Indoor Air Quality (IAQ) guideline: Contribution for Portuguese Measures

Jesus, L. [1], Almeida, M.[2], Pereira, E.[3]

[1]University of Minho, Campus de Azurém – 4800-058 Guimarães, Portugal
Email: lunetto7@yahoo.com.br http://www.uminho.pt
[2]University of Minho, Campus de Azurém – 4800-058, Guimarães, Portugal
[3]JCS- Serviços e Consultadoria, Ed. Via Norte – Rua do Espido nº 164, Maia, Portugal

Summary: *This work intends to create an orientation line for professionals of the construction sector, in a way to guarantee the Indoor Air Quality (IAQ) inside the buildings in Portugal. "Guidelines for the Sustainability" is being prepared and in it, the indoor air quality is considered as one of the most relevant parameters to be characterized. In an evident and didactic way, a guide will be published for architects, engineers and users, with some strategies to be applied in different project phases, from the design phase, through the utilization and up until the demolition phase.*

Keywords: *IAQ guideline, sustainability, buildings*

1 Introduction

The concern with the indoor air quality is recent and still insufficiently discussed and disseminated. The first initiatives were mainly concerned with the control of the emission of outdoor gases, in the greenhouse effect and their inconveniences. This has resulted in initiatives for important worldwide discussions, as in Rio de Janeiro in 1998, as well as the Quioto`s Treaty for control of the emissions. However, little has been discussed on the impact of the low indoor air quality that is responsible for numerous allergies (about 20 to 30% of the European population), psychiatric disturbances, Legionary's disease, skin infections, and in more fatal cases, lung cancer.

From the Industrial Revolution on, intoxication problems started to appear but not sufficiently evident. Other problems were considered more relevant, as the exploitation of the women and children's work, besides the lack of hygiene and the excessive workload. After protests, starting from the 19th century, significant alterations occurred, generating better work conditions. However, it is only in the 20th century that the real work conditions have been clearly identified and assessed. In the machine era, man starts to do less physical work and ends up developing more intellectual work, usually in closed spaces, enjoying the new acclimatized buildings. It's from this moment on that the consequences of the indoor air quality become more evident. The spaces with low air renewal ratio are known by the English denomination as "Sick Building Syndrome". This situation is increasing work accidents and problems with the worker's health, with negative economical impacts. In accordance with The Environmental Protection Agency (EPA) of the USA:
"The cost of the polluted air results in a medical cost of approximately a billion dollars a year and for the company, the cost is approximately sixty billion dollars a year, with employees that get sick and reduce their production "(EPA, 2003).

This not only happens in working atmospheres, but also in residences, schools, hospitals, hotels, and other buildings. The consequences are quite evident:

"Forty per cent of the children will develop breathing problems, partly due to the presence of chemical products in their residences and the vicious process of the air conditioning" (New English Newspaper of Medicine, 2003).

"Second hand smoke causes lung cancer in adult non smokers and impairs the respiratory health of children. Only 15 other substances, including asbestos, benzene and Radon, carry the group the carcinogen designation" (EPA, 1993)

These reports only come to reinforce that the indoor air quality is directly linked and dependent on factors like the construction type, the choice of materials, the use of conservation and maintenance products, the irregular (most of the times absent) maintenance of the HVAC (Heating, Ventilation and Air Conditioning) systems and the contradiction between insulation for energy efficiency purposes and free ventilation for IAQ purposes (insulation is an essential measure but should be managed conscientiously to assure a minimum quality of the indoor air).
This means that the environmental impact of the construction is significant on a global scale, as well as, on the future user's scale. In developed countries, during construction, about three billion tons of raw materials are consumed; from these, 25% to 40% are solid wastes, 50% are CFC, and 30% are CO2 besides other substances. It has also been proved that the indoor air in new houses is ten times more polluted than the external air (EPA 2003).
In this way, it is possible to conclude that besides control and maintenance measures of the HVAC systems, it is also necessary to improve the indoor air quality through the application of sustainable measures, applied in all of the different phases of the project, in order to control the effects distributed in the whole construction process.

2 IAQ`s management measures

The continuous increase on the demand for HVAC systems, the increase occurred in the Construction industry and some measures taken at a governmental level, besides the real quantification of some measurable parameters related to air quality, were responsible for a general mobilization and consciousness of this problem and for the definition of some criteria to assure a good indoor air quality. Also it is evident a larger performance responsibility, before little monitored, disseminated and controlled.

Some initiatives were the following:

- European Directive (Directive 2002/91/CE) – This directive imposed to the members' states the adoption of energy reduction measures, for both new and refurbished buildings, with the mandatory quantification of the energy consumption and of the air quality in both project and use phases. This directive also demands, for large buildings, the public exhibition in visible places (p.ex. buildings entrances) the energy and indoor air quality certificate.
- Quioto's Protocol - the countries that signed this document assumed the commitment of controlling the greenhouse gases emission through the promotion of better energy efficiency, leading to a consequent decrease on CO2 emissions.

This general mobilization is perceptible both at legislative level as well as at institutional level.

At legislative level, as requested by the directive 2002/91/CE, the members' states had a period of three years to revise their legislation in order to meet the new requirements. Since then, each country has defined and approved new regulations or promoted the necessary changes in the existent laws. In Portugal, two regulations related to the energy performance of buildings and systems have been revised ("RCCTE" - related to the thermal performance of the envelopes [RCCTE, 2006], and "RSECE" - related to the thermal performance of the HVAC systems [RSECE, 2006]) and it was established a new and mandatory Buildings Energy Certification system.

But it is the revised RSECE code, approved on the 26th of January 2006 that imposes the new requirements related to the indoor air quality, based on four main objectives:

1. To define thermal comfort and hygienic requirements, in spaces with different activities, assuring energy efficiency conditions;
2. To improve the energy efficiency in buildings, either in new or existent ones;
3. To improve the HVAC systems efficiency and to guarantee the indoor air quality maintenance (in both installation and operation level);
4. To promote periodic maintenance of the HVAC systems for energy efficiency and indoor air quality.

These goals are clearly evidenced in the 1st article of this document [RSECE, 2006]:

"This regulation establishes:

a) The conditions that should be observed in the project of new HVAC systems, namely:

i) The requirements in terms of thermal comfort and indoor air quality that should be assured in conditions of energy efficiency by the appropriate selection of equipment and its organization in systems;

ii) The requirements in terms of conception, of the installation and maintenance conditions that HVAC systems should obey to assure quality and safety during its normal operation;

iii) (…)

e) The monitoring and auditing operations defined in terms of energy consumption and indoor air quality."

However, it is in chapter IV (Article 13th) that it is explained how these measures will be put into practice, either through requirements or control strategies (in licensing phase and in construction and use phases) [RSECE, 2006]:

1 - It will be mandatory the installation of natural, mechanical or hybrid means to guarantee adequate air renewal ratios inside new buildings.

2 - It will be mandatory, for all office buildings, the control of the concentration levels of pollutant agents in order they do not exceeded the security levels (see table 1).

3 - It will be mandatory making periodic audits to the indoor air quality in the extent of the Portuguese Buildings Energy Certification and Indoor Air Quality System (SNCEQAIE).This will be mandatory for all office buildings with HVAC systems, with a periodicity and complexity adapted to the type and dimension of the building (it can vary from two, three to six years, depending on the type of building).

4 - These audits should measure all kind of pollutants concentration and other dangerous materials.

5 - In the case of hospitals, for specific reasons, they can make auditing out of the Extent of SNCEQAIE system, as long as they accomplish the periodicity imposed by the regulation (every two years).

6 - If the auditing detects concentration levels above the established limit, it should be put into action a corrective plan in a maximum period of thirty days (starting from the date of the auditing conclusion).

7 - In case the period is not accomplished, the owner can be punished with the sanctions foreseen in the law.

8 - In cases of serious IAQ occurrences, the period to put into action a corrective plan can be reduced to eight days or, if necessary, the closure of the establishment can be ordered.

In this document, some parameters to assess the indoor air quality are defined in order to allow future monitoring and audits that must be performed under the Portuguese Buildings Energy Certification and Indoor Air Quality System (SNCEQAIE). The complexity and periodicity of the actions to be taken must be tailored to the nature, dimension and use of

the building, mainly in what concerns the required air renewal ratios, maximum concentrations allowed for some gases or microorganism or particles in suspension (See table 1).

Table 1 - Allowed maximum concentration under RSECE.

Parameters	Allowed maximum Concentration
Particles in suspension in the air (PM10)	0,15
Carbon dioxide	1800
Carbon monoxide	12,5
Ozone	0,2
Formaldehyde	0,1
Volatile organic Compounds	0,6
Microorganisms - Bacterium	500 UFC
Microorganisms – Fungous	500 UFC
Legionella	1000 UFC
Radon	400 Bq/m3

At institutional level, some countries, like USA, promoted the free analysis of the air quality in residences and schools.

In parallel, some manuals oriented for sustainability and air quality management and ventilation control are being developed by several institutions and universities.

For the majority of the manuals, the air quality control strategies contemplate the following measures:

1. Occupation activity control - establish and maintain policies of non smokers. Monitor equipment to assure that the systems releasing chemical products are placed in ventilated areas.

2. Ventilation - develop ventilation strategies that maintain the windows operable, when appropriated. Foresee a mechanical ventilation plan to maintain an acceptable air renewal ratio, in areas where the air is infected or polluted.

3. Construction methods – control of the indoor air quality during the construction.

4. Construction materials - the choice of appropriate construction materials.

5. Pollutant sources control - such as external sources that can include atmospheric pollution, as other sources resulting from the use of chemical substances such as cleaning products, pesticides, fragrances and others.

6. Operation and maintenance of the building.

7. Control Systems - when possible, it is advised the use of sensors to control humidity, temperature and carbon dioxide concentration.

Nowadays, concerns with indoor air quality are growing and parameters related with its control are achieving a higher relevance even in the design phase (before the use of the building). However, up till now, from these manuals, little has been adapted to the Portuguese reality, taking into account different climatic conditions, local legislative framing and coherence with national market supply, and, even more important, none are targeted to the different phases and requirements of the buildings life cycle.

In this way, this work intends to create an understanding vehicle for the dissemination of good practices in order to obtain a good Indoor Air Quality inside the Portuguese buildings, which will pass, firstly, by the conscientiousness of the building professionals and later by the responsibility of the users (final consumers).

3 IAQ Guideline development

The Manual which is being developed, "Guideline for Sustainability", has as overall objective, the application of sustainable concepts, defined in a logical preservation of the future, focusing on three fundamental aspects: community (social and cultural aspects), economy (interaction with the base model of society development) and the ecology (by eco resource efficiency perspective). The manual will focus on different subjects related with the energy and water management, materials use and recycling, integration of the buildings in the urban environment and indoor quality where IAQ is clearly identified (See figure 1).

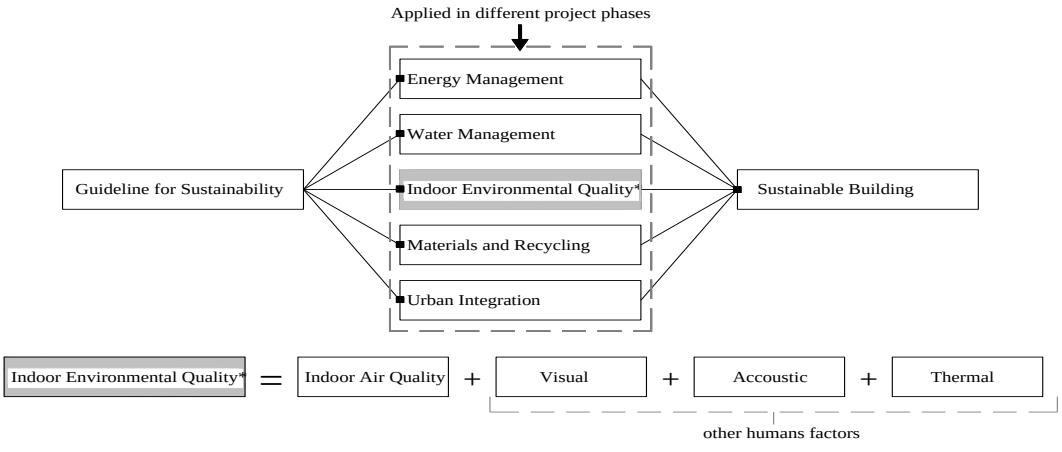

Fig. 1. The Guideline structure.

It is necessary to emphasize that in this manual, IAQ will be integrated in the "Indoor Environmental Quality" section in order that indoor air quality become inseparable from other human factors (visual, acoustic and thermal). In this manual, the suggested rules will also meet the new regulations requirements. As mentioned, this guideline will be supported by similar foreign manuals, now adapted to our reality, language and market (services dissemination and national sites which promote sustainable measures). At the same time, it will also identify some national "gaps" which will require the application of some sustainable procedures, already implanted in other countries, and start developing them from then on.

One of the most interesting aspects of this manual is the way it will be organized. Many sustainable efforts are concentrated in the initial phases of the project. The objective of this manual is to be an added value to the project team and users, giving advice, phase by phase, on the daily measures to be taken to guarantee the sustainability of the building and a healthy environment.

Opposite to other manuals, it won't have separate categories, but project phases, in order to facilitate reading, and use and to make it more accessible to the construction professionals. (See table 2).

Table 2. The Guideline for Sustainability organization.

Parameters and project phases	Energy Management (category 1)	Water Management (category 2)	Indoor Environmental Quality (category 3)	Materials and Recycling (category 4)	Urban integration (category 5)
Planning phase (A)	A.1	A.2	A.3	A.4	A.5
Design phase (B)	B.1	B.2	B.3	B.4	B.5
Building construction (C)	C.1	C.2	C.3	C.4	C.5
Operation and Maintenance (D)	D.1	D.2	D.3	D.4	D.5
Demolition (E)	E.1	E.2	E.3	E.4	E.5

The phases will be organized and divided by certain categories. This way, the construction technicians will be able to visualize the chapters and linked advices, in the project phase.

Below, it will be showed, as an example, how the manual will be applied, using as model the theme in subject, Indoor Air Quality, in its different phases. It will be supplied, only to exemplify, some of the proposed measures, for the project phase (see figure 2):

Category 3 - Indoor Environmental Quality

Main goals, linked to the Indoor Air Quality:

- Monitor and avoid problems of indoor air quality during construction, renewal and demolition;
- Provide an adequate Indoor Air Quality for construction workers and subsequent users;
- Minimize the mold risks, mushrooms and chemical substances that threaten the Indoor Air Quality;
- Provide appropriate ventilation rates for pollution's control and thermal comfort;
- Use materials with low emission of VOCs (volatile organic chemicals).

Main goals, linked to the other human factors:

- Provide the appropriate thermal conditions;
- Assure the adequate levels of natural and artificial lighting, appropriate for different activities and specific tasks;
- Provide the appropriate acoustic conditions;
- Provide visual accesses and real connection with the natural atmosphere.

Examples of applied measures:

A.3 - Indoor Environmental Quality - Planning Phase:

- In the land choice phase, proceed with air quality analyses to determine the presence of chemical substances and other harmful gases. It is important that this task is accomplished in the worst situation possible, regarding the season and the wind conditions. These analyses should be done by certified laboratories;
- Evaluate the performance of the soil and of the hydrographical basin. These tests try to identify the past activities in the land, and to identify the presence of chemical substances in the soil and hydrographical basin, such as the noxious presence of pesticides, forced, for instance, by agricultural activities, or the presence of heavy metals, carbons and dumps forced by industrial activities. This evaluation is fundamental, so much as to determine the local viability as for the definition of methods to remove the local or adjacent contamination;

- Define and select an enterprise, agreeing to present and implement an indoor air quality management plan.

B.3 - Indoor Environmental Quality - Design Phase:

- Develop an indoor air quality management plan to be included in the project proposal and in the tasks notebook;
- Provide an easy access to the HVAC systems for periodic maintenance and cleaning;
- Architects should choose coatings and coverings materials with easy maintenance and that do not request dangerous conservation products;
- Install porous materials, such as insulation, only after the building is weather tight;
- Install noxious chemical products (asphalt screen, coatings, paints and sealing materials) before the installation of other materials, like carpets, woods, linings, acoustic panels and furniture, able to absorb chemical substances/VOCs. This will prevent these porous materials from absorbing dangerous products and releasing them later on during the lifecycle of the building.

C.3 - Indoor Environmental Quality - Building Construction Phase:

- Define adequate procedures to prevent the propagation of the dust, like the creation of physical barriers through a layer of polyethylene or other barriers, isolating each section of the building,;
- When it's not possible to create a proper sequence of a favourable installation procedure, the absorbent surfaces should be protected through the application of steam barriers, and temporary or permanent ventilation systems must be provided.
- Provide the filtration and the appropriate ventilation rate, through 100% of external air, during the drying period, to help removing the pollutants of indoor spaces (humidifier should be requested in certain applications);
- Avoid the operation of HVAC systems during the construction phase. If it is inevitable, all the filters, ducts, and surfaces of the equipment should be cleaned in order to obtain the same level of cleanness as the new equipment.

D.3 - Indoor Environmental Quality - Operation and Maintenance Phase:

- Allow a period of approximately seven to fourteen days after the construction for the building's occupation. During this period, the impact of the recently installed materials in the indoor air quality is bigger since many products, like paints or glues, contain considerable levels of VOCs in the first days of application;
- Check periodically the combustion systems;
- Don't smoke in closed spaces;
- Don't use pesticides or insecticides;
- If solvents, cleaning products, fuel or other potential poisonous liquids are spilled on the floor, clean immediately to reduce advanced contamination.
- If a leak of a poisonous product affects replaceable material, replace it immediately with new material. Odors of a significant leak can take several years to disappear, causing discomfort and health problems to the future occupants.

E.3 - Indoor Environmental Quality - Demolition Phase:

- Install barriers between work areas and in use areas;
- Install barriers and close ceilings in order to avoid the duster transmission between adjacent areas;
- Use extraction systems in areas that suffer strongly from the contamination of mould;
- During the mould cleaning process it is important to minimize the occupant's exhibition in the building, therefore, this process is advisable out side of regular working hours;
- Don't allow dust accumulation and debris in the working place, removing it daily. Adjust the bins well with clean layers and maintain them covered when they transport residues through other building's areas. Before leaving construction areas, wash all the reservoirs with a wet sponge to prevent dust residues.

4 Conclusion

Through this work, it is possible to conclude that the management measures of the Indoor Air Quality cannot be divested from the term "Sustainability", which is supported in social, economical and environmental aspects. More than any other defined category, the Indoor Air Quality is the one that is better framed to these factors, in a historical precedence which has been provoking strong affects in referred sustainability bases.

This work intends to perform an important role in the dissemination of the Indoor Air Quality requirements, and it is expected that it will help construction professionals and also users to implement the right IAQ strategies.

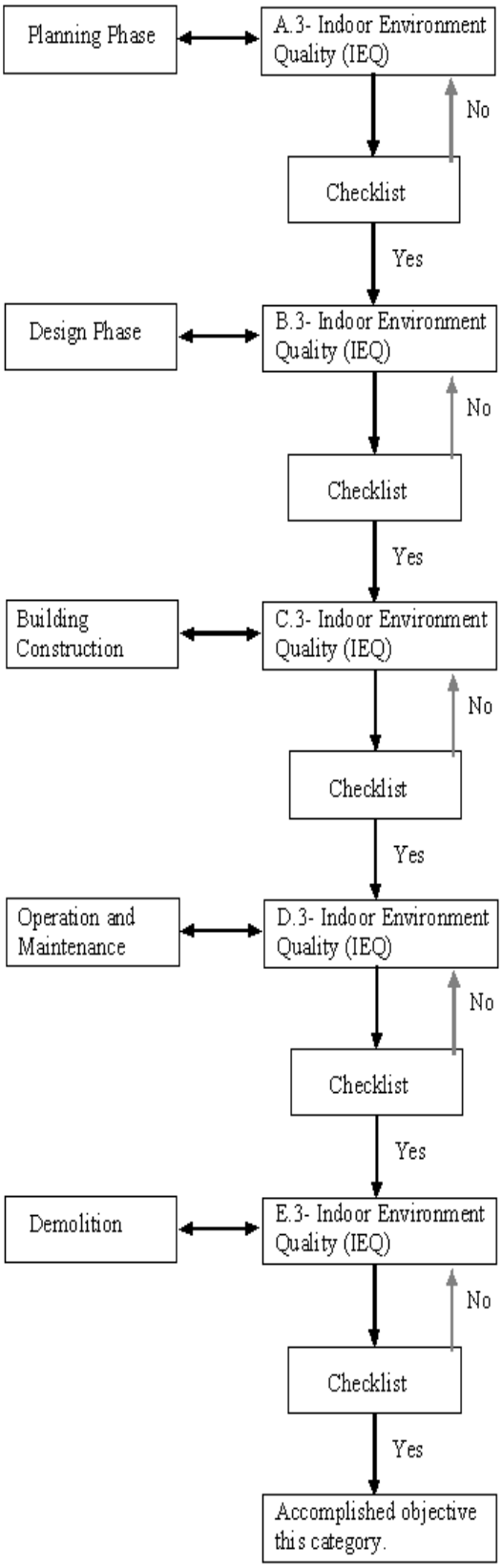

Fig. 2. The example of application of the IEQ category.

References

[1]Several authors. Green Building Guidelines for home Remodeling. Marin County Community Development Agency. Alameda. 2002.
[2] European Directive 2002/91/CE. Brussels, 2002
[3] Proposta de Revisão do Decreto-lei nº 118/98 do Regulamento dos Sistemas Energéticos de Climatização dos Edifícios (RSECE), Portugal, 2004.
[4]B.Anthony. Sustainable Building Technical Manual. Public Technology. 1996.
[5]H. Steven, G.Ronald and G. Nicholas. Indoor Air Quality – Solutions and strategies. McGraw-Hill, Inc. New York. 1995.
[6]Federal Office for building and Regional planning. Guideline for Sustainable Building. Germany. 2001.
[7]Several authors. Green Guidelines for Healthcare Construction. American Society for Healthcare Engineering. USA. 2003.
[8]Several authors. Field Guide for Sustainable Construction. The United State Department of Defense. USA. 2004.
[9] www.epa.gov/iag/