# RISK FACTORS AND EFFECTS OF POTENTIAL SUBSTANCE PRESENT IN INDOOR AIR ON OCCUPANTS HEALTH

*Vasilica VASILE* [*, 1)], *Alina CIOACĂ*[1)]

**ABSTRACT**

Polluting emissions from building materials are among the construction "problems", but when they occur along with other factors (particle allergens, cigarette smoke, gas exhaust, electromagnetic fields, etc.) together can lead to so-called syndrome "sick-building". Why should we so intensely interested in the hazards present in our houses? The answer is: because the highest dose of exposure to toxic substances is right here in our houses or in the spaces in which we work.

*Key-words:* indoor air, health, constructions

**REZUMAT**

Emisiile poluante ale materialelor de construcţii se numără printre "problemele" construcţiilor, însă atunci când acestea se produc concomitent cu alţi factori (particule alergene, fum de ţigară, gaze de eşapament, câmpuri electromagnetice etc.), împreun pot conduce la aparicia aşa-numitului sindrom "sick-building"(cas bolnav). De ce ar trebui să ne intereseze atât de mult noxele prezente în casă? Răspunsul este: pentru că cea mai mare doză de expunere la substanţe toxice se află chiar în casa în care locuim sau în spaţiile în care lucărm.

*Cuvinte cheie:* aer interior, sănătate, construcţii

## 1. INTRODUCTION

The house in which we live is made of materials that can cause various diseases ranging from simple allergies to incurable diseases, such as cancer. Long-term exposure in a harmful indoor environment may cause changes in genetic structure, weakening the immune system, leaving the body vulnerable to many kinds of diseases and infections. Construction materials is now a complex combination between chemistry and engineering but, in addition to satisfying the many demands arising over time directly related to energy consumption, an extremely important factor that should not be missed is the one related to the environment.

There are several factors that can contribute to environmental pollution inside the home space in which people operate, namely: basic factors, represented by the chemical pollutants emitted from building materials and from materials used for interior finishing of construction elements, and secondary factors that contribute to increase the first category of factors, which are represented by temperature, humidity, inefficient system of indoor air ventilation, light (natural or artificial) and the presence of various bacteria found in many heating, cooling and dehumidification equipments.

What is not yet fully realize is that indoor air pollution is a risk that can seriously affect the health of the occupants given that 90% of the time is spent inside homes or workspaces. Some levels of individual pollutants may not present a health risk to occupants, but taking into account that in homes where we live or work there are more than one source that contributes to indoor air pollution and their cumulative effect may lead to serious problems.

## 2. TYPOLOGY OF POLLUTANTS PRESENT IN INDOOR ENVIRONMENT

Indoor environmental quality, important factor in terms of health and wellbeing of the occupants of a building, is determined by the composition of the air (with reference to chemical pollutants, physical, biological or otherwise) and comfort (with the main components: acoustic, thermal, visual).

[*)] Corresponding author: V. Vasile, e-mail: lppf@incerc2004.ro

[1)] National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development "URBAN-INCERC", INCERC Bucharest Branch, Romania

The building may present health risks for the occupants when hosts chemical or physical pollution sources, and / or provides favorable conditions for development of microorganisms.

The main pollution sources in buildings could generate:

*a) Chemical pollutants*

Synthetic chemical products are an integral part of our ambient environment. They can be found in food, water, air and are emitted from construction materials, furniture, cleaning products etc. The effects of chemical pollution on health are multiple and range from simple sensory perception to very serious effects, which may affect the respiratory system, nervous system or gastrointestinal tract [1]. Some chemical pollutants are classified in the category of carcinogens. If the individual toxicity of most of these pollutants is known, no one knows nothing of their toxicity when they are in the mixture and have lower concentrations, as shown most often in indoor air of buildings where we live or work.

*b) Physical pollutants*

The main physical pollutants inside buildings are excessive moisture, radon, dust, fibers (including asbestos), electric and magnetic fields, electro-magnetic fields of low and high frequency. The presence of these pollutants can cause various symptoms, such as dryness of the respiratory ways, loss of memory and concentration difficulties, up to cancer.

*c) Biological pollutants*

In the category of biological pollutants can be included microbes, viruses, bacteria, pollen and odors that develop in indoor air and coming from human beings, pets, dust mites, cockroaches, indoor plants, mold, etc. They cause allergies, respiratory diseases, the most vulnerable being children and the elderly persons. The risks associated with these pollutants are even greater in that the concentration is higher.

Good air quality requires knowledge of pollutant sources, the mimimum possible reduction of emissions and continuous evacuation of air pollutants by ventilation.

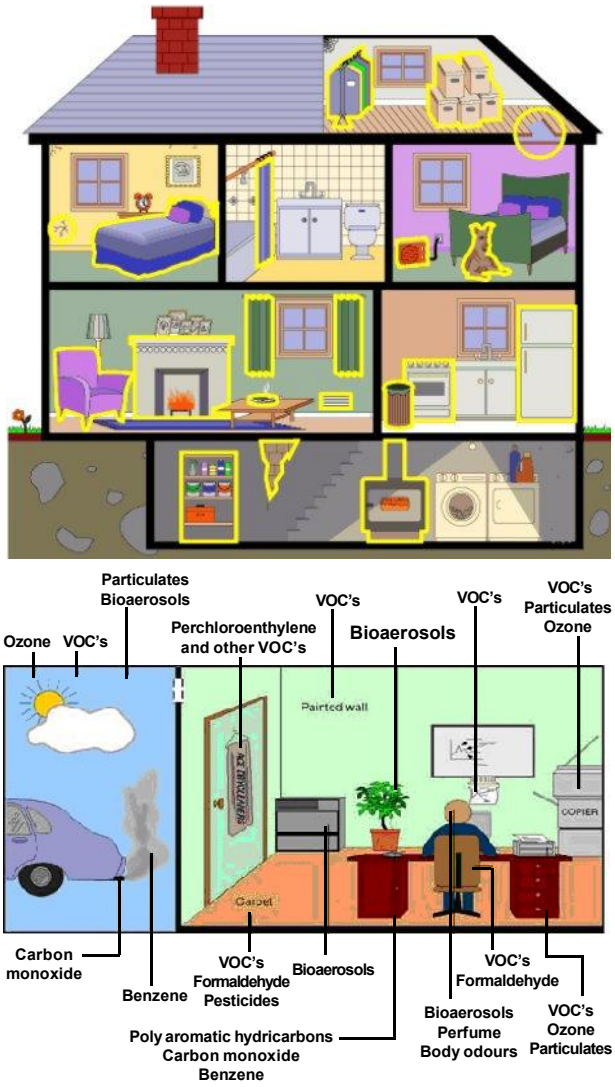



**Fig. 1.** Emission sources in indoor environment

Further, will be presented issues related to the presence of chemical pollutants in indoor air and the effects that they can produce on occupants health.

## 3. RISK ASSESSMENT ON THE HEALTH OF THE OCCUPANTS BY EXPOSURE TO POTENTIALLY HARMFUL SUBSTANCES PRESENT IN INDOOR AIR, EMITTED BY BUILDING MATERIALS

There are a large number of chemicals and biological agents that contribute to indoor

environmental pollution. The inside air of a building may contain sources of chemical pollution from both indoor environment (emission sources: building materials) and the external environment. More than 900 chemicals were identified in the indoor air composition and their number is constantly growing.

Physical factors, temperature, humidity, light, vibration and noise contribute to intensification of the problems related to indoor air pollution. So we are dealing with a complex situation involving the combinative action of the physical factors and of the pollutant species taking into account the rate of emission and the inadequate ventilation, leading eventually to adverse effects on health of occupants.

Among the chemical emission sources from building materials the largest share is represented by the volatile organic compounds resulting largely from the solvents used in the manufacturing of coatings, adhesives, wallpaper etc.

Volatile organic compounds health effects can be grouped as:

– hypersensitivity (asthma or allergies);
– cellular effects (cancer);
– cardiovascular effects:
– sensory and neurological effects (irritation);
– respiratory effects other than immunological.

Volatile organic compounds effects on the health of the occupants [2] depend on:

– their level of toxicity;
– route of exposure of occupants to volatile organic compounds;
–dose of volatile organic compounds in which the occupant is exposed;
– individual susceptibility to volatile organic compounds;
– ability of volatile organic compounds to react with other chemicals.

There are about 150 compounds that are part of the volatile organic compounds, predominantly hydrocarbons with 4-12 carbon atoms.

Concentrations of many VOC's are much higher in indoor air (even 10 times higher) than outdoor air.

In addition to volatile organic compounds, indoor air may contain various particles can also be generated internally or from external sources.

Sources generating particles in indoor environment are:

- occupants activities;
- smoke;
- construction materials;
- indoor finishing materials;
- furniture;
- cleaning products.

The wide range of particles present in indoor air may be the result of a single source or multiple sources generating compound. Quantitative contribution of particle sources is still difficult to measure because indoor air contains a dynamic mixture of pollutants emitted. Over time, the mixture goes through constant change as a result of interactions between pollutants and mixture components. Particles present in indoor air can be characterized in terms of physical (shape, density and size distribution), chemical (elemental composition, chemical characterization) or biological properties.

Identification of particles can be achieved by size, the generated processes or they ability to penetrate the respiratory tract [3].

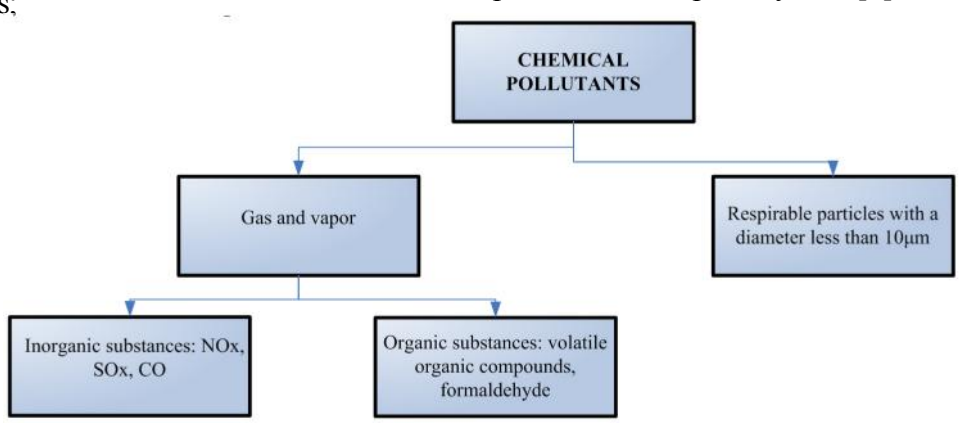



**Fig. 2.** Classification of chemical pollutants

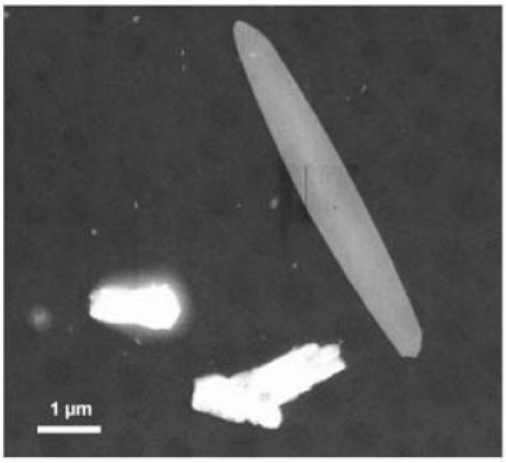
Small particles (submicrometre ranges) are generated mainly from combustion or conversion processes of gas particles, from nucleation or photochemical processes, while large particles are generated from mechanical processes (cutting, tear, dust resuspension).

In indoor air can be present aerosols, defined as liquid or solid particles suspended in a gaseous medium. Generating processes are responsible for determining particle shape and size. Most particles have a high degree of irregularity, but there are also particles whose shape is simple and regular. Different types of particles present in indoor air are illustrated in figure 3.

The chemical composition of particles present in indoor air is extremely complex and depends on their origin and postforming processes. Some particles are inorganic (e.g., particles from glass fiber) but there are also organic particles (e.g. particles from cellulose fibers). The most important characteristics needed to define particles from the chemical point of view include:

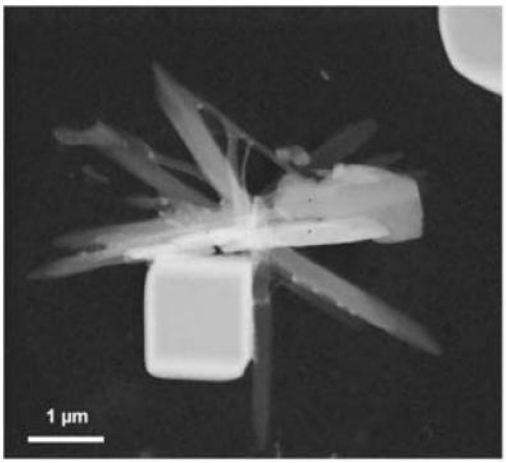
- elemental composition;
- inorganic ions;
- carbon compounds.

The interest from the elemental composition derives from the potential effects they may have, heavy elements arsenic, mercury, lead, cadmium, on the health of building occupants [5]. Particle effects on health and the environment are closely related to particle size, penetration ability and

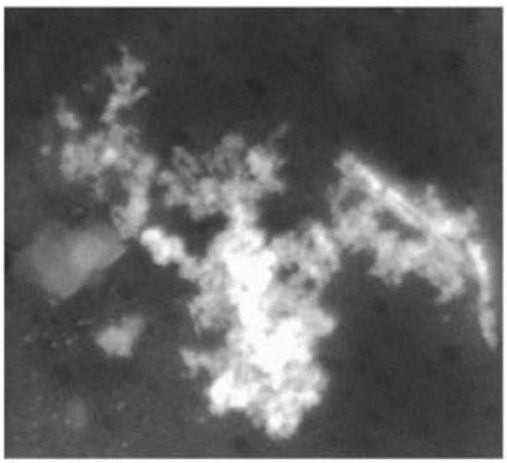



1A: Three large particles in which chemical elements are dominant: S, Ca, Na, O and Mg

1B: Particles from fiber




1C: Two types of particles, one particle with regular structure (sodium chloride crystal) and fibrous particles such as dominant chemical elements are: Ca, S, Na, O, Mg



1D: More joined particles where the dominant chemical elements are: Fe, Pb and Si

**Fig. 3.** Images taken with electron microscope
These particles may come from car emissions [4]

transport them from the outside to indoors. Emission rate of a source generating particles is given by the quantity of chemical species, mass and number of particles emitted per unit of time. Particle concentration in indoor air depends on several factors:

- type, nature and number of sources;
- source characteristics;
- building characteristics;
- concentration of pollutants coming from the outside;
- weather.

In the context of those presented, in table no. 1 are shown some pollutants from construction materials and their effects on health of occupants.

**Table 1.**

*Pollutants from construction materials and health effects on occupants [6]*

| Types of chemicals | Effect | Types of chemicals | Effect |
|---|---|---|---|
| Acrylonitrile | Carcinogenic, irritates mucous membranes; especially poisonous to water organisms | Fungus (collective name for many micro-organisms including aspergillus, cladosporium and penicillin) | Cause asthma and infections in inhalation routes |
| Aliphatic hydrocarbons (collective name for many organic compounds, naphthenes and paraffins) | Irritates inhalation and oral route and skin; promotes carcinogenic substances | Hydrochrinon | Allergenic, irritates inhalation routes |
| Amines (collective group for different aromatic and aliphatic ammonium compounds) | Irritates inhalation routes; cause allergy; possibly a mutagen | Hydrogen chloride | Strongly acidifying; corrosive; irritates inhalation routes and mucous membranes |
| Ammonia | Corrosive; irritates mucous membrane; over fertilizing effect; strong acidifies water | Hydrogen fluoride | Corrosive; can cause fluorose; extreme irritant of mucous membranes; extremely damaging to water organisms; poisonous |
| Aromatic hydrocarbons (collective name for many organic compounds such as benzene, styrene, toluene and xylene) | Carcinogenic and mutagenic; irritate mucous membranes; damage the nervous system | Isocyantes (collective group including TDI, MDI) | Very strong allergenics; irritates mucous membranes and skin |
| Arsenic and arsenic compounds | Bio-accumulative; can damage foetus; mutagenic; many are carcinogenic | Ketones (group of substrates including methyl ketone and methyl isobutyl ketone) | Slightly damaging to reproductive organs; generally weak nerve poisons; poisonous to water organisms |
| Benzene | Anaesthetizing; carcinogenic; irritates mucous membranes; mutagenic | Lead and lead compounds | Bio-accumulative; can lead to brain and kidney damage |
| Bitumen (mixture of aromatic and aliphatic compounds, such as benzolalpyrene) | Contains carcinogenic compounds | Mercury and mercury compounds | Allergenic; bio-accumulative; can damage the nervous system and reproductive system; persistent |
| Boric salts (collective name for borax and boracic acid) | Slightly poisonous to humans; poisonous to plants and organisms in fresh water in heavy doses | Nickel and nickel compounds | Allergenic; bio-accumulative; carcinogenic; extremely poisonous to water organism |
| Cadmium | Bio-accumulative; carcinogenic; even in low concentrations can have chronic poisonous effects on many organisms such as liver, kidney and lung damage | Nonyl phenol | Bio-accumulative; environmental oestrogen; persistent; poisonous to water organisms |

| Types of chemicals | Effect | Types of chemicals | Effect |
|---|---|---|---|
| Calcium chloride | Irritant; strongly acidifying | Organic acidic anhydrides (collective name for substances) | Acidifying; irritate the inhalation routes |
| Chlorine | Acidifying; strongly irritates mucous membranes | Organic tin compounds | Bio-accumulative; persistent, extremely poisonous to water organisms |
| Chlorofluorocarbons | Break down the ozone layer | Pentane | Slightly damaging to water organisms |
| Chrome and chrome compounds | Allergenic; bio-accumulative; carcinogenic; oxidizing; can cause liver and kidney damage | Phenol | Carcinogenic; mutagenic; poisonous to water organisms alkylphenols and bisphenol A are suspected environmental oestrogens |
| Copper and copper compounds | Bio-accumulative; poisonous to water organisms | Phosgene | Extremely poisonous: causes lung damage; breaks down to hydrogen chloride when added to water |
| 2-cyano-2-propanol | Extremely poisonous | Phthalates | Environmental oestrogen; damaging to the reproductive system; generally persistent; moderately poisonous to water organism; certain phthalates are allergenic and carcinogenic |
| 1,2-dichloroethane (ethylene dichloride) | Carcinogenic; persistent; extremely poisonous to water organisms | Polycyclical aromatic hydrocarbons (group of substances which includes benzo(a)pyrene) | Bio-accumulative, carcinogenic, mutagenic; persistent; particularly damaging to water organisms |
| Dichloromethane (methylene chloride) | Carcinogenic; persistent; extremely poisonous to water organisms | Propene | Belived to change to 1,2 propylene oxide in the body, which is carcinogenic |
| Diethyltriamine | Acidifies heavy water; corrosive; strongly irritates mucous membranes | Quartz dust | Carcinogenic |
| Dioxin (2,6 dimethyl-dioxan-4yl-acetate) | One of the most toxic materials known: persistent bio-accumulative nerve poison; carcinogenic; extremely poisonous to water organisms | Radon gas (gas that contains radioactive isotopes of polonium, lead and bismuth) | Carcinogenic |
| Dust | Irritates inhalation routes; forms part of photochemical oxidants | Styrene | Irritates inhalation routes – can make them very sensitive; damages reproductive organs |
| Epoxy | Very strong allergen | Sulphur | Acidifying |
| Esters (collective name of buthyl acetates and ethyl acetates) | Irritate mucous membranes; mutagen; medium strength nerve poison | Syntethetic mineral wool fibre (group of substances including glass wool and rock wool) | Slightly carcinogenic; irritates inhalation routes |
| Ethene, ethylene | Possibly carcinogenic because it becomes ethylene oxide in the body | Thallium | Extremely poisonous |
| Ethyl benzene | Strongly irritates mucous membranes; poisonous to water organisms | Vinyl acetate | Possibly carcinogenic possibly neurotoxicant, possibly respiratory toxicant; poisonous to water organisms |

| Types of chemicals | Effect | Types of chemicals | Effect |
|---|---|---|---|
| Fluorides | Changes in bone structure; damages forests and water organisms; generally poisonous in varying degrees of accumulation | Vinyl chloride | Carcinogenic; irritates the inhalation routes; narcotic; persistent; poisonous to water organisms |
| Formaldehyde | Allergenic; carcinogenic; irritates inhalation routes; poisonous to water organisms | Wood dust | Dust from oak and beech can be carcinogenic; irritates inhalation routes |

## 4. CONCLUSIONS

Emissions studies of different chemical compounds coming from building materials involve the achievement of a multidisciplinary research located at the interface between medicine and chemistry. Knowledge of risk factors present in indoor air has a role to raise public awareness about the importance of a clean indoor environment, mainly aimed at the possibility of selecting materials of construction to ensure a healthy indoor climate. This can be achieved only if exist a tool to quantify emissions from building materials that can perform a screening based on classification criteria for chemical substance with potential health risk to occupants.

**REFERENCES**

[1] Roulet, C. – *Sante et qualite de l'environnement interieur dans les batiments*, Presses Politechniques et Universitaires Romandes, Lausanne, 2003

[2] Brandford, O., William, F. – *Understanding indoor air quality*, p. 19-68, 1992

[3] Hinds, W. – *Aerosol technology: properties, behavior, and measurement of airborne particles,* Wiley, New York, 1982

[4] Pluschke, P. – *The handbook of environmental chemistry – Indoor air pollution*, vol. 4, part F, p. 181-182, 2004

[5] Morawska, L., Salthammer, T. – *Indoor environment, airborne particles and settled dust*, Wiley-VCH, Weinheim, 2003

[6] Bjorn, B. – *The ecology of building materials*, p. 29-32, 2001