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Department of Civil Engineering

PROJECT REPORT

Study of Indoor air Pollution

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Firstly, I would like to thank civil department for providing such an opportunity that increased our knowledge about the new technological advancement. I would also like to thank our Project supervisor "Mr. Saurav" for giving us proper guidance throughout the duration to complete this report. Moreover, I would also like to thank him for giving us the freedom to choose the topic of our interest and his motivation otherwise this report would have been a set of blank paper.

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"Study of Indoor Air Pollution"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by " **PRASHANT KUMAR"** during a period from **Feb 2016** to **May 2016** under the supervision of "**MR SAURAV"**, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

HOD (Ashok kumar gupta) **Supervisor** (Mr saurav)

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ABSTRACT

"Air pollution and population health" is one of the most important environmental and public health issues. Economic development, urbanization, energy consumption, transportation/motorization, and rapid population growth are major driving forces of air pollution in large cities, especially in megacities. Air pollution levels in developed countries have been decreasing dramatically in recent decades. However, in developing countries and in countries in transition, air pollution levels are still at relatively high levels, though the levels have been gradually decreasing or have remained stable during rapid economic development. In recent years, several hundred epidemiological studies have emerged showing adverse health effects associated with short-term and long-term exposure to air pollutants. Time-series studies conducted in Asian cities also showed similar health effects on mortality associated with exposure to particulate matter (PM), sulfur dioxide (SO2), nitrogen dioxide (NO2) and ozone (O3) to those explored in Europe and North America. The World Health Organization (WHO) published the "WHO Air Quality Guidelines (AQGs), Global Update" in 2006. These updated AQGs provide much stricter guidelines for PM, NO2, SO2 and O3. Considering that current air pollution levels are much higher than the WHO-recommended AQGs, interim targets for these four air pollutants are also recommended for member states, especially for developing countries in setting their country-specific air quality standards. In conclusion, ambient air pollution is a health hazard. It is more important in Asian developing countries within the context of pollution level and population density. Improving air quality has substantial, measurable and important public health benefits.

1. INTRODUCTION

In many people's mind air pollution is associated with contamination of urban air from automobiles exhaust and industrial influents. But every year the indoor air pollution is responsible for the death of 1.6million people, that is a death in every 20 second .Exposure is high among women and children who spend most of their time near the domestic hearth.

The severity of indoor air pollution is aggravated by the fact that the more than half world's house wife cook their food on unprocessed solid fuels, buildings are built more air tightly to save money spent on heating and cooling .At the same time people are using more and more irritating products such as hair spray, other cleaning detergents pesticides and other which are harmful to health.

Indoor air pollution is the presence of one or more contaminants indoors that carry a certain degree of human health risk. Indoor air issues may be traced to the beginning of civilization. Prehistoric records note the problem of smoke in caves. However, over the last three decades the public has become more aware of indoor air pollution. Various studies show that people spend 65 to 90 percent of their time indoors; 65 percent of that time is spent at home. Field studies of human exposure to air pollutants indicate that indoor air levels of many pollutants may be two to five times, and on occasion more than one hundred times, higher than outdoor levels.

2.1 INDOOR AIR POLLUTION

Indoor air pollution is the presence of one or more contaminants indoors that carry a certain degree of human health risk. Indoor air issues may be traced to the beginning of civilization. Prehistoric records note the problem of smoke in caves. However, over the last three decades the public has become more aware of indoor air pollution. Various studies show that people spend 65 to 90 percent of their time indoors; 65 percent of that time is spent at home. Field studies of human exposure to air pollutants indicate that indoor air levels of many pollutants may be two to five times and on occasion more than one hundred times, higher than outdoor levels.

a. INDOOR AIR QUALITY (I.A.Q)

It is the term referring to the air quality within and around buildings and structures, it is related to the health and comfort of the building occupants.IAQ can be affected by microorganisms, gas, particulates or any mass or energy stressor that can induce adverse health conditions. Indoor air is becoming an increasingly more concerning health hazards than outdoor air.[1]

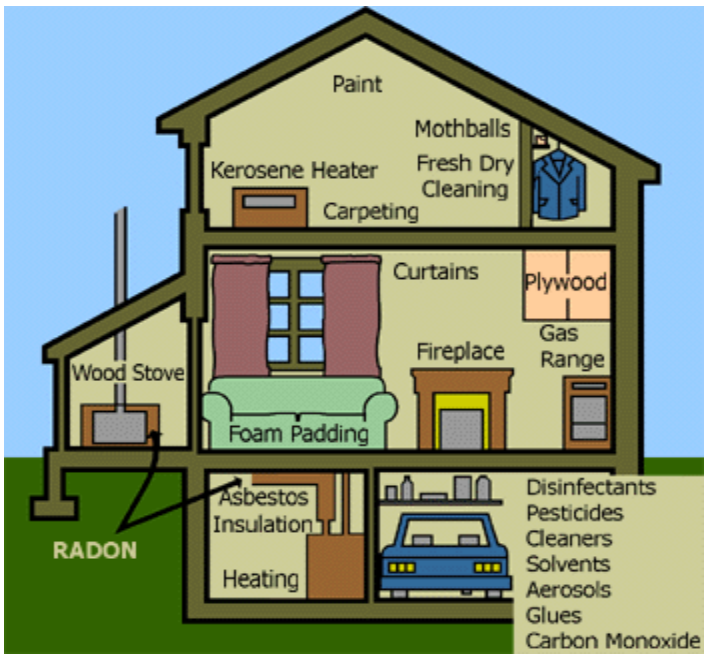


Fig2.1 Air pollution sources in house

2.2 COMMON POLLUTANTS

The four principle sources of pollutants of indoor air.

1. Combustion.
2. Building materials.
3. The ground under the building.
4. Biaerosols.

In the developed countries the most important indoor air pollutants are thecompustion products. Radon, asbestor, volatile organic compound, pesticides, heavy metals animal danfe mits , moulds and environmental tobacco smoke.

In developing countries the pollutants are combustion product's of unprocessed solid biomass fuel used by the poor urban and rural folk for cooking and heating .A recent report of WHO states the "Rule of thousands" .Which states that a pollutant released in indoor is thousand times more likely to reach peoples lung than a pollutant released outside.

a. Radon

It is a invisible, radioactive atomic gas that result from radioactive decay of radium, which may be found in the formation beneath buildings .It will tend to accumulate at the floor level. These deposits in the lung of the occupants either directly or by attaching to air born particles, which are then inhaled. To dilute the way that they occur from nature decays, ventilation is provided.

b. **Molds and Allergens**

These biological chemicals can arise from a host of means , but there are two common classes

- moisture induced growth of mold colonies
- Natural substances released from animal calendar.

Moisture build inside the home may arise from the water penetrating compromised area of the building envelops and the skin, plumbing leaks, from condensation due to improper ventilation or from the ground moisture penetrating into the building parts. In the area where the cellulosic material fail to dry within 48 hours , mold mildew can propagate and release allergenic spores into the air

.Indoor mold growth can be inhabited by keeping humidity level below 50% and eliminating any water leak.

c. Carbon monoxide

A colorless, odorless, gas that is a by product of incomplete combustion of fossil fuels. Common source of carbon monoxide are tobacco smoke, space heaters using fossil fuels ,defective central heating furnaces and automobiles exhaust .Indoor carbon monoxide levels may rise about 25-35 ppm.[4]Current ventilation standard recognize that significantly more air flow is needed in smoking areas than in the non-smoking area .This need is based primarily on achieving acceptable odor level than controlling carbon dioxide level.

d. Volatile organic compound (V.O.C)

It is emitted as gas from the certain solid or voc are emitted by a wide array of products such as paints , varnish , pesticides , building materials and furnishing , office equipments such as copier , printer correction fluid , carbonless copy paper ,graphics and craft materials including gluye ,permanent marker , photographic solutions. Testing emission from building materials used indoor has been increasing commonly for floor level, paint.

e. Legionella

It is water born bacterium that grows best in slow moving or silt water. The primary route of exposure is aerosolation, most commonly from evaporative cooling or showerhead. It is mostly found in commercial building is from poorly placed or maintained evaporative cooling tower , which often release aerosolized water that may enter nearby ventilation intake .Outbreak in medical facilities and nursing homes where patients are immuno-supressed . The reason is legionella .Prevention measures include adjusting normal hot water level to allow far for 120 degree at the tap , evaluating facility design lay out , removing affect aerators and periodic testing in suspect area.

f. Asbestos Fiber

Asbestos is found in older homes and buildings, but it is most dangerous in school and industrial setting .It is once widely used in shingles, fire proofing heating system, and floor and ceiling tiles in the older buildings. When they damage it is dispersed into the air .The removal of the asbestos contains material is not always wise because these fiber can release harmful substance into the air during the removal process. The symptom of this disease does not occur for 20-30 years after

the first exposure. A management program for intact asbestos –containing material is often recommended instead.

g. Carbon di oxide

It is a surrogate for the indoor pollution emitted by the human beings. If co_2 level is high it causes the occupant to grow drowsy , get headaches , or function at lower level .Indoor ideas are the indicator of the adequacy of outdoor air ventilation relative to indoor occupant density. This total co_2 should be reduced to a difference of less than 600ppm above the outdoor level.

h. Formaldehyde

It is a component in the urea formaldehyde which is used as building material for insulation It is used as plywood, adhesive, a binder in particle board and a component in floor covering, fabrics .It may also causes cancer.

i. Respirable Particular Matter (R.P.M)

There is another board category of indoor pollutants that including particles such as dust and pollens and aerosols in the size range that can reach the lunge when inhaled. High RPM can cause eye and respiratory tract irritation. For many people the main exposure to RPM is from tobacco smoke .Smokers receives a higher close than non smokers. And smoking can cause an increase factor of 3-40 in RPM over back ground level. If the sources of RPM are confined to relatively small area, air cleaner can be used. Limitation on smoking may be a solution when tobacco is major source of RPM.

j. Pesticides

Pesticides in home or office can irritate eye , nose and throat and may damage the central nervous system or may lead to an increased risk of cancer . Some pesticides such as chloride, deriding used to kill terminate have been banned and their indoor use restricted because they remain for such a long period.

k. Role of Humidity

- Low humidity can cause particles and vapors in air to be more irritating at high levels.

- High humidity aggravates odor problems and favor mold growth .It lead to complaint of stuffiness and thermal discomfort.

Fig 2.2 Indoor house pollutants

Table 3.1: Pollutants and max concentration

Pollutant	Max Concentration Living area	Max Concentration Work place
Carbon dioxide (CO2)	0.1%	0.5%
Carbon monoxide (CO)	3 mg/m³	30 mg/m³
Sulphurous gases	0.5 mg/m³	20 mg/m³

Table 3.2: Types of fuel used and their concentration in different areas

Type of fuel	CO concentrations (ppm) Kitchen	CO concentrations (ppm) Bedroom	CO concentrations (ppm) Outdoor
Coal briquettes			
	5	4	2
	26	19	2
Wood			
	17	16	2
	30	31	2

2.3 SOME DISEASES ASSOCIATED WITH INDOOR AIR POLLUTION

Indoor air pollution has been associated with a wide range of health outcomes, and the evidence for these associations has been classified as strong, moderate or tentative in a recent systematic review. Included in the above assessment were only those health outcomes for which the evidence for indoor air pollution as a cause was classified as strong. There is consistent evidence that exposure to indoor air pollution increases the risk of pneumonia among children under five years, and chronic respiratory disease and lung cancer (in relation to coal use) among adults over 30 years old. The evidence for a link with lung cancer from exposure to biomass smoke, and for a link with asthma, cataracts and tuberculosis was considered moderate. On the basis of the limited available studies, there is tentative evidence for an association between indoor air pollution and adverse pregnancy outcomes, in particular low birth weight, or ischemic heart disease and nasopharyngeal and laryngeal cancers.

a. Respiratory Diseases

The effect of air pollution generally would depend on the consumption of the air that is inhaled which will depend on the inhaled which will depend on the inhalation occur .It is most common in women and children**.**

b. Chloric Pulmonary Disease

In India only 75% of the men and 10% of the women are smokers .But the chronic pulmonary disease is more common in young women**.**

c. Pneumonia

It is the disease of industrial workers occupationally exposed to fine minerals dust particles over a long time. It is the single most important cause of death in children under five year. More than 900000 of the 2million annual death due to pneumonia.

d. Lung cancer

Smoking is the major cause of lung cancer .The tuberculosis which is common in Indian women it is a risk factor of developing lung cancer in Indian non smoking ,it may be concluded that at the present there is no evidence for biomass fuel.[2]

e. Cataract

During cooking particularly with biomass fuel, air has to be blown into the fire from time to time, especially when the fuel is moist and fire is smoldering. This causes considerable exposure of eye to the emanating smoke .The growing evidence that the environmental tobacco smoke causes cataract.

f. Adverse Pregnancy Effect

Low birth rate is an important public health problem in the developing countries attributed mainly to under nutrition in the pregnant women. It causes serious consequences including increased possibility of death during the infancy. Exposure to the carbon monoxide from tobacco smoke during the pregnancy has been associated with LBW.

While precise mechanism of how that small particles causes disease is still unclean, it is known that small particles and several of pollutants contained indoor cause's harmful diseases.

Table 4.1 Health Symptoms Associate with Different Environmental Condition

Environmental Condition(s)	Symptoms
• Ergonomic Conditions	• Headache
• Noise and Vibration	• Fatigue
	• Poor Concentration
	• Dizziness
	• Tiredness
	• Headache with nausea
	• Ringing in ears
	• Pounding heart
• Relative Humidity	• Dry throat
	• Shortness of breath or bronchial asthma
	• Irritation and infection of respiratory tract
• Relative Humidity	• Nasal problems (stuffiness, irritation)
• High Temperatures	
• Warm Air	• Skin problems (dryness, irritation, rashes)
• Low Relative Humidity	
• Excessive Air Movement	
• Artificial Light	• Eye problems (burning, dry gritty eye)

2.4. PREVENTIVE MEASURES

- The air pollution control regulation should have provision for compulsory testing of products at the point of manufacture to assure that they will not pollute indoor air.

- Architect and Engineer should make sure that air flow is not reduced to a danger point in the guest for energy efficiency.

- Cautionary label should be attached to the construction material that contains formaldehyde resin.

- Municipal health authorities should be authorized to test air within the homes when a physical suspect .Presence of any harmful pollutants might be damaging the resident's health.

- Switching to cleaner alternatives such as gas , electricity or solar energy

- Improve stove or hoods that vent health damaging pollutants to the outside.

Table 5.1 **Major indoor air pollutants, sources, health effects and control**

Pollutants	Sources	Health Effects	What to do?
By-products of combustion (such as CO, CO_2, NO_x)	Unvented kerosene and gas heaters, gas appliances, wood- and gas-burning fireplaces, leaking chimneys and furnaces, tobacco smoke, automobile exhaust in attached garages	Eye, nose, and throat irritation, impaired lung function and respiratory function in children, bronchitis, lung cancer, flu-like symptoms.	1. Avoid use of unvented gas or kerosene space heaters 2. Keep gas appliances and furnaces properly adjusted 3. Install and use exhaust fans 4. Change filters on heating/cooling systems and air cleaners 5. Increase of supply of outside air 6. Proper location of air intakes to avoid exhaust from vehicles
Environmental	Cigarettes, cigars,	Eye, nose, and	1. Stop smoking

Pollutants	Sources	Health Effects	What to do?
tobacco smoke	pipes	throat irritation, headaches, pneumonia. Increased risk of respiratory and ear infections in children. Lung cancer and increased risk of heart disease.	2. Discourage others from smoking 3. Isolate smokers outdoors
Formaldehyde	Pressed wood products (hardwood, plywood wall paneling, particleboard, fiberboard) used in buildings and furniture, urea-formaldehyde foam insulation, permanent press textiles, glue, ETS, vehicle exhaust, stoves, fireplaces	Eye, nose, and throat irritation, coughing, fatigue, rashes, and allergic reactions. Causes cancer in animals. Death at very high concentration.	1. Use products with lower emission rates of formaldehyde 2. Keep humidity

Pollutants	Sources	Health Effects	What to do?
			low in house 3. Increase ventilation 4. Aging or baking of products
Other volatile organic compounds	Paints, solvents, wood preservatives, aerosol sprays, cleaners and disinfectants, moth repellents, air fresheners, hobby supplies, and dry cleaned clothes	Eye, nose, and throat irritation, headaches, loss of coordination; nausea, damage to kidney and central nervous system. Some cause cancer in animals. Some may cause cancer in humans.	1. Buy only what you need 2. Read labels and follow instructions 3. Use in well-ventilated areas or outdoors 4. Hang dry cleaned clothes in an open area for about 6 hours.
Radon	Local geology, soil, water	Lung cancer, possibility of stomach cancer	1. Seal cracks and openings in the basement 2. Ventilate crawl

Pollutants	Sources	Health Effects	What to do?
			space 3. Sub slab suction 4. Increase ventilation
Pesticides	Garden and lawn chemicals, poisons for pest control	Eye, nose, and throat irritation, damage to central nervous system and kidney, cancer	1. Use nonchemical if possible 2. Avoid storage in the house 3. Follow manufacturer's instructions 4. Increase ventilation
Asbestos	Deteriorating or damaged insulation, fireproofing, or acoustical materials	Cancer and lung diseases (smokers at higher risk)	1. Test the suspected material 2. Remove asbestos by a trained contractor or develop a maintenance plan 3. Encapsulation of material containing asbestos

Pollutants	Sources	Health Effects	What to do?
Heavy metals	Paints, automobiles, tobacco smoke, soil, and dust	Headaches, irritation in mouth, rash, excessive perspiration, kidney damage	1. Vacuum regularly
			2. Removal of lead based paint
Bioaerosols	Humans, pets, moist surfaces, humidifiers, ventilation systems, drip pans, cooling coils in air handling units, plants, outside air	Legionnaires' disease, humidifier fever, influenza	1. Remove the source
			2. Maintenance of equipment
			3. Humidity control to 40% to 60%
			4. Use of filters in ventilation
			5. Air cleaning by the use of disinfectants

SOURCE: Adapted from U.S. Environmental Protection Agency and Consumer Product Safety Commission.

3. INTERVENTION

Adequate evidence exists to indicate that indoor air pollution in India is responsible for a high degree of morbidity and mortality warranting immediate steps for intervention. The intervention program should include

(i) Public awareness;

(ii) Change in pattern of fuel use;

(iii) Modification in stove design;

(iv) Improvement in the ventilation; and

(v) Multispectral approach.

3.1 Public Awareness

The first and the most important step in the prevention of illnesses resulting from biomass fuels is to educate the public, administrators and politicians to ensure their commitment and promoting awareness of the long-term health effects on the part of users. This may lead to people finding ways of minimizing exposure through better kitchen management and infant protection. Change in Pattern of Fuel Use The choice of fuel is mainly a matter of availability, affordability and habit. The gobar gas plant which uses biomass mainly dung has been successfully demonstrated to produce economically viable quantities of cooking gas and manure. Recently, the Government of Andhra Pradesh has introduced a program me called the Deepam Scheme to subsidize the cylinder deposit fee for women from households with incomes below the poverty line to facilitate the switch from biomass to LPG. Such schemes will encourage the rural poor to use cleaner fuels. The use of solar energy for cooking is also recommended.

3.2 Modification in Stove Design

Use of cleaner fuels should be the long-term goal for the intervention. Till this goal is achieved, efforts should be made to modify the stoves to make them fuel efficient and provide them with a mechanism (e.g. chimney) to remove pollutants from the indoor environment. Several designs of such stoves have been produced. NIOH study showed significant decrease in levels of SPM, SO2, Nox and formaldehyde with specially designed smokeless stoves in comparison with traditional cooking stoves. However, they have not been accepted widely. Large scale acceptance of improved

stoves would require determined efforts. The most important barriers to new stove introduction are not technical but social.[3]

3.3 Improvement in Ventilation

In many parts of the country poor rural folk are provided with subsidized houses under various government/international agencies aided schemes. Ventilation in the kitchen should be given due priority in the design of the houses. In existing houses, measures such as putting a window above the cooking stove and providing cross ventilation through the door may help in diluting the pollution load.

3.4 Multispectral Approach

Effective tackling of indoor air pollution requires collaboration and commitment between agencies responsible for health, energy, environment, housing and rural development.

4. THE STRATEGY OF CONTROLLING INDOOR AIR QUALITY THROUGH THE WHOLE ACTUALIZATION COURSE OF SUSTAINABLE BUILDING

How to create a good indoor air quality has become the key issue in the indoor environment of sustainable building. The main factors that affect the indoor air quality include: pollution of outdoor air, building materials and decoration materials, fresh air quantity, mildew, particle and other pollutants caused by the air-conditioning system, air current form of single area and multiple-area, office equipment, furniture, electrical appliance, indoor fuel and cooking oil, the domestic chemicals, smoking, staff activities, etc. The actualizations of a building include the process of planning and design, construction, assessment, check and accept running and management. In traditional concepts, people think much of the indoor air issues after using while neglect the effect of planning design and running management stages. How to achieve a good indoor air quality? In fact, the actualization of indoor air quality must analyze the effect of different stages and adopt different technical means in light of building cycle approach. We can see that the key application stage of indoor air quality is the design and running management stage from the technical guidelines of the sustainable building issued by the Ministry of Construction, China. Persisting in controlling strategy of indoor air quality all along during the whole process of building actualization is the feasible and effective measure to solve the air pollution issue.

4.1 The stage of the planning and design

Major factors that affect indoor air quality for key technology of indoor air quality control in the planning and design stage include the planning and design of building (location and the surrounding environment of building, room function and room location, location of public garbage channels, building materials), decoration design (walls, ceilings, decorative materials of floors), fitment design (furniture, electricity appliances, location of office equipment and its distribution intensity, purification equipment), the design of drainage facilities (water storage equipment, water storage height), staff, design of ventilation system (system form, air form, purification mode and its efficiency, fresh air quantity, location of fresh air collection and approach of fresh air). With the development of simulation technology at present, making pre-assessment to concentration field and

temperature field in the design stage can find existent problems in the design effectively and prevent accident occurred. From the point of view of health building and building sustainable development, one of the major ways to improve indoor air environment is controlling the indoor air pollutants effectively and eliminating all sources of pollutants. Moreover, not using polluting materials in the building design is also important. In order to improve the efficiency of natural ventilation in building design, effect on air quality from materials of indoor decoration and fitment should accord with the request of "pollution control criterion of civil environment" (GB5032532001) requirements. Until now, the ventilation is still the most effective means of air purification for civil building.

In the technical guidelines of the sustainable building issued by the Ministry of Construction, China, technique kernels of planning and design of sustainable building on the part of indoor air quality are stipulated as follows:

(1) For those building that demand for natural ventilation, space that people often bide to work or dwell in should be natural ventilation. Building design can be combined to enhance the efficiency of the natural ventilation, such as adopting windows that can be turned on, making use of draught, and so on.

(2) Mounting the position of place with a draught in reason, organizing air flow effectively, taking effective measures to prevent gases colluded with each other and extended, combining full ventilation with part ventilation to avoid polluted air from the kitchen, bathrooms, smoking lounges and other places circulated.

(3) Impact on indoor air quality from materials of indoor decoration and fitment should accord with the requirements of "Control Criterion of Indoor Environment Pollution" GB50325.

(4) Making use of new decoration and fitment materials that can improve indoor air quality.

(5) For those buildings that have concentrated air conditionings, monitoring system of indoor air quality should be mounted to maintain the health and comfort of customers.

(6) Moreover, some effective measures should be taken to prevent producing dew and growing leaf mold.

4.2 The stage of Construction

Major problems in construction for key technology of indoor air quality control are as follows: how to select the accessory material effectively, not to use or only use binder containing formaldehyde a little, pay attention to construction according to criterion, at the same time, avoid producing second pollution during the course of construction, avoid the accumulation of dust caused by materials and structure, recover and clean up construction rubbish timely. Environmental awareness should be throughout the whole construction. The construction process of the sustainable building can significantly reduce the interference to the surrounding environment, reduce the quantity of landfill wastes and natural resources consumed in the construction process and reduce the adverse effects to the indoor air quality to the minimum.

4.3 The stages of check and accept and running management

Monitoring the air quantity index, analyzing cause of problems happened and putting forward the corresponding improvement measures are the sixty-four-dollar questions for key technology of indoor air quality control in the stages of check and accept and running management. At this stage the normal running and maintenance of ventilation systems is especial important to ensure good air quality. In the stage of building running daily, central air conditioning and ventilation equipment should be overhauled and cleaned up promptly. Some facilities in disrepair should be replaced promptly. In addition, people in the room should cultivate good work and life habits, such as no smoking in the room, using the pesticides and other things that are easy to cause air pollution carefully, no sitting in the vicinity of the central air-conditioning vent, paying attention to change the water every day to prevent producing microorganism in the water during the use of humidifier, and so on. In the field of running and maintenance, techniques and methods of sustainable building can ensure goals of building planning and design realized.[5] By setting the reasonable environmental objectives and intelligent system control and making use of scientific and applied consumption patterns, people can ensure running of the building equipment system with security and cleaning, reduce the energy consumption of system, safeguard indoor air quality, thermal environment, acoustic environment and light environment, reduce pollutants in the course of running and increase the running efficiency of the overall building.

5. MAINTAINING INDOOR AIR QUALITY DURING RENOVATION PROJECTS

5.1 Early identification

Early identification of existing building hazards is the first step toward eliminating the development of an IAQ problem. Inspect the area to be renovated during the project planning stage. Look for possible asbestos and lead containing materials which may be disturbed. Attempt to identify sources of dust and microbial contamination. Consult EH&S documentation and arrange for surveys and analyses when appropriate.

Strategy of source management by choosing one or more of the following:

5.2 Source Removal

Identify a source of contamination and relocate it so that it will not impact the IAQ. For example, do not locate a diesel generator or a roofing kettle near a building air intake.

5.3 Source Substitution

Identify a material likely to impact the IAQ and select a similar but less toxic substitute. Review MSDS's, manufacturer specifications, and consult with EH&S. For example, choose latex over oil based paint, hardwood over pressed wood, water based over solvent based adhesives, low formaldehyde emitting fabrics, and continuous filament carpet. Consult Boston College Standards for materials which have been reviewed and determined to be acceptable.

5.4 Source Encapsulation

Create a barrier around the source and isolate it from other areas of the building so that there is no recirculation of air from the work area into occupied spaces. This may include physically isolating a section of the building with polyethylene sheeting or other barriers, as well as isolating the space from the general ventilation system by blocking return air grilles. Keep doors closed and seal stairwells so that they do not act as conduits for contaminants.

5.5 Ventilation

Utilize either dilution ventilation or local exhaust ventilation in conjunction with isolation techniques to reduce contaminant levels. Dilution ventilation increases the amount of outside air passing through an area to dilute and flush out low levels of contaminants. If the building ventilation system will be in contact with the work area, consider installing additional filters to keep particulates out of the ductwork. Change all filters at the conclusion of the project. When strong odors and higher contaminant levels are expected, the area should be encapsulated and placed under negative pressure. This technique isolates the work area from the building ventilation system and uses exhaust fans to directly remove contaminants to the outside. Explosion proof fans must be used while there are flammable chemicals being used in the work area. Positively pressurizing non-work areas and running ventilation systems overnight will minimize contaminant migration into occupied spaces.

5.6 Exposure Control

It may be unrealistic to attempt to completely eliminate airborne contaminants during a construction project, but it is possible to minimize occupant exposure to those contaminants by carefully scheduling the work during periods of low occupancy such as holidays, evenings and weekends. In addition, allow for a "flush out" period of ventilation prior to reoccupying the work area. It is recommended that the area be flushed out with maximum outside air at normal temperatures for 72 hours prior to reoccupancy. Increased ventilation may also be warranted for 2 weeks to 2 months post occupancy to remove low level off gassing. Finally, be sensitive to the fact that some individuals are more susceptible to low level contaminants than most, and these people may need to be temporarily relocated. Health Services and occupational health specialists may need to be involved in these determinations.

5.7 Housekeeping

Good housekeeping practices will go a long way toward containing dusts and construction debris, and allowing building occupants to feel confident that the project is well managed. Consider using a HEPA filtered vacuum cleaner to minimize recirculation of contaminants. Suppress dust with wet methods. Quickly clean up spilled materials. Protect porous materials such as insulation from exposure to moisture and contaminants.

5.8 Renovation project for

- **Flooring**
- **Painting**
- **Roofing**

5.8.1 Flooring

During flooring operations, existing building materials (sheet & tile flooring and mastic) which must be removed or prepared must first be examined to see if they are asbestos containing materials (ACM). Consult EH&S or the building survey for this information. Grinding, surfacing, sanding, abrading, breaking or removing ACM flooring may only be done by a licensed asbestos contractor according to all pertinent regulations.

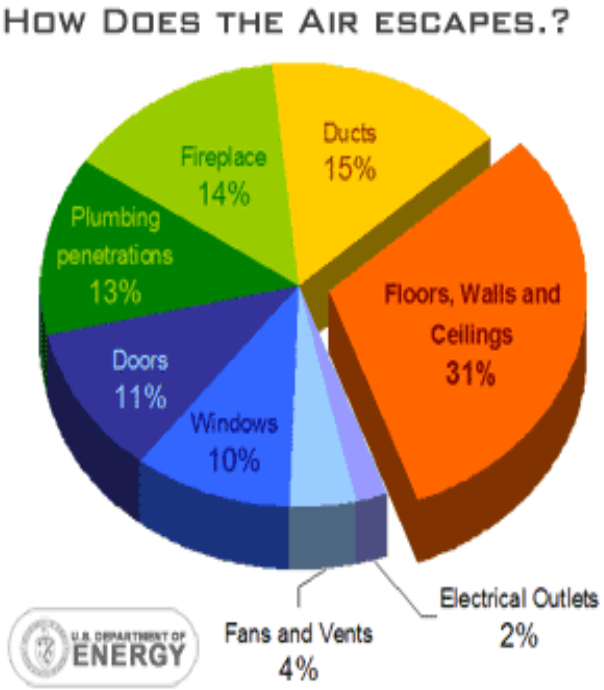
Review the manufacturer's specifications on replacement carpet and vinyl flooring and select those with low emission data. New products which are opened and unrolled at the contractors' facility will emit fewer VOCs upon installation. More importantly, consult the approved products listing and select a low emitting adhesive for flooring installation. Always follow the manufacturer's recommendations for use and ventilation. Maintain a copy of the MSDS on site. Minimize the amount of chemical product stored at the construction site, and ensure that containers not in use are kept sealed. Select the most appropriate flooring material for the space. Carpeting used in areas subject to moisture will promote microbial growth contributing to IAQ problems in the future. Implement some combination of the source management techniques to control contaminant levels generated during and after construction.

5.2.2 Painting

Painting operations should begin with the confirmation that the painted surface to be prepared is lead free. Consult EH&S and building surveys for this information. Sanding of lead paint is prohibited and removal may only be done by a licensed delegating contractor according to all pertinent regulations. Select a low VOC emitting paint that is free of lead and mercury. Minimize occupant exposure to interior painting by scheduling it during off hours, isolating the space, and ventilating the area well both during and after the painting is completed. Refer to the source management techniques referred to previously.

5.2.3 Roofing

Outdoor work, such as roofing, can also have a significant impact on indoor air quality. Hot tar and hot asphalt materials are intensely odorous, and will generate many complaints if the emissions are drawn into the building. Locate these sources away from air intakes when feasible, and consider wind patterns. Instruct occupants to keep doors and windows closed. Indoor air intakes may need to be temporarily shut down. Whenever possible, schedule this work during low occupancy periods and provide good communication to all impacted parties which may include neighboring buildings. Roofing materials may also contain asbestos.



5.9 HEAT VENTILATION AIR CONTROL (HVAC) DESIGN

The "green design" movement in the commercial and residential HVAC ind*ust*ry emphasizes paying attention to the issue of indoor air quality throughout the design and construction stages of a building's life.

One technique to reduce energy consumption while maintaining adequate air quality is *demand controlled ventilation*. Instead of setting throughput at a fixed air replacement rate, carbon dioxide sensors are used to control the rate dynamically, based on the emissions of actual building occupants.

For the past several years, there have been many debates among indoor air quality specialists about the proper definition of indoor air quality and specifically what constitutes "acceptable" indoor air quality.

One way of quantitatively ensuring the health of indoor air is by the frequency of effective turnover of interior air by replacement with outside air. In the UK, for example, classrooms are required to have 2.5 outdoor air changes per hour. In halls, gym, dining, and physiotherapy spaces, the ventilation should be sufficient to limit carbon dioxide to 1,500 ppm. In the USA, and according to ASHRAE Standards, ventilation in classrooms is based on the amount of outdoor air per occupant plus the amount of outdoor air per unit of floor area, not air changes per hour. Since carbon dioxide indoors comes from occupants and outdoor air, the adequacy of ventilation per occupant is indicated by the concentration indoors minus the concentration outdoors. The value of 615 ppm above the outdoor concentration indicates approximately 15 cubic feet per minute of outdoor air per adult occupant doing sedentary office work where outdoor air contains 385 ppm, the current global average atmospheric CO_2 concentration. In classrooms, the requirements in the ASHRAE standard 62.1, Ventilation for Acceptable Indoor Air Quality, would typically result in about 3 air changes per hour, depending on the occupant density. Of course the occupants aren't the only source of pollutants, so outdoor air ventilation may need to be higher when unusual or strong sources of pollution exist indoors. When outdoor air is polluted, then bringing in more outdoor air can actually worsen the overall quality of the indoor air and exacerbate some occupant symptoms related to outdoor air pollution

The use of air filters can trap some of the air pollutants. The Department of Energy's Energy Efficiency and Renewable Energy section wrote "[Air] Filtration should have a Minimum Efficiency Reporting Value (MERV) of 13 as determined by ASHRAE 52.2-1999.Air filters are used to reduce the amount of dust that reaches the wet coils. Dust can serve as food to grow molds on the wet coils and ducts and can reduce the efficiency of the coils.

Moisture management and humidity control requires operating HVAC systems as designed. Moisture management and humidity control may conflict with efforts to try to optimize the operation to conserve energy. For example, Moisture management and humidity control requires systems to be set to supply Make up Air at lower temperatures (design levels), instead of the higher temperatures sometimes used to conserve energy in cooling-dominated climate conditions. However, for most of the US and many parts of Europe and Japan, during the majority of hours of the year, outdoor air temperatures are cool enough that the air does not need further cooling to provide thermal comfort indoors. However, high humidity outdoors creates the need for careful attention to humidity levels indoors. High humidity’s give rise to mold growth and moisture indoors is associated with a higher prevalence of occupant respiratory problems.

The "dew point temperature" is an absolute measure of the moisture in air. Some facilities are being designed with the design dew points in the lower 50's °F, and some in the upper and lower 40's °F. Some facilities are being designed using desiccant wheels with gas fired heater to dry out the wheel enough to get the required dew points. On those systems, after the moisture is removed from the makeup air, a cooling coil is used to lower the temperature to the desired level.

Commercial buildings, and sometimes residential, are often kept under slightly-positive air pressure relative to the outdoors to reduce infiltration. Limiting infiltration helps with moisture management and humidity control.

Dilution of indoor pollutants with outdoor air is effective to the extent that outdoor air is free of harmful pollutants. Ozone in outdoor air occurs indoors at reduced concentrations because ozone is highly reactive with many chemicals found indoors. The products of the reactions between ozone and many common indoor pollutants include organic compounds that may be more odorous, irritating, or toxic than those from which they are formed. These products of ozone chemistry include formaldehyde, higher molecular weight aldehydes, acidic aerosols, and fine and ultrafine particles,

among others. The higher the outdoor ventilation rate, the higher the indoor ozone concentration and the more likely the reactions will occur, but even at low levels, the reactions will take place. This suggests that ozone should be removed from ventilation air, especially in areas where outdoor ozone levels are frequently high. Recent research has shown that mortality and morbidity increase in the general population during periods of higher outdoor ozone and that the threshold for this effect is around 20 parts per billion (ppb)

6. CONCLUSION

Finally, there is enough evidence to accept that indoor air pollution in India is responsible for a high degree of morbidity and mortality warranting immediate steps for intervention. The first and the most important step in the prevention of illnesses resulting from the use of biomass fuels is to educate the public, administrators and politicians to ensure their commitment for the improvement of public health. There is utmost requirement to collect better and systematic information about actual exposure levels experienced by households in different districts and climatic zones and develop a model for predicting the exposure levels based on fuel use and other household data therein (exposure atlas) to protect the health of children, women and elderly persons.

As most of us spend large part of our life indoor, indoor air pollution is the major problem to solve and as, such all our effects should be taken to minimize and finally eliminate the deleterious effects of indoor air pollution.

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