwards and backwards, conducting 2 complete passes over the second strip of carpet/rug. Continue these motions until the entire sub-sample area (between the 2 strips of tape) has been sampled.

2. Be sure to push the sampler with consistent speed and pressure, passing at approximately 1.5 feet per second (about 3 seconds per pass in one direction). Also be sure to **NOT step inside of the sub-sample area** while collecting the sample.

3. Repeat the steps to collect from 2 or more additional sub-sample areas in the home, to create a composite sample. If the first sample bottle becomes full, use a second bottle to continue with the sampling. Make sure that the correct house sample ID # is recorded on the second sample bottle, and that the use of a 2^{nd} bottle is recorded on the sample data sheet.

4. Once the samples have been collected and the power has been turned off, remove the sample bottle from the cyclone and fasten the sample bottle lid securely.

5. Samples will remain in the sample bottles and will be stored at ambient room temperature until analysis.

6. Once the sample bottle has been removed subsequent to sample collection, open the butterfly valve to maximum flow and tip the sampling train so that the nozzle is 2 inches (5 cm) off of the ground. Switch the power to ON. Place a glove-covered hand on the bottom of the cyclone (*i.e*. where the sample bottle was attached) and alternate opening and closing the cyclone for 10 seconds to free any loose material from the walls of the cyclone and tubing.

7. Labelled samples of dust will be sent to an accredited analytical laboratory for chemical analysis. A chain of custody form will accompany each batch of samples submitted to the laboratory.

5.2.7 Collection of Blank Samples

1. Blank samples must be collected during the sampling process in order to correct for any modifying factors. To be consistent, a blank sample should be collected at every sixth house visited. A sample collection schedule will be completed for each sampler throughout the study to ensure blank samples are collected at regular intervals.

2. To collect a blank sample, attach a clean, un-used sample bottle to the HVS3 cyclone and tip the vacuum nozzle upwards, laying the handle parallel to the floor. Turn the vacuum on and run the blank sample for 60 seconds (1 minute).

3. Once the sample has been collected, replace the lid securely on the sample bottle and record the date, time, and blank number (BLANK-###) on a label on the bottle. Also fill out the blank sample collection tracking sheet for the appropriate sampler (*i.e.* HVS3#1).

5.2.8 Cleaning the HVS3 Sampler

NOTE: THE CLEANING PROCEDURES SHOULD BE CONDUCTED IN THE VAN WITH GLOVES AND SAFETY GOGGLES ON.

1. Switch the power to OFF. Unplug the vacuum and place it in the back of the van for cleaning.

2. Once the vacuum is ready to be cleaned, proceed by removing the cyclone cone (D), bellows connector (E), and elbow (J), at the top of the nozzle tubing (F). While wearing rubber gloves, hold each section of the sampler over the methanol waste tub and use the 500 mL squeeze bottle to rinse the interior of each part. After washing with methanol, use a brush to scrub the interior of the tube, remembering to rotate the tube while scrubbing with the brush. Repeat this process for each section of the vacuum individually, rotating each item and alternating between applying methanol and brushing, so that each piece is washed and brushed 3 times.

3. Use alcohol wipes to wipe down and clean the gaskets and connections between each section of the tube.

4. Once each section of the vacuum has been cleaned and rotated, the clean sections can be placed in the plastic tub or on the lid (laid upside down inside the van). Ensure that the “clean” plastic tub is sealed with the lid after every cleaning, to avoid the collection of any contaminants or dust inside the tub.

5. Once each piece has been cleaned, place them individually in the tub or on the lid and allow the pieces to air dry while the soil samples are being collected.

6. Once the inside of the individual sections are dry, re-assemble the HVS3 sampler. Conduct a leak test at the next use of the sampler to ensure that all of the clamps and gaskets have been re-assembled correctly.

6.0 LABORATORY ANALYSIS OF SAMPLES

Samples should be individually sieved to separate out the <63 um fraction for analysis. Samples should be analyzed using standard soil/dust sampling procedures. Analytical procedures should ensure that sample detection limits are sufficient for comparative and risk assessment purposes. The laboratory should ensure that analysis methods are able to obtain the following detection limits:

Table 1 Method Detection Limits (MDL) for each of the Chemicals of Concern

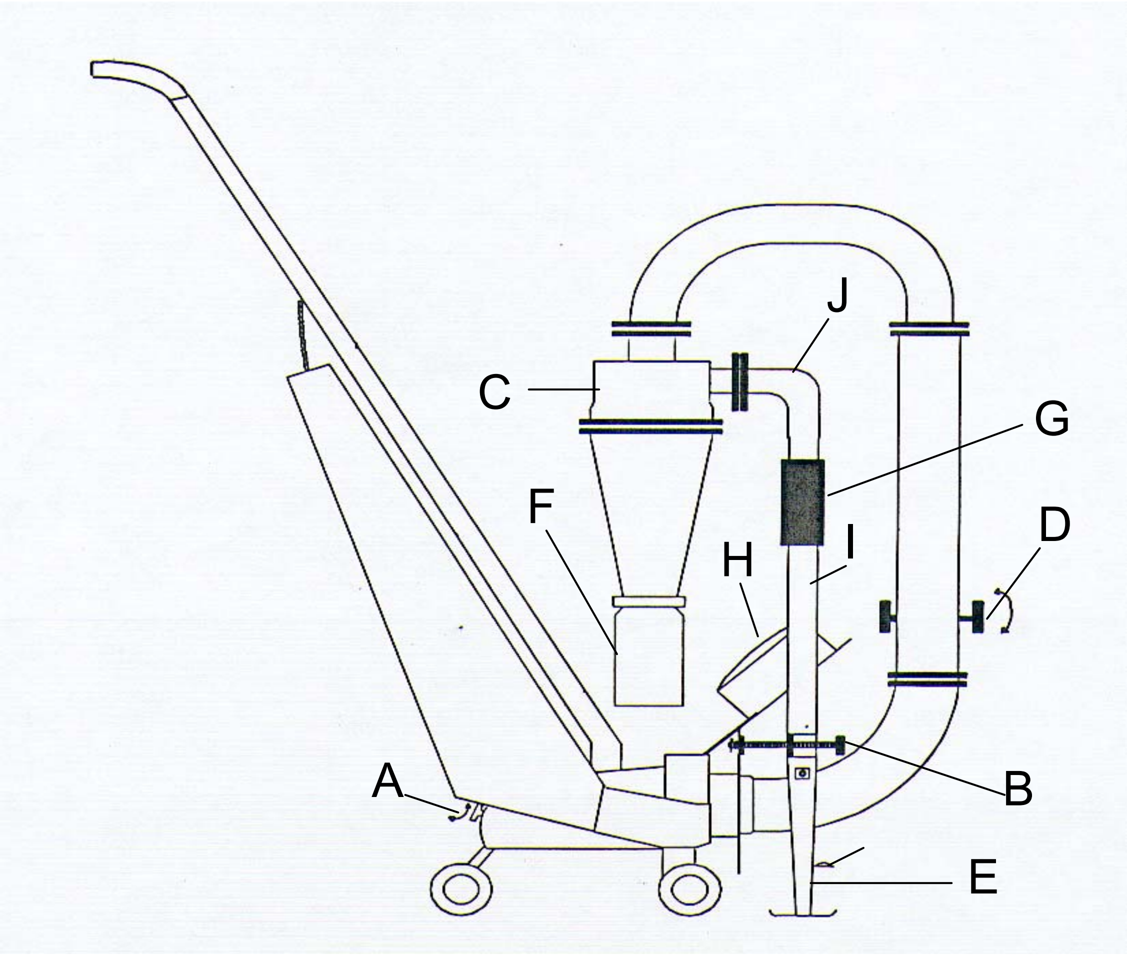
Parameter	MDL (ug/g)
Arsenic	1.0

Cobalt	2.5
Copper	5.0
Lead	10
Nickel	2.5
Selenium	1.0

Figure 1: Identification of HVS3 parts

LEGEND:

A	Height control knob
B	Nozzle level adjustment
C	Cyclone
D	Flow rate butterfly valve
E	Suction nozzle with level
F	Sample bottle
G	Flex joint
H	Magnehelic gages
I	Bellows connector
J	Elbow tube



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