An Experimental Investigation in Indoor Air Quality in Kitchen

INDOOR AIR POLLUTION

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***Abstract:-* Air pollution normally means contamination of the open (ambient) air outside our structures. Most air pollution law is directed at reducing the contamination of that air. Air contamination inside our factories and workplaces is regulated by an entirely different set of laws and a different agency of the government than the one that regulates outdoor air pollution. The average person spends 80 percent of the day in an indoor environment, either in the home or in the work place, a public building, a vehicle etc. It is a fact that the issue of indoor air contamination has gained increased attention, due to the health-related problems. In India 400million people, of which 90% are women, are exposed to indoor air pollution from inefficient cook stoves. This results in respiratory, pulmonary and vision problems. High temperature and humidity levels can also increase concentrations of some pollutants. Improving ventilation can also drastically improve the air quality of the environment. Opening windows and allowing the household air to exchange with air outdoors will decrease levels of many pollutants in the environment, as indoor air levels are more concentrated. In this review a detailed analysis is performed to study the distribution of CO_2, CO with respect to relative humidity and temperature present in kitchens.**

Keywords*: Indoor air quality, Carbon-di-oxide, Carbon monoxide, Relative humidity and Ventilation

I. AN INTRODUCTION TO INDOOR AIR QUALITY

Air pollution normally means contamination of the open (ambient) air outside our structures. Most air pollution law is directed at reducing the contamination of that air. Air contamination inside our factories and workplaces is regulated by an entirely different set of laws and a different agency of the government than the one that regulates outdoor air pollution. The average person spends 80 percent of the day in an indoor environment, either in the home or in the work place, a public building, a vehicle etc. It is a fact that the issue of indoor air contamination has gained increased attention, due to the health-related problems.

The EPA's Indoor Environments Division (IED) is responsible for conducting research and educating the public about indoor environmental issues, including health risks and the means by which human exposures can be reduced. IED educates the public about health risks associated with a variety of indoor environmental pollutants and sources of pollution, including radon, mold and moisture, second hand smoke, indoor wood smoke and environmental asthma triggers sneezing, coughing and minor eye and skin irritation are some symptoms after the start of exposure to a polluted environment. Respiratory and cardiovascular problems, even potential carcinogenicity have been reported after long exposure to certain indoor air contaminants. It is known that several factors viz. indoor sources and activities, building's design and ventilation pattern, outdoor environment influence the quality of the indoor air. A respectable number of studies monitoring the indoor air pollution have been conducted so far in residences, schools, hospitals, public buildings, working places, means of transport etc. The scientific interest is focused on the different characteristics of the sources located or the activities occurred in the environments of different use, without excluding the outdoor environment's contribution.

The purpose of this review is to analyze the environmental pollutants occurring by breathing the air indoors. These pollutants come from activities, products and materials we use every day. The air in our homes, schools and offices can be 2 to 5 times more polluted, and in some cases 100 times more polluted, than outdoor air. Indoor air quality is a significant concern, because most of the hours are spent during sleeping, working in offices or at school. People on average spend the vast majority of their time in indoors where they are repeatedly exposed to indoor air pollutants. Hence improving the quality of indoor air is vital for human health.

A. Indoor Air Contaminants

Here are examples of common indoor air contaminants and their main sources:

- Carbon dioxide (CO_2), tobacco smoke, perfume, body odours -- from building occupants.
- Dust, fiberglass, asbestos, gases, including formaldehyde -- from building materials.
- Toxic vapours, volatile organic compounds (VOCs) -- from workplace cleansers,
- Gases, vapours, odours -- off-gas emissions from furniture, carpets, and paints.
- Dust mites -- from carpets, fabric, foam chair cushions.

Our scope of the study will be to measure the indoor air quality parameters of the places (hostel kitchen, laboratories, seminar hall, auditorium, classrooms) located within the college campus. The parameters to be measured include CO_2, CO, relative humidity and temperature. The factors influencing the indoor air quality of the above places are to be found and finally will be investigated the by developing mathematical models.

II. EPIDEMIOLOGICAL STUDIES ABOUT KITCHEN IN INDIA

The 1991 National Census included for the first time a question about the primary household fuel used and reflected that about 95% of the rural population still relied primarily on biomass fuels (dung, crop residues, and wood). A small fraction uses coal, which means about 97% of households relied principally on these unprocessed solid fuels. Nationwide 81% of households relied on these fuels; 3% used coal and 78% used biomass. An independent probability-weighted national survey of 89,000 households in 1992 derived very similar results [National Family Health Survey,1995].

Unfortunately, such fuels are substantially more polluting per meal than the liquid and gaseous fuels. The amount of important health-damaging pollutants (e.g., PM10, CO, PAH, HCHO, VOC) breathed by a cook during a typical meal is about 2 orders of magnitude lower when burning bottled gas than burning wood or crop residues. Thus, as a first approximation, the use of unprocessed solid fuels in the household is an indicator of the potential for excessive air pollution exposures. In this way, access to clean fuels is parallel to the often-cited statistic on access to clean water as an indicator of disease risk. [Kirk R. Smith 2000]

Fig 1 Kitchen in Rural area (India)

In India 400million people of which 90% are women, are exposed to indoor air pollution from inefficient cook stoves. This results in respiratory, pulmonary and vision problems. The following table shows the average particulate doses per day during cooking for Indian Women [Sandip Verma, The Hindu, 2013]

Table 1: Annual Deaths Due To Air Pollution In Urban and Rural Areas (Parivesh, CPCB)

Region	Urban outdoors	Urban Indoors	Rural Indoors	Total
Developed Countries	14	252	28	294
Developing Countries	186	644	1876	2706
Total	200	896	1904	3000

Source: Report of the Committee on Environment and Health (MoEF), May 2000

Indoor air quality has been receiving more and more attention and increasing interest has been directed towards controlling of indoor obnoxious gases such as CO_2, CO etc. In a hostel's kitchen working conditions are especially demanding. The air quality is affected by high emissions rate of contaminants released from the cooking processes. Ventilation plays an important role in providing comfortable and productive working conditions and in securing contaminant removal [Shubhajyoti Saha *et al.*, 2011].

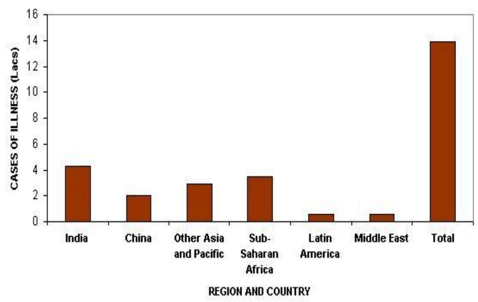

FIG. 2 BURDEN OF DISEASE FROM SOLID FUEL USE

Source: Indoor Air Quality, ESMAP, World Bank, 2000 (Parivesh.,CPCB)

Indoor air pollution is bigger killer than outdoor air pollution in India with the recent global burden of diseases report listing the former as second biggest killer and latter as fifth largest. Unlike many western countries, India does not have any norm for indoor air pollution, which mandates emission norms for home appliances such as refrigerators, air-conditioners and bread toasters and a limit beyond which dirty air inside homes can be bad for one's health.

There is no dearth of Indian studies on adverse impact of indoor air pollution on one's health, especially the women. The Energy and Resources Institute (TERI) in a recent study said that 27.5 % of under-five infant mortality in India is because of indoor air pollution. Another study said that about 80 % of women in India are affected by indoor air pollution. Rise in air pollution has direct co-relation with death. The ICMR study in Chennai on around 1200 people showed an increase of 0.3 % to 0.6 % in mortality with rise in particulate matter pollution by 10µg/m^3 (Chetan Chauhan, Hindustan Times, 2013).

- 1.3 million people in India die because of indoor air pollution every year, says a WHO study
- About 27.5 % of under-five mortality is because of indoor air pollution, says a TERI study
- Average indoor air pollution in India is 375 unit grams in cubic meter of air
- The WHO norm is 20 unit grams in cubic meter of air
- India does not have a norm for indoor air pollution(ChetanChauhan,Hindustan Times,2013)

In developed countries indoor levels of NO_2, for example, are affected by gas heaters and cooking ranges (used in 20-80% of houses in some countries). In five European countries, the average NO_2 concentrations (over 2-7 days) were in the range of 40-70µg/m3 in kitchens [M.Ghasemkhani *et al.*,2007]. Peak values of up to 3800µg/m^3 for 1 minute have been measured in the Netherlands in kitchens with unvented gas cooking ranges [Harlos,1987]. The most important indoor source of nitrogen dioxide is the use of unvented gas appliances [Moran *et al.*, 1999]. Indoor NO_2 concentrations were measured in the kitchen of 612 houses in two different areas in the Netherlands. It was determined that gas appliances inside the house are the most important factor with respect to NO_2 exposure [Fischer *et al.*, 1986]. Gas stoves are among the major contributors to indoor NO_2 exposure. Studies conducted in New York [Palmes *et al.*, 1977] and London [Mella *et al.*, 1978] showed that NO_2 concentrations in the kitchens of homes with gas stoves (49.1 and 72.3ppb, respectively) were higher than in the kitchens with electric stoves (8.3 and 9.5ppb, respectively).

III. RECOMMENDATION:

Mechanical ventilation systems in kitchens are often not required by building codes [Kimball 1998; Manclark 1999]. For example, a New York study found that only 67 percent of homes surveyed had kitchen exhaust fans [NYSERDA 1998]. Although a window may be adequate to meet code requirements, most kitchen designers, as well as indoor air quality experts believe that a mechanical ventilation system is necessary in the kitchen.

The recommended variables [Kathleen Parrott *et al.*, 2000] that are to be considered are

Type of cooking

Type of cooking appliance Type of cooking fuel

Location of the range and/or cook top within the kitchen

Size and location of the hood, if used

Size and length of ducts needed to connect from the fan to the exterior vent

Type and size of fan used in the system Make-up or replacement air available to the fan.

A. Ventilation efficiency

Generally, a range hood with an exhaust fan vented to the outside (updraft) is considered the most effective system (Kimball 1998; McDonald, Geragi, and Cheever 1996). The hood helps capture the pollutants, such as moisture and grease, before they disperse in the air in the kitchen. The placement of the fan above the cooking area takes advantage of the natural rise of the heated air. The size of the hood and its distance above the cooking surface are important factors to consider.

Effective ventilation is more critical with a gas cooking system. With gas cooking, there are by products of combustion, such as carbon monoxide. In addition, gas combustion produces water vapour, so moisture is more of an issue with gas cooking. Commercial style gas ranges, in particular, need larger capacity ventilation systems.

B. Fan size

Most kitchen design experts recommend a ventilation fan that is sized according to the recommendations of the Home Ventilating Institute (HVI 2001) or the National Kitchen and Bath Association (McDonald, Geragis, and Cheever 1996). The minimum recommendations of the Home Ventilating Institute are comparable to that of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 62 (ANSI/ASHRAE 1999). Although these requirements are determined somewhat differently, the recommendations are similar (Table 2).

Table 2. Recommendations for kitchen ventilation fans

Recommendations			**Fan needed for a typical 30-inch range**
Home Ventilating Institute	Hood placed along a wall	Minimum: 40 CFM per lineal foot	100 CFM
		Recommended: 100 CFM per lineal foot	250 CFM
	Hood above an island or peninsula (no wall)	Minimum: 50 CFM per lineal foot	125 CFM
		Recommended: 150 CFM per lineal foot	375 CFM
National Kitchen and Bath Association	Hood placed along a wall	50 to 70 CFM x the area of the hood in square feet	250 CFM to 350 CFM
	Hood above an island or peninsula (no wall)	100 CFM x the area of the hood in square feet	500 CFM to 700 CFM

Note*:* CFM is cubic feet per minute.

Source: *HVI 2000; McDonald, Geragi, and Cheever 1996*

C. Tips for Buying and using Range Hoods

- Turn on the hood every time you cook, and set the fan to the highest setting that the noise is tolerable.
- Make sure it vents to the outdoor. If it doesn't, the hood will simply re-circulate air in the kitchen.
- If having a range hood is not possible, opening a window while cooking does help (Julie Chao,2013).

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