

## Sick Building Syndromes and Their Effects on Homes within Riyadh City

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**Abstract.** Sick-building syndrome is one of the growing health problems. It includes headache, irritation of the eyes, nose, and throat, inability to concentrate, objectionable odors, nausea, dizziness, chest tightness,.... etc. Most sick-building problems are caused by poor indoor air quality, excessive background noise, chemical emissions from artificial building and furnishing materials, chemical and biological contaminants, and inappropriate lighting systems.

To reduce the health problems associated with sick-building syndrome, designers and occupants should understand the sick-building syndrome, their cause, and how to deal with it.

This paper offers information about SBS, and its reflection on the houses of Riyadh city. A general picture about the common sources of SBS and their effects, are discussed with some details by using a survey questionnaire. Especially, Riyadh city has a dusty weather, where dust contributes strongly in sick building syndromes.

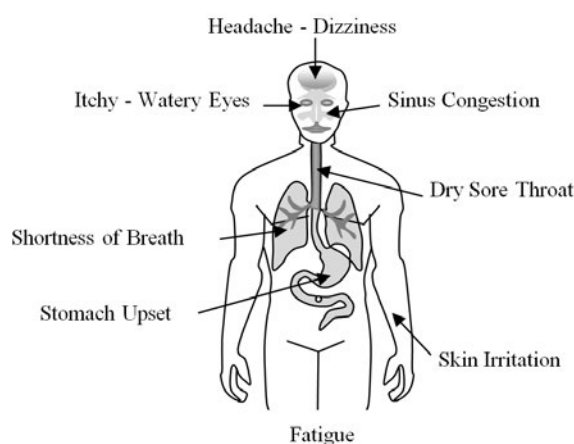
### 1. Introduction

The term “sick building syndrome” (SBS) is a particular set of acute health and comfort effects that exist in a particular place at a particular time. Building occupants may experience different types of symptoms ranging from specific symptoms such as itchy eyes, irritation of mucous membranes, dizziness, skin rashes, lethargy and nasal allergy symptoms, to more vague symptoms such as fatigue, aches and pains, and sensitivity to odors (Fig. 1).

Recently, a number of people suffering from different irritating symptoms have increased with unspecified stimuli. These symptoms appear to people only in a specific building and they disappear once they are out of that building. Thus, became known as the “Sick Building Syndrome” (Iyagba, 2005).

Human reaction to the indoor environment can be divided into six main categories. First, indoor air quality, for example, unventilated building is found to be the most important cause of sick building syndrome. Second, the dust, which is accumulated on textured surfaces, including carpets, curtains, and other textiles. Third, the chemical contaminants, such as volatile organic

compounds (VOCs), which might emit from carpeting, upholstery, manufactured wood products, pesticides, and cleaning agents. A fourth category is the biological contamination, for example viruses, bacteria, molds, and pollen. Finally, people may suffer from indoor or outdoor noise and from inappropriate lighting systems.



**Fig. 1. Symptoms of sick building.**

## 2. Objectives

This paper attempts to study briefly the sick building syndromes (SBS) and its impact on the houses in the environment of Riyadh city. The paper aims to identify the reasons and causes of SBS in the local homes. These causes are classified into six main categories; indoor air quality-ventilation, dust, chemical contamination, biological contamination, noise pollution and lighting systems.

Through a survey questionnaire, this study will discuss these sources and their relation to the residential buildings in Riyadh city.

## 3. The Significant of the Study

The importance of the study stems from the fact that many residents, while they are in the building, experience some irritating symptoms with unspecified stimuli. Understanding these symptoms and their causes will help the designers and the residents to eliminate these sources and to protect their homes from harmful contamination.

## 4. Indicators of SBS

The U.S. Environmental Protection Agency (EPA) identifies three indicators of sick buildings:

- Building occupants complain of symptoms associated with acute discomfort, e.g., headache, eye, nose, or throat irritation; dry cough, dry or itchy skin, dizziness and nausea, difficulty in concentrating, fatigue and sensitivity to odors.
- The cause of the symptoms are not known.
- Most of the sick residents report relief soon after leaving the building.

## 5. Causes of SBS

### 5.1. Inadequate ventilation

The ventilation system is specifically found to be the most important cause of sick building syndrome. Usually the quality of the ventilation of building is affected by building design, maintenance and air conditioning system. Sometimes an inadequate ventilation system can lead to a building up of substances that pollute the indoor environment.

Basically, inadequate design and maintenance of air conditioning or ventilation system might increase the negative health effects of both biological and chemicals factors.

Based on ASHRAE Standard 62.2-2003, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings", the air change rate requirement can be calculated by adding 3 cfm/100 sq. ft. (15 L/s/100 sq. m.) to the 7.5 cfm/person (3.5 L/s/person).

### 5.2. Dust

Dust can be found in textured surfaces such as carpeting, curtains, and other textiles. Furthermore, dust can accumulate on open shelving, beneath furniture, refrigerator, oven and other appliances.

Massive amounts of dust are generated from wearing clothes and from airborne dust which might be circulated by sweeping and vacuuming. Particles of the dust are taken into the air conditioning and then blown back, or accumulate in the air conditioning system create major environmental contaminants to breed.

Some organic materials may present in dust, like cotton, wool, animal hair, plant fibers, human skin, fungi and insects (Taib, 2003).

Also, chemical materials may exist in dust. For instance, flame retardants that are commonly used in electrical equipment and on furniture, accumulate dust therefore, a building must be maintained free from dust by regular cleaning (Taib, 2002).

### 5.3. Source of chemical contaminants

#### 5.3.1. Furniture

Adhesives, carpeting, upholstery, manufactured wood products, pesticides, and cleaning agents may emit volatile organic compounds (VOCs), including formaldehyde.

Usually, high levels of formaldehyde emit from a particle board. A particle board, or a chipboard, is a product manufactured from wood particles, such as wood chips, sawmill shavings, or even saw dust, and an artificial resin or other suitable binders. A particle board is considered a main source of VOCs due to the high contents of artificial adhesives.

Formaldehyde and other VOCs emit from particle boards for years, with the highest concentrations being emitted in the first six months.

There is a large number of chemicals used in carpet manufacture, including artificial adhesives, glues, backing materials, flame retardants, and dyes. Thus, this makes carpet another major source of VOCs. The new carpet emits acetone, toluene, xylene, formaldehyde, and benzene derivatives. These VOCs cause irritation, affect breathing, and produce various neurological symptoms. Many of them are carcinogenic substances.

### 5.3.2. Painting

Fresh paint and varnishes can emit the VOCs due to the high content of solvents and binders.

The U.S. Environmental Protection Agency (EPA) has estimated that the VOCs emission from architectural coatings is about 9% from all consumer and commercial products.

### 5.3.3. Personal activities

Cooking, body odor, cosmetic odors and tobacco smoke (which contributes in high levels of VOCs), toxic compounds, and respirable particulate matter.

### 5.3.4. Cleaning materials and procedures

Some chemical contaminants might emit from cleaning materials, pesticides, deodorizers and fragrances.

Cleaning products contain a range of toxic VOCs including:

- Diethyl phthalate is found in several cleaning products. It is a known endocrine disrupter, which interferes with hormone activity.
- Toluene is found in stain removers. It is a known carcinogen (cancer causing agent) which can cause neurological problems.
- Hexane/Xylene are found in aerosol sprays. Both of them can also damage the nervous system.

Some high concentrations of VOCs or medium levels of multiple VOCs can cause chronic and acute health effects.

### 5.3.5. Combustion pollutants

Poorly maintained gas fired appliances, such as stoves, burn fuel inefficiently which will produce various chemical pollutants that can affect the health of a building's occupants. The main pollutants of combustion pollutants are as follows<sup>(1)</sup> (Taib, 2003).

#### 5.3.5.1. Carbon monoxide (CO)

Carbon monoxide, also called carbonic oxide, is a gaseous asphyxiant. CO is known as the "silent killer" as it is a colorless, odorless gas which is to some extent lighter than air. It is highly toxic to humans and animals in a higher dose. It combines with hemoglobin to produce carboxy hemoglobin, which prevents red blood cells from carrying oxygen

and cause suffocation to the victim, makes ineffective oxygen delivery to tissues of the bodily.

#### 5.3.5.2. Sulphur dioxide (SO<sub>2</sub>)

Sulphur dioxide is a colorless gas with a strong odor. Sulphur dioxide is an irritant to the respiratory system. Exposure to high concentrations of SO<sub>2</sub> for a short time can narrow the blood vessels in the lungs and increase mucous flow, making breathing difficult.

#### 5.3.5.3. Nitrogen dioxide (NO<sub>2</sub>)

Nitrogen dioxide is another toxic gas produced from the combustion of fuels. Exposure to high concentrations of NO<sub>2</sub> is fatal, whilst lower levels, like SO<sub>2</sub>, act as irritants to lung tissues. Moreover, exposure to low level concentrations for a long time may destroy lung tissues and lead to emphysema. Also, it makes people more liable to respiratory infections such as pneumonia and influenza.

### 5.4. Biological contaminants

Viruses, bacteria, molds, and pollen are types of biological contaminants which may exist in sick homes. The stagnant water, which accumulated in duct and humidifiers, or where water has collected on carpeting or insulation, creates a good environment for contaminants to breed. Also, dry traps in the bathrooms and kitchens allow the passage of sewer gas to come in.

In addition, some insects or bird dung can participate in biological contaminants.

These biological contaminations cause several symptoms, such as cough, fever, chest tightness, chills, muscle aches, and allergic responses such as mucous membrane irritation and upper respiratory congestion<sup>(2)</sup>.

The biological contaminants can cause these symptoms through three different ways:

1. Infection, for example, bacterium "Legionella" causes both Legionnaire's Disease and Pontiac Fever.
2. Allergy/Hypersensitivity.
3. Toxicosis - symptoms caused by toxins produced by micro-organisms, e.g. mycotoxins produced by mold/fungi.

The following are the main sources of biological contaminants.

<sup>(1)</sup> [http://www.ei-resource.org/illness-information/related-conditions/sick-building-syndrome-\(sbs\)](http://www.ei-resource.org/illness-information/related-conditions/sick-building-syndrome-(sbs))

<sup>(2)</sup> <http://www.epa.gov/iaq/pubs/sbs.html>, U.S. Environmental Protection Agency.

#### **5.4.1. Toxic black mold**

Toxic black mold is found to be the primary cause of sick building syndrome. Mold grows rapidly in warm and damp environments. They have the ability to grow on dead organic matter everywhere in nature, and they can breed under very low temperatures. In fact, there are many different mold types which vary extremely in their acceptance to temperature and humidity. Certain molds can grow in harsh environments such as refrigeration, highly acidic solvents, and even petroleum products such as jet fuel. When conditions are not suitable for growth, molds may remain alive in a dormant state before they die. Molds have a musty odor.

#### **5.4.2. Viruses and bacteria**

Viruses and bacteria are common in every building. These micro-organisms can make a significant contribution to causing SBS. Viruses consist of genetic materials (DNA or RNA) covered by a protective coat of protein. Viruses can't breed on their own, but they have to attack a "host" cell and take over its machinery in order to be able to breed. Most exposed cells for virus invading are those of the mucous membranes without a protective skin, such as those lining the respiratory passages. On the other hand, bacteria are organisms that consist of one cell. They are capable of self breeding. They have different shapes, some of them are harmless, but some bacteria can cause diseases.

Viral and bacterial infections are spread in a sick building through three ways:

1. Spread through the air.
2. Bacteria or viruses are transferred by touching contaminated objects.
3. Body fluids such as blood, saliva and semen can contain the infecting organisms and transmission of such fluids, e.g. injection or sexual contact, are major causes of viral infections like hepatitis or AIDS.

#### **5.4.3. Dust mites**

The house dust mite (sometimes referred to by allergists as HDM) feed on organic detritus such as small parts of a skin layer detached from human skin that accumulate in carpets, soft furniture, and other areas. Dust mites like warm and relatively humid environments. It is found that the house dust mites are a common cause of asthma and allergic symptoms worldwide. Some of the gut enzymes produced by the house might exist in their fecal and can be strongly allergenic.

#### **5.4.4. Pollen**

Pollen is an allergy substance that causes a severe allergy for a great number of people. Pollens can be spread by air through open doors or windows or by the occupants shoes and clothing. It can be accumulated in the furniture and circulated by the air conditioning system, thus usually occurs when there is no proper cleaning, and when ventilation and filtering systems are not maintained.

#### **5.4.5. Insect body parts**

Some insects cause potent allergens for some people. For example, cockroach allergens are particularly troublesome for some people. Insect's allergens are commonly linked to sick building syndrome, especially when sanitation is poor.

#### **5.4.6. Reasons for a building becoming biologically contaminated**

##### **5.4.6.1. Moisture**

Dampness in the building structure and/or a high level of humidity in the air creates a good source for biological contamination. The following are common sources of moisture accumulation:

- Leaks in plumbing system, or from air conditioners systems.
- Condensation on HVAC components.
- Condensations on cool surfaces where insulation does not exist or it is damaged. For example, uninsulated air conditioning pipes.
- Dehumidifiers and humidifiers.
- Moisture from unvented or inadequately vented bathrooms and kitchens.
- Defective air system and refrigerator such as blocked condensation drain lines and full drip pans.

##### **5.4.6.2. Hygiene and cleaning**

Poor sanitary and cleaning practices contaminate a building with biological contaminants. For instance, contamination from dirty bathrooms can easily be spread to the rest of the building. Also, inadequate or poorly maintained vacuum cleaners might participate in spreading dust, dust mites, pollens, and other allergens around, rather than picking them up. Therefore, an efficient vacuum cleaner is an essential equipment for avoiding a building to be sick. Vacuum cleaners with "high-efficiency particulate air" (HEPA) filters are recommended due to their ability to remove tiny particles.

### 5.5. Noise

The impact of noise reaction may range from a minor disturbance to a loss of hearing. It includes apathy, frustration, depression, anger, exhaustion, agitation, and helplessness. Also, it might cause hearing impairment, hypertension, ischemic heart disease, annoyance, bowel movements, and sleep disturbance.

Noise can be a single, unexpected sound or a continuous one. It can be too soft or too harsh (Soames, 1999).

In fact, the effects of noise are determined by the level of the noise, its duration and its frequency. High-frequency noises tend to be more annoying and more harmful to the hearing system than low-frequency noise. However, low frequency noise contributes in sick building syndrome. Many people may be exposed to low-frequency noise in their dwellings. Sleep disturbances are commonly reported which might come from being exposed to low frequency noise.

Usually, the low frequency noise (20-200 Hz) is emitted by numerous sources in the society. Most of it comes from transportation, such as lorries, diesel-driven busses, airplanes and helicopters. It is also emitted by heating, cooling and ventilation systems (Waye, 2004).

The discontinuous noise appears to be less damaging to hearing than continuous sounds because of the ear's ability to recover during the intervening quiet periods. Nevertheless, discontinuous and impulsive noise tend to be more annoying because of their irregularity (Suter, 1991).

### 5.6. Light

Glare, flicker, lack of contrast, inadequate illumination or unsuitable lighting might cause tiredness, dry eyes and headaches. People commonly feel unwell after spending time in buildings that are illuminated by fluorescent lights due to their flicker.

The flickering light is very harsh and tends to give healthy people headaches and other symptoms. Also, it is found that conventional white fluorescent lighting is likely to cause eyestrain and headaches. People can see flicker lights, flashing on and off up to about 50 flashes per second (50 Hz). However, flickers above 50 Hz cannot be noticed, but this does not mean that it cannot affect people<sup>(3)</sup>.

In addition, inadequate illumination, uniform or dull lighting, discomfort glare and tinted windows

that reduce the amount of daylight create potential problems.

### 6. Causes of Sick Building Syndrome and Its Impact on the Domestic Houses in Riyadh City

During the last 10 years, the city of Riyadh has faced a remarkable increase in air pollution in many parts of it due to the following reasons:

- Increasing demand for basic materials for construction (the activities of quarries and transport of soil and cement industry, etc.).
- Increasing traffic within the city to cope with the growing need to move between parts of the city.
- Increased industrial activities.
- Establishing new power plants to meet the growing demand for electricity.

Some air pollutants had been examined such as particles suspended solids, lead, carbon monoxide and oxides of nitrogen in some areas of the city, and it was noted that there are some gases that exceed the allowable concentrations limit in the world.

According to the High Commission for the Development of Arriyadh, it is found that the emissions of carbon monoxide poison from transportation is about 98% of the total of emissions of these gases, while the emissions of oxides of nitrogen, which participates in the formation of toxic ozone gas and smog, is mostly 70% approximately comes from power plants.

In another study, the elemental composition of indoor and outdoor dust in Riyadh had been studied using the x-ray fluorescence (XRF) technique. The results show a similarity between the composition of the indoor and outdoor dust which most of them have mineral origin (Tables 1 and 2). It was noted that the concentration of iron, Fe, increases in all indoor samples in detriment of a decrease in the concentration of calcium, Ca, compared to outdoor samples. Regarding the heavy elements, only small traces of lead were detected. The Fe enrichment was existed due to the presence of furniture such as carpet, cupboard, tables and the building material. The traces of lead, Pb, which was observed inside and outside, were suspected from the combustion of gasoline in the car's engine (Al-Eshaikh, 2005).

<sup>(3)</sup> [http://www.ehso.com/fluorescent\\_safety.php](http://www.ehso.com/fluorescent_safety.php), Environment, Health and Safety Online.

**Table 1. Elemental composition of indoor dust in Riyadh city**  
Concentration %

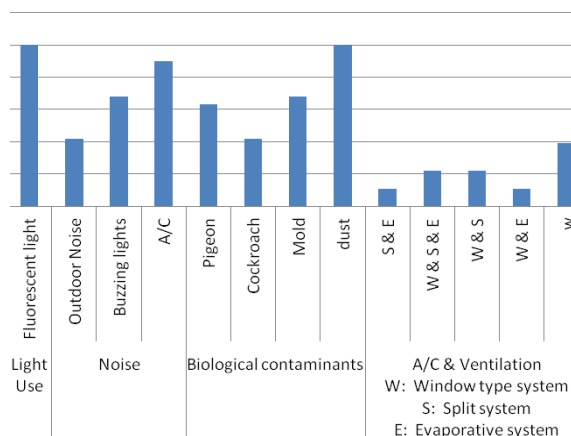
Elements	North	East	South	West	Center
Calcium	46.65	47.18	42.58	41.06	48.22
Titanium	1.18	1.48	2.18	1.62	1.41
Iron	41.09	35.58	37.97	45.53	36.03
Zinc	6.39	8.09	8.86	5.64	5.98
Strontium	3.03	3.14	4.09	4.04	3.21
Lead	3.67	4.53	4.31	2.11	5.14

**Table 2. Elemental composition of outdoor dust in Riyadh city**  
Concentration %

Elements	North	East	South	West	Center	Desert
Calcium	57.21	58.32	61.37	60.68	54.07	66.41
Titanium	1.21	1.17	0.92	0.87	0.97	1.47
Iron	32.61	29.45	30.22	32.25	31.85	25.61
Zinc	3.13	4.41	2.48	1.15	4.46	0.74
Strontium	3.58	4.34	3.08	3.51	5.19	5.77
Lead	2.27	2.31	1.93	1.55	3.47	0

In fact, dust is considered a severe problem in Riyadh city due to its dusty weather. Dust can be accumulated almost everywhere. It can be found in textured surfaces such as carpeting, curtains, and other textiles, on open shelving, beneath furniture, refrigerator, oven and other appliances. Thus, it is imperative to clean the entire home constantly.

The main pollutant sources related to Riyadh's home were conducted by using a questionnaire survey. The total sample size was 19 houses chosen randomly, and the survey covered the following areas (Fig. 2).

**Fig. 2. The main pollutant sources within Riyadh's home.**

### 6.1. Inadequate ventilation

Usually in Riyadh's houses, ventilation is a part of air conditioning system, which is supposed to supply fresh air and remove some portions of the indoor air from inside a building.

There are three common systems used: a window type system, split system air conditioners and evaporative cooler. The window type unit is equipped with a mechanism that enables the unit to supply the building with fresh air. Unfortunately, due to the Riyadh's dusty weather, users disable this mechanism to prevent the dust from entering the building, thus leading to an increase of the pollutants in the indoor air.

The second system is a split system air conditioner. It consists of two units, outdoor and indoor units. The outdoor unit includes a compressor, a fan and a condenser coil. The indoor unit includes an evaporator coil, a fan and a refrigerant. These two units connect with each other through two copper tubes. There is no contact between the indoor unit and the outdoor fresh air. So, this kind of systems does not supply the building with a fresh air.

The third system, the evaporative cooler, consists of a metal box with three vented sides. Each side has a removable wetted pad door. Usually, evaporative cooler pads are made of excelsior (wood wool) inside a bag of net. The cooled air is delivered by a centrifugal fan which is connected to a electric motor through pulleys and belt. Water is circulated by a small water pump to wet the evaporative cooling pads.

The evaporative coolers have several advantages; they save cooling energy comparing to the previous systems. They are friendly environment, and provide the building with a fresh humid air.

However, evaporative cooling consumes a huge amount of water to wet the pads. The evaporative mechanism will leave salt deposits on the pads and on the interior surfaces of the cooler.

In fact, the majority of the commercial wetted pads are wood-based, where the salt deposition and mold forming usually clog their surfaces, declining the flow rate of air and decrease the performance of the evaporative cooler (Al-Sulaiman, 2002).

The survey indicated that 39% of the house samples are using window type air conditioning systems, 11% are using window type system and evaporative cooler, 22% are using window type and split air conditioning systems, 22% are using evaporative cooler, window type and split air conditioning systems, and 11% are using evaporative cooler and split air conditioning system (Fig. 1).

### 6.2. Chemical contaminants sources

It has been mentioned, in the earlier section, that chemical contaminants come from different sources; furniture, painting, house activities, cleaning materials and combustion pollutants. These can be found in each home, but with different levels based

on the several factors; number of users, type of appliances and the age of the house and its furniture.

Based on the survey, all houses are using chemical products for cleaning and house activates, such as clothes bleaching products, insecticides and furniture polishing sprays.

### 6.3. Biological contaminants

These biological contaminants are discussed in previous sections with some details. Since Riyadh city has a dusty weather, and there is a strong relation between dust and biological contamination, it is found that the accumulated dust creates a good environment for biological contaminants to grow. Based on the survey, the dust can be accumulated within the houses in these locations:

- Over or beneath the furniture, such as the roof of cupboards or appliances.
- In an unreachable location such as some decoration pocket (for example, a space which is usually created between decoration gypsum ceiling and a concrete ceiling) (Fig. 3).



Fig. 3. Decoration pocket<sup>(4)</sup>.

- In the textiles such as carpet, bed pillows and mattresses; dust in these textiles create great places for dust mite to live. Dust mites love these areas where they find warmth and humidity and are filled with dust.
- Inside air conditioning systems; most of the filters are made of a sheet of mesh, which cannot, totally, prevent dust particles from entering the A/C unit. Inside the A/C unit, a condensed humidity, which comes from the

evaporative section, participates with the dust to create a good biological atmosphere.

- Inside the evaporative cooler, where outdoor dust is mixed with water and precipitates in the base of the cooler. This creates a good atmosphere for biological contaminants (e.g. mold) to breed.

According to the survey, all houses (100%) are suffering from the dust.

The other noticeable contaminant is mold. Mold can grow in exposed and unexposed areas. It can breed in bathrooms, air ducts, basement spaces or wall cavities. It has been noticed that in many homes there is black mold growing behind the clear silicone caulk surrounding the bath tub or behind the sink. Also, mold can be found in an evaporative cooler or in some air conditioning systems.

Exposure to certain types of fungi, known as toxic mold, can cause a serious (allergic) reaction. They produce chemical substances called mycotoxins, which can be transferred to the human body through nose, mouth, and skin, lodging perhaps in your digestive tract, your lungs, or your brain<sup>(5)</sup>. The survey indicated that 68% of the samples are suffering from the mold problem.

Another common problem in some houses is cockroach (American cockroach). American cockroaches live in warm, dark, wet places. Therefore, the preferable space for them is the sewage manholes. The common manhole, usually in Riyadh houses, is built from concrete brick as a small room (60 x 60 x 60 cm) connecting several pipes. By the time, the manhole's walls are subjected to cracking and create good places for cockroaches to breed.

Cockroaches crawl through these dirty areas and then walk through home spaces spreading a lot of bacteria and germs. They are known to carry human pathogens, such as Salmonella and *E. coli*, which can cause human diseases, such as food poisoning or diarrhea. In addition to this, their body parts, skins and waste byproducts can greatly increase allergen concentrations indoors. They can trigger allergic reactions, asthma and other illnesses<sup>(6)</sup>. The survey came up with 42% of the samples are suffering from the cockroaches problem.

One more external problem is pigeon, which is widely believed that pigeons participate in sick building syndrome by transferring the diseases through air conditioners and water systems. The

<sup>(4)</sup> <http://www.right-uae.com/cwork.html>

<sup>(5)</sup> [http://www.moldinspector.com/mold\\_&\\_health.htm](http://www.moldinspector.com/mold_&_health.htm)

<sup>(6)</sup> <http://www.extension.umn.edu/distribution/housingandclothing/dk1003.html>



estimated life span of a pigeon is around 10-20 years and keeps propagating until it becomes 10 years old. A single pair can lay eggs up to eight times a year, two eggs at a time, 16 birds per year. In addition, the pigeon is the only bird in the world that builds its nests using its own droppings. These droppings, when dry, can carry over 40 known diseases including Cryptococcosis, Salmonellosis, Histoplasmosis and Ornithosis, the latter two causing blindness and even death. In addition, accumulating and decomposing pigeon droppings create offensive odors and will attract flies and other disease carrying insects<sup>(7)</sup>.

In Riyadh houses, pigeons, usually, prefer to sit and build nests on deep sills windows, sills of exhaust openings and over facade's decorations frames. Thus, these can be seen clearly in some homes, especially in the fixed or inaccessible windows such as the one used on stairwell (Fig. 4). The survey shows that 63% of the samples are suffering from the pigeon's nests and their drops.

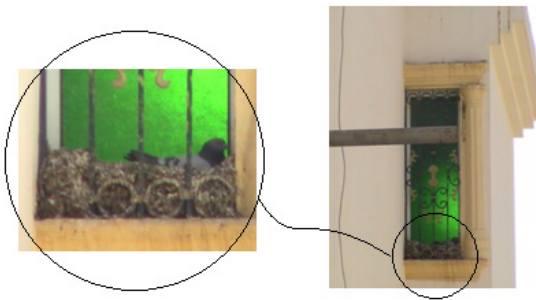


Fig. 4. Pigeon's nest built by using its own droppings (stairwell window).

#### 6.4. Noise

The most common noise sources in houses are: air-conditioning systems (constitutes 90% of the sample), noises from buzzing lights (constitutes 68% of the sample), and noise from outside the building (constitutes 42% of the sample).

The noise of the air conditioning system is observed to be in the first level. The window type air-conditioning system is considered as the loader system among the three conditioning systems; window types, split, and evaporative systems. The split cooler might be the less noisy one.

Noise from a fluorescent light is likely due to unfastened or damaged ballast. The ballast is an electrical device that supplies the proper starting and

operating power to the lamp. Changing a damaged lamp might loosen the ballast mounting or other parts of the fixture and the minor vibration from the ballast causes a buzzing or hum. The noise level may change – up or down – as the fixture warms up. Noise can also be an indication that the ballast is about to fail. Ballasts normally last 10-20 years, but often become noisy just before they fail. If the ballast needs replacing, it is better to be substituted with electronic ballasts, where electronic ballasts are quieter than electromagnetic ballasts<sup>(8)</sup>.

Harmful indoor noise might also come from some devices such as hairdryers, blenders, food choppers, food processors, and other convenience appliances. Besides that, children's toys have been observed to be hazardous too, e.g., toys with horns and sirens, toy vehicles, musical instruments and talking dolls<sup>(9)</sup>.

The outdoor noise is based on buildings location. Buildings that are located near major intersections or roads, shopping centers and sporting facilities are suffering from high traffic noise. Based on the results of a comprehensive monitoring of traffic noise, it is concluded that the arterial roadways in Riyadh were noisy and that the level of noise pollution at major roadways in Riyadh exceeded the permissible international standards (Koushki, 1993).

#### 6.5. Light

Based on the survey, most people in Saudi Arabia (constitutes 100% of the sample) depend on fluorescent light tubes and compact fluorescent light bulb to light their homes.

Usually, fluorescent light bulbs contain mercury substances. Mercury emits UV radiation when it is electrically excited, and then interacts with the chemicals inside the bulb to generate light. Thus, UV might cause some skin damage, especially in people with certain skin diseases. This has been confirmed by the British Dermatological Association where it has been found that their patients have adverse reactions to fluorescent light bulbs.

However, unlike compact fluorescent light bulbs, tube fluorescent bulbs can be provided with prismatic diffusers to filter UV radiation and to reduce its effects.

Moreover, research has shown that fluorescent lights are associated with Irlen Syndrome (also known as Scotopic Sensitivity Syndrome). An Irlen

(7)

[http://www.birdcontrolservices.co.za/index.php?option=com\\_content&view=article&id=107&Itemid=53](http://www.birdcontrolservices.co.za/index.php?option=com_content&view=article&id=107&Itemid=53)

(8)

[http://www.gelighting.com/na/business\\_lighting/faqs/fluorescent.htm#6](http://www.gelighting.com/na/business_lighting/faqs/fluorescent.htm#6)

(9) <http://www.asha.org>, the American Speech-Language-Hearing Association (ASHA)



Syndrome refers to visual perceptual disorder(s) affecting primarily reading- and writing-based activities.

Conversely, incandescent lamps have proven to be the most favorable source of artificial light for people with Irlen Syndrome (Havas, 2008). But, incandescent lamps are not appreciated by the general public due to their high electric consumption and the color of their emitting light.

## 7. Conclusion

Riyadh city suffers from a dusty weather which is reflected from the indoor atmosphere quality. With inadequate ventilation, dust and humidity create good environment places for biological contaminants. Biological contaminants can be found in carpets, textiles, kitchens, bathrooms, over or beneath the furniture, and inside the air conditioning systems.

Like any other house, Riyadh's houses suffer from chemical contaminants coming from furniture, painting, house activities, cleaning materials and combustion pollutants.

On the other hand, the most irritating noise sources in houses are: buzzing lights, noises from air conditioning systems, equipments, and noise from outside the building.

The final contaminant type is anticipated on lighting system. Fluorescent lighting bulb, which is the popular light bulb in Saudi Arabia, has been found that it has a relationship with sick building syndrome.

These types of contaminant sources vary from house to house, based on the level of maintenance, hygiene's degree, number of users, type of appliances and the age of the house and its furniture.

Finally, to keep our home healthy, it is recommended to consider these following points:

- It is recommended to install an exhaust fan vented to outdoors over gas stoves to eliminate and reduce the carbon monoxide (CO), and introduce fresh air into the house several times a day. In addition, using a Hepa filtration system will clean the indoor environment from any air pollutants.

- For harmful volatile organic compounds, it is better to expose the new carpet, drapes and furniture to the outdoor air before installing them inside, to let them release any VOCs outdoor.
- To reduce dust mites, bedding materials must be washed frequently in hot water, and it is recommended to use natural latex mattresses which are naturally resistant to dust mites.
- To prevent insects from breeding, it is recommended to repair any cracks that might occur in basement, floor, walls or manholes.
- To eliminate mold, it is recommended to repair any water-leaking and install a proper ventilation system, especially in the kitchen and bathrooms.
- To minimize the noise of the air conditioning system, effective soundproofing materials, vibration absorbing mats or dampers must be used based on the chosen type of the air conditioning system.
- Attempt to rely on natural lighting as much as possible.

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## متلازمة المباني المريضة وتأثيرها على منازل مدينة الرياض

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**ملخص البحث.** تعتبر متلازمة المباني المريضة من أحد أهم المشاكل الصحية المتنامية. ويظهر تأثيرها على شكل أعراض مرضية تصيب مستخدمي المباني وساكنيها بصور مختلفة. وتهيمن أعراض الصداع وتهيج العينين والأنف والحلق، وعدم القدرة على التركيز والروائح الكريهة، والغثيان، والدوخة، وضيق الصدر على معظم ساكني المباني المريضة. وينتج ذلك في الغالب بسبب انعدام التهوية وتلوث الهواء وخصوصاً في الأماكن المغلقة وانتشار الضوضاء والإزعاج واستخدام الإضاءة غير المناسبة وانتشار الملوثات البيولوجية وكذلك الملوثات الكيميائية الصادرة من مواد البناء والمنبعثة من الأثاث المنزلي.

وللحد من المشاكل الصحية المرتبطة بمتلازمة المباني المريضة، يجب على المماريين والمهندسين والعاملين في حقل التصميم والإنشاء فهم متلازمة المباني المريضة وكيفية التعامل معها.

تقدم هذه الورقة دراسة عن متلازمة المباني المريضة، ومدى انتشارها في منازل مدينة الرياض. كما تناقش بصورة عامة مسبباتها وآثارها، خصوصاً أن طقس مدينة الرياض يعتريه في بعض الأحيان أجواء مغبرة تساهم بقوة في انتشار متلازمة المباني المريضة.