

## PSYCHOLOGICAL EFFECTS OF INDOOR AIR POLLUTION

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**Abstract.** *Office buildings need to provide clean, cozy and comfortable working environment with good indoor air quality in order to create favorable conditions for psychological and physical functioning. Most people are not satisfied with the quality of air in an enclosed office space, which is one of the factors that affect people's work, productivity and stress levels. Indoor air pollution reduces person's ability to respond to the demands of the environment, which often leads to fatigue, malaise, anxiety, headaches, mental confusion, reduced mental and physical performance, as well as irritation of the eyes and throat, coughing and wheezing. The outcome of exposure to air pollution is largely mediated by the intervening perceptive and cognitive processes that shape behavioral and health responses to stressors.*

*Longer exposure to pollutants can lead to behavioral and mood changes, personality changes, impaired memory, slower motor responses and other functional deviations. Poor indoor air quality can cause diseases such as "sick building syndrome" mass psychogenic illness, and environmental diseases caused by the influence of environmental stress.*

**Key words:** *air pollution, air quality, behavior, stress, sick building syndrome*

### 1. INTRODUCTION

Indoor air quality is increasingly attracting attention worldwide [1,2,3]. Good indoor air quality is an important component of a healthy indoor environment. It contributes to a favorable ambience for employee productivity, comfortable feeling, health and well-being [4,5].

Indoor environment of any building is the result of an interaction between the site, climate, construction systems (original design and subsequent modifications in the structure and mechanical systems), construction techniques, sources of pollution (building materials and furnishings, moisture, processes and activities within the building and external sources) and occupants of the building [6]. Whether the source of air pollutants causes the problem with the quality of the indoor air or not depends on the type of air pollutants, the amount and rate at which it is released from its source and the ventilation level available for its removal from the enclosed space [7].

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Indoor air quality depends on the quality of the outside air and the interior characteristics of the emission sources. Many health consequences are associated with internal biological and chemical pollutants and with construction conditions, such as poor ventilation and moisture. This includes diseases and symptoms of upper and lower parts of the respiratory system, headaches, skin problems and fatigue. The air in most indoor environments contains a multitude of particles and gaseous pollutants. These pollutants are known as indoor air pollutants. From the standpoint of health, the most important indoor air pollutants are dust (or particulate matter), carbon monoxide, sulfur dioxide, nitrogen dioxide and volatile organic compounds. Amounts of carbon dioxide, which are common in buildings do not have adverse health effects [8,9,10,11,12].

## 2. PROBLEMS OF INDOOR AIR QUALITY

Good ventilation of the buildings creates comfortable and healthy indoor conditions. For thermal comfort ventilation, indoor spaces must receive a sufficient quantity of outdoor air that is warmed or cooled to satisfy human thermal comfort needs. Comfort ventilation is assessed by measuring occupant perceptions of indoor air quality, including their assessments of odors, thermal conditions, and the adequacy of ventilation.

For health-proper ventilation, indoor spaces must receive air that is free from hazardous chemical or microbiological contaminants. Therefore, indoor spaces must receive a sufficient quantity of outdoor air that has been filtered and cleaned to create acceptable indoor air quality conditions. Health ventilation is measured by comparing levels of indoor air pollutants against occupational health standards, which are usually expressed as threshold limit values or permissible exposure levels for air pollutants.

Poor indoor air quality can cause indoor air pollution which has been defined as an indication of acceptable limits of air pollutants, how air satisfies the thermal comfort, and standard concentration of gases for respiration [13]. Five factors contribute to indoor air pollution:

- Poor and inadequate ventilation system;
- Any horrible occupants' activities such as smoking;
- Bad personal habits such as unmanageable clothes, shoes or hair;
- Any product that is used in construction, such as powder and fibers;
- Any processing method done such as heating, grinding, sawing or crushing [14].

In buildings several types of indoor air quality problems may occur: complaints about indoor air quality; reports of the sick building syndrome; toxic reactions from acute or chronic exposures to contaminated air; and building-related illnesses; toxic reactions from acute or chronic exposure to contaminated air, and building-related illnesses. Toxic reactions from acute or chronic toxic exposures can be verified by measuring concentrations of indoor air contaminants. Episodes of building related illness can be diagnosed because sufferers develop measurable physiological changes and show clinical signs, such as a high temperature. Symptoms of building-related illness are usually similar to those of other acute respiratory diseases and they persist when the person is away from the building, only being alleviated when the illness is treated or has run its course. These diseases often indicate that the indoor air is contaminated with microorganisms. In both types of complaints remedial action involves treating affected workers and removing or controlling contaminant sources [15]. In the buildings in which air is proven to be contaminated, however, all occupants will not

develop problems because various non-environmental factors differently influence the sensitivity of the individual.

### 2.1. Perceptions of indoor air quality

Perception of the indoor air quality depends on the various sensory processes. For example, irritating air pollutants arriving at the mucus membranes are detected by the receptors for the general chemical sense, and the resulting sensations of eye, nose, and throat irritation are indicators of poor indoor air quality. Odors detected by the olfactory nasal mucosa can also signal poor air quality. However, the sensitivity of the evaluation of irritants and odors are typically outputs of relative rather than absolute perceptual process. The perception of odors or irritants depends on the intensity of stimulation of the sensory receptors relative to the background activity in the nervous system, called the signal/noise ratio. Sometimes sensory system will fail to detect pollutants - there are a lot of hazardous air pollutants that we cannot detect, such as for example carbon monoxide. Sometimes our sensory systems can cause us to imagine that we are being or have been exposed to a hazardous pollutant, when this is not the case, and people can show psychogenic illness. Psychogenic illnesses can arise because the sensitivity to irritation and odors is not fixed but varies between people and changes over time and with beliefs about the potential hazard. For example, to a person who likes a particular fragrance, a high concentration of that fragrance may be desirable while for another person who dislikes the same fragrance the same exposure may be highly unpleasant. Also, for the same person, the perceived intensity of an odor which is being emitted at a constant rate also varies with time because of sensory adaptation processes, and consequently odor judgments made immediately upon entering a room are more intense than odor judgments made 30 minutes later.

### 2.2. Sick Building Syndrome

The World Health Organization in 1982 found a number of subjective symptoms that are called Sick Building Syndrome which occur in a high proportion which is around 30% or more, most frequently in buildings with air-conditioned offices but without clearly identified causes. Raw has summarized sick building syndrome into several types (Table 1).

**Table 1** Sick building syndrome symptoms and consequences [16]

No	Organ	Symptoms	Consequences
1	Eyes	Irritated (dry/watery)	Itching, fatigue, redness or difficulty wearing contact lenses.
2	Nose	Irritated (runny or stuffy nose)	Congestion, nosebleeds, itchy or stuffy nose.
3	Troat	Dry or sore	Irritation or symptoms of inflammation of the throat, irritation of the upper respiratory tract or swallowing difficulty.
4	Skin	Dry, itchy skin or irritated skin	Rash or specific clinical terms such as erythema, rosacea, urticaria, pruritus, xerodermia.
5	Other	Headache, irritability, lethargy, poor concentration	

According to Ho et al., a healthy building is one that has an environment with encourages positive well-being in its occupants as they referred to the health definition by the World Health Organization which is a state of complete physical, mental and social well-being and not merely the absence of disease [17].

Rousseau and Wasley have suggested that the positive elements of well-being such as air, thermal comfort, aural comfort and space should be optimized in order to be of benefit to occupants. [18] Wong stated that an office and its environment behavior must match with the worker's satisfaction and requirements as it affects the worker's productivity [19]. On the other hand, Haynes argues that the office environmental quality consist of related components to the office worker's skills and ability to physically connect with their office environment, how well the office workers connected among each other, and the possible effects of individual behaviour on the office environment [20].

Cases of the sick building syndrome typically report vague symptoms which cannot be objectively measured, and sufferers usually show no clinical signs of illness. According to the World Health Organization, symptoms of sick building syndrome include headache, lethargy and irritation of the eyes, nose, and throat, as well as breathing problems and skin irritation. Symptoms of sick building syndrome are linked to building's occupants because they get better after leaving the building. However, indoor air quality surveys of sick buildings often fail to find pollution problems, even though complaints are chronic and symptom prevalence among occupants is high with up to 80% of workers reporting at least one symptom [21].

In newly constructed or recently remodeled spaces, reports of sick building syndrome may be acute and temporary, typically dissipating within 6 months. It is believed that many of these symptoms stem from acute exposure to volatile organic compounds emitted from the new building materials, paints, furniture and finishes, although there are no conclusive evidence. In a permanent "sick" building, a high prevalence of symptoms can last for several years and exposure to emissions of volatile organic compounds from new materials cannot explain the symptoms. Moreover, the concentration of indoor air pollutants is still low. However, poor indoor air quality is considered responsible and the cause of the symptoms because they soften when occupants are away from the building.

Buildings with high prevalence of sick building syndrome cases are labeled as "sick" buildings, although there is no standardized method for gauging symptom prevalence and no agreement on the criteria which can discriminate between "sick" and "healthy" buildings. Regrettably, there is no consensus on the number, pattern, severity, or frequency of symptoms which define an SBS case, on how to measure symptoms, over what time period, or even what symptoms should be measured. There is also no agreement on the criteria for classifying a building as "sick".

### 3. PSYCHOLOGICAL ASPECTS OF THE QUALITY OF INDOOR AIR

Dubos found that poor air quality, when the air may contain toxic elements, can prevent or affect the adaptation of people. In addition, these effects may be direct or specific, which result in a clearly identifiable biological effects and psychological effects in response to the stressors in the environment [22]. Furthermore, according to Selye, the response to the environmental stressor is a common adaption syndrome that produces

psychological effect such as a feeling to get out of the building [23]. Colligan has suggested two types of psychological effects due to the indoor air pollution which involves specific and direct effect of particular pollutants on the behavioural system, for example on occupant's memory performance and complex psychological reactions involving mood state, motivation, and interpersonal relations. The second way is general arousal of the sympathetic nervous system where the occupants will feel tense and anxious whenever they are in any part of the building. This symptom will also make the occupants feel anxiety, panic or fear and in some situations their heart and breathing rates will increase unexpectedly [24].

Because we cannot directly sense many indoor air quality hazards, such as airborne bacteria, or colorless, odorless and toxic gases, we rely on beliefs and imagination to help us anticipate and avoid invisible hazards. These same belief and imagination processes also change how we interpret internal bodily sensations. Belief and imagination processes work in that way as to influence what we create or choose as hypotheses to explain what we believe to be happening in the environment and inside our bodies. Once we believe that the air we are breathing contains a colorless, odorless, yet noxious pollutant which causes eye irritation, we will selectively attend to eye sensations for confirmation of exposure, and unconsciously we may even rub our eyes more frequently than normal thereby increase irritation sensations. Such behaviors are, for example, quite common. If a person thinks about how itchy his/her nose is, they will eventually scratch it. If a person thinks about mites and fleas crawling over their body, they will eventually experience sensations of itchy skin and want to scratch it. At musical concerts audience members are more likely to feel the urge to cough when they hear others cough. At comedy shows audience members are more likely to start laughing when they hear others laugh. These contagion effects are very powerful. Studies of medical students have shown that 70% of freshman students believe they have developed the symptoms of diseases being studied [25]. Similar processes influence all perception, including a worker's perception of indoor climate conditions. Symptoms of sick building syndrome are also percepts affected by the same cognitive processes which influence all other aspects of perception.

Mass psychogenic illness, or mass hysteria, refers to the collective occurrence of a set of physical symptoms and related beliefs among two or more individuals in the absence of any identifiable pathogen [26]. Social psychological processes of contagion, where complaints and symptoms spread from person to person, and convergence, where groups of people develop similar symptoms at about the same time, underlie mass psychogenic illness. Environmental events, like an unpleasant odor, can trigger contagion and convergence processes, and occupants who cannot readily identify what has triggered their symptoms often attribute these to any visible environmental changes, such as installation of a new carpet, or invisible agents. Mass psychogenic illness symptoms include headache, nausea, weakness, dizziness, sleepiness, hyperventilation, fainting, and vomiting, and occasionally skin disorders and burning sensations in the throat and eyes [26,27,28,29].

Reactions of mass psychogenic illness probably arise from the interaction of pre-existing poor physical environment conditions (poor ventilation, poor lighting, excessive noise), stressful work conditions (tedious work, poor organizational climate, poor labor-management relations), disposition differences among individuals (gender differences, differences in anxiety levels), with the occurrence of a triggering event (bad odor), followed by inappropriate management response to the perceived threat. Studies of MPI typically find a similar sequence of events leading to the incident.

People diagnosed as suffering from multiple chemical sensitivity or environmental illness are thought to be extremely susceptible to environmental agents. However, this susceptibility can also be influenced by psychological factors. Research suggests that for many sufferers the symptoms which they report are comparable to those of one or more commonly recognized psychiatric disorders, such as mood disorders, affective disorders, and anxiety disorders [30].

A number of toxins from the environment can influence the development and functioning of the nervous system and cause a mental disorder with a wide range of psychiatric symptoms, such as:

- Changes in mood;
- Changes in personality;
- Impaired memory;
- Slower motor responses;
- Other functional deviations.

These toxins can cause shifts in the distributions of intelligence test scores, developmental delays, and accelerated aging [31].

Both environmental stress and environmental toxins can produce symptoms compatible with anxiety and depression, among them cognitive and behavioral changes. Differential diagnosis must include organic mental disorders, adjustment disorders, and other reactive or preexisting psychiatric conditions. Studies dealing with the relationship between air pollution and psychiatric emergencies, have established that there are positive correlations between psychiatric admissions and ambient levels of carbon monoxide and nitrogen dioxide [32], namely that the emergency psychiatric cases had correlation with particulate matter and carbon monoxide nitrogen dioxide [33].

A number of studies have documented the influence of air pollution on behavior. For instance, bad odors and cigarette smoke can increase aggression. High levels of negative ions have also been found to increase aggression in certain individuals. Polluted air has been shown to decrease helping behavior and altruism and to interfere with social interaction. Chronic air pollution leads to feelings of hopelessness. Bullinger studied the influence of ambient pollutant concentrations on psychological well-being (mood and perceived stress) and neuropsychological functioning (concentration and reaction times). She found that a decrease in well-being comes with increased sulfur dioxide levels and that air pollution can cause neuropsychological impairments [34,35].

It should be noted that the stress from exposure to actual or suspected toxic air pollution can cause symptoms similar to those of organic mental disorders, including fatigue, anxiety, and a decline in mood, concentration, and memory. Specifically, it is necessary to understand how people experience and how they cope with the dangers and traumas from the environment in order to help those who were exposed to stress. The degree of stress depends on the cognitive appraisal of danger and injury of the individual, the assessment of experts and individual sense of loss of control.

Stress can affect the negative outcomes of exposure to polluted air and polluted air can also lead to maladaptive forms of coping responses. For example, the correlation between stress (violence in the community) and ambient air pollution (measured by nitrogen dioxide) leads to an increased risk of getting asthma in children [36] that grow up in an urban environment, suggesting that stress exacerbates the effects of air pollution on respiratory

diseases. In addition, the increased risk of asthma is correlated with low socio-economic status [37]. Bearing in mind that social stress tends to follow socio-economic gradients, poor communities are at greater risk of toxic ambient air pollutants partly due to the greater psychosocial stress.

#### 4. CONCLUSION

The achieved results of any company depend on the performance and quality of the performance of its employees. This means that, if the effect of occupants in the facility increases, the performance of the companies will also be increased, and vice versa. Therefore, to ensure that the quality of the work achieved meets the satisfaction of the employer, it is important to assure that the quality of the working environment is on a satisfactory level for workers. One of the elements that must be taken into consideration in order to ensure a quality environment in the building is the quality of indoor air, including ventilation and thermal comfort of the building.

If the indoor air quality of the building does not meet the needs and requirements of its occupants, there will be a few symptoms of sick building syndrome and affect them, such as headaches, irritated eyes or nose, stuffy nose, etc. Since syndrome affects individuals in the building, they will feel bad and reduce their desire to work because they know that as soon as they come to work and enter the building, there will be a syndrome that makes them sick. Accordingly, if workers feel reluctance when they come into the office, it will affect their productivity and they will not be focused on the fulfillment of their duties and obligations; if they finish their business partially or insufficiently well, it may later result in a negative effect on their psyche, and such condition can cause severe stress. This situation will also affect the performance of the company since a high level of stress for employees affects the reduction in the overall performance of the company. In addition, it was found that the level of sense of comfort of occupants in the facility, their health, sick building syndrome symptoms and satisfaction with the quality of internal ventilation are the main factors that influence the psychological functioning of occupants themselves.

Problems with the air quality of the interior are due to the poor construction of the building, inadequate building maintenance, poor cleaning and poor ventilation. The indoor air quality is affected by different sources of pollution - building and decorative materials, as well as the activities of building occupants (e.g. smoking, cleaning products, paints, adhesives and other consumer products, the accumulation of moisture and carbon dioxide). Outside air that touches an object can also be a source of pollution - due to the poor position of the entrance to the outside air ventilation system or windows instead of fresh air, the products of combustion from motor vehicles, air from the sewer outlets or the kitchen air outlet and sanitary facilities may have an impact as indoor air pollutants. Also, bacteria, fungi, pollen and viruses cause biological contamination of buildings, and the source of pollution may be the standing water accumulated in the ducts, evaporators and drains.

The quality of indoor air can affect the individual psychologically in two ways. The first involves direct and specific neurobehavioral effects of individual pollutants, which represents the traditional domain of Behavioral toxicology, where the focus is on the impact of chemical elements on such system responses as information processing, sensory-motor

performance and learning. Another way in which pollution can affect psychological functioning is more diffuse, and includes the overall impact of the environment on the autonomic system. In this sense, the air quality is one of many possible sources of stress that provoke the body, producing a state of general discomfort.

Poor quality and indoor air pollution, in addition to somatic disorders, lead to discomfort, mental changes and psychiatric symptoms. Direct effects of air pollution inside the buildings, backed by stress can cause conditions that correspond to anxiety, depression, and lead to cognitive and behavioral changes. Maintaining indoor air quality of the building is essential for mental and physical health of its occupants having in mind that the poor air quality of the interior space can lead to discomfort, irritation and other short-term and long-term health problems, aggravate existing health problems, including asthma and allergies, lead to the spread of infectious diseases transmitted by air and reduction in productivity.

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## PSIHOLOŠKI EFEKTI UNUTRAŠNJEG ZAGAĐENJA VAZDUHA

*Poslovne zgrade moraju da obezbede čisto, udobno i komforno radno okruženje uz dobar kvalitet unutrašnjeg vazduha kako bi se stvorili uslovi za povoljno psihofizičko funkcionisanje. Većina ljudi nije zadovoljna kvalitetom vazduha u zatvorenom kancelarijskom prostoru, što je jedan od faktora koji utiču na rad ljudi, produktivnost i nivo stresa. Zagađenje unutrašnjeg vazduha umanjuje sposobnost osobe da odgovori na zahteve životne sredine što često dovodi do umora, malaksalosti, anksioznosti, glavobolje, mentalne konfuzije, smanjenju psihofizičkih performansi kao i iritaciju očiju i grla, kašlja i teško disanje. Ishodi izlaganja zagađenom vazduhu u velikoj meri posredovani su intervensivnim perceptivnim i kognitivnim procesima koji oblikuju bihevioralne i zdravstvene odgovori na stresore.*

*Duže izlaganje zagađujućim materijama može dovesti do promena u ponašanju i raspoloženju, promenama ličnosti, pogoršanja memorije, sporijih motornih odgovora i drugih funkcionalnih devijacija. Loš kvalitet unutrašnjeg vazduha može izazvati bolesti, kao što su "sindrom bolesne zgrade", masovne psihogene bolesti i ekološke bolesti prouzrokovane uticajem ekološkog stresa.*

**Ključne reči:** *zagađenje vazduha, kvalitet vazduha, ponašanje, stres, sindrom bolesne zgrade*