**INVESTIGATING THE INDOOR ENVIRONMENT QUALITY PARAMETERS ON OCCUPANTS’ SATISFACTION AND WELL-BEING: A REVIEW**

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# Abstract

# Occupants’ comfort is a critical area of research which has a lot of aspects; however, when it comes to building the indoor environment quality is a highlighted fact with a strong influence on occupants’ comfort and well-being. In this regard, this study tried to go through the science world and document the parameters of the indoor environment quality which has a massive effect on occupants’ comfort and well-being. Following parameters have shaped the body of knowledge for this study as a thermal comfort, indoor air quality, lighting quality, acoustic quality. The importance of these parameters is not only because of their critical influence but they have a complex relationship with each other as well as their relationship with energy saving and their effect on occupants’ productivity. According to the finding of post occupancy researchers, the designers and any one whose has a role in building construction should consider the effect of IEQ on occupants’ comfort at the very first stage of the design while it should be considered in the life cycle of the building as well to provide satisfaction for occupants. Therefore, this paper has brought the effort to investigate how the IEQ parameters affect occupants and document the information for those who want to understand IEQ relationship with occupants’ comfort, well-being and health.

# Keywords:

# Indoor environment quality, occupants’ satisfaction, occupants’ comfort, occupants’ well-being, occupant, productivity, office building.

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# BACKGROUND OF STUDY

# After the introduction of Green building or Green construction to the global community, an incredible alternation has happened to the practices of construction. The greenery building construction has been aiming to save the energy and become environment-friendly since the green methods applied to construction process; however, there is indistinct information about green construction effect on occupants’ satisfaction and well-being which needs more study and investigation. It has been claimed by numerous studies that indoor environment condition has a strong influence on occupants’ satisfaction and health, although most of these researches have been done in conventional buildings (Abbaszadeh et al., 2006; Altomonte et al., 2013). Therefore, there is a lack of information about green buildings effect on occupants, where there is a belief that green construction should represent a better indoor environmental quality. More studies needed to reach a consensus point about the overall comfort of the green buildings indoor environment condition.

# The role of overall comfort for a human is critical as it has a major influence on human physical condition as well as their psychology. This becomes highlighted when these days people spend more than 80% of their life inside the buildings (ASHREA, 2010). As a result, studies tried to rationalize the relation between IEQ condition and humans to achieve more suitable IEQ condition for different purposes (Leaman et al., 1999). For, instance the IEQ requires for schools to get a better performance in learning process should be different from an office building with the aim of work performance. Any technical flaw or weakness in the system which presents an indoor environment in the building has potential to dramatically reduce the overall satisfaction and adversely influence human health. The worth case is being exposed to this condition for a long time which can fatally affect users’ health (Takigawa et al., 2009). In this scenario, the importance of presenting flawless IEQ to serve the occupants can be divided into two categories as an influence on health and satisfaction or well-being. These two categories have an undisputable role to increase the work performance in an office building from the indoor environmental view.

# The significance of IEQ relation to performance has led numerous studies to tailor baseline standards for the IEQ condition. For instance, ASHREA (2010) tried to prepare and propose a guideline for IEQ which is suitable for the human body. Alternatively, when it comes to office building the IEQ aim’s is to increase the productivity. Studies indicated that not optimal condition in an office building has a potential to reduce the productivity even only a few signs of discomfort have been reported as reasons for the reduction in productivity on office buildings (Issa et al., 2011). Moreover, the characteristics of IEQ as thermal, indoor air quality (IAQ), acoustic, lighting, office layouts, etc might be able to change human psychology and terminally influences the productivity of occupants (Vischer, 2008). Therefore, the performance of the building has become a vast area of research which ultimately has a strong influence on human behaviour(Al horr et al., 2016). Regarding building performance, numerous studies indicated that preparing a proper workplace which supports, assists and motivates workers by physical and psychological directions is a crucial fact that cannot be neglected from building design (Cohen et al., 1986).

# METHODOLOGY

# This study tries to peer-review the state of the art and brings out the practical information from several resources to document the significant information about occupants’ health, satisfaction and well-being in office buildings. Moreover, by investigating the world of science has been tried to discuss the inter relation among IEQ parameters and their effect on each other while the final objective has led this research to identify the characteristics of the building with the robust influence on human behaviour pertain to satisfaction and productivity. To cover the objectives a range of studies was hired and reviewed to found the key parameters and absorb information which shaped the body of the current manuscript. The studies included refereed Journal, conference proceeding, book, thesis and reports. Moreover, this study includes three critical steps to finalize the body of knowledge for the current manuscript as identifying and collecting, classifying and analyse.

# The first stage identified the critical key words requires for conducting the next stage. Therefore, the following key words were hired as indoor environment quality, thermal quality, acoustic, light quality, indoor air quality, post occupancy evaluation, occupants’ satisfaction, occupants’ well-being and green building to cover the objectives. The key words were used to find the proper literature by searching through the vast number of data bases as web of science, Science Direct, Wiley and Google scholar. Then, the collected articles were scrutinised to identify which article is more important and related to the study.

# The next round was to classify the finding from the first stage. For this purpose, three major categories were created to discriminate the articles as the year of publication, the reputation of the journal and article citations.

# a) Year of Publication: Wide variety of articles from different time lines since 1980 to 2016 were hired to make sure the manuscript covers the progress of IEQ in different buildings and times.

# b) The reputation of the journal: The process of choosing superior and high-quality materials required to select them from famous journals. Therefore, among the articles with same material the articles have been chosen with the more famous journal.

# c) Hight cited papers: articles were used for this study was divided into two categories base of citation and it has been tried to use high citation ones to maximize the quality of the current research.

# The last step of the study was to analyse the founded manuscripts. According to the analysis, the papers were distributed to the categories base on their research and topics as indoor environmental quality, thermal comfort, indoor air quality, light quality, acoustic quality. Therefore, these categories shaped the structure of the research.

# LITERATURE

# Indoor Environment Quality (IEQ)

# Studies indicated that the interaction between occupants’ satisfaction and IEQ is a complex one, therefore occupants’ condition has a direct relationship with the quality level of IEQ (Abbaszadeh et al., 2006; Wyon, 2004). IEQ includes a range of parameters, which according to the objectives of the study can be variable; however, some physical parameters are known as common ones in numerous studies because of their interests and considerable effect on occupants. These parameters are identified as thermal, acoustic, IAQ, and light quality (Ravindu et al., 2015). These parameters can have a short-term or long-term effect on Human’s well-being and health which make their relationship more complex (W. J. Fisk et al., 2007). Moreover, insufficient indoor environment quality is often manifest in some forms and symptoms of sick building syndromes (SBS) prevail in many office buildings (Bakó-Biró et al., 2004). For instance, William J Fisk (2002) indicate that better IEQ resulted in a potential reduction of sick leaving, therefore worker’s productivity increment shown its benefit in annual gain in United State.

# *Thermal comfort*

# When it comes to indoor environment quality thermal comfort always stays as one of the crucial parameters since the influence of it on occupants is widely accepted. ASHRAE Standard 55 (2004) defined thermal comfort as “the state of mind that expresses satisfaction with the thermal environment in which it is located”. Thermal comfort includes some parameters which can be classified into two categories as environmental parameters and personal factors. Environmental parameters include air temperature, air velocity, air relative humidity and mean radiant, while personal factors contribute to human metabolic rate and their body insulation by clothing (Katafygiotou et al., 2015). Comfortable workspace for occupants should be thermally comfortable otherwise it causes dissatisfaction and brings health issues problem (Woo, 2010). In this regard, it has been tried to create benchmarks and standards for thermal comfort to make it simple for every designer; however, it is various because of individual’s thermal adaptation which is correlated to characteristics such as race, culture, time of year, gender, age, body, psychology and geographic location and climate (Quang et al., 2014).

# *Indoor Air quality (IAQ)*

# The term comfort is not commonly used in relation to indoor air quality and it is mainly linked with the lack of discomfort due to odour and sensory irritation. Poor indoor air quality is widely regarded as a significant health, environment and economic problem. Wyon (2004) declared that there is a correlation between reduction of offices performance and percentage of occupants dissatisfied with indoor air quality. The reason may refer to large numbers of indoor air pollutants that can influence occupant health and the perceived acceptability of indoor air. In this regard, Ha (1998) claimed that indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems. Indoor air pollutants including carbon dioxide (CO₂), odours and other volatile organic compounds (VOC) are produced by human activities in the building.

# *Indoor environment light quality*

# Good lighting should provide the needed level of visual performance, but it also determines spatial appearance, it provides for safety, and it contributes to well-being (Rea, 2000). Recent studies aimed to find a correlation between environmental lighting and human performance and health, with positive results. What is known, is that insufficient or inappropriate light exposure can disrupt standard human rhythms which may result in adverse consequences for performance, safety and health (Burgess et al., 2002). However, the relation of light quality and IEQ depends significantly on several aspects of lighting including the illuminance (intensity of light that impinges upon a surface), luminance, control of glare, distribution, uniformity and light source colour (Veitch et al., 1998).

# *Acoustic comfort*

# Poor acoustic properties of offices will make occupants unable to concentrate on their work. Navai et al. (2003) defined acoustic comfort as “a state of contentment with acoustic conditions”. However, the term acoustic comfort is not commonly used and providing a good acoustic environment is mainly associated with preventing the occurrence of discomfort (annoyance). The most common concerns related to office acoustics are privacy and distractions (Banbury et al., 2005), which Huang et al. (2012) believe that distractions can affect productivity. The most common noise sources in buildings, other than the inhabitants, are related to heating, ventilating, air conditioning (HVAC) systems, plumbing systems, and electrical systems. However, when it comes to open plan offices noise becomes a major problem, some cross-sectional office surveys that have compared different office layouts, have shown that the most severe factor causing office dissatisfaction is noise (Becker et al., 1983).

# CONCLUSIONS

# As discussed green construction has been employing methods to reduce the energy consumption and being environmentally responsible manner (Robinson et al., 2012). These methods require a specific way of design, for instance, one common method for reduction in lighting energy consumption is to hire daylight and use it as the main source of lighting in the building. Although the daylighting system has been known as the most legitimate source for human health; however, it causes glare from the sky which is reported as one of the most dissatisfaction items by various respondents (Abbaszadeh et al., 2006). Moreover, daylight can have a strong influence on thermal comfort specifically at the places adjacent to the window where the light is more intensified. However, despite different benefits of green building, an innovative approach has been raised among all aspects of the green building to compromise whether green building outperforms to the non-green building, especially in industrial and commercial building. In this concept US Green Building Council (2016) claims that green building has better performance than non-green building, hence; numerous researchers have started to identify this aspect of green building (Liang et al., 2014).

# In this regard, assorted studies tried to evaluate building performance by POE and come up with a solution for next generation of building design. To assess green building IEQ, MacNaughton et al. (2016) by hiring POE compared occupants satisfaction, which they moved from conventional building to green building and result showed that the participants in green buildings reported more satisfaction in compare of conventional one. The relation between occupants’ satisfaction from IEQ and building performance is complex one which a confliction might happen depends on the occasion. For instance, thermal comfort inside the building has a direct effect on energy efficiency means for providing a more comfortable temperature or air velocity there is a need for more energy which has a conflict with energy efficiency(Koponen et al., 2001).

# Besides the complication of occupants’ satisfaction and energy consumption, a conflict might occur among the IEQ parameters. For instance, another way to redact the energy consumption is to apply natural ventilation method which it causes the increase of air velocity and higher ventilation rate. Consequently, the background noises might be increased which has an adverse on users’ comfort with noise (Pellerin et al., 2003). To summarize, green buildings are required an innovative design to create a balance between IEQ parameters with energy saving and occupants’ satisfaction and well-being. As it was mentioned the confliction among parameters could cause a challenge for designer and following that a monitoring system is essential to ensure that buildings are delivering the performance which they are designed for.

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