Role of Indoor Air Quality To Enhance Human Comfort In A Corporate Office Building For Tropical Climate

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Abstract

When we talk about the building, every aspect plays an important role, even during the occupational phase. One of such important aspects to consider is air. Air plays an indispensable role in sustaining life which if polluted can be very harmful for a human life. One of the main reasons for the deficit in the human productivity in an office building is due to the poor Indoor Air Quality (IAQ). Since most people spend their time indoor it is important for the occupants to get less exposed to these pollutants. The indoor air quality decides the type of work environment which is created and human comfort which is obtained. In this paper, the Indoor Quality assessment is done on a corporate office building due to its huge demand in the present economical context for India being in a tropical climate.

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Keywords: *Indoor Air Quality, Sources, Factors, Human Comfort, Building Typology, Climate, Filtration systems, Volatile Organic Compound (VOCs)*

1. Introduction

This paper gives a brief about IAQ, factors affecting and its importance in building design and its impact over human comfort. We have taken two major important sources that affect indoor air quality i.e. HVAC and materials used for buildings. While considering HVAC, the most important component is the air filters. This paper we have covered the types of air filters that can be used, and the major building materials used for the construction of a building

2. Indoor Air Quality

It refers to the air quality within and around buildings, especially when related to the health and comfort of occupants. Understanding and controlling common pollutants indoors can help reduce your risk of indoor health concerns. (Wong-Parodi, 2018)

2.1. Factors Affecting Indoor Qir Quality

Contaminants may originate from a variety of sources both inside and outside of a building, and may include airborne chemicals, bacteria, fungi, pollen etc.

Figure 1 Info-graphic representing of contaminants in indoor air

Source-https://catalysts.basf.com/poducts-and-industries/indoor-air-quality

2.2. How to Control These Pollutants

There are three methods to control- first one, eliminate the source of pollutants or isolate it from the people through planning and designing. Second one, dilute pollutants and remove them through ventilation i.e., increasing air exchange. Third one, usage of filters before the air entering the space.

2.3. Impact of IAQ

Indoor pollutants are prone to various health problems. Few could be immediate like cold, cough, throat irritation and few could take a while to see those symptoms in our body.

3. Human Comfort

One of the most important considerations when coming to designing is the indoor atmosphere which is given to the occupants using it. Various factors affect human comfort inside the building butt we are focusing on indoor air quality. (Eitorial, 2019)
Comfort can be defined as state of satisfaction a person has with their surrounding environment.

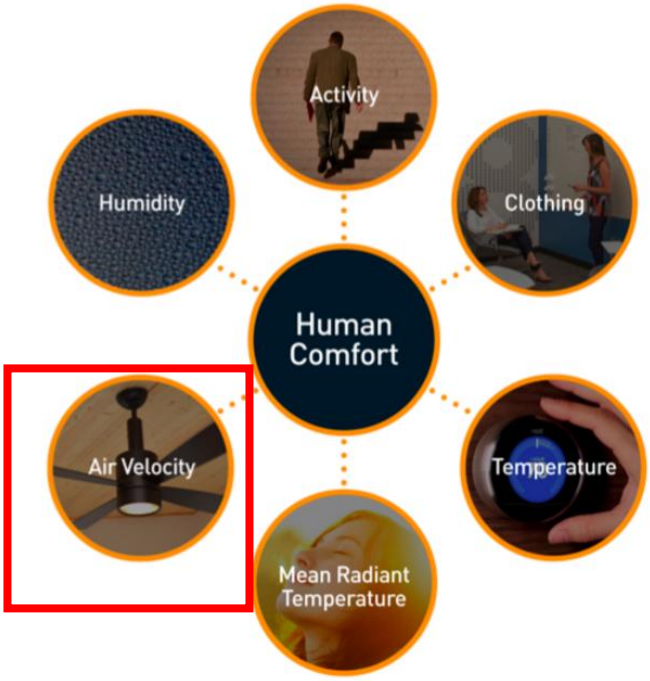

Figure 1. Factors required in achieving human comfort

Source-https://www.rmi.org/top-5-steps-redifining-thermal-comfort/

4. Building Typology

India is one among the fastest growing developing counties in service sector and this plays the major role in defining the economy of the country. When compared to agriculture and industry, this sector covers the 50% GDP of the country. The service sector has highest growth rate and is the least volatile sector. The software services in Indian economy have increased by 33 per cent which registered revenue of USD 31.4 billion. (Kaur, 2016)

5. Filter Rating

There are two types of rating system for different kind of filters available in market. They are classified into two types-

5.1. MERV- Minimum Efficiency Reporting Value

This was developed by American Society if Heating, Refrigerating and Air- Conditioning (ASHRAE). The scale "represents a quantum leap in the precision and accuracy of air-cleaner ratings. This scale is designed for particle sizes varying between 0.3- 10 micrometers. This rating is from 1 to 16.

5.2.MPR- Micro particle Performance Rating

This scale was developed by Minnesota Mining and Manufacturing company (3M). This scale is designed to capture particles which size vary between 0.1-0.3 micrometers. Higher the MPR, better is the filtration process.

6. Factors Affecting The Quality Of Indoor Air

6.1 Heating, cooling and air conditioning (HVAC)

Air conditioning plays a vital role in IAQ. It collects the air from exterior, conditions the air, transports it to the confined space. It controls and maintains the amount of air movement, humidity, air velocity, sound from the exterior source, cleanliness etc. There are different types of air conditioning units available and most used are-

6.1.1. Individual Room Air Conditioning Systems

This air conditioning employs for a single room. There are two types of categories one is wall mounted conditioning and package terminal air conditioning.

6.1.2. Chilled Water Air Conditioning System

In this process, water is been evaporated at a given temperature. During the evaporation process there is a release of cooling effect. This cooling effect is used on air to cool it down directly or indirectly.

6.1.3. Desiccant-Based Air Conditioning Systems

In this system, sensible cooling is achieved by evaporative cooling and latent cooling is performed to desiccant the dehumidification. One advantage of this system is that expensive vapor compression refrigeration is replaced by inexpensive evaporative cooling. This system is a fusion of dehumidification, refrigeration and evaporative cooling.

7. Air Filters

In this paper we will be discussing about the most important component i.e., air filters. Filter quality is measured based upon the amount of dirt that filter can hold, the size of smallest particle that could be removed and degree of discoloration on the exhaust side of the filter being tested. There are five basic types of filters:

7.1. Disposable Filter

These are most efficient filters which are cost friendly and have MEPR rating up to 16. These filters can capture maximum of 95% of large particles. They can capture pollen, dust, bacteria, virus etc. these filters are easy to maintain.

7.2. Washable Filters

These filters are not efficient in capturing small particles. They have MEPR rating between 1-4. They have the tendency in particles like dust and soot but as the particle size decreases, they are not efficient. They have a longer durability and resistance to water.

7.2. Electrostatic Filter

These filters are usually electrically self-charging cotton fiber. This principle works same as the static charge, which is produced and attracts clothes, this static charge in filters attract large particles. They have MEPR rating between 1-3. These filters remove large particles from entering the room like dust, pollen etc but don't work well with smaller particles.

7.3. High Efficiency Particular Air Filter (HEPA)-

These filters have MEPR rating up to 16. These filters remove all the smallest particles passing through it. They have a tendency of providing 99.97% efficient air. These filters can purify up to 0.3 micrometers.

8. What Are Building Materials?

A building is an integration of varied materials coming together to serve a purpose of functionality. These materials serving the purpose are majorly exposed and made with the composition of chemicals and elements that could be very harmful for the human lives. New materials and products for the buildings emit a large number of organic chemicals into the atmosphere. These organic components that get emitted into the interiors of a building space are called VOC and SVOC. (Editorial, 2017)

8.1. What Are VOC'S AND SVOC'S?

Volatile organic compounds (VOC's) and Semi Volatile organic compounds (SVOC's) are the organic chemical compounds present in the day to day materials used by the human beings. The composition of these organic compounds cannot be fully eliminated as they are the key ingredients in the manufacturing process.

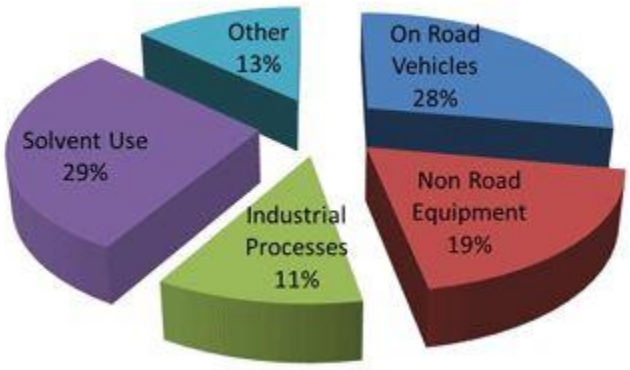

Figure 1 Sources of VOC

Source-https://stylesatlife.com/articles/type-of-air-pollution/

8.2. Causes Of VOC'S AND SVOC'S

The major elements that contribute are walls, roofs, windows, surface paintings etc. The building elements chosen here for the comparison study are:

- Bricks and Blocks
- Glass
- Cement/ Concrete

Higher the volatility that is lower will be the boiling point, more will be the amount of the compounds emitted into the atmosphere. Very volatile organic compounds are found in the form of the gases in the air as compared to be discharged from a material. The least volatile compound will be present in fragments and mostly in the form of solid or liquid.

8.3. Classification Of VOC'S

There are different classifications of VOC's based upon their boiling point and compounds used to derive them. The given table is listed with few.

Table 1. Classification of VOC'S and their boiling points

Description	Abbreviation	Boiling Point Range (c)	Example Compounds
Very volatile organic compounds	VVOC	<0 to 50-100	Propane, Butane, Methyl chloride
Volatile organic compound	VOC	50-100 to 240-260	Formaldehyde, d-limonene, Toluene, Acetone, Hexanal
Semi volatile organic compound	SVOC	240-260 to 380-400	Pesticides, Fire retardants (PCB's, PBB)

(Editorial, 2017)

8.4. Comparison Of Measuring Data Sheets

- **BRICKS AND BLOCKS**: The contents of the bricks and blocks consume marginal amount of chemical for the manufacturing

- **FLAT GLASS:**

Table 2. Chemicals used in with respect to their boiling point

S.NO	Chemical	Scientific Formula	Boiling Point	Category
1.	Silica	SiO2	2230	Non
2.	Sodium Oxide	Na2O	1950	Non
3.	Calcium Oxide	CaO	2850	Non
4.	Soda Ash	Na2Co3	1600	Non
5.	Limestone	CaCo3	825	Marginal SVOC
6.	Potassium Oxide	K2O	500	SVOC
7.	Magnesium Oxide	MgO	3600	Non
8.	Aluminium Oxide	Al2O	2297	Non

(Author, 2019)

- **CEMENT/CONCRETE:**

Table 3. Chemicals used in with respect to their boiling point

S.NO	Chemical	Scientific Formula	Boiling Point	Category
1.	Tricalcuim Silicate	Ca3O5Si	10	VVOC
2.	Di Calcuim Silicate	Ca2SiO2	N/A	Non
3.	Calcium Oxide	CaO	2850	Non
4.	Tricalcuim Aluminate	Ca3AlO6	N/A	Non
5.	Calcuim Hydroxide	Ca (OH)2	2850	Non
6.	Calcuim Sulfate Dihydrate	CaH4O6S	163	VVOC

(Author, 2019)

8.5. Result

FLAT GLASS - The amount of limestone and the Potassium Oxide used for the manufacturing of Flat Glass shows marginal SVOC and the SVOC category as mentioned in the classification of VOC's.

CEMENT – Tricalcium Silicate and Calcium Sulphate Dihydrate have a peak amount of VOC contents that even at a regular room temperature, it can induce to cause human discomfort in terms of health.

9. Case Study

IMPROVING INDOOR AIR QUALITY AND THERMAL COMFORT IN AN OFFICE Building by using combination filters- (Kabrein, 2017)

Performance evaluation of indoor air quality is done on an office building using environmental control chamber with dimension 5m x 5m x 2.8m. Walls and roofs are polyurethane insulation board (10cm). This chamber is equipped with HVAC system. There is a supply duct which is located on roof. Supply duct is divided into two branches which supplies air through ceiling diffusers (0.4 m x 0.4 m) and return air duct (0.55m x 0.45 m). Air flow is maintained at 560 CFM with air exchange of 3 h-1. Chamber environmental condition was adjusted between 23 ºC to 26 ºC and 78% for RH. Chamber was studied into different cases- 1. Recording the environmental conditions for two months with MERV- 13 pre filters and ACF. 2. Measurement of CO2 concentration.

9.1. Result

9.1.1. Environmental Assessment

This study shows us that the temperature inside the chamber varying between 23.2-25.1 ºC. The thermostat was adjusted to 25 ºC. the RH (outdoor) was fluctuating between 78-95% whereas in chamber it was between 69-89% and the average was 80%. The air movement in the chamber ranged between 0.13 to 0.2 m/s.

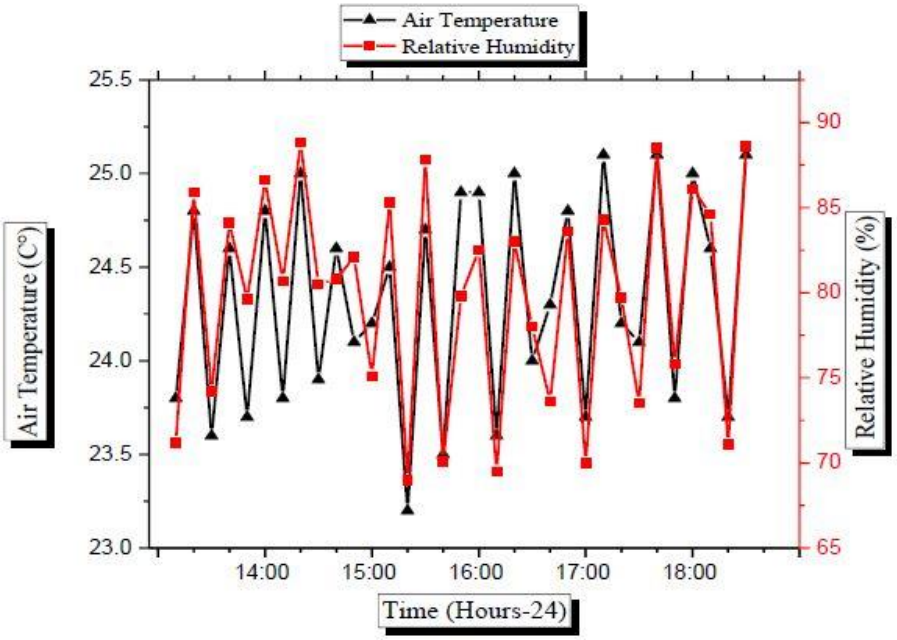

Figure 2 Air temperature and relative humidity variation in office

(Kabrein, 2017)

9.1.2. Air Quality Assessment

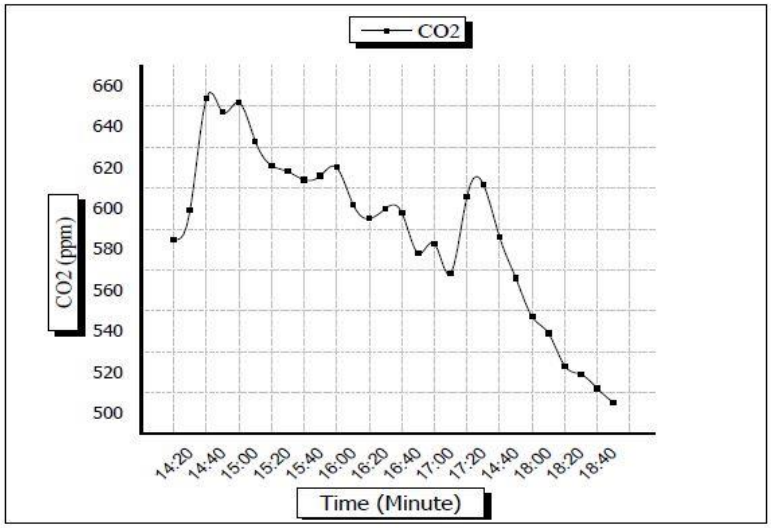

Figure 3 CO2 concentrations in chamber with four occupants

(Kabrein, 2017)

10. Conclusions

Constant inhalation of stagnated air without proper amount of air exchanges and ventilation system can put the health of a building occupant at risk. Air pollution can cause both short term and long-term effects on health, some of the leading problems such as heart or lung conditions, breathing and even psychological issues such as building sick syndrome are effects. The components mainly used for the comfort of an office building occupants can be nailed to the type of HVAC system used and https://www.rmi.org/top-5-steps-redefining-thermal-comfort/the type of building material used during the construction phase. The filtration process being the core part of the HVAC plays an important role in removing the amount of microbes such as the pollen, dust and other pathogens from the air which the filters such as Electrostatic filters, High efficiency Particular Air filter can easily do by removing 99.9% pathogens.

A case study with a controlled environment for an office building suggests that there is a positive response from the occupants regarding to the quality of air when combination filters were combined with the HVAC system used, more over it was acceptable within the ASHRAE standard. The air temperature achieved inside chamber was 24 ˚C, and the relative humidity ranged between 69 to 89%. Furthermore, the air movement was between 0.13 to 0.2 m/s, which is in the range of ASHRAE standard recommendation whereas the CO2 concentration were high when involved in some further activities by the occupants, which will need a future research in finding a balance in the temperature and the CO2 concentration involving activities in a tropical climate.

Another important factor affecting the Indoor Air quality is the presence of Volatile Organic components in the very main elements of the building materials such as Glass, cement etc. The key ingredients such as the polycarbonates used in the manufacturing of Glass and in cement have the tendencies to release Volatile gases into the atmosphere with increase in the

atmospheric temperature. The percentage or the alternative use of ingredients in the materials that have minimal impacts on the human health must be taken into considerations.

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