CHAPTER 8

ENVIRONMENT AND HEALTH

Introduction

In recent years, in relation to the prevention of health risks arising from environmental factors, greater attention has been paid to indoor pollution, that is to say the air quality of indoor living environments, such as homes and schools. These environments may be affected by conditions of pollution having a different nature and origin that may prove detrimental to the health of those who spend there most of their time. In fact, these persons are potentially exposed on a daily basis and for extended periods of time to biological, chemical or physical pollutants with which they come into contact mostly through the air they breathe. Various studies have highlighted that not only is the indoor concentration of some pollutants higher than their concentration on the outside, therefore confirming that there are also indoor sources of pollution, but also that even at low concentrations they may affect human health, especially for subjects particulary vulnerable such as children and allergic and asthmatic individuals.

In indoor living environments, such as homes, schools and workplaces, people are exposed on a daily basis to biological, chemical or physical pollutants with which they come in contact mostly through the air they breathe.

Our current prevention systems and the regulations that regulate indoor pollution address for the most part a few types of indoor environments, such as workplaces, and fewrisk factors, such as radon, asbestos, electromagnetic fields and noise. Still, the protection of the biological and chemical quality of indoor air lacks a reference system that may be likened to the one provided for outdoor air pollution and this also applies at a Community level and in many Countries outside the European Union.

This situation is leading to a growing awareness among researchers and policy makers in consequence both of the outcome of epidemiological studies, which stress the health-related significance of airborne chemical and biological contaminants, and of the increasing qualitative and quantitative spread of outdoor and indoor pollution sources. Outdoor sources , such as vehicle traffic,release chemical substances contaminating indoor air through ventilation, while air pollution from indoor sources is caused by furniture, furnishings, building materials, home detergents and other consumer goods. At the same time, even the changing local meteoclimatic conditions (warmer winters and more frequent summer heat waves, heavy rains or floods alternated with periods of drought) not only promote the spread of other biological risk factors, such as pollens, vector insects, and pests, but may also alter indoor humidity level, facilitating the proliferation of moulds or other pathogens that affect the human body (Table 8.1).

The air quality is affected more and more by both outdoor sources of pollution, which release chemical substances that spread indoor (vehicle traffic), and indoor sources of pollution peculiar to indoor environments (furniture, furnishings, building materials, home detergents, etc.).

Indoor air quality, therefore, depends on many factors that are subject to different policies and/or sectors, such as transports, productive activities and salubrity of consumer goods, and last but not least environmental monitoring and health prevention systems. There are also other potentially perturbing elements that need to be

The protection of the indoor air quality depends on a variety of factors that, in their turn, are subject to

taken into account, such as introduction of new building materials, the need of an effective thermal and acoustic insulation, and the increasing use of mechanical ventilation and air conditioning systems in newly built buildings. While these new techniques meet the modern energy saving requirements, on the other hand, in absence of adeguate design and building maintenance, can lead to insufficient ventilation of indoor environments and to increased airborne pollutants concentrations.

different policies and/or sectors, such as means of transport, productive activities and salubrity of consumer goods, environmental monitoring and health prevention systems.

If quit a few sectors are involved,many are the responsible parties: central institutions, governments and local authorities, designers and manufacturing firms and, last but not least, the individuals with their choice of consumer goods and furnishings. There are also several types of indoor environments (offices, homes, schools, etc.) that differ in exposure patterns. Hence, indoor air quality is a complex issue from the point of view of both science and governance.

In line with the major European and national guidelines (as specified later on), this document focuses on the quality of indoor air in schools for prevention of acute respiratory and allergies diseases in children, with the aim to prevent the most frequent causes of both absences from school and poor school performance. Hence, this document does not take into account other classical risk factors, such as radon or noise – already dealt with in different reports – which, as everybody knows, imply different effects on health.

As usual, the ultimate goal is not only to inform but also incite remarks and comments on the environmental monitoring and control system and its potential role in protecting e indoor air quality .

Table 8.1:Indoor quality and health risks[1]

Health risks determined by the presence of pollutants in indoor environments.

Pollutants/Allergens		Sources	Health risks
Biological agents	Bacteria (Gram-negative endotoxins)	Infected carriers Animals Environments with temperature and dampness favoring their spread Materials damaged by dampness Conditioning/ventilation systems Air conditioning systems Dehumidifiers Contaminated sanitary fixtures	Diseases of the upper respiratory tract Pneumonia Bronchial affections
	Mite	Wall-to-wall carpeting Carpets Pillows, mattresses, eiderdowns Upholstered furniture Soft toys Dust	Rhino-conjunctivitis Eczema Bronchial asthma
	Moulds	Damp environments (walls, floors) Mattresses Sofas/upholsteries Wall paper Air conditioners Humidifiers Gaskets of refrigerator doors Unsuitably preserved food Indoor plants	**Acute effects:** Irritation of the mucous membranes Migraine Difficulty in concentrating **Chronic effects:** Hay fever Allergies Asthma Rhinitis Mixed-type hypersensitivity Extrinsic allergic alveolitis (EAA) Hypersensitivity pneumopathy

[1] Source:ISPRA processing of data taken from: *Qualità dell'aria nelle scuole: un dovere di tutti, un diritto dei bambini*,Annex 1: *Principali inquinanti e allergeni indoor*, MATTM-REC,2010, http://isprambiente.gov.it/site/it-IT/Progetti/SEARCH/; US-EPA: *An introduction to Indoor Air quality* (IAQ), http://www.epa.gov/iaq/ia-intro.html; ISPRA - Inquinamento indoor: Agenti inquinanti, http://www.indoor.apat.it/site/it-IT/AGENTI_INQUINANTI

Pollutants/Allergens		Sources	Health risks
	Allergens of animal origin (dog, cat, horse scurf)	Dust Pillows/mattresses Blankets/ eiderdowns Clothes	Breathing difficulty Eye irritation/conjunctivitis Eczema Allergic rhinitis
	Pollens	Spread from the outdoor environment	Allergies in general (rhinitis, conjunctivitis, cough, dispnea, asthma)
Chemical substances	Carbon dioxide (CO_2)	Motor vehicles Human metabolic processes (breathing)	Trouble in concentrating Respiratory ailments **In high concentrations:** Loss of consciousness Death
	Carbon monoxide (CO)	Gas, kerosene, wood burning boilers/heating plants Ovens/cookers Gas, kerosene, coal/wood burning stoves Fireplaces Passive smoking Motor vehicles	Headache Nausea Dizziness **In high concentrations:** Hypoxia Death
	Nitrogen dioxide (NO_2)	Gas, kerosene, wood burning boilers/heating plants Ovens/cookers Gas, kerosene, coal/wood burning stoves Welding processes Environmental tobacco smoke Motor vehicles and machinery	Irritation of the mucous membranes Pulmonary edema Asthma Increased risk of respiratory infections
	Sulfur dioxide (SO_2)	Natural sources (volcanoes/fires) Solid/liquid fuels Industrial processes Incineration of wastes Stoves/ovens Gas/kerosene heating plants	Chronic bronchitis Tracheitis Asthma Tachypnea, tachycardia Irritation of the mucous membranes
		Tobacco smoke	
	Volatile organic compounds (VOC)	Cleaning products Paints, glues and adhesive products Pesticides Cosmetic and personal hygiene products Car products Furniture and textiles Building materials Printers and photocopiers Tobacco smoke Industrial emissions Motor vehicles	Irritation of the mucous membranes Headache Nausea Dizziness Asthma **In high concentrations:** Kidney/liver failure Damages to the central nervous system Carcinogenic action
	Formaldehyde	Upholsteries/wall-to-wall carpeting Particle board/plywood Insulating materials Coloring agents Plastic materials Textiles Detergents/cleaners Glues Additives Disinfectants Tobacco smoke	Irritation of the skin and mucous membranes Neurological effects Migraine Nausea/dizziness **In high concentrations:** Carcinogenic action
	Benzene	Tobacco smoke Stoves/heating plants Glues Paints Furniture wax Detergents Motor vehicles Industrial emissions	Dizziness Drowsiness Tachycardia Neurological disorders (confusion, memory disorders, blackouts) **In high concentrations:** Acute toxic effects **Chronic exposure** Carcinogenic action
	Polycyclic aromatic hydrocarbons (PAH)	Wood-fired ovens/fireplaces Cooked/smoked food Tobacco smoke Industrial processes Fossil fuels	Carcinogenic action
	Ozone (O_3)	Photocopiers/laser printers Ultraviolet lamps Air purifiers Outdoor air	Headache/nausea Cough Irritation/Inflammation of the airways Reduced respiratory functionality Asthma
	Particulate	Cooking	Respiratory ailments

Pollutants/Allergens		Sources		Health risks
	matter (PM_{10}-$PM_{2,5}$)	Home detergents/sprays Heating plants Tobacco smoke Bacteria Spores/pollens Dried secretions of house pets Vehicle traffic Sands/dusts Volcanic eruptions Combustion and industrial processes		Asthma Chronic bronchitis Heart trouble Changes in the immune system Increased sensitivity to allergens
	Environmental tobacco smoke (ETS)	Combustion of tobacco products		Chronic respiratory ailments Chronic obstructive pulmonary diseases/asthma Bronchopneumonia Otitis Ischemia Atherosclerosis Thrombosis Increased infarction risk Carcinogenic action **Exposure during pregnancy:** Reduced weight at birth Increase SIDS (Sudden Infant Death Syndrome) risk
	Asbestos	Resulting from materials used in the past in: Buildings (plates, panels, pipes, tanks, flues, linings, plaster, false ceilings, floors) Industry (raw material for manufactured products/objects, thermal insulating material, sound absorbent material) Products for home use (hair driers, ovens/stoves, irons, oven gloves, ironing sheets, fire wire mats and fire-resistant elements) Means of transport (insulation of trains/ships/buses, brakes/clutches, fireproof screens, gaskets)		Asbestosis Pulmonary carcinoma Mesothelioma Carcinogenic action in general
	Pesticides	Products for home use (wood preserving agents, plant products, cleaning products and disinfectants, kitchen products) Products for gardening and agriculture		Headache/dizziness Muscular contractions/tingling sensation Weakness Nausea Irritation of the mucous membranes Damages to the central nervous system Liver damages Renal damages A few pesticides are classified as potential or possible carcinogenic agents
	Lead	Drinking water (pipes) Food Paints		Brain damages Damages to the central nervous system Renal damages Blood damages **In children:** Delayed development Low intellectual faculty Reduced attention span Behavioral problems
Radon		Natural sources (lava, tuff, granite, etc.)		Carcinogenic action (in particular, pulmonary neoplasia)
	Electro-magnetic fields (EMF)	Static fields (0 Hz)	Magnetic levitation trains Industrial electrolytic devices	The subject is still controversial
			Diagnostic imaging equipment (MR)	**ELF:** classified by IARC as **possible human carcinogens** based on epidemiologic studies relative to child leukemia
				Intermediate frequencies: to date, no final judgment has yet been made

Pollutants/Allergens		Sources		Health risks
		Extremely low frequencies (ELF) from >0 to 300 Hz	Electric energy production devices (50-60 Hz) Electrical appliances Trains	**Radiofrequencies:** to date, just the thermic effect has been confirmed
		Intermediate frequencies (IF) from >300 to 10 MHz	Antitheft devices Induction heaters Video display units	
		Radio-frequencies and micro waves from 10 MHz to 300 GHz	Cellular phones Telecommunication equipment Radar Medical appliances Diathermic units Micro wave ovens	
	Noise	Road traffic Railway traffic Air traffic Noisy (industrial and craft) working activities Discos/nightclubs Indoor sources (electrical appliances, service plants, heating systems, etc.)		**Auditory effects:** Progressive loss of one's hearing **Extra auditory effects:** Annoyance Psycho-physiological effects Effects on performance and learning Cardiovascular effects (adults)

INDOOR AIR QUALITY IN SCHOOLS AND CHILDREN'S HEALTH

The indoor air quality in schools and the respiratory health of children

The air quality in school buildings is important owing to both the long exposure linked to the time children spend there and the greater susceptibility of children and teens to the exposure to pollutants.

The air quality in school buildings, or rather the air quality determined by conditions of microclimatic comfort and concentrations of some pollutants, is important for long time exposure of children to spend in their classrooms (on average, 6-8 hours per day), and the higher susceptibility of children and adolescent to the exposure to those environmental factors. Therefore, it is considered an important factor for the prevention of respiratory and allergic diseases. The issue have also quantitative aspects: it has been estimated that 15% of the population, that is nearly 10,000,000 persons including schoolchildren and teachers, study or work on a daily basis in nearly 45,000 public buildings throughout the national territory[2].

Many studies have shown a positive association between acute respiratory diseases, asthma, allergies and numerous factors present in a school environment, including dampness and pollutants such as particulate matter, ozone, volatile organic compounds (VOC), CO_2, formaldehyde and allergens. Studies have also shown that poor air quality combined with non optimal microclimatic conditions adversely affect the pupil's school performance as well as their educational continuity.

The Agreement of 18 October 2010 focuses the attention on the relevance of the hygienic and air quality conditions in school environments for the health of children.

One of the latest national institutional documents, the Agreement of 18 October 2010[3] among Government, Regions, Autonomous Provinces of Trent and Bozen, Provinces, Municipalities and Mountain Communities concerning the "Guidelines for the prevention of indoor risk factors in schools for allergies and asthma"[4], focuses the attention on the relevance for children's health of hygiene and air quality conditions in school . Furthermore, it lays emphasis on the inadequacy of the normative framework governing a number of aspects connected with school buildings, indoor air quality and microclimate., Current regulations appear to be ineffective or not up-to-date with respect to the latest scientific evidence and fail to comply with the building energy saving and bio-climatic requirements and with the characteristics of salubrity and safety of materials and furnishings[5].

With a view to preventing allergic and respiratory diseases, it has been ascertained that the indoor air quality depends on various factors, including:

- architectural, constructive and plant-engineering characteristics of the building, which affect the microclimate (temperature,

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2 GARD Italia – *La qualità dell'aria indoor nelle scuole and rischi per malattie respiratorie e allergiche - Quadro conoscitivo sulla situazione italiana e strategie di prevenzione*, 2011.

3 O.G. of 13 November 2011, G.S. no. 9.

4 http://www.normativasanitaria.it/normsan-pdf/2001/36589_1.pdf

5 GARD Italia – *La qualità dell'aria indoor nelle scuole and rischi per malattie respiratorie and allergiche - Quadro conoscitivo sulla situazione italiana and strategie di prevenzione*, 2011.

humidity, ventilation) and, therefore, comfort;

- presence of sources of biological (mite, moulds) and chemical (tobacco smoke, VOC, $PM_{2,5}$ and PM_{10}) indoor pollutants
- input of pollutants originating from the outside as particulate matter, NO_x, benzene, PAH and ozone.

The European initiatives and projects that deal with indoor pollution in schools and the health of children include the SEARCH project (2007-2010). The latter is one of the earliest European multicentric experiences. It has provided for the administration of questionnaires and the monitoring of pollutants deemed relevant for their respiratory and allergic risk.

In Europe, quite a number of initiatives and projects deal with indoor pollution. The purpose is to study the pollutants, their sources , their effects on health and the monitoring methods , as well as to develop more effective solutions to counter and limit the impact of the phenomenon. At any rate, the studies that have dealt specifically with indoor pollution in schools and children's health are quite limited (Table 2). From this point of view, SEARCH (School Environment and Respiratory Health of Children, 2007-2010) Project is one of the earliest European multicentric experiences.

The Project - promoted and financed by the Ministry of the Environment and the Protection of the Territory and the Sea (MATTM) through the Italian Trust Fund of the REC (Regional Environmental Centre for Central and Eastern Europe) – has been conducted at the same time in six European Countries (Italy, Albania, Bosnia-Herzegovina, Serbia, Slovakia and Hungary). It has entailed the inspection of 60 schools and 243 classrooms, with the measurement of the main environmental pollutants deemed relevant for their respiratory and allergic risk, such as PM_{10}, NO_X, aldehydes, including formaldehyde and the so-called BTEX (benzene, ethyl-benzene, toluene and xylenes). Over 5,000 children between 11 and 12 years of age have been interviewed through questionnaires and checked with spirometric analyses[6].

The "SEARCH Italy" working Group (coordinated by MATTM and ISPRA) has involved the ARPA (Regional Agency for the Protection of the Environment) of six Italian Regions (Piedmont, Lombardy, Emilia-Romagna, Lazio, Sicily, Sardinia), the Maugeri Foundation and Federasma, a non-profit association. The investigations have been carried out in 55 classrooms of 13 lower secondary schools, and entailed the study of over 1,100 schoolchildren. The main project results, presented by ISPRA on the occasion of a national Conference[7], have shown that, considering the same pollutants, the indoor concentrations are higher than those reported outdoor (Figure 8.1),confirming indoor sources contribution in the release of chemical substances.

[6] The international results have been presented at the 5th Ministerial Conference on "Environment and Health" held in Parma and organized by the WHO and the Italian Government. http://www.salute.gov.it/salaStampa/dettaglioEvento.jsp?id=47

[7] http://www.isprambiente.gov.it/site/it-IT/Progetti/SEARCH/ISPRA_per_indoor_scuole/Progetto_SEARCH_I/

In Italian classrooms, the indoor concentrations of the pollutants being monitored proved higher than the outdoor concentrations of those very pollutants.

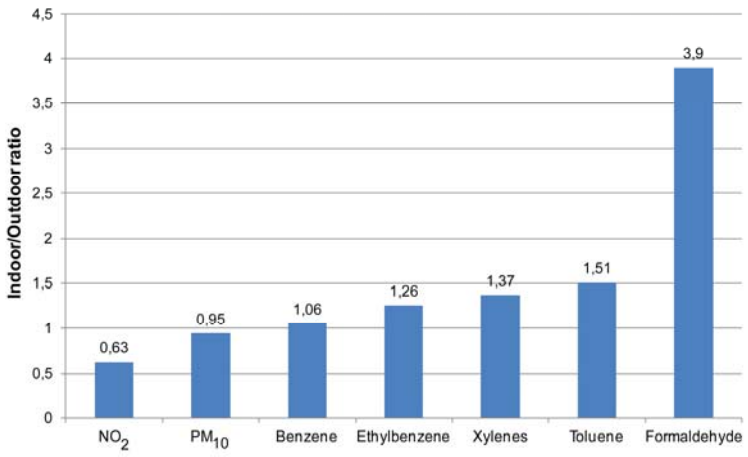


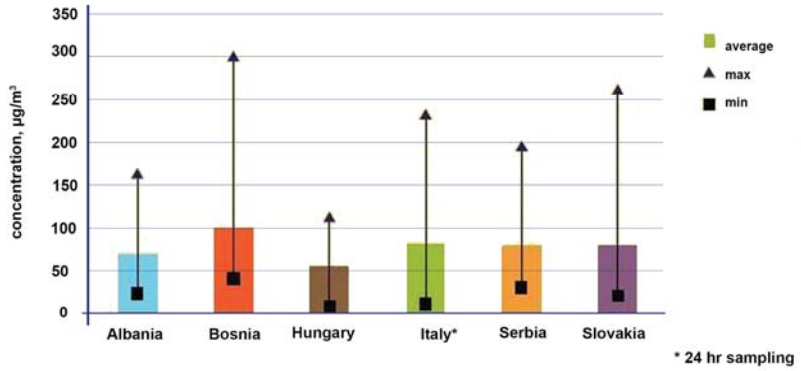
Figure 8.1: SEARCH-I Project: Relationship between indoor and outdoor concentrations of pollutants in school environments[8]

In particular, PM_{10} concentration inside schools proved to be higher than the concentration in outdoor air (on average, 80 $\mu g/m^3$). Furthermore, formaldehyde values discovered in the Italian schools were found to be the highest among all the European schools being investigated (Figure 8.2)[9].

[8] Source: *School environment and respiratory health of children* (SEARCH). *International research project report within the Indoor air quality in European schools: Preventing and reducing respiratory diseases program.* Edited by Eva Csobod, Peter Rudnay, Eva Vaskovi, Szentendre, Hungary, February 2010.

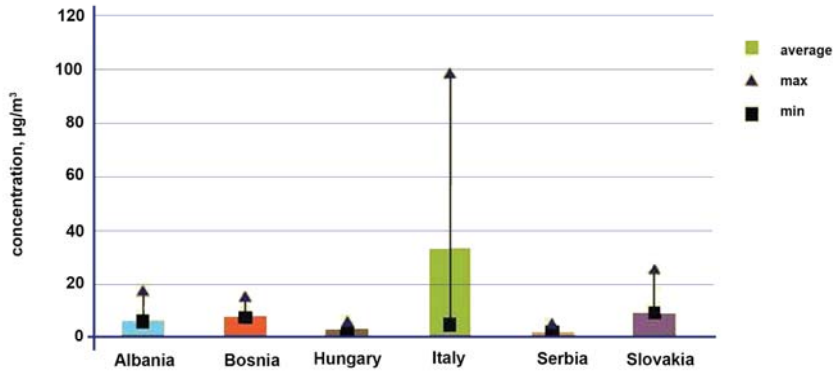
[9] http://www.isprambiente.gov.it/site/it-IT/Progetti/SEARCH/

(A)



(A) The average concentration of PM_{10} in Italian schools proves higher than the outdoor concentration of the same pollutant.

(B)



(B)In Italian schools, the levels of the formaldehyde concentration proved to be the highest of all the European schools being monitored.

Figure 8.2: SEARCH-I Project: concentrations of PM_{10} (A) and formaldehyde (B) in the classrooms[10]

The examination of children's respiratory health has also confirmed the prevalence of some symptomatologies, as already observed in other epidemiologic studies (Figure 8.3).

[10] Source: *School environment and respiratory health of children* (SEARCH). *International research project report within the Indoor air quality in European schools: Preventing and reducing respiratory diseases program.* Edited by Eva Csobod, Peter Rudnay, Eva Vaskovi, Szentendre, Hungary, February 2010.

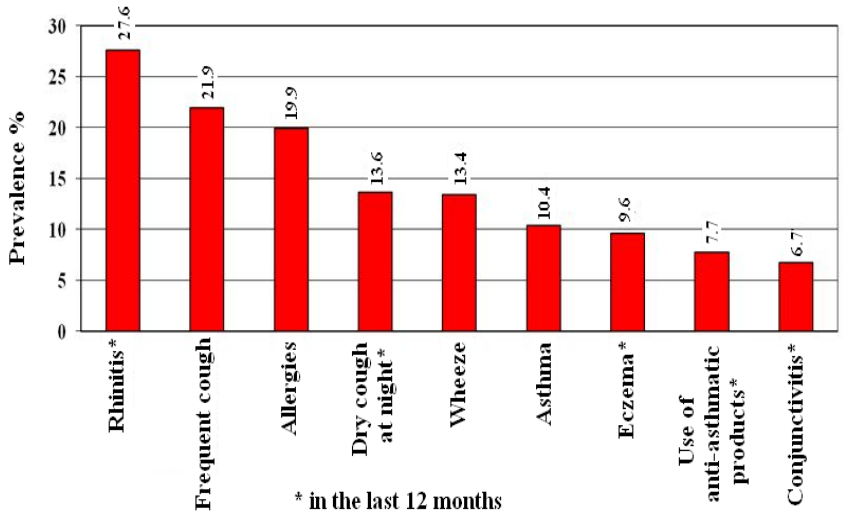


Figure 8.3: SEARCH project in Italy. Prevalence of respiratory symptoms in schoolchildren[11]

There are additional projects currently under way, such as SEARCH-II and SINPHONIE, which see the REC among the coordinators and Italy as a partner.

The SEARCH-I Project has, also, promoted the start of additional project activities involving REC as a coordinators and Italy as a partner. The ,

- SEARCH-II Project
- SINPHONIE Project

are currently under way and the results should be available by 2013.

The SEARCH-II Project[12], which sees the participation of the SEARCH-I Countries and a few Countries in central Asia, purposes to continue and complete the study and the analysis of indoor risks in schools. the 2nd phase of SEARCH Project want deepen the study of other risk factors, for instance, the use of energy and the energy requirements, which - combined with the constructive features of school buildings - affect such important variables for the individual well being as temperature and humidity., These data shall be a very useful source of information in Italy where, very soon, every school will be required to have an energy certification, as it has already been done in many Regions.
The Italian workgroup of SEARCH-II project has been entrusted, in collaboration with other experts of the participating Countries, with the draft of a working paper on the causes and risks and health effects of indoor pollution, with specificr eference to the salubrity of the cleaning products and building and furnishing materials, including materials used to improve energy performance.
The SINPHONIE Project (Schools Indoor Pollution and Health: Observatory Network in Europe)[13], promoted and financed by the European Commission through the DG SANCO (Directorate

[11] Source: *Qualità dell'aria nelle scuole: un dovere di tutti, un diritto dei bambini*. MATTM-REC publication, 2010, http://www.isprambiente.gov.it/site/it-IT/Progetti/SEARCH/
[12] http://www.isprambiente.gov.it/site/it-IT/Progetti/SEARCH/ISPRA_per_indoor_scuole/Progetto_SEARCH_II/
[13] http://www.rec.hu/sinphonie/about.html. The project falls within the European Environment and Health Action Plan 2004-2012.

General for Health and Consumers), involved 38 institutions operating in the environmental and health fields in 25 different Countries. By focusing on schools and children facilities, this project aims to develop recommendations for policy maker and to improve school environment and prevent respiratory and allergic diseases in children.

Table 8.2: Indoor air quality: major European-wide projects and surveys[14]

Main projects and surveys promoted over the last ten years throughout the European territory that deal with indoor air quality.

Study areas	Projects and surveys
Policy-Science framework	EnVIE (Co-ordination action on IAQ & Health Effects) –Porto University (2004-2008) IAIAQ (Impact Assessment of IAQ) – JRC (2009-2011)
Identification of priority pollutants/health risks	THADE (Towards Healthy Indoor Air in Dwellings in Europe – EFA (2002-2004) INDEX (2005), SCHER report (2007), WHO (2007 – dampness/mould, 2010 – chemicals)
Definition of standards/guideline values for priority pollutants	WHO IAQ (2007 – dampness/mould, 2010 – chemicals) INDEX and INDEX-UPRIC – JRC (2003-2005, 2009-2010) HEALTH-VENT (Health based ventilation guidelines) – DTU (2010-2012)
Patterns of exposure for priority pollutants	Danish EPA National Survey of Chemical Substances in Consumer Products (2006) CLEAR-UP (Clean and resource efficient buildings for real life) – Tübingen University (2008-2012) RADPAR (Radon Prevention and Remediation) – UoWM (2009-2012) OFFICAIR (On the reduction of health effects from combined exposure to indoor air pollutants in modern offices) – UoWM (2010-2013) EFHECT (Exposure Patterns and Health Effects of Consumer Products in the EU) – VITO (2010-2013)
Indoor setting and vulnerable groups: indoor school air and children's health	HESE (Health Effects of Schools Environment) – Siena University HESE-INT (Interventions on Health Effects of School Environment) – Siena University (2009) EFA project (Indoor Air Pollution in Schools) (2003) BIBA (Indoor Air Pollution in Schools) – VITO French Schools Monitoring – French Observatory for Indoor Air Quality (OQAI) 2001-2005 SEARCH (School environment and respiratory health of children) – ITF Italian Ministry of the Environment /REC (2007-2009) SINPHONIE (Schools Indoor Pollution and Health: Observatory Network in Europe) – REC 2010 SEARCH II (energy and comfort assessment in schools/children's health) – ITF MATTM/REC (2010-2013)
Indoor sources/preventing the emission of pollutants	BUMA (Building materials prioritization as indoor pollution sources) – JRC/UoWM (2006-2009) HEALTHY AIR (Effects of building materials on indoor air quality, health and comfort) – TNO (2008-2010) European Collaborative Action: Urban Air, Indoor Environment and Human Exposure (JRC Ispra): Report 18: Evaluation of VOC emissions from building products (1997) Report 24: Inventory of existing emission labeling schemes in the EU (2005) Germany research project (BAM, TU Berlin, UBA): Building products: Determining and avoiding pollutants and odors

[14] Source: ISPRA processing of data taken from JRC, *Promoting actions for healthy indoor air* (IAIAQ) Directorate General for Health & Consumers, 2011.

The quality of indoor and health of children in European and national policies and guidelines

European policies and guidelines

The WHO stresses the relevance and urgency for each Country to implement a "National Plan for the creation of a sustainable indoor environment".

The World Health Organization (WHO) has highlighted the relevance and the urgency for each Country to adopt a "National Plan for the creation of a sustainable indoor environment" and, since 1999, has disseminated a publication specifically designed to identify the optimum strategies for the implementation of that Plan. In the last ten years, it has, also estabilish a set of reference guidelines for managing indoor environments:

- WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur (2005)[15], applicable to indoor environments and including actions, schools and means of transport;
- WHO Guidelines for indoor air quality: dampness and mould (2009)[16], dealing with dampness and moulds in buildings, health risks and prevention measures;
- WHO Guidelines for indoor air quality: selected pollutants (2010)[17], determining the limits for a number of priority chemical pollutants.

Besides, the latest WHO policies for the European Region focus on the protection of children's health from environmental risk factors.

The Parma Declaration on "Environment and Health", signed on the occasion of the 5th Ministerial Conference, lays emphasis on the relevance attached to protecting the health of children from environmental threats.

Italy has been one of the signatories of the Parma Declaration on "Environment and Health" signed in March 2010 on the occasion of the 5th Ministerial Conference of the Health and Environment Ministers of 53 Countries in the European Region of WHO. With this document, the governments reconfirmed the commitments they had undertaken in the previous Conference held in Budapest (June 2004), which enphatized the importance of protecting children's health from environmental threats, a goal that had been re-proposed with even greater emphasis among the priorities of the CEHAPE (Children's Environment and Health Action Plan for Europe)[18]. In fact, the third priority goal of the CEHAPE is to guarantee that, by 2020, all children enjoy a healthy indoor environment particularly at home, at school and in childcare facilities, with a view to prevent the main childhood diseases related to air pollution (bronchial asthma, allergies and respiratory diseases).

Quite a number of initiatives addressing such intersectoral policies as health, education,

In recent years, even the European Union has promoted several initiatives[19] to fight chronic childhood diseases and raise the awareness of the institutions, particularly health institutions, to promote intersectoral policies between health, education, environment, labor and research. Among these the most important

15 http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf

16 http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf

17 http://www.euro.who.int/en/what-we-publish/abstracts/who-guidelines-for-indoor-air-quality-selected-pollutants

18 http://www.hpa.org.uk/AboutTheHPA/WhatTheHealthProtectionAgencyDoes/InternationalWork/ChildrensEnvironmentAndHealthActionPlanForEuropeCEHAPE/

19 *Childhood asthma - The Council's Conclusions*, 2 June 2004 [9507/04 (Press 163)]; Warsaw Conference, *Prevention and control of childhood asthma and allergy in EU from the public health point of view: an urgent need to fill the gaps*, Ossa (Poland), 21-22 September 2011.

are:

environment, employment and research have been promoted in recent years by the European Union.

- The SCALE Environment and Health Strategy[20] of the European Union, which aims primarily at preventing childhood respiratory diseases, asthma and allergies.
- The Sixth Community Action Program concerning Environment and Health (2001-2012)[21], which stresses the need "to reduce environmental pollution down to levels that may minimize adverse effects on human health, with special reference to the vulnerable groups, and on the environment as a whole".
- The Environment and Health Action Plan 2004-2010 that, within the framework of Action 12 concerning the improvement of the air quality, stresses the need to develop networks and guidelines on other factors that adversely affect indoor air quality (dampness, moulds, building materials, indoor pollutants) through research, exchange of information and best practices.
- The Report and Resolution of the European Parliament on the Action Plan (2005)[22] that, among the major research areas, includes the impact of new building materials on health, inviting the Commission, in cooperation with Member States, to introduce a system for the environmental and health labeling of building products and materials. Furthermore, the Report stresses that the indoor building quality may not be improved without having a multidisciplinary approach that takes into account the variety of pollution sources present inside buildings (heating system, plants, furnishings, and activities being carried out).

Indoor air in the national health policies: regulations and initiatives

At present , our Country still lacks an organic regulation designed to ensure the protection of health from the risks related to confinated space. The regulations governing the salubrity of housing premises are laid down in each Municipality by the Hygiene and Health Regulation (Table 8.3).

Our Country still lacks a regulation ensuring the actual protection of health from the risks connected with indoor environments.

Based on the Consolidated Health Law (Royal Decree no. 1265 of 27 July 1934 – Title III, Chapter IV, on the sanitation of urban and rural built-up areas and houses), the local hygiene and health regulations estabilished the standards for the salubrity of the urban and rural built-up areas and houses according to the outline guidelines issued at present by the Ministry of Health. Hence, the Municipal Regulation represents an important regulatory tool to deal with the salubrity of indoor environments, as it maintains a specific usefulness even further to the implementation of the Health Reform (Law 833/78) that transfers to the Regions the authority to regulate the performance in the matter of public health and hygiene.

Legislative Decree 502/92 (amended by Legislative Decree 517/93) has introduced considerable innovations with respect to both the

20 http://europa.eu/legislation_summaries/environment/general_provisions/l28133_en.htm

21 http://europa.eu/legislation_summaries/agriculture/environment/l28027_it.htm

22 http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A6-2005-0008&language=IT#title1

overall setup of the health system and the specific sector of prevention, laying down that the Regions are required to create a Prevention Department (PD) within each Local Health Authority (LHA). The DP is going to be entrusted with the public health and hygiene duties that were previously performed by the LHA services that had been set up by Law 833/78. Subsequently, Legislative Decree 229/99 redefined the functions of the Prevention Departments, their organization and inner and outer coordination with other bodies and institutes (Regional environment agencies, Centers for infectious diseases in animals, Labor inspectorates and INAIL, etc.). Hence, it entrusted the Departments with additional tasks detection and removal of the causes of harmfulness and diseases having an environmental origin. In order to carry out these tasks, they could have recourse to the Regional and Provincial Agencies for the protection of the environment. Furthermore, it laid down that the collective prevention and environmental control functions carried out by PD and ARPA should also provide for coordinated and integrated measures. At present, from the point of view of operations, these provisions are implemented with different instruments and methods in the various local authorities and, regarding indoor expertise no clear competences have so far been well defined, nor sectors of joint action and the relative programs of operations have been identified.

Based on the international health indicators and targets ("Health for All-21"), the National Health Plan (NHP) for the 1998-2000 period[23] has dealt for the first time (compared to the previous planning documents) with main health issues through a multidisciplinary and intersectoral approach, where inherent health and environment issue has been taken jointly into account. The 3rd objective of the NHP, "improvement of the environmental context" had set the reduction of the health risks related to indoor pollution as a priority to be implemented in the three-year reference period within the context of the NHS competences and in concert with not heath related institution.

With the National Health Plan for 1998-2000, it is the first time that Italy has dealt with the health issues with a multidisciplinary and intersectoral approach.

Since 1998, the Ministry of Health to implement the NHP objectives by the Ministerial Decree of 8 April 1998, has appointed the "National Indoor Commission", which was entrusted with the task of developing technical guidelines to reduce health risks related to indoor pollution. The Commission had a multidisciplinary nature, as it comprised engineers, architects, occupational health-care professionals, hygienists, oncologists, allergists, epidemiologists, physicians, chemists, biologists, etc. In July 1999, the Commission drafted the first report on Italy's major health problems arising from indoor pollution and provided a series of general guidelines for the implementation of a national program for prevention health promotion in confined space.

The outcome of the said report has led to the State-Regions Agreement of 27 November 2001[24] containing "Guidelines for the

In the "Guidelines for the protection

[23] http://www.salute.gov.it/imgs/C_17_pubblicazioni_947_allegato.pdf

[24] O.G. of 27 November 2001, no. 276 G.S., O. S. no. 252.

protection and promotion of health in indoor environments"[25]. Based on this Agreement, the Minister of Health meant to implement a countrywide "Pact" for the prevention of indoor risks through the involvement of both health institutions and stakeholders. The Agreement provided for regulatory measures based on public health standards, arrangement of technical tools, training campaigns for the technical staff of the NHS and other sector's, and the support of a national research plan, as well as the information and education of the population (to raise the awareness of its role in the prevention of risks and the promotion of health) and the involvement of the social partners and associations.

and promotion of health in indoor environments" included in the State-Regions Agreement of 27 November 2001, the Minister of Health proposed the implementation of a "Pact for the prevention of indoor risks"

To promote the implementation of the national indoor prevention program, the Agreement of 27 November 2001 was followed by a series of provisions and guidelines, including:

The State-Regions Agreement of 27 November 2001 has led to a series of provisions and guidelines that purposed to promote the implementation of the national program for the prevention of risks arising from indoor environments.

- Guidelines for the prevention and control of the Legionnaires' disease of 4 April 2000[26] ;
- State-Regions Agreement of 13 January 2005, laying down the "Guidelines containing information about the Legionnaires' disease for tourism operators and receptive facilities and spas"[27];
- State-Regions Agreement of 5 October 2006, containing "Guidelines for the definition of technical protocols for the diagnostic maintenance of air conditioning plants"[28];
- National Radon Plan (NRP)[29] "to reduce the risk of lung cancer in Italy arising from the exposure to radon", which was an organic and coordinated series of measures aimed to reduce the radon risk in Italy (including standards, mappings, information, training). The NRP obtained the favorable opinion of the Higher Health Council and the State-Regions Conference and, starting from 2006, it has been partly financed within the context of the project of the Center for the Prevention and Control of Diseases (CCD);
- Agreement of 18 October 2010[30] among Government, Regions, Autonomous Provinces of Trent and Bozen, Provinces, Municipalities and Mountain communities, concerning "Guidelines for the prevention of indoor risk factors related to allergies and asthma in schools"[31], which focused on the relevance of hygiene and air quality in schools for children's health. Within this Agreement, the regulatory framework, governing a number of aspects connected with school buildings, indoor air quality and microclimate proves inadequate or outdate with respect to the latest scientific evidence. Besides, it is not in keeping with the building energy saving and bio-climatic requirements and with the characteristics of salubrity and safety

25 http://www.radon.it/site/download/lineeguida.pdf
26 O.G. of 5 May 2000, G.S. no. 103
27 O.G. of 4 February 2005, G.S. no. 28
28 O.G. of 3 November 2006, G.S. no. 256
29 http://www.iss.it/binary/tesa/cont/PNR-Testo%20completo.1195145887.pdf
30 O.G. of 13 November 2011, G.S. no. 9
31 http://www.normativasanitaria.it/normsan-pdf/2001/36589_1.pdf

of both materials and furnishings.

- e fight against passive smoking is another important objective of the National program for the prevention of indoor risks developed by the Ministry of Health . The Law no. 3 of 16 January 2003[32], "Legislative provisions concerning the Public Administration". Under article 51 "Health protection of non-smokers", the law extended the smoking prohibition to all the indoor environments, the only exceptions being smoking rooms and strictly private environments. Furthermore, with a view to protecting the health of children and unborn children, it has introduced higher sanctions against those who smoke in presence of children or pregnant women.

Furthermore, a series of important projects and programs were promoted in recent years to contrast the main environmental risk factors for chronic respiratory diseases through specific projects and programs initiated within the context of the activities of the National Prevention Plan by the Center for the Prevention and Control of Diseases[33] and GARD Italia (Global alliance against chronic respiratory diseases in Italy)[34].

A series of important projects and programs promoted in recent years aim at countering the main environmental risk factors for chronic respiratory diseases.

- The three-year (2009-2012) project financed by the CCD, "Exposure to indoor pollutants: guidelines for assessing the risk factors in schools and definition of the measures to protect the respiratory health of school children and adolescets" (Indoor-School), is coordinated by the National Institute of Health (NIH) and includes in the study the schools of seven Italian Regions (Lombardy, Friuli, Tuscany, Lazio, Apulia, Sardinia and Sicily).
- The activities of GARD Italia are coordinated by the Ministry of Health together with the CCD. GARD is a voluntary association established in Rome in June 2009 on the occasion of the 4th general assembly of the International Global Alliance against Chronic Respiratory Diseases, an alliance established by the WHO in order to promote common strategies for reducing the impact of chronic respiratory diseases. An *ad hoc* workgroup "for the prevention of indoor risks in schools" set up within GARD Italia has been entrusted specifically with the task of facilitating the implementation of the State-Regions Agreement of 18 November 2010 to prevent allergy and asthma risk factors in schools. The working group comprises university and institutional experts, including representatives of the Ministries of Education and Environment, ISPRA and HIH. Finally, the State-Regions Agreement of 29 April 2010 launched the New National Prevention Plan 2010-2012[35], which includes strategic guidelines addressing the improvement of sanitary requirements for indoor air in schools and in all the other

The new National Prevention Plan 2010-2012 includes specific strategic guidelines addressing the improvement of the sanitary requirements for indoor air quality

32 http://www.parlamento.it/parlam/leggi/03003l.htm

33 http://www.ccm-network.it

34 http://www.salute.gov.it/gard/gard.jsp

35 Just as in 2005, further to the State-Regions Agreement of 29 April 2010, the Regions and the Autonomous Provinces have appropriated 200 million Euro for the full implementation of the Prevention Plan for the 2010-2012 three-year period.

premises attended by children. Based on these guidelines, a number of Regions have already developed their respective Regional Prevention Plans.

in all the premises attended by children.

Table 8.3: Current national and international standards inherent to indoor air quality[36]

Subject	Standard	Synthesis
International technical regulations and standards for microclimate and ventilation control	Standard ISO/FDIS 7730	Guidelines for qualifying and assessing comfort.
	UNI EN 13779	Ventilation in non-residential buildings.
	UNI 15251	Assessment of the energy performance of buildings.
Control of plants	Guidelines dated 4 April 2000 for the prevention and control of the Legionnaires' disease,	It provides plant management guidelines for preventing the Legionnaires' disease.
Passive smoking regulations	Law no. 3 of 16 January 2003	It bans smoking in public environments.
Regulation concerning dangerous chemical substances and compounds	REACH – EC Regulation no. 1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals	Registration, evaluation, authorization and restriction concerning all the substances produced or imported in the European Union.
Hygiene regulation	Decree of the Ministry of Health of 5 July 1975	It lays down the main hygiene and sanitation requirements concerning housing premises, specifying the minimum housing space in relation to the anticipated number of occupants.
Directives relating to construction products	89/106/EEC, implemented in Italy with DPR no. 246 of 21 April 1993	It requires the compliance of construction products with the fundamental health requirements.
	Regulation no. 305/2011 relating to construction products	
Regulations concerning the environmental performance, sustainability and environmental energy savings of buildings	ISO 21931-1:2010	It aims at improving the performance of buildings laying down a single reference framework on the methods to assess their impact.
	ISO 13823:2008	It defines general principles and suitable procedures for assessing the durability/ resistance of building structures to natural events.
	Directive 2002/91/EC implemented with Legislative Decree no. 192 of 19 August 2005	Methodology for calculating the energy performance of buildings.
	Standards UNI TS 11300	Technical standards for calculating the energy requirements of buildings.
	Directive 2010/31/EC	It promotes the improvement of the energy performance of buildings.
Ecolabel	EC Regulation no. 66/2010	Community trademark ensuring the environmental quality of a product.
Radon	Decree Law 241/2000	The decree sets a reference level of 500 Bq/ m^3: where exceeded, the employer is required to step in with more in-depth assessments and, in case of need, with remedial

Standards that, promoted in recent years at both a national and an international level, are currently in force for the prevention of risks arising from indoor air quality.

36 Source: ISPRA

		actions affecting workplaces, including schools.
	Recommendation 90/143/Euratom	It lays down the reference values for the home radon concentrations: where exceeded it recommends remedial actions for reducing the radon concentration: 400 Bq/m^3 for existing buildings and 200 Bq/m^3 for future constructions.
	National Radon Plan	Coordinated action plan designed to reduce the risk of health effects connected with the exposure to radon.
Noise	Law no. 447 of 26 October 1995	General policy law on acoustic pollution and subsequent implementation decrees.
	Directive 2002/49/EC of 25 June 2002, implemented with Legislative Decree no. 194 of 19 August 2005	It relates to the assessment and management of environmental noise and provides for remedial actions in the presence of health risks.

The prevention of risks arising from the indoor air quality in sectoral policies: the role of environmental policies

The prevention of risks arising from the indoor air quality involves a series of sectors that are affected by the environmental policies through rules and regulations that limit the release into the atmosphere of pollutants and provide for a direct control of the sources present in indoor environments.

As previously pointed out, the prevention of risks arising from the indoor air quality involves a series of sectors such as, for instance, productive activities and certification systems, urban mobility policies, as well as climatic and the energy policies. In a few of these sectors, the environmental policies play a peculiar role of their own, contributing to the prevention of the risks arising from the indoor air quality through two main groups of rules and standards:

- the rules and standards that limit the release into the atmosphere of pollutants from industrial activities, transports, agriculture, waste management, household activities, such as Legislative Decree no. 155 of 13 August 2010, the IPPC Directives, AIA and EMAS, the regulations that fixes and update the performance standards for new cars and commercial vehicles and the policies for a sustainable mobility;
- the rules and standards that provide for a direct control of the sources present responsible for the release of pollutants and hazardous substances in indoor environments and promote the use of ecological products and sustainable building materials. They include the REACH Regulation, the Ecolabel Regulation (EU trademark of ecological quality), the recent Regulation no. 305/2011 concerning construction products, the strategies and the action plans for the promotion of eco -friendly products (Integrated Product Policy, Action Plan for green purchases, Strategy for the sustainable use of resources, Eco-innovation plan), the regulations relative to the ecological design of products as well as the development of specifications useful for the ecologically compatible design of energy-using products (ECODESIGN), the policies promoting the purchase of clean products (such as cars, motor vehicles, electrical appliances, etc.) and the development of environmental friendly buildings.

An important role is also played by the policies addressing the energy efficiency of buildings adopted at an EU-wide level through the energy efficiency plan (COM (2011) 109) that is progressively being implemented in our Country. The latter contributes to the reduction of the emissions into the atmosphere (therefore, to the prevention of outdoor pollution) and it should also ensure a better microclimatic indoor comfort thanks to an adequate design (including the choice of healthier materials for buildings and furnishings) and an adequate maintenance, in order to avoid adverse effects on the indoor air quality. In fact, even though the air-conditioning/heating systems using air recirculation to avoid thermal losses, in association with the techniques for building insulation (i.e., use of special window and door frames for thermal and/or acoustic insulation), lead to proper energy savings, they may adversely affect internal ventilation, reducing the dispersion of pollutants and favoring the concentration of pathogens (i.e., Legionnaires' disease, as well as in general viral and bacterial infections) and the increase in indoor concentrations of dusts and airborne pollutants (CO_2, CO, TSP, etc.) with repercussions on their salubrity.

At present, an important role is also played by the policies addressing the energy efficiency of buildings that, promoted at a European level through the Energy Efficiency Plan provided for by COM(2011)109, are progressively being implemented even in Italy.

Last but not least, as previously mentioned, in our Country shall be better addressed competences and indoor air monitoring systems, for which to date is not yet a system knowledge and reference as for outdoor air pollution.

In general, the role of the policies mentioned is not subordinate to the protection of respiratory health.

As summarized in Figure 8.4 and in Table 8.4, a recent JRC study [37] analyzed the impact of the indoor air quality on health (IAIAQ), assessing the main pathologies attributable to exposure to indoor pollution (asthma, pulmonary carcinoma, chronic obstructive bronchitis, respiratory infections/symptoms, acute intoxications).

the study quantified the impact attributable to indoor pollution in approximately 2 million DALYs[38] per year.

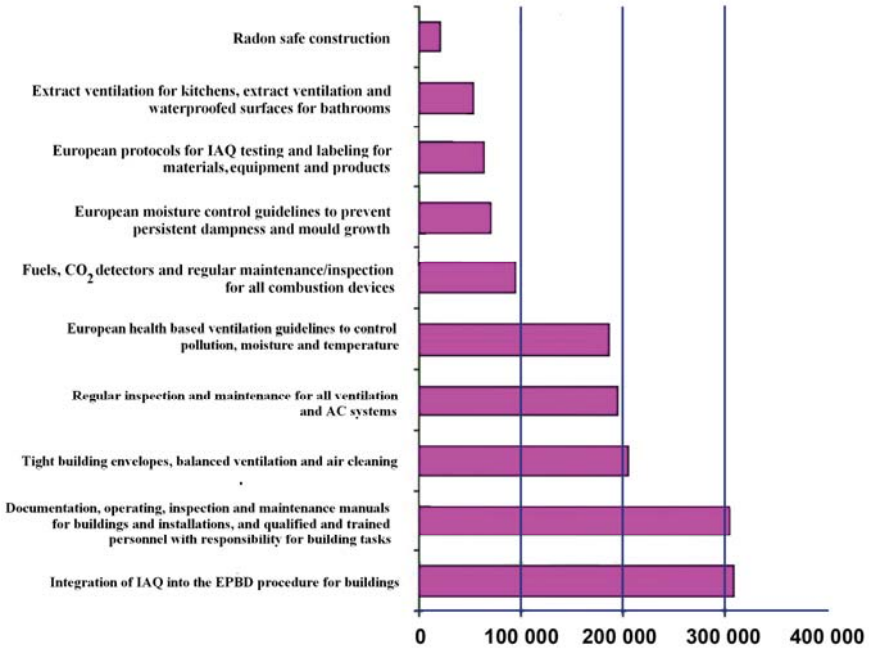
Then, it assessed the health benefits from 2004 to 2010 in terms of DALY/year of the EU policies (the REACH regulation, the directives on construction products, the energy efficiency of buildings and the labeling of products, the green paper on tobacco smoke, and the WHO guidelines on indoor air).

Finally, different scenarios have been taken into consideration depending on the implementation of the European policies.

A recent JRC study analyzed the impact of the air quality on health, taking into consideration the main pathologies linked to the exposure to indoor pollutants and quantifying the impact attributable to indoor pollution and the health benefits resulting from the EU policies for 2004-2010.

37 JRC, *Promoting actions for healthy indoor air* (IAIAQ), Directorate General for Health & Consumers, 2011.

38 DALY (*Disability-Adjusted Life Year*): years of life lived net of disability. The DALY is a measure of the overall disease burden and is the result of the sum of the numbers of years lost (YLL) due to an early death with the years lived with disability or disease (YLD). This method has been developed by Harvard University in 1990 and has been adopted in 2000 by the WHO.



Assessment of the health benefits in terms of DALY/year resulting from the implementation of the EU policies on the air quality in indoor environments.

Figure 8.4: DALY benefits at the 10th year of implementation of the indoor air quality policies[39]

[39] Source: ISPRA processing of data taken from: JRC, *Promoting actions for healthy indoor air* (IAIAQ), Directorate General for Health & Consumers, 2011.

Table 8.4: Temporal increase in the public health benefits in terms of DALY thanks to the implementation of the policies concerning the energy efficiency of buildings and building materials[40]

Increase over time of the public health benefits (expressed in terms of DALY) resulting from the implementation of the EU policies dealing with the energy efficiency of buildings and building materials.

EU-regulation and IAIAQ scenarios		Start year	Annual health benefit in DALY/ year					∞
			2000	2005	2010	2015	2020	
Scenario 1	CPD (89/106/EEC Construction Products)	2000	0	35	70	100	120	400
	GPSD (2001/95/EC General Product Safety)	2002		2	5	6	7	9
	EPBD (2002/91/EC Energy Perfor□ance of Build□ngs)	2003		60	190	300	400	800
	REACH (EC/1907/2006 Chemicals)	2007			5	10	13	17
Scenario 2	REACH implementation	2011				10	15	30
	CPD+GPSD+ Integration of IAQ impacts of indoor combustion equipment	2011				100	180	600
Scenario 4	European protocols for IAQ for buildings and indoor materials and products	2011				60	120	300
Scenario 5	Fuels, CO monitoring systems, regular operation/maintenance of combustion systems	2011				100	180	300
Scenario 6	EPBD + Integration of IAQ	2011				160	350	1,200
Scenario 7	Integration of IAQ into EU CLIMT ACTS and Energy Policies	2011				300	600	2,000

POSSIBLE INDICATORS OF INDOOR AIR QUALITY IN SCHOOLS (DPSIR MODEL)

At present, there is still no set of indicators that may be populated in order to characterize either indoor air quality, or its pressures and impacts on health.

A set of indicators, that may be actually populated, in order to characterize the state of indoor air quality or its pressures and impacts on health, is still no available at the moment since there is no structured system to gather the necessary data.

Therefore, to describe indoor air specifically in schools, an attempt was made to identify a series of possible indicators that could be effectively developed if adequately supported by available and up-to-date data. This would require the commitment and willingness of the institutions involved at a national level (Ministry of Education, Ministry of Health, Ministry of the Environment, etc.) as well as at a local level (Municipalities, ARPA and Health Departments) to gather and d share data and information needed through the implementation of institutional instruments (standards, regulations, guidelines, etc.) and ad hoc databases.

40 Source: ISPRA processing of data taken from: JRC, *Promoting actions for healthy indoor air* (IAIAQ), Directorate General for Health & Consumers, 2011.

As shown in Table 8.5, the indicators for the characterization of indoor air quality may be split in two categories. The former relates to pollutants (PM, VOC, benzene, radon etc.), while the latter relates to the microclimatic comfort (CO_2, temperature, dampness, ventilation, noise, lighting, etc.).

Table 8.5: Indoor air quality indicators classified based on pollution and microclimatic comfort categories [41]

	Pollution	Comfort
Determinants/ Pressures	Sources of pollution (roads/ industrial facilities) close to schools Existence of school protocols for the use of non-toxic detergents, furnishings and school materials	Classroom crowding Number of schools in the A energy class
Status	Concentrations of PM, O_3, NO_x, VOC, benzene, radon (survey)	CO_2, temperature, dampness, change of air, moulds (survey), Lighting, noise
Impact	Non-infectious respiratory diseases (asthma, allergies, OBP)	Viral/bacterial affections (influenza, bronchitis, pneumonia, exanthematous diseases, etc.), headache
Responses	Number of firms/manufacturers of school furnishings and materials with Ecolabel certification Health monitoring/ supervision protocols in schools Number of policies to improve the school air quality (survey)	Number of Regions that have made laws on the energy efficiency of school buildings (energy certification requirement)

The indicators for characterizing the quality of indoor air may be broken down in two categories. The first category relates to pollutants (PM, VOC, benzene, radon, etc.), while the second one relates to microclimatic comfort (CO_2, temperature, dampness, ventilation, noise, lighting, etc.).

DETERMINANTS-PRESSURES

Possible indicators associated with pollutants

Different furnishing materials and teaching accessories, as well as sanitation and cleaning products may be responsible for the emission of pollutans such as TSP, VOC, PAH and POP[42] in the areas attend by schoolchildren. For instance, the use of chalk for traditional blackboards promotes the dispersion and accumulation of dust, particularly if during school hours doesn't take place aproper

Furnishing materials, teaching accessories, and sanitation and cleaning products may be responsible

[41] Source: ISPRA

[42] TSP: Total Suspended Particulate; VOC: Volatile Organic Compounds; PAH: Polycyclic Aromatic Hydrocarbons; POP: *Persistent Organic Pollutants.*

and regular ventilation of the classrooms .

for the emission of polluting substances (TSP, VOC, PAH, POP).

From this point of view, organization and management of the operations of environmental hygiene s become essential In fact, if these operations are not scheduled after school hours and are carried out without an adequate ventilation of the premises and without the use of specific products that do not release pollutants in the air after they have been used, they are likely to promote the dispersal of potentially toxic substances, thereby increasing the exposure of student attending the school . Even the choice of furnishings that are certified for low emissions of formaldehyde and other VOC is relevant to the elimination of these pollutants from the indoor environment.

At the same time, the location of the school buildings and, therefore, an adequate town planning represent additional indoor air quality determinants. A school located in an area with high vehicle traffic or close to an industrial area will be characterized by higher concentrations of indoor pollutants ($PM_{10-2,5}$, NO_2, PAH, CO_2, etc.) than a school located in a less polluted area.

Possible indicators associated with comfort

The crowding[43] may be considered an environmental quality determinant. In fact, several studies have shown that a large number of schoolchildren per cubic meter is associated with both higher concentrations of CO_2 and a higher risk that bacterial and viral infections might spread in indoor environments. Besides, it may result in a decreased attention (and learning) of the schoolchildren and the onset of headache.

The comfort is also described by the energy class of school building. Information about the latter is gathered through the energy certification procedure that is gradually being implemented in various Regions. The certification provides for an assessment with respect to the class of thermal insulation and the quality of the high-energy efficiency plant engineering. An energy-efficient building have to combine living comfort and energy –saving.

[43] Decree of the Minister of the Interior (fire-preventing regulations for school buildings) of 26/08/92 that, in addition to specifying the building characteristics, has provided for a "maximum crowding" limit of 26 persons per classroom (including schoolchildren, teachers, support staff, etc.) with no mention at all to the minimum area.

STATUS

Possible indicators associated with pollutants

In susceptible individuals, the indoor pollutants may give rise to allergies, eye and skin irritations, infectious diseases as well as non-specific symptomatologies, such as headache, trouble in concentrating, etc.

High concentrations of indoor pollutants, whether chemical or biological in origin, may result in an increased risk of allergies, eye and skin irritations and infectious diseases as well as non-specific symptomatologies, such as headache, impaired concentration, etc in susceptible individuals. Within this context, one of the indicators suggested by the WHO to assess indoor air quality is represented by the actual exposure to specific indoor pollutants (PM, O_3, NOX, VOC, benzene, radon, noise) in schools. This datum is assessed through surveys[44] that provide also for the monitoring of the concentration values of these pollutants. The methodology suggested for these surveys provides for the collection of passive diffusion samples in at least three classrooms , one outdoor location (average concentration in a week) and analysis in QA/QC accredited laboratory . The three classrooms should be monitored in the period when the heating system is on, while the schools, ranging in number from a minimum of 100 to a maximum of 300, should be selected in different geographical and climatic areas considering both urban and rural buildings.

Possible indicators associated with comfort

The microclimate, that is the series of physical and chemical factors (such as CO_2 concentrations, poor temperature conditions, dampness, lighting, noise) that characterize air in indoor environments, contributes to the individual psychophysical wellbeing, which is based on a delicate balance between individuals and environment. Any alteration of this balance may have an impact on children by negatively affecting their school performance and health conditions. Two indices are often used to assess microclimatic comfort: the katathermometric index that assesses thermal exchanges and the actual temperature index.

One of the indicators proposed by the WHO to assessindoor air quality is the insufficient ventilation of classrooms45. This indicator may be characterized through surveys that measure CO_2, temperature, dampness and ventilation values, as well as the presence of moulds inside the classrooms.

Carbon dioxide is one of the pollutants most often found in high concentrations in indoor environments as it comes from the normal processes of people breathing in a closed environment. The use of simple CO_2 monitoring devices could significantly support the management of indoor air quality. In fact, CO_2 represents an air quality indicator and, therefore it may be used to assess the performance of air treatment systems. CO_2 health effects become manifest at high concentrations (3,500 ppm of CO_2) and adverse effects become manifest above 5,000 ppm, but generally people start having a negative perception of the indoor air quality when

[44] M. Krzyzanowski, *Current WHO activities on IAQ*, WHO European Centre for Environment and Health, Bonn Office, 2011.

[45] M. Krzyzanowski, *Current WHO activities on IAQ*, WHO European Centre for Environment and Health, Bonn Office, 2011.

CO_2 indoor level of exceeds 600 ppm. For this reason it is recommended to increase the indoor ventilation starting from a CO_2 concentration of 800 ppm.
The temperature in indoor environment should be affected as little as possible by changes in the outdoor temperature in order to promote the constant presence of thermal wellbeing conditions . Optimum temperature values are between 20 and 25 degrees during the winter, while they should be a few degrees lower during the summer. Even the level of humidity is an important determinant of environmental comfort: values lower than 12% give rise to symptoms such as dryness of the mucous membranes, while values in excess of 80% are perceived as an uncomfortable sense of humidity. In fact, optimum relative humidity values are between 30 and 60%46 and are affected by the hygrometric levels present inside the buildings, the number of persons present within the premises and the actual structure of the building walls (i.e., dampness oozing from inadequately water-proofed walls).

Another microclimatic parameter that should be taken into account is the indoor ventilation: a poor ventilation lead e to an increase of both humidity and temperature, as well as to an accumulation of CO_2, resulting in a variable symptomatology that includes headache, generalized indisposition, tiredness, irritability.
On the other hand, even an excessive ventilation,especially if related to extreme heat or cold, or at least to considerable differences between the internal and external temperature, can be unpleasant and /or harmful.

Table 8.6: Optimum microclimatic values[47]

Period	Temperature	Humidity	Ventilation
winter	19-22°C	40-50%	0.05-0.1 m/s
summer	24-26°C	50-60%	0.1-0.2 m/s

Optimum microclimatic values of temperature, humidity and ventilation referred to the winter and summer periods

Noise is another status determinant that affects health and wellbeing of the individuals in special indoor environments. In fact, it has been shown that noise values exceeding 65Db(A) cause annoyance and fatigue and may trigger psychic and neurovegetative damages. Specifically, many studies have shown that the exposure to noise may cause a decline in school performance, disturbing verbal communication, memorization process and reading comprehension (learning disturbances), and it may even lead to behavioral changes with an increased aggressiveness. Children represent a particularly

It has been shown that noise values exceeding 65Db(A) cause annoyance and fatigue and may trigger psychic and neurovegetative damages. In children, who are particularly

46 P. Marinelli, *Igiene, medicina preventiva e sanità pubblica*, Piccin, Padua, 2002.

47 Source: ISPRA processing of data taken from: P. Marinelli**,** *Igiene, medicina preventiva and sanità pubblica*, Piccin, Padua, 2002.

vulnerable group to these effects. As a rule, they still lack adequate cognitive tools to understand and anticipate stressors and they have not developed strategies to cope with them. Furthermore, the fact that children are still in full cognitive and psychic development may cause stressors such as noise to determine irreversible negative consequences. At any rate, it should be noted that these effects do not occur in a uniform manner to all the exposed subjects[48].

vulnerable, the exposure to noise may cause a drop in school performance and may even lead to behavioral changes.

48 S. A. Stansfeld, B. Berglund, C. Clark, I. Lopez-Barrio, P. Fischer, E. Ohrstrom, M. M. Haines, J. Head, S. Hygge, I. van Kamp, *Aircraft and road traffic noise and children's cognition and health: a cross-national study*, Lancet, 2005, vol. 365, no. 9475, pp. 1942-1949.

IMPACT (exposure/effects)

Even though the exposure to airborne indoor pollutants is not likely to determine acute effects, it may lead to a variety of adverse health effects (including the onset of specific diseases or the worsening of existing pathologies) the severity of which depends on personal characteristics (health status, genetic predisposition, sensitivity, etc.), the type of pollutant and its concentration, and the mode and time of exposure.

Even though the exposure to airborne indoor pollutants is not likely to determine acute effects, it may give rise to adverse health effects the seriousness of which depends on personal characteristics, the type of pollutant and its concentration, and the type and time of exposure.

Children who spend most of their day at school (on average, 6 to 8 hours per day) are exposed to a series of multiple risk factors such as:

- chemical, biological and physical pollutants, sometimes in high concentrations;
- inadequate microclimatic comfort (inadequate temperature, ventilation, lighting and humidity);
- excessively noisy environment;
- classroom crowding.

The resulting health effects resulting may be divided into two typologies:

Building Related Illness (BRI) and Sick Building Syndrome (SBS).

Possible indicators associated with pollutants

The building related illnesses (BRI) are pathologies that are clearly defined by a clinical point of view and are consequence of a specific contamination within the premises. They include non-infectious respiratory diseases,(such as allergies arising from the household dust mite, cat hair or moulds) and the respiratory affections caused by moisture dampness, which may aggravate existing pathological conditions such as asthma, COBP, etc.

Possible indicators associated with comfort

Various viral/bacterial affections of the respiratory system, such as the so-called legionellosis (caused by the *Legionella* bacteria), the humidifier lung (a form of allergic alveolitis) and the humidifier fever, are associated with buildings and, in particular, with the crowding of indoor environments. As a rule, these pathologies result from an improper maintenance of the humidification, ventilation and air-conditioning systems.

Table 8.7: Relationship between exposure and health effects [49]

Disease/symptoms	Exposure	Model
Allergy or asthma	Bio-aerosols, PM, VOC, ETS	Attributable fraction
Lung cancer	Radon	Dose/response
	PM of indoor combustion origin, ETS	Attributable fraction
Cardiovascular disease	PM of indoor combustion origin, ETS	Dose/response
Chronic obstructive bronchitis	PM of indoor combustion origin, ETS	Attributable fraction
Respiratory infections	Dampness, ETS	Attributable fraction
Intoxication	CO	Incidence

Correlation existing between the different types of pollutants and their effects on human health.

The sick building syndrome (SBS) is a widespread syndrome with an undefined etiology and a non-specific symptomatology. While the BRIs affect a limited number of subjects, the SBS affects a large number of persons (50-60%) attending confined unhealthy evnviroment. With this type of syndrome, the symptomatology disappears when leaving the building.

The SBS includes a series of general health problems such as irritation of the eyes, nose, skin and respiratory tract, as well as general symptoms such as headache, asthenia, slight illness, dizziness and difficulty in concentrating. There are a variety of causes for the SBS, generally triggered by a number of factors, including inadequate ventilation, unhygienic air-conditioning systems, emission of odors and irritating substances by materials and equipment, moisture damages, as well as an unpleasant climate in the premises, permanent and irritating noises, and inadequate placement of workstations. Unfortunately, there are no European data on the incidence or causes of the SBS[50].

The sick building syndrome is a widespread syndrome with an undefined etiology and a non-specific symptomatology. Nearly 50-60% of the individuals that spend time in unhealthy indoor environments complain of it.

49 Source: ISPRA processing of data taken from JRC, *Promoting actions for healthy indoor air* (IAIAQ) Directorate General for Health & Consumers, 2011.

50 M. Jantunen, THL, E. Oliveira Fernandes, FEUP, P. Carrer, *Promoting actions for healthy indoor air* (IAIAQ), Milan University, Kephalopoulos S., EC/JRC/IHCP, 2011.

RESPONSES

Possible indicators associated with pollutans -

it is possible to have a general picture of the effectiveness of the measures implemented to minimizing exposure to indoor risk factors. By identifying a series of response indicators, ranging from the management of indoor hygiene to the reasoned choice of certified furnishings and consumer goods,

At present, the environmental quality of materials/products is mrun by the Ecolabel regulation (EC Regulation no. 66/2010). The latter is of particular important in identifying the low-emission consumer and furnishing products and building materials that should be preferred in school management programs. Hence, a response indicator could be represented by the number of firms and manufacturers of building materials, furnishings, school and consumer products Ecolabel certified.

Within this context, a further indicator could be represented by the number of policies implemented to improve air quality in schools. A survey could single out and register all the town planning measures and programs throughout the national territory that provide for the strategic location/zoning of new school buildings in strategic areas far away from sources of atmospheric and noise pollution, and the air quality and mobility management plans providing for mitigation and possible reorganize of road traffic in the areas where school buildings are already present.

By determining a series of response indicators, ranging from the management of the sanitation and environmental building of schools to the reasoned choice of certified furnishings and consumer goods, it becomes possible to have a general picture of the effectiveness of the measures implemented with a view to minimizing the indoor exposure risk factors

Possible indicators associated with comfort

At present, the new Directives on the energy efficiency of buildings have to be taken into account (Directive 2002/91/EC implemented with Legislative Decree n. 192 of 19 August 2005; Standard UNI TS 11300; Directive 2010/31/EC). At any rate, these regulations require an careful evaluation and application in order to avoid that buildings energy performance is achieved to the detriment of the indoor air quality. The response indicator used in this context could be represented by the number of regions which have legislated on the energy efficiency of school buildings (energy certification requirement).

GLOSSARY

Allergens:

Substances recognized as alien to a given organism (antigens) that may give rise to an immediate hypersensitivity.

Allergies:

Hypersensitivity reactions of the body immune system to a variety of substances (allergens).

Indoor environments:

Non-industrial living and working premises such as homes, offices, schools, libraries, hospitals, barracks, hotels, recreational facilities, means of transport.

Microclimatic comfort:
Psychophysical state that causes individuals to be satisfied with the microclimate that characterizes the environment where they spend their time.

Formaldehyde:
Volatile organic substance having a carbonylic nature, occasionally present in the air of living premises. It is a colorless gas with a strong and pungent odor. Upholsteries, chipboards, insulating materials, coloring agents, plastic material, wall-to-wall carpeting, textiles, detergents, additives, disinfectants and tobacco smoke represent the main sources of emission.

Indoor pollution:
Pollution that affects indoor environments and arises from the accumulation of generally airborne pollutants emitted by various sources both indoor and outdoor.

Outdoor pollution:
Atmospheric pollution of the outdoor environment.

Airborne pollutants: chemical substances that may be present in the air in such a concentration as to adversely affect human health, other life forms or materials.

Indoor air quality:
Quantitative assessment of the air pollution in indoor environments.

Radon:
Naturally occurring radioactive noble or inert gas. It is produced by the radio present everywhere in the soil by “nuclear decay” and is present in the environment particularly in the areas having a volcanic origin. Its dangerousness is higher in indoor environments since the latter hinder its dispersion in the atmosphere.