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2. Air pollution and health

2.A Indoor Air Pollution: The enemy within

Heaven is where home is, they say. But not when air inside is heavily polluted due to smoke from *chulhas*. *The greatest threat of indoor pollution still occurs in the developing countries where 3.5 billion people, not only in rural areas but even in cities, continue to rely on traditional fuels for cooking and heating.* [1] Women exposed to wood smoke while cooking inhale huge quantities of harmful pollutants such as total suspended particulates and suffer from alarming health problems. In one of the first studies on domestic pollution conducted in four villages of Gujarat in 1981, average levels of total suspended particulate in indoor air were estimated to be 7,000 µg/cum, about 100 times higher than the WHO standard of 60-90 µg/cum. *The World Bank has designated indoor air pollution in developing countries as one of the four most critical global environmental problems.*[2]

Indoor particulate concentrations from biomass combustion in developing countries

Region	Number of studies	Duration of exposure to biomass combustion	Micrograms per cubic metre
Pacific	2	12hours	1300-5200
South Asia	15	Cooking period Non cooking 24hours Various Urban infants,24hours	850-4400 880 2000-2800 2000-6800 400-520
China	8	Various Various	2600-2900 1100-11000
Africa	8	Cooking/heating Cooking/heating 24hours Urban area 24hours	800-1700 1300 1300-2100 400-590
Latin America	5	Cooking/Heating 24hours	440-1100 720-1200

Source- WHO, Health and Environment in Sustainable Development: Five years after Earth Summit

According to the WHO, concentrations of indoor pollutants in households burning dirty fuels are excessive. Daily averages in the developing countries often exceed the current WHO standards by a factor of 10,20 or even more at times. Peak levels during cooking may exceed these standards by a further factor of five or so. The data also suggest that tens of millions of people in developing countries routinely encounter pollution levels reached during the infamous London killer fog of 1952, leading to a huge toll in disease and premature deaths .WHO has recently` pointed out that as many as 2.8 million deaths per year result from breathing elevated levels of indoor smoke from dirty fuels around the world. The finding translates to about 6% of all deaths per year.[3]*Results of a TERI study*

published in 1998 show that the total mortality and morbidity impacts of indoor air pollution only due to pm10 particles amount to Rs 885 billion – 4250 billion annually.[4] With this kind of effect indoor air pollution would be responsible for one of the largest single risk factors for health and economy of any country.
A new World Resources estimate shows that 100 developing countries rely on biomass fuels for some of their residential energy needs. Epidemiological studies have indicated that indoor air pollution due to biofuels is linked to at least four major groups of illness- acute respiratory infection (ARI) in children, chronic obstructive lung diseases like asthma and bronchitis, lung cancer, still births and other birth related problems [5]. According to a 1998 study by Kirk Smith, about 500,000 adult women and children under five die premature due to polluted indoor air in India. **(***See box: Interview of Kirk Smith).*

When most people think of air pollution, they think about ambient or outdoor air pollution – smokestacks spouting dark grey clouds of toxic smoke into the atmosphere or choking exhaust from autorickshaws, scooters and buses. These sources of air pollution are most visible to people in cities. It is not surprising, then, that whatever monitoring is done by pollution boards takes place within the ambient environment.

However, the source of pollution with the greatest health consequence remains unseen or overlooked. A silent majority of the population, namely poor women and children, continue to suffer from air pollution in the indoor environment. While benefits of agricultural tools and machinery have spread to most rural populations, changes which improve working conditions of women inside the home remain limited to affluent rural households.

Several studies found that women suffer from heart diseases such as cor pulmonale (enlargement of heart) and chronic bronchitis when exposed to wood smoke. The magnitude of the problem of domestic pollution was known by the early 1980s, and was documented in *The State of India's Environment – Citizens' Second Report.* The report also indicated that several steps can be taken to cut down exposures to smoke while cooking and reduce its adverse impact on health. These include efforts to increase the use of alternative biomass fuels such as biogas and charcoal, design stoves so that exposure to smoke is reduced, and increase ventilation in homes of the poor.

- *Women in India, exposed to domestic smoke during pregnancy, have one-and-a-half times the odds of stillbirth, compared to mothers who are unexposed.* [6]

- *Pollution levels in homes with wood-burning* chulhas *in Delhi are 50 per cent higher than those using kerosene.* [7]

- *About 23 per cent of the Indian women using biomass fuels (wood, crop residues and animal dung) reported having respiratory symptoms, compared to 13 per cent of kerosene users and 18 per cent of liquefied petroleum gas (LPG) users.*[8]

- *At least one-third child death is due to acute respiratory infections, with an overwhelming majority being in developing countries. If children were exposed to less smoke, up to 25 per cent of respiratory infections could be eliminated.*[9]

And yet. . .

- *Biofuels account for nearly half of India's total energy supply, including more than 80 per cent of household energy consumption.*[10]

• *Today, the smoke still remains within the houses and the walls continue to be covered with soot. Above all, the plight of women has not improved an iota. What has then been done to improve the situation of domestic pollution? All efforts have focused on epidemiological studies to look further into the linkage between biomass smoke and health. But very little has been achieved in terms of setting and implementing national policies relating to domestic energy use and health.*

2A.1 The impact of biomass burning on health

Use of biomass fuels for cooking is the primary source of indoor pollution.[11] "Such fuels are used by more than three-quarters of Indian households and nearly half of the world's population relies on them," writes Kirk R Smith, professor of environmental health sciences at the University of California, Berkeley, US, and expert on indoor air pollution. And unlike the highly visible pollution from vehicles or smokestacks, which is heavily diluted by the time it travels from the source to the air we breathe, domestic pollution due to biomass burning is inhaled much closer to the source, and in much higher concentrated levels.

Health effects of the polluted air indoors go hand-in-hand with exposure. Biomass fuels, open *chulhas* and inadequate ventilation, all wreak havoc with the lives of two major vulnerable groups – women and children, who spend large amounts of time within the home and experience the worst health effects due to indoor air pollution (*see Box: Biofuel menace*).

Particulates, as Smith points out, are the "oldest" but still the "most important single class of air pollutants." According to an estimate made by him, out of a total of 8.2 million deaths in India in 1989, almost 0.9-3.6 million could be attributed to particulate air pollution. Concentrations of particulates found indoors, according to available studies, often exceed the levels found outdoors. Considering the fact that people spend the maximum number of hours indoors in the developing nations, exposure to and the resultant negative impact on health from particulates constitute a notable threat.

Rural populations in developing nations bear the greatest burden of exposures to particulate matter. An average particulate concentration of 551 μg/cum overwhelms rural homes in developing countries, which is a shocking nine times higher than the corresponding levels in developed countries. In developing countries, indoor concentration of particulate matter exceeds that of outdoors. Despite growing outdoor pollution due to vehicles and industries, urban concentrations of particulate matter are 278 μg/cum, which is 50 per cent lower than the rural indoor levels. [12]

Particulate concentrations present indoors in rural homes of developing countries is equivalent to the entire world breathing 176 μg/cum. It is, however, not surprising that exposure to and the resulting negative impact on health from particulates constitute a significant threat (see Graph 8.1.3).

It has been found that compared to modern cooking fuels like kerosene and liquefied petroleum gas (LPG), biofuels generate 10-100 times more respirable particulates per meal owing to their low thermal and heat-transfer efficiencies. Biofuel combustion is also responsible for the emission of pollutants such as sulphur dioxide, nitrogen dioxide, carbon monoxide, total suspended particulates and polycyclic aromatic hydrocarbons. *A TERI study in 1998 also estimated that if all the households in Delhi alone that use biofuels for cooking were to change to cleaner fuel like kerosene, the net economic gains would be at least Rs 280 million.[13]*

Respiratory infections, one of the three major causes of infant mortality in India (the other two being diarrhoea and malnutrition), is a result of exposure to fine particulate matter both outdoors and indoors. *The incidence of ARI is considerably higher in developing countries; 51-20% of children under 5 years of age suffers from pneumonia every year. Of these, ARI accounts for 15-30% of childhood deaths, with mortality ranging from 3.2 to 13.8 deaths/1,000 children. On an average, a child in an urban area suffers from five to eight episodes, whereas in rural areas, three to five episodes of ARI occur per year.[14] A community-based epidemiological study conducted in Beijing, China, showed that*

the highest incidence of ALRI occurred in children under 1 year of age: 4.2 episodes per child per year in infants compared to 2.1 episodes per child per year among children 4-5 years old). Board on Science and Technology for International Development (BOSTID) researchers also found that the pattern of age-specific rates of ALRI has a striking pattern of decreasing incidence rates with increasing years of age.[15]

Studies in a number of countries and settings have shown that there is a definite linkage between exposure to smoke from cook stoves with the development of Acute Respiratory Infection in children. For instance in Nepal a recent study observed a significant relationship between the number of hours spent near the fire and the incidence of moderate and severe cases among 2 year olds.[16] *Likewise a study in Gambia found that children carried on their mother's backs as they cooked over smoky stoves contracted pneumococcal infections - one of the most serious kind of infections at a rate 2.5 times higher than non-exposed children. Overall studies indicate that exposure to wood smoke from cookfires in poorly ventilated conditions may increase the risk of a young child contracting a serious respiratory infection by two to six times.*[17]

Ill effects of severe indoor pollution influence adults as well. Various studies have found strong links between chronic lung diseases in women and exposure to smoke from open cookstoves. Among adult women, chronic lung ailments and cor pulmonale are the common killers, while adverse outcomes of pregnancy and eye disorders constitute other significant problems. *A recent Colombian study found women exposed to smoke during cooking were more than three times more likely to suffer chronic lung disease* [18]*. A study in Mexico showed that women who had been exposed to wood smoke for many years faced 75 times more risk of acquiring chronic lung disease than unexposed women - about the level of risk that heavy smokers face* [19]*. Lung cancer too is associated with high levels of smoke specially coal smoke which contains a plethora of carcinogenic compounds. More than 20 studies suggest that women who use coal for cooking and heating over many years are prone to the risk of lung cancer 2-6 times higher than those women who use gas. Rural coal smoke exposure which tend to be higher seem to increase lung cancer risks by a by a factor of nine or more.*

Exposure to high indoor smoke levels has also been related to pregnancy related problems like still births and low birth weight. One study in western India showed that a 50% increase in still births associated with the exposure of pregnant women to indoor smoke. Indoor air pollution most likely contributes to excess heart disease in developing countries as well. The most sought after transition from dirty to clean fuel will greatly reduce the threat from indoor air pollution in developing countries. The speed of this transition will however depend upon several factors including energy prices, trends in personal income.[20]

Blindness

Eye problems are not uncommon in India considering that one-third of global cataracts occur in India. [21] And cataracts are responsible for at least 50 per cent of complete blindness worldwide.[22] The findings of this research suggest that prevalence of blindness in India could be significantly reduced by decreasing people's exposure to smoke from biofuel combustion.

A 1997 study by researchers at the East-West Center in the US suggests that 18 per cent of blindness may be attributed to the use of biomass (wood, dung, crop residue) for cooking. This translates into 29 per cent of blindness in rural areas, and 6 per cent in urban environment.[23] A case

study of cataract patients at a New Delhi ophthalmic clinic showed that low-quality cooking fuels were significantly associated with three of the four major types of cataracts.

Researchers found that persons living in households using biomass as the primary source of cooking fuel had 1.24 times the rate of complete or partial blindness than those using cleaner fuels. Prevalence rates of partial blindness were 7,206 per 100,000 people in biomass using households compared to 5,489 per 100,000 people in households using cleaner fuels. The prevalence of partial blindness is about 10 times higher than that of complete blindness. Blindness and cataract are major health problems in India. Studies have indicated that cataract accounts for more than 80 per cent of complete blindness in India.

Biomass fuels are used for cooking by about three-quarters of the population. The proportion is almost three times higher in rural areas (93 per cent) than in urban areas (32 per cent).

Neonatal immune system

Indoor air pollution can affect the immune systems of newborns, making them more susceptible to illness. A 1995 study of infants from tribal families in east India found that newborns exposed to indoor pollution had higher levels of gastro-intestinal tract and respiratory tract infections than unexposed infants. [24]The presence of indoor air pollution was correlated with disturbance and depression of serum immunoglobulin levels in newborns, suggesting that their immune systems may be less able to combat illness in the future as well.

Respiratory disease

About 15 million children fall prey every year to acute respiratory infections, the overwhelming majority being in developing countries. Of these, around one-third or 5 million children under the age of five die of respiratory disease every year in developing countries.[25] Since respiratory disease is preventable and curable, this is especially disturbing. Levels of indoor air pollution are significantly correlated with acute respiratory infections in infants, and must be studied as a risk factor in child survival.[26]

In 1997, homes with wood-burning stoves in Delhi were found to have pollution levels which were 50 per cent higher (at 318 mg/cum) than those using kerosene. Infants in these homes had an annual average of 34 episodes of acute respiratory infections per 1,000 child-weeks.[27] Decreasing the amount of smoke exposure could prevent a great deal of respiratory infections. In 1997, the results of a study conducted in Nepal suggested that if all children were moved into the lowest smoke exposure group, up to 25 per cent of moderate and severe respiratory infections could be eliminated.[28]

A study in Lucknow attempted to assess the association between air pollutants and respiratory symptoms complex in pre-school children during 1996. Respiratory symptoms complex includes running nose, cough, sore throat, difficulty in breathing, noisy respiration and wheezing. Even after controlling ambient pollutants, which are known to increase mortality rates, the risk of respiratory symptoms and its duration, pre-school children who remained indoors during cooking hours had double the risk of respiratory symptoms.[29] Moreover, a linkage between respiratory symptoms complex and the use of dung, wood, coal, and kerosene for cooking and heating has been established. This suggests that although increasing ambient pollution levels are of great health concern, the health risks of biofuel combustion continue to be an independent risk factor for respiratory symptoms (*see Graph 8.1.4). A study conducted by The Indian Institute for Population Sciences in Mumbai (IIPS) has revealed that one in every fifteen children under the age of three suffered from ARI marked by cough accompanied by short, rapid breathing. The institute's National Family Health Survey (NFHS) conducted in 1992-93 has shown that children under the age of three in households that use wood or animal dung as their*

primary cooking fuel face an added possibility of contracting ARI than children in households using cleaner fuels. The problem arises mainly from the use of traditional chulhas and poor ventilation. These stoves with their inefficient fuel combustion release a lot of fumes containing a number of noxious pollutants. Long period of exposure to these irritants may impair the clearing ability of the lungs and make them more susceptible to infections. The effects on children who tend to stay indoors are particularly severe.[30]

Chronic respiratory disease

Chronic or long-term exposure to respiratory irritants, namely, oxides of nitrogen, sulphur dioxide and particulate matter, is believed to be the chief cause of respiratory damage. Studies conducted in the early 1980s found a higher occurrence of chronic bronchitis and cor pulmonale in rural women exposed to *chulhas* fuelled with cowdung cakes and firewood.[31]

Even healthy women in rural areas have been found to have a lower ventilatory capacity compared to urban females.[32] Therefore, more research is necessary to determine whether *chulha* smoke is actually the cause of the higher levels of respiratory symptoms, as other factors such as recurrent respiratory infections during childhood, overcrowding, malnutrition and ambient air pollution could be responsible.

Studies done in the 1980s found similar associations between *chulha* smoke and respiratory distress in urban populations. A 1996 study of 315 women using biofuels, kerosene and LPG (105 each) within an urban slum of Pondicherry
concluded that 23 per cent of women using biofuels reported having respiratory symptoms (which were cough, cold, breathlessness or chest illnesses, which limited household activity for more than one week) as against 13 per cent of kerosene and 8 per cent of LPG users. [33]

While women in the Pondicherry study, who used kerosene and LPG cooked for about three hours, biofuel users spent approximately four hours cooking each day. In addition, women who used biofuels spent a larger percentage of their cooking time near the stove. They reported spending about 37 per cent of cooking time in front of the stove, compared to around 25 per cent for women who used other types of fuel (*see Table 8.1.5*). [34] Both, the prolonged exposure to pollutants, and increased time spent in close proximity to the stove, could have a deleterious effect on their respiratory health. A negative correlation between lung functioning, duration of cooking and exposure has been observed elsewhere, too.[35]

Chronic obstructive lung disease

Chronic bronchitis predominantly affects males in the developed world.[36] However, in developing countries, despite the fact that men smoke much more heavily than women, both groups are equally affected by chronic bronchitis. Exposure to biomass fuels in the home has been responsible for the additional burden of the disease in women. Their exposure to smoke in the domestic environment for several hours every day and over several years, leads to pulmonary hypertension and cardiac enlargement, ultimately resulting in cor pulmonale**.**[37]

In fact, although 75 per cent of the males who suffer from chronic bronchitis are smokers compared to 10 per cent of women who smoke, the rate of cor pulmonale among men and women in northern India is same.[38] Researchers suggest that as nearly all women who suffer from chronic bronchitis use biofuels for cooking, exposure to smoke was responsible for the increased prevalence of the disease in them. This also explains the earlier onset of disease in women, who may have been

exposed to biofuel smoke much before men started smoking (*see Box: Cigarette smoke versus* chulha *smoke)*

Tuberculosis

Research indicates that cooking with biomass fuels has a major effect on the risk of tuberculosis even after a number of other factors that add to the risk are statistically controlled by holding them constant. It is estimated that in India among persons age 20 and over, 51% of the prevalence of active TB is attributable to exposure to cooking smoke from biomass fuels.(10)[39]The world's leading cause of death from a single infectious agent, TB claims an estimated 3million people each year worldwide.). India has the largest pool of TB infected people of any nation. It is estimated that more than half of India's adult population are infected with the TB bacterium and the disease claims about 500,000 lives each year in the country. At nearly 5% of the total, India has a larger fraction of its national burden of disease due to TB than any other region, although the actual risk per person is less than in Sub Saharan Africa. [40]

"The mechanism by which cooking smoke increases the risk of TB are not clearly known. What seems most probable is that cooking smoke interferes with the ability of the respiratory system to resist infection by the TB bacterium or to resist development of active TB in already infected persons" says Vinod Mishra. Smoke emanating from biomass fuels is also known to interfere with important pulmonary immune defence mechanisms in animals. There is evidence that exposure to polycyclic aromatic hydrocarbons, especially benzo[a]pyrene(B[a]P), can cause immune suppression in both animals and humans. B[a]P is a known carcinogen which is found in large quantities in biomass smoke along with various other polyaromatic hydrocarbons.[41]

The figure below shows unadjusted and adjusted effects (rates are said to be adjusted when all variables except one are controlled to assess the effect due to that particular variable whereas unadjusted rates certify the totality of the effect brought about by more than one variables operating on it.) of cooking fuel type on prevalence of TB. The unadjusted prevalence rates of TB is substantially higher among persons living in households using biomass fuels (1046 per 100,000 persons) than among persons living in households using cleaner cooking fuels (296 per 100,000 persons). [42]Adjusting for the control variables reduces this difference to a certain extent. The adjusted TB prevalence rate is 969 among those using biomass fuels and 378 among those using cleaner fuels.
Figure 3

Source:Mishra Vinod K, Robert D Retherford and Kirk R Smith.1998. Biomass Cooking Fuels and Prevalence of Tuberculosis in India. *International Journal of Infectious Diseases* (forthcoming)
Note: Adjusted and unadjusted rates
Adjusted and unadjusted ratios are estimated by logistic regression. Unadjusted ratios are based on separate logistic regressions for each variable whereas the adjusted ratios are based on a single logistic regression consisting of all variables.

Cancer

While no study is available in India to link domestic air pollution to cancer, studies have been conducted in China on the association between using coal as fuel and lung cancer.[43] Research pinpointed many

chemicals such as the potent poly-aromatic hydrocarbons in biomass smoke, which are known to cause cancer in test animals in laboratories. Further investigation of this association is necessary before any conclusions can be reached.

Adverse pregnancy outcomes

Although there is a lack of research focusing on adverse pregnancy outcome, a 1991 study in Ahmedabad had shown that women exposed to domestic smoke during pregnancy had one-and-a-half times the odds of stillbirth compared to mothers who were unexposed. [44]

Indirect evidence suggests that increased carbon monoxide content, which occurs as a result of biomass burning, could lead to stillbirths, neonatal deaths or low birth weight. As documented in research on maternal cigarette smoking and birth outcomes, carbon monoxide limits oxygen delivery to haemoglobin of both the mother and the foetus.[45] Considerable amounts of this undesirable gas has been detected in the blood streams of women cooking with biomass in India and Guatemala. Besides, studies conducted in western India associate a 50 per cent increase in stillbirths to exposures suffered by the region's pregnant women.

2A.2 Monitoring air quality in homes

More than 60 per cent of the total worldwide exposure to particulates is attributable to biofuel combustion. However, enclosed spaces within the home are not systematically monitored by the pollution boards. In fact, a 1995 study conducted by the World Bank on the economy-wide costs of air pollution did not consider the impact of indoor air pollution, supposedly due to absence of data in this field. The study did, however, acknowledge that "indoor air pollution, due to cooking and heating with biofuels, is potentially a large public health factor in both urban and rural areas." [46] This is quite an understatement considering that 80-100 per cent of daily exposure to air pollution is contributed by the indoor environments.[47] In other words, if people are spending most of their time indoors, the quality of their indoor air has greater health consequences than the outside or ambient air.

Quality of air is often monitored in the occupational setting. This is important, since people spend about 40 hours per week at the workplace. However, for many women home is their occupational setting. Studies have revealed that women spend 80-100 per cent of their time indoors, hence, the quality of indoor air has greater health consequences than the outside air. While the World Bank study on health effects of air pollution estimated that around 40,000 deaths in India can be attributed to air pollution in 1991-92, a 1997 study by Tata Energy Research Institute (TERI), a consultancy working in the area of energy, of total number of women using the fuel type which takes indoor levels of pollution into account puts the number of premature deaths each year at around 2.2 million.

In an essentially 'back of the envelope' study, the researchers considered fuels that emitted different levels of PM10 (different fuels emit different levels of PM10 — for Example, biomass such as dung, charcoal and wood emit up to 1.4 mg/cum, while LPG emits only about 0.4 □g/cum), for seven major activity-based groups of the Indian population (women workers, housewives, infants, male workers, elderly, school/college children, and unemployed males). Among other things, the study concluded that 440 million asthma attacks could be attributed to PM10, annually (*see Table 8.1.6*).

Decreasing people's exposure to domestic pollution involves three types of improvement — improved ventilation, stoves and fuels. But this is easier said than done. There are different people, policies and practices involved at every level of domestic pollution. Domestic pollution cannot be addressed without

looking at the issues of women's empowerment. At the same time, a purely grassroots approach, however well-intentioned, will not be able to improve people's overall health and well-being. Domestic pollution is an issue energy, social justice as well as availability of resources. Educational programmes to promote increased ventilation, keeping children away from the kitchen during cooking or the use of improved *chulhas* will not address the underlying issues of willingness to change or access to less polluting fuels and cooking methods.

Cooking on *chulhas* results in pollutant emissions much higher than those recommended by National Ambient Air Quality Standards (NAAQS). On an average, *chulha* smoke contains 457.6 µg/cum of sulphur dioxide, 118.4 µg/cum of oxides of nitrogen, and 2018.18-2544.5 µg/cum of SPM.[48] [49] This is especially alarming, given that sulphur dioxide and PM10 (the respirable or inhalable component of SPM) are the pollutants responsible for 95 per cent of the health impacts of air pollution.3

Tests conducted within laboratory settings demonstrate that improved *chulhas* can decrease the levels of pollutants emitted. .[50] [51] A study comparing the minimum emission value of the traditional *chulha* with improved *chulhas,* reports 96 per cent to 100 per cent decrease in sulphur dioxide levels. In addition, oxides of nitrogen levels fell by 36 per cent and
48 per cent, while formaldehyde levels decreased to 32 per cent and 76 per cent below the minimum emission values for a traditional stove. .[52] [53] However, improved stoves are not likely to be the only cure to indoor pollution. Access to cleaner burning, processed biofuels should be the long-term goal.[54] But *chulhas* do address the short-term goal of decreasing levels of pollutants emitted from biomass combustion.

The National Programme of Improved *Chulhas* set a target to install 2 million improved *chulhas* every year.[55] By 1994, the programme had reached an impressive 119 per cent of the goal. About 15 million improved *chulhas* were installed by 1994 while an estimated 3 million were installed every year thereafter. However, in a large number of cases, faulty construction and poor maintenance resulted in poor performance. Moreover, a survey by the National Council of Applied Economic Research found that 62.2 per cent of the users did not even know whom to contact in case of any problem.[56] This clearly underlines the importance of improving dissemination programmes. . Biogas technology, if properly implemented, has the potential to free people from ill-effects of biomass smoke. " *The mixed experience so far is that biogas remains one of the most promising solutions to the indoor air pollution problem" says Dr. Jamuna Ramakrishna, indoor pollution expert and Head HIVOS, India Regional office. [57] However the rate of market penetration of biogas has not really grown rapidly with time. She adds further " though many questions can be raised about why biogas has not lived upto its potential so far, top priority should be accorded to identifying the constraints in increasing the rate of penetration. Biogas in combination with LPG and kerosene could play a major role in reducing exposure to indoor pollutants". [58]* Unfortunately, socioeconomic conditions, such as low livestock ownership, is a constraint for many families. Dung availability is a major constraint for families which do not own livestock.[59] The Ministry of Non-conventional Energy Sources (MNES) estimates that 12 million biogas plants, representing 10 per cent of the total rural households, could potentially be installed. However, as of 1995, only 18 per cent of this potential had been achieved.[60]

2A. 3 The fuel ladder

In the past, it was thought that as development and industrialisation take place, people's use of fuels would go up the 'energy ladder' — towards higher quality fuels subsequently, from dung to crop residues, to wood, to kerosene, to gas and then to electricity.[61] However, this has not proved to be easy.

People use specific types of biofuels not out of preference, but out of practicality. A study conducted in the Tehri Garhwal area in 1995 states that 44 per cent of the people interviewed chose their primary source of fuel because of low cost and easy availability and 29 per cent chose their fuel

based only on easy availability. Of these, 41 per cent used mud *chulha,* while 44 per cent used both *chulha* and kerosene stoves.[62] However, 93.8 per cent of the respondents felt smoke was a problem and 95.2 per cent of mothers felt smoke was a problem for the health of their children. But still they were not ready to change their fuel.

Jamuna Ramakrishna, indoor air pollution expert with HIVOS-India, a Dutch funding agency, points out, "the problem of indoor pollution is an outward sign of the low value placed on the time and labour of women." Since the large amount of time and energy spent in collecting fuel does not produce cash income, it is not regarded as 'work' by the society and, thus, no investment is made to save women's labour.

It is clear that estimates of the health effects of air pollution must incorporate the indoor environment. Until this happens, the source of pollution with the greatest health consequences will remain unchecked, and poor women and children will continue to suffer the most.

2A.4 The way ahead

It is clear that estimates of the health effects of air pollution must incorporate the indoor environment. Until this happens, the source of pollution with the greatest health consequences will remain unchecked, and poor women and children will continue to suffer the most.
Epidemiological studies to show the linkage between exposure to indoor pollution and adverse health effects are still not carried out to the required extent and absence of such studies impede proper actions." There is a need to conduct a greater number of studies and at the same time make inferences from research done elsewhere" says Kirk Smith.[63]
Better ventilation has shown improvement in the status of indoor air where biofuels are used**.** Sumeet Saxena ,environmental expert with TERI says "Kitchens under government housing schemes in both rural and urban areas should have proper ventilations. Studies exploring effectiveness of various interventions like alternative fuels and smokeless chulhas should be carried out." [64]Designing of houses with proper ventilations and smoke outlets from kitchens can go a long way in improving the health of indoor air and the occupants. To focus attention "design competitions can be held at regular intervals" Suggests Ramakrishna.[65]
Due to a poor health surveillance system, there is a lack of adequate information on the health effects due to domestic pollution. While surveillance systems are useful for detecting infectious disease outbreaks such as dengue and tuberculosis, they are also necessary in order to get a sense of the baseline health status of the population.

One way to reduce health damages due to indoor air pollution is to improve household ventilation but the strategy often worsens the outdoor environment. A more effective approach would be to promote the use of improved stoves that remove the smoke from the house through a flue or chimney. In the past 20 years hundreds of improved stove programmes have met with success in many developing countries round the world**.** [66]

Although most of these programs had the chief objective of improved fuel efficiency rather than smoke removal studies have shown that a well designed, well built and maintained stove can reliably lower the indoor air pollutants from cooking to levels 10-40% of those in Kitchen with open fires. However at times the programmes may also fail due to reasons like ignorance about the end user or because of the policies guiding them. For instance the National Improved Chulha Programme in India failed to achieve results as "it did not take into account the health considerations and needs of the women in designing and disseminating the improved stoves" says Madhu Sarin , an expert on indoor pollution.[67] Thus

improved stoves should be seen as an interim solution in the transition to less polluting and more efficient liquid fuels like LPG and kerosene and electricity as well.[68]

National governments can help facilitate this transition to cleaner household fuels. Poor families can benefit from policies that reduce the upfront cash costs of new appliances or of obtaining electricity connections. The urban poor can benefit from what is known as the life line electricity rates. This is being carried out in Thailand on an experimental basis. Here the urban poor pay much less for the same amount of energy utilized as the wealthier households and the entire country has near universal electricity. The menace of biofuels also decreases as usage of electrical energy and improvised equipment's reveal their advantages[69]. The experience can well be utilized in India too where the government takes an initiative to provide cleaner fuels at a life line rate which may also be referred to as a highly subsidized rate meant for the population that require it most and can afford it least

A shift from biofuels to cleaner fuels will probably occur slowly because the latter option is expensive than the biomass fuels. Considering such constraint it may be feasible to say that the government should initially strengthen its efforts to improve the biofuel burning stoves and also their dissemination to the population that needs it most. Stoves that emit less smoke and are more fuel efficient have to be made widely available or else the wait for cleaner fuels might just prove to be too futile. The cost will be high, health and environment.

Boxes
Box: 1
Cigarette smoke versus *chulha* smoke

Wood smoke is as bad as cigarette smoke

Tobacco smoke and wood smoke are similar mixtures in many ways. Suspected carcinogens in cigarette smoke, such as benzo(a)pyrene and formaldehyde, are also present in wood smoke.[70] Assuming that an average smoker smokes around 40 cigarettes per day, the exposure of a person cooking with biofuels can be compared to both active and passive (second-hand smoke) smokers. Active smokers inhale pollutants with every "puff", but a filter absorbs some of the toxins present. In contrast, both passive smokers and people who cook with biofuels are exposed with every breath.

Until more epidemiological studies are conducted on the health effects of biomass combustion, information from literature on smoking and health can be used to get an idea about possible effects of domestic smoke exposure.

[70] **Box:1**

K R Smith 1987, *Biofuels, Air Pollution, and Health:* A Global Review, Plenum Press, New York (Available in CSE library, Class No.106A2, Accn. No. 19346).

Box: 2
Biofuel menace

About 75 per cent of India's households use biofuels

Traditional biofuels include fuelwood, crop residue, dried animal dung and scrub plants. [71] Half of the world, including 75 per cent of India's households, cook with biofuels.[72] In fact, this accounts for more than 80 per cent of India's domestic energy consumption, with approximately 1 kilogramme of air-dried fuelwood equivalent being used per person per day.[73] If space heating, water heating, fodder preparation and alcohol manufacture is done using biofuels, this estimate would be even higher.

Six major pollutants — carbon monoxide, particulates, benzo(a)pyrene, formaldehyde, oxides of nitrogen and sulphur dioxide — are emitted as a result of biofuel combustion.[74] [75] [76] Different biofuel sources emit varying levels of pollutants. However, in general, biofuel sources at the lower levels of the 'energy ladder' (dung and crop residues) give off higher emissions.[77] Every kilogramme of wood burnt emits 40 milligramme (mg) of carbon monoxide, 2,000 mg of particulates, 1 mg of benzo(a)pyrene and 200 mg of formaldehyde.

Box: 3
Case study of Fuel usage in three villages of the Garhwal Himalayas [78]

In the Garhwal Himalayas, as in most rural areas of developing countries, biomass continues to be the major source of domestic energy. Investigations have been conducted in India and Nepal to obtain data related to time budgets of rural communities and were mainly concerned with the implications of the data for planning rural energy programs and for development in general. It is also important to know how people distribute their time over space i.e information is needed on how much time is spent on a particular activity and in which specific polluted environment.

In recent years, scientists and planners have been concerned about the gap between forecasted estimates of biomass supply and demand. A study in 1989 (Gadgil, Sinha, and Pillai) estimated that the demand for fuelwood in eight districts of Garhwal and Kumaun was 1.8 million tons (Mt), while 20.3 Mt was available as a fuel from forests and wastelands. [They projected that the demand would be 2.2 Mt in 1991; 2.5 Mt in 1996; and 2.8 Mt in 2001.It is expected that the supply would not change significantly from 1989 levels]. In a study of the hill and mountain regions of Nepal, fuel wood and timber production was estimated to be 0.7 Mt, while the requirement would be 4.3 Mt in the period 1985-2005 (Hrabovszky and Miyan, 1987). Biomass resources are spread widely, and their use as fuel is largely in uncontrolled and in non-commercial sectors. Therefore, the data on these resources and their use are scanty, and are not available in adequate detail for carrying out an appropriate energy development study. While the difference in estimated of supply and demand may in large part reflect actual scarcity of future surplus, it is also likely a result of measurement errors in questionnaire-based surveys of demand. There is an urgent need for regional ecological studies of biomass budgets that rely on measurements made in the field (Mahat et al., 1987).

This study in the Garhwal Himalayas aimed to assess the daily exposure of women and other population groups to pollutants (total suspended particulates and carbon monoxide) released during the combustion of biofuels. In contrast to earlier studies this one recorded the exposure to pollutants in all micro-environments and not only in the kitchen. In addition, the assessment required estimates of how much time each population group spend in these micro-environments which typically include kitchen, living room, and fields

The study focussed on the seasonal and altitudinal variations in fuel usage in Garhwal Himalayas along with the time spent in six important micro-environments by four population (men, women,

youths, and children in three villages in the Pauri district of the Garhwal Central Himalayan region of north India.

The villages and the sample of households were based primarily on criteria related to the assessment of exposure to pollutants. Villages located away from roads were chosen to avoid interference from vehicular emissions. The three villages chosen for this study were Kweerali, Kadola and Bhainswara) with populations of 88, 69, and 400 people respectively. Four households were that had a fully protected kitchen located downstairs as a part of the house but not connected to any other room were chosen in each village. The sample size was 75 individuals.

Table 1. Time spent (number of hours) in various micro-environments

		Micro-environment					
Group	Season	1	2	3	4	5	6
Children	Monsoon	1.2	0.6	14.0	1.0	4.6	2.7
	Winter	1.0	1.0	14.0	4.0	4.0	0.0
	Summer	1.1	0.3	14.7	1.3	4.0	2.7
Women	Monsoon	4.3	0.8	9.3	0.4	6.0	3.1
	Winter	5.2	1.0	9.2	1.1	3.2	4.4
	Summer	3.2	1.3	7.7	0.0	3.9	7.9
Men	Monsoon	0.4	0.0	10.0	1.7	2.9	9.0
	Winter	0.3	0.0	11.1	1.4	2.0	9.2
	Summer	0.0	0.0	8.2	0.2	2.1	13.5
Youths	Monsoon	0.4	2.2	8.8	1.8	2.1	8.7
	Winter	0.1	0.0	11.6	1.7	2.2	8.4
	Summer	0.3	0.2	9.7	1.3	2.9	9.7

The fuel used in the sample households are no different from that used across the region. Woody biomass is the primary fuel used in this region. Crop residues and animal dung are rarely used for cooking and fuel is seldom bought or sold.

The fuel burn rate (burn rate is the amount of fuel burnt in a unit of time. It determines the power output-and , therefore, the performance-of a cooking system) was 1.49 kg h^{-1} (range: 0.32-4.85, n=96).; Variations due to differences between households contributed only 5-19% of the total number of variations. Given the uniformity in fuels and stove designs that households use, this implies that women of different households tend the fire in a similar fashion.

Results of this study confirm that in these three villages, as in other rural areas, women work longer hours than men However, time spent in fuel collection by the women in this study far exceeds that in other parts of India and in Nepal This may be attributed to the rapidly shrinking forest cover, whatever its cause may be. It was also observed that collection of fuel-wood and fodder here are activities that are performed exclusive of any other activity and of each other. That is other chores are rarely combined with these tasks even during the agricultural seasons although exceptions may occur when the crops are being harvested. This observation contrasts with information from other areas. Time spent in collecting fuel is strongly influenced by season. It is likely that these women may perceive time saving in fuel collection as a benefit, while this may not be so in other areas. Fetching water is not as time consuming as reported elsewhere. The villages in this study have tanks and natural springs in their vicinity.

Women and children in this area are the only groups that stay indoors for a longer period than they stay outdoors. But even for these two groups the time spent indoors is significantly less than the time spent indoors by their counterparts in more developed societies. In an agricultural society, such as the one in the Garhwal Himalaya, such patterns are to be expected. For all groups of the population, the indoor micro-environments contributed more to the daily integrated exposure than the outdoor micro-environments. Only women and children were exposed to high levels of carbon monoxide because of the time they spend in the kitchen. Exposure in summer was high than the exposure in winter. This was mainly owing to the higher concentrations in summer and not because of the difference in time spent in cooking. For women, cooking contributed the most to the daily exposure to TSP (total suspended particulates). For men. Youths and children it was the time spent in the living room that was responsible for most of the daily exposure to TSP. For these three groups it was the greater percentage of time in the living room in winter than in summer. Agricultural activity contributed significantly to the daily exposure to TSP for men and youths in summer (Saksena et al., 1992).

The results of this study on the assessment of exposure to pollution include remote rural areas, where there are no sources of air pollution other than biofuel combustion, 80-100% (depending on the pollutant) of the daily exposure of women and children is contributed by indoor micro-environments. Specifically, these are the kitchen-cooking and kitchen-non-cooking micro-environments.

In each village we observed little diversity in the species of wood used. This did not reflect the choice of the users, but the low diversity of available species. Per capita consumption of fuel for cooking was found to decrease with altitude. This should not be taken to mean that net useful energy consumption would necessarily have the same relationship with altitude. To establish that, we would need to understand the properties of the species of wood used and other characteristics of the complete cooking system such as physical and chemical characteristics of the fuel, thermal efficiency of the stove, type of vessels, and fire tending habits.

Results show that, for consumption of fuel, economies of scale do exist. Yet, beyond a family size of eight. This does not hold well. The variation of per capita consumption with family size has serious implication for traditional forecasting methodologies as does also the significant variation with respect to season.

Box: 4
Interview with Kirk Smith

Kirk Smith is a Professor of Environmental Health Sciences at University of California, Berkeley and a leading expert on indoor air pollution. For over two decades, he has championed the cause of air pollution in poor households in India. His recent work to evaluate the national burden of disease due to indoor air pollution echoes his concerns once again. He spoke to Priti Kumar and Max Martin about this. [79]

What are the results of the study you recently completed?

According to the study, it is estimated that there are five lakh premature deaths a year from indoor air pollution exposure in India. This represents about 6 per cent of the overall deaths, which is 9 million.

The study considers two population groups; children under 5 years and adult women. Men were not included in the study because men receive lower exposures as usually they don't cook indoors.

There are several factors such as poor nutrition which can influence the number of deaths in India. In light of this, how do you then explain 5 lakh deaths due to indoor air pollution alone?.

It means that if we reduce the air pollution indoors and do nothing else at all in India, that is, retain the number of households, nutritional status, medical care, crowding and other conditions then would be 5 lakh fewer premature deaths. However, if you improve the nutritional status of some people before improving the air pollution there won't be so many deaths as some of those people will be resistant to air pollution because they have better nutrition. So the risk factors for nutrition and air pollution to some extent overlap.

How is your study different from the previous studies done in the area of air pollution?
We applied a new technique which is more accurate to evaluate the disease impacts of indoor air pollution and also it reveals not only the number of deaths but also the illnesses involved, the age groups involved. So we get a much better feeling for the impact than just total number of premature deaths which previous methods gave. The previous methods estimated the air pollution exposure and then applied the risk estimates from developed countries city studies mainly studies in Europe and United Stated. The problem with doing this is that the populations where these studies were done are very different that those exposed to air pollution indoors in India which are mainly rural and poor. So the background, the health, nutritional status the disease pattern is very different. It is therefore not entirely convincing to apply these risk estimates that have been developed in Europe and US to the Indian situation. There are now several dozen studies that are done in developing country households using solid fuels like biomass or coal whose results can be applied to the Indian situation. This is what we did.

What prompted you to take India as a case study?

I've worked in India on these problems since the late 1970s and known India best in terms of the data and information. India, although it has a lot of data gaps, there is more information on these situations than any country except China. So it is possible to do these estimates here and also in China. But it really isn't possible in other parts of the country. For example, Sub-Saharan Africa makes greater use if biomass in households and there is even a greater background rate of disease, but there is so few data that it is hard to do anything quantitative. We could have done such a study in Pakistan or Bangladesh, but doing it for India gives an idea as to what's going on in other countries which have similar populations.

So you find India representative of other developing countries?

India certainly represents the South Asia. But it is not representative of China. In China, there is so much use of coal and coal causes different kinds of problems such as lung cancer. On the other hand, biomass in India seems to produce a lot of acute respiratory infections.

How much of the problem can be rectified by better fuels and better kitchens?

I can tell you that simply all of this can be rectified by cleaner fuels. Its difficult to say how much can be rectified by improved stoves and improved kitchens. I don't have much hope for improved kitchens if you're still using a dirty fuel. Consider this example. If you're burning wood a kilogramme an hour in a

typical indoor household for a meal and in the kitchen you have a one square metre opening in one wall and the same in another wall. The question is how much air would have to come through in order to bring the concentration of pollution down to the Indian situation. The answer is a 100 kilometre per hour wind. Therefore, ventilation is not a practical solution. It may improve the situation.

What is your view of the effectiveness of the improved chulha programme?

The total amount of money spent on improved stove programme in India, for that matter, any part of the developing world is less than the air pollution controls on one new thermal power plant. So I'm not convinced that enough money is being spent to decide that is a hopeless. On the other hand, the number of people and institutions involved in the programme is very small to make a difference.

Box: 5
Modern decor: Foul Air: Indoor Air Pollution Due to Modernisation of Indoor Environment

Home, sweet home - the most sought after abode at the end of a day or even to spend a day. Well how does the picture of a modern home look like?

A huge house decorated with carpets, air conditioners, wall mats
with dirty air to breathe.

An office full of computers, photocopiers, coolants
and foul air.

Does that appeal?

No more a 'developed country' syndrome

As we try and compete with the developed countries in decorating our homes and offices we deliberately try to ignore that pollution is omnipresent today not only in developed countries but in developing ones too. The Indian concept of air pollution till date remains associated with the quality of air outdoors when indoor air has been attacked aggressively and we suffer most when we assume to have evaded the monster outdoors. Indoor air pollution actually poses a greater health risk on a global level. Energy efficiency improvements sometimes make houses relatively airtight, reducing ventilation and raising indoor pollutant levels. Under such circumstances small pollution sources emanating from a furnace, a new carpet or from naturally occurring radon gas- can lead to significant human exposures.

As technologies in the global village commute swiftly so do their disadvantages. So can we really say that modernisation of indoor environs and their results still remain restricted to the developed world?

Criminals galore

How many of us really know who the criminals are even if we want to fight the crime? The answer encompasses a host of substances that today have become a part of our daily lives and so are probably used thoughtlessly. Biological agents, gases, particulates and chemicals. Biological agents include proteins from dust mites, insects and pets (hide, urine, faecal droppings), moulds and mildews, infectious agents and pollen. Building material may contribute agents from wood, wall coverings,

carpeting, fibreglass, paints and resins. Cleaning solutions, perfumes and insecticides are other sources of indoor agents that may affect the health of occupants.

Table1:Common indoor air agents: Acute health effects, mechanisms and susceptible population.

Agent/source	Indoor source	Acute effect or symptoms	Mechanism	Susceptible population
Gases				
Nitrogen dioxide	Malfunctioning gas or oil furnace, hot water heaters, fireplaces, tobacco products	-Respiratory tract irritation and inflamm-ation . -Increased air flow resistance in respiratory tract. -Increased risk of respiratory infection.	-Sensory and pulmonary irritation Possible peroxidative damage (oxidative stress)	-Vitamin E and C deficient individuals -Exercising individuals
Carbon monoxide	Garage, transfer of outdoor air indoors, malfunctioning gas stoves and heaters, tobacco smoke	-Impairment of psychomotor faculties -Headache, weakness, nausea,dimness of vision and dizziness -Coronary effects with high concentrations	Binding to biomolecule	Individuals with advanced cardio-vascular disease
Sulphur dioxide	Kerosene heaters	-Bronchoconstriction, often associated with wheezing	-Sensory and pulmonary irritation -Mast	Asthmatics particularly during exercise

		and respiratory distress -Impairment of lung function -Increased asthmatic attacks	cell degranulation	
VOCs				
Formaldehyde	Tobacco smoke, glues and resins	-Irritation of eyes and respiratory tract. -Headaches and nausea -Bronchial asthma at high doses -Allergic contact dermatitis and skin irritation	Sensory irritation	Sensitised individuals(allergic contact dermatitis)
Reactive Chemicals				
Isocyanates	Paints and foams, structural supports	-Upper and lower respiratory tract irritation -Bronchoconstriction -Contact dermatitis -Pulmonary sensitisation	-Sensory and pulmonary irritation -Immediate hypersensit-vity	Sensitised individuals
Trimellitic anhydride	Plastics, epoxy, resins and paints	-Bronchial asthma, rhinitis -Contact dermatitis	-Sensory and pulmonary irritation -Immediate hypersensitivity	Sensitised individuals

			-Cytolytic hypersensitivity -Sensitised T cells	
Environmental protectants				
Biological allergens: cockroaches,insects, pollen etc.	Pests, insects, plants	-Hypersensitivity pneumonitis causing cough, dyspnea and fatigue -Allergic rhinitis -Asthma	Immediate hypersensitivity	Sensitised individuals
Toxins: fungi, bacteria	Fungus and bacteria	-Hypersensitivity pneumonitis causing cough, dyspnea and fatigue -Humidifier fever causing flulike illness with fever, chils, myalgia and malaise	-Immediate hypersensitivity -Comple-ment fixation -Cytokines, inflamation	-Sensitised individuals -Hypereresponsive individuals -Atopic individuals -Asthmatics
Airborne infectious agents				
Legionella pneumophila	Bacteria in contaminated water sources such as humidifiers and cooling systems	-Pneumonia -Pontiac fever	Bacterial infection	-Population exposed to nitrogen dioxide and ozone -Possibly immune suppressed individuals, smokers, asthmatics and

				individuals with chronic obstructive pulmonary disease.
Complex Mixtures				
Tobacco smoke	Indoor smoking	-Eye,nose and throat irritation -Nasal congestion, rhinorrhea -Inflammation of lower respiratory tract	-Sensory and pulmonary irritation -Possible peroxidative damage (oxidativ estress) -Binding to biomolecule	Active and passive smokers

Source: Susan M Zummo and Meryl H Karol, Indoor Air Pollution:Acute adverse health effects and host susceptibility, Environmental Health, Jan-Feb,1996, p.27-28

The table represents a number of agents that are responsible for indoor air contamination though it is not an exhaustive list. Most of these agents may be found in both residential and occupational buildings, however compounds such as nitrogen dioxide and many other biological agents can be expected only in residential settings. Acute effects associated with the listed agents vary depending on the concentration and duration of exposure. Additionally, a number of other factors may influence an individual's response including temperature and humidity of the air. Because their is a considerable degree of overlap in the population with regard to thresholds for symptoms and health effects and because the concentrations of pollutants within residential and occupational buildings vary based on ventilation, specific concentrations of pollutants are not listed.

Pollution - going sky high

The more the number of skyscrapers the more developed the city is. High rise buildings with a tight construction, decorated with thick synthetic carpets, air conditioners, wall mats and of course the necessary evil called computers - a very common sight and a status symbol of the new world. But there is a heavy price awaiting to be paid. All these substances release a host of chemicals that affect both men and machines.

Experts often link increased indoor air pollution problems to tighter building construction beginning in the 1970s with the energy crisis. In addition to the trend towards such construction design, the components being used for the purpose have also changed in the last few years with more emphasis on plastics and polymers rather than granite and wood. The development of new sealants and caulks and

other building materials has also presented additional sources of volatile organic compounds(VOCs).[80] (17) The VOCs have been charged with the offence of deteriorating the indoor air quality during the last few years but recent studies suggest that it is only the tip of the iceberg, there is a lot to reveal as yet. When the VOCs mix with other reactive chemicals such as ozone, the resultant chemical mixture is far more damaging. These along with poor lighting and ventilation are possible contributing factors to what is referred to as the 'sick building syndrome'. [81] More than 250 different VOCs have been identified in office air.[82]

Floor tiles, carpets, paint, varnish, new furniture, glues and wall coverings all emit a complex mixture of organic compounds ranging from small reactive compounds such as formaldehyde, to large molecules with long chains of carbon atoms such as decane and glycol esters. People themselves are a major source of VOCs, says Charles Weschler of Bell Communications Research in 1996. Weschler found out that the total concentration of VOCs in densely occupied offices was more twice that in telecommunications buildings where only a few people work. For example, freshly dry-cleaned clothes emit a stream of trichloroethane and pleasant smelling perfumes and deodorants emit chemicals such as limestone, terpinene, camphene and alpha pinene - some perfumes contain as many as 100 different chemicals providing potent additions to the Noxious soup.[83]

As a result of these factors and personal lifestyle choices the air we breathe in our homes, offices and other indoor spaces may contain any number of airborne agents capable of exerting adverse health effects. Exposure to agents in indoor air may result in allergic reaction, irritation and other toxic effects or infection. Individuals exposed to the same concentration of the same agent may respond differently. Individuals may be more sensitive as a result of exaggerated exposure, some innate predisposing trait, life-style or the universal factor of age.

But why is Weschler a researcher for a telecommunications company so concerned about VOCs and their sources?. He has shown that circuit boards suffer from their own form of sick building syndrome. In diagnosing the cause of the problem, he has uncovered a whole new reactive dimension to the chemical soup - one that could also be responsible for the symptoms seen in humans. According to Weschler, the key culprits among indoor air pollutants are a chemical species known as hydroxyl radicals which react quickly and voraciously with most compounds in the atmosphere. Contrary to the accepted belief that there are no radicals indoors, Weschler and colleague Helen Shields recently found as many as a trillion hydroxyl radicals in a cubic metre of indoor air. So where are all these radicals coming from? Radicals are formed by reactions between ozone produced by equipment such as photocopiers and sucked from outdoors - and complex VOCs given off by people. The formation of radicals further leads to formation of harmful chemicals including formaldehyde and other small aldehydes, ketones, acetic acid and nitric acid. These compounds are more reactive than their parent VOCs and play a key role in damaging electronic equipment. (17)[84]

If Weschler's research about hydroxyl radicals and VOCs have helped to explain how machines suffer in the office, they have simply added to the uncertainties of how humans respond to airborne pollutants. After 20 years, scientists have yet to find out how different amounts of
VOCs in offices have their effects on health.

Plants gobble up harmful VOCs

Not only aesthetics plants also act as anti pollutants and that too by eating up the harmful VOCs.

After 20 years of research, retired NASA scientist Bill Wolverton has shown that at least 50 different house plants can gobble up harmful VOCs from the chemical soup present in offices. Azaleas, rubber plants, tulips, poinsettia and bamboo palms can all remove formaldehyde from the atmosphere. Many plants can eat a range of VOCs -the peace lily removes acetone, methanol, ethanol, benzene, trichloroethane, and ethyl acetate from the atmosphere, as well as formaldehyde and toluene. Wolverton first discovered that house plants could eat up VOCs in 1980 while studying the 300 or so VOCs found in the spacecraft air from Skylab missions. A build-up of these chemicals could pose problems in self-containing life support systems such as space stations but Wolverton showed that air quality could be controlled by cultivating the right plants. Using this approach in 1989, he kept the air virtually free of VOCs in NASA's Biohome experiment. Without the plants occupants of the Biohome experienced breathing problems, running eyes, sore throats and blocked noses. So the simplest way to avoid all symptoms of the sick-building syndrome in yourself and your office equipment is to pay a visit to a plant nursery and stock up on plants.

Cancer-out there in the air

Mixer grinders, microwaves and other such electronic items have invaded our homes with a vengeance, They have undoubtedly made our lives easier but not without a price. The cost is health. Exposure to electro magnetic fields (EMFs) in occupational and residential environments might cause cancer. The suggestion came from epidemiological studies conducted by scientists of the western world about a decade back. Reports through the last few years have indicated association between exposures to low frequency (50-60 Hertz) fields and rare cancers, principally leukemia and to cancers that are currently increasing in the US population including brain and breast cancer. Acute lymphocytic Leukemia (ALL) which accounts for 85% of all childhood leukemias in the US has been linked to EMF exposure. Investigators in the University of North Carolina at Chapel Hill's School of Public Health recently assessed the relationship between EMFs and breast cancer mortality in female electrical workers in the US. Their findings indicated that women in electrical occupations have a nearly 40% higher mortality risk from breast cancer than women in the labour force without occupational exposure to strong electric or magnetic fields.(published in the June 1994 issue of JNCI) A stark fact that needs attention is that the studies to associate indoor air pollution with adverse health effects mostly remains restricted to the developed world, the developing countries are still reeling under the 'outdoor pollution' syndrome . The reality is that homes and offices in India specially in the urban areas are designed to pose enough health related problems to the occupants.

COMPUTERS - the web is too tight
Since the explosion of workplace computing started in the 1970s , a wide array of physical ailments has been linked to long hours spent staring at the cathode ray tubes and pounding on the keyboards. In professions like data entry, more than 50% of workers report repetitive stress injuries to hands and wrists. Additional physical symptoms that have been reported are back and neck pain, spontaneous abortions and gastrointestinal ailments, although a cause and effect relationship has not always been substantiated.

The uninvited guests - Asthma an unavoidable curse

Cockroaches, a common sight in the night in most Indian homes may well be the reason behind increase in asthma. In England, in May 1996 the Department of Environment commissioned a survey by the Building Research Establishment which measured formaldehyde, volatile organic compounds (VOCs), nitrogen dioxideand biological particulates over a period of 12 months in 174 homes in South

West England. Findings included a higher count of house dust mites in living rooms with indications that the carpets themselves were a habitat for the mites as well as the matresses and other soft furnishings (7).The study also confirmed that levels of nitrogen dioxide are determined in part by outdoor concentration, but are highest in kitchens with gas cookers(8). Another study published in the year 1996 in the journal Pediatr Nurs stated that up to 60% of the children with asthma test positive to cockroach allergens. According to National Asthma Education and Prevention Program (NAEPP) of the National Institute of Health, US cockroach allergen is the most common source of skin test reactions in the population.[85]

Evidence from a five year National Co-operative Inner-city Asthma Study, done by a team led by David L. Rosenstreich and his colleagues from the Albert Einstein College of Medicine , Bronx, New York and completed in 1997suggests that cockroaches play an even greater role than envisaged earlier.(16)This study in the eight urban areas of US found that asthma was most pronounced among children who are allergic to cockroach allergens and are exposed to a high level of that allergen in bedroom dust. Clues can be derived from studies made abroad that Indian homes are at no less a threat from these denizens, there is hardly a home where these visitors are not seen during the night but there is not a single study in India to explore the conditions of the households infested with such nocturnal visitors. This study was conducted in eight medical centres in seven cities. It primarily aimed to look at why asthma related problems were severe among children in inner-city areas who were allergic to a specific allergen especially in bedroom dust. The researchers were able to trace in more than half the bed rooms of these children to have high levels of cockroach allergen in dust. Children exposed to cockroach allergen also had significantly more days of wheezing, nights with lost sleep, missed school days and their parents or care givers were awakened during the night. They were also 80 percent more likely to have unscheduled medical visits for asthma.

The NAEPP expert panel guidelines recommend control through use of baits and traps to avoid irritating odoursassociated with chemical secretions which itself may produce asthma symptoms. A factor complicating the control of asthma originating from cockroach is that the allergen may be present even when there is no visible sign of infestation. To date there are no conclusive data to link interventions to control cockroach antigens to improvements in asthma symptoms.[86]

Asthma is a debilitating respiratory condition that strikes about one child in every 10 in the United States. It appears to be far more serious in some Indian cities. A study from Bangalore revealed that the instances of asthma have risen from 9 percent in 1979 to 24.5 percent in 1994. Which means that every fourth child is an asthmatic which is significantly high. Chest physicians estimate that even among adults it is about 10 percent and is on the rise with increasing pollution levels in the metros. Most instances result from viral infections, tobacco smoke, allergic reaction to mold, animal dander, dust mites, pollen or other allergens- including the faeces, saliva and other body parts of cockroaches. [87]

Over the past two decades researchers have reported a startling rise in the prevalence of asthma among children and young adults. This trend persists today and mostly in affluent countries leading asthma to be renamed as the disease of the 20th century industrialised world .[88]Though present to a less extent in the developing world, there are distinct signs of emergence of the disease in the urban areas of the developing regions of the world.[89]In many countries where asthma is common today its prevalence has climbed nearly 50% in just a decade.[90] Particularly disturbing is the number of deaths associated with asthma. Among people between the age of 5 and 34 asthma deaths increased by more than 40% between the mid 70s and mid 80s in most countries studied.[91]Asthma in children and young adults is strongly associated with sensitization to allergens found in homes. For instance tobacco

smokes known to increase the risk of asthma. Children have about twice the risk of developing asthma if one or both parents are cigarette smokers.[92] Beyond tobacco the chief culprits indoors are dust mites, cockroach parts and animal dander. Toxic chemicals and pesticides may also be involved.[93]

In common with other allergens, even in the present study the researchers have not been able to explain exactly how cockroach-allergens are implicated in the rising incidence of asthma. But in an editorial accompanying the study, Thomas Platts-Mills of the University of Virginia, Charlottesville and Melody C. Carter of the Emery University, Atlanta cite changes in the housing conditions over the past three decades that might have contributed to allergen exposure, including higher temperature in damp houses, decreased ventilation after energy crisis and the use of more upholstered furniture and carpets. In addition, people were spending more time indoors than ever. Expectedly, experts emphasised that relatively small expenditure in cockroach control could pay substantial public health dividends.

Cleaning homes to breathe diseases

Pesticides commonly used to keep the indoors free from germs and termites but may be we are paying a heavier cost for the same. Chlorpyrifos (common commercial names are Dursban and Lorsban) is one of the most commonly used pesticides in the indoor environment today. It is an active ingredient in flea collars and dips, animal sprays and shampoos, carpets, crack and crevice sprays and subterranean termite treatment as well. According to EPA 972 registered products contain chlorpyrifos including widespread uses for roach and termite control and home and garden use.[94] Recent studies by Gurunathan and her associates at the Environmental and Occupational Health Sciences Institute at Rutgers University (the EOHSI study) indicate that broadcast spraying of chlorpyrifos in the indoor environment may pose considerable risk to public health.[95]In the study, application of chlorpyrifos by trained applicators following recommended procedures produced pesticide residues on children's toys and on hard surfaces in test rooms approximately 21-119 times above the recommended reference dose(RfD) of 3μg/kg/day for chlorpyrifos exposure to children from all sources. Earlier studies have demonstrated that chlorpyrifos air concentrations peak well after broadcast applications and that substantial redistribution of chlorpyrifos from treated to untreated surfaces can occur in the first 24hours after applications.[96] [97] Among the symptoms reported to be linked with chlorpyrifos applications are headache, dizziness, loss of coordination, diarrhoea, blurred vision, mental confusion and muscular weakness. The chemical is widely used in insect control programmes worldwide and has also been linked to respiratory hypersensitivity reactions.[98] In addition a number of cases have been reported of birth defects in children born to mothers who have previously had healthy babies. Prenatal exposure to normal levels of chlorpyrifos has been identified as a possible explanation of these defects.[99]

Act before it gets too late

Monitoring pollutants present indoors is more difficult and their control in part must depend on individual choices. It may be practical to enforce standards for ventilation in new houses and for emissions from new gas appliances but it would be unreasonable to limit the availability of furnishings and household equipment that pose a risk to the exposed population.[100]

Indians even today lack an awareness that there is a term referred to as indoor air pollution and even if there is it still remains restricted to the poor homes that use unclean fuel .The fact is the more decorated and stuffy your homes and offices are, the more are your chances of suffering from pollution related diseases. The authorities and the scientific community of the country need to sit up and give serious thought to the existing scenario before it is too late. There is still a lack of information on

allerginicity due to various agents present in the air, no coordinated study or information to suggest the prevalence of such agents both indoors and outdoors and that needs to be started with.

Next time you want to stuff your house with mattresses and conditioners and your offices with computers think again. Before healthy air becomes a fantasy.

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