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Control and Regulation of Indoor Air Quality in Canada

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Abstract
Canadians spend over 80% of their time within the indoor environment. There has been growing concern regarding the quality of indoor air due to commonly attributed adverse effects on comfort, health and productivity. Thus several organizations have been working to develop and establish indoor air quality (IAQ) standards and/or guidelines. Two approaches have been observed for controlling IAQ: (1) set permissible levels for indoor air contaminants or (2) set minimum ventilation rates. In the residential sector, Health and Welfare Canada has published permissible levels for indoor air contaminants, while building codes, at the national and provincial levels, specify minimum ventilation rates. Federal and provincial labor authorities, along with several other government agencies, have published standards and guidelines for nonindustrial buildings. These publications suggest maximum exposure levels for air contaminants, as well as the necessary ventilation requirements. The findings and recommendations made in these and other documents have been reviewed and presented in this paper.

Introduction

Building-related adverse health effects have attracted increasing national and international attention since the mid 1970s, in parallel with the introduction of energy conservation measures, particularly those that reduce the infiltration rate. In Canada, new dwellings are built more airtight than in the past and are often heavily insulated against heat loss. A recent study showed that houses built today are approximately 30% 'tighter' than those built less than a decade ago [1]. At the same time, buildings are being constructed with increasing amounts of glues, adhesive and other materials which are known to emit chemical gases into the building air [2], and as a result, concentrations of certain contaminants in some buildings are one order of magnitude higher than in outdoor air. This has raised growing concern and uncertainty about the quality of indoor air in Canada and its commonly attributed adverse effects on comfort, health and occupant productivity resulting in a growing interest to develop indoor air quality (IAQ) guidelines and standards for nonindustrial, office and residential buildings.

Guidelines and standards have been developed for building owners, managers, engineers and government officials. The focus of this paper is to review the existing provincial and federal IAQ standards and guidelines with

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particular reference to the residential, office and nonindustrial environments as a source of exposure to airborne contaminants.

Human Health Symptoms

People react to their environment in markedly different ways, and it is often difficult to identify the sources which are the cause of particular problems. The symptoms observed in building occupants are varied, and they depend greatly on the contaminants present, their concentrations as well as the sensitivity of those exposed. The symptoms include headaches, dizziness, coughing, eye irritation, unpleasant odors, fatigue, respiratory problems, and nose and throat irritation. Sensitive individuals, usually those with existing health problems such as asthma, are especially vulnerable to the symptoms listed above [3].

There is a plethora of factors affecting the IAQ. These factors include: temperature, relative humidity, air speed, carbon dioxide, carbon monoxide, nitrogen oxides, polycyclic aromatic hydrocarbons, formaldehyde, ozone, radon, particles and volatile organic compounds (VOCs). There are thousands of VOCs that volatilize into the air at room temperature; over 5,000 have been identified in indoor air. Major sources of VOCs in buildings are e.g. consumer products, floor waxes, particle board, cleaning agents or building materials. Formaldehyde is the most commonly identified VOC in the indoor environment, and its exposure causes eye and nose irritation and respiratory problems [3].

In residential buildings, most contaminants are introduced into the indoor air through the use of appliances such as gas stoves or space heaters, from automobile emissions from a connected garage and from human activities such as breathing, cooking and smoking; the presence of domestic animals, aerosols, cleansers and other consumer products also contributes.

A further contaminant of significant concern in some residential and small nonindustrial buildings is radon. Radon, a decay product of uranium-238, is radioactive and found naturally in soil. A house built on a radon-emitting site may experience infiltration of the gas through the basement walls. Inhaled by the building's occupants, the bronchial tract and lungs are exposed to α-radiation, which is thought to increase the possibility of lung cancer.

In nonindustrial buildings, such as office buildings, the contaminants and human symptoms listed earlier are also found. However, in addition, other contaminants, such as those associated with printers and photocopy machines, are present. More complaints may be generated in a nonindustrial building than in a residential building for one of two reasons: (1) the occupants have less control over their environment, or (2) there is more dependence on the mechanical ventilation system. Most modern office buildings are mechanically ventilated, and any problems with the system will lead to the deterioration of the IAQ. Such problems can be related to a defective or poorly installed component of the mechanical system, poor or inadequate design, or inefficient operation which fails to ventilate the occupied space thoroughly and properly. Another problem is related to the maintenance of the mechanical system. If not maintained regularly, microbiological, bacterial and fungal growths may result where stagnant water or high humidity occur within the mechanical system, including ducts. The bacteria and fungi may be spread into the occupied zone, and this can lead to such diseases as Legionnaire's disease or humidifier fever. Legionnaire's disease is caused by a microbiological bacterium called *Legionella pneumophilia.* The symptoms include headaches, fever, shortness of breath, digestive problems and malaise [4].

Standards and Guidelines

Webster's dictionary defines a standard as 'something that is established by authority, custom, or general consent as a model or example to be followed; a definite level or degree of quality that is proper and established by authority as a rule for the measure of quantity, weight, extent, value of quality', and the International Organization for Standardization defines a standard as 'A technical specification or other document available to the public, drawn up with the cooperation and consensus or general approval of all interests affected by it, based on the consolidated results of science, technology and experience, aimed at the promotion of optimum community benefits and approved by a body recognized on the national, regional or international level'.

Furthermore, Webster's dictionary defines a guideline as 'an indication or outline of future policy or conduct'.

Several organizations and authorities within Canada are involved in the assessment of the problems related to poor IAQ. Many have published reports and guidelines based on the recommendations and observances made by committees established for this purpose. At the provincial level, some of the organizations involved and mentioned in this report are: Ontario Ministry of Housing, Ontario Interministerial Committee on Indoor Air Quality, Commission de la Santé et de la Sécurité du Travail du Québec, the City of Montreal and the City of Vancouver.

At the federal level, organizations involved in the development of IAQ standards and guidelines are: Health and Welfare Canada, Institute for Research in Construction, National Research Council, Public Works Canada, Canada Mortgage and Housing Corporation, Consumer and Corporate Affairs, Canadian General Standards Board, Labour Canada and Canada Standards Association.

To date, very few standards related to IAQ have been established which require compliance by law (some exceptions are the national and provincial building codes, the Labour Code of Canada, and some provincial acts). Rather, guidelines have been developed, which are suggested by the authors, for implementation in all buildings. However, the degree of implementation is left to the discretion of the building owner, manager or building inspector. The standards and/or guidelines suggest two procedures for maintaining an acceptable IAQ.

The first procedure, indoor contaminant levels, relates to the health of the building's occupants. Its objective is to define and recommend acceptable concentrations for individual indoor contaminants. An acceptable contaminant level would be the maximum concentration permitted without causing adverse health effects in those exposed to the indoor environment. The period of exposure may vary from short term (1, 8, 24 h) to long term (1 month, 3 months, lifetime) and is usually specified with the corresponding contaminant level.

For the most part, the levels specified above are for individual contaminants only. Permissible levels for mixtures of contaminants are presently difficult to determine because of the lack of data available on the health effects of mixtures of contaminants. However, the Health and Welfare document, which will be discussed shortly, tries to consider combined effects wherever feasible [5].

As a second procedure, a standard may choose to specify minimum ventilation requirements, which relate to the 'comfort' felt by the occupants within an occupied space. It defines criteria for the mechanical or natural ventilation systems in order to provide accetable fresh air (e.g. air exchange rates, intake volume) as well as specific ranges for parameters such as the temperature and relative humidity.

Residential Buildings

In 1981, the Federal-Provincial Advisory Committee on Environmental and Occupational Health convened for the first time to deliberate over the effects of eighteen selected known indoor air contaminants. The mandate of the group was to provide a definition for acceptable IAQ, to define guidelines for concentrations of the selected contaminants and to recommend methods of improving or maintaining these concentrations in indoor air [3]. The document, published in 1987 and updated in 1989, is entitled *Exposure Guidelines for Residential Indoor Air Quality.* This guideline was the first of its type in the world.

The selected substances were separated into three groups. The first group specified permissible ranges of concentration for a given noncarcinogenic substance. The concentrations were based solely on health considerations. They included an acceptable long-term exposure range (ALTER) which specified the concentration of a given substance an individual may be exposed to throughout a lifetime without jeopardizing his/her health. Alternatively, an acceptable short-term exposure range (ASTER) defined the concentration of a substance within a specified time to which people can be safely exposed without jeopardizing their health. These ranges were based on available information at the time and were developed using a lowest observable adverse effect level (LOAEL). The LOAEL is a clinically determined level below which no adverse health effects are observed. Depending on the accuracy of the studies used to determine the LOAEL, the Committee used a factor of safety which varied between 1 and 5 for different substances [3, 6].

The second group, similar to the first group described above, is for potentially carcinogenic substances. The derivation of the ASTER and ALTER values is not only based on health effects but also cost and the technology available to reach these specified levels. In determining the LOAELs for proven or potentially carcinogenic substances, extrapolation methods were used. In the case of radon, extrapolation of existing statistics regarding the occurrence of lung cancer amongst workers exposed to high levels of radon was used. Extrapolation of the results obtained in animal studies was used to determine the LOAEL for formaldehyde [3].

The third group includes substances to which the committee believed specifying concentration ranges were inappropriate due to lack of data or too broad a category. Exposure to these substances may foster health risks. Thus, the committee chose to list measures which may be

Table 1. Comparative table of existing IAQ guidelines

A *World Health Organization [17] and ASHRAE standard 62-1989 [13]*

Contaminant	Nonindustrial buildings [17]			Residential and nonindustrial buildings [13]		
	average concentration mg/m³	concentration of no concern mg/m³	concentration of concern mg/m³	long-term concentration mg/m³	short term concentration mg/m³	continuous exposure concentration mg/m³
Particulate matter	0.01–0.15	<0.1	>0.15	0.075 (1 year)	0.260 (24 h)	–
NO_2	0.02–0.4	<0.15	>0.40	0.1 (1 year)	–	–
CO	1–11	<2% COHb <10, >30	>3% COHb	10 (8 h)	40 (1 h)	–
SO_2	0.01–0.08	<0.25	>0.35	0.08 (1 year)	0.365 (24 h)	–
CO_2	300–2,000	<2,000	>7,000	–	–	1.8
O_3	0.01–0.1	<0.13, >0.12	–	–	0.235 (1 h)	0.1
Formaldehyde	0.02–0.06	<0.06	>0.12	–	–	–
Lead	–	–	–	0.0015 (3 months)	–	–
Radon gas	–	–	–	–	–	0.027 WL
Chlordane	–	–	–	–	–	5
PAHs	–	–	–	–	–	–
Tobacco smoke	–[a]	–[a]	–[a]	–	–	–

B *Health and Welfare Canada [3] and Commission de la Santé et de la Sécurité du Travail [15]*

Contaminant	Residential buildings [3]		Industrial and nonindustrial buildings [15]		
	ASTER mg/m³	ALTER mg/m³	average concentration mg/m³	maximum allowable concentration, mg/m³	remarks
Particulate matter	0.1 (1 h)	≤0.04	–	–	–
NO_2	≤0.48 (1 h)	≤0.1	9	–	P
CO	≤11 ppm (8 h) ≤25 ppm (1 h)[b]	–	55	440	–
SO_2	≤1.0 (5 min)	≤0.05	13	–	–
CO_2	–	≤6,300	9,000	18,000	–
O_3	≤0.240 (1 h)	–	0.2	0.6	–
Formaldehyde	–	0.120[c]	3	–	P
Lead	–	–	0.15	0.45	–
Radon gas	–	800 Bq/m³[d]	–	–	–
Chlordane	–	–	0.5	2	T
PAHs	–[e]	–[e]	0.2	–	C
Tobacco smoke	–[e]	–[e]	0.5[f]	1.5[f]	T[f]

COHb = Level of CO present in hemoglobin; WL = working level; PAHs = polycyclic aromatic hydrocarbons;
P = maximum value not to be exceeded for an extended period of time; T = toxicity absorbed through the skin;
C = carcinogenic substance.

[a] The WHO specifies that the values observed for respirable particulate matter include tobacco.
[b] Units used are parts per million to eliminate the dependence of ambient pressure.
[c] Concentration at which remedial action is recommended. It is chosen for its feasibility; however, the target value is 0.060 mg/m³.
[d] Concentration at which remedial action is recommended. However, the lower this value, the better.
[e] See table 2.
[f] Refers to the acceptable concentration of nicotine.

Table 2. Recommendations by Health and Welfare Canada [3] for substances for which guidelines are not specified

Contaminant	Recommendations
Aldehydes	$\Sigma c_i/C_i \leq 1^{1a}$
Water vapor	30–80% relative humidity in summer 30–55% relative humidity in winter
Biological agents	Ensure that: excess humidity/condensation not present; surfaces free of dust; stagnant water sources kept clean and disinfected; appropriate personal hygiene maintained
Chlorinated hydrocarbons	Keep exposure to a minimum by ensuring adequate ventilation and observed all instructions on product labels
Pest control	Keep exposure to a minimum by ensuring adequate ventilation and observe all instructions on product labels; use only when absolutely necessary
Aerosols	Keep exposure to a minimum by ensuring adequate ventilation and observe all instructions on product labels
Fibrous materials	Minimize inhalation and skin contact; examine periodically for deterioration; seek professional help when dealing with potential asbestos sources
PAHs	Ensure that combustion systems are properly installed, maintained and operated with adequate ventilation
Tobacco smoke	Exposure indoors should be minimized

PAHs = Polycyclic aromatic hydrocarbons.
[1] Where C_i equals 120 μg/m^3 formaldehyde, 50 μg/m^3 acrolein, 9,000 μg/m^3 acetaldehyde and where c_i is the concentration, respectively, measured during a 5-min duration.

employed to reduce and/or prevent exposure to these substances [3, 6].

All the values and conclusions formed by the committee are presented in tables 1 and 2. These are compared with other published guideline values and recommendations. As not all possible residential contaminants are listed, further updates will be made to this document as data become available. Presently, toluene, xylene, 1,4-dichlorobenzene, benzene and tetrachloroethylene are being investigated for the possibility of establishing reasonable exposure guidelines [5].

Health and Welfare Canada has published a report entitled *Significance of Fungi in Indoor Air: Report of a Working Group.* The report concentrates solely on the presence and effects of fungi and microflora as a contaminant in buildings, chiefly houses. The recommendations include [7]: (1) further testing and research into the effects of fungi on IAQ; (2) future design, construction and maintenance of buildings should encourage a reduction of airborne fungi and microflora; (3) methods of testing and analyzing airborne fungal contaminants should be standardized; (4) testing and approval of materials for residential buildings should include a consideration of their ability to cause biological problems.

The building codes available in Canada (national and provincial) specify comfort levels for residential buildings, that is, they do not provide maximum indoor contaminant levels. The Canadian Housing Code specifies a ventilation rate of 'not less than 0.3 ACH (air changes per hour) averaged over a 24-hour period' in a single dwelling unit [8]. For individual rooms or spaces not provided with a means of natural ventilation (window), the air change per hour should be 0.5 for a room mechanically cooled during the summer and 1.0 if it is not [8]. During the winter, the Code specifies that a residential building should be supplied with a heating system capable of maintaining an indoor temperature of 22 °C [8].

The Province of Ontario Building Code, published by the Ontario Ministry of Housing, Buildings Branch, specifies comfort levels which comply thoroughly with the Canadian Housing Code. The Code includes one clause which refers to the contaminant levels in a residential building: 'Air contaminants released within buildings shall be exhausted in so far as possible at their points of origin and shall not be permitted to accumulate in unsafe concentrations' [9].

Residential Mechanical Ventilation Systems (CAN/CSA F326-M91) is a standard published by the Canadian Standards Association which specifies the performance and installation requirements of ventilation systems in residential buildings. It also defines a methodology for verifying existing systems [10].

The values for the minimum ventilation requirements specified by F326 are based on contaminant production rates normally found in residential units [10]. F326 specifies ventilation air capacity for individual rooms. These values are presented in table 3. For an entire house or apartment, the required ventilation is the greater of [10]: (1) the sum of the ventilation requirements for the individual rooms comprised in the dwelling unit or (2) 0.3 ACH based on the volume of the dwelling unit (i.e. the volume of the space including the basement but excluding the garage and crawl spaces).

According to a recent survey [1], the ventilation capacity in 63% of current houses meets the requirements specified above, assuming at least one fan in each the kitchen and bathroom.

Sibbitt and Hamlin [11] studied several low-cost ventilation systems which were tested in the field and through computer simulation. It was shown that the systems were able to comply with F326 and maintain contaminant levels of formaldehyde and carbon dioxide within guidelines specified by the ASHRAE standard 62-1989 *Ventilation for Acceptable Indoor Air Quality* and the *Exposure Guidelines for Residential Indoor Air Quality* [3].

Among its installation requirements, F326 considers the prevention of mould growth [12]. The Ontario Building Code will likely adopt *Residential Mechanical Ventilation Systems* F326 in its 1993 version, and the National Building Code will adopt it in 1995.

Table 3. CAN/CSA F326-M91: minimum ventilation air requirements [8]

Space classification	Minimum ventilation capacity, l/s	Intermittent exhaust l/s	Continuous exhaust l/s
Category A			
Master bedroom	10	–	–
Basement	10	–	–
Single bedrooms	5	–	–
Living room	5	–	–
Dining room	5	–	–
Family room	5	–	–
Recreation room	5	–	–
Other habitable rooms	5	–	–
Category B			
Kitchen	5	50[1]	30
Bathroom	5	25	10
Laundry	5	–	–
Utility room	5	–	–

Values are based on an air temperature of 20°C. Either intermittent or continuous exhaust is required. Category A = Rooms that may be occupied for extended periods and are not major sources of moisture. Master bedroom is the bedroom most likely to be occupied by two adults. Where a basement incorporates rooms of the types designated in this table, the ventilation requirements for each room shall be specified as above. Basement areas used for other purposes that exceed two thirds of the total basement area shall have a minimum ventilation requirement of 10 liters/s; those that are less than two thirds of the total area shall have a minimum ventilation requirement of 5 liters/s. This standard does not require ventilation of mechanical service and storage rooms. Ventilation requirements for any combined living room, dining room and kitchen shall be determined as if they were individual rooms. Other habitable rooms not listed shall have a minimum ventilation requirement of 5 liters/s. This does not include spaces intended solely for access, egress or storage, such as vestibules, halls, landings, storage rooms, service closets and furnace rooms. Category B = Rooms which are not typically occupied for extended periods and/or are sources of moisture and/or odor.

[1] This minimum rate assumes the use of a hood consistent with clause 8.13.5. If a higher rate is required by clause 8.13.5, it shall apply. With other exhaust configurations such as ceiling, wall and range-top fans, higher rates of flow may be required; see manufacturer's literature.

Nonindustrial Buildings

The Canadian Labour Code has a section devoted to the health and safety of individuals in their work environment. Its mandate is the 'elimination, at the source, of dangers to the health, safety, and physical well-being of workers' [12]. Based on the Canada Labour Code, federal laws concerning the health and welfare of workers stipulate that 'the design and construction of all buildings must conform with the standards set by parts 3–9 of the National Building Code' [4].

In referring to these articles, it is stipulated that the norms set by ASHRAE [existing standards of interest are *Thermal Environmental Conditions for Human Occupancy (55-1981)* and *Ventilation for Acceptable Indoor Air Quality (62-1989)*] must be met [13, 14] (tables 1 and 4).

The Ontario Interministerial Committee report on IAQ, published in September 1988, discusses the problems related to IAQ in detail. Based on this study, many recommendations were made, some of which are the following [6]:

For existing buildings, based on the assumption that the existing 'make-up air is of satisfactory quality' [6]: (1) the ventilation rate should be ≥ 7 liters/s/person, which is equivalent to 1,000 ppm CO_2; (2) if the IAQ is still not satisfactory after the implementation of 1, then the guidelines stipulated by Health and Welfare Canada's *Exposure Guidelines for Residential Indoor Air Quality* should be met (tables 1 and 2); (3) if the IAQ is still not satisfactory after implementing 1 and 2, then it is recommended to ensure that the guidelines published by the World Health Organization (WHO) are met (table 1).

Table 4. Comparative table of existing ventilation and room requirements

	ASHRAE 62-1989 [13]	RQMT [15]	ASHRAE 55-1981 [14]	Canadian Housing Code 1990 [8]	Province of Ontario Building Code 1986 [9]	Montreal Law No. 4936 [4, 16]
Office buildings						
Outdoor air requirement for ventilation, l/s/person	10	2.4	–	–	–	3.5–5.0
Temperature, °C	–	≤20	19.5–23 (winter) 22.6–26 (summer)	–	–	–
Relative humidity	30–60%	≥20%	≥1.7°C[1] ≤16.7°C[1]	–	–	–
Occupant density, m²/person	≈14.3	10	–	–	–	–
Residential buildings						
Outdoor air requirement	≥7.5 liters/s/person[2]	–	–	≥0.3 ACH	0.5 ACH (AC) 1.0 ACH (NAC)	–
Temperature, °C	–	–	as per office buildings[3]	22	22	–
Relative humidity	–	–	as per office buildings[3]	–	–	–

AC = Air-conditioned space; NAC = non-air-conditioned space.
1 The relative humidity is expressed in terms of the dew point temperature.
2 This value is specified for living areas in dwellings. The value is slightly higher for kitchens and bathrooms.
3 ASHRAE 55-1981 does not differentiate between residential and nonindustrial buildings.

For new buildings: (1) from the onset, building design should incorporate the above recommendations for existing buildings; (2) low VOC-emitting materials and construction products should be used wherever possible; (3) the heating, ventilating and air-conditioning system should be designed to discourage growth of microbiological contaminants; (4) regular inspections and maintenance should be a part of the building design; (5) the Ontario Building Code should be modified to take into account the above recommendations made by the Committee.

The Commission de la Santé et de la Sécurité du Travail is an organization in Quebec responsible for the documentation of all laws related to health and safety within the workplace and for ensuring that these laws are respected in the work environment [4]. The *Règlement sur la qualité du milieu de travail* (RQMT) is the publication incorporating all the regulations, including those for IAQ, lighting and sound. The most recent edition is dated September 21, 1992. The objective of this document is to provide such values as to ensure the quality of the workplace in all establishments and to protect the health of the workers [12].

Regarding IAQ, acceptable concentrations for many pollutants are presented in one of the appendices of the RQMT. It must be pointed out that the RQMT does not differentiate between industrial and office workplaces. While many of the concentrations listed are acceptable in areas where industrial processes occur, they are not reasonable for office spaces. Many of the listed contaminants should not even be present in office buildings. With this in mind, only those contaminants which are relevant to the office environment are listed in table 1. If at times the concentrations seem high, it is because of the consideration made to the industrial workplaces. Though these values are inappropriate for an office environment, they are presented for comparison purposes.

The ventilation requirements made by the RQMT in office buildings are also listed in table 4. These values are based on a density of 10 m²/person [15].

The RQMT also stipulates parameters for the thermal comfort of the worker. Minimum temperatures range from 12°C for strenuous standing work to 20°C for light sitting work (the type most common in the office environment). For office and commercial buildings, the RQMT specifies a minimum relative humidity of 20% [15]. The

RQMT does not make provisions for biological contaminants [15].

In 1975, the City of Montreal adopted bill No. 4936, which is still in use today. This regulation specifies a minimum ventilation rate of 3.5 liters/s/person for office buildings [4, 16]. It is argued that, though this value was higher than that specified by the Provincial and ASHRAE standards before 1989, it is now considerably lower. It is, therefore, strongly suggested that revisions to bill No. 4936 are required [16].

In September 1989, the *Problématique de la qualité de l'air dans les édifices ventilés mécaniquement à Montréal* was published [4]. The report was written to satisfy a request made by the Commission de l'Aménagement, de l'Habitation et des Travaux Publics de la Ville de Montréal. The report generalized the status of IAQ in Montreal by analyzing data obtained in investigations made in several buildings within the Montreal area. Two procedures were used: (1) questionnaires were distributed to building occupants, and (2) the environmental parameters within the working zones were measured. Based on the questionnaires, it was demonstrated that a large majority of the buildings' occupants were dissatisfied with the air quality of their environment. Many occupants had suffered health effects. This subjective response was supported by the measurements made within the spaces [4]. The Centre des Loisirs de Services Communitaire defined and recommended the following ranges for adequate comfort: CO_2 concentration ≤ 600 ppm; relative humidity between 40 and 60%; temperature between 20 and 24°C. It was shown that the measured values usually failed to conform to these prescribed limits. The authors of the report made the following suggestions [4]: (1) modify existing standards to remove the discrepancies identified by the investigations made in real-life buildings and to address the problem of microbiological contaminants in greater detail; (2) ensure that the newly modified standards in 1 are implemented and respected in buildings; suggestions are made to improve the IAQ in existing buildings at little cost (e.g. adopt strict maintenance programs for the mechanical system); (3) keep in mind the needs of the individuals within the building; it is suggested that allowing occupants to gain more control over their environment (e.g. temperature control) will lead to fewer complaints and better productivity.

Health and Welfare Canada, Public Works Canada and the provincial governments are nearing the completion of a project involving the IAQ in nonresidential buildings. Similar to the Health and Welfare Canada document for residential buildings discussed earlier, a working group was established to discuss the IAQ problems evident in office buildings and to prepare a handbook on IAQ investigations. This handbook should be available shortly [5]. The Canadian Standards Association has also established a technical committee to develop a guideline for IAQ in office buildings. This guideline is expected to be published in 1993.

Conclusion

It is clear that IAQ standards within Canada are still in the early stages of development [17]. Regarding residential buildings, the provincial and federal building codes, which comply well with one another, have yet to stipulate norms for air contaminants, especially in newly constructed or renovated homes. This can be solved by adopting the Health and Welfare Canada publication already described.

Though many guidelines and standards exist for office buildings, not all are in compliance with one another. This provokes the questions: Which standards should be adopted by the building owner, manager or building inspector? Can standard X overrule standard Y? Which standards should be revised?

Another problem which must be addressed is the limited knowledge available to date on certain biological contaminants and their effects on human health. The existing guidelines and standards may or may not adequately accommodate for these contaminants.

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