



Review Paper / Derleme Makalesi
HUMAN HEALTH EFFECTS OF AIR CONDITIONERS

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ABSTRACT

Air conditioners which are used in buildings can be useful or harmful for human health. A wrong place or poor quality of air conditioners is harmful factors for health. Many bacteria and fungi can be also proliferated because of dense and water accumulations in cooling systems. These problems can cause illness and some symptoms called sick building syndrome. Generally building occupants who have this syndrome complain of symptoms such as sensory irritation of the eyes, nose, and throat; neurotoxic or general health problems; skin irritation; odor and taste sensations. On the other hand, scientific authorities proved that air-conditioners can have great benefits for human health when they are used consciously. Especially the usage of air conditioners is recommended to the people that are old and diabetic, and heart patients. Moreover, air conditioners which are used in buildings have the important negative effects on environment such as the effects of cooling fluids on ozone layer and global warming, and energy consumption. In this study, the effects of air conditioners used in the buildings on the human health were evaluated by comparison of the pros and cons.

Keywords: Air conditioners, air conditioning filters, sick building syndrome, human health.

KLİMALARIN İNSAN SAĞLIĞI ÜZERİNE ETKİLERİ

ÖZET

Binalarda kullanılan klimalar insan sağlığı için faydalı ya da zararlı olabilir. Yanlış yer seçimi veya düşük kalitedeki klimalar sağlık için zararlı faktörlerdir. Aynı zamanda bir çok bakteri ve mantar, soğutma sistemlerindeki buhar ve su birikintileri yüzünden çoğalabilirler. Bu problemler insanlarda hastalığa neden olabilir ve hasta bina sendromu olarak ta bilinen bazı semptomlara yol açabilirler. Genellikle, bu sendroma sahip bina sakinleri gözler, burun ve boğazlarının tahrişi, nörotoksik ve genel sağlık sorunları, deri iritasyonu, koku ve tat hislerinin kaybı gibi semptomlardan şikayet ederler. Diğer taraftan bilimsel otoriteler, klimaların bilinçli bir şekilde kullanıldığı takdirde insan sağlığına büyük faydaları olabileceğini de kanıtlamışlardır. Klima kullanımı özellikle yaşlı, şeker ve kalp hastalığına sahip insanlara tavsiye edilmektedir. Ayrıca, binalarda kullanılan klimaların soğutma sıvılarında çevre üzerine, ozon tabakası ve küresel ısınmaya ve enerji tüketimindeki artışa önemli negatif etkileride olabilmektedir. Bu çalışmada, binalarda kullanılan klimaların insan sağlığı üzerine etkileri olumlu ve olumsuz yönleriyle birlikte karşılaştırılarak değerlendirilmiştir.

Anahtar Sözcükler: Klimalar, klima filtreleri, hasta bina sendromu, insan sağlığı.

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1. INTRODUCTION

Air is one of the most important vital elements for human being due to its necessity in body metabolism. Beside the presence of air, its quality is also very important. In this context, the concept of air conditioning comes into consideration. Air conditioning is a treatment that controls the temperature, humidity, purity, composition, pressure and motion of air, independent of outside conditions [1, 2]. In an air-conditioning unit, air is heated in a boiler unit or cooled by being blown across a refrigerant-filled coil and then distributed to a controlled indoor environment [2].

The air conditioning concept is known since Ancient Rome, where aqueduct water was circulated through the walls of certain houses to cool them. The first modern air conditioning unit was invented by Willis Haviland Carrier in 1902 [3]. After the usage of the modern air conditioners in 1902 for factories, the first home and car air conditioner was not brought in until 1950 [3]. In 1950s with the increased popularity of air conditioners, indoors automatically became more comfortable and safe.

There are two basic types of air conditioning systems according to the usage objective as comfort or precision air conditioning systems: comfort air conditioning provides the optimum conditions which are suitable for the comfort of people while precision air conditioning provides cooling electronic equipment, rather than people [4].

Due to many advantages, the use of the air conditioners has become popular recently. Air conditioners have great benefits for indoor air quality. Temperature, humidity and freshness etc. can be regulated easily by air conditioners and so, the work capacity of the people can increase with comfortable conditions. But there are also some disadvantages of air conditioner systems beside their advantages. The moisture in air conditioner and humidification systems can result in microbiological exposures that cause health effects through mechanisms that are irritant, toxic or allergic. The presence of visible moisture and mold in many kinds of buildings is consistently associated with increased risk of respiratory symptoms and asthma [5, 6]. On the other hand, porous insulation materials, condensation pans, some painted metal surfaces of air conditioning systems have been shown as a nidus for the amplification of fungi [7, 8]. Fungi have been implicated as predominant bioaerosol component of unhealthy indoor air recently and may have immunomodulating activity [9, 10]. In the literature, it was documented that some microorganisms (fungi, bacteria) may be colonize on air filters and there were some studies about determination of bacteria, fungi in the units of air conditioning systems [9-13].

There are a lot of health problems as mucous membrane irritation, breathing difficulties, irritated skin and neurological symptoms such as headache, fatigue and sleepiness that are caused by air conditioning systems [5, 14, 15]. This set of non-specific symptoms, often referred to as building related symptoms or sick building syndrome, which is a medical condition caused by poor indoor air quality, interior, exterior and biological contamination [16].

In this study, the effects of air conditioners used in the buildings on the human health were evaluated by comparison of its pros and cons.

2. ADVANTAGES OF AIR CONDITIONER SYSTEMS

In recent years, climates change due to global warming, and *summers* are getting *hotter* and *winters* are getting colder anymore compared to the past years. In this context, air conditioners come into consideration in today.

People spent 80-95% of their time indoors, thus optimal thermal environment is necessary [4, 17]. The purpose of most of air conditioning systems is to provide thermal comfort and acceptable indoor environmental conditions [18]. The indoor air temperature and humidity can be controlled better with air conditioner systems than the natural ventilation. Besides humidity and temperature, freshness is very important for indoor air quality. Moderately dry and cool air is fresh and invigorating, whereas warm air is stuffy and depressing for people [1]. So, air

conditions are also very important for working people. Because people feels uncomfortable at very high or cold temperatures and this situation causes the lack of concentration in business [19].

Generally, people of low socioeconomic status can not live in air-conditioned environments, thus, they can not be easily protected from hot air [20]. For example, during the heat wave in 1995, the number of black people died was greater than white people in Chicago. It was thought that this event was caused due to low socioeconomic conditions of black people [20].

Moreover, the usage of air conditioners is especially recommended to the people that are old and diabetic, hypertension and heart patients. Warm air can be dangerous for these people. Air conditioners are also good solutions for comfort of people in some ways. For example, there is no need to dress up extra clothing in winter. One of the useful functions served by proper air conditioning is the mitigation of odors, particularly in such public places as theaters, restaurants and transportation vehicles [1].

By the usage of air conditioners there is no need to open window. So occupants does not expose to noise that comes from outside. With the development of air conditioners, office environments are much less noisy than they were in the 1960s or before [21]. Several studies reported the effects of noise on various psychosocial outcomes [21]. According to these studies, people are most comfortable if they can control noise to suit their own requirements [22]; and individual stress may decrease when noise can be controlled [23]. In addition, quietness maintains peace inside the hospitals [19] and a lot of air pollutants such as smoke, gases and dust from outside with opening the window can be also prevented.

There are some contaminants in houses or workplaces such as dust mites, microorganisms, bacteria, mold, mold spores and smoke fumes etc. It is possible to prevent these contaminants by using of air conditioner systems properly. The circulating and filtering of air help to the removal of these contaminants from air inside room [19].

Temperature in an automobile cabin is very important for driver's caution [24, 25]. By the usage of air conditioner systems in automobiles, driving performance of drivers and safety in different driving conditions can be improved [25]. Also, more comfortable environment can be provided during humid or hot trips for drivers and passengers. Air conditioning technologies have been constantly developing in recent years. For example, portable personal air conditioners have been developed for surgeons and these devices include a portable battery similar to those used on laptop computers, a helmet with the cooling unit and a light paper-plastic like suit to contain the cooler air.

3. DISADVANTAGES OF AIR CONDITIONER SYSTEMS

Indoor pollution is currently a major public health problem, because the most of the urban population spend more than 80% of their time indoor and the various pollutants present in indoor environments may be harmful to human health and can cause even an increase in human mortality [26, 27]. Generally, in air-conditioned buildings indoor air quality is dependent on the efficiency of air-conditioning and humidifier systems which systems provide a suitable environment for the proliferation of microorganisms if they are not used properly [23]. Especially, the central air-conditioning systems of buildings can increase the levels of indoor pollutants since pollutants termed "bioaerosols" released by microorganisms may be spread in the indoor environment through the air-conditioning system [23]. Temperature, humidity, air exchange rate, air movement, ventilation, particle pollutants, biological pollutants, and gaseous pollutants can be a source of indoor air pollution [28]. For example, some important indoor air pollutants are produced by burning of oil, gas, wood and tobacco products [29]. Volatile organic compounds are one of the indoor air pollutants which belong to very different chemical groups (hydrocarbons, alcohols, acids etc.) [30, 31]. Adhesives, carpeting, furniture and cleaning agents may emit volatile organic compounds [29]. Also, there can be outdoor pollution sources effecting indoor air environment such as motor vehicle exhausts, plumbing vents and building exhausts.

In the indoor environment, air conditioners and carpets are a major source of microbial allergens. Due to high humidity, a damp building may lead to increased levels of dust mites and mold which are biological contaminants, leading to increased allergic respiratory symptoms, as well as the worsening of asthma, tuberculosis [4]. Even if someone is not allergic, molds may produce mycotoxins and volatile organic chemicals that smell bad and may cause respiratory irritation.

All of these contaminants will cause different illnesses such as Legionnaires' disease, sick building syndrome and asthma etc. Legionnaires' disease is an environmentally acquired bacterial pneumonia caused by *Legionella* species that are widely distributed in man-made and natural environments [13, 32]. In 1976, Legionnaires' disease acquired its name when an outbreak of pneumonia occurred among legionnaire soldiers attending a convention of the American Legion in Philadelphia [33]. *Legionella pneumophila*, the bacteria of Legionnaires' disease is capable of infecting humans by aerosol inhalation or by drinking and subsequent aspiration of water [34].

Occupants of office buildings with air conditioning systems consistently report more symptoms in their buildings than do occupants of buildings with natural ventilation [5]. This is known as sick building syndrome symptoms which do not indicate either a particular exposure or a specific disease [35]. Upper respiratory and mucosal symptoms such as dry, itchy, sore, burning, irritated eyes, nose, sinus or throat; lower respiratory irritation or distress such as cough, tight chest, wheeze or difficulty breathing; neurophysiological symptoms including headache, drowsiness, lethargy, tiredness, mental fatigue, dizziness, etc.; and skin irritation symptoms such as itching or stinging, dryness or reddening are sick building syndrome symptoms [35-37].

Some people living in newly-built or renovated residential buildings in Japan began to complain of various nonspecific subjective symptoms in the 1990s [38] and these symptoms are similar to sick building syndrome related symptoms and have been called "sick house syndrome". So Takigawa et al. [38] made a study to explore possible environmental risk factors, including indoor chemicals, mold, and dust mite allergens, which could cause sick building syndrome type symptoms in new houses in 2004 and 2005 in Okayama, Japan and the results showed that elevated levels of indoor chemicals increase the risk of sick building syndrome in newly built houses.

Righi et al. [26] conducted a study in four libraries of the University of Modena in Northern Italy to determine the presence of polluting agents such as total dusts, formaldehyde and other volatile organic compounds including benzene, toluene and xylenes and to assess the sense of well-being perceived by library users. And, the highest prevalence of sick building syndrome symptoms was found in library where environmental discomfort as perceived by users was greatest [26].

Cheonga et al. [39] reported a study of perceived air quality and sick building syndrome using tropically acclimatized subjects in a field environmental chamber served by displacement ventilation system. The aim of the study is to evaluate the influence of temperature gradient and room air temperature on air quality and sick building syndrome. It was found that temperature gradient had insignificant impact on perceived air quality and sick building syndrome. However, dry air sensation, irritations and air freshness decreased with increase of room air temperature [39].

Assimakopoulos and Helmis [40] reported the sick syndrome episodes by the employees in Athens Air Traffic Control Tower. In this study obtained indoor air quality measurements, during selected meteorological conditions, taken in the Athens Air Traffic Control Tower, are presented and discussed. The results presented that the central ventilation system is not sufficient for the building needs, and in some areas, either due to cleaning negligence or to the construction material used, volatile organic compounds' pollution sources have developed [40].

Jaakkola et al. [41] found that sick building syndrome symptoms increased when the temperature was considered too cold and too warm, indicating that these symptoms can also indicate a general dissatisfaction with the temperature.

Also, a microbiological growth may occur in an air conditioning system which has low-efficiency filters, humidifiers [42-44]. Thus, these systems can spread microorganisms that can be inhaled by the people working or living in buildings [44]. Bonetta et al. [44] investigated level and composition of bacteria and fungi in the indoor air of an Italian office building equipped with a heating, ventilation and air conditioning system. It was shown that indoor seasonal distribution of fungal genera was connected to the fungal outdoor distribution. Studies carried out by Cooley et al. [45], McGrath et al. [46], Herbarth et al. [47] showed that sick building syndrome was associated with indoor fungi. *Penicillium* and *Aspergillus* are dominant fungus in sick building syndrome [31].

In addition to this review paper, SEM micrographs and microscope images of filter of air conditioner in office room at our university were presented in terms of visual support to the fungal occurrence in the filters of air conditioners. SEM micrographs and microscope images of contaminants in air conditioner filter were taken by using a Jeol Model JSM 5410 Scanning Electron Microscope and Olympus model inverted phase contrast microscope, and all images were given in Figure 1 and 2, respectively.

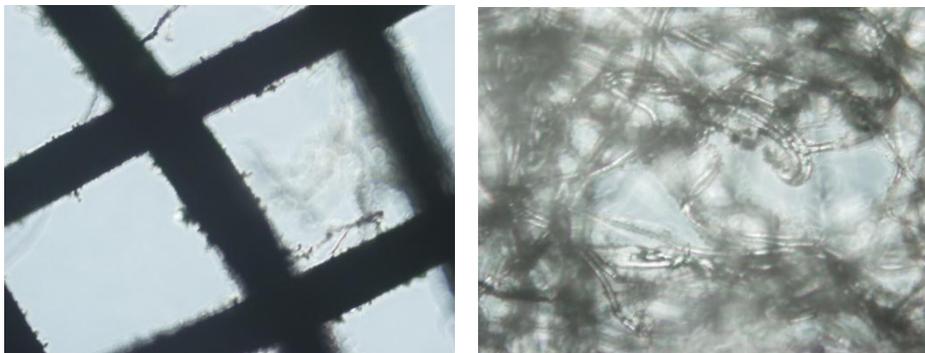
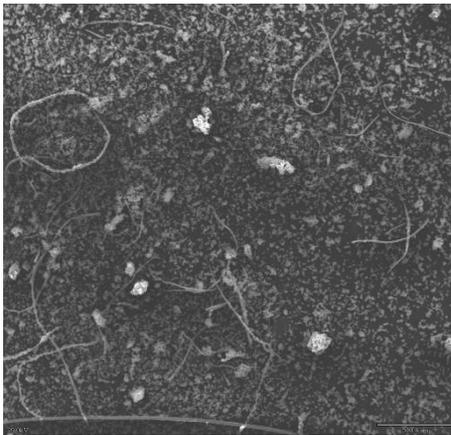
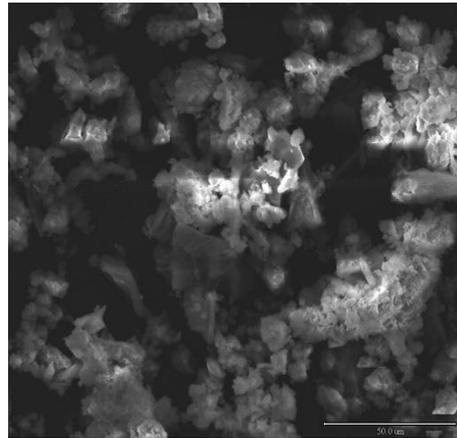


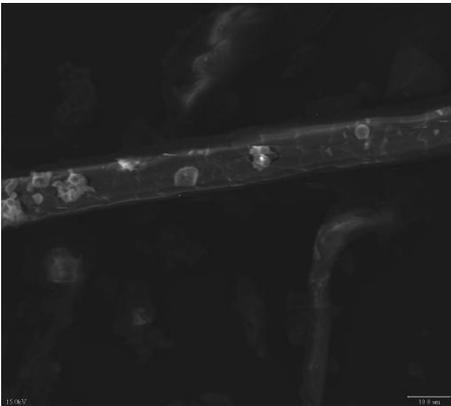
Figure 1. Microscope images of air conditioner filters (40X).



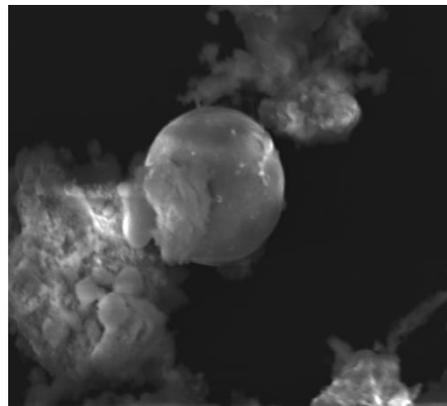
A) 35 X



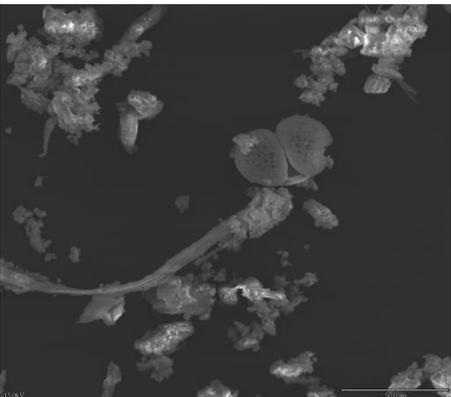
B) 500 X



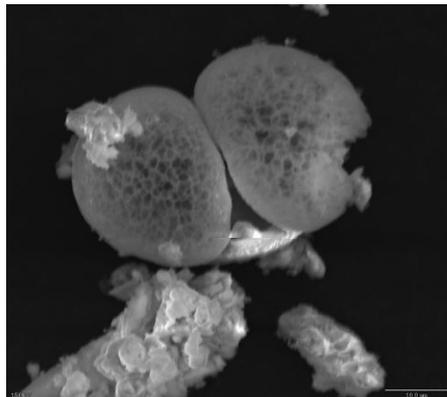
C) 1000 X



D) 2000 X



E) 500 X



F) 1500 X

Figure 2. SEM Micrographs of contaminants in filter of air conditioners.

As can be seen from SEM micrographs and microscope images, there are some contaminants in air conditioner filter such as dust, hairs, mold, mold spores and fungi. A and B micrographs present the general projection of filter contaminants mentioned before, and at high power of images in C-F SEM illustrates that individual round conidiogenesis of fungi. The hypae and conidium of fungi can be observed from SEM images. According to the images, the type of fungi can be called as *Aspergillus* that is one of the most common fungi in indoor air of building. The images are found agreeable with the images in car air conditioner filter in the study of Simmons at Figure 3 [9]. For the further research, fungal characterization study would be useful to make.

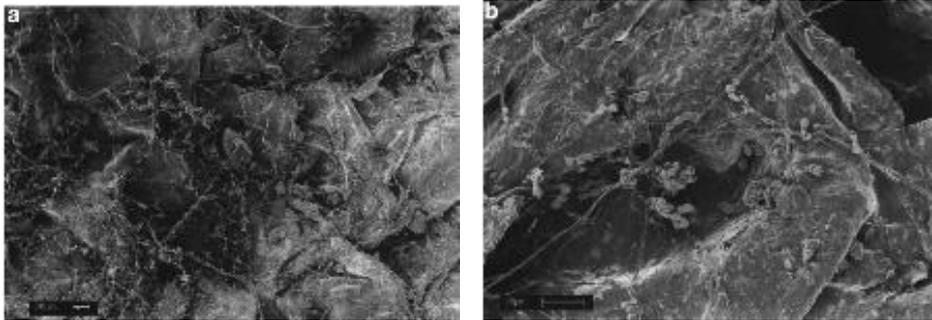


Figure 3. a) Extensive hypae b) conidiogenesis of fungi at air conditioner unit of automobile [9].

4. CONCLUSION

Air conditioners have a lot of disadvantages besides their advantages. Some precautions must be taken to remove these disadvantages. Using a correctly sized heating, ventilation, several construction practices and the selection of shape and place of an air conditioner system can make a significant difference in improving indoor air quality. Proper ventilation involves introducing air from a known source and then filtering, dehumidifying and pre-cooling or heating it [2]. Also some useful apparatus like a high efficiency particulate arresting filter (HEPA) can be preferred in air conditioners [48-50], because the use of apparatus like HEPA can be highly efficient for allergen sensitive people. In this study, the micrographs of air conditioner filter were also added to paper for supporting to disadvantages of air conditioners. As can be seen from Figures 1 and 2, some different kind of contaminants and fungi may be also occurred in uncleaned filters of air conditioners and also in water reservoirs of air conditioner. So, filters and other apparatus of air conditioner systems must be upkeep, cleaned and decontaminated by using effective cleaning solutions regularly to prevent the proliferation of some contaminants [13, 51].

Moreover, in terms of global warming and its environmental effects, environment-friendly air conditioners should be chosen and new air conditioning techniques need to be developed as soon as possible [9].

In conclusion, the indoor air quality is very important for people. The indoor air conditions can be controlled easily with air conditioner systems if it is used properly. Thus, the people life can be more comfortable with air conditioners.

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