

## **A method for assessing indoor air quality in office buildings**

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### **ABSTRACT**

Health complaints related to indoor air quality are increasingly common. Hence, it is well known that environmental factors act on the emergence of certain illnesses. Today, many people consider that their health problems are due to a specific building environment. Chemical, microbiological and particulate pollutants are of interest, but only as one category of potential factors. Other risk factors have been identified ranging from the individual's sex and health status to psychosociological issues and buildings characteristics.

Based on French and international research experiences, works is being conducted in order to produce a multidisciplinary audit method in order to classify office buildings in terms of indoor air quality on given criteria.

The investigation protocol uses walk through survey, questionnaires, measurement of indoor climate factors and comparison with threshold values. In addition, the protocol gives a strategy when solving indoor air problems. The visual inspection list is used to collect information on the building, its equipments, its operation conditions and potential pollutant sources. The aim of the questionnaire is to know the prevalence of health and comfort problem as well as environmental conditions and other aspects of the office environment of the building occupants.

### **I. INTRODUCTION**

Indoor air quality (IAQ) has becoming a major question because occupants of buildings, nowadays, are more and more concerned by their environment and because their demands for acceptable "health", including physical, mental and social well being, are growing as health conditions have been improved.

The study of the exposure schemes shows that people spend more than 80% of their time indoor and even more when it concerns children or elderly. As a result, occupant exposure to atmospheric pollution is mostly dependant of the indoor environment (office buildings, houses, public and private buildings for collectif use, undergrounds, transportation ...).

Owing to poor air quality, a large number of persons suffers from symptoms that can be attributed to the building they live in. A wide types of diseases (Legionnaires'disease, allergic rhinitis, humidifier fever, lung cancer ...), symptoms (irritation of skin, mucous membranes in the eyes, nose and throat, headache, tiredness and malaise or Sick Building Symptoms) or discomfort (cold or high temperature, stuffy air, odour...) have been documented in the indoor environment [1, 2, 3]. However although diseases are serious but rare, the troublesome symptoms such Sick Building Syndrome are very common in the general population (representing about 30% of new or refurbished buildings through the world [1, 2]). As a results, although most of indoor air quality problems deals with low risk effects for individuals there are still a major concern of public health due the high collectif risk for the exposed population.

Understanding small effects and low risks has conducted the field of indoor air epidemiology to face specific problems related to the greater necessity for understanding the causative mechanisms that lead to indoor air quality problems. The various risk factors identified today in office buildings may be classified as followed [3] :

- physical, chemical, microbiological and sensory quality of the environment,
- choice of building design, building materials, fittings, furnishings and equipments,
- operation and maintenance of the building,
- types of activities carried out in the building,
- psychosociological working environment and personal conditions of occupants.

The evaluation of indoor air quality in buildings is a complicated problem due to the complexity of the buildings, the highly charged emotions and the number of confounding factors that sometimes make standard epidemiology and industrial hygiene evaluation techniques inconclusive. Several IAQ investigation protocols have been developed for conducting effective IAQ audit in the context of occupant complaints regarding health, comfort or perceived conditions [3, 4, 5, 6]. Moreover a guidebook concerning curative IAQ investigations is actually under preparation by the french standardization body [7].

The objective of the present work was to develop a multidisciplinary audit method aiming at evaluating and classifying the office building stock in terms of indoor air quality. The definition of the audit strategy as well as the description of the different steps of the investigation are deccribed in the following.

## **II. SCOPE OF THE IAQ INVESTIGATION**

Primary objectives of the Indoor Air Quality investigation developped in the frame of this study is to evaluate the IAQ level of the office buildings stock. As such, a descriptive approach of the indoor air quality has been proposed in order to identify complaints or IAQ deficiency in buildings with/without identified

IAQ problems. Based on French and international experiences, the IAQ audit protocol was developed as a standard procedure that could be used in a large number of buildings, one of the main goals being to assess buildings in a comparable way so that the results could have a relative validity.

The IAQ investigation protocol is aimed to be used by any competent persons with an expertise in building such consulting engineer and technical building controllers. Nevertheless, if specific measurements are revealed necessary they must be subcontracted to competent persons or body.

Moreover, as a descriptive IAQ audit procedure, the audit will be used in a large number of buildings. Hence the IAQ audit procedure must be associated with low cost and thus short duration.

### III. IAQ AUDIT STRATEGY

As previously described, the evaluation of indoor air quality in buildings is depending of complex and heterogeneous factors that have to be taken into account when describing the level of air quality in the office building stock. The audit procedure will focused on the two major parameters involved : building and occupants. Hence building will be assessed through careful evaluation of it design, use and the chemical, microbial and physical quality of it indoor air and outdoor air. On the other hand, as complaints and health effects, if ever, are only suffered by people, a screening of the health and comfort will be assessed through direct interview of building occupants.

The proposed strategy includes the step by step approach used in the frame of a number of international IAQ investigations developed for curative IAQ audit [3, 4, 5, 6]. A first screening of the building and the occupants is conducted at the first stage following, if needed, by more detailed, often expensive and time consuming, site investigations. This step by step methodology allows to avoid resources being expended on investigations of greater complexity that could lead to uninterpretable measurements or which have no relationship with the real problems.

The investigation will focused on 3 major steps described in the Figure 1 :

Step 1 : preliminary visit

Step 2 : walk through survey and occupant questionnaires

Steps 3 (depending of step 1 and 2) : detailed investigations.

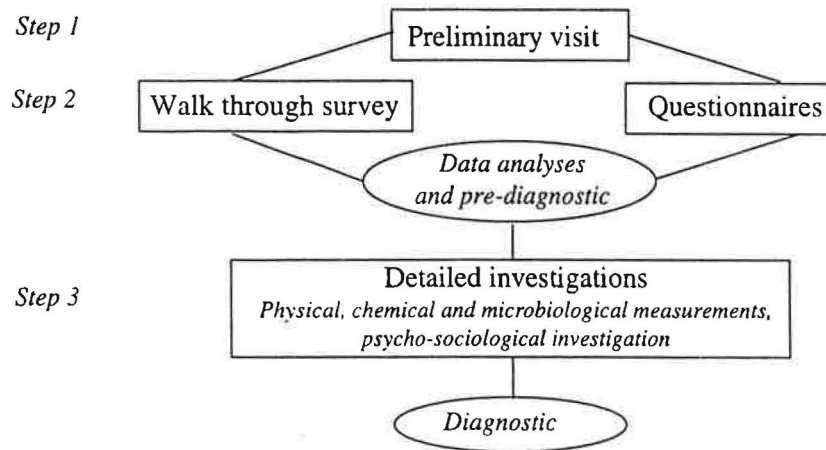


Figure 1 : IAQ audit methodology

### 1. Step 1 : Preliminary visit

This preliminary visit allows to gather a number of historical and practical informations on building and the occupants such as 1) for building : date of construction, type of ventilation systems, previous problems, recent renovations, maintenance setup ; 2) for occupants : number of occupants, types of work, kinds of symptoms or complaints if ever.

The preparation of the plan for action including the choice of offices and specific systems and equipment to be investigated during the following steps is also decided during this initial visit on site. The participation of the building actors such as industrial hygienist, safety organisation, maintenance and cleaning manager, ventilation engineer, representative of the occupants and industrial health service are very important at that point.

### 2. Step 2 : Walk through survey and questionnaires

This second step is the most important phase of the investigation. It will allow to make a first diagnostic of the IAQ level of the building and serve as a base for the further investigations conducted in the frame of the step 3 (detailed investigations).

Two parallel investigations focused on building and occupants respectively will be conducted in this frame : i.e. walk through survey and questionnaires (see Table 1).

STEP 2	
<i>WALK THROUGH SURVEY</i> ↓ <b>BUILDING</b>	<i>QUESTIONNAIRES</i> ↓ <b>OCCUPANTS</b>
<b>Materials and equipments</b> Building design Building materials, Fittings and furnishings, Office machines Ventilation Operation and maintenance  <b>Indoor environment</b> Physical, chemical, microbiological quality	<b>Symptoms</b>  <b>Personal factors</b> Sex, Illness, Smoking  <b>Psychosociological factors</b> Type of office work, Job satisfaction, Personal control over building Stress

Table 1 : Building and occupant screening in step 2

### **2.1. Walk through survey**

The walk through survey is conducted in order to draw up an additional description of the building and its services not obtain from the preliminary information and to gain a visual appreciation for the design and use of the building. The technical description provides a basis for an assessment of any risk factors inherent in the building or its use and operation. A check list focused on the important points of the indoor and outdoor environment to be screening has been developed. It includes information on design, use and operation of the building (type and condition of building materials, mechanical services and their operational condition and strategy, rate of ventilation, and its distribution per unit area and person, cleaning condition ...) as well as potential pollution sources (plants, parking, roads, vegetations, office equipments, tobacco smoke, cleaning agents ...).

### **2.2. Questionnaires**

The simplest way to characterize the building population and determine the associated symptoms or complaints is to use a questionnaire. Such questionnaire is designed to collect all relevant data on :

- the prevalence of health and comfort problems in the building (type of symptoms or complaints, magnitude of the problem, targeted population ...)
- the personal (sex, illness, smoking habits) and psychosociological risk factors (type of work, perception of the environment, personal control over building ...).

The standard questionnaire developed by G. Raw [8, 9] for studies of Sick Building Syndrome will served as a base for the one designed in the frame of this study.

### **3. Step 3 : Detailed investigations**

Following the step 2, detailed investigations including environmental monitoring (physical, chemical and microbiological air quality) and psychosociological study may be conducted in order to confirm or to rule out a number of problem source possibilities identified from the preliminary information of the initial site assessment (walk through survey and questionnaires). Due to the time consuming and high cost, indoor climate measurements and detailed psychosociological approach must be undertaken under a proper assessment of whether they will provide new information.

In the case of environmental measurement, sampling strategy will especially be very important in order to take into account the chronological and spatial variation of the effects of indoor and outdoor climate, the activity inside the building (cleaning ) or the operational condition of the ventilation plant.

An other limiting factor in understanding what environmental measurements mean, occurs with the evaluation criteria or acceptable levels that are available to compare findings against. As pollutant levels are often very low compared to the classic industrial hygiene, it is increasingly difficult to determine a safe level by epidemiological means (a no effect level may even not exist). Moreover available data from industrial hygiene are not relevant for workers in an office setting, whose primary concern may be for comfort or simply an absence of unusual sensory stimuli over their working period. On the other hand, the limit values are highly dependant of for what they are using for : i.e. ideal temperature and relative humidity will be different if occupant's comfort, dust mites problems or energy conservation are considered. A list of guidelines based on national or international available regulations or guidelines will be proposed in the document. A guide to indoor climate measurements will also be included in the protocol.

### **III. CONCLUSION**

An indoor air quality audit procedure have been designed in order to collect informations concerning indoor air quality level in office buildings. Based on descriptive approach, the protocol is aimed at screening IAQ looking at both building design, use and equipment and the building population. Requiring interdisciplinary expertise, the protocol is designed to be used by any competent people with building knowledge (consulting engineer, building controllers ...), detailed investigation being subcontracted to specialised laboratories or experts.

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