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The Effects of Building Materials on Building Biology and the Resultant Air Quality

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Abstract

The basic need of a human being is to lead a healthy life. Since people spend 90% of their life indoors, the main function of a building should be providing a healthy environment for its occupants. A building should meet its occupants' biological, psychological, social needs through its quality indicators related to the outdoor-indoor environmental characteristics. Buildings, which are designed, constructed and presented in a health supporting condition, may lose their healthiness over time. The reason for this is that the quality indicators' may change over time (aging of the building and the user) and circumstances (function, environmental characteristics, characteristics of the user). Building Biology can be defined as the study of the relationships between people and their constructed environment. It is a science that leads to natural healthy ecological buildings that exist in harmony with the planetary environment. The main aspects of building biology are interior climate, heat and moisture comfort, air quality, radioactivity, electro-climatic pollution, acoustic violence and natural lighting conditions and its effects. According to the studies, 65% of our buildings are polluted, sometimes as much as five to ten times higher than outdoor city pollution. The harmful gases, volatile organic compounds, particulate matter, lead, asbestos and dust have been receiving considerable interest in indoor air field studies because of their high emission rates from materials used in indoor environments. They can cause diseases such as cancer, asthma, allergic reactions, pulmonary fibrosis and many more.

In this study; the definition of building biology, types and sources of indoor air pollutants and the impact of materials on indoor environment and human health are discussed in detail.

Key words

Building Biology, Building Materials, Human Health, Indoor Air Quality

1. INTRODUCTION

People, by nature, tend to create a shelter by using materials readily available to them. With the help of technology and the expansion of the available resources, societies developing and gaining more information day by day, have been constructing more practical structures but sometimes they are more threatening also to human health. Because of the improved industry, rise of the economic inadequacy and the awareness of the work variety, villagers who have fewer materials and opportunity moving to the bigger cities; have enabled the rapid growth of the urban areas. Population growth and industrial development have caused a decline in the quality of the urban environment. Due to industrial development, natural materials have simulated using artificial materials. Biological structures that are made of artificial materials have begun to adversely affect human health.

Indoor air quality has a significant influence on the main purpose of a building which otherwise is providing a comfortable environment that meets the need of human beings [1]. Human and environmentally friendly buildings, should be able to take part in the ecological cycle of the local topography and should not stand as a foreign object, instead it should reflect its

locale. In this respect, the building has to be constructed with the natural materials that were provided from where building will stand. In order to design a healthy building, the users have to take part in every stage of the construction. In today's world, people still tend to buy psychologically, sociologically and biologically unhealthy materials which adversely affect their health.

Researches proved that indoor air quality is polluted by the harmful materials used in construction. On this matter "Sick Building Syndrome (SBS)", resulting from the building lived in, is mainly caused by poor indoor air quality. It is possible to avoid the pollution by reviewing material sources. The concept of Building Biology arises at this point. With the help of this concept, the principle of human guides himself to nature not the vice-versa has become important. [2].

The aim of this paper is to describe the definition of the Building Biology, the effects of building materials on indoor air quality, human health, and to determine the points to take into consideration when selecting materials.

2. THE DEFINITION OF BUILDING BIOLOGY

Every living creature adapts to its own environment and is affected by it in a good or a bad way. All mammals start life in a womb that is their first environment. This environment has positive effects to sustain life features and at the same time it would damage the child if negative traits were present. Environmental conditions are very important for people to live a healthy life. The relationship of a building with the human and the environmental structures can be considered as a micro-ecosystem. In this micro-ecosystem, the building is in a harmonious relationship with people and nature. Therefore, the building must be designed to be environmentally friendly and protect human health [2].

Since we spend a large part of our lives in buildings, it is not enough to focus only on heat insulation, water insulation, acoustical conditions and so on for comfortable conditions. Building and interior elements must be in harmony with human health and nature. In the light of this, a science called "Building Biology " has developed as a new branch [3].

The first studies in Turkey on building biology were initiated in 1989 by And Akman. According to him, building biology has adopt convenience of technological values to ecosystem and the human nature (bio) in stucture (building) and spiritual values in a cultural way (logi) as the principles [2] (Table 1).

Table 1 The semantic expansion of building biology [2].

Building	Bio (Biyos)	Logi (Logos)
skin, home, nest, motherland, settlement, habit, security, welfare, shelter, shell, protection	vitality, life, natural, guidance, habitat	attitude, creativity, power, incarnation, modularity, the world order, universe, holism, integrity

Here are a few definitions for the sicence of Building Biology;

Ersoy (1994) describes the building biology as;

"It is the science which works on the harmony of the human health and the nature of which interior conditions must have in the building [3]".

Akman (1990) describes the building biology as;

"It is the science from the researches that it effects on occupant's physical, mental and spiritual health of the built environment and the alternative structures in this direction [4]".

Güler (2005) describes the building biology as;

"Arising from poor quality materials and unqualified implementation, It is a science that examines the causes and the effects of buildings, spaces, building materials and equipments on people [5]"

Based on all these information, building biology can be defined as: Building Biology is a science that eliminates the negativity which will affect human life by connecting people with building and its environment, produces and controls the formation and usage of the building which will direct the human health [6].

3. HOW BUILDING MATERIALS EFFECT THE INDOOR AIR QUALITY AND THE HUMAN HEALTH

The air in nature is continually being renewed and refreshed. Fresh air physiologically contains the proper amount of coli basileus, and ions that are in optimal proportions. It does not contain harmful gasses and its scent doesn't annoy [7]. Most of the chemicals in building materials, furniture, paints and polishes and most of the cleaning materials used indoor for cleaning purposes spread harmful gasses year by year. Adequate ventilation of closed space helps to eliminate air pollution

spreading from the materials. It is estimated (thought) that a human being needs 30/ m³/hour of fresh air in order to feel comfortable. The above value (30/ m³/hour per person) would be optimal if using natural building materials, whereas when using plastic materials, the value goes up to, 60/ m³/hour per person [3]. The Union of American Allergists stated that occurrence and spreading of an illness is 50 percent caused by indoor pollution; and 1/6 of patients, complaining from allergies consult doctors for medical treatment. These kinds of problems are mostly caused by unfavorable indoor air quality, they present as allergies, muscle pains, fatigue, respiratory tract infections even toxicity health problems [8; 9].

Problems of indoor air quality are recognized as important risk factors for human health in both low and middle countries. A report prepared by World Heath Organisation (WHO) in 2012 shows the death percentage due to indoor air pollutants in some countries (Figure 1).

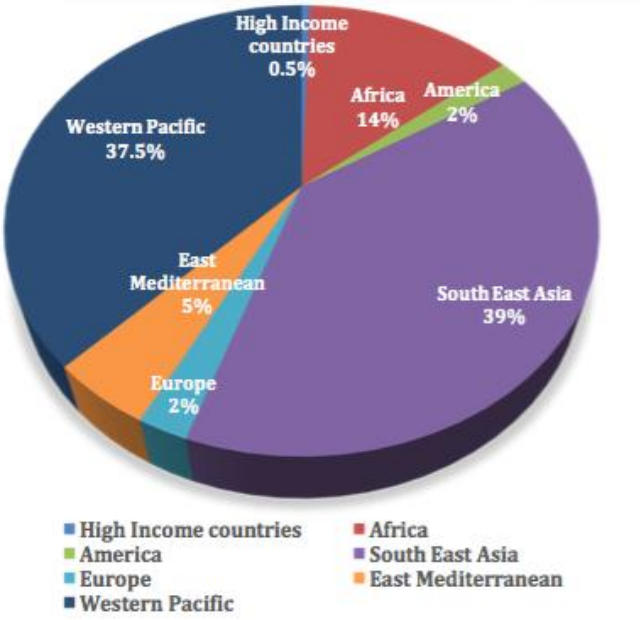

Figure 2 Death percentage due to indoor air pollution [10]

According to the research by Masters in 1998, people are affected by indoor air pollution caused by building materials; through inhalation, digestion, and the skin. The indoor air polluters differ due to physical conditions indoors, the design of the buildings, environmental features that exist in the building and also the behavior of the people living there [11]. Research has shown that, healthy circumstances cannot be maintained in buildings that are newly developed or improved; furthermore, it is reported that 30% of the buildings caused "Sick Building Syndrome" [12]. In addition, it is estimated that about half of all buildings (structures) in the United States have indoor environmental drawbacks. [13].
The main air polluters affecting air quality in buildings are:

1. Harmful gases (Carbon dioxide, Carbon monoxide, Nitrogen oxides, Ozone, Sulphur oxides, Radon)
2. Bioaerosols (Biological Contaminants)
3. Volatile Organic Compounds (Formaldehyde, Benzene, Chloroform, Toluene, Xylene, Pesticides)
4. Particulate Matter
5. Lead
6. Asbestos
7. Dust
8. Odors

Some of the hazardous effects of these substances on health are known; however, many have likely not yet been documented. Indoor air polluters' potential sources and affects on people's health are shown in Table 2.

Table 2: Indoor air pollutant's potential sources and their impact on human health [1; 14; 15; 16; 17; 18; 19; 20; 21]

Pollutant	Potential Source	Impact on Human Health
Carbon dioxide	Gas boilers, oil boilers, chimneys, HVAC system	Respiratory stimulant effects, reducing the ability to perform strenuous tasks in humans, calcification in the kidney and pulmonary alveoli, muscle pain, fainting, spasm, death
Carbon monoxide	Water heaters, ovens, wood heaters, chimneys, HVAC system	Strengthens the drowning effects for the patients, reducing the workforce for healthy men, headaches, eye shrinkage, faults in the cardiovascular system, electrocardiographic abnormalities, strengthening the heart-lung mismatch on patients, nausea, fainting, death
Nitrogen oxides	Non-ventilated gas stoves, kerosene heaters, chimneys	Reductions in lung function in asthmatics, affecting lung functions of children and adults, preclusion of the smell, airway complaints
Ozone	The combustion of sulfur-containing fuels, office sets, photocopy machines, HVAC system, air cleaning appliances	Reduction of the oxygen pressure on the artery, changes in lung function parameters, decrease of the night view
Sulphur oxides	Stoves, the combustion of coal and fuel, HVAC system	Increased respiratory symptoms in patients with chronic bronchitis, increase in the frequency of asthma attacks, negative effect on respiratory systems
Radon	Building materials based on soil and rock, underground waters	Lung cancer
Bioaerosols	Pillows, beds, curtains, carpets, dust, wet or moist materials, draped armchairs, walls and floors of the basement, window frames, washing machine and the back side, kitchen, wallpaper, HVAC systems, upholstery	Infectious diseases, allergic reactions; toxic effects.
Formaldehyde	Particleboard, fibre board, plywood	Allergic reactions, lacrimation, nose and throat irritation, contagion of the smell, asthma attacks, drowsiness, lack of energy, memory loss, sneezing, skin rash, cough, chest tightness, chest pressure, head pressure, heartthrob, pulmonary edema, and infection, death
Benzene	Dissolvents, paints, varnishing, printers pastes including latex, water based adhesives, wood panels, carpets, vinyl floor coverings, fabric cleaners foamed plastics and synthetics	Short-term inhalation results in loss of consciousness, drowsiness, dizziness, headache, skin and respiratory tract irritation; red blood cells as a result of long-term inhalation, aplastic anemia, leukemia and other blood diseases.
Chloroform	Coatings, adhesives	Affects the circulatory, immune, fertility system, blood diseases, cancer, activity on liver, kidney, stomach and intestinal, death
Toluene	Upholstery (vinyl, wood, carpet), office sets, wall and ceiling coverings furniture, treated timber dissolvents and adhesives	lung injury, asthma, eye diseases, insomnia and incoordination
Xylene	Upholstery (vinyl, wood, carpet), office sets, wall and ceiling coverings furniture, treated timber dissolvents and adhesives	Lung plunge, renal impairment, mucous membrane irritation, circulatory disorder, headache, nausea, fatigue and lethargy
Pesticides	Wallpaper adhesives, paints, and plasters	Poisoning and sensitising the brain and the liver
Lead	Paints based on lead	Effect on kidney, nervous system and the blood cells
Asbestos	Pipe and boiler insulation, ceiling and the floor boards, decorative sprays, roof coverings, wall coverings	Mezotelis

According to Table 2; indoor air quality is polluted by materials such as paints, wood panels, carpets and plastics we use in everyday life. Health problems like allergic reactions and cancer occur by using artificial materials. adhesives, polishes and protectors.

4. MATERIAL SELECTION ON BUILDING BIOLOGY

It is important to consider biological aspects when selecting building materials. According to Akman, apart from the materials that differs with climate, 30-40 % organic materials (i.e wood, straw, reed) and 60-70% inorganic materials (i.e brick, tile,natural stone, lime) were used at buildings. Nowadays, especially in modern buildings in larger cities, materials used are 90-100 % artificial, foreign to nature, life and to human metabolism. Indoor air pollution, caused by building materials, is due to material structure, application, usage, and having completed its service life. Therefore, at the time of selection, building materials should be described with all features, positive and negative, so that those choosing can

minimize harm to the environment throughout the life cycle of the material, This creates an environment that would least threaten human health.

The selection of materials considered for Building Biology should include the following:

- Durable materials
- Biologically demountable materials
- Materials that reduce energy consumption in their application,
- Formation of low - energy materials
- Materials with the least environmental impact
- Materials from the manufacturers that were taken by material recycling programmes
- Materials that reduce the urban heat island effect
- Certified wood
- Materials that emit very low levels of radiation
- Materials produced and used in local topography
- Materials that reduces water consumption in their application
- Materials with the least water pollution impact
- Materials produced from renewble sources
- Reprocessed materials
- Minimum processed future materials
- Materials that can be recycled or have the potential to be recycled
- Materials that do not contain harmful chemicals as pigments, thickeners, fire retardant [22; 23; 24; 25].

Unfortunately, these criteria are not known well enough to be applied. Research about ecological buildings has been made by Krusche and friends in 1982 for the classification of building materials. They specified materials which must be used and which mustn't be used.

Materials that must be used are:

- Pressed brick and wood as facade materials
- Wood, brick and adobe as wall structure materials
- Wallpaper, natural and artificial wood panels, wainscot, surface fabric coatings
- Stone, wood and linoleum as flor covering
- Wool and linen carpets
- Wood wool and chaff as insulation materials
- Natural paints such as water based oil paints.

Materials that must not be used are;

- Tuile
- Aluminium, zinc, lead, sheet metal, cement, mineral based materials like asbestos boards
- Synthetic carpets
- Fibreglass, expanded perlite, polystyrene foam, synthetic foam
- Synthetic resin based paints.

5. CONCLUSIONS

It is essential to provide basic principles so that humans can continue their vital activities and maintain optimal health. These basic principles which occur with the help of Building Biology (biological, psychological and by meeting social needs) accelerate the process of creating a positive environment for people. To create livable environments on behalf of future generations, using material that not only looks beautiful but also is environmentally friendly, durable, recyclable, energy-efficient, and economical, thoughtful material selection is necessary. Studies have proved that unnatural environmenral conditions created by unhealthy building materials spread various pollutants threatening human health. These contaminants which disrupt indoor air quality causing "Sick Building Syndrome", must be considered beginning with the design of the structure and in order to maintain the occupants' health.

To create better environments and protect human health;

- Enhance the awareness of Building Biology by means of presentations, media, books, leaflets etc..
- It should be make compulsory by all the governments for the production of environmentally friendly materials.
- People should be encouraged to use natural materials as much as possible.

- Checklists about the specifications of the building materials and their effects should be made by the people (users, architects, producers, inspectors, advisers, etc.) who plays part in the design of the building.
- Every material has to have material data sheets (MSDS) and should be clearly understood and accessible.

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BIOGRAPHY

Nil Kokulu is an architect who graduated from Bahcesehir University with a bachelor degree in 2013. The degree included an internship in Montevarchi in Italy for a year. The internship project was shown in Venice Biennale. She worked with Polimeks Construction, Yalın Tan and Partners and Tabanlioglu Architects where she took part in big projects such as Eskişehir Bademlik Rixos Hotel, Astana Railway Station, Yenitepe Kadıköy Urban Transformation project. Even through, these experiences, her dream was to learn more about the specifications of building materials. While working for Tabanlioglu Architects, she entered İstanbul Technical University and met with her thesis adviser, Seden Acun Özgünler who affects her life positively. She will graduate with a Master's Degree of 'Material Selection on Building Biology' in December 2016.

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