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PROPER VENTILATION CAN CONTROLS THE INDOOR AIR POLLUTION IN BUILDINGS

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Abstract

Environment, as we all understand, is nothing but our surroundings, which can be badly affected by smokes, smells, dusts, gases, oxygen deficits, noises, and vibrations, etc. When such substances or actions hazardously affect our Environment, we call them as pollutants, and the process whereby the surroundings get adversely affected, is known as environmental pollution. Public health engineer, who is responsible for removing all kinds of wastes of a society, is evidently responsible for cleaning the environment from such pollutants, and, thus, to ensure a healthy and wholesome surroundings, to ensure health and happiness for the people. On an average, about 17 litres per hour of CO, is exhaled by an adult human being through respiration. CO_2, is not toxic, and its smaller concentrations up to about 0.04 percent rather stimulates respiration; but the higher concentrations of about 1.5 percent cause nausea, depression, and headache. When CO_2, concentration rises to about 2.5 percent or so, it may even extinguish a burning candle. Still higher concentrations of the order of 5 percent may cause fainting and prove fatal. To avoid such CO2, excesses in a building, it is necessary to provide sufficient entry of fresh air, through proper ventilation.

Keywords: *Indoor Air Pollution, Ventilation, Systems of Ventilation, Room Air Purifiers, Controlling Indoor Air Pollution.*

1. INTRODUCTION

Environmental sanitation, which evidently means cleaning of the Environment, therefore, becomes the major task of a public health engineer, In this task primarily, includes; collection and disposal of refuse and sewage Rom houses, buildings, and other public areas, the subject which has already Been dealt in the earlier chapters of this book.

Provision of sufficient and Wholesome air to the buildings and residents for controlling indoor air Pollution, is also included as a work of environmental sanitation, and hence, Usually, included in the subject of ‘Public Health Engineering Because it is the wholesome air, on which depends the health of the public. Under this context, we are adding this chapter on Ventilation of Buildings, although strictly speaking, the topic should normally be covered under ‘Building Construction’. However, before we discuss design aspects governing ventilation of Buildings, we shall first describe the harmful effects caused by indoor air Pollution and its present status.

1.1. Sources, Effects and Status of Indoor Air Pollution: In a developing country like India, the most important source of indoor air Pollution is combustion of domestic fuel (such as cow dung, wood, and crop Residues) used for cooking, on which 80% (1991 census) of our population Relies. It has further been estimated by Indian Council of Medical Research (ICMR) New Delhi, that globally 30 lakh people die over year due to air Pollution, out of which 18 lakh people die due to indoor air pollution in Developing countries, In India alone, 5.89 lakh people die annually due to Indoor air pollution (4.96 lakh in rural areas and 0.93 lakh in urban areas).

The indoor air pollution has infect, been found to be much worse than the Outdoor air pollution, since a pollutant released indoor is thousand times more likely to reach the lungs than a pollutant released outdoors. It is generally the Women and young children and infant who face the maximum adverse effect of indoor air pollution. In poor households, there is no separate kitchen, and people usually stay in the same room where they cook, or burn fuel to heat during winter. Moreover, women who work on cooking, and their young children particularly the infants, always necessarily stay at the place of cooking or burning of traditional fuel. This exposes them to continuous indoor air pollution over long hours. This proves worst for the children (up to the age of about 6 years), whose lungs are in the developing stages.

Promoting the use of cleaner fuels, improved stoves and better ventilation of Homes and kitchens should therefore be given top priority to reduce indoor air Pollution, Moreover, children and pregnant women, who are most susceptible to ill effects of indoor air pollutions, need to be protected on top priority from Indoor air pollution.

2 VENTILATION

Ventilation may be defined as the art of supplying air to a given space, and also includes the art to remove the old vitiated air from that space. In order to understand as to how a particular space is to be provided with sufficient and wholesome air for its residents, it is necessary to understand as to how a particular space get affected by the manner in which it is occupied by humans or other living creatures.

2.1. Effects of Occupancy of a Space: When an enclose space is inhabited by humans and/or animals, etc., the following effects are produced: Oxygen content of the space reduces; Carbon dioxide content of the space increases; Temperature of the space increases; Humidity of the space increases; and Organic matter and odours in the space increases; as discussed below:

Fresh air usually contains 21% of oxygen (by volume); whereas, the exhaled air contains only about17% oxygen. The continuous respiration will, therefore, continuously reduce the available oxygen in an enclosed space. More is the number of occupant’s respiration in the given space, more deficiency of oxygen will be created. Such oxygen deficits cause headache, anorexia, vertigo, nausea etc. In order to avoid such oxygen deficits in a given building inhabited by people, it is necessary to ensure supply of sufficient quantity of fresh air through ventilation. Similarly, fresh air normally contains about 0.04% of carbon dioxide; whereas the exhaled air contains as high as 50% of carbon dioxide. On an average, about 17 litres per hour of CO, is exhaled by an adult human being through respiration. CO_2, is not toxic, and its smaller concentrations up to about 0.04% rather stimulates respiration; but the higher concentrations of about 1.5% cause nausea, depression, and headache. When CO_2, concentration rises to about2.5% or so, it may even extinguish a burning candle. Still higher concentrations of the order of 5% may cause fainting and prove fatal. To avoid such CO2, excesses in a building, it is necessary to provide sufficient entry of fresh air, through proper ventilation.

A person, on an average, produces about 300 B.Th.U. (- 69 k) of heater hour. A large part of this heat is lost by leakage through the rooms. Inspire of such leakage, the room temperature may considerably rise, if it is occupied by many persons. This is because of the reason, that about 38 B.Th.U. (8.7 kC)of heat can raise the temperature of about 38 cum-sized room (4 m x 3 m x 3 m, approximately) by about 1°C. The heat so produced by occupants of the room is either to leak out to the atmosphere, or is to be ultimately absorbed by their bodies. And since a body temperature is to be maintained at 37°C (98.4° F), this extra heat has to be continuously dissipated by the occupants themselves. Higher outside temperatures retard this dissipation, reduces leakage, and thereby causing discomfort to the occupants. If things become severe, it may lead to heat exhaustion, heat cramp, and finally heat stroke. Continuous supply of fresh air through proper ventilation is, therefore, very necessary to avoid heat effects.

Moisture, in the form of water vapour, is released by inhabitants of building @ about 1.08 kg per day (46 gm. per hour). This increases the humidity of the room/building, thereby decreasing evaporation and cooling of the bodies of the inhabitants, and thus causing them discomfort. This moisture, supported by the dust particles, also acts as carrier of germs and pathogenic bacteria from one person to another, causing water borne diseases. Organic matter and odours are released by human beings from their skins, clothing, and mouths. The increase of these in an enclosed space, occupied by several persons, may cause nausea, headache, and may even aggravate ones existing illness.

2.2. Purpose of Ventilation: Ventilation, as stated earlier, is meant for supply of fresh air, and to replace the old hot used up (exhausted) air. The ventilation ensures the removal of bad effects of occupancy of an enclosed space; By providing necessary oxygen to remove oxygen deficit caused by respiration; by removing and diluting CO, in the air; by lowering down the temperature by removing hot used up air and replacing it by colder fresh air;(i.e.) by reducing humidity; and by reducing body odours.

2.3. Extent of Ventilation required and Ventilation Standards: In olden days, it was thought that the poisonous CO2, released by inhabitants is mainly responsible for causing pollution in houses and buildings. It was also thought that CO, content increasing beyond 0.06%% in the room, would cause very harmful effects. Accordingly, the ventilation standards were framed on limiting the CO2, of the used up air to 0.06%, as against the normal content of 0.04% of fresh air. This purification standard of 0.06% of CO2, means that the air gets contaminated when its CO2, content increases from 0.04% to 0.06%. In other words, addition of 0.02% of CO, in the air by respiration will contaminate the air, which further means that the addition of 0.02 cum of CO2, will contaminate the air of a room of 100 cum capacity. Moreover, since an adult person releases 17 litres (0.017 cum) of CO, per hour, we can, conclude that 0.02 cum of Co, will be released by an adult in 0.02/0.07 x 60 min = 70.6 minutes. Hence, an adult person, if kept in a closed room of 100 cum volume, will contaminate its air in 70.6 minutes. If we consider a room of an average size 10 ft x 10 ft x 10 ft, i.e. 1000 ft-28 cum volume, we find that such a room of 28 cum capacity will be contaminated by a single adult in = 70.6 min. x= 20 min.

3. SEWAGE DISPOSAL AND AIR POLLUTION ENGINEERING

Whereas, in fact, in these days, it has been established that CO_2, contents up to 1% or so, can be easily withstood. Due to these reasons, the air requirement was considered much more in olden times than in modern days. The air requirement of as high a value as 50 cum per hour per person" was not considered infrequent in olden days. This requirement has, nowadays, not only been toned down to about 15-30 cum/hr, but rather the entire concept of ventilation has undergone a change. Now-a-days, it has been established that maximum air change is required not for keeping CO_2, under control, but is to ensure proper heat dissipation and cooling of the human body, as explained below:

- The blood in the body carries the heat to fine capillaries near the skin, and from there, it dissipates into the atmosphere by conduction. Due to this, the temperature of the surrounding air rises, which sets up the convection currents. Fresh air comes nearby, and carries away heat. If the rate of its passage is slow, the body feels discomfort; whereas if this passage is accelerated through fans, etc. more relief is secured.
- During summer season, the temperature difference between the body (at 37 C) and the surrounding air, becomes very low, and the heat gradient becomes very flat, and hence the rate of conduction falls down. Mechanical ventilation then becomes most essential.
- It thus becomes evident that ventilation is mainly required to control the body heal, and not to overcome CO_2 alone. The rate of ventilation required for body cooling exceeds the rate required for removing other bad effects of occupancy, such as decrease of O_2, increase of odours etc. Hence, the air changes are required and provided these days on the bases of body cooling alone, and not on the consideration of CO_2.
- On this consideration and in actual practice, the fresh air is supplied at threat of 15 to 30 cum per hour per person, depending upon the type of building. When the number of occupants cannot be easily determined, the rate of air supply may be based upon the number of air changes to be provided.

Table 1

Requirements of Air Supply and Air Changes with Mechanical Ventilation

Sl. No.	Types of buildings	Air required per person per hour in cum.	No. of air charges required per hour.
1.	Kitchens	60	10 to 40
2.	Factories and Workshop; workshops with flumes closely occupied open type	 30-40 20-30 15-30	 20-30 6-8 1-4
3.	Hospitals;		

	operation theatres X- rooms Treatment rooms open ward	15-40 15-40 15-40 15-40	10 10 6 3
4.	Lavatories and lab.	30-40	6-12
5.	Assembly halls, crowded dinning places, public halls, lecture rooms, meeting rooms etc.	35-40	6-10
6.	Restaurants, shops and canteens.	30	6
7.	Schools, (classroom)	20-25	3-6
8.	Living rooms and bed rooms	15-25	2-5
9.	General offices and libraries	15-30	3

4. SYSTEMS OF VENTILATION

A good ventilation system should generally fulfil the following requirements: It should admit sufficient quantity of fresh air, and remove the requisite used up or vitiated air. Admitted air should be properly controlled with respect to its quantity as well as velocity of movement. The system should be capable of changing the old air thoroughly, without leaving any stagnant pockets in the room. Should avoid draughts, for which maximum permissible velocity of admitted air should not exceed 15 m/min i.e. 0.25 m/sec. The system should admit clean and humid air. The system should also be capable of controlling the temperature of admitted air. The ventilation systems can be broadly divided into two categories; viz. Natural ventilation; and artificial mechanical ventilation.

4.1. Natural Ventilation: Natural ventilation is based upon providing suitable openings in a room, at lower levels for admitting free atmospheric air, and also at upper levels for removing the warmer and lighter used-up air. Doors and windows near the floor level, thus, admit fresh air, and ventilators near the ceiling, take out the vitiated air from a room. In order to ensure privacy of a room, windows are generally provided at about 0.75 to 0.9 m above the floor level, for admitting fresh outside air into the room. The size and the number of the windows provided will depend upon the size of the room, number of occupants, the purpose and use of the room, etc. Besides admitting fresh air, the windows help in admitting natural day light. On minimum side, a window area of 0.052 m^2 per person* should generally be provided, so as to ensure admission of at least 28 cum- (i,e. 1000 cft) of air per hour with a velocity not greater than 9 m/min*. Another recommendation is to provide about 1/10 to 1/15th of the floor area in the living rooms for windows. Every room should preferably be provided with at least 2 windows, and at least one of them should face open space or a veranda. Kitchens must be provided with more window area. Provision of deflectors (also called fan lights) of 30 cm height at the bottom or top of a window, opening inward, permits the ventilation of the room, even when windows are closed, as shown in Fig.

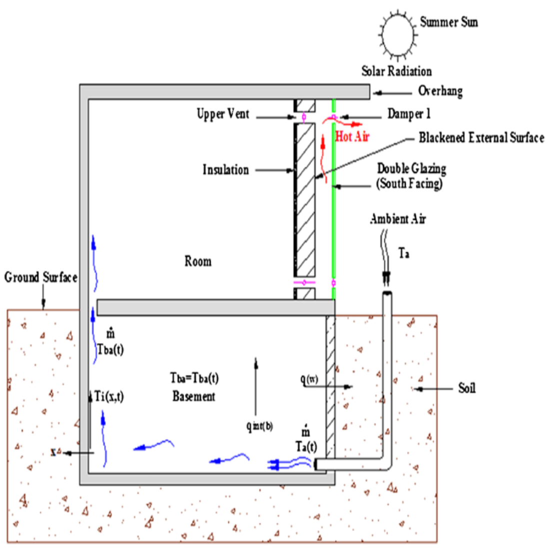

Fig 1: Natural Ventilation in Room

In hot summer months, during day time, hot outside air may be warmer than the inside room air, and the ventilators may then reverse their functions .In other words, the bottom openings may start letting out the room air, whereas the top openings may start admitting outside air to fill up the partial vacuum created thereby. The inside of room will, therefore, become worse, unless the admitted air is cooled down by some method. Khas curtains may, therefore, be hanged at the roof level ventilators to cool the air by evaporation. But during night time, when outside temperature falls, all windows and Ventilators may have to be kept open for allowing them to function in a normal manner.

4.2 **Ridge Ventilator:** In a hot and humid climate like that of India, natural ventilation fails to provide the requisite comfort, and hence artificial ventilation methods are adopted.

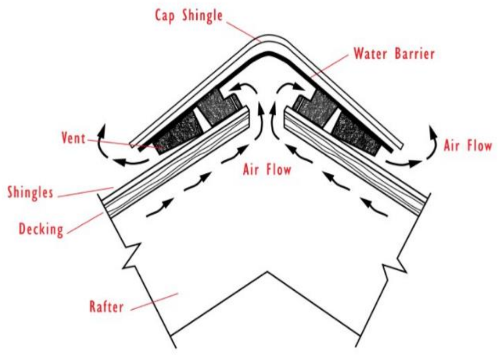

Fig 2: Ridge Ventilator

5. SEWAGE DISPOSAL AND AIR POLLUTION ENGINEERING

This system is simple and cheaper, but contains number of demerits, such as; there is no control on the quality of the incoming air. It can, hence, be installed only where outside are is not contaminated and overcrowded. It is also apt to cause draughts. In spite of these demerits, this system is largely used for kitchens, public halls, industrial plants, etc. In kitchens, the system helps in exhausting smokes and odours; in public halls, the system helps in exhausting out the ill effects of heavy occupancy; and in industrial plants, the system helps in exhausting out dusts and fumes, etc.

5.1 Ventilation of Buildings for Controlling Indoor Air Pollution: Serve us any useful purpose. In such conditions, it is necessary to completely control the temperature and quality of the outside air, before it is admitted into the room, and also to remove the heavy vitiated air at the optimum rates. All these problems have been solved in these modern days, by air- conditioning the buildings, in which all the doors, windows, and ventilators are kept closed. The air-conditioning may be defined as the process of controlling the temperature, humidity and distribution of air in a building, with simultaneously removing the dirt, bacteria and toxic matter from the air. Air- conditioning, thus, provides a comfortable and whole-some ventilation to the buildings. However, as the atmospheric conditions vary, the -requirements of occupants also vary with respect to season. In other words, during summer season, an air-conditioning system will be required to produce cool air inside the building; and in winter season, it will be required to produce warmer air in the building.

5.2. Summer Air-Conditioner: Atmospheric temperature is high, and the hot air has to be cooled before it can be distributed in the building. During the process of cooling, however, the humidity of this air increases, because at lower temperatures with the same amount of moisture, the relative humidity increases. Hence, after cooling, it becomes necessary to reduce the humidity of this air, by drying it through dehumidifier. A dehumidifier is in the form of a hygroscopic substance like ammonia, calcium chloride, etc., or the air is cooled and dried through the process of condensation. The clean, cooled, and dried air is then finally forced out into the space to be conditioned. A line diagram of this system is shown-

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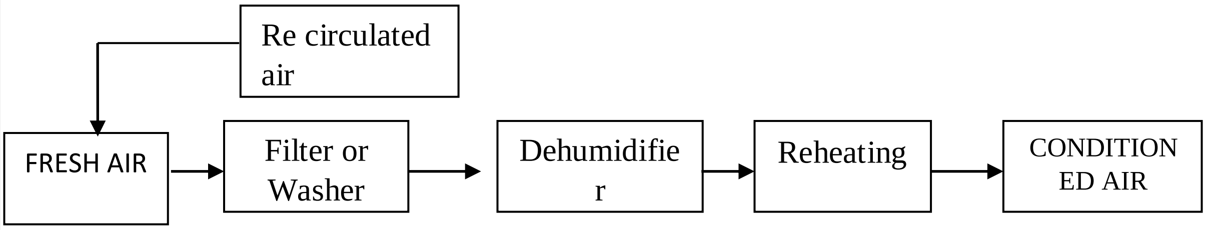

Fig 3: Line Diagram

5.3. Ventilation of Buildings for Controlling Indoor Air Pollution: Individual air conditioning machines, called room air conditioners, are fitted on the windows of rooms; whereas, for larger spaces, central air- conditioning may be adopted. In a room air conditioner, the conditioned air comes out through a grill opening, as it is forced out by a fan. On the other hand, in central air conditioning, the conditioned air is produced by keeping the plant in one separate room, and distribution ducts are carried to individual rooms, and at various points in a big hall, for distributing the conditioned air, through fans and blowers. Recirculation of Air. During summer season, the temperature of room air is lower than the temperature of the outside air. And since an air conditioner has to cool down the hot air, it should be economical for it to cool the room air rather than the outside atmospheric air, if it becomes available to it.

5.4. Room Air Purifiers: The air inside our houses and offices can be 10-300% more polluted than the outside air. Outdoor air pollution in fact, can easily enter our home, when the windows and doors are open; and even when they are closed, natural ventilation can bring in allergens and small particulates-under 2.5 micrometres, into our rooms, Pollen is a common indoor allergen released by trees, weeds and plants that can trigger allergy symptoms. Another indoor allergy is Dust, which contains dust mites, outdoor minerals, and other particles that can trigger severe allergic reaction and asthma. Indoor pollutants can occur from cooking, cleaning and having a household pet. New indoor decorations and furnishings may also sometimes release gases and volatile organic compounds (VACS). To prevent bacteria and viruses from growing, the humidity levels of our homos should be 40-60%. A well humidified room makes the air more comfortable to breathe, and helps keep our skin free from drying out. In order to avoid contracting bad health effects of polluted indoor air, room air purifiers, of various sizes and makes, have now-a-days been released in the market, and are becoming popular for common use, particularly in a city like Delhi, where the outdoor air is excessively bad, almost throughout the winter months. The room air purifiers, which are commonly available at reasonable rates in the markets these days, are from: Companies like Atlanta, Philips, Kent, Godrej, Eureka Forbes, Hind ware, HSIIL Ltd. (making Moon bow brand air purifiers) etc; etc. Most of these room air purifiers work on the technology to suck and filter the room air through a series of filters, such as: (i) prefilter; (ii) HEPA filter; (iii) Activated carbon filter; (iv) UV lamp; and (v) Refreshing energizers.

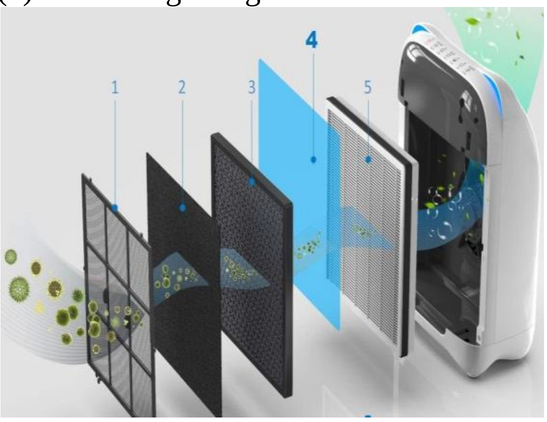

Fig 4: Five Stages Air Purification in a Typical Room Air Purifier.

The above indicated five stage purification process helps to capture indoor particulate pollutants and carcinogenic ultra fine particles .the clean air obtained after passing the above filtration stages, is finally released from the purification process, air borne pollutants like dust, smoke, pollen, bacteria, viruses, and other particles as small as 0.3 microns are usually removed. Some of the designs do display real time values of PM 2.5, as existing in the room, prior to starting the unit as well as during its operation.

CONCLUSION

The various filters used in these purifiers evidently need regular cleaning and replacement, when needed. Some units and design do have and indicator to glow when such a cleaning or replacement is required.

The most important role of five stage filtration process is that HEPA filter, that removes micro-scope particles. It can usually remove 99.97% of particles larger than 0.3μm. Further to capture gases and odours, activated charcoal filter is used in conjunction.

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