INVESTIGATIVE TOOLS AND TECHNIQUES FOR INDOOR AIR QUALITY STUDIES

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ABSTRACT

Indoor air quality problems are diverse and often complex. Adverse indoor air quality problems can exist which create symptomatic conditions for building occupants. Often, the exact cause, or causes, of the substandard indoor air quality are unknown. Therefore, an investigative approach must usually be taken to identify the source(s) of the air quality problem, and if present, air contaminant concentrations. As the general public becomes more aware of the problems associated with poor indoor air quality conditions, an

can be expected.

This paper discusses some of the various investigative tools and techniques that can be utilized to identify air quality contaminants when performing an indoor air quality evaluation. These investigative tools and techniques can be used to develop a site specific list of possible contaminants and their sources, and can then be used to determine which contaminants are, in fact, present in adverse concentrations. Some of the investigative tools and techniques to be discussed in this paper include the following: visual inspections and site observations, information searches, review of building construction, review of ventilation systems, interviews, low and high volume sampling pumps, flow and oxygen meters, portable photoionization and flame ionization detectors (PID & FID), various types of vapor detector tubes, and gas chromatograph/mass spectrophotometer (GC/MS) analysis.

This paper will be an introductory overview of the above listed investigative tools and techniques. The paper's attempt is to acquaint

techniques, and how they can assist the reader in an air quality evaluation.

INTRODUCTION

The general public is becoming more aware of environmental issues and concerns as a result of massive amounts of media attention with respect to environmental problems. One environmental subject of recent attention is indoor air quality and the "sick building syndrome". As the public continues to become more aware of indoor air quality problems, an associated increase in air quality evaluation requests can be

expected, especially those relative to complaints from building occupants.

Adverse indoor air quality problems can exist which create symptomatic conditions for building occupants. Indoor air pollutant concentrations may be 2-5 times greater indoors than outdoors, and most people spend approximately 90% of their time indoors. Indoor air quality problems can be diverse and complex. Often, the exact cause, or causes, of the substandard indoor air quality are unknown. Therefore, an investigative approach must usually be taken to identify possible source(s) of the air quality problem, and if present, any air contaminant concentrations.

Various investigative tools and techniques can be utilized to identify air quality contaminants when performing an indoor air quality evaluation. These investigative tools and techniques should be used to develop a site specific list of possible contaminants and their sources. The possible contaminant list, once developed, can then be used to determine which contaminants are, in fact, present in adverse concentrations. Some of the investigative tools and techniques that can be utilized include the following: visual inspections and site observations, information searches, review of building construction, review of ventilation systems, interviews, low and high volume sampling pumps, flow and oxygen meters, portable photoionization and flame ionization detectors (PID & FID), various types of vapor detector tubes, and Gas Chromatograph/Mass Spectrophotometer (GC/MS) analysis.

PRELIMINARY INVESTIGATIVE TECHNIQUES

The first step in conducting an indoor air quality investigation should be the utilization of various investigative tools and techniques to develop a site specific list of possible contaminants and their sources. This preliminary investigation should be performed prior to the employment of air sampling and monitoring equipment, or other hardware, and the use of analytical services. By properly conducting a preliminary investigation, costs can be minimized and a more efficient investigation can be achieved. Some of the investigative tools and techniques that can be utilized for the preliminary investigation are as follows:

1.) personal interviews with those individuals that are knowledgeable about the building and any "affected" occupants,
2.) visual site inspections and observations,
3.) a review of the subject building construction,
4.) a review of the ventilation systems, and
5.) informational data searches and area reconnaissance.

In order to diagnose an indoor air quality problem, proper research (preliminary investigation) should be conducted. Research can be performed by utilizing the

five (5) items listed above, and which are explained below.

Personal Interviews

One of the primary methods for obtaining information is to interview "affected" occupants and determine the specific complaints or symptoms. How many occupants are being affected, and are the complaints similar? What time of the day are they experiencing the symptoms? Are the occupants experiencing general fatigue, headaches, nausea, vomiting, dizziness, etc? Are the affected persons generally occupying a certain part of the building or are they occupying the entire interior building space? Does the symptom disappear or lessen in severity after leaving the building or work place? Has someone recently changed perfume, or had a virus? Is anyone smoking in the building or immediately outside the building, etc? The answers to these and other similar questions can provide a significant amount of valuable information. This type of interviewing process is generally the most important aspect of the preliminary investigation.

Site Inspections

Another method for obtaining useful information is to conduct a visual inspection of the building, both the interior and exterior, and the general vicinity where the building is located. Examples of items to look for in these inspections include, signs of new furnishings (carpet, drapes, flooring, and furniture), stagnant "dead air" spaces with little or no air movement, closed loop ventilation with no fresh air intakes, the use of chemicals (cleaners and solvents) that could be producing air contaminants, cooling towers, clogged or malfunctioning traps, fall out from air ducts, mold or evidence of microbiological activity, fresh air intake vents that are located near vehicle traffic areas (especially vehicle loading and unloading areas), vegetation inside and outside the building, and generally any items or activities inside or outside the building that could be a source of airborne contaminants.

Building Construction and Ventilation System Review

In conjunction with the visual inspection, a review of the subject building construction, as well as a review of the ventilation system should be conducted. Look for construction material items, either original or newly installed, that may be a possible source of contamination. Examine the ventilation system for possible deficiencies which could lead to decreased oxygen levels and increased levels of carbon dioxide and/or carbon monoxide during occupancy. For example, is there an inadequate volume of fresh air into the ventilation system or poor air return circulation which is creating a poor indoor air quality environment?

Data Searches and Area Reconnaissance

During the preliminary

investigation, it is also important to look at the general area in the vicinity of the subject building and immediate site. This can be accomplished by conducting informational data searches and an area reconnaissance. This is especially necessary if the previously discussed preliminary investigative methods do not yield any possible sources of indoor air quality pollutants, and/or the subject building is located near construction activities or an industrial area. Contaminant sources could be coming from off-site. Wind direction information can be useful in identifying possible off-site contaminant sources. Informational data searches can provide environmental databases on the general area, which can reveal possible contaminants. These database searches can be performed by firms that specialize in providing this type of information.

Information provided by these searches typically includes federal and state information. The information consists of environmental data regarding enforcement proceedings, emergency response notifications, Resource Conservation and Recovery Act (RCRA) data, Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, or otherwise known as Superfund) data, toxic release inventories, petroleum storage tank sites, leaking storage tank sites, landfill sites, waste storage sites, incinerators, illegal dumpings, spill incident sites, and others. In addition to these database searches, local records should be reviewed at the city, county, and state levels. Good sources of information regarding local facilities include local emergency response teams and fire departments, as well as state agencies, which should have information provided as required under the Superfund Amendments and Reauthorization Act (SARA) Title III, the Emergency Planning and Community Right-to-Know Act of 1986.

Data Interpretation

Interpretation of the data obtained in the preliminary investigation will determine subsequent investigation activities. The primary purpose of the preliminary investigation is to develop a site specific list of possible contaminants and their sources. Once the site specific list of possible contaminants and their sources has been developed, then additional investigative activities should be conducted to determine which possible contaminants are actually present in adverse concentrations. A preliminary investigation almost always reveals one or more possible contaminants that could be present in indoor air. However, should a rare preliminary investigation reveal no obvious possible contaminants, then the investigation can proceed in one of three primary options.

Option 1.

The first option is for the investigation to be considered complete and no further investigative studies

performed. This option may be viable if a thorough preliminary investigation was performed, and the reason for the investigation request was based on minor complaints that are not indigenous only to poor indoor air quality and are from a single or very small minority of building occupants.

Option 2.

The second option is for the preliminary investigation to be performed more thoroughly. Additional sources of information specific to the site could be investigated, and different personnel, or a team of personnel could be used to conduct a more complete preliminary investigation. These additional efforts may provide information that was not noted previously. If the second option fails to provide any additional information on possible contaminants, then the first option could be used, or the investigation could proceed with the third option.

Option 3.

The third option consists of performing additional investigative techniques to screen or analyze indoor air for the presence of general contaminants. Contaminants that typically would be tested for a general quality assessment would be oxygen, carbon dioxide, humidity, air temperature, carbon monoxide, and any other "speculative" parameters that the investigator may consider worthwhile to test. The degree to which the investigation for this third option is performed should be based upon the severity of the "alleged" problem, and the client's needs or reasons for the investigation.

CONFIRMATIVE INVESTIGATIVE TECHNIQUES

Assuming that a site specific list of possible contaminants and their sources was developed during the preliminary investigation, subsequent investigative activities should be conducted to determine which possible contaminants are actually present, and if present, their concentrations. The purpose of the investigation during this phase is to confirm whether any suspected contaminants are present in concentrations that could be deleterious to health. Some of the tools that can be used to complete the indoor air quality investigation are as follows:

1.) air flow and oxygen meters,
2.) portable photoionization and flame ionization detection (PID & FID) meters,
3.) low and high volume air sampling pumps,
4.) various types of vapor detector tubes, and
5.) laboratory analytical services including gas chromatograph/mass spectrophotometer (GC/MS) analysis.

The presence of possible air contaminants, including volatile organic compounds (VOCs), semi-volatile organic compounds (semi-volatiles), and particulates (asbestos, lead, and dust, etc.), can be confirmed by employing the above list of tools. It

should be noted that the determination of contaminant levels in an indoor air quality study, should only be performed in the final stage of the investigation. All preliminary investigation activities, and usually the more general inspection of the ventilation system and the detection of non-specific contaminants, should be performed prior to the collection of air samples for the detection of specific contaminants. The following is a description of the five investigative tools previously listed.

Air Flow and Oxygen Meters

Air flow and oxygen meters can be used to determine if the ventilation system is providing sufficient air flow and fresh air to prevent a buildup of carbon dioxide and carbon monoxide and a possible decrease in oxygen levels throughout the day during building occupancy. The volume of air circulated to building occupants can be measured by use of a air flow meter. Air flow meters measure air flow and velocity. Some meters can measure differential pressure and temperature which affect true air velocity. Air delivery at outlets or inlets can be measured directly by use of a capture hood. A sufficient volume of fresh air to each building occupant is critical when conducting indoor air quality studies. An oxygen meter can be used to measure the concentration of oxygen in air. Generally, oxygen level measurements are taken throughout the day to determine if levels are fluctuating adversely.

PID and FID Meters

Other meters that can be employed are photoionization (PID) and flameionization (FID) meters. The PID will detect many aromatic (ring structure) hydrocarbon vapors, while the FID will detect some aromatics and aliphatic (straight chain structure) hydrocarbon vapors. For example, the PID will detect volatiles such as benzene, toluene, and xylenes, but it will not detect methane. The FID will detect benzene, toluene, and xylenes, as well as methane. The PID and FID cannot differentiate specific compounds. Some PID meter models also have the additional capability of being utilized as a low volume air pump to collect air samples for further analysis.

Low and High Volume Air Sampling Pumps

For more specific studies of possible contaminants, air samples can be collected by the use of various types of air pumps. Indoor air can be collected by the pumps into impermeable and inert bags, absorbent traps, or cassettes, that can be delivered to an analytical laboratory for quantitative analysis. The air can be pumped through detector tubes that can provide qualitative and quantitative measurements for some contaminants, and the air can be pumped through particulate filters, particulate traps, or cassettes, for laboratory analysis of items such as nuisance dust, lead, asbestos, molds, and other particulate contaminants.

Nearly all airborne

contaminants can be sampled using a wide range of sampling pump configurations. All of the pump configurations depend on a calculated volume of air being drawn through the sampling device. The volume of air drawn through the pump is calculated by measuring the air flow rate, usually in liters per minute, and recording the start and ending times of the air test. Sampling intervals can be designed for short durations, generally 15 to 30 minutes, to calculate short term exposure limits (STEL), or increased to calculate permissible exposure limits (PEL). Generally, larger air volumes produce a lower analytical detection limit. Air pumps come in all sizes ranging from small "personal" air pumps to large "area" air pumps.

The majority of particulates (dust and fibers) are collected on filters that are contained in cassettes and analyzed by optical, chemical or physical measurements. Flow rates can be low to high depending on analytical methodology and detection objectives. Most organics sampled with pumps use very low flow rates, calibrated in tenths or hundredths of liters per minute. The sample is normally collected by absorption, or adsorption onto a chemical containing glass tube, or collected within an impermeable and inert air sample bag.

Detector Tubes

In indoor air investigation studies, detector tubes can be a cost effective and simple means of determining the presence of a suspected contaminant, both qualitatively and quantitatively. A specified volume of air, that is typically dependent upon the type of tube, is drawn through the detector tube using a low volume pump. A small, simple hand operated pump is usually employed. The tubes can provide an indication of air quality at the moment that the test is performed (instantaneous sample), and they can provide for long term measurements in determining time weighted averages as well.

Detector tubes are very useful when measuring the more common air contaminants associated with poor indoor air ventilation and other common indoor air contaminant parameters. These parameters include carbon dioxide, carbon monoxide, benzene, toluene, xylenes, and formaldehyde. In recent years, detector tubes also have become available for a tremendous variety of specialized contaminants such as chlorinated, phosphorous-containing and sulfur-containing solvents, monomers, and other many other compounds.

Laboratory Services

At times it will become necessary in indoor air quality studies, for the presence of air contaminants and their concentrations to be determined and quantitated by the use of sophisticated laboratory analysis. Meters and detection tubes may not provide the level of quantitative analysis, the differentiation required, or the detection level necessary for many contaminants, if they

can measure the contaminant of interest at all. In these situations, it may become necessary to collect representative air samples and submit them to an independent laboratory for analysis.

Air sample collection for more rigorous analysis can be accomplished by a variety of techniques. The specific technique required is dependent upon the target parameters to be tested. Some of these techniques are as follows:

1.) Adsorption of contaminants on a solid media such as charcoal or adsorptive polymer,

2.) Filtration using high and low volume paper or fiber-glass filters,

3.) Sample intake into a pre-evacuated collection vessel, and

4.) Percolation of the sample through an absorption solution.

Once in the laboratory, the samples are prepared for analysis by extraction with an organic solvent for organics or acid digestion for metals. The prepared samples can then be analyzed in parallel with analytical standards of varying concentrations, method blanks, duplicates, and other controls.

Results for laboratory-based test methods, as opposed to field methods, tend to produce data of better precision and accuracy because of more extensive calibration and quality control techniques which can be applied.

SUMMARY

As the public becomes more aware of indoor air quality problems, requests for indoor air quality evaluations are expected to increase. An investigative approach can be used to identify sources or causes leading to poor indoor air quality. Various investigative tools and techniques can be utilized in performing these investigations.

A preliminary investigation is first conducted to gather information to determine probable site specific contaminants or causes of poor indoor air quality. The preliminary investigation is generally cost effective since further investigative activities are more focused on probable contaminants or causes.

Once the site specific list of probable contaminants has been identified, further investigation is needed to confirm which contaminants are actually present, and their sources. Various tools can be used to confirm the presence or absence of suspected contaminants in indoor air. These tools include various meters, air sampling pumps, air sampling devices, portable analytical tools, and full laboratory services.

Once the contaminant and source have been identified and confirmed during the air quality investigation, steps can then be taken to mitigate the indoor air quality problem. It is up to the

investigator to use these available resources in conducting air quality investigations.