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RANKING OF SELECTED INDOOR CHEMICAL POLLUTANTS

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ABSTRACT

Numerous scientific studies show that indoors are the source of potentially harmful substances called indoor air pollutants. They come from various sources. Indoor levels are often much higher than outdoor level and most people spend the bulk of their time indoors. As indoor air pollution is relatively new problem, health and comfort problems are associated with it. The starting point for studies on constituents of the indoor environment is to realize that the problem to be solved is complex. Facing the number and variety of physical, chemical and biological pollutants in indoor environment urgently needs strategies to distinguish severe from less severe health hazards. The term sick building syndrome has come into vogue during the past several years and refers to a range of occupant complaints and illnesses. The cause of sick building syndrome remains unknown, although it is likely that there are connections between psychological factors, inadequate ventilation and the level of hygiene in the building. Classification of health effects of indoor air pollution is introduced from comfort point of view. Factor identified as possible causative agents are as conclusion of several research reports indicated in the paper. In order to determine the priorities the ranking of selected indoor chemical pollutants in Slovakia was made on the base of measurements carried out. Frequency of exposure for selected substances was estimated.

KEYWORDS: SBS, radon, VOC, risk assessment

INTRODUCTION

Despite the fact that indoor environments vary from one country or even region to the other, due to differences in construction habits, climatic conditions and life-style, the industrialized societies tend to face a growing number of similar indoor air quality problems. Indoor environmental problems have five common causes, and more than one may be active at any time: an inadequately cleaned or maintained environment, insufficient ventilation, pollutants emitted from sources and activities inside the building, contamination from outside sources, and biological contamination due to a lack of moisture control. These causes can often intensity or add to the stress that occupants suffer from inadequate temperature, humidity, or lighting, or by excess noise. Exposure to pollution indoors also adds to stress of occupant density, job dissatisfaction, lack of personal privacy and control over the environment. The inadequately maintained environment is the consequence of inattention to the different emissions and by-products of activities indoors and the need for constant ordering. Poor ventilation sometimes is the result of dirty air filters that need periodic cleaning or replacement. Emission from cooking or tobacco products always need to be removed. Left alone, they accumulate damaging materials, causing odors, and in some cases increasing cancer risks to humans. Particles from the outside are constantly being tracked or blown inside. They need to be removed through cleaning and maintenance. Before energy crisis, most buildings were designed to provide maximum comfort to inhabitants. Heating,

ventilating, and air conditioning systems were designed to provide fresh outside air for each building occupant. Later, buildings have been designed to save energy. The size of spaces for heating and cooling has been reduced, and outdoor air ventilation lowered. Moreover, many ventilation systems do not effectively distribute air to people in buildings. Inadequate air diffusion combined with reduced ventilation causes pollution levels to grow and, as pollutant concentrations rise, so do health complaints [1]. As already discussed, many indoor pollutants come from sources inside the building, while others may enter the building with outdoor air or from the soil. Indoor environment and its pollutants are presented in the Figure 1.

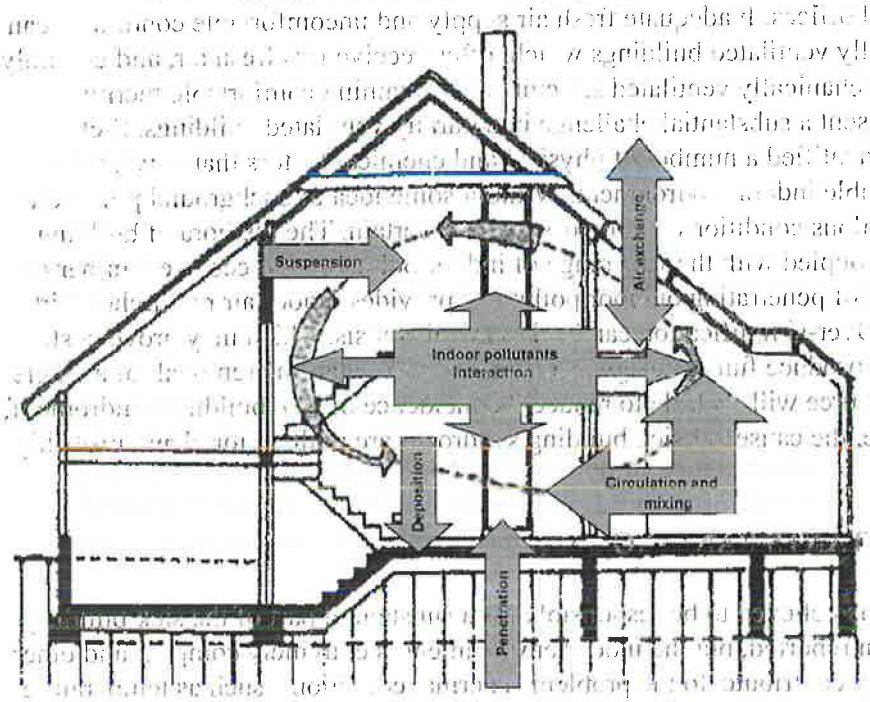

Figure 1. Indoor environment and its pollutants

SICK BUILDING SYNDROME

Buildings may cause illness to their occupants, producing symptoms like irritation in the nose, throat, eyes, and skin, as well as shortness of breath, nausea, dizziness, and fatigue. These symptoms are commonly referred to as the sick building syndrome (SBS). Such illness is usually minor and disappears when the sufferer leaves the building. Low rates of ventilation are often mentioned as a contributory factor. Allergy to indoor air contaminants is the main syndrome of sick buildings. These contaminants can be in the form of fine dust, fumes, fibers, odors or gases which are not removed by air conditioning filters or cleaning.

The World Health Organization has defined the sick building syndrome as an excess of work related irritations of the skin and mucous membranes and other symptoms, including headache, fatigue, and difficulty concentrating, reported by workers in modern office buildings [2]. The term Sick Building Syndrome describes a collection of non-specific symptoms. These symptoms have been grouped into five categories [3]:

- sensory irritation of the eyes, nose, and throat, including dryness, pain, stinging sensations, hoarseness, and changes in the voice and in sounds from the respiratory system
- skin irritation, including blushing, pain, stinging or itching sensations, and dry skin

- neurotic symptoms, such as headache, nausea, drowsiness, tiredness, lethargy, reduced mental capacities, and fatigue
- unspecific hyperactivity reactions, such as runny eyes, runny nose, and asthma-like symptoms among non-asthmatic
- odor or taste complies, including changes in odor or taste and unpleasant odors or tastes.

On the whole, research has been focused on the workplace where media attention to sick building syndrome originated, but sick building syndrome is not the exclusive domain of modern air-conditioned offices. Inadequate fresh air supply and uncomfortable conditions can also be found in naturally ventilated buildings which often receive less fresh air, and certainly less filtered air than mechanically ventilated structures. Maintaining comfortable thermal conditions can also present a substantial challenge in naturally ventilated buildings. Sick building research has identified a number of physical and chemical factors that may combine to create an uncomfortable indoor environment. Without some idea of background pollution levels, however, anomalous conditions are impossible to ascertain. The plethora of building styles and conditions, coupled with the vast range of indoor pollution sources, the number of reactive and the impact of penetrating outdoor pollutants provides indoor air researches with enormous challenges. Over-simplification can lead to misdiagnosis, which may prove costly in time and money and produce future design problems. In particular, the removal of a single pollutant or pollutant source will do little to reduce the incidence of sick building syndrome if, as it is so often the case, the causes of sick building syndrome are multifactorial and probably synergistic[4].

CHEMICAL POLLUTANTS RANKING

Poor quality indoor air is believed to be responsible for a substantial part of the sick building syndrome that has been reported, but the indoor environment is extremely complex and other factors also undoubtedly contribute to the problem. Thermal conditions, such as temperature and humidity, microbial agents such as dust mites and chemical pollutants can produce sick building syndrome symptoms in the indoor of buildings. The term sick building syndrome has come into vogue during the past several years and refers to a range of occupant complaints and illnesses. Classification of health effects of indoor air pollution is possible to introduce from comfort point of view. The cause of sick building syndrome remains unknown, although it is likely that there are connections between psychological factors, inadequate ventilation and the level of hygiene in the building. Factor identified as possible causative agents are indicated in Table 1. As a conclusion of several research reports based on measurements ranking of selected chemical pollutants is suggested in Table 2 [5,6,7,8].

With regard to carbinogenity radon and environmental tobacco smoke (ETS) including some of VOC_s as major components constitute the non occupational indoor air pollutants with greatest risk to human health because of both frequent exposure and probable health effects. In contrast, risks by other well-known indoor air pollutants like Odors, fibres and ozone in non occupational settings were assumed to be lower. Finally, several other chemical indoor air pollutants were put into no category of risk mainly because of a lack of sufficient exposure data. On the base of our measurements it is possible to assume that over standards exposure will be obtained in more than 50 % buildings for radon, nitrogen oxides and volatile organic compounds[9,10,11].

Table 1. Indoor Air Pollutants [5,6,7,8]

Pollutants	Source	Health effects	Reaction
CO_2	Humans	SBS	Comfort
RH, Temperature	Services	SBS	
Odors	Services	SBS	
VOC_s	Furnishing, materials	SBS	
ETS	Smoking	SBS	
CO	Combustion	Respiratory, Neurology	Acute risk
NO_x	Combustion	Respiratory	
O_3	Laser printers	Rhinitis	
VOC_s	Furnishing, materials	Various	
ETS	Smoking	Various	
Radon	Geology, materials	Cancer	Chronic risk
Fibres	Materials	Cancer	
VOC_s	Furnishing, materials	Leukemia	
ETS	Smoking	Cancer	

Table 2. Ranking of selected chemical pollutants [5,6,7,8]

Pollutants	Frequency of exposure	Health effects	Over standards exposure	Priority
Radon	High	Probable	57 %	1st
ETS	High	Probable	-	1st
VOC_s	Increased	Possible	52 %	2nd
NO_x	Increased	Possible	54 %	2nd
Odors	Increased	Low		3rd
Fibres	Low	Low	13 %	3rd
O_3	Low	Low	6 %	3rd

DISCUSSION

With regard to both, exposure assessment and health effect assessment, there is not sufficient data for most the commonly known indoor air chemicals except for radon. Radon is one of the rare examples of agents which leads to scientifically accepted health effects under environmental exposure situations. From legal aspects, existing proposal for indoor air standards of radon refer to the European Commission [12] and to the Slovak Health Service Ministry Standard [13] is described in the Table 3.

Table3. Indoor radon limiting exposures

	Slovak standard [Bq.m^{-3}]	EC standard [Bq.m^{-3}]
Building under construction	100	200
Existing building	200	400

Until now there is no general consensus on what risk level might constitute a health hazard. It is necessary to say that standard limiting value need not be conceived as a limit value, but upper value of optimalizating alternatives, which should lead in practice to low levels as possible. According to the 1992 Slovak Standard for indoor radon, the value of 100 Bq.m^{-3} was exceeded in 57 % indoor spaces. Maximum level of 981 Bq.m^{-3} and the average radon

activity of 95 $Bq.m^{-3}$ were measured. On the other side the level of 200 $Bq.m^{-3}$ was exceeded only in 10 %. The radon concentration in atmospheric air was between 5 - 15 $Bq.m^{-3}$. These screening measurements are consistent with the results previously obtained [14,15]. Radon obtains the highest priority in ranking of selected indoor chemical pollutants.

A few VOCs which are recognized hazardous occur environmentally at levels at which it is believed they constitute a risk to health. Principal among these benzene and formaldehyde are also suspect. Limiting value was generally exceeded in 52 % indoors for benzene and formaldehyde. Frequency of the exposure is increased and possible health effects are expected. Most of the studies and health effects described so far are due to single compounds. In reality people are exposed to mixtures but we still know very little detailed toxicology about it. Concentrations of benzene, formaldehyde and other VOC_s recorded in buildings indoor environment were much higher respectively than concentrations outdoors.

Nitrogen oxides as chemical pollutant with increased frequency of exposure and possible health effects were like VOC_s also classified to second priority. Limiting value for indoor NO_x concentrations was exceeded in 54 % buildings. The problem become serious in short time exposure concerning to combustion and this probably involves a certain health risk.

RISK ASSESSEMENT

Since indoor air qualities affects directly people's health, it should be taken as a risky factor. Missing its importance can cause hazardous effects from headache to death of a person. To identify and control the risky conditions, indoor air qualities can be covered by Risk Assessment . Adverse health effects of monitored or suspected indoor air pollutants, groups of occupants who are affected, sources that are likely to release air pollutants, and possible spaces that indoor air pollution occurs are examined in detail and determined by risk identification. Emission rates, concentrations and combinations of indoor air pollutants, occurrence of exposure in long or short term, and effects of results of indoor air pollution on people's health and productivity, non-human based occupant's health (animals or plants) or contents of the indoor spaces are stated or estimated during risk estimation. Indoor air qualities related actions, outcomes, exposures and results of all actions are judged by giving ranks, which are based on various criteria, to them on some scale during risk evaluation.

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