

STUDY REPORT

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The management of contaminated sites and soils:

**Characterisation of indoor air quality in relation to
potential soil pollution by volatile and semi-volatile
chemicals**

INERIS

*maîtriser le risque |
pour un développement durable*

The management of contaminated sites and soils:

Characterisation of indoor air quality in relation to potential soil pollution by volatile and semi-volatile chemicals

In the frame of CityChlor research project, the original French report prepared in 2010 for the French Ministry of Ecology, was translated by one of the project partner.

Report prepared for

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FOREWORD

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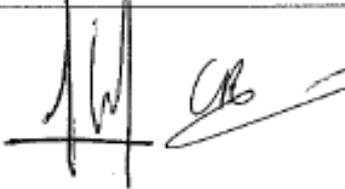
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ABSTRACT

The possible transfer of volatile substances from polluted soils and/or groundwater to media exposure is a major concern, especially for indoor air.

When a transfer is suspected, direct measurement of the indoor air is to be preferred over a transfer model. The investigations to be carried out on the indoor air will be conditioned by the results of the measurements performed on the soils and/or groundwater and/or soil gas. Elements from the historical study of the site should be also studied. Furthermore, the spatial and temporal representativeness of the measurements and measurement methods implemented in relation to the objectives and the context (substances in question, sampling techniques, detection and quantification limits) must be provided with an appropriate sampling plan and a quality control.

So, indoor air investigations must be suited to the type of site and its use, the objectives and an understanding of the environment..

In this context, this paper provides technical support and best practices enabling the different users to design and take samples of indoor air which may potentially be contaminated with gases from the soil and/or groundwater. The operator must use its knowledge and skills to select and adapt to the context and this requires the expertise of the teams conducting the investigations.

The resources and methods given in this report relate exclusively to the characterisation of gaseous chemicals in indoor air for the general populations, excluding monitoring for workers (labour regulation). This excludes particulates (dust from the soil) and radioactive (radon and decay products) chemicals, bio-contaminants, allergens, mites and microorganisms (moulds, etc.). This document does not cover the preceding stages such as soil and/or groundwater and/or soil gas investigations or the document review (site history, concept diagram, etc.) for which there are guides and tools available.

The premises covered by this document are homes and offices open to the public including educational and early childhood facilities (nurseries, nursery schools, primary schools, high schools and colleges, leisure centres, etc.) and offices.

This document is structured as follows:

- Scope and limitations;
- Normative references and reference documents, including general documents and others dedicated to certain substances;
- Sampling strategy;
- Sampling devices and implementation;
- Measurement campaign reports.

This report is based on the elements available during its preparation, which may be subject to updates where necessary, depending on the feedback and progress made in relation to the issue of managing contaminated sites and soils and future standards.

GLOSSARY

AASQA	<i>Associations Agréées pour la Surveillance de la Qualité de l'Air (France)</i>
AFSSET	<i>Agence française de sécurité sanitaire de l'environnement et du travail (France)</i>
ATSDR	Agency for Toxic Substances and Disease Registry (United States)
BTEX	Benzene, toluene, ethylbenzene, xylenes
CMV	Controlled Mechanical Ventilation
CSTB	<i>Centre scientifique et technique du bâtiment (France)</i>
DIY	Do it yourself
DGS	Direction générale de la santé (France)
EMD	<i>École des Mines of Douai (France)</i>
FID	Flame Ionisation Detector
HCSP	<i>Haut conseil de Santé Publique (France)</i>
HDPE	High-density polyethylene
HSE	Health, Safety and Environment
IAGV	Indoor Air Guideline Value (AFSSET)
INRS	<i>Institut National de Recherche et de Sécurité (France)</i>
LCSQA	<i>Laboratoire central de surveillance de la qualité de l'air (France)</i>
MDHS	Methods for the determination of hazardous substance
MEDAT	<i>Ministère du développement durable (France)</i>
MEEDDM	<i>Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer (France)</i>
OEHHA	Office of Environmental Health Hazard Assessment (EPA of California)
OQAI	<i>Observatoire de la Qualité de l'Air Intérieur (France)</i>
OSHA	Occupational Safety and Health Administration
PID	photo-ionisation detector
Ppb	Part per billion
PCE	Perchloroethylene (tetrachloroethylene)
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
PTFE	Polytetrafluoroethylene
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (Dutch National Institute for Public Health and the Environment)
TPHCWG	Total Petroleum Hydrocarbon Criteria Working Group
TRV	Toxicity Reference Value
US EPA	United States Environmental Protection Agency (United States)
VDI	Verein Deutscher Ingenieure (Germany)
VOCs	Volatile organic compounds
WHO	World Health Organisation

1. INTRODUCTION

The possible transfer of volatile substances from polluted soils and/or groundwater to media exposure is a major concern, especially for indoor air.

When a transfer is suspected, direct measurement of the indoor air is to be preferred over a transfer model. The investigations to be carried out on the indoor air will be conditioned by the results of the measurements performed on the soils and/or groundwater and/or soil gas. Elements from the historical study of the site should be also studied. Furthermore, the spatial and temporal representativeness of the measurements and measurement methods implemented in relation to the objectives and the context (substances in question, sampling techniques, detection and quantification limits) must be provided with an appropriate sampling plan and a quality control.

So, indoor air investigations must be suited to the type of site and its use, the objectives and an understanding of the environment..

In this context, this paper provides technical support and best practices enabling the different users to design and take samples of indoor air which may potentially be contaminated with gases from the soil and/or groundwater. The operator must use its knowledge and skills to select and adapt to the context and this requires the expertise of the teams conducting the investigations.

In addition, the resources dedicated to understanding the state of the environments must be proportionate and appropriate to the health issues encountered.

This document is structured as follows:

- Scope and limitations;
- Normative references and reference documents, including general documents and others dedicated to certain substances;
- Sampling strategy;
- Sampling devices and implementation;
- Measurement campaign reports.

2. SCOPE AND LIMITATIONS

This document is dedicated solely to indoor air measurements and does not cover the preceding stages such as soil and/or groundwater and/or soil gas¹ investigations or the document review (site history, concept diagram, etc.) for which there are guides and tools available (MEDAD, 2007).

The resources and methods given in this report relate exclusively to the characterisation of gaseous chemicals in indoor air for the general populations, excluding monitoring for workers (labour regulation). This excludes particulates (dust from the soil) and radioactive (radon and decay products) chemicals, bio-contaminants, allergens, mites and microorganisms (moulds, etc.).

¹ The subject of a report currently being drafted by INERIS.

The premises covered within the framework of this document are:

- homes;
- premises open to the public including educational and early childhood facilities (nurseries, nursery schools, primary schools, high schools and colleges, leisure centres, etc.);
- offices.

Due to the diversity of contamination sources, other than those related to emissions from soil and/or groundwater, the chemical composition of the air may vary greatly between locations. So, the characterisation of the indoor air quality within the “local non impacted environment”, outside the influence of any impact of volatile substances emissions from the soil and/or groundwater is also addressed.

However, this document does not cover the sample analysis stage described in the *ad hoc* standards, or the interpretation of the results, since these are specific to each case study. This document has been designed within the following interpretation framework:

- specific concentrations within the “local non impacted environment” inside the specific site. These values will also be compared to the “background” concentrations found in the literature, including those listed in documents by OQAI, INERIS, AFSSET, etc. (see references in chapter 7) for similar environments, in order to ensure their consistency with the ranges given;
- values regulating the quality of environmental media in France: current regulatory management values and quality objectives for various media. Article R221-1 of the Environment Code (Decree 2008-1152 of 7 November 2008) establishing air quality objectives, alert thresholds, recommendation and information thresholds as well as the limits for air quality monitoring and target values (see decree of 15 February 2002 on air quality monitoring)²;
- Toxicity Reference Values (TRV) for exposure by inhalation for threshold and non-threshold effects. The recognised organizations and agencies normally consulted are the US EPA, ATSDR, OEHHA, RIVM, Health Canada and the TPHCWG. In terms of selecting TRVs when there are several values available, INERIS' position is to propose the best approach in light of available knowledge; the level of detail in the best available knowledge will be proportionate to the issues. This approach is consistent with the DGS circular (DGS/SD circular no. 2006-234 of May 2006) taking into account the best approach in light of available knowledge.

Furthermore, the actions to be taken following the observation of significantly high concentrations are not covered in this document.

² There are currently no specific regulatory values for indoor air quality management in France for substances commonly observed with the problem of contaminated sites and soils. The French Agency for Environmental and Occupational Health and Safety (AFSSET) has proposed the first Indoor Air Guideline Values (IAGV), based exclusively on health criteria for formaldehyde and carbon monoxide (published in July 2007) as well as for benzene, trichlorethylene, naphthalene and tetrachloroethylene. However, these do not currently have regulatory status.

Furthermore, the HCSP provides “guide” values to assist in the air management of enclosed public spaces (ref, the principle of monitoring Indoor Air Quality (IAQ) in enclosed public spaces was decided following the Grenelle Environment Forum (commitment no. 152)). Values for formaldehyde were published by the HCSP in 2009 and should be available for benzene very shortly.

Based on the advice of the HCSP and the guideline values of the AFSSET, the Government will draft a decree defining “Guideline values for indoor air” (extract from the Ministry's website: <http://www.developpement-durable.gouv.fr>).

This report is based on the elements available during its preparation, which may be subject to updates where necessary, depending on the feedback and progress made in relation to the issue of managing contaminated sites and soils and future standards.

3. NORMATIVE REFERENCES AND REFERENCE DOCUMENTS

The following sections list the normative and national documents, particularly those drafted by the LCSQA, INERIS, etc. that aim to provide recommendations in terms of the metrology and the sampling strategy to be used. Foreign references are also given for information.

3.1 NORMATIVE REFERENCES

Standard NF EN ISO 16000-1: Air intérieur, Partie 1 : Aspects généraux de la stratégie d'échantillonnage. 2006.

Standard NF EN 689: Atmosphères des lieux de travail. Conseils pour l'évaluation de l'exposition aux agents chimiques aux fins de comparaison avec des valeurs limites et stratégie de mesurage, 1995.

Standard NF EN 13528: · Qualité de l'air ambiant - Échantillonneurs par diffusion pour la détermination des concentrations des gaz et des vapeurs. 2003.

Norme NF ISO 16017-2 : Air intérieur, air ambiant et air des lieux de travail - Échantillonnage et analyse des composés organiques volatils par tube à absorption/désorption thermique/chromatographie en phase gazeuse sur capillaire - Partie 2 : échantillonnage par diffusion. 2003.

Standard XP X43-401: Qualité de l'air - Audit de la qualité de l'air dans les locaux non industriels - Bâtiments à usage de bureaux et locaux similaires.

Experimental Standard XP X 43-402: Qualité de l'air Stratégie d'échantillonnage des polluants chimiques de l'atmosphère intérieure des locaux – Recommandations. 1995.

Standard XP X43-403: "Qualité de l'air - Audit de la qualité de l'air dans les locaux non industriels - Bâtiments à usage d'habitation et locaux similaires".

Experimental Standard XP X 43-407: Qualité de l'air: Audit de la qualité de l'air dans les locaux non industriels – Bâtiments à usage d'enseignement. 2006.

3.2 STANDARDS DEDICATED TO ONE OR SEVERAL SUBSTANCES

Norme NF EN ISO 16000-3 : Air intérieur, Partie 3 : Dosage du formaldéhyde et d'autres composés carbonylés - Méthode par échantillonnage actif. 2002.

Norme NF ISO 16000-5 : Air intérieur. Partie 5 : Stratégie d'échantillonnage pour les composés organiques volatils (COV). 2007.

Norme NF ISO 16000-6 : Air intérieur. Partie 6 : Dosage des composés organiques volatils dans l'air intérieur des locaux et enceintes d'essai par échantillonnage actif sur le sorbant Tenax TA®, désorption thermique et chromatographie en phase gazeuse utilisant MS/FID. 2004.

Norme NF EN ISO 16000-12 (2007-01-05) : Indice de classement : X43-404-12 : Air intérieur Partie 12 : Stratégie d'échantillonnage des polychlorobiphényles (PCBs), des polychlorodibenzo-p-dioxines (PCDDs), des polychlorodibenzofuranes, (PCDFs) et des hydrocarbures aromatiques polycycliques (HAPs)

Norme NF ISO 16017-1 : Air intérieur, air ambiant et air des lieux de travail - Échantillonnage et analyse des composés organiques volatils par tube à adsorption/désorption thermique/chromatographie en phase gazeuse sur capillaire - Partie 1 : échantillonnage par pompage. 2000.

NF ISO 22155 : Dosage des hydrocarbures aromatiques et halogénés volatils et de certains éthers par chromatographie en phase gazeuse. 2005.

Compendium Method TO-15. Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/ Mass Spectrometry (GC/MS). Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. EPA/625/R-96/010b, January 1999.

Compendium Method TO-14A. Détermination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially-Prepared Canisters With Subsequent Analysis By Gas Chromatography. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. EPA/625/R-96/010b, January 1999.

ASTM D3686-08 (2006) Practice for Sampling Atmospheres to Collect Organic Compound Vapors (Activated Charcoal Tube Adsorption Method) (<http://www.astm.org/Standard/index.shtml>).

ASTM D4490-96 (2006) Practice for Measuring the Concentration of Toxic Gases or Vapors Using Detector Tubes (<http://www.astm.org/Standard/index.shtml>).

VDI-Richtlinie 4300 Blatt 1/Part 1 Indoor air pollution measurement. General aspects of measurements strategy. December 1995³.

3.3 OTHER DOCUMENTS

In France:

Direction Générale de la Santé: Mesures dans l'air intérieur dans les établissements ouverts au public: Guide de gestion des dépassements de seuils. Being finalised.

LCSQA Protocols: CSTB-INERIS-EMD DRC-08-94298-15176A: Élaboration de protocoles de surveillance du formaldéhyde, du benzène et du monoxyde de carbone dans l'air des lieux clos ouverts au public. 2008.

LCSQA Report: EMD-INERIS. Mesure du benzène 2/3: Projet de guide de recommandations concernant la mesure du benzène dans l'air ambiant. 2007.

LCSQA Report: EMD: Surveillance du benzène et des COV, Laboratoire Central de Surveillance de la Qualité de l'Air. November 2005.

LCSQA Report: EMD: Mesure des COV toxiques chlorés par échantillonnage passif. 2007.

LCSQA Report: EMD: Programme d'évaluation du tube Radiello pour la mesure des BTEX. 2004.

Report INERIS-DRC-04-56770-AIRE-n°1056-IZd: Exposition par inhalation au benzène, toluène, éthylbenzène et xylènes (BTEX) dans l'air: Sources, mesures et concentrations. 2004.

³ VDI (Verein Deutscher Ingenieure) is a professional association that publishes a large number of technical specifications. Although they have no regulatory powers, in Germany they are used in the same way as DIN standards (they are fee-based and presented exactly like AFNOR and DIN standards).

Report INERIS-DRC-04-56770-AIRE-n°1057-IZd: Exposition par inhalation au formaldéhyde dans l'air: Sources, mesures et concentrations. 2004.

Report INERIS-DRC-05-56770-AIRE-n°0094-IZd: Trichloréthylène, tétrachloréthylène et chlorure de vinyle dans l'air : Sources, mesures et concentrations. 2005.

With regards these last three documents, due to the date that they were written, the reader should take into account possible updates to references, such as standards and documents illustrating air concentrations, etc.

Abroad:

Various documents focusing on methods of analysis and devices, with several guidelines regarding samples can be accessed from the OSHA website <http://www.osha.gov/>.

4. SAMPLING STRATEGY

4.1 DATA REQUIRED FOR THE SAMPLING PLAN

The sampling plan must be based on the documentary review, especially the site history, the conceptual diagram and what is known about the length of time populations spend in the premises.

A visit to the premises is also required. This will be used to identify the location's specific characteristics, such as certain parameters that influence the transfer of volatile pollutants from soil and/or groundwater to indoor air or the presence of other contaminant sources related to the indoor environment. All these parameters are covered in greater detail later (see section 4.2).

The context of the study and the comparison criteria selected to interpret the concentrations observed in the ambient air determine the detection limits to be obtained. These detection limits subsequently determine the choice of sampling methods and devices.

4.2 DESCRIPTION OF THE PREMISES

There are many parameters governing indoor air quality. So, detailed knowledge of the premises is required before defining the sampling plan and the implementation of sampling devices. This information collection stage relates in particular to the location, its immediate environment and the people who spend time there. These elements will also be needed to interpret the analysis results.

This knowledge is acquired through:

- the document review (plans, description of the building constructional features, the ventilation, etc.);
- a detailed inspection of the premises.

The key points to be collected about the indoor environmental conditions of the buildings are given in Annex 1. These include the description of the environment (presence of other potential contamination sources such as building materials, internal floor and wall coverings, furniture, etc.) and the activities of the occupants (for example, smoking, DIY activities, cleaning, etc.). A non-exhaustive list of the substances present in indoor air and their potential sources is given in Annex 2.

Any preferential pathways for pollutants from the soil and/or groundwater, such as pipe outlets (sinks, etc.), electrical ducts, lift shafts, chimneys etc. must also be described. Sampling points must not be located nearby.

4.3 TEMPORAL SAMPLING

4.3.1 Documentation for temporal sampling conditions

The variation in substance concentrations inside buildings over time due to the temporal development of many factors (heating, ventilations, activities at the premises, weather conditions, etc.) requiring careful selection of the sampling period based on any known influences of these factors along with those identified during the visit.

In order to assess concentrations in indoor air potentially contaminated by gas from the soil and/or groundwater, samples should be taken under normal occupation conditions as far as possible, and failing this, conditions that are as close as possible. These measurement conditions must be documented, not only during sampling but also on preceding days for some operations, and should include ventilation and heating conditions in the buildings, the buildings' internal and external temperatures, wind speed and direction, changes in barometric pressure and groundwater levels, etc. These factors influence the pressure difference between the soil and the buildings and are potentially instrumental in the transfer of soil gases to indoor air (soil gas pulled in).

Building depressurisation relative to the soil⁴ and thus the transfer of vapour to the indoor air is caused by:

- the heating system and an internal temperature higher than the external temperature ("stack effect" Waitz et al., 1996, US EPA, 2004);
- depressurisation using CMV type ventilation;
- the wind (Waitz et al., 1996, US EPA, 2004);
- a fall in barometric pressure (during a depressurisation, INERIS, 2006). A lack of accuracy with regards the time taken to rebalance the pressure between the ground and the atmosphere⁵, the barometric pressure will be taken over *at least* one full day before sampling;
- an increase in the groundwater level, leading to the transfer of air from the soil to the surface⁶.

⁴ The difference in pressure between the building and the soil can be measured during sampling, by installing a gas well (or other controlled opening) through the building's floor. The pressure difference measurements are accurate to about 1 Pascal (and even less with the latest devices), and are adequate enough in relation to the expected orders of magnitude (several Pascal). If possible, this measurement is used to check for building depressurisation relative to the soil within known orders of magnitude. However, it does not provide direct information about whether the on site measurement conditions are "normal" since there are no records of this pressure difference specific to the building in question representative of the sampling duration.

⁵ Advice of the INERIS expert incorporating on site observations from the field of mines and quarries: rebalancing varying from a few hours for sandy soils to one day for 5m of unsaturated zone.

⁶ As an illustration, a 1m increase in the groundwater level over 3 months (initially located at a depth of 5 m) corresponds to an excess air pressure in the soil of 0.25 atm discharged over 3 months, which is 280 Pa/Day ($0.25 \times 1.013 \times 10^5$ Pa/90 days), compared with 1000 Pa/Day (or 10 mb/Day) for a rapid barometric change in Europe (Wiedersich, 1996 p 111-113).

Consequently, in order to evaluate the transfer of soil gas to indoor air, *at least two annual measurement campaigns are recommended: one during the winter (with heating) and one during the summer;*

If the samples are not taken under the premises' normal occupation conditions (for example for organisational reasons), it is recommended that they are taken in conditions that are as close as possible, particularly in terms of ventilation (doors and windows usually open, re-simulation of air movements) and heating habits. It is preferable to ensure that no potentially counter contributing activities (population activities such as DIY, smoking, etc.) take place at the same time as the sampling, but if so, this must be documented(see Annexes 1 and 3⁷).

Samples must not be taken during periods of excess barometric pressure.

Weather data should preferably be collected from one or several mobile weather stations located on and/or near the site in question.

Fluctuations in the groundwater monitoring must also be recorded, particularly in the event that the groundwater is polluted or its static level is close to the "ground source".

4.3.2 Sampling time

Sampling times must be adapted to the study objectives and consistent with the manufacturer specifications for the devices used and the appropriate detection limits with regards the comparison criteria selected for interpreting the concentrations observed.

For example:

- for active sampling, the experimental standard XP X43-402 gives a time of 24 hours, which however, is not always feasible in homes. Ideally, in order to be representative of the space/time budget of the premises' occupants, the duration for active sampling time would be about 8 hours;
- for passive sampling, various sampling times can be recommended depending on the type of environment studied, the occupation conditions of the premises and the study objectives. For example, the LCSQA (2008) recommends a sampling time of 4.5 days (from Monday to Friday) in its monitoring protocols for formaldehyde and benzene in educational and early childhood facilities⁸ (places unoccupied at the weekend) while the protocols used for a study conducted into French housing (Observatoire de la Qualité de l'Air Intérieur, 2006) gives a sampling time of 7 days, in order to take the weekend period into account.

4.4 SPATIAL SAMPLING

4.4.1 Rooms to be studied: "sample" rooms

Preferred rooms, consistent with the conceptual diagram must be selected i.e. those which best combine the following characteristics:

- above the sources of soil and/or groundwater contamination;

⁷ Annex 1 also allows these activities to be recorded under normal conditions. This may be useful for interpreting any reports of smells and putting the measurement results into perspective.

⁸ For the moment, these protocols relate only to educational and early childhood facilities, but other enclosed public spaces may be addressed in subsequent versions.

- the premises' use;
- occupancy period;
- building constructional elements with influence on vapour intrusion (stairwells, lifts, service ducts, etc.)

At least one sampling point per "sample" room is recommended. This sampling point must be as representative as possible of the air breathed by occupants in the room, especially in terms of vapours rising from the soil and/or groundwater. So the air sample should generally (and unless there is a specific argument) be taken in the centre of the room at least 1 m from the walls/ceiling, at a point level with the respiratory tracts, of for example, approximately:

- 1.5 m from the ground for an adult standing up;
- 1.0 m from the ground for an adult sitting down (for offices in particular) or 0.5 m from the ground for a lying position (for bedrooms);
- 0.2 m for a child in the case of a nursery.

Areas of the room that are heavily exposed to air currents, such as areas near doors and windows and areas near heat sources should be avoided. Likewise, areas close to known sources of indoor environmental pollution for the analytes (painting activities, cleaning product storage, etc.) in the same room should be avoided.

In the event that there are preferential pathways in the same room (sinks, electrical shafts, heating pipes, etc.), the sample point will be chosen with particular care. These sampling locations should not be used initially⁹ for the overall characterisation of the quality of breathing air (except in the case of the extended presence of occupants nearby).

In addition, for passive sampling, it is recommended that two devices are positioned simultaneously. Similarly, if the context justifies, it may be wise to perform two simultaneous measurements¹⁰ for some sampling points.

4.4.2 Other measurement points: "local non impacted environment" points

In order to interpret the results, the ambient air quality of the "local non impacted environment" will be characterised in parallel, outside the influence of any impact of volatile substance emissions from the soil and/or groundwater. This means additional indoor and outdoor field measurements.

"INDOOR NON IMPACTED ENVIRONMENT"

A sampling point should be created inside the building or group of buildings¹¹, which is, as far as possible in a room that will be used for the same type of activity and with the same type of layout as the "sample" rooms but (on a horizontal and vertical planes) removed from the "sample" rooms. This sampling must be performed following the same recommendations as those given in paragraph 4.4.1.

⁹ Targeted sampling at these locations may be performed within the specific framework of research into transfer pathways, using field instruments: PID, FID, chromatography. The results are only indicative and detection limits are often high (the detection limit of some PIDs is in the order of a few ppb), particularly with regards the interpretive framework provided.

¹⁰ Without systematic analysis of the replicate if the first measurement is valid.

¹¹ When required, "local non impacted environment" sites must be found by using the same principles at a greater distance. The number of on- and off- site points will be adjusted according to the scale of the site.

“OUTDOOR NON IMPACTED ENVIRONMENT”

Since concentrations inside a building are likely to be influenced by those in the outdoor air, *at least* one sampling point should be created outside the building at a point where the impact of the soil/groundwater pollution is estimated to be minimal (preferably in an upwind and/or upstream location). To define the contribution of outdoor sources, the experimental standard XP X43-402 specifies that a sample must be taken at a reasonable distance from the building's wall, at a minimum of 2m and a maximum of 5m, taking into account the location of fresh air inlets.

It is recommended that “local non impacted environment” measurements are taken in parallel with those taken in the "sample" rooms, over the same period and using the same method.

The room description and sampling conditions must be documented in the same way as for the "sample" rooms.

In the event that abnormal or significant concentrations are observed in terms of the selected interpretation criteria, it may be necessary to conduct a campaign to confirm the measurements for the sample rooms and the “local non impacted environment”.

5. SAMPLING DEVICES AND IMPLEMENTATION

5.1 INTRODUCTION

There are several available sampling procedures:

- trapping compounds from the air to be sampled on solid supports (adsorbent cartridges) by pumped sampling (active sampling) or diffusive sampling (passive sampling);
- sampling of raw air in a Canister (stainless steel vessel treated internally to prevent the compounds being adsorbed into the walls);
- automatic sampling by analytical system (BTEX analysers, *online* analysers for other VOCs).

Due to the specific nature of each site studied and the associated substances and devices, only general information is given hereafter. The reader can refer to the previously mentioned standards on specific substances (chapter 3). In addition, depending on the analytes, interference phenomena can occur, thus disrupting the sample (for example, light for photo-sensitive compounds, ozone during aldehyde sampling, moisture for other compounds, etc.). Expertise will be required to take into account all the precautions against these interference phenomena during measurements. Some of these interferences are indicated in the following paragraphs.

This chapter does not cover the safety measures that should be taken for both operators and populations.

5.2 ACTIVE (PUMPED) SAMPLING WITH ADSORBENT DEVICE

5.2.1 General principle

Using a pump the gaseous compounds are drawn through a device containing one or several adsorbent beds. Depending on the compounds targeted, the adsorbent may be impregnated with a derivatizing agent (case of aldehydes). Once the sampling has finished, the trapped compounds are extracted (thermal desorption, chemical desorption, etc.) for analysis.

The aforementioned standards and INERIS and LCSQA documents (chapter 3) present the different measurement techniques available for certain specific substances and can therefore be used as supporting documentation.

5.2.2 Presentation of several types of devices

Several types of devices are given as examples depending on the test substances, but the reader can also refer to the aforementioned references and any updates.

For Volatile Organohalogen Compounds

For chlorinated substances, the most suitable devices are Carboxen (carbonated devices) due to their significant absorption capacity combined with strong hydrophobic properties. A thermal desorption is then performed. Tenax TA (polymer based resin) is another adsorbent with interesting characteristics in terms of these substances.

There are also adsorbent mixtures: Carbopack C and B, Carbosieve SIII (Air Toxic, CT300...), developed specifically for sampling chlorinated substances. Saturation of chlorinated compounds on these devices is quite high. They are well suited for analysing low concentrations.

Carbon molecular sieve type devices (Carbosieve SIII, Carboxen 1000, Carbosphere...) are recommended for "light" compounds (chloromethanes and vinyl chloride). However, for "heavy" compounds (above dichloroethane) graphitized carbon type devices (Carbopack B, Carbopack X, Carbotrap B Carbograph 4 or 5...) are more suitable.

Furthermore, several suppliers offer tubes specifically for PCE, for areas with particular concentrations. Activated charcoal, although not ideal as an adsorbent for chlorinated species, is also frequently used.

It should be noted that the devices' adsorption capacities are dependent on several factors, including the presence of other organic compounds (competition between compounds with regards the adsorbent). In addition, moisture reduces the adsorption effectiveness; in this case, a water separator must be installed upstream of the system.

Details on implementation activated charcoal devices are given in ASTM D3686-08. Furthermore, the ISO 16000-6 standard contains a precise definition of the sampling flow rate, sampling volumes and desorption temperatures for Tenax TA. Similar informations can be found in the British standards on measurements in working environments (MDHS 72, 80, 88 and 96). The conditions of use for the tubes are specified by tube type, but this regulatory framework is different to that for contaminated soils.

For BTEX

For BTEX, Graphitized Carbon Blacks with an average specific surface area in the order of 100 m²/g are used: Carbotrap, Carbopack B, Carbopack X, Carbograph 4. These adsorbents have the advantage of being slightly hydrophilic, allowing samples of large volumes of air to be pump, even in the presence of high relative humidities, without trapping significant quantities of water.

Tenax, widely used in the 1990s is no longer recommended for benzene because the saturation is very low. Furthermore, it is a polymer type adsorbent which degrades over time and with successive thermal desorptions, which causes an increase in the level of blanks and it cannot therefore be used to measure very low concentrations.

For information, Annex 4 presents several devices depending on the analytes.

5.2.3 Sampling equipment and procedure

If there is a standard available for the substances studied, the sampling equipment must be selected according to the recommendations in the *ad hoc* standard. In particular, compliance with the conditioning instructions for certain devices before use is recommended (NF EN ISO 16000-6 for example).

Active devices require the installation of a sampling pump (Figure 1), air is drawn through the device by the pump connected downstream. The device must be connected to a pump using inert hose so that the whole system is as “airtight” as possible. Indeed, hoses can be the source of leaks (if they are porous) or potential contamination (if they come undone). In addition to the hose material itself, the connections must also be airtight. For example, for Volatile Organohalogen Compounds, the use of stainless steel is recommended while silicon and PVC must be avoided. Some authors recommend HDPE and PP as material.



Figure 1: Example of active sampling

Any use of adhesives, glues or greases that may emit Volatile Organohalogen Compounds is prohibited.

Current standards recommend ensuring that, once assembled, the sampling system can provide a constant flow rate for the entire sampling period.

Pumps must be calibrated using the same type of device as that used for sampling and at the desired flow rate, consistent with the detection threshold and the specific properties of the device given by the manufacturer.

A calibration check must also be performed at the end of the sampling period. The pumps are usually battery operated and can lose their charge during the sampling; so the flow rate once the sampling has been completed must be known in order to estimate the average sampling flow rate.

The sampling procedure to be followed is:

- Firstly connect the pump to the sampling device using an inert hose. This connection must be as short as possible;
- Open the sampling devices which is closed initially to begin sampling;
- Start the pump, then on the field data sheet note the start time, the pump number, the sample number, the flow rate, the device number... (the person taking the samples is forbidden to use any felt-tip pens or markers with vapours that may contaminate the samples);
- Stop the pump at the end of the sampling period, note the time. The sampling period and the pump flow rate will be used to calculate the volume sampled and be sent to the laboratory in order to have the results as a volume concentration;

- Disconnect the device from the sampling line, then re-close both ends of the device using suitable protection.
- Check the pump flow rate (for information, the variation between the initial and final flow rates should not exceed 5%).

5.2.4 Storage and transport

The storage conditions before use (room temperature or refrigeration at 4°C) and storage times can vary depending on the sampling device used and the analytes.

After sampling, the hermetically sealed devices must be stored in a cool (around 4°C) and dark place.

If the samples are to be transported to a laboratory for analysis, any non-refrigeration period should be as short as possible.

In all cases, storage and transport times should be compatible with the non-denaturing of any substances collected.

5.3 ACTIVE SAMPLING BY NATURAL VACUUM IN CANISTER

5.3.1 General principle and sampling equipment

The Canister (Figure 2) is cleaned, the blank level is checked, then it is placed under a vacuum before being used on site. Under these conditions, opening the Canister valve on site, allows the air to enter through a natural vacuum, where the filling speed depends on the veriflow valve setting (control valve for filling the Canister).

In the specific case of indoor air measurements (potentially in busy places), their shock resistance, the lack of noise for inhabitants (no pump) and the fact that they do not require a power supply for several hours are some of the advantages compared with the sampling pumps needed for the devices presented above.



Figure 2: Canister

Canisters also have the following advantages:

- a single canister can be used for several analyses (of the same compound and different compounds);
- the available volume means analytical constraints related to a concentration which is too high or too low (which causes problems with adsorption devices) can be avoided.

However, due to the way in which they work, Canisters must be used on site shortly after their preparation (especially once they are placed under a vacuum) and must therefore also be analysed quickly after sampling, which means certain logistical constraints compared with other devices. Furthermore, both temperature and altitude influence the rate setting. The laboratory must therefore be informed of exceptional temperature or altitude conditions.

5.3.2 Storage and transport

The aforementioned standards and INERIS documents (chapter 3) can be used as supporting documentation on this point.

The storage conditions correspond to ambient (temperatures that are too low or too high are not recommended).

5.4 PASSIVE SAMPLING

In the context of contaminated sites and soils, passive sampling is not usually the preferred method for taking samples. While this type of device provides an opportunity to take samples over a longer time period than active sampling (in the order of several days), therefore giving an improvement in the representativeness of the measurements, it can be more "restrictive" for the occupant. Indeed, in particular, the occupant is required to provide information about all counter contributing activities in terms of soil gas and/or groundwater during the sampling period over several days as opposed to several hours for an active sampling.

5.4.1 General principle

Samples are taken using diffusion through a porous membrane (diffusive body) to a trapping surface. This sampling does not involve any pumping or drawing in of air. When the passive sampler (diffusion tube) is exposed, a concentration gradient is established between the air outside the tube and the air in contact with the adsorbent surface. This concentration differential will lead to a diffusion of the compound through the porous membrane, from the most concentrated zone (ambient air) to the adsorbent surface (cartridge) where it is captured and stored.

5.4.2 Presentation of several types of passive samplers

The standards and documents given in chapter 3 present several types of passive samplers.

This type of device (Figure 3) is available in particular for BTEX, chlorinated compounds, aldehydes (trapping medium impregnated with a derivatizing agent, like active sampling), etc.



Figure 3: Example of passive sampler

5.4.3 Sampling equipment and procedure

If there is a standard available for the test substance, the sampling equipment must be selected according to the recommendations in the *ad hoc* standard. In particular, compliance with the conditioning instructions for certain devices before use is recommended. The LCSQA documents given in chapter 3 also constitute supporting documentation.

This type of device has the advantage of being simple to implement, not requiring a pumping system and being very small.

This type of device is generally comprised of an adsorbent cartridge and a diffusive body. Sampling begins at the moment the adsorbent cartridge is taken out of its hermetically sealed, protective tube and placed in the diffusive body. Once sampling is completed, the adsorbent cartridge must be replaced in its protective tube and hermetically sealed.

When handling, neither the diffusive body, nor the cartridge must be touched with the fingers. Any use of adhesives, glues or greases that may emit Volatile Organic Compounds is prohibited.

The start and end date and time of the tube's exposure must be filled. Depending on the type of device used, recommendations for the sampling time may vary, but are generally around 7 days. As previously indicated, this period must be adapted to the study's objectives¹².

Furthermore, the average temperature relative to the exposure time of the device must be recorded since the diffusion flow rate is dependent on this data. The calculation for the concentrations measured must take into account the flow rate correction depending on the temperature.

5.4.4 Storage and transport

The storage conditions before use (room temperature or refrigeration at 4°C) and storage times can vary depending on the sampling device used and the analytes.

After sampling, the hermetically sealed devices must be stored in a cool place (away from light depending on the analytes).

If the samples are to be transported to a laboratory for analysis, any non-refrigeration period should be as short as possible.

In all cases, storage and transport times should be compatible with the non-denaturing of any substances collected.

5.5 BLANKS (FIELD AND ANALYTICAL)

In the case of substances sampled on devices/deferred analysis, in order to verify the absence of contamination on the sampling devices during their transport and storage, a "field blank" (sampling device belonging to the same batch of devices as those used for sampling) must be implemented and subjected to exactly the same operations as the devices used for the sampling, except that the air does not penetrate the device. In the case of active sampling, every field measurement campaign must include at least one field blank and in the case of passive sampling, at least 2 field blanks (1 indoor and 1 outdoor).

At least, one analytical blank (or batch blank) will also be created; this is a device kept at the laboratory that has not been subject to any processing (field transport, sampling) and which belongs to the same batch of devices as those used for the sampling. At least 1 analytical blank (same batch of devices conditioned) is to be implemented, in the event that the devices are not conditioned/cleaned before use.

The field and analytical blanks will then be analysed using the same procedure as the exposed devices.

The associated analysis results must be included in the measurement campaign report and integrated into the data validation process. In the case of analytical blanks, the residual mass measured on the media should be subtracted from the mass measured on the sample device. With regards field blanks, the value of the field blank should be checked and must be less than 10% of the sample value. If this is not the case, the measurement results must be considered with caution.

¹² In the case of measurements in a home, a 7 day sampling period is recommended, however, in an office or school, a 5 day sampling period (working week) is recommended.

5.6 OTHER SAMPLING TYPES

The case of continuous indoor air quality monitoring is not covered here. For information, elements are available in two INERIS reports (2008, 2009) dealing with tetrachloroethylene. The 2009 report states in particular that a continuous measurement device for tetrachloroethylene has been tested in order to obtain information quickly on (tetrachloroethylene) concentrations present in dry cleaning facilities and adjoining premises, especially in accommodation located on the upper floors. This type of device provides dynamic monitoring of concentration levels using a response time for the device of a few minutes at most. Such measurement devices are particularly interesting with regards estimating the acute exposure of populations or the study of emission sources. A summary of the devices available on the market has been created, referencing the measurement principles, their advantages and disadvantages compared with the constraints identified in relation to the problem (varied concentration ranges, weight, selectiveness, ease of implementation, etc.) as well as their cost (INERIS, 2009).

6. MEASUREMENT CAMPAIGN REPORTS

The investigation report must contain the following information *as a minimum*:

- a situation map for each sampling (including those performed outside the buildings) with photographs of each one;
- the survey forms from the visit (see Annex 1);
- the sample sheets (see Annex 3);
- the description of the sampling procedure, specifying the normative references where they exist or other reference documents;
- the measurement results (samples and blanks);
- observations that may have influenced the samples or the subsequent analyses as well as, if necessary, the analysis of any identified issues.

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8. ANNEXES

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Annex 2	Annex for information: table of substances and potential sources of indoor air contamination (excluding contamination from soil gases)	3
Annex 3	Example of an active sampling sheet for indoor air in connection with a potential soil and/or groundwater source	1
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ANNEX 1

Questionnaire "Information on the building, the indoor activities
and measurement conditions"

Building name:	Date:
A questionnaire covering the entire site studied To be completed by the operator with the assistance of the owner or site manager	
1. Nearby outdoor area (500 m radius)?	
1.1 Presence of groundwater	
Yes	
No	
If yes, please specify the depth range:	
Further information (known contamination, etc.):	
1.2. Road situation?	
Motorway.....	
Very busy road.....	
Moderately busy road.....	
Quiet road.....	
1.3 Location of the monitored site	
Urban area.....	
Peri-urban area.....	
Industrial area.....	
Rural area.....	
1.4 Presence of an industrial area (1km radius)?	
Yes	
No	
If yes, please specify the nature of the surrounding industrial activities:	
.....	
1.5 Potential sources of surrounding pollution	
Industry (specified in 1.2.).....	
Parking	
Cooling tower.....	
None.....	
1.6 Nature of previous activity on the site? (industrial or not)	
.....	
2. General description of the building	
2.1. Year of construction	
2.2. Number of floors	
2.3. Number of rooms	
2.4. Building use:	
Offices	
Residential.....	
Mixed: please specify.....	
Nursery.....	

School/pre-school.....	
Other: please specify.....	

2. General description of the building	
2.5. Construction type	
Breeze blocks.....	
Wood.....	
Other: please specify.....	
2.6. Existence of adjoining premises	
Crawl space.....	
Underground parking.....	
Basement.....	
Cellar.....	
Other: please specify.....	
2.7. Any significant events that have occurred in the building	
Fire.....	
Other: please specify.....	
2.8. Recent site renovation (under 6 months)?	
Yes.....	
No.....	
2.9. Drainage type	
Collective.....	
Private.....	
2.10. Primary heating energy	
Gas.....	
Fuel oil.....	
Electric.....	
Other: please specify.....	
If boiler: please specify the location.....	
If oil tank: please specify the location.....	
2.10.1. Frequency with which additional heating is used in winter	
Always.....	
Frequently.....	
Occasionally.....	
Never.....	
2.10.2. Additional heating type	
Fuel oil.....	
Electric.....	
Other: please specify.....	
2.11. Presence of a specific ventilation/air-conditioning system (mechanical extraction, natural ventilation shaft)	
Yes.....	
No.....	
2.12. Presence of a garage adjoining the building?	
Yes.....	
No.....	

No air inlets



3. Description of the room investigated	Name:.....	Control <input type="checkbox"/> Sample <input type="checkbox"/>
Complete one questionnaire per room studied for this section		
3.5. Nature of the heat distribution elements		
Radiators/convectors		
Ground		
Air conditioning		
3.5.1. Can the temperature settings be changed by the occupants?		
Yes		
No		
3.6. Is there a combustion source in the room?		
Stove		
Fireplace		
Range		
Water heater		
Other: please specify		
3.7. Is there a specific ventilation system in the room?		
Yes		
No		
If yes -> 3.7.1 (If no -> question 3.8.)		
3.7.1. What type of specific ventilation system?		
Natural ventilation (grilles or shafts).....		
Controlled mechanical ventilation		
No specific ventilation system.....		
3.7.2. What is the condition of the air vents or air blowers?		
Good		
... ..		
Average.....		
. . .		
Poor		
3.8. Window type: can be opened?		
Yes		
No		
3.8.1. Glazing type		
Single		
Double		
Triple.....		
3.9. Preferential pathways within the room		
Toilets, sinks		
Pipes, plumbing.....		
Electrical ducts		
Other pathways		
3.9.1. Inspection of the room's walls and sub-slab (cracks...)		
Good state.....		
Poor state.....		
No easy visual access to the sub-slab		
3.9.2. Thickness of the sub-slab		
Please		

specify:.....	
3.10. Storage of chemicals/cleaning products/hydrocarbons in a neighbouring room?	
Yes.....	
No.....	

4. Activity and observations ¹³ of occupants before and during sampling and under normal conditions			
4.1	Are the measurements taken under the premises' normal occupation conditions		
	Yes		
	No		
4.2.	Population occupying the sample room	Bef	Dur
	Children.....		
	Newborns.....		
	Adults		
	Elderly people		
4.2.1.	Normal times of activity in the room		
	Approximate times spent inside the room		
		
	Total time spent inside the room		
4.3.	Complaints or descriptions relating to smells or problems?	Bef	Dur
	Yes		
	No		
4.4.	Frequency with which the room is cleaned		
		
4.4.1.	Types of products used (bleach, wax...)		
		
4.4.2.	Storage location of cleaning products used		
		
4.4.3.	Were the premises cleaned during the sampling period or the day before?		
	Yes		
	No.....		
4.5.	Were there any specific activities that took place during sampling?	Bef	Dur
	Gluing, use of markers.....		
	Leisure activities (drawing, painting, ...)		
	Mechanical activities.....		
	DIY		
	Cooking food		
	Gardening (weed killer...)		
	Other: please specify.....		
4.6.	Presence of smokers / ashtrays in the sample room?		Dur
	Yes		
	No.....		
4.7.	Presence of a photocopier / printer?		
	Yes		
	No.....		
4.8.	Use of insecticides, insect repellent or moth repellent in the room?	Bef	Dur
	Yes		
	No.....		
4.9.	Lifestyle		Dur
	Barbecue use.....		
	Storage of beauty products, soaps, nail varnish remover.....		
	Perfumes, air fresheners.....		
Dur: during sampling; Bef: over the preceding few days; Nor: under normal conditions.			

¹³ To be distinguished from the sampler's observations reported on the sampling sheet (Annex 1).

4. Activity and observations ¹⁴ of occupants before and during sampling and under normal conditions			
4.10.	Was there an unusual event during sampling (in the premises or nearby outside (fire, generator started, etc.))		
	Yes		
	No.....		
5. Equipment activity during and before sampling			
5.1.	Number of combustion appliances used simultaneously in the room studied		
5.1.1.	Are they all connected to the outside?	Bef	Dur
	Yes		
	No.....		
5.1.2.	Usage frequency		
	Continuous.....		
	Several times over a measurement period.....		
	Once over a measurement period.....		
	Never.....		
5.1.3.	Type of fuel used in combustion appliances	Bef	Dur
	Gas		
	Oil		
	Wood		
	Coal		
	Oil cooler.....		
	Other		
	None (additional heating not used).....		
5.2.	Have other combustion sources been used (candles, incense, cigarettes, etc.)	Bef	Dur
	Yes		
	No.....		
5.3	Ventilation		
5.3.1.	A working VMC?	Bef	Dur
	Yes		
	No.....		
5.3.2.	Frequency with which windows are opened (specify if necessary)		
	Continuously.....		
	Several times over a measurement period.....		
	Once over a measurement period.....		
	Never.....		
5.3.2.	Frequency with which doors are opened (specify if necessary)		
	Continuously.....		
	Several times over a measurement period.....		
	Once over a measurement period.....		
	Never.....		
5.4	Heating:	Bef	Dur
5.4.1.	Heating control (slider)		
5.4.2.	Temperature in the room		
Dur: during sampling; Bef: over the preceding few days; Nor: under normal conditions.			
6. Outdoor activity during the sampling			
6.1.	Construction site near the room during sampling		
	Yes		
	No.....		
	If yes, brief description		
		

¹⁴ To be distinguished from the sampler's observations reported on the sampling sheet (Annex 1).

ANNEX 2

Annex for information: table of substances and potential sources of indoor air contamination (excluding contamination from soil gases)

The table below lists a certain number of sources for different compounds and families of compounds for which most of the information is derived from data from the Observatoire de la Qualité de l'Air Intérieur (OQAI)¹⁵ and therefore not systematically related to substances currently observed on contaminated sites and soils.

Family	Sub-family	Example of compound	Potential sources
Combustion gas			
		Carbon monoxide (CO)	External urban pollution including car traffic Heating and hot water systems
Inorganic gas			
		Ammonia	Human presence, tobacco smoke, cleaning products
		Nitrogen oxide (NOx)	External urban pollution including car traffic Burning gas
		Ozone	Old photocopiers (the newer ones are fitted with an ozone filter)
Semi-volatile organic compounds (SVOC)			
	Polycyclic aromatic hydrocarbons		
		Naphthalene	Residential heating systems Moth repellent Plasticizer additives
	Polybrominated diphenylether (PBDE)		
			Flame retardants in plastics
	Pesticides		
		Biocides	Lawn treatments
		Lindane	Wood preserver
		Pentachlorophenol	Wood preserver
		Pyrethrin	Insect control, plant treatments
	Phthalates		
		DEHP	Plasticizers: perfumes, shower curtains,... Food containers
Volatile organic compounds (VOC)			
	Organic acids		
			Wall and floor coverings, paints, adhesives, insulation, furniture, etc.
	Alcohols		
		2-Ethylhexanol	Aqueous solvents
		Alkylphenols	Plasticizers
		Other alcohols	Wall and floor coverings, paints, adhesives, insulation, furniture, etc. Felt pens

¹⁵ Links: <http://www.air-interieur.org/oqai.aspx?idarchitecture=8&Country=> and <http://www.air-interieur.org/oqai.aspx?idarchitecture=7&Country=>.

Family	Sub-family	Example of compound	Potential sources
Volatile organic compounds (VOC)			
	Aldehydes		
		Acetaldehyde	Photochemistry Rough wood panels, chipboard, insulation Cigarette smoke Photocopiers
		Acrolein	Exhaust emissions Cigarette smoke, burning and heating animal and vegetable fats
		Benzaldehyde	Solvent-borne paints, treated wood flooring Photocopiers
		Formaldehyde (AFSSET, 2007)	Photochemistry Chipboard, MDF, pressed wood panels, rough wood panels, Solvent-borne paints, materials containing formaldehyde based compounds (binders or urea formaldehyde glues) New books and magazines Everyday products (cleaning and treatment products, body and cosmetic hygiene products) Burning, cigarette smoke Photocopiers
		Hexaldehyde	Chipboard and rough wood panels, solvent-borne paints, New books and magazines, wood treatment products (aqueous phase)
		Isobutyraldehyde	Photocopiers
		Butyraldehyde	Photocopiers
		Isovaleraldehyde	Treated wood flooring, chipboard panels
		Valeraldehyde	New books and magazines Solvent-borne paints, chipboard panels
	Ketones		
			Wall and floor coverings, paints, adhesives, insulation, furniture, etc.
	Esters		
		2-butoxy ethyl acetate	Hydrophilic and lipophilic solvents, paints, adhesives, inks, varnishes, diluents
		Butyl acetate	Cosmetics, cleaning products Wood flooring, solvent
	Glycol ethers		
		1-methoxy-2-propanol	Lacquers, paints, varnishes, hydrophilic and lipophilic solvents, adhesives, inks Soaps, cosmetics, cleaning products
		2-Butoxyethanol	Hydrophilic and lipophilic solvents, paints, adhesives, inks, varnishes, diluents, wood treatments, silicon sealant
		2-Ethoxyethanol	Cosmetics, cleaning products, fungicides, weed killer Paints, lacquers, varnishes

Family	Sub-family	Example of compound	Potential sources
Volatile organic compounds (VOC)			
	Aromatic hydrocarbons		
		1,2,4-Trimethylbenzene	Petroleum solvents, fuels, tar Varnish
		Benzene (AFSSET, 2008)	Fuels Cigarette smoke Furniture, building and decorating products, DIY products
		Ethylbenzene	Exhaust emissions Waxes
		Styrene	Plastics, insulating materials Fuels Cigarette smoke
		Toluene	Fuels Paints, varnishes, adhesives, inks, carpets, rugs, silicon sealant
		Xylene	Paints, varnishes, adhesives Insecticides
	Halocarbons		
		1,1,1-trichloroethane	Adhesives
		1,4-dichlorobenzene	Moth repellent, air fresheners
		Organophosphorus compounds	Insect control, plant treatments
		Tetrachloroethylene	Emissions from dry cleaning processes
		Trichloroethylene	Paints, varnishes, adhesives Metal degreasers
	Aliphatic hydrocarbons		
		Cyclohexane	Paints, varnishes, adhesives
		Decane	White spirit, wax, wood varnish, floor cleaner Carpets, rugs, floor adhesives
		n-decane, n-undecane	White spirit, wax, wood varnish, floor cleaner Carpets, rugs, floor adhesives
	Terpenes		
		alpha-Pinene	Air freshener, home fragrances, cleaning products
		Limonene	Air freshener, home fragrances, wax, floor cleaner

ANNEX 3

Example of active sampling sheet for indoor air in connection
with a potential soil source

Date :		Code de gestion:				
SITE (dont commune, département):		ECHANTILLON Nom		Référence(s)		Heure : déb. pompage
REALISATION DES PRELEVEMENTS:						
Entreprise:		Département		Signature		Heure : fin pompage
Opérateur:						
Contrôleur:						
MODE DE PRELEVEMENT	Tube actif:				CANISTER	
	Type :				Veriflow	
	POMPE					
	hauteur (m):					
CONDITIONNEMENT/CONSERV		Débit (ml/mn)	Durée(s) pompage	Volume(s) pompé(s) (Pompe	au froid? à l'obscurité?
Type de tube		Pression début	Pression fin	durée pompage	débit	
CANISTER						
LABORATOIRES DE DESTINATION			moyen transport	temps transport		
Autre laboratoire 1						
Autre laboratoire 2						
DESCRIPTION ECHANTILLON						
Couleur: oui non		Description:			Température moyenne : °C	
Odeur		Type d'odeur				
1: sans		01 : "acide"/phéni		05: fraîche		09: mat. fécales
2: faible		02: ammoniacque		06: H2S		10 : solvants
3: moyenne		03: aromatique		07 : huile minérale		11: terre
4: forte		04: chlorée		08: marée		12 : autre (à préciser)
PARAMETRES PHYSICO-CHIMIQUES			CONDITIONS ENVIRONNANTES			
PID/FID (ppm) _____			Type de temps (vent, soleil, pluies):			
% oxygène (vol) _____			- Aujourd'hui:			
% CO2 (vol) _____			- Jours précédents:			
% CH4 (vol) _____			Milieu (urbain,...):			
% CO (vol) _____			Revêtement sol:			
H2S (ppm) _____			Vide sanitaire, cave?			
Autre: _____			Mode ventilation/expos° vent:			
			Remarque, croquis, réf. photo:			
FICHE SIGNALÉTIQUE DE PRÉLÈVEMENT D'AIR ATMOSPHERIQUE						

ANNEX 4

Annex for information:
types of media according to the targeted compounds (INERIS, 1996)

Type	Dénominations commerciales	Applications	Porosité	Granulo. (mesh)	Surface spécifique (m ² /g)	Densité (g/ml)	Stabilité thermique (°C)	Affinité pour l'eau	Désorption
Charbons actifs	Coconut Charcoal (Anasorb CSC)	Composés non polaires (acétone, benzène, chlorure de vinyle ... (bp de -60 à 50°C))	μ	20/40	500 à 2000	0,4	220	hydrophile	Solvant ou Thermodés.
	Petroleum Charcoal								
Noirs de carbone graphitisés (GBC)	Carbotrap (B)	C ₃ - C ₁₂ (bp >75°C, amines, cétones, aldéhydes, composés apolaires ...)	NP <i>(sauf Carbotrap X et Carbopack X qui sont poreux)</i>	20/40	100	0,36		Hydrophobes <i>(les Carbotrap X et Y sont les plus hydrophobes)</i>	Solvant ou Thermodés.
	Carbotrap C	C ₈ - C ₃₀ } Alkyls benzène jusqu'à PCB > C ₂₀ C ₃ - C ₅ C ₁₂ - C ₂₀		20/40	10	0,72			
	Carbotrap F			20/40	5	0,66			
	Carbotrap X			20/40	250	0,41			
	Carbotrap Y			20/40	25	0,42	> 400		
	Carbopack B (Anasorb GCB1, Carbograph 1)			C ₃ - C ₁₂ (bp >75°C, amines, cétones, aldéhydes, composés apolaires ...)	60 - 80	100	0,36		
	Carbopack C (Anasorb GCB2, Carbograph 2)	C ₈ - C ₃₀ (alkyls benzènes)		60 - 80	10	0,72			
	Carbopack F	> C ₂₀		60 - 80	5	0,66			
	Carbopack X	C ₃ - C ₅		60 - 80	250	0,41			
	Carbopack Y	C ₁₂ - C ₂₀		60 - 80	25	0,42			

M : macropores m : mésopores μ : micropores NP : non poreux

Type	Dénomination commerciale	Applications	Porosité	Granul. (mesh)	Surface spécifique (m ² /g)	Densité (g/ml)	Stabilité thermique (°C)	Affinité pour l'eau	Désorption	
Les polymères poreux	Tenax TA	C ₃ - C ₂₆ , 100 < bp < 400°C, apolaires avec bp > 100, polaires avec bp > 150	M	60/80	35	0,25	350	Hydrophobes	Solvant, T°	
	Tenax GR	C ₇ - C ₁₀ , 100 < bp < 450°C, alkyls benzènes, PAH, PCB, Alcools lourds	(720 Å)	60/80	35	0,55	350		Thermique	
	Chromosorb 101	Ex : Organométalliques (Hg)	M (3500Å)		30		275	Hydrophobes	Thermique	
	Chromosorb 102	Ex : C ₆ - C ₁₂ , pesticides chlorés, pd oxygé.	M (85 Å)		300 - 400		250			
	Chromosorb 103	Ex : amines	M	40 - 80	15 - 25		275			
	Chromosorb 104		M		100 - 200		250			
	Chromosorb 105	C ₆ - C ₁₂	m		600 - 700		250			
	Chromosorb 106	50 < bp < 200°C	m		700 - 800		225			
	Chromosorb 107		m		400 - 500		225			
	Chromosorb 108		M		100 - 200		225			
	Amberlite XAD - 1	Composés non polaires : hydrocarbures halogénés, pesticides, herbicides, aldéhydes, PCB, composés azotés, dioxines	Composés polaires	m (90) m (50) m (90) M (235)	20 - 50	350 725 450 140		200 200 200 200	Moyennement hydrophobes	Solvant
	Amberlite XAD - 2									
	Amberlite XAD - 4									
	Amberlite XAD - 7									
	Amberlite XAD - 8									
	Amberlite XAD - 9									

M : macropores m : mésopores xlm : micropores

Type	Dénomination commerciale	Applications	Porosité	Granulo. (mesh)	Surface Spécifique (m ² /g)	Densité (g/ml)	Stabilité thermique (°C)	Affinité pour l'eau	Désorption
Tamis Moléculaires carbonés	Carbosieve G								
	Carbosieve S - II	C ₂ - C ₅ (- 60°C < bp < 60° C ; cétones).	M (15 à 40 Å)	60/80	820	0,61	> 400	hydrophobes	
	Carbosieve S - III (Anasorb CMS et 747)								
	Carboxen 563 (Ambersorb XE-340)								
	Carboxen 564 (Ambersorb XE-347, 747, Anasorb CMS)	C ₁ - C ₅	M (15 à 40 Å)	20/45	510	0,53			
	Carboxen 569								
	Carboxen 1000 (Anasorb CMS, Carbosphere, Anasorb 747, porosieve, spherocarib)	Oxyde d'éthylène, CS ₂ , CH ₂ Cl ₂ , CH ₃ Cl, méthanol, éthanol, acétone, cétones (- 30°C < bp < 150° C)	M	20/45	485	0,58	> 400	Très hydrophobes	Solvant ou Thermodés. (300 à 400°C)
	Carboxen 1001	Adapté au prélèvement de petit volumes et de composés très volatils							
	Carboxen 1002								
	Carboxen 1003								
	Carboxen 1004								

M : macropores m : mésopores μ : micropores NP : non poreux