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DESIGN FOR INDOOR AIR QUALITY IN THE GLOBAL ENVIRONMENTAL CONTEXT

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Abstract: Indoor air quality deteriorated because it was largely ignored as other issues were addressed. In spite of the currently increasing recognition of worldwide environmental deterioration, there is inadequate understanding and consideration of the impacts of building design, construction, operation and demolition on the environment. This paper identifies and quatifies the magnitude of buildings' contributions to environmental problems based on life cycle inventory data categories. It describes criteria used to identify and weight important environmental problems. The weightings it provides can inform choices among building alternatives with varying environmental impacts and may be useful in reconciling indoor air quality design goals with broader environmental concerns.

Keywords: Environment, buildings, indoor air quality, indicators and management.

1. INTRODUCTION

Designing buildings to optimize indoor air quality may not address worldwide environmental concerns unless they are identified and considered in the design process. Failure to consider the broader environmental context while addressing indoor environmental concerns might lead to a repetition of the process that exacerbated indoor air quality deterioration during the 1960s and 1970s [1]. Historically, indoor air quality deteriorated because it was largely ignored in favor of other issues. During the last 40 years mechanical ventilation systems became the means primarily for meeting buildings' heating and cooling needs rather than for providing outdoor air ventilation. Energy conservation efforts reduced attention to outdoor air delivery; variable air volume distribution systems produced significant shortfalls of outdoor air supply. Often this occurred when temperatures were warmest, pollutant source emission gassing rates highest and occupant tolerance of indoor air pollutants lowest, precisely the times when the most outdoor air was needed.

In the same period, the introduction of new building materials, consumer products and equipment resulted in increased source strengthts for indoor air contaminants. Materials made from composite wood and adhesives, from textiles or from plastics replaced many more durable and more chemically stable traditional building materials. Consumer contributed to much higher indoor pollution levels. The problem was identified in the early 1970s but only recently became widely recognized.

Presently there is growing recognition of the causes and importance of environmental deterioration worldwide [2]. World population has reached unprecedented levels and exponential growth rates. Current per capita consumption rates stress environmental resources and pollution sinks beyond their capacities. Stratospheric ozone depletion, global climate change and biodiversity losses are grave global problems; local and regional environmental resources shortage are associated with famine and disease; biodiversity losses are occuring at dramatic rates. Local air, soil and water pollution, soil erosion and acidification are widespread globally. Buildings are significant environmental stresors. It appears essential that some combination of reductions in population growth, resource consumption, environmental pollution and land encroachment be effectuated soon on a global scale.

2. SCOPING BUILDING CONTRIBUTIONS TO ENVIRONMENTAL PROBLEMS

Buildings contribute to environmental deterioration through processes of design, construction, operation and demolition that fail to consider their larger environmental context. Indoor air quality control and other indoor environmental solutions must also take account of their impact on the total environment. Building ecology was defined in 1981 as the study of the interrelationships between buildings, their occupants and the larger environment. Building ecology is based on the methods used in the field of ecology, a sub-discipline of biology.

Understanding the larger context for building design and prioritizing environmental problem lead to informed decisions that reconcile indoor air quality goals with broader environmental concerns. By applying sustainability criteria, specific, measurable targets can be established to evaluate alternative design or building environmental performance. Progress made in determining impacts of many building products and processes through life cycle inventories (of flows to and from the environment) can assist when there is a context for interpreting inventory data [3]. That context requires the following:

1. a scoping analysis of buildings contributions to environmental problems to asses the potential for improvement through building-related decisions;
2. a uniform set of environmental problem definitions;
3. standardized methods for normalization of classified environmental impact inventory data
4. weighting factors for environmental problems to be used in an overall scoring or ranking of building design or other alternatives.

These methods plus reliable inventory data and impact analyses are necessary for scientifically reasonable decision making. The paper presents some recent work to address the first two and the last of these needs.

2. DEFINING ENVIRONMENTAL PROBLEMS

Defining environmental problems of concern is an essential step in developing building performance evaluation methods [4]. Goals of the problem identification are:
1) comprehensive (inclusive); 2) simply stated; 3) readily recognized; 4) consistent (problems stated at a uniform level of detail and specificity). These goals are developed in a set of criteria prepared to the four goals above:

1. There should be no mixing of sources, receptors and media within distinct problem topics.
2. The problems areas should be selected based on the potential types of environmental stress they cause, not based primarily on their physical / chemical properties.
3. The problems should have no considerable degree of redundancy for a single type of environmental stress.
4. The problems are formulated either in terms of processes/mechanisms or in terms of environmental effects.

The problem statement terminology was evaluated according to the criteria mentioned above, as an important way to simplify the ranking or weighting process (table 1).

Table 1. Building related environmental problems

ECOLOGICAL PROBLEMS	HUMAN HEALTH PROBLEMS
Top priority	***Building occupants***
Habitat destruction/deterioration (directly resulted in biodiversity loss)	Indoor air pollution – biological agents
Global warming	Indoor air pollution – chemical products
Stratospheric ozone depletion	Accidents in buildings (electrical, fire)
High priority	***Building workers***
Soil erosion	Building construction / demolition / material manufacturing, etc.
Depletion of freshwater resources	
Acid deposition	
Urban air pollution/smog	
Surface water pollution	
Soil and groundwater pollution	
Depletion of mineral reserves	

3. WEIGHTING ENVIRONMENTAL PROBLEM CATEGORIES

A weighting scheme [5][6] was developed to express the relative importance of various environmental problems. An elaborate procedure (including specific criteria) were developed and the basic criteria used for weighting are represented by:

1. *The spatial scale of the impact* (global, regional, local – large worse than small)
2. *The severity of the hazard* (More toxic, dangerous, damaging being worse)
3. *The degree of the exposure* (Well-sequestered substances being of less concern than readily mobilized substances)
4. *The penalty for being wrong* (Longer remediation times of more concern)

5. *The status of the affected sinks* (An already overburdened sink more critical than a less-burdened one. Sinks = receptors, environmental compartments)

Assigning one hundred points for the maximum impact did scoring and other impacts were rated relative to the maximum. Scores on each of the criteria are averaged to determine the final weighting score for each environmental problem area (table 2). The potential contribution of buildings can be used to identify leverage points for applications. In the absence of an environmental scheme, all environmetal problems are treated as equal and clearly they are not and should not be treated as such.

Table 2. Weighting for ten environmental / ecological problems

Environmental problem category	***Weighting***
Habitat destruction / deterioration (biodiversity loss)	88
Global warming	80
Stratospheric ozone depletion	90
Soil erosion	19
Depletion of freshwater resources	12
Acid deposition	24
Urban air pollution	26
Surface water pollution	25
Soil and groundwater pollution	35
Depletion of mineral reserves	50

To develop tools specifically for application to building related problems and decisions a professional management must be focused on the hygienic conditions which promote a clean indoor environment . This means that considerations has to be taken in handling of materials (dust, pollution), cleaning and clearing including removal and deposition of waste.

4. INDICATORS AND MANAGEMENT OF INDOOR AIR QUALITY

Indoor air quality studies consist of four major segments: air quality measurements, evaluation of the heating, ventilation and air conditioning systems, interviews with the building occupants and statistical analysis of the data. Indoor air quality indicators should be related to a systematic process of building investigation, should reflect comfort and ventilation of the building air and should be measured in relation to the presence of critical sources rather than be applied in all buildings. The final quality of indoor air is influenced simultaneously by several factors not only ventilation but also emissions from building materials, air handling systems, construction methods and materials, operation and maintenance of buildings [5][6]. Good indoor climate provides that all these factors are taken into consideration in design, construction and operation. The following indicators are recommended for use in the building system approach for indoor air assessment [7]:

1. ***Comfort indicators***
   Thermal comfort requirements, optimum relative humidity 50%.

2. ***Ventilation indicators***
   Carbon dioxide concentration of max. 0,1% in public buildings
3. ***Source indicators and locations***
- *asbestos:* use applicable codes in buildings construction;
- *radon:* earth-constructed dwellings, habitable basements;
- *environmental tobacco smoke:* nicotine and suspended respirable particles;
- *house dust mite*: allergen levels in dust from dwellings to be below regional ten percentile level;
- *microbials:* moist/damp surfaces with or without visible growths are unacceptable; no confirmed pathogens or toxigenic fungi in air or surface samples;
- *formaldehyde*: new buildings;
- *volatile organic compounds*: total volatile organic compounds > 500μg/m^3 indicates significant sources; determine irritants / carcinogens when potential sources are present;
- *pesticides:* measure concentrations if residue are present (if foundations are treated with termicides);
- *carbon monoxide*: all buildings with local heating systems (unflued gas heaters);
- *ozone:* rooms with heavy use of electrostatic photocopiers, laser printers and at outlets of ozone-based air sterilizers.

There is a growing awareness of the significance of indoor air quality management and the relationship between a high standard of health, safety and indoor/outdoor environment. A professional management (figure 1) is a management focusing on quality and profitable production as well as on the environment, health and life quality [7][8]. It is also, a continuous process built on three basic principles:

- *Prevention*: systematic planning of activities and processes to avoid errors.
- *Disclosure*: errors and deviations shall be identified and dealt with as soon as possible to avoid negative consequences
- *Correction*: when errors and deviations have been dealt with, the causes have to be analyzed and removed so that the same errors will not appear again.

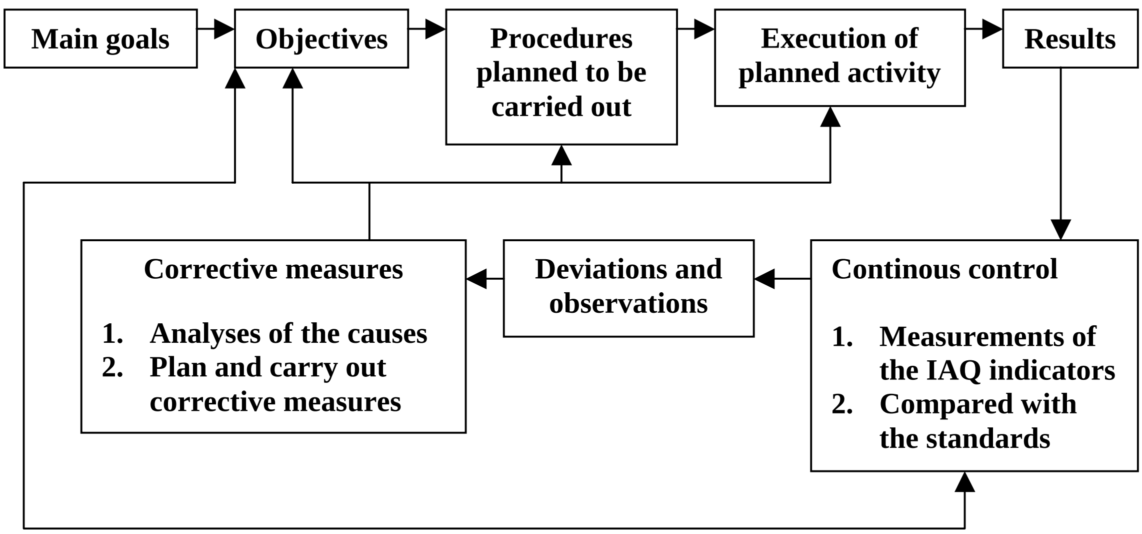

Figure 1. The basic scheme of the indoor air quality management

The emphasis of the control strategy is to provide advice to the public on how to reduce exposure to air pollutants in their homes or in public spaces. The strategy depends healthy alliances among the public, the institutions and industry, each playing their part to reduce the levels of indoor air pollution [9].

5. CONCLUSIONS

The indoor pollution problem grew due to unbalanced emphasis on narrow goals. By attending to indoor air quality in the context of the larger environment, it is hoped that building design can address both indoor and general environmental concerns simultaneously and systematically. The world needs examples to demonstrate that companies, governments and individuals can create built environments in harmony with nature. A necessary activity of professionals is to establish criteria, guidelines and standards that ensure that problems like indoor air quality are addressed and hopefully prevented. Housing is a fundamental element of the built environment. Through the design of homes and planning of communities, healthier indoor and outdoor environments can be realized.

REFERENCES

[1] Popa, M. (2001)*”Concepte şi tendinţe privind poluarea mediului înconjurător”* Editura Quo Vadis, Cluj-Napoca, Romania.
[2] Miller, G.T. (ed), (1994) *“Living in the Environment: Principles, Connections and Solutions”* (eight edition), Belmont, California, Waldsworth Publishing Company.
[3] de Haes, U.H.A. (ed), (1996), *“Towards a methodology for Life Cycle Impact Assessment”*, SETAC-Europe, Brussels.
[4] Popa, M., Popa, M.S. “Research activities on indoor air quality in Romania” in *Proceedings of 5th International Symposium on Measurement Technology and Intelligent Instruments,* Cairo, Egypt, pp.365-371.
[5] Popa, M. (2000) *”Poluarea interioară- expunere, efecte, control”* , Editura Quo Vadis, Cluj-Napoca, Romania.
[6] Popa, M.; Popa, M.S. (2000) “Indoor air quality problems in Romania: monitoring and control” in *Proceedings of the 2nd Brazilian Congress of Metrology*, SaoPaulo, Brazil, 4-7 Dec. 2000, vol.I, pp. 476 – 482.
[7] ISO (International Organization for Standardization) “Environmental Management - Life cycle assessment – Principles and Framework (ISO 14040) / Goal and Scope Definiton and Life Cycle Assessment (ISO 14041) – LIfe Cycle Impact Assessment (ISO 14042) - Life Cycle Interpretation (ISO 14043), ISO Geneva, 1997, 1998, 1999 and 2000.
[8] Consoli, F. (ed), (1993), “Guidelines for Life Cycle Assessment – A Code of Practice” Society of Environmental Technology and Chemistry (SETAC), Brussels and Pensacola.
[9] Harrison, R. (2001) *“Pollution- causes, effects and control”* (fourth edition), The Royal Society of Chemistry, Bookcraft Ltd., UK.