

# *Session 1B Introduction of EnVIE concept and overview of EnVIE project*

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## **BACKGROUND**

European citizens want to live longer, healthier, in an environment of low involuntary risks, and at an affordable cost. Urban environmental policies should, therefore, manage the determinants of health as far upstream as possible and improve the citizens' quality of life. People are exposed to a multitude of chemical, physical and biological stressors in their environment, some of which are apparently harmless, others of low health significance and some incur significant risks to health, at least for vulnerable individuals. Human exposure to environmental contaminants occurs via various pathways (air, water, food...) and routes of entry (inhalation, ingestion and dermal). Exposure via air occurs outdoors and in different indoor environments; e.g. home, workplace, transit. Indoor air pollution from different sources may cause or aggravate illnesses, increase mortality, and have major economic and social impacts.

Knowing the relative contributions of these environments to exposure and health effects is essential for effective risk management and resources allocation.

## **HEALTH EFFECTS OF INDOOR AIR**

Different pathways from indoor sources lead to a broad variety of health outcomes that are attributable to the indoor environment (See Figure 1, Jantunen et al. 2000).

Building-related illness (BRI) is a term referring to illness brought on by exposure to the building air, where a defined illness, directly linked to agents in the indoor environment, is diagnosed. Legionaire's disease and hypersensitivity pneumonitis are examples of BRI that can have serious, even life-threatening consequences. Some indoor pollutants are known or suspected carcinogens (radon, environmental tobacco smoke (ETS), asbestos, benzene) and add to the underlying cancer risk for the European populations. Lung cancer, in particular, has been clearly associated with indoor radon, ETS, and asbestos.

Also hypersensitivity initiation and allergies are sometimes associated with contaminated indoor air; various reports have linked indoor allergens with one or more of the following allergic manifestations among the occupants:

- Rhinitis, with ‘hay fever’ symptoms such as nasal congestion, runny, nose, sneezing, conjunctivitis..
- Asthma, with symptoms such as wheeze, tightness of the chest and shortness of breath.
- Extrinsic allergic alveolitis (hypersensitivity pneumonitis), with acute pneumonia-like fever, cough, tightness of the chest and lung infiltration, or chronic development of cough, shortness of breath and infiltration of the lungs.
- Humidifier fever, with symptoms including fever, chills, muscle ache and malaise, but no obvious respiratory effects.

The term sick building syndrome (SBS) is used to describe cases in which building occupants experience acute symptoms and discomfort that are apparently linked to the time they spend in the building, but for which no specific illness or cause can be assigned. The complaints may be localised in a particular room or zone or may be widespread throughout the building. Many different symptoms have been associated with SBS, including respiratory complaints, irritation, and fatigue. Sensory perception of odours and mucous irritation lead to perception of poor air quality and possible risks thereof, and consequently to stress or behavioural responses (opening a window, leaving the building). The symptoms of stress vary, depending on the host, not on the cause of the stress. Other environmental stressors such as noise, vibration, crowding, ergonomic stressors and inadequate lighting can produce symptoms that are similar to those of poor air quality.

Finally discomforting information about exposures and health risks, and job-related psychosocial problems may cause stress symptoms that are undistinguishable from those of sensory perceptions.

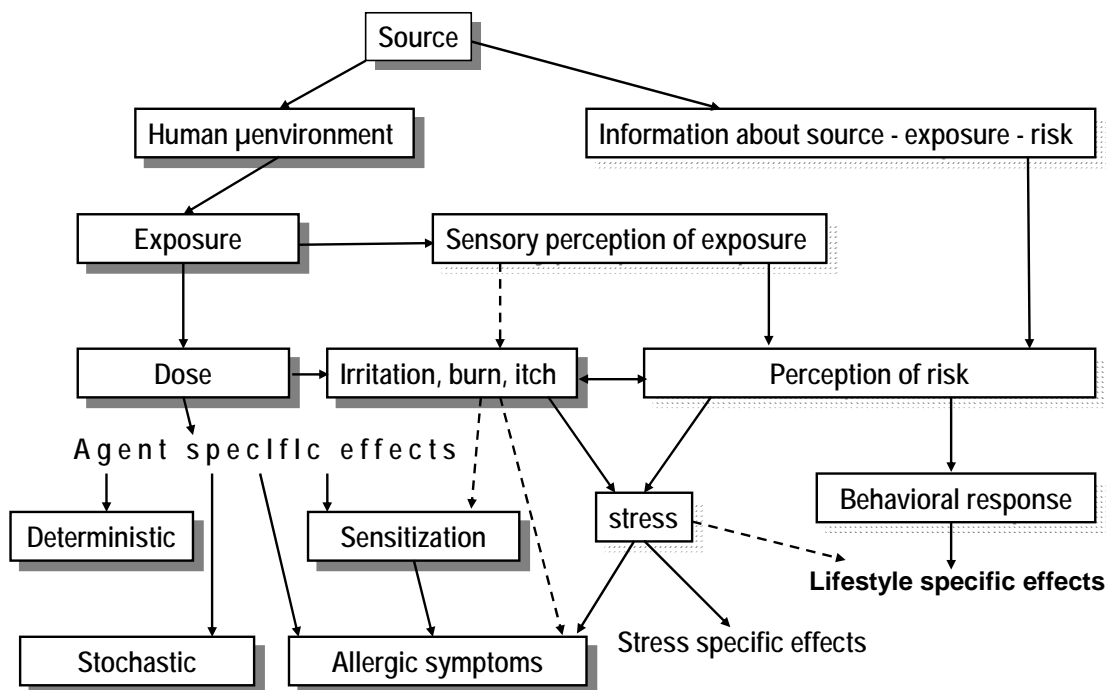


Figure 1. The entangled pathways from source to the different agent, stress and lifestyle related health outcomes.

## REVIEWS OF MAIN IMPORTANT INDOOR AIR RELATED HEALTH EFFECTS

### INDEX project

The INDEX project “Critical appraisal of the setting and implementation of indoor exposure limits in the EU (2002–2004)” was funded by the European Commission’ DG SANCO and JRC was given the assignment to identify priorities and to assess the needs for a Community strategy and action plan in the area of indoor air pollution by: setting up a list of compounds to be regulated in indoor environments with priority on the basis of health impact criteria; providing suggestions and recommendations on potential exposure limits for these compounds; and providing information on links with existing knowledge, ongoing studies, legislation etc. at world scale (Kotzias et al. 2005).

On the basis of the available information 14 compounds (out of initial 41 candidate compounds) were selected for a detailed assessment i.e.: acetaldehyde, alpha-pinene, benzene, carbon monoxide, d-limonene, formaldehyde, meta-, orto- and para-xylene, naphthalene, ammonia, nitrogen dioxide, styrene and toluene.

Finally a list of compounds, consisting of 5 chemicals, with potential of high indoor concentrations, uncontested health impacts, and options for effective risk management were selected to be regulated with priority.

### *Formaldehyde*

Predominant symptoms of formaldehyde exposure in humans are irritation of the eyes, nose and throat, together with concentration-dependent discomfort, lachrymation, sneezing, coughing, nausea and dyspnoea. Because of its high chemical reactivity, formaldehyde is the most important sensory irritant among the chemicals assessed in the present report. Due to being ubiquitous pollutant in indoor environments and to the increasing evidence indicating that children may be more sensitive to formaldehyde respiratory toxicity than adults. IARC announced there was sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans and re-classified it as a Group 1, known human carcinogen (previous classification: Group 2A). IARC also reported there was limited evidence that formaldehyde exposure causes nasal cavity and paranasal cavity cancer and “strong but not sufficient” evidence linking formaldehyde exposure to leukemia.

### *Carbon monoxide*

Carbon monoxide (CO) is a tasteless, non-irritating, odourless and colourless toxic gas which can cause acute and lethal poisonings (a large number of deaths occur annually in fires, workplaces and in indoor environments). Currently available evidence suggests that individuals with heart disease (including stable exercise-induced angina, coronary artery disease, and ischaemic heart disease), in fact with any condition that may compromise oxygen sufficiency, are under the greatest risk from exposure to CO. In addition, population groups with either increased probability or increased severity of health effects include fetuses, pregnant women, and young

infants, individuals with anemia or respiratory disease, the elderly, children, and persons with peripheral vascular disease and chronic obstructive lung disease.

### *Nitrogen dioxide*

Exposure at NO<sub>2</sub> indoor levels could generate effects in the pulmonary function of asthmatics, considered to be the subjects most susceptible to acute NO<sub>2</sub> exposure. For long-term exposures, increased respiratory symptoms and lung function decreases in children have been documented to be the most sensitive effect in the general population. On the other hand, indoors, as well as outdoors, NO<sub>2</sub> is strongly associated with other combustion products, most notably fine particulate matter (fPM), and it is difficult to separate its effects from those of these co-pollutants. The independent effects of NO<sub>2</sub> have been only observed at much higher concentrations than normally found in indoor air.

### *Benzene*

It is a genotoxic carcinogen (IARC class 1). Results from nine monitoring surveys indicate that the European population is experiencing in their homes an increased risk in contracting leukaemia induced by benzene from the indoor air.

### *Naphthalene*

In relation to carcinogenicity, naphthalene is not genotoxic in vivo and thus tumour development, observed in rodents, is considered to arise via a non-genotoxic mechanism. Also, the underlying mechanism for the development of nasal tumours in the rat is considered to be the chronic inflammatory damage seen at this site. Two to 20% of individuals in defined Mediterranean subpopulations exhibit an inherited deficiency in glucose-6-phosphate dehydrogenase (G6PD). They may develop haemolytic anemia and its sequel at low naphthalene exposures than are harmless to most. Infants and neonates form the other subpopulation, which is sensitive to naphthalene toxicity.

### THADE project

The European Federation of Allergy and Airways Diseases Patients Associations (EFA) carried out the EU-funded project entitled “Towards Healthy Air in Dwellings in Europe – THADE” (Franchi et al. 2006). This study was endorsed by the European Academy of Allergology and Clinical Immunology (EAACI), European Respiratory Society (ERS), European Federation of Building Services Engineers (REHVA), Global Initiative on Asthma (GINA), International Society on Indoor Air Quality and Climate (ISAIQ); sixteen associations affiliated to the EFA network took part in the project.

The major health exposures affecting occupant health in dwellings were found to be tobacco smoke, dust mites, pet allergens, cockroaches, mould, pollen, nitrogen oxide, formaldehyde, VOCs, indoor-generated particulate matter, man-made mineral fibres, radon, CO and CO<sub>2</sub>.

Four main conditions have been related to indoor air quality:

1. Building-related illnesses are conditions that are directly attributable to environmental agents present in the air of a building (e.g. CO intoxication).
2. Several allergic diseases have been associated with indoor air pollution, namely rhinitis with hay fever symptoms, asthma with wheezing, tightness of the chest and shortness of breath. In addition, extrinsic allergic alveolitis with acute pneumonia-like bouts of fever, cough and lung infiltration can result from poor air quality.
3. Sick building syndrome refers to buildings in which most of the building occupants experience acute health and comfort effects that seem to be linked to the time they spend in the building, but in which no specific illness or cause can be identified.

In particular, indoor pollutants can affect the respiratory system in various ways. In fact, they can cause or exacerbate acute and chronic respiratory diseases and they can also cause a decline in respiratory functions and sensitization to common aeroallergens.

Subjects particularly susceptible to indoor air contaminants include people with allergy or asthma; people with chronic respiratory disease; people with a suppressed immune system; and contact lens wearers. Other subjects may be vulnerable to certain pollutants. For example, people with heart disease may be more affected by exposure to lower levels of CO than healthy individuals.

#### US National Occupational Research Agenda on indoor work environments

The US National Institute for Occupational Safety and Health (NIOSH) and diverse partners within the US occupational health community developed the National Occupational Research Agenda (NORA) that identified 21 priority areas in which new research could most effectively reduce work-related illnesses, injuries, and deaths in the coming decade. For the priority area “Indoor work environment” the team identified 3 types of health effects as priorities for increased research (Mendell et al. 2002):

1. building-influenced communicable respiratory infections, due to occupant sources (e.g. influenza, common cold, tuberculosis) or building sources (Legionnaires’ disease, Pontiac fever, fungal infections);
2. building-related asthma, hypersensitivity pneumonitis and allergic diseases;
3. non-specific building-related symptoms (including so-called sick building syndrome)

The implementation of preventive measures has been estimated to prevent adverse health effects among millions of indoor workers and provide annual economic benefits in the order of a billion dollars.

The NORA team has not proposed research on all adverse health effects potentially related to indoor work environments. For the prevention of such exposures as environmental tobacco smoke, radon, asbestos and carbon monoxide and their respective health effects, strategies were considered to be well understood. On the

contrary, for some exposures, such as those that might influence cancer, neurotoxic effects, reproductive effects or “multiple chemical sensitivity” insufficient evidence was available to specify the responsible exposures and to estimate health or economic effects in indoor work environments.

### WHO guidelines for indoor air

The working group of the recently published Global Update of the WHO Guidelines for Air Quality (WHO, 2006), recommended development of WHO guidelines for indoor air quality. Based on this recommendation World Health Organization convened a working group meeting for the development of indoor air quality guidelines representing scientific expertise in epidemiology, toxicology, exposure assessment, developing country issues, indoor combustion, biological agents, building construction, ventilation and indoor air quality management. The working group outlined three tasks required for the guideline development in 2007-2009 (WHO, 2007):

1. To list the specific chemicals for which numerical guidelines can be prepared;
2. To assess the biological contamination of indoor air
3. To assess the effluents of indoor combustion of solid fuels

#### *1. List of chemicals*

The group identified two groups of pollutants.

- Group 1: Pollutants for which the development of guideline is recommended, including Formaldehyde, Benzene, Naphthalene, Nitrogen dioxide (NO<sub>2</sub>), Carbon monoxide (CO), Radon (Rn), Particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), Halogenated compounds (tetrachloroethylene, trichloroethylene), Polycyclic aromatic hydrocarbons (PAH), especially Benzo-a-pyrene (BaP).

- Group 2: Pollutants for which the current evidence is uncertain or not sufficient for guidelines, including Toluene, Styrene, Xylenes, Acetaldehyde, Hexane, Nitric oxide (NO), Ozone (O<sub>3</sub>), Phthalates, Biocides, Pesticides, Flame retardants, Glycol ethers, Asbestos, Carbon dioxide (CO<sub>2</sub>), Limonene, Pinene, TVOCs.

#### *2. Biological agents*

Exposures to biological agents in indoor environments were identified as a significant health hazard causing a wide range of health effects. It is usually impossible to identify individual species of the microbes or other specific biological agents responsible for the health effects; the exceptions are some common allergies, which can be attributed to specific agents or exposures, such as house dust mites or pets.

#### *3. Combustion of solid fuels and kerosene*

The group set the focus of the development of indoor air quality guidelines on exposures to emissions from household use of solid fuels and kerosene, not just for heating and cooking but including also e.g., lighting and small commercial activities in households. The group also recognized that the health relevant exposure to combustion products is affected also by the outdoor air quality. While moving

pollution emitted indoors to the outdoor air with venting radically improves indoor air quality, it still causes harmful exposure to people both outdoors as well as via outdoor pollution infiltrating back indoors. Therefore the reduction of the emission should be an objective of the health relevant actions. In some areas processed solid fuels, e.g., charcoal and “clean coal” may be part of the solution. Control of household use of coals contaminated with S, F, As, Pb, Hg needs to be considered as particularly important.

EU Scientific Committee on Health and Environmental risks (SCHER): Preliminary report on risk assessment on indoor air quality

To provide a scientific basis for the assessment of risks to human health from indoor air quality and for the development and implementation of policies, the SCHER was asked to identify a Risk Assessment Strategy to support policy on indoor air quality (SCHER, 2007).

A number of factors in the indoor environment can affect well-being and health. The main factors are: Chemicals for intended use or unintentional emissions from different sources, radon, particles, microbes, humidity, pets and pests.

Indoor environment contains a large number of different chemical compounds. Availability of data on exposures to specific chemicals, their toxicity and associated health risks are highly variable. Therefore, a priority ranking of chemicals and exposures which cause concern is difficult and uncertain. However, the SCHER considered that formaldehyde, carbon monoxide, nitrogen dioxide, benzene, naphthalene, environmental tobacco smoke (ETS), radon, lead and organophosphate pesticides are agents of concern in indoor environment.

For most other pollutants the data available are yet too limited for risk assessment as indoor air pollutants. Consumer products, one source of chemicals in indoor environment, emit mostly volatile organic compounds. Lack of data on true exposure for emissions from consumer products has hampered the evaluation of the associations with possible health effects most of which are also caused by other factors. The recent data suggest that some of the emitted products may react further in air and on surfaces producing secondary products, including ultrafine particles. The health effects of those reaction products are poorly known.

The association of adverse health effects with dampness and water damage in buildings is repeatedly demonstrated in epidemiological studies, but the causative agents, mechanisms and all health consequences are not known. This is potentially a serious indoor air problem in EU. More research is needed to understand the associations between exposure indicators and the magnitude of the health effects in the EU countries.

Combined and mixture effects of indoor air pollutants can so far only rarely be assessed. Neither the databases nor methodologies exist to evaluate the breadth and depth of such combined effects. The SCHER recommends the production of data in order to make the evaluation of combined effects of indoor air pollutants feasible. In addition, the SCHER recommends taking also into account routes of exposure other

than inhalation (dermal, ingestion) in risk assessment and contribution of indoor exposure to the total exposure from other sources in all environments.

The risk assessment should be transparent to allow the evaluation of its strengths and weaknesses.

## **ENVIE: THE MOST IMPORTANT INDOOR AIR RELATED HEALTH EFFECTS**

Aim of the EnVIE project is to evaluate the overall impact of poor indoor air quality on health in Europe and to inform policy makers about evidence-based preventive policies.

The following diseases (not in rank order) have been prioritised as being caused or aggravated by poor indoor air quality:

- Asthma & asthma-like symptoms
- Allergies: rhinitis, conjunctivitis, atopic dermatitis
- Lung cancer
- Chronic obstructive pulmonary disease (COPD)
- Respiratory infections
- Acute cardiovascular effects
- Acute/chronic CO poisoning
- SBS symptoms

One way of providing information for evidence-based policy is “health impact assessment”, i.e., the quantification of the health effects of the exposure to indoor pollution. The health impact assessment of indoor pollution needs (i) epidemiology, to provide data on the relative risks at real life exposure settings and levels, (ii) toxicology to assess the mechanisms of action of and thus to provide biological plausibility for the health effects of indoor air contaminants, and (iii) frequencies, distributions and determinants of the exposures within the population.

Causal relationships between some indoor exposures and diseases have been well established and some quantitative assessments of the relative risks or of the dose response function are already available from published meta-analyses. For example: ETS has been well recognized to be causally associated with lung cancer, other respiratory and cardiovascular diseases; indoor air CO is an unquestioned cause of thousands of deaths from acute poisoning annually in Europe; indoor radon has been classified by IARC as a carcinogen and the results of a large European collaborative study on radon and lung cancer is about to be published. There are other exposures that have been causally associated with diseases, but for which comprehensive meta-analyses have not yet been published. Finally, in many cases no casual associations between contaminants and certain outcomes have been confirmed in spite of suggestive evidence in the literature.

It has to be underlined that in a recent review about indoor air quality it has been stated that the improvement of indoor air quality by a factor of 2-7 compared with

existing standards not only decreases the risk of health effects (like allergic symptoms and asthma in the homes), but also increases the productivity in offices and learning in schools (Fanger, 2006; Seppänen et al, 2006).

## ROLES OF BUILDINGS, INDOOR AIR AND VENTILATION IN AIR POLLUTION EXPOSURES AND RISKS

Modern European citizens spend – in average – over 90% of their time indoors. Indoor air originates from outdoors, carrying outdoor air contaminants indoors with varying degrees of penetration: some are effectively transferred indoors (e.g. PM<sub>2.5</sub>, P = 50–90%), others are adsorbed on building structures and indoor surfaces (e.g. H<sub>2</sub>S), some readily react with indoor air co-pollutants (e.g. O<sub>3</sub>). Also indoor environments contain sources of contaminants, which, due to the low indoor air exchange rates compared to outdoor environments, may lead to quite high levels. These have been widely studied for a range of chemicals, particles and biological contaminants, and in the presence of indoor sources, indoor contaminant concentrations are higher, sometimes 10 or 20 times higher (e.g.: formaldehyde) than the respective outdoor air levels. The combination of the generally higher indoor concentrations and the overwhelming fraction of time spent indoors results in the overall domination of indoor air in air pollution exposures – and their respective health consequences - regardless of whether the sources are indoors or outdoors.

Radon is a natural and carcinogenic air contaminants, which is produced in the soil as the only gas phase radioactive decay product of natural uranium, and drawn into indoor air by the air pressure gradient caused by the normally lower indoor relative to outdoor air pressure. The indoor air radon concentrations often exceed outdoor air levels by 1...2, even 3 orders of magnitude.

Indoor exposures to allergens from outdoor sources – e.g. pollen - affect sensitive individuals. The sources of other sensitising agents, e.g. mould spores and particles, are often found indoors. While the building – in particular persistent moisture in its structures - is often the cause of the latter, it may, at the same time, provide significant protection against the former exposures, and this protection can be further enhanced by the ventilation equipment, indoor space cleaning and occupant behaviour.

The function of ventilation is to ensure the delivery of fresh air and extraction of the contaminants from the indoor sources (e.g. human metabolism, occupant activities, consumer products, furnishing, building equipment and materials). Yet, ventilation may also draw in polluted outdoor air, the ventilation system may itself become contaminated and, thus, a source of pollution. Insufficient ventilation may cause moisture to accumulate in the building, unbalanced ventilation may result in radon buildup, uncontrolled air leaks, and moisture condensation in hidden building structures, and excessive ventilation with no heat (or cool) recovery wastes energy.

## AIR QUALITY POLICIES & INDOOR AIR

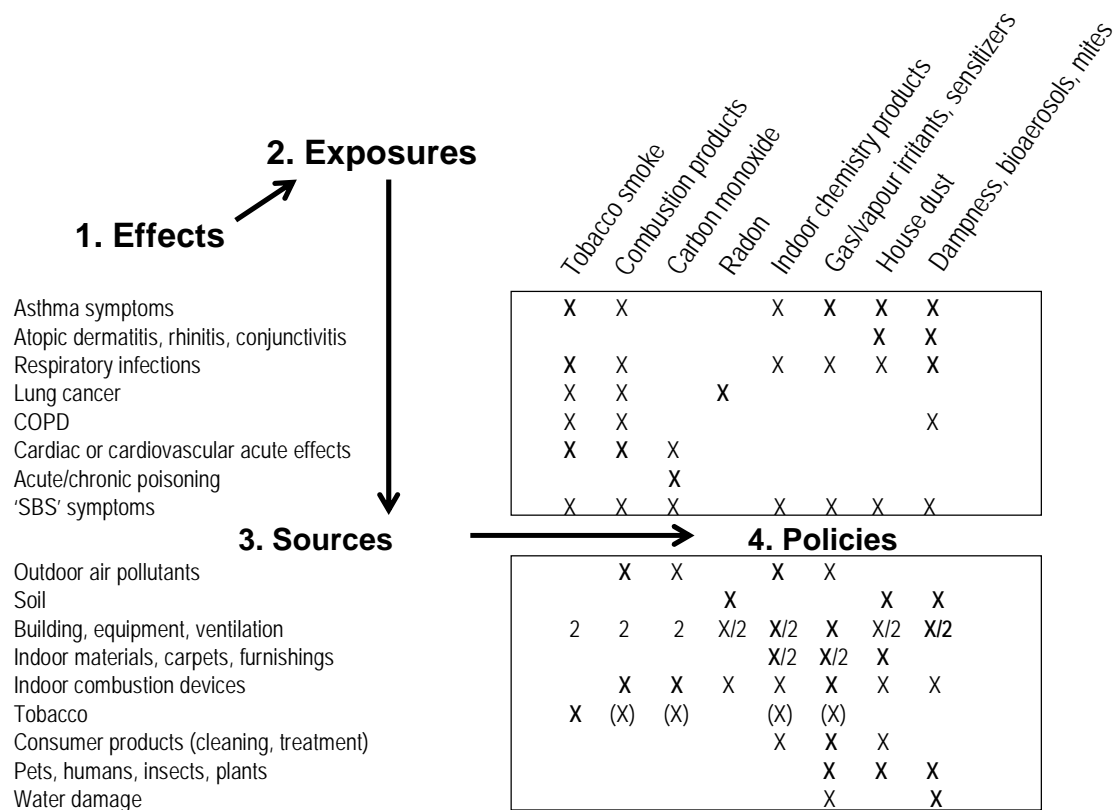
European air quality policies have devoted most of their efforts to control the urban outdoor air concentrations of a short list of regulated air contaminants from heat and power generation, industrial processes and traffic. Although there is no reason to relax the society's preoccupation towards these issues, it is now recognized that new policies should be focussed on indoor exposures to identify, control and eliminate the indoor sources of pollution, and to also reduce the exposures to air pollution of outdoor origin. In the case of most VOCs, the focus should be on the indoor sources, building materials, consumer products and occupant activities. In the case of NO<sub>2</sub> and fine PM, both indoor source control and filtration of the outdoor air contaminants may be considered. Exceedances of the European and National outdoor air CO standards are becoming rare. Yet toxic CO exposures are not vanishing, they claim thousands of lives annually and are currently caused almost exclusively by indoor combustion sources, which could be regulated more easily than many other sources in the buildings.

National air quality policies on indoor air have until recently consisted of scattered regulations on building materials and equipment, HVAC equipment in particular, ventilation rates and concentration guidelines on a few chemicals (mainly formaldehyde) and radon. The indoor air issues in Europe have since 1987 been broadly covered in the 27 reports of the European Concerted Action on Indoor Air Quality and its Impact on Man (Since 1999, Indoor Air, Human Exposure and Urban Environment). DG Sanco funded the JRC/IHCP Coordinated IndEx project (2002-2005), which for the first time in Europe evaluated the indoor air chemicals for which exposure and health data was available in Europe, and recommended general IAQ policies concerning ventilation, combustion devices, source control, occupant behaviour, building maintenance, etc. and regulations for a shortlist of chemicals consisting of Formaldehyde, Benzene, NO<sub>2</sub>, CO and Naphthalene. Biological contaminants, radon and ETS were not included, because they were not chemicals. In 2006 WHO/Europe initiated the preparation for Indoor Air Quality Guidelines, expected for 2008-9.

## EnVIE OBJECTIVES AND APPROACH

It is therefore the objective of the EnVIE project to increase the understanding of the Europe-wide public health impacts of indoor air quality. The project will identify the most widespread and significant indoor causes and sources for these health impacts, and evaluate the existing and optional building and housing related policies for controlling them. It will address in particular how indoor air quality might contribute to the observed rise in asthma and respiratory allergy, together with other acute and chronic health impacts. The project does not intend to conduct new experimental or field research, but rather to build on the broad scientific experience, as well as the literature of reports and articles which have accumulated in the domestic and international indoor air research projects as well as the EU, WHO, ISIAQ and CIB committees and expert groups during the past 20 years.

Many previous indoor air quality and policy assessments have taken specified contaminants or indoor sources as the starting points. The logic behind is the flow of molecules from sources via environment to exposure, dose and the consequent health outcome. EnVIE follows an opposite logic, starting from the most pronounced indoor air related health outcomes (which have often also other sources and causes), then identifying the most widespread indoor air exposures which are likely to cause these health outcomes, and the most common sources which dominate the indoor air exposures – see Figure 1. The 1st objective of this approach is to focus from the start on those indoor air quality issues of the highest Europe-wide health relevance. Having defined a shortlist of such indoor health-exposure-source chains, the project will evaluate the policy alternatives for minimising the unwanted health consequences in terms of achievable public health benefits, invasiveness, as well as political, legal, technological, economical and social feasibility. The 2nd objective is to identify and describe a set of beneficial and feasible indoor air quality policy alternatives for Europe. Europe wide applicability brings, aside of the health benefits, also the economical benefits of enhanced competition in a broader marketplace.



'X, X, X' denote different levels of impact. '2' denotes secondary influences.

Figure 2. Flowchart of the EnVIE project highlighting the health, exposure, and source issues selected in the first stage of the project.

## ENVIE ACTIVITIES AND PRODUCTS

The EnVIE project will centre around two EnVIE Conferences. The 1st EnVIE Conference will cover the selected issues from health outcomes, via exposures to sources. The 2nd EnVIE Conference will focus on alternative source control policies, evaluating the achievable exposure and health impact gains, as well as the other requirements and consequences of these alternatives. In EnVIE Workshops the WP:s will on one hand create the detailed programmes for the EnVIE Conferences, and on the other hand critically evaluate and edit their results. Through (i) careful planning by the EnVIE steering committee and (ii) well instructed preparation by the conference presentation authors, the presentation texts, (iii) critically reviewed and edited by the EnVIE WP:s and complemented with discussion summaries, will form core chapters of the EnVIE project report.

The EnVIE Final Report will consist of the edited EnVIE Conference proceedings complemented with a general introduction and an executive summary, which will also include the general recommendations.

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