International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.5, No.6, June 2016 DOI:10.15693/ijaist/2016.v5i6.67-74

# HOUSEHOLD ENERGY: A STUDY OF SITAPUR, INDIA

Mohammad Arif
Research Scholar, Department of Environmental Science, Sharda University

Rajesh Kumar
Professor, Department of Environmental Science, Sharda University

Afaq Ahmad
Environmental Consultant,
United Nation Development Programme, New Delhi

***Abstract*—India relies predominantly on fossil fuels to meet its energy needs. As much as 40 percent of the energy generated in the country comes from coal, 34 percent from fuel wood and 15 percent from petroleum. Meeting the energy access challenges and ensuring lifeline supply of clean energy to all is essential for empowering individuals, especially women and girls, who have the task of collecting and using non-commercial fuels such as fire wood, crop residues, and dung cakes that remain the primary energy source for cooking in over two-thirds of the households. The use of biomass fuel and associated health was investigated over 760 rural housewives in 19 blocks of District Sitapur in the Uttar Pradesh India. As per the survey the consumption of traditional energy ratio was found as 40.5% firewood followed by 48.2% of dung cake and 10.1% of crop residue. The contribution of fuel from forest, animal waste, orchard and others was found to be 33.0, 28.8, 19.3 and 11.1 percent respectively. The study shows a wide range of possible health impacts due to biomass smoke exposure and emphasizes the urgent need for cleaner fuels and strategies to safeguard the health of women and children of rural areas.**

**Keywords:** Rural Households, Biomass Fuel, Black Carbon, Respiratory and Systemic Effects, Indoor Air Pollution

.

## I. INTRODUCTION

Energy consumption has been linked to human development and with the growth of the economy. Therefore, it is not surprising that energy consumption over time, as reported by the different National Sample Survey Organization (NSSO) consumer expenditure surveys, has also shown an increase. In India, energy use is divided among five main sectors, with households accounting for about 37%, the industrial sector for about 40%, the service and transport sectors combined for 17%, and the rest is being used by the agriculture sector. Therefore, the domestic sector is the primary end-user of energy in the Indian economy. Estimates also show that the per annum growth rate (1950–2005) in energy consumption by the domestic sector was 1.7% [**1**]. India is the fourth largest consumer of energy in the world (in terms of primary energy). Primary energy consumption in India was 362 million tones of oil equivalent (MTOE) in 2005. It increased to 469 MTOE in 2009, which is an increase of 29.4% in five years (or an annual increase of 5.2% from 2005–09). This rising trend in energy consumption is likely to continue in order to achieve the 8% rate of growth of the gross domestic product (GDP) targeted for the Twelfth Five-year Plan [2].

With increasing energy consumption, there is also growing concern about energy related emissions and their impact on the environment and climate change. In 2007, energy related emissions in India were of the order of 1100 million tonnes (MT) of carbon dioxide equivalent ($CO_2$-eq), or 58% of the net $CO_2$-eq emissions (MoEF, 2010). India ranks among the top four emitters of greenhouse gas (GHG) emissions in the world in aggregate terms after USA, China, and Russia. Total emissions have increased by 3% annually, from 1228 MT of $CO_2$-eq in 2004 to 1728 MT of $CO_2$-eq in 2007**[3]**. However, the per capita emissions (including land use, land-use change, and forestry, or LULUCF) in India in 2007 were 1.5 tones per capita, which is among the lowest in the world. Given its growing importance in the international arena, efforts are being made in the country to take appropriate action to combat climate change and reduce GHG emissions **[4]**.

According to the NSSO data (64th Round, 2007/08), the primary source of cooking in rural India is firewood, followed by LPG. Kerosene is used as the primary cooking fuel by 0.6% of rural households. With regard to primary cooking fuel, 77% of rural households use firewood, 9% use LPG, and 7% use dung cakes. The per capita per month consumption of firewood is 26.7 kg and LPG is 0.2 kg. The per capita monthly consumption of kerosene through the Public Distribution System (PDS) is 0.5 litres, which includes consumption for cooking as well as lighting.LPG is being used by 62% of the urban households as primary cooking fuel, while the percentage distribution with regard to firewood is 20%. Kerosene is used as the primary cooking fuel by 8% of urban households. A small proportion of urban households (1%) use dung cake as the primary cooking fuel. The per

International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.5, No.6, June 2016 DOI:10.15693/ijaist/2016.v5i6.67-74

capita monthly consumption of firewood is 6.6 kg and LPG is 1.8 kg **[5]**.

### *A. Leading Causes of Biomass Fuel Use in Rural India*

Due to population growth and economic development, India's energy consumption is increasing rapidly. Energy and energy technologies have a central role in social and economic development at all scales, from household and community to regional and national. Among its welfare effects, energy is closely linked with public health both positively and negatively, the latter through environmental pollution and degradation. The three main determinants in the transition from traditional to modern energy use are:

- Affordability/Accessibility
- Fuel availability, and
- Cultural preferences

### *B. The Vulnerable Group*

Populace of the developing countries are typically exposed to very high levels of indoor air pollution for 3 to 7 hours a day **[6]**. Since it is always the women who cook daily household meals, their exposure is much higher than men **[7]**. Young children are often carried on their mother's back while she is cooking, so that from early infancy, children spend many hours breathing smoke **[8]**. The factors influencing the emission of pollutants and making rural areas vulnerable can be summarized point wise as below.

a) Fuel Type: Dung Cake, Crop Residue, Kerosene and Coal

b) Kitchen Type: Common kitchen types are present in rural areas

c) Age and Activity of the People

The study describes the present situation of households, use of fuel for cooking and their possible impacts on human health especially in the rural areas to estimate the impact of biomass and suggest how to improve the situation The study is focused in Sitapur Districts of Uttar Pradesh, India where biomass is the major domestic fuel used for cooking, and consists mainly agricultural by-products and gathered wood.

## II. MATERIALS AND METHOD

To estimate the impact of biomass and suggest how to improve the situation; a survey of households were conducted in selected areas of Sitapur. The sample for the survey is drawn from the households belonging to economically weaker section of the society during April, 2015. The location map of the Sitapur District where the survey has been done is shown in **Figure 1**. The total population of the district is 4483992**[9]**.


**Figure 1**: Location map of study area showing the survey point in different parts of the Sitapur.

In order to cover the geographical spread of the district 4 villages were randomly selected from each *block (tolal 19 in numbers)*. From each selected village, the 10 households purposive randomly selected such that they reflect the condition of rural areas of the respective *village* as closely as possible on various criteria such as percentage of poor population, worker population ratio, female and overall literacy rate, sex ratio and health infrastructure available. The size of the village in terms of households and population was also considered so that it is neither too big nor too small compared to the average in the blocks. An extensive survey at 760 locations were conducted which covered 76 villages of 19 blocks of Sitapur District.

### *A. Tools Used in Assessment*

In the process of planning of the study and to plan development for the understanding of the possible health problems and economic condition of the users, interviews were conducted with biomass users. The methodology adopted for the survey is discussed below:

- Selection of study location and population
- Represent the economic strata (High, medium and low income), Fuel usage
- Baseline information collection through Questionnaire survey:

  Household information such as

  - ✓ Details on Family members
  - ✓ Type of Household (Wholly kaccha (non-concerted), Pacca (concreted) and Chhappar (hut)
  - ✓ Cooking pattern (fuel, cooking device, and ventilation)
  - ✓ Separate Kitchen within the household

- ✓ Source of Lighting within the house
- ✓ Occupation
- ✓ Source and usage of Biomass

*B. Indoor Air Quality Monitoring*

Concentrations of BC were measured in the kitchen microenvironment close to mud cookstoves in 60 randomly selected households in six selected villages during 5 April to 29 June 2015. The indoor BC concentrations were automatically measured in Sitapur by aethalometer AE-42 (Magee Scientific, Berkeley, CA) with a quartz fiber filter tape system with a five-minute time interval.

## III. RESULT AND DISCUSSION

*A. Social Condition of Household*

As per primary survey the ratio type of households was maximum wholly Kaccha (non-concreted) (52.9) followed by Pacca (concreted) 23.8% and 23.4% Chhappar (hut) in the district. There is a serious concern of poorly ventilated cooking areas of Indian households and many houses do not have separate kitchen **[10]**. This has been further observed that the indoor air pollution from biomass burning varies with the kitchen type **[11]**. As per the Census 2011 the percentage of available separate kitchen within house was 22.02% in the Sitapur while in primary survey it was 23.9 % and as per primary survey percentage of separate space not available for kitchen within house was 76.1% while in Census 2011 it was 74.65%. The separate kitchen with ventilation facility is very important for every household for minimization of impacts due to indoor air pollution.

*B. Environmental Conditions*

We propose a Mobility Oriented Trust System (MOTS) in MANETs without using any centralized infrastructure. It uses trust table to favor packet forwarding by maintaining a trust vector for each node. A node is reprimanded or satisfied by decreasing or increasing the trust vector value. Each intermediate node marks the packets by adding its recommendation about the neighborhood node, probability that the data packet will be successfully transmitted and evaluation about the ability of forwarding packets towards the destination node. The destination node verifies the recommendation, probability of packet forwarding values and checks the trust vector. If the recommendation and probability of packet forwarding is verified, the trust vector is incremented, otherwise it is decremented. If the trust vector value falls below a trust vector threshold value, the corresponding the intermediate node is marked as malicious.

**Fuel Use for Cooking**

Non-commercial energy resources include the traditional fuels such as wood, cow-dung, crop-residue, and biogas and constitute a significant percentage of total primary energy consumption in the district. A larger share of these fuels is used by the households, particularly in rural areas, for meeting their cooking and heating needs. The consumption of traditional energy ratio was found as 40.5% firewood followed by 48.2% of dung cake, 10.1% of crop residue in primary survey while in census 2011 it was 70.78% firewood, 9.38% dung cake and 9.81% crop residue in the district. Around 98.5% of biomass is used in household for cooking purpose in the district. The above results are pictorially represented through **Figure 2**.

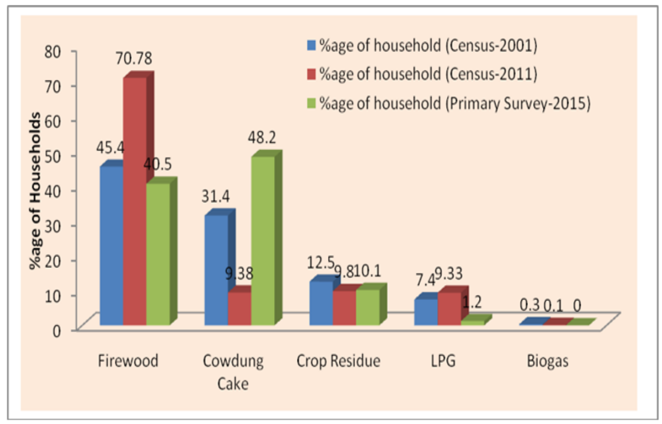


**Figure 2: Varieties of fuel being used as per the primary survey (2015) and the Census data**

**Source of Fuel for Cooking**

As per survey, forest was found to be the major supply source of fuel for cooking and other purpose leading with animal waste, orchard and other (coal/lignite/kerosene). The ratio of source of fuel was Forest (33.0%), Animal waste (28.8%), orchard (19.3%) and other (11.1%). The same results are graphically represented through **Figure 3**.

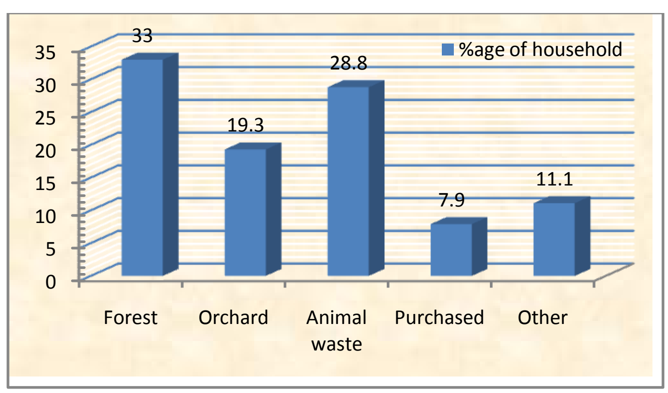


**Figure 3:** Source of fuel being used for household (%) in the Sitapur District

International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.5, No.6, June 2016 DOI:10.15693/ijaist/2016.v5i6.67-74

Recognizing the problem of rural household and benefits of cook stoves, the Govt. of India was launched a national programme on improved cook stoves with several objectives in 1983 and National Biomass Cookstoves Initiative (NBCI) was launched by Ministry of New Renewable Energy, Govt. of India on 2nd December 2009 with the primary aim to enhance the availability of clean and efficient energy for the energy deficient and poorer sections of the country. But we observed several barriers related to these initiatives (Table-1) in implementation.

**Table 1: Barriers of Indian National Programme on Improved Cookstoves**

| | |
|---|---|
| **Financial** | High Initial Costs |
| | High Fuel Costs |
| | Fossil Fuel Subsidies |
| **Social** | Reluctance to Abandon Accepted Practices |
| | Limited Awareness (Impacts, Alternatives, Government Programs) |
| | Limited Stakeholder Engagement |
| **Technical** | Poor Stove Design |
| | Acceptability of Technologies |
| | Lack of Repairs and Maintenance |
| | Lack of Local Manufacturers |
| **Institutional** | Bureaucratic Fragmentation |
| | Lack of Capacity, Training and Monitoring |
| | Lack of Approved Suppliers, Entrepreneurs and Vendors |

## IV. EMISSIONS FROM BIOMASS BURNING DUE TO DOMESTIC COOKING

### *A. Qualitative and quantitative emission from biomass burning*

Some of the highest exposure to air pollutants occurs inside homes where biomass fuels are used for daily cooking **[12]**. Biomass consists primarily of two polymers cellulose and lignin while other biomass fuels also contain these polymers, but their relative proportions differ compared to wood. Besides polymers, small amounts of low molecular weight organic compounds such as resins, waxes and sugars, and inorganic salts are present in biomass. During combustion, pyrolysis occurs and the polymers break apart producing a variety of smaller molecules. Biomass combustion is typically inefficient and as a result, a multitude of partially oxidized health-damaging pollutants are generated. The latest National Ambient Air Quality Standards of the U.S. Environmental Protection Agency requires the daily average concentration of $PM_{10}$ (particulate matter less than 10μm in diameter) to be less than 150μg/m$^3$ and annual average to be less than 50μg/m$^3$ and the details of emissions are presented in Table -2**[13]**. In contrast, concentration $PM_{10}$ ranged from 500-2000 microgram/m$^3$ during cooking in typical Indian households**[14]**.

**Table 2: Qualitative and quantitative emissions from wood burning**

| Pollutant | Physical state | Emissions (g/kg wood) |
|---|---|---|
| Carbon monoxide | Volatile | 80-370 |
| Methane | ,, | 14-25 |
| Volatile organic compounds | ,, | 27-Jul |
| Benzene | ,, | 0.6-4.0 |
| Toluene | ,, | 0.15 -1.0 |
| Phenol (and derivatives) | Volatile/Particulate | 0.2-0.8 |
| Nitrogen oxides (NO, NO2) | Volatile | 0.2-0.9 |
| Sulfur dioxide | ,, | 0.16-0.24 |
| Total particle mass | Particulate | 30-Jul |
| Particulate organic carbon | ,, | 20-Feb |
| Particulate elemental carbon | ,, | 0.3 - 5 |
| Oxygenated PAHs | Volatile/Particulate | 0.15-1 |
| Benzo(a)anthracene | ,, | $4 \times 10^{-4} - 2 \times 10^{-3}$ |
| Benzo(a)pyrene | ,, | $3 \times 10^{-4} - 5 \times 10^{-3}$ |
| Dibenzo(a,h) anthracene | ,, | 2 x 10$^{-5}$ - 2 x l0$^{-3}$ |
| Iron | Particulate | 3 x l0$^{-6}$ - 5 x 10$^{-3}$ |

### *B. Indoor air quality*

Black carbon (BC) is an aerosol particle emitted as a by-product of the incomplete combustion of fossil fuels or biomass (Firewood, cow dung cake and crop residue etc.). India has highest rank in South Asian black carbon emissions

International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.5, No.6, June 2016 DOI:10.15693/ijaist/2016.v5i6.67-74

at 64% with other countries Pakistan, Sri Lanka, Bangladesh, Nepal and Bhutan. In India, residential (Households) sector represents the largest single source of black carbon emissions from the use of cow dung cake, wood or coal, in heating stoves, Chullah's and Kerosene lamp. Approximately 72% of all households in India rely on traditional energies for their cooking needs. Reducing atmospheric concentrations of black carbon in India can result in improved public health and a slowing of the rate of near-term climate change. Because of the very high particulate matter burden in India in general, reductions in black carbon could prevent a greater number of premature deaths [**15**] found that acute respiratory infections, the leading cause of childhood mortality in India, were almost twice as likely in households in India that used only biomass for cooking and heating as in households using cleaner fuels. The actual impact of black carbon could not quantify in India and need a greater research studies on impact of black carbon.

**Figure 4** displays the sectoral breakdown of black carbon emissions in India. Note that, as shown in Figure 4**,** residential sector represents highest emissions followed by open burning, transport brick kilns and other industries in India. The Census data (2011) reports firewood as the primary cooking fuel in India, followed by LPG. All-India sample indicates firewood as the primary energy source for cooking in 49% of households, whereas LPG is the primary cooking fuel in only 29% of households. Dung cakes exhibit considerable significance in the cooking fuel list as 8% of households use these as the primary cooking fuel. Kerosene is used as the primary cooking fuel by 3% households.

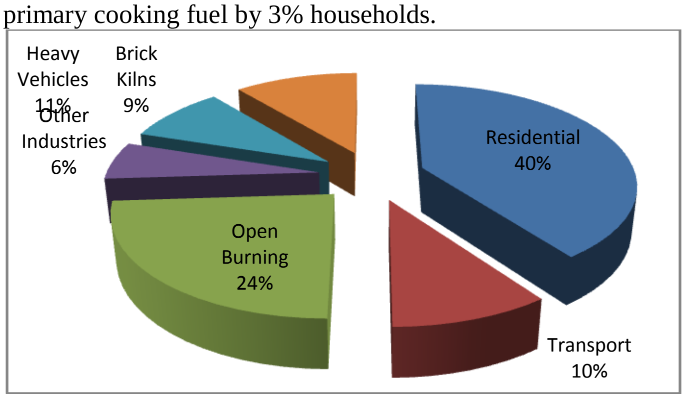


**Figure 4: Sectoral black carbon emissions in India**

The major finding of this study is that BC concentrations during cooking hours, both indoors and outdoors have anomalously large concentrations. The type of cooking fuel was also a major factor in concentrations of BC. Focusing on the quantitative values, **Figure 5** shows the indoor variation of BC concentrations in selected households. During morning cooking hours (06:00 to 09:00 AM) BC concentrations varied from 3.80 to 43.4 µgm$^{-3}$ with an average value of 14.25 µgm$^{-3}$. Similarly, during evening cooking hours (17:00 to 20:00 PM) BC concentration varied from 3.90 to 42.5 µgm$^{-3}$ with an average value of 15.7 µgm$^{-3}$. The large variation in the BC concentrations observed during cooking hours could be attributed to the fact that not all households cook at the same time; some households start cooking early around 05:00 AM while other start a little later. Similar reasoning also explains occasionally sharp peaks in BC concentration (>30 µgm$^{-3}$) during the morning and evening cooking hours.

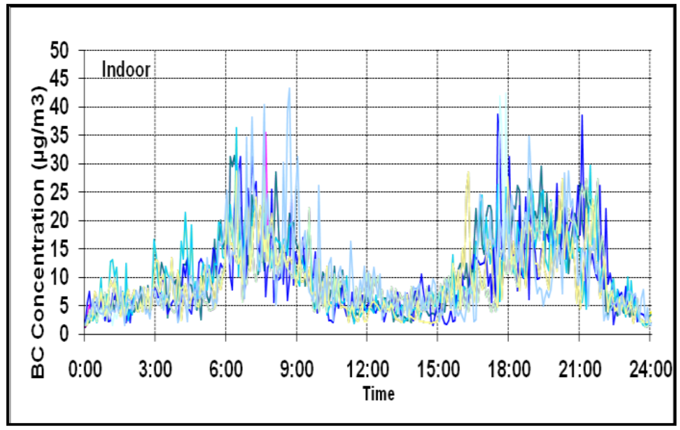


**Figure 5:** Black Carbon Emission in Households

### *C. Outdoor air quality*

**Figure 6** shows the daily variation of outdoor BC concentration in the villages. The data was recorded simultaneously with indoor measurements. During morning cooking hours, outdoor BC concentration varied from 1.70 to 22.4 µgm$^{-3}$ with an average value of 7.80 µgm$^{-3}$. Similarly, during evening cooking hours outdoor BC concentration varied from 1.96 to 20.54 µgm$^{-3}$ with an average value of 8.74 µgm$^{-3}$. The ambient BC diurnal variation had a similar trend to indoor BC mass concentrations with the peaks following closely the morning and evening cooking cycle, suggesting a strong influence of indoor cooking on outdoor BC concentration.

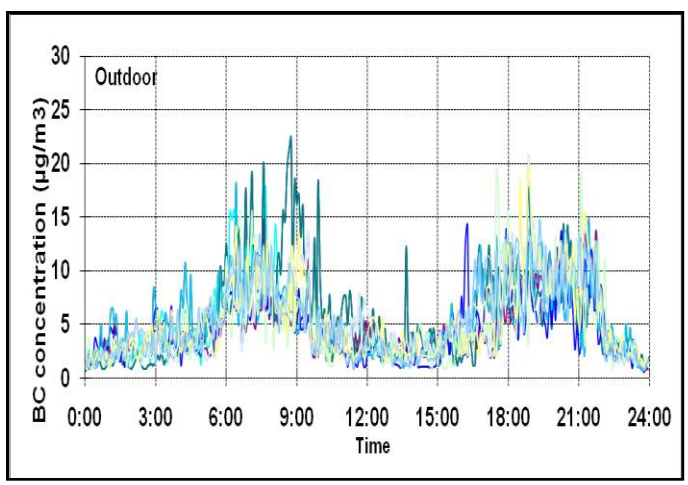


**Figure 6:** Outdoor (Ambient) Black Carbon Concentration

## V. POSSIBLE HEALTH IMPACT DUE TO BIOMASS FUEL

The health effects of biomass smoke inhalation may not be restricted to the lungs because biomass smoke contains fine and ultra fine particles [**16**] that readily cross the alveolar-capillary barrier and reach vital organs of the body through circulation [**17**]. It is conceivable; therefore, that biomass smoke exposure could lead to systemic health impairment. However, little attention has been focused on the health impact of biomass fuel use in rural India. Cooking areas of many Indian households are poorly ventilated, and half of the households do not have separate kitchen [**18**]. To a considerable extent life revolves around the cooking area, and women spend much of their time there, exposing themselves to high pollution levels. In India, 0.4 to 2 million premature deaths occur per year due to indoor air pollution with a majority of deaths occurring in children under five due to acute respiratory infections [**19**] [**20**] [**21**]. There is also strong evidence of impact on women, up to 34,000 deaths resulting from chronic obstructive disorders [**22**]. In contrast, mortality due to outdoor air pollution is 200,000 to 570,000 representing about 0.4 to 1.1 % of total annual deaths [**23**]. The mechanism which are helpful in understanding some of the key pollutants in smoke from domestic sources which are responsible for the health problems are summarized in Table 3.

**Table 3: Mechanisms by which some key pollutants in smoke from domestic sources may increase risk of respiratory and other health problems**

| **Pollutants** | **Mechanism** | **Potential health effects** |
|---|---|---|
| Particulate matter: small particles less than 10 microns, and particularly those less than 2.5 microns aerodynamic diameter | ▪ Acute: bronchial irritation, inflammation and increased reactivity<br>▪ Reduced muco-ciliary clearance<br>▪ Reduced macrophage response and reduced local immunity | ▪ Wheezing, exacerbation of Asthma<br>▪ Respiratory infections<br>▪ Chronic bronchitis and Chronic Obstructive Pulmonary Disease (COPD)<br>▪ Exacerbation of COPD<br>▪ Excess mortality, including from cardiovascular disease |
| Carbon Monoxide | ▪ Binding with Haemoglobin (Hb) to produce COHb which reduced $O_2$ delivery to key organs and the developing foetus. | ▪ Low birth weight (fatal COHb 2 10%, or higher)<br>▪ Increase in perinatal deaths |
| Benzo[a]pyrene | ▪ Carcinogenic (one of a number of carcinogenic substances in coal and biomass smoke) | ▪ Lung cancer<br>▪ Cancer of mouth, nasopharynx, and larynx |
| Formaldehyde | ▪ Nasopharyngeal and airways irritation<br>▪ Increased allergic sensitisation | ▪ increased susceptibility to infections<br>▪ May lead to asthma |
| Nitrogen dioxide | ▪ Acute exposure increases bronchial reactivity<br>▪ Longer term exposure increases susceptibility to bacterial and viral lung infections | ▪ Wheezing and exacerbation of asthma<br>▪ Respiratory infections<br>▪ Reduced lung function(children) |
| Sulphur dioxide | ▪ Acute exposure increases bronchial reactivity<br>▪ Longer term: difficult to dissociate from particulate effects | ▪ Wheezing and exacerbation of asthma<br>▪ Exacerbation of COPD, CVD |
| Biomass smoke (component uncertain) | ▪ Absorption of toxins into lens, leading to oxidative changes | ▪ Cataract |

## VI. CONCLUSION

The consumption of traditional energy ratio was found as 40.5% firewood followed by 48.2% of dung cake, 10.1% of crop residue in primary survey while in census 2011 it was 70.78% firewood, 9.38% dung cake and 9.81% crop residue in the district. Around 98.5% of biomass is used in household for cooking purpose in the district. Forest was found to be the major supply source of fuel for cooking and other purpose leading with animal waste, orchard and other (coal/lignite/kerosene). The ratio of source of fuel was Forest (33.0%), Animal waste (28.8%), orchard (19.3%) and other (11.1%). The ratio type of households was maximum wholly

Kaccha (non-concreted) (52.9) followed by Pacca (concreted) 23.8% and 23.4% Chhappar (hut) in the district. Indoor, BC emission varied from 3.80 to 43.4 $\mu gm^{-3}$ in morning time and in evening it varies from 3.90 to 42.5 $\mu gm^{-3}$. While in outdoor, BC emission varies from 1.70 to 22.4 $\mu gm^{-3}$ in morning hours and from 1.96 to 20.54 $\mu gm^{-3}$ in evening time.

From the above observations and their analyses, it can be concluded that most of poor people of the country who cannot afford cleaner fuel have no other alternative but to use traditional biomass for cooking and room heating. In the process, their health is adversely affected and the major victims are the women who cook with these fuels and their children who spend a long time with their mothers. In fact, air pollution and related health hazards are considered as problems of urban life while the villages are treated as abode of peace, tranquillity and freshness. Moreover, since the victims are mainly women and children and that too from poor rural areas, they suffer in silence while everybody seems busy with so many 'important' issues.

**Recommendation**

Based on the findings above, the following recommendations can be made:

1. Provision of clean fuels or at least wood plantation within one km of habitation and dissemination of technology for use of clean fuels is vital for good health.
2. Environmental awareness campaign should be carried out to sensitize the people on the need to harness alternative and renewable energy resources such as biomass fuel rather than continuous exploitation of oil and gas.
3. Smoke stalks should be provided in burners and kitchens in order to disperse the particulate matter released during burning wood fuel in cooking.
4. Kitchens and cooking places should be adequately ventilated.
5. Renewal of woodlots should be aggressively carried out by community members.
6. Periodic health check up either at PHCs or health camp.
7. Progressive and increased use of energy mix (including non conventional energy) for energy generation and consumption in the area.
8. A comprehensive survey of all the energy needs in a village community should be carried out.
9. A study should be made to install community type biogas plants and the utilisation of gas from such plants for households, pumping and industrial applications should be explored.

## REFERENCES

[1] Reddy B S and Srinivas T. 2009. Energy use in the Indian household sector: an actor oriented approach. *Energy* 34(8): 992–1002.

[2] MoEF (Ministry of Environment and Forests). 2010. *India's Greenhouse Gas Emissions* 2007. New Delhi: MoEF, Government of India.

[3] Planning Commission of India, 2012

[4] Tata Energy Research Institute. Indian Energy Sector: An Overview, *Energy Data Directory and Yearbook 2010*.

[5] NSSO (National Sample Survey Organization). 2010. Unit level data, household consumer expenditure round 64 (July 2007 to June 2008). New Delhi: NSSO, Ministry of Statistics and Programme Implementation, Government of India

[6] Engle PL, Hurtado E, Ruel M. Smoke exposure of women and young children in highland Guatemala: predictions and recall accuracy. *Human Organisation*, 56, 408-417, 1997.

[7] Behera D, Dash S, Malik S. Blood carboxyhaemoglobin levels following acute exposure to smoke of biomass fuel. *Indian J Med Res,* 522-42, 1988.

[8] Albalak R. Cultural Practices and Exposure to Particulate Pollution from Indoor Biomass Cooking: Effects on Respiratory Health and Nutritional Status among the Aymara Indians of the Bolivian Highlands, Doctoral Dissertation, University of Michigan, 1997.

[9] Census of India (2011) Office of the Registrar General & Census Commissioner, India

[10] Mishra VK, Retherford RD, Smith KR. Biomass cooking fuels and prevalence of tuberculosis in India. *International J. Infect. Dis.,* 3, 119-129, 1999a.

[11] Balakrishnan K, Sankar S, Parikh J, Padmavati R, Srividya K, Venugopal V, Prasad S, Pandey VL. Daily average exposures to respirable particulate matter from combustion of biomass fuels in rural households of southern India. *Environ Health Perspect* 110, 1069-1075, 2002.

[12] Dutt D, Srinivasa DK, Rotti SB, Sahai A, Konar D. Effect of indoor air pollution on the respiratory system of women using different fuels for cooking in an urban slum of Pondicherry. *Natl Med J India* 9, 113-117, 1996

[13] US Environmental Protection Agency, 2002.

[14] Balakrishnan K, Sankar S, Parikh J, Padmavati R, Srividya K, Venugopal V, Prasad S, Pandey VL. Daily average exposures to respirable particulate matter from combustion

of biomass fuels in rural households of southern India. *Environ Health Perspect* 110, 1069-1075, 2002.

[15] V. Mishra, Kirk R. Smith and Robert D. Retherford, 2005. "Effects of Cooking Smoke and EnvironmentalTobacco Smoke on Acute Respiratory Infections in Young Indian Children

[17] Tesfaigzi Y, Singh SP, Foster JE, Kubatko J, Barr EB, Fine PM, McDonald JD, Hahn FF, Mauderly JL. Health effects of subchronic exposure to low levels of wood smoke in the rats. *Toxicol Sci.*, 65, 115-125, 2002.

[18] Nemmar A, Hoet PH, Vanquickenborne B, Dinsdale D, Thomeer M, Hoylaerts MF, Vanbilloen H, Mortelmans L, Nemery B. Passage of inhaled particles into the blood circulation in humans. *Circulation*, 105, 411-414, 2002.

[19] International Institute for Population Science, 1995.

[20] Awasthi, S, Glick H, Fletcher R. Effect of Cooking Fuels on Respiratory Diseases in Preschool Children in Lucknow, India. *American Journal of Tropical Medicine and Hygiene*, 55, 48–51, 1996.

[21] Smith KR. The national burden of disease from indoor air pollution in India. In: Raw G, Aizlewood C,Warren P,eds. Indoor Air 99, the 8th International Conference on Indoor Air Qualityand Climate, August 1999, Edinburgh, London, Construction Research Ltd., 13-18,1999.

[22] Smith KR. Indoor air pollution implicated in alarming health problems. In: Indoor Air Pollution Energy and Health for the Poor. Newsletter published by World Bank, p. 1, 2000.

[23] World Health Organization. The World Health Report 2002: Reducing Risks, Promoting Healthy Life, Chapter 4, Quantifying Selected Major Risks to Health, No.8, Environmental Risks, WHO, Geneva, 2002.

### Authors Profile

**Mohammad Arif** received the **M.Sc.** degree in Sustainable Development from the Sikkim Manipal University, Gangtok, India, in 2010.Currently doing **Ph.D.** in Environmental Science in Sharda University, Greater Noida, India. His research interest includes Climate Change, Indoor Air Pollution, Health Impacts, Short lived climate pollutants, Environmental Impact Assessment and Environmental Management Plan and policy research.

Dr. Rajesh Kumar, Ph.D. from Banaras Hindu University (BHU) is currently working as Professor and Head, Department of Environmental Science, School of Basic Sciences and Research (SBSR), Sharda University. He has vast experience of working on the influence of changing climate and the global warming on Snow and Glacier that impacts the availability of water resources in the Indian Himalaya.

**Afaq Ahmad** received the **Advance Diploma in Environmental Engineering.** Degree from Aligarh Muslim University, Aligarh, India, in 2007.Currently doing **job** for United Nation Development Programme, India as Environmental Consultant. His research interest includes Air Pollution, Health Impacts, Solid Waste Management, Environmental Impact Assessment and Environmental Management Plan.