Introduction
Contents

Introduction 1-30

- Concept and significance of the study
- Literature review
- Objectives
- Database
- Methodology
- Hypotheses
- Study area: Aligarh city
- Chapter scheme
The provision of air that is safe to breathe is just as important as safe water or food. When most people think of air pollution, they think of outdoor air pollution – smokestacks, spouting grey clouds of smoke or choking exhaust from vehicles. Indoor air pollution, the source of pollution with the greatest health consequences, remains unseen (Down to Earth, March 31, 1999). In terms of environmental risks, indoor air pollution is the second most important risk factor, after unsafe water. It accounts for twice the number of deaths reported from urban outdoor air pollution (fig. 1, Down to Earth, July 15, 2007). According to recent findings, indoor air pollution is five times more hazardous than outdoor air pollution and the major source, the solid fuels is the second most environmental cause of disease after water-borne diseases and fourth most important of overall excess mortality and burden of diseases (WHO, 2002). Yet many millions of people, predominantly women and children in the developing countries, are obliged to breathe air that is heavily polluted with biomass emission products.

![Fig.1: Indoor air pollution is second most important risk factor: Twice the number of excess deaths reported than outdoor air pollution](image)

Source: Down to Earth, July 15, 2007, Centre for Science and Environment, New Delhi

Air pollution is associated with contamination of air or imbalance in composition of air, while ‘**indoor air pollution can be defined as the totality of attributes of indoor air that affects a person’s health and well being**’. Breathing of polluted air is as old as mankind, particularly since the domestication of fire. Evidence of fire accompanied hominid remains from 500,000 years ago in China (James, 1989) and offered people
then a survival advantage through cooking foods heating and keeping bugs and beasts away. When people built shelters for dwellings, they also brought pollutants into the indoor living space (Spengler and Samet, 1991). Indoor air pollution can be traced to prehistoric times when humans first moved to temperate climates (200,000 years ago). These cold climates necessitated the construction of shelters and the use of fires indoors for cooking, warmth and light. Ironically fire which allowed humans to enjoy the benefits of living indoors, resulted in exposure to high levels of pollution as evidenced by the soot found in prehistoric caves (Albalak, 1997).

There are four principal sources of pollutants of indoor air, (i) combustion, (ii) building material, (iii) the ground under the building and (iv) bio aerosols (Behera, 1998). In developed countries the most important indoor air pollutants are radon, asbestos, volatile organic compounds, pesticides, heavy metals, animal dander, mites, moulds and tobacco smoke. However, in developing countries, the most important indoor air pollutants are the combustion products of unprocessed solid biomass fuels used by the poor urban and rural folk for heating and cooking. One of the major cause of the indoor air pollution is burning of cooking fuel (such as wood, agricultural residues, animal dung, coal, kerosene, LPG, etc.). Even today one half of the world’s population, 95 percent in poor countries and more than 90 percent households of India still rely on solid fuels including biomass fuels. Biomass fuel, refers to a plant or animal based material deliberately burned by humans and wood is the most common bio fuel, but use of animal dung and crop residues is also wide spread(De Koning et al, 1985). In developing countries some 3.5 billion people belonging to the low and very low income group face greatest threat from indoor air pollution because they continue to rely on traditional fuels such as fire wood, charcoal, cow dung for cooking and heating. The percentage of people using solid fuels varies widely among different regions and countries ranging from 77 per cent in Sub-Saharan Africa, 75 per cent in South-East Asia, 74 per cent in Western Pacific Region to 36 per cent in Eastern Mediterranean Region and 16 percent in Latin America and Caribbean and in Central and Eastern Europe. In most of the industrialised
countries, use of solid fuels falls below 5 per cent (Rehfuess, et al, 2006). The Indian National Census in 1991, for the first time inquired about the fuel used for cooking. In India 78 per cent of the population relied upon biomass fuel and 3 per cent used coal (Census of India, 2001).

Over the last 25 years, the trend in global bio fuel use has changed a little and in some parts of the World where poverty and prices of alternative fuels such as kerosene and bottled gas has increased, the use of biomass fuel has increased (WHO, 1997). A wide variation in use of type of cooking fuel and stoves is also spectacular in different income strata due to which level of exposure also varies which has been specified by the number of researchers using the energy ladder model (Baldwin, 1986; Hosier & Dowd, 1988; Smith, 1987; Leach, 1992). The energy ladder model has been derived from the empirical evidence so-called modern fuels are increasingly used as household income increases in urban areas. Preferences for switching include convenience in obtaining, storing, and using the fuels (cleanliness, versatility and a large and easily controlled range of power output) (Leach, 1988) and lower fuel costs (Reddy & Reddy, 1994) (fig. 2). Policy recommendations deriving from the model include increasing the availability of modern fuels to poor households either through

![Fig.2: The energy ladder: household energy and development inextricably linked](image-url)
subsidies, improvements in the network reliability of modern fuels, better commercialization schemes for alternative stoves, and other measures. In extreme interpretation, the process of fuel switching (termed fuel transition) has been equated with a "development path" (Smith, 1987). According to this view, households using different fuels belong to different "development levels," at the bottom of the scale are fuel wood users, and at the top electricity users. In addition, the process of moving from wood to a higher value modern fuel has been interpreted as a linear, unidirectional, or "natural" process driven by increasing household incomes. In the energy ladder, biomass fuels which are the dirtiest fuels, lie at the bottom and are used mostly by the poor people (Singh, 2004) (fig. 2).

The unprocessed solid fuels typically release 50 times more noxious pollutants than gas (Smith, 1990). Traditional fuels are characterised by low combustion efficiency leading to emission of suspended particles and poisonous gases and on the other hand the modern fuels are specifically commercialized and are expensive but characterized by high combustion efficiency of around 30 to 60 per cent and low emission of toxic pollutants. The stoves or chulhas (u shaped open stoves made of bricks and mud) used for cooking purpose are not energy efficient in which the fuels are not completely burned. The incomplete combustion releases hundreds of complex toxic pollutants hazardous to health. Among these health damaging pollutants, toxic and irritant gases, the most important include particulate matter, carbon monoxide, nitrogen dioxide, sulphur dioxide, formaldehyde and carcinogens such as benzo (a) pyrene and benzene (Ezzati et al, 2000). Levels of indoor particulate matter, which are commonly measured in milligrams per cubic meter, reach transient peaks of as high as 20-80 mg/m³ when fires are started or stirred; these peaks form up to half of total exposure in women, as they are required to stay close to the fire while cooking. The emission levels of these substances in indoor environment of most poor households are as high as 20 times more as the recommended limits of the World Health Organisation (WHO) and United States Environment Protection Agency (USEPA). The poor are the main sufferers of indoor air pollution because they rely predominantly on biomass fuels using simple stoves or chulhas or open fires, often without chimneys, flues or appropriate ventilation devices. Nearly three fourth of the Indian households (including 3 out of 10 urban households and 8 out of 10 rural households) use open fires or chulhas without chimneys (NFHS-3, 2007).
The exposure to indoor smoke is particularly high among women and children because women are responsible for cooking and children often spend time with their mothers while they are engaged in cooking. Women generally begin regular cooking or start assisting in cooking around the age of 12 to 15 which leads to longer period of exposure to pollutants. Women spend between 3 to 7 hours per day near the stove for cooking food (Singh, 2010). Due to customary involvement in cooking women’s exposure is very much higher then men’s and many times the young ones are carried on mother’s backs or on laps while cooking and thus they spend many hours breathing toxic pollutants.

It is estimated that about half a million women and children die every year from indoor air pollution in India (WHO, 2005). Despite the threat of indoor air pollution on women’s and children’s health, there is little systematic evidence on the usage of traditional cooking fuels and stoves in India. India has among the largest burden of diseases due to use of unclean household fuels and 28 per cent of all the deaths due to indoor air pollution in developing countries (Smith, 2000). The exposure of women to responsible particulates and carbon monoxide shows a wide variation in relative risk depending on cooking fuel used (Parveen, 2009). Findings estimated that, three million people die yearly all over the world due to air pollution, of which nearly 1.8 million die because of indoor air pollution in developing countries, while in India 589,000 people die due to indoor air pollution of which 93,000 are from urban and 496,000 are from rural areas (Singh, 2004). Despite adverse health effects of indoor air pollution, this complex problem is rarely highlighted and discussed. Many sources of air pollutants normally monitored outdoors as a part of investigations under the National Air Quality strategies and very little is known about air pollution indoors (Taneja et al, 2008). Moreover, the toxic pollutants released from combustion of traditional fuels has been implicated as the causal factor for various respiratory diseases (including acute respiratory infections, chronic obstructive pulmonary diseases, tuberculosis, asthma, etc), adverse pregnancy outcomes, eye problems, cancers, accidental problems, etc, particularly among women who are traditionally regarded responsible for cooking and household work management in Indian culture.

Indoor air pollution is the most direct physical health risk. While the precise mechanism of how exposure causes disease is still unclear, it is known that small
particles and several of other pollutants contained in indoor smoke cause inflammation of airways and lungs and impairs the immune response. Carbon monoxide also results in systematic effects by reducing the oxygen carrying capacity of the blood. High concentration of indoor air pollution increases the risk of acute respiratory infections (ARI) in young children; chronic lung diseases and cancer in adults and adverse pregnancy outcomes (such as still births) in women exposed during pregnancy. On the basis of site of infection it is referred to as ARI of upper (AURI includes common cold, pharyngitis, and otitis media) or lower (ALRI includes epiglottis, laryngitis, laryngotraechitis, bronchitis, bronchiolitis, and pneumonia) respiratory tract (Park, 2007). It increases the risk of other health problems including low birth weight, prenatal mortality, asthma, otitis media, tuberculosis, nasopharyngeal cancer, cataracts, blindness and cardiovascular diseases (WHO, 2005). Respiratory illness, cancer, tuberculosis, perinatal outcomes (still births and deaths in first week of life), eye diseases are the morbidities associated with indoor air pollution but the ill impact of indoor air pollution is directly and more pronounced to respiratory problems and diseases.

Annually, 1.5 million people die of problems related to indoor air pollution world wide- two third of the deaths occur in South East Asia and Sub Saharan Africa (fig.3).

Fig. 3: Deaths from indoor smoke from solid fuels

Source: WHO World Health Report, 2002
How it kills,

- The PM$_{10}$ levels in homes using biomass (Africa, Asia and Latin America) range from 300-3,000 microgrammes per cubic metre ($\mu$gm$^3$). This can also go up to 10,000 $\mu$gm$^3$. During cooking the PM$_{10}$ concentration in an Indian kitchen varies between 500-2,000 $\mu$gm$^3$.
- Inefficient burning of solid fuels indoor emit a mist of pollutants including carbon monoxide, particulate matters, nitrogen oxides, benzene and polyaromatic hydrocarbons. The fine particles PM$_{2.5}$- less than 2.5 micrometers in diameter penetrates into the respiratory system.
- Women spend 3-7 hours in the kitchen everyday and breathe in smoke equivalent to consuming 2 packs of cigarette. This causes acute and chronic respiratory cardiovascular diseases.
- Pollution also causes pneumonia and other acute lower respiratory infections (ALRI) among children and chronic obstructive pulmonary diseases (COPD) and lung cancer in adults.

![Fig.4: In the line of fire: Poor countries suffer more from IAP](image)

- In 21 countries indoor air pollution accounts for about 5 per cent of total deaths and diseases (fig. 4).

Source: Down to Earth, July 15, 2007, Centre for Science and Environment, New Delhi
Tobacco smoke and wood smoke are similar in many ways. Suspected carcinogens in cigarette smoke (benzene, pyrene and formaldehyde) are also present in wood smoke. Assuming that an average smoker smokes around 40 cigarettes a day, the exposure of a person, cooking with biofuels can be compared to both active and passive smokers. Active smoker inhales pollutants they can be compared to women who cook with biofuels and are exposed with every breath. In India men smoke much more heavily than women, but both are affected, one by tobacco the other by smoke of biofuels. Exposure to biomass fuels at home for several hours everyday and over several years is responsible for the diseases in women. Indoor Air Quality (IAQ) is one of the complex issues than any of the other environmental issues. Environment health, i.e health problems that results from changes in the environment are nobody’s business today. Millions in India continue to die and in years to come more and more millions will die. There is also now the constant evidence that the indoor air pollution particularly due to cooking fuel used increases the risk of a range of common and serious diseases. Thus, there is an urgent need to think about these problems. A growing consensus is observed as social scientists have recently become interested in indoor air pollution. In order to give this complex problem its due importance there is a need to assess the cooking energy uses, monitoring of indoor pollutant levels and make people aware of the hazardous effects on a person’s health, women in particular.

**Literature Review**

The problem of indoor air pollution is a global concern in developing countries like India and is growing due to continued use of biomass fuels. The survival of any living organism is totally based on the breathing of pure natural air and if it gets polluted because of one reason or the other, various undesirable and serious effects may occur. Mankind has no other choice except to keep the breathing air extremely pure and free from the effect, of air pollution. Since air is universal, the effects of air pollution are widespread and have no boundaries whether outdoor or indoor. Therefore efforts have to be
made to minimize air pollution. The study done by the various researchers on indoor air pollution has been given.

Schwartz (1994) in his work focussed that air pollution has been consistently linked with substantial burden of ill health in developed and developing countries. Smith and Mehta (2003) in their work focussed on the burden of diseases from indoor air pollution in developing countries and suggested that the bulk of indoor air pollution research and control has focussed on sources of concern in developed countries based on solid fuel and tobacco combustion. Sathaye and Meyers (1990), UNCHS (1991), Smith (1994), Nathan and Kelkar (1997) in their work pointed out that the urbanization is an important determinant of both the quantity and type of fuel used in developing countries. Studies have shown that at the household level, urban domestic energy consumption generally follows the “energy ladder” whereby residents move from consuming less costly and less conventional fuels (wood, biomass) to energy of intermediate price and quality (charcoal, kerosene) to more expensive, highly convenient types of energy (LPG, electricity) as their income rises and/or habits change over time. Dzioubinski and Chipman (1999) highlighted in their article that the major factors contributing to the differences in use of household energy pattern are levels of urbanization, economic development and living standards. Parisot (1986) in his article pointed out that the firewood is the poor man’s fuel in the rural and urban areas of India and the demand for this source of energy is very high. Leach and Gowen (1987) in their study gave the relationship between income and fuel use. Florig (1997), Saksena and Dayal (1997), World Bank (1997), World Health Organization (1997 and 2002) in their studies pointed out that the exposures to indoor air pollution are of importance because of morbidity and mortality in developed as well as developing countries and pointed out that the most important indoor air pollutants are the combustion products of unprocessed solid biomass used by the vulnerable section of urban and rural people in developing countries for cooking and heating purpose. Zhang (1999) Smith et al (2000), Bruce et al (2000) pointed in their studies that the burning of biomass fuel emits high levels of particulate matter, particularly carbon monoxide (CO), carbon dioxide (CO2), nitrogen dioxide (NO2), sulfur dioxide
(SO2), and volatile organic compounds (VOCs). *Barnes et al. (1994), Reddy et al. (1996), World Health Organization (1999)* estimated that use of open fires with biofuels exposes nearly 2 billion people in the world to enhance concentrations of particulate matter and gases, up to 10-20 times higher than health-based guideline values available for typical urban outdoor concentrations. *Bruce et al (2000)* examined indoor air pollution in developing countries as a major health challenge. *Smith et al. (2000)* in his article highlighted the health effects of indoor air pollution in developing countries.

Although people spend (especially women and children of less than 4 years of age) most of their time indoors, but still more importance is given for the monitoring of outdoor air pollutants. Thus, it becomes necessary that studies have to be conducted to gather the information of Indoor Air Pollution and its indoor level. There has been a significant increase in burden of diseases and deaths due to indoor air pollution which has highlighted the importance of measurement for the indoor air pollutants. Not much work has been done to monitor indoor air quality compared to the monitoring of outdoor air pollution. *Freeman and Tejada (2002)* in their work gave the methods for monitoring time/activity pattern information related to exposure to combustion products in indoor environment. *Moschandreas et al. (2002)* gave methodologies of exposure modelling. *Dasgupta et al. (2004)* quoted in his work the indoor air quality for poor people through indoor air monitoring. *WHO (2005)* gave report on indoor air pollution and household energy monitoring which highlights indoor air pollution measurement options by different methods including by placing monitors. *Whitesell (2008)* in his work gave a system for monitoring indoor air quality with the help of sensors.

Indoor air pollution is recognized as a significant source of potential health risk to exposed populations throughout the world. Various researchers worked on the health impacts of indoor air pollution. *Bruce et al. (2000), Boadi and Kuitunen (2006)* in their article elucidated that the indoor air pollutants are risk factors of a number of diseases and poor health, such as acute respiratory tract infection (ARI), chronic obstructive pulmonary disease (COPD), low birth weight, cataract, and blindness, especially in developing countries. *Pandey (1984a), Ramakrishna et al. (1989), Smith et al. (1983)* in
their earlier studies pointed that the exposure to biomass smoke enhances the risk of acute respiratory infection among women and children below five years and highlighted the evidence linking indoor air pollution from biomass combustion with respiratory health came from studies carried out in Nepal and India. **Bruce et al. (2000), Smith et al. (2000)** studies based especially on women who cook with biomass fuels and young children and linked their health with indoor air pollution and found strong association of ill effects on health due to indoor air pollution. **Chen et al. (1990), Ellegard (1996), Pandey (1984b)** elucidated exposure to indoor air pollution, especially to particulate matter, from the combustion of biofuels which has been implicated as a causal agent of respiratory diseases in developing countries. **Armstrong and Campbell (1991), Robin et al. (1996), Ezzati and Kammen (2001)** documented in their studies the associations between exposure to indoor air pollution and increased incidence of chronic bronchitis in women and acute respiratory infections in children. **Behera et al. (1991), Smith (1993), Awasthi et al. (1996), Smith (1996), Mishra and Retherford (1997)** in their studies highlighted that that the cooking smoke increases the risk of acute respiratory infections in children. **Parikh (1996)** in a study focussed that infants who were exposed to smoke by being carried on their mother’s backs during cooking were nearly three times more likely to develop significant cases of acute respiratory infection. A study in Colombia expresses that women cooking over open fires had almost four times more chronic lung disease compared to those cooking in other manner. **World Bank (2000)** in its study elucidated that children younger than five years who died of acute respiratory infection were almost three times more likely to be sleeping in a room with an open cook stove than healthy children in same age group and many studies in India, Nepal and Papua New Guinea show that non-smoking women who have cooked on biomass stoves for many years exhibit a higher prevalence of chronic lung disease while a women exposed to smoke during cooking were three times more likely to suffer from chronic lung diseases and with increased risk of stillbirth. The study also highlights that the considerable amount of carbon monoxide is being detected in the bloodstream of women cooking with biomass in India and Guatemala. **Smith (2000a)** in his study estimated that about half a
million women and child die each year from air pollution in India. Compared to other countries India has among the largest burden of disease due to the use of dirty household fuels and 28 per cent of all death due to indoor air pollution in developing countries occur in India. Smith (2000b) in his article pointed that the incidence of chronic obstructive pulmonary disease in non-smoking women using biomass for cooking is dependent on the number of years cooking with biofuels and often to be comparable to that of men who usually have high smoking rates. Based on this evidence, it has been estimated that the indoor air pollution contributes to 3-5 per cent other causes as well, it is difficult, lengthy, and of the national burden of disease in India. Mishra et al. (1999), Zodpey and Ughade (1999) in their epidemiological studies have provided some evidence of an association between cataract or blindness and exposure to indoor smoke from household use of solid biofuels fuels such as animal dung, wood and crop residues and with a cross sectional design, used data from the 1992-93 Indian National Family Health Survey which found an association between biomass fuel use and partial and complete blindness after adjustment for a number of potentially confounding factors. Smith and Mehta (2003) assessed the burden of disease attributable to use of biofuels use in India and have put the figure at 3-5 percent of the national burden of disease. WHO (2007) in its report estimated a total disease burden of 3.6% is associated with indoor air pollution worldwide. Edelstein et al, (2008) elucidated that the burning of biomass fuels results in exposure to high levels of indoor air pollution, with consequent health effects.

Objectives

The focus of the thesis entitled, 'Health Impacts of Indoor Air Pollution from Household Energy Used in Aligarh City’ was to conduct indepth surveys of the city and sampled households (2,101) to collect information regarding the socio-economic characteristics of the women respondents/households; household characteristics, kitchen characteristics, household energy used, monitoring of solid and gaseous pollutants and to assess the exposure to indoor air pollutants, to identify the risk factors and to examine the relationship between the risk factors and associated diseases; finally to examine the vulnerability of women to indoor air pollution and
identify vulnerable areas of the city for future planning and to suggest suitable solutions to reduce the ill effects of indoor air pollution. Earlier work has been done on the health impacts of indoor air pollution due to household energy used in larger cities of developed and developing countries (De Koning et al, 1985; Smith, 1990, 2000; Lioy, 1990; Bruce et al, 2000; WHO, 1997, 2005; Ezzati, and Kammen, 2001; Singh, 2004; Rehfues, et al, 2006; NFHS-3, 2007; Park, 2007) but the medium and smaller cities were neglected. Keeping these aspects in mind Aligarh city has been selected as the study area. This study includes the appraisal of:

(i) type of household energy used among different income groups
(ii) monitoring of indoor air pollutants
(iii) identifying risk factors associated to indoor air pollution
(iv) assessment of diseases associated to indoor air pollution
(v) Identifying vulnerable women/households and the vulnerable areas of Aligarh City for future planning.

The present study has certain specific research objectives:

(1) To examine the income-wise socio-economic characteristics of sampled women/households (income status, religion and caste group, age, marital status, educational and occupational status, basic family type and size etc.).
(2) To examine the income-wise household characteristics - housing conditions (house type, number of rooms in house, floor space/per person/in the sleeping room, ventilation condition, provision of basic services etc.).
(3) To examine the income-wise kitchen characteristics - place of cooking food (separate kitchen, multipurpose room, verandah, open air), size of kitchen, kitchen ventilation and time spent for kitchen work per day etc.
(4) To examine income-wise type of household energy used for cooking (traditional (agricultural residues, cow dung, coal, wood, kerosene); modern- (LPG, electricity)); types of stove (traditional (chulhas, kerosene stove) modern- (gas stove, electric heater)) used for cooking.
(5) To monitor both solid (PM_{10} and PM_{2.5}), and gaseous (CO, CO_{2}, SO_{2}, NO, NO_{2}) air pollutants emitted from different types of fuels/stoves (traditional and modern) from different cooking sites (chulha in verandah, chulha in open space) and different types of kitchen (separate kitchen without ventilation, separate kitchen with ventilation, cooking in verandah, cooking in...
multipurpose room) and in living room and to assess the differential exposure to indoor air pollutants in the different income households.

(6) To assess the income-wise health conditions of women (instant and short term problems and specific diseases) associated with indoor air pollution.

(7) To identify the risk factors associated with indoor air pollution and assess the relationship between IAP related risk factors and occurrence of associated specific diseases (ALRI, AURI, COPD, asthma, pulmonary tuberculosis, perinatal mortality, low birth weight, eye irritation and cataract).

(8) To identify income-wise vulnerability of women/households and to identify and map vulnerable areas of the city for the purpose of planning.

(9) Finally to suggest suitable solutions for solving and minimizing the problems of indoor air pollution.

**Database**

The study is mainly based on primary sources of data which have been collected through,

(i) City surveys to identify the wards from where households belonging to different income groups were selected for sampling.

(ii) Indepth survey of sampled households

(iii) Questionnaire (Appendix I) interviews with the sampled women respondents from the sampled households belonging to different income groups

(iv) Discussion with the residents belonging to different income group from different wards, and with doctors at different health care centres and hospitals (Out Patient Departments of Jawahar Lal Nehru Medical College Hospital, Malkhan Singh Government Hospital, Mohan Lal Gautam Women’s Government Hospital and various private doctors clinics of Aligarh city).

Field work was done during the years 2008 and 2009. From every sampled household, in most of the cases a senior woman was selected as respondent because they are involved in cooking and they know more about their household conditions. For getting accurate information sampled households were visited frequently.

Data from secondary sources have been collected from various Government Offices, health care centres, hospitals, bulletins of Aligarh city and from various libraries,
Methodology

To achieve the objectives, the following methodology was adopted for the study.

1. **Sampling procedure:**

   The process through which the sampled households/women respondents were selected has been outlined in fig. 5.

   **Fig. 5: Design for survey for the selection of wards and households/women respondents for sampling in Aligarh city (2008-09)**

<table>
<thead>
<tr>
<th>Aligarh city, Total 70 wards</th>
<th>Selected 14 wards on the basis of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location (old part (5), new part (3), fringe area (6))</td>
</tr>
<tr>
<td></td>
<td>Population</td>
</tr>
<tr>
<td>From 14 wards, 10 per cent households were selected belonging to different income groups</td>
<td></td>
</tr>
<tr>
<td>Total sample 2,101 household (hh)</td>
<td></td>
</tr>
<tr>
<td>High income hh-300</td>
<td></td>
</tr>
<tr>
<td>Med. income hh-620</td>
<td></td>
</tr>
<tr>
<td>Low income- 647</td>
<td></td>
</tr>
<tr>
<td>V. low income-533</td>
<td></td>
</tr>
<tr>
<td>Women respondents 2,101</td>
<td></td>
</tr>
</tbody>
</table>

   For the purpose of selecting the sample, multistage stratified random sampling design was adopted:

   - The first stage consisted of selection of 14 wards from the 70 wards of the Aligarh city on the basis of their location (from old part (5), new part (3) and from the fringe areas (old part 3, new part 3) of the city), and population (table 1, fig. 9).

   In second stage, about 10 percent households were selected from each selected ward (14) on the basis of income. From each household a senior woman was selected.
Table 1: Selection of wards and selection of income-wise households from each selected ward for sampling from Aligarh City (2008-09)

<table>
<thead>
<tr>
<th>Location of wards</th>
<th>1. Profile of selected wards</th>
<th>2. Selection of households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ward No.</td>
<td>Ward name</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old city (inner wards-5)</td>
<td>13</td>
<td>Nagla Masani</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Krishna Puri</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Gambhir Pura</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>Khai Dora</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>Tan Tan Para</td>
</tr>
<tr>
<td>Old city (fringe wards-3)</td>
<td>6</td>
<td>Pala Sahibabad</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Beema Nagar</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Slaughter House</td>
</tr>
<tr>
<td>New city (inner wards-3)</td>
<td>29</td>
<td>Sudama Puri</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Begum Bagh</td>
</tr>
<tr>
<td></td>
<td>59</td>
<td>Nagla Jamal Pur</td>
</tr>
<tr>
<td>New city (fringe wards-3)</td>
<td>7</td>
<td>Dori Nagar</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>Jeewan Garh</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>Maulana Azad Nagar</td>
</tr>
<tr>
<td>Total sample</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Mo-Mohallas, P-Population, HH-Households, S-Sampled, H-High, M-Medium, L-Low, V-Very
3. Based on field survey 2008-09

Table 2: Distribution of sampled households (in percentages) in Aligarh city according to income per month (2008-09)

<table>
<thead>
<tr>
<th>Total sampled women respondents</th>
<th>Income group</th>
<th>Income in Rs.* per month</th>
<th>Number of sampled women respondents</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,101</td>
<td>High</td>
<td>&gt; 25,000</td>
<td>301</td>
<td>14.33</td>
</tr>
<tr>
<td>Total sample</td>
<td>Medium</td>
<td>15,001-25,000</td>
<td>620</td>
<td>29.51</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5,000-15,000</td>
<td>647</td>
<td>30.79</td>
</tr>
<tr>
<td></td>
<td>Very low</td>
<td>&lt; 5,000</td>
<td>533</td>
<td>25.37</td>
</tr>
</tbody>
</table>

* 1 $ = 45.2 Rs. (August, 2010)
Source: Based on field survey, 2008-09
chosen as the respondent because women know more about their household condition and are actively engaged in household activities (cooking etc.). The total sample size consisted of 2,101 households, of which, 300 (14 per cent) were from the high income group (> Rs. 25,000 per month), 620 (30 per cent) from medium income group (Rs. 15,001-25,000 per month) and 647 (31 per cent) from low income group (Rs. 5,001-15,000 per month) and 533 (25 per cent) from very low income group(< Rs. 5000 per month).

- Total sample size consisted of 14 wards and 2,101 women respondents/households belonging to different income groups (table 1, fig. 5).

2. Interview schedule

The data was collected by interviewing the sampled women respondents personally by using interview schedule. The questions were developed with the help of questionnaires used in similar studies (Smith, 1990, 2000; Lioy, 1990; Bruce, 2000; Ezzati, and Kammen, 2001; Singh, 2002-2003), consulting relevant literatures and discussion with experts in indoor environment and medical practitioners, and keeping in mind the objectives of the study a draft schedule was then prepared. The first part focussed on the socio-economic characteristics of the women respondents/households and housing and kitchen characteristics; the second part sought information about the different types of household energy used for cooking in different income households and the levels of solid and gaseous air pollutants emitted from different types of cooking fuels; third part focuses on the occurrence of problems and diseases identification of risk factors associated to indoor air pollution and its correlation to associated diseases while the last part sought information about the income-wise vulnerability of women/households and vulnerable areas in Aligarh city.

3. Collection of data

Data was collected through personal interviews with the help of the questionnaire (Appendix I). The researcher visited the sampled households and on the basis of schedule interviewed the women respondents were personally interviewed. The households were visited at least twice to check the information provided. First the
women respondents were put at ease and then they gradually opened up and gave all the relevant information about their house, kitchen, type of energy used for cooking, indoor air pollution and associated health conditions. Nearly more than one year time was spent for data collection. The data collected were then tabulated and entered in spreadsheets. Later analysis was done.

4. Monitoring of indoor air pollutants

**Fig. 6: Design for IAP monitoring in different cooking places, using different cooking fuels (biomass and LPG)**

| From total sample (2,101), 10 per cent (200 HH) were selected for monitoring IAP | IAP monitoring (i) At different cooking places (separate kitchen without ventilation, separate kitchen with ventilation, cooking in *verandah*, cooking in multipurpose room, open air) (ii) Using different cooking fuels (biomass, LPG) | Instruments used (i) For SPM monitoring—Portable GRIMM Dust Monitor Series 1.109 (ii) For CO, SO$_2$, NO, NO$_2$ monitoring—YES-205 multigas monitor (iii) For CO$_2$ monitoring—YES-206 Falcon IAQ monitor |

Indoor air pollutants were monitored in different cooking places (separate kitchen, cooking in multipurpose room, *verandah*, open space), different types of cooking fuels used (traditional, modern) and in living room to diagnose the indoor air quality (IAQ). In order to find out the concentration of suspended particulate matter (PM$_{10}$, PM$_{2.5}$) and gaseous pollutants (CO, CO$_2$, SO$_2$, NO, NO$_2$), from the total sample (2,101 households) monitoring was conducted in 10 per cent households (200) cooking in different places and using different types of cooking fuels (biomass and LPG). The indoor air quality of the living room in those houses were also monitored.

- **Monitoring of suspended particulate matter (PM$_{10}$, PM$_{2.5}$):** For the purpose of monitoring of suspended particulate matter (PM$_{10}$, PM$_{2.5}$), a handy sampler “Portable GRIMM Dust Monitor Series 1.109” (Grimm Aerosol technik; Dorf strabe 9; 83404 Airring-[Germany]) was used.

- **Monitoring of gaseous pollutants:** For the monitoring of indoor gaseous pollutants (CO$_2$, CO, SO$_2$, NO, NO$_2$), handy samplers were used having separate sensors for sensing the concentration of each
type of pollutant. The indoor gaseous pollutants like CO, SO$_2$, NO, NO$_2$ were measured by portable YES-205 multigas monitor (Young Environmental System Inc. Vantage way, Delta, BC, Canada). The concentration of CO$_2$ was measured by a portable YES-206 Falcon IAQ monitor (Young Environmental System Inc. 140-8771 Douglas St. Richmon, B.C V6X1V2 Canada).

5. Statistical techniques applied
   - Simple percentages were used for calculation and easy understanding of data
   - Karl Pearson’s correlation co-efficient (r) method was used to examine the relationship between indoor air pollution related risk factors and associated diseases,

\[
r = \frac{\sum xy - \frac{\sum x \sum y}{N}}{\sqrt{\frac{\sum x^2 - (\frac{\sum x}{N})^2}{N}} \sqrt{\frac{\sum y^2 - (\frac{\sum y}{N})^2}{N}}}
\]

Where,
- \( r \) = coefficient of correlation
- \( x, y \) = the two given variables
- \( n \) = number of observation

To find out the computed ‘t’ value in the test of significance

\[
t = r \sqrt{\frac{n-2}{1-r^2}}
\]

Where,
- \( t \) = calculated value of ‘t’ in the test of significance
- \( n \) = number of observations
- \( r \) = computed value of coefficient correlation

6. Assessment of vulnerability
   - For the assessment of income-wise vulnerability of women/ households, vulnerability criteria was developed on the basis of household survey, consultation with medical practitioners and current related literatures. A total of 14 criterias under 4 subheads - housing conditions (house type (kutcha/semi-pucca), number of rooms household occupies (only one room), average sleeping floor space (<20 sq. feet), improper ventilation in house), cooking conditions (cooking in a multipurpose room, small sized kitchen
(<30 sq. feet), use of traditional (biomass) fuels and stoves, duration of kitchen work (>5 hours per day), exposure conditions (exposure to smoke (>1 hour per day), exposure to heat (>2 hours per day), prevalence of smoke in kitchen/house (>1 hour per day)) and health conditions (instant problems, short term problems, specific diseases) were selected and considered. On this basis the women/ houseolds were categorized in three groups – most vulnerable (>60 per cent being affected), moderately vulnerable (20-60 per cent being affected) and least vulnerable (<20 per cent being affected).

- For the assessment of vulnerable areas (i) data regarding income wise dominance in the different wards (70) of Aligarh city was gathered from the Municipal Corporation and with the help of household surveys. On this basis, the 70 wards of the city were categorized into 3 groups- 32 medium wards, 21 low and 17 high income wards. A strong relationship exists between income and the use of energy for cooking especially use of biomass fuels/traditional stoves was in the low income households. Thus, two criteria (i) income-wise dominance and (ii) use of biomass fuels/traditional stoves and chulhas were taken into consideration for mapping the vulnerable wards/areas of Aligarh city. On this basis the 70 wards were grouped into 3 categories, most vulnerable (>90 per cent of households use biomass fuels for cooking), moderately (<25 per cent of households use biomass fuels for cooking) and least vulnerable (None of households use biomass fuels for cooking) areas of the city.

Hypotheses

- Indoor air pollution, source of pollution with greatest health consequences, remains unseen.
- The major cause of indoor air pollution is burning of traditional/biomass fuels which releases toxic pollutants.
- The low and very low income households face the greatest threat from indoor air pollution because they continue to rely on traditional/biomass fuels.
• The exposure to indoor smoke is particularly high among women because women are responsible for cooking and they spend long hours in the kitchen.
• The greatest health impacts from indoor air pollution occurs among the poorest and vulnerable population.

**Study Area: Aligarh City**

Aligarh city (27°53’N latitudes and 78°4’E longitudes) is a medium sized city located in the fertile tract of Ganga-Ymuna doab in north India, in the western part of the state of Uttar Pradesh, was selected as the study area. It is situated along the Delhi-Kolkata railway line about 130 kms away from the country’s capital, New Delhi (fig.7 and 8).

It is the administrative headquarter of Aligarh District. Topographically the district represents a shallow trough saucepan shape like appearance with the rivers Ganga (north- east) and Yamuna (north- west) forming the highland peripheries. A broad low lying belt is found in the centre of the district with the city lying in the centre of this low lying belt. The old part of the city is located on a mound. The drainage system of the city is defective. The city gets its rain from summer monsoon (June to September) which is erratic and scanty, ranging from 65 to 75 cm per year. The city experiences tropical monsoon type of climate. Temperature during the summer seasons is very high and sometimes reaches up to $46^0$ C while in winter it may fall up to $4^0$ C.

The city covers an area of 36.7 sq. km. of which only 67.48 per cent is developed. Nearly half is used for residential purposes and rest for commercial, industrial, transport, public utility, administrative, recreational and parks and open spaces. The city is subdivided into 70 wards, spread over 427 mohallas and has 102,004 households (Aligarh Municipal Corporation, 2006). The Delhi-Kolkata railway line divides the city into 2 parts, the old (western side) and new (eastern side) part of city.

**Population of city:** The population of Aligarh city is estimated to be nearly 669,087 (53 per cent males, 47 per cent females). Projections based on geometric extrapolation shows that by 2011 the population will be 921,388 and by 2021 it will be 1,249,352. Aligarh city has high rate of population growth nearly 4 per cent annually of which 1.8 per cent is natural growth and 2.2 per cent migratory. During the decade 1981 – 1991 the population growth was 49.75 per cent while during 1991 – 2001 it was only 39.24 per cent.
population density varies, as socio-economic condition of the city changes. The density of the congested part of the city i.e. old part is 171 persons / hectare while the density in the university area is just 26 persons / hectare (ADA Report, 2011-2021).

**Historical development and morphology of Aligarh city**

Aligarh is a city of great antiquity wrapping in its folds many dynasties and their rise and fall. Its origin dates back to about 1500 B.C. when a Buddhist settlement existed here. There is a considerable archaeological evidence to support this view (Aitkinson, 1875 and Nevil, 1909).

During the ancient period, development of the city took place around a Hindu temple at the bank of a small lake ‘Achal Tal’. The ancient settlement like the Buddhist did not live any recognizable trace except the Achaleshwar temple. Archaeological remains dating back to 5th and 9th century A.D. have been unearthed here.

After a gap of couple of centuries when nothing was known about the area, from the end of 12th century, Muslims made their appearance at the scene and exercised their control over the area. The hegemony of the Muslims lasted for about 600 years when an area called Upper Kot developed next to the ancient area, with a predominantly Muslims population. Throughout the medieval period Aligarh remained an important administrative, industrial, agricultural market town. After the final collapse of Muslims rule in mid nineteenth century the city passed into British hands. The British developed a separate area to the north-east of the old nucleus for the reason of safety and prejudices, the British officers prefer to live away from the local population.

From the proceeding description it is observed that in each period a different area developed. Thus, there are three neatly delineated areas in the city,

- The ancient area, dominated by Hindu population
- The medieval area, dominated by Muslim population
- The modern area, dominated by a mixed population of both Hindus and Muslims.

These areas instead of losing their identity with time have retained it. Spate of communal riots have strengthened the segregation on communal lines. The city developed in different period under different rules. These areas grew independently of each other.
ALIGARH CITY
LOCATION MAP

Source: Based on Survey of India map, The Oxford School Atlas, 2001

Fig. 7
Aligarh City: Location Map
(In India, Uttar Pradesh and in Aligarh District)

Aligarh City

Morphology of the city

- Upper kot area
- Achal Tal area
- Civil line area – New City
- Peripheral / ring area

Source: Municipal Corporation, Aligarh City, 2001

Fig. 8
Aligarh city
Location of the selected wards from where income-wise households were sampled (2008-2009)

Source: Aligarh Munciple Corporation, Aligarh city, 2007

Fig 9
<table>
<thead>
<tr>
<th>Ward No.</th>
<th>Name of the ward</th>
<th>Ward No.</th>
<th>Name of the ward</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indra Nagar Khair Road</td>
<td>36</td>
<td>Avas Vikas Colony (Iglas Road)</td>
</tr>
<tr>
<td>2</td>
<td>Sarai Garhi</td>
<td>37</td>
<td>Jamalpur</td>
</tr>
<tr>
<td>3</td>
<td>Nagalakalar</td>
<td>38</td>
<td>Kala Mahal</td>
</tr>
<tr>
<td>4</td>
<td>Sarai Lavaria</td>
<td>39</td>
<td>Jeewangarh</td>
</tr>
<tr>
<td>5</td>
<td>Sarai Kaba</td>
<td>40</td>
<td>Badar Bagh</td>
</tr>
<tr>
<td>6</td>
<td>Pala Sahibabad</td>
<td>41</td>
<td>Shiv Puri</td>
</tr>
<tr>
<td>7</td>
<td>Dori Nagar</td>
<td>42</td>
<td>Vikas Nagar (ADA Col)</td>
</tr>
<tr>
<td>8</td>
<td>Naunar Gate</td>
<td>43</td>
<td>Rawantila(Jwalapuri)</td>
</tr>
<tr>
<td>9</td>
<td>Naurangabad</td>
<td>44</td>
<td>Begum Bagh</td>
</tr>
<tr>
<td>10</td>
<td>Delhi Gate</td>
<td>45</td>
<td>Zohara Bagh</td>
</tr>
<tr>
<td>11</td>
<td>Beema Nagar</td>
<td>46</td>
<td>Janakpuri</td>
</tr>
<tr>
<td>12</td>
<td>Sarai Deen Dayal</td>
<td>47</td>
<td>Ashok Nagar</td>
</tr>
<tr>
<td>13</td>
<td>Nagla Masani</td>
<td>48</td>
<td>Nagala Tikona</td>
</tr>
<tr>
<td>14</td>
<td>Sarai Bala</td>
<td>49</td>
<td>Lekh Raj Nagar</td>
</tr>
<tr>
<td>15</td>
<td>Krishna Puri</td>
<td>50</td>
<td>Rasal Ganj</td>
</tr>
<tr>
<td>16</td>
<td>Durga Puri</td>
<td>51</td>
<td>Ghanshyampuri</td>
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<tr>
<td>17</td>
<td>Chawani</td>
<td>52</td>
<td>Firdaus Nagar</td>
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<tr>
<td>18</td>
<td>Gambhir Pura</td>
<td>53</td>
<td>Maulana Azad Nagar</td>
</tr>
<tr>
<td>19</td>
<td>Nai Basti</td>
<td>54</td>
<td>A.D.A. Colony Area</td>
</tr>
<tr>
<td>20</td>
<td>Exibition Ground</td>
<td>55</td>
<td>Usman Para III</td>
</tr>
<tr>
<td>21</td>
<td>Slaughter House</td>
<td>56</td>
<td>Brahmanapuri</td>
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<tr>
<td>22</td>
<td>Sanichari Penth</td>
<td>57</td>
<td>Iglas Road Pumping S</td>
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<td>23</td>
<td>Kalideh</td>
<td>58</td>
<td>Medical College</td>
</tr>
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<td>Kishanpur</td>
<td>59</td>
<td>Nagla Jamalpur</td>
</tr>
<tr>
<td>25</td>
<td>Sarai Hakim</td>
<td>60</td>
<td>University Area</td>
</tr>
<tr>
<td>26</td>
<td>Sarai Nabab</td>
<td>61</td>
<td>Kela Nagar</td>
</tr>
<tr>
<td>27</td>
<td>Kanawari Ganj</td>
<td>62</td>
<td>Shah Jamal Area</td>
</tr>
<tr>
<td>28</td>
<td>Bhamola</td>
<td>63</td>
<td>Manik Chowk</td>
</tr>
<tr>
<td>29</td>
<td>Sudamapuri</td>
<td>64</td>
<td>Khai Dora</td>
</tr>
<tr>
<td>30</td>
<td>Fir Brigade</td>
<td>65</td>
<td>Bhujpura</td>
</tr>
<tr>
<td>31</td>
<td>Begpur</td>
<td>66</td>
<td>Sir Syed Nagar</td>
</tr>
<tr>
<td>32</td>
<td>Gandhi Nagar</td>
<td>67</td>
<td>Tan Tan Para</td>
</tr>
<tr>
<td>33</td>
<td>Kishor Nagar</td>
<td>68</td>
<td>Hamdard Nagar</td>
</tr>
<tr>
<td>34</td>
<td>Sarai Pakki</td>
<td>69</td>
<td>Badam Nagar</td>
</tr>
<tr>
<td>35</td>
<td>Dodhpur</td>
<td>70</td>
<td>Baniya Para</td>
</tr>
</tbody>
</table>

Note: ward number and name in dark are the sampled wards
Like other cities of India, Aligarh has a distinct demarcation between the old and new city. The civil lines area is separated by the Delhi-Kolkata railway line. Aligarh with passages of time had grown into 4 parts. This can be classified on the basis of their uniqueness (fig. 8).

(1) Achal Tal area (ancient period)

East of the pre- Christian and medieval zone in the ancient area, dating back to the tenth century, there are few remains here of that period except Achal Tal of masonry and the Achaleshwar temple. This is a site inhabited predominantly by Hindus. In later period development of this area took between the Manik Chowk and Madar Gate which have whole sale markets.

(2) Upper kot area (medieval period (core/ centre of the old part of city))

The growth pattern and consequent morphological components of Aligarh city are rather distinct and are woven around the Upper Kot (Balai Quila), which historically and textually represents the core and centre of the city. For most of its medieval history it was a walled city with gates (Turkman gate, Madar gate, Delhi gate) opening towards Delhi, Agra, Budaun etc. The antiquity of sequential occupation, contained within the wall has produced a very high population density and congestion. With the passage of time vertical growth took place and most of the buildings became two to three stories high. Larger mansions were compartmentalized adding to residential congestion. The congested and overcrowded houses and areas, with the framework of narrow circular lanes, bylanes and blind alleys speak of age and territorial constraints. The mohallas are separated by very narrow lanes. These are just broad enough to allow access to pedestrians and rickshaws. They are choked with traffic in the day time, with labourers pushing hand carts and rickshaws piled high with goods sent to other mohallas for processing, assembling and packaging. All mohallas have shops, household manufacturing units, factories and residences, but retail and wholesale outlets are concentrated on the main roads leading in and out of the city.

This area acquired its basic form in the medieval period that is continuing. Generally concentric but occasionally sectoral growth has taken place in this area. Fact is that the numerous sarais (inns), which were lying outside the city, along the roads leading to the city have become full- fledged mohallas and were drawn into the
city matrix. *Mohallas* with pre-fix *sarai* like Rahman, Hakim, Qazi Kaba, Qutub, Mansingh, Virandhavan, Narottam and Mian are all known as *sarais*. Upper Kot area is largely inhabited by Muslim working class and middle class people. Some of the families trace their history to the medieval period and represents the social elite of the area. Industry and trade has improved the well being of a section of the people. Households industries are having like lock, dyes, biscuit, *mutry*, building fitting etc. which are polluting the environment.

(3) **Civil lines area (british period (new part of the city))**

This area was developed by the British during the nineteenth century. It has much enlarged now. It is characterized by almost complete segregation from the first and second area. Its remoteness from earlier areas of ancient and medieval settlements speaks of the British intentions of keeping a distance from commoners and from the people to be governed. Development of the railway line in the later half of the nineteenth century, dividing the city into a western and eastern half, made the segregation of this area more pronounced. This segregation however was overwhelmed by the post independence of the city.

The principal lines of development were along the Marris road, University road, Anup Shahar road, Ramghat road and The Russel Ganj (now Rasalganj). The grain of this zone has a linear north-south bias. All the aforesaid roads have a north-south trend and seem to have been oriented with reference to the railway station. The British brought to bear upon Indian scene their experience of town building and made straight broad roads, buildings set well back on them. Clock tower, Government Press, Church and the Collectorate bear the imprints of British period. The civil lines houses, Aligarh Muslim University campus, the main government offices such as the law court, the main post office, the railway station and residences of the ex-*zamindars* elite and wealthier businessmen. In the west lies the Industrial Estate which harbours factories and Government Offices dealing with industrial development, such as the District Industrial Centre and Small Scale Industrial Centre (SSCI). This area is sparsely built having large spacious houses with lawns in front and kitchen gardens in the backyard. It presents a refreshing contrast to the congested and dilapidated areas of old city. Gradually this part is also getting congested.
(4) Peripheral / Post independence period (fringe area)

Lastly, is the most recently developed area of the city lying in the peripheral fringe. They do not make a well-demarcated zone but appears in the form of small clusters that have developed in the post independence period. Most of them are residential but some are industrial. These areas are well laid out on rectangular patterns. Many of these areas were till recent past villages; well outside the city limits and its infrastructure not well developed but then the sprawling city swapped their lands and occupations. Villages like Kishanpur, Dodhpur, Begpur, Jamalpur, Bhamola, Nagla Baraula etc. witnessed in mute silence their transformation. New industrial and residential colonies have developed, many of them, like Industrial colony, Tubewell, Loco, Medical, Begpur, Kaila Nagar, Dodhpur and Janakpuri colonies. These have developed on the northern circumference of the city. While in the south, Jawalapuri, Mahindra Nagar, Saheb Singh Nagar and Nagala Masani Colonies were developed.

Chapter scheme

The thesis starts with an introduction (concept and significance of the study, literature review, objectives, database, methodology, hypothesis, study area and chapter scheme).

It is divided into three parts and spreads over five chapters. Part one is devoted to an overview of characteristics of the sampled households belonging to different income groups in Aligarh city. This part comprises of only one chapter which has been divided into three parts; in the first part an attempt has been made to examine the income-wise socio-economic characteristics of the sampled women respondents/households their income status, religion and caste, age, marital status, educational and occupational status, basic family characteristics etc., the second part is devoted to an assessment of income-wise housing characteristics i.e. house type, number of rooms in the house, floor space/per person/in the sleeping room, ventilation in house and provision of basic services like water supply, latrine facilities, drainage conditions, garbage collection and disposal etc. while the third part is devoted to an assessment of kitchen characteristics i.e place of cooking food, size of kitchen, kitchen ventilation time spent in kitchen and children in and around cooking place etc.
Part two is devoted to household energy used in different income groups in Aligarh city. This part comprises of two chapters. In the second chapter an attempt has been made to examine the type of household energy/stoves used for cooking, type of exposures while cooking (exposure to smoke and fire/high temperature, time taken for smoke to exit from kitchen/house, use of lids on pot, preference of smell of smoke in cooked food) and other sources of indoor air pollution. In the third chapter an attempt has been made to examine cooking related exposures through monitoring of indoor air pollutants (particulate pollution and level of exposure in indoor environment, gaseous pollution and level of exposure in indoor environment and cooking related exposures in different types of cooking places, with different types of cooking fuel used and in living rooms).

Part three deals with the health impacts of indoor air pollution in different income women/households in Aligarh city. This part comprises of two chapters. In fourth chapter an attempt has been made to examine the health impacts of indoor air pollution i.e., health of women (instant and short term problems and specific diseases), identification of risk factors associated with indoor air pollution, relationship between household energy used and indoor air pollution related risk factors and associated specific diseases in Aligarh city. In the fifth chapter an attempt has been made to examine the vulnerability to indoor air pollution, vulnerable women/households have been identified and vulnerable areas of the city were identified and mapped for future planning, lastly some solutions to vulnerability issues and policies to minimize indoor air pollution have been suggested.

Finally a brief conclusion based on the results has been given.