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CONTROL OF INDOOR AIR POLLUTION IN RESIDENTIAL BUILDINGS IN NIGERIA

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Abstract

The World Health Organization (2005), estimates that 4.6 million people die each year from causes directly attributable to air pollution. Many of these mortalities are attributable to indoor air pollution which is responsible for large numbers of deaths and cases of respiratory disease in residential buildings world wide. In Nigeria, there are many sources of air pollution in residential buildings such as burning wood, fire places, stoves, furnaces, incinerators, uncontrolled fires, and motor vehicles generating air pollution emissions. The lack of ventilation indoors concentrates air pollution where people have greatest exposure time. This paper therefore examines adequate ventilation as a key to controlling exposure to indoor air pollution in residential buildings in Nigeria. The paper also looks at the role building materials play in emitting substances that cause indoor air pollution. The paper concludes by suggesting the available indoor air pollution control

technologies, devices and urban planning strategies to reduce indoor pollution in the built environment.

Key words: ventilation, pollution, control, residential, buildings.

Introduction

Pollution is the presence of impurities in the environment, these impurities, may be of natural or non-made origin. Natural pollutants include pollen and dust. The most serious and persistent types of pollution result from man's activities (New standard encyclopedia). New Age Encyclopedia defines it as an objectionable change in the physical, chemical or biological characteristics of air, land, or water resource that has an adverse effect on human or animal life or otherwise degrades the environment. Longman Dictionary of Geography defines it as the direct or indirect process by which any part of the environment is affected in such that it is made potentially or hazardous to the welfare of the organisms which live in it, i.e. the results are harmful.

Air pollution in the other hand is the release of noxious gases, such as sulphur dioxide, carbon monoxide, nitrogen oxide, nitrogen oxide and chemical vapours. These can take part in further chemical reactions once they are in atmosphere. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the earth's ecosystem.

Sources of Air Pollut0n

Air pollutants are classified as either directly released or formed by subsequent chemical reactions. A direct release of air pollutant is one that is emitted directly from a given source, such as the carbon monoxide or sulphur dioxide, all of which are by products of combustion; whereas, a subsequent air pollutant is formed in the atmosphere through chemical reactions involving direct release pollutants. The formation of ozone in photochemical smog is the most important example of a subsequent air pollutant. The sources are:

Anthropogenic sources (human activity): this is related to burning different kinds of fuel, burning wood, fireplaces, cooking and heating appliances like stoves, furnaces and

incinerator. Others include motor vehicles generating air pollution emission and fumes from paint, building materials and furniture cause pollution inside building.

Natural sources: Dust from natural sources, usually large area of land with little or no vegetation. Volcanic activity produces sulphur, chlorine and ash particulates. Methane is emitted by the digestion of food by animals, for example cattle. Smoke and carbon monoxide are produced from wildfires, while Radon gas is from radioactive decay within the earth's crust.

The pollution of the air environment and other human activities has degraded air quality with adverse effect on public health and welfare. The main pollutants from these activities include carbon dioxide, nitrogen oxide, carbon monoxide, nitrogen dioxide, sulphur dioxide, hydrocarbons, cement kiln dust, petrochemical compounds, unleaded gasoline, and totally suspended particulates.

Indoor Air Pollution

It has been recognized many people spend large portion of time indoor as much as 80-90% of their lives (Satterthwaite 2005). People eat, drink and sleep in enclosed environments where air circulation may be restricted. For these reasons, some experts feel that more people suffer from the effects of indoor air pollution than outdoor pollution. A variety of factors contribute to poor indoor air quality in buildings, including indoor pollutants, outdoor pollutants near the building, pollution transport through ventilation systems and emissions from building materials poor indoor air quality can harm the health of families in their own homes. The lack of ventilation indoors concentrates air pollution where people have greatest exposure times. According to Koenigsberger, (1973), the deep body temperature must remain balanced and constant around 37 degree centigrade. Hence, to maintain body temperature in residential buildings, all surplus heat must be dissipated to the environment. Adequate ventilation is therefore a key to controlling exposure to indoor air pollution. However, home should therefore be properly planned and monitored for adequate air flow and proper exhaust systems installed.

Role of Architects in Controlling Indoor Air Pollution in Residential Buildings

Ventilation

Humans consume oxygen, taken from the air by breathing, and exhale carbon dioxide. In a closed environment oxygen content is reduced and the carbon dioxide is increased by man's presence. Body smells, fumes and vapours produced by a variety of processes, such as smoking, all add to the deterioration of an enclosed volume of air. A supply of fresh air at a rate substantially higher than the volume of actually inhaled air will be necessary. Our daily life cycle comprises states of activity, fatigue and recovery. It is essential that the mind and body recovers through recreation, rest and sleep to balance the mental and physical fatigue resulting from the day's activities. The control of indoor air quality in residential buildings on man is of considerable importance. The occupants of a building judge the quality of the design from a physical as well as an emotional point of view. The task of the designer therefore, is to create the best possible indoor climate. Human response to the thermal environment does not only depend on air temperature alone. It has been established beyond doubt that air temperature, humidity, radiation and air movement all produce thermal effects and must be considered simultaneously if human responses are to be predicted.

The human body

Heat is continuously produced by the body. Most of the biochemical processes involved in tissue-building, energy conversion and muscular works are exothermic, i.e. heat producing. All energy and material requirements of the body are supplied from the

consumption and digestion of food. The deep body temperature must remain balanced and constant around 37 degree centigrade. In order to maintain body temperature at this steady level, all surplus heat must be dissipated to environment. If there is some form of simultaneous heat gain from the environment (e.g. solar radiation or warm air) that also must be dissipated. The human body can release heat to its environment by convection, radiation and evaporation- and to a lesser extent by conduction. Convection is due to heat transmission from the body to air in contact with the skin or clothing which then rises and is replaced by cooler air. The rate of convective heat loss is increased by a faster rate of air movement, a lower air temperature and a higher skin temperature. Radiant heat loss depends on the temperature of the body surface and the temperature of opposing surfaces. Evaporation heat loss is governed by the rate of evaporation, which in turn depends on the humidity of air and the amount of moisture available for evaporation. Evaporation takes place in the lungs through breathing, and on the skin as imperceptible perspiration and sweat. Conduction depends on the temperature difference between the body surface and object the body is in direct contact with. The thermal balance of the body can then be expressed by an equation. If the heat gain and heat loss factors are:

Gain:	Met	=	metabolism (basal and muscular)
	Cnd	=	conduction (contact with warm bodies)
	Cnv	=	convection (if the air is warmer than the skin)
	Rad	=	radiation (from the sun, the sky and hot bodies)
Loss	Cnd	=	conduction (conduction (contact with cold bodies)
	Cnv	=	convection (if the air is cooler than the skin)
	Rad	=	radiation (to night sky and cold surfaces)
	Evp	=	evaporation (of moisture and sweat)

Then thermal balance exists in when Met-Evp+or-Cnd+or-Cnv+orRad=0

Heat exchange of a building

A building is also considered as a defined unit and its heat exchange processes with the out-door environment can be examined thus:

Conduction of heat may occur through the walls either inward or outwards, the rate of which is donated as Qc.

The effect of solar radiation on the opaque surfaces can be denoted as Qs.

Heat exchange in either direction may take place with the movement of air, i.e. ventilation, and the rate of this is donated as Qv.

An internal heat gain may result from the heat output of human bodies, lamps, motors and appliances. This is equally donated as Qi.

There may be a deliberate introduction or removal of heat (heating or cooling), using some form of outside energy supply. The heat flow rate of such mechanical controls is denoted as Qm.

Finally, if evaporation takes place on the surface of the building,(e.g. a roof) or within the building and the vapours are removed, this will produce a cooling effect, the rate of which is donated as Qe.

The thermal balance therefore, i.e. the existing thermal condition is maintained if: Qi+Qs+Qc+Qv+Qm-Qe=0.

If the sum of this equation is less than zero (negative), the building will be cooling and if it is more than zero, the temperature in the building will increase. The indoor air quality therefore needs to be regulated to enhance air flow through residential buildings.

Residential building planning strategies for control of indoor air quality

Orientation: to ensure good quality of indoor air, residential buildings should be properly oriented. This is done by orienting the building in such a way that the largest openings are facing the wind direction as illustrated in the figure below.

Cross ventilation: a building with an absence of an outlet opening or with a full partition there can be no effective air movement through a building.

Position of opening: to be effective, the air movement must be directed at the body surface. In building terms this means that air movement must be ensured through the space mostly used by the occupants: Through the living zone. If the opening at the inlet side is at a high level, regardless of the outlet opening position, the air flow will take place near the ceiling and not in the living zone.

Size of openings: with a given elevational area a given total wind force the largest air velocity will be obtained through a small inlet opening with a large outlet. For effective cross ventilation, there must be at least two openings an inlet and an outlet, on opposite or at least adjacent walls of an enclosure.

Control of openings: sashes, canopies, louvers and other elements controlling the opening, also influence the indoor air flow pattern. Sashes can divert the air flow upward. Only a casement or reversible pivot sash will channel it downwards into living zone.

External features: Wind shadows created by obstructions upwards, should be avoided in positioning the building on the site in positioning the openings in the building.

Suggestions and Recommendations

The Federal Environmental Protection Agency was created in 1988 in respect of environmental impact. The agency drafted laws and guideline to combat the effects of pollution on our environments, the enforcement of these laws has not been very effective. Therefore the agency should establish more criteria, guidelines, specification and standards for air quality and enhance the quality of Nigeria's residential buildings. This should include:

1) The controls of concentration of substances in the air which separate and in combination are likely to result in damage or deterioration of property, human, animal or plant heath.
2) Minimum essential air quality standards for human, animal or plant health;
3) Standards application to emission from any new mobile source which in the agency's judgment causes or contributes to air pollution which may be anticipated to endanger public health or welfare;
4) The use of appropriate mean to reduce emission to permissible level;
5) The most appropriate means to prevent and combat various form of atmospheric pollution;
6) Controls for atmospheric pollution originating from energy sources that is produced by aircraft and other self-propelled vehicles and in built power generation stations;
7) The agency should establish monitoring stations or networks to locate where atmospheric pollution exist and determine their actual or potential danger.

Conclusion

There is growing need for environment protection and applicable laws, to stem the consequences of human activities. The activities of design of buildings and their surroundings rest majorly on architects whose responsibility is to adapt to its environment. Every building activity becomes a responsibility for the architects and consequently, they are to re-design their professional role to adapt to changing circumstance of environmental

air pollution in Nigeria. The architect is undoubtedly a major stakeholder in its effective management. (Onolaja 2004). There will be need for substitution of problematic and harmful material by the infusion of cleaner technologies and manufacture of non-toxic products and the efficient use and re use of materials, coupled with organized city-planning- a city where buildings are organized and designed to use solar energy power, cars are powered by solar energy or hydrogen in order to pollute less, green spaces preserved, and expanded recycling schemes and promoted and environmentally friendly buildings designed and modified to suit microclimates. Architects must learn to build naturally by developing projects that are capable of creating clean air.

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