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Indoor Air Quality Monitoring of Biomass Fuel vis-à-vis Smoke Emission in Rural Poor Communities and Their Health Risks in Bundelkhand Region, Central India.

Abhimanyu Singh[1], A.H. Khan[2], Swati Gupta, Ambrish K. Verma[3], Dheerendra S. Chauhan[1] and Jamshed Zaidi[1]

[1]Institute of Environment & Development Studies, Bundelkhand University, Jhansi, India.

[2]Indian Institute of Toxicology Research-Lucknow, India

[3]Civil engineering Department, Shri Ramswaroop Deva Road-Lucknow, India

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ABSTRACT

The indoor air pollution especially in rural communities of Bundelkhand region in central India is suffered from indoor kitchen air-born diseases due to large scale using principal biomass fuels such as wood (W), crop residues (C.R.), cow dung cakes (D.C.) and also fossil fuels of low grade coal. All these fuels are producing as a smoke emission in various forms with hazardous composition contain harmful pollutants which adversely affect on human health. The indoor particulate and gaseous pollutants in mean level range from TSPM; 383.2-468.5 µg/m^3 , SOx, 12.7-25.4 µg/m^3 NOx; 34.1-44.5 µg/m^3 and other certain toxic elements emission as trace amounts associated with health problems depends upon the magnitude and types of biomass combustion from the open chulas in kitchens with close non-ventilated environments. A number of health risk related problems are created such as chronic obstructive pulmonary disease (COPD), silica-born tuberculosis(TB), asthma, pneumoconiosis, pharynx and laryns (forms of neoplasm), eye-disorders, depress cellular and humorial immunities etc; mainly based on survey ,HVS monitoring with some pathological data from the investigated areas. This paper is emphasized and attempt should be needed to adopt integrated approaches in domestic pollution free energy use involving fuel diversity resulted keeping in views relating to up-grading socio-economic and reduce health risk aspects with new techniques adaptation where feasible and highly effective in below poverty limit (BPL) of the rural communities for the maintaining conceptual sustainable development supporting the solution of the energy problems in Bundelkhand region.

Introduction

Air pollution is a significant cause of morbidity and mortality. The greatest health impacts from air pollution worldwide occur among the poorest and most vulnerable populations. The amount of exposure in terms of the number of people, exposure intensity and time spent exposed is far greater in the developing world (Smith, 1993) approximately 76% of all global particulate matter air pollution occurs indoors in the developing world. World Health Organization WHO (2002) stated that a pollutant released indoors is 1,000 times more likely to reach people’s lung than a pollutant released outdoors. It has also reported 2.2–2.5 million annual deaths in developing countries due to indoor air pollution caused by ignition of rural sources of energy. Indoor pollution in developing countries has been gaining more attention recently (Balkrishnan et al., 2002; Smith and Mehta 2003; Bhargava et al., 2004; Smith et al., 2004; Peabody et al., 2005; Naeher et al., 2007). According to the World Health Organization (WHO), India accounts for 80% of the 600,000 premature deaths that occur in Southeast Asia annually due to indoor air pollution (Devakumar et al., 2009).When attention is focused on the problem of indoor air pollution resulting from the use of ‘biomass fuels’. (http://www.ncbi.nlm.nin.gov/PCM/articles / PMC 2568866) . Biomass fuels like wood, agricultural waste and dung cakes are used by about half the world’s population as a major, often the only, source of domestic energy for cooking and heating (Koning, et al., 1985). A disproportionate number of these biomass fuels, consumptions like 95%in Chad, 87% in Ghana, 82% in India, 80% in China, and so forth (WHSA, 1983). It is known that the approximately 30% of urban households and 90% of rural households in developing countries rely on biomass fuels for cooking (Hughart, 1979).

Inefficient burning of biomass fuel (BMF) on an open fire or traditional stove generates large amounts of particulate matter as well as carbon monoxide, hydrocarbons, oxygenated organics, free radicals and chlorinated organic (Naeher et al., 2007). The particulate matter component of this smoke is classified according to its size, with inhalable material <10 µm in aerodynamic diameter referred to as PM10. The 24-h mean particulate matter levels set in the WHO guidelines for air quality are 50 µg/m3 for PM10 and 25 µg/m3 for PM2.5 (WHO, 2006b), but in many parts of the developing world the peak indoor concentration of PM10 often exceeds 2000 µg/m3 (Ezzati and Kammen, 2001; Regalado, et al., 2006). Critically, there are age, gender and socio-economic differences in levels

Tele:

E-mail addresses: abhimanyu_geol@yahoo.co.in

of exposure and the consequent health effects (Bruce, et al., 2000). Exposure to BMF has been estimated to have caused 0.5% of all deaths and 0.4% of all disability-adjusted life-years in South Africa in 2000 (Norman, et al., 2007).

Health impact of indoor air pollution show prevalence of respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis, and acute respiratory infections in all sexes and age groups (WHO Europe 1997; Robin, et al., 1996; Smith, et al., 2000). Seppo, et al., (2006) reports decreased pulmonary function among children exposed to indoor air pollution due to biomass combustion. About 18% of rural population exposed to indoor pollution develops blindness (Mishra, et al., 1999).

Biomass fuel emission having sensitive to a health hazards whose effects vary in specific type and their severity depending on the local situation, type of fuel used and resultant affecting the population at risk. The culture, customs, and housing conditions of the people are important determinates of the level and nature of the risk. Climate and weather conditions also influence the exposure to biomass fuel emissions because people will spend more time indoors when it is old and wet than when it is dry and sunny. The people affected will include infants and children as well as the women who do the cooking (Koning, et al., 1985).There is great variation factor in housing condition, fuel type, fueling rate, type of chulhas construction (consisting of three rocks; a U-shaped hole in a block of clay, mud or bricks; a pit in ground or similar arrangements) , cooking method and their practices in terms different climatic conditions especially in the development countries; but crowding, proximity of infant and children to the cooking area lives where, use of low efficiency stoves, long time spent in a house around at these burning stoves, and contain poor ventilation are common factors (Aggarwal,1983).

During the investigation, find out more than two- thirds of the household in the Bundelkhand lie in developing stage for the up-grading the old traditions and having about three quarters of these belts are comes in rural areas. Thus, the most prevalent deterioration continue of indoor environment today is the same follow one that has dominated traditionally practices in most of human history-huts in rural communities in Bundelkhand region. In this region, most of un-developed rural areas are faces the greatest threat from indoor air pollution in relation to human diseases , where majority of the people continue to rely on traditional fuel such as firewood, charcoal, and dung cakes for cooking and heating. Concentrations of indoor air pollutants in households that burn traditional fuels are alarming stage. Burning of such fuels produces large amount of un-burned smoke with ash and other air pollutants in the confined apace of the home, resulting in high exposure. Women and children groups are the most vulnerable as they spend more time indoors and are exposed to the smoke for the high health risks.

Materials and Methods

Study Area

Jhansi is well known district of Bundelkhand region of Uttar Pradesh in India with a geographical area of 502.75 thousand hectare. The district is situated in the south west corner of the region at 24º11' N - 25º57' N latitudes and 78º10' E- 79º23' E longitudes. Population of Jhansi is near about 4, 79,612.The western area of the district is covered with hillocks. It is located in the plateau of central India dominated by rocky reliefs and different types of minerals underneath the soil. The city has a natural slope in the north as it lies on the south western border of the vast Tarai plains of Uttar Pradesh. The elevation rises on the south. The land is suitable for citrus species fruits. Crops include wheat, pulses, peas, oilseeds. The region relies heavily on monsoon rains for irrigation purposes. Under an ambitious Rajghat canal project where, the government is constructing a network of canals for irrigation in and around Jhansi and Lalitpur district and some extended area of Madhya Pradesh .

For the investigation covering eight rural villages of each block levels are chosen which based on using traditional biomass fuels, configuration of houses, family size and also non-scientific chulah specially in Jhansi district. In concerned to the traditional, cultural and poor socio-economic values, the principal biomass fuels are mostly used as dung (60%),wood (10%) and crop-residues (30%) in the non-ventilated kitchen type houses gives the human health at risk by the emission of SPM,SOx and NOx beyond the standards permissible limits by recommended the by World Health Organization .

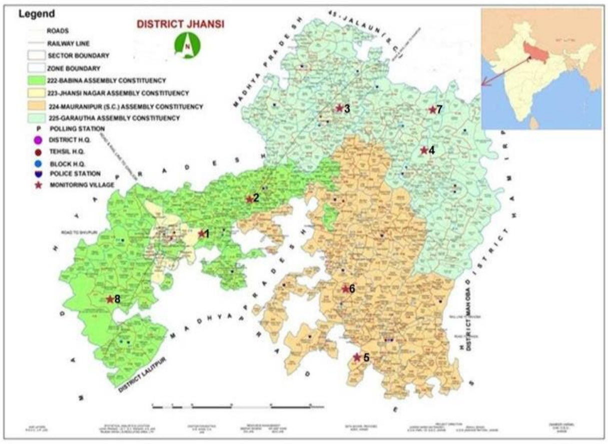


Fig 1. The monitoring villages of the study area

Methodology for Indoor air monitoring

The selection of the specific villages at block level from each monitoring site was done whose only using traditional biomass fuels. Sampling and selection of households within the selected sites were performed based on monitoring in systematic by handy air sampler for the detection of SOx and NOx and HVS (High Volume Sampler) for TSPM emissions. The survey was carried out at household level including in individual responses who spent long time in and around kitchen rooms. It is made highly smoky for status of residential energy consumption and using different type of energy consumption pattern of biomass fuels in house and their data generate specially health aspect in relation to members in household affecting by the emission of pollutants during and after the cooking and space heating.

Results and Discussion

The monitoring of indoor air pollution status in eight selected villages at block level in Jhansi district in central India shown in Table 1. based on types of traditional biomass fuels, numbers of rural households, family size, duration of cooking in morning and evening ,type of house construction with non-ventilated kitchens, amount of fuel consumption per day with different summer and winter seasons using open chulah without flue.

The Bundelkhand region in Central India comes under the semi-arid climatic condition, the rural poor communities of this study areas ,for their energy need are depends prinicipally on the traditional varying species as biomass fuels like Babul (*Acacia nilotica*), Neem (*Azadarachta indica*), Mahua (

Madhuca indica), Mango (Mangifera indica), cactus and brushes which occur in large scale. Besides these, some of the others usage as a biomass fuels like dried dung from livestocks and also crop residues in the form of mustard stalks, pea husk with stem rice straw and wheat stem in a wide range using of these materials in different physical forms contain varying heat with different indoor pollutants emission concentration depends upon the local conditions prevailed.

The regular monitoring of six months in the morning and evening covering both winter season(January to March) and summer season (April to June) were carried out for the status of indoor pollution concentrations in the selected villages in the study area.

Total Suspended Particulate Matters (TSPM)

In the study area, most of the poor rural communities were using mentioned above traditional biomass fuels amount of average 80% of required domestic energy consumption. Due to using different types of biomass fuels produces various level emissions as indoor particulate matters depends upon the micro-weather variation in morning and evening cooking time on open kachha chulhas in non-ventilation type of kitchen room with constructed in small size and less height roof.

In winter season specially in morning cooking time(high wind velocity) where author's have observed readings as low level of total suspended particulate matter in comparison to evening time (low wind velocity).In morning time, the indoor particulate level ranges from µg/m3 (Av. 419.00 µg/m3)was observed, whereas in evening time it ranges from 390-578 µg/m3 (Av.468.51 µg/m3) shown in Table- 1. This is result due to the difference in ratios of the incomplete combustions of differ biomass fuels and also depends upon the quality and quantity of the dung cake and combined wood with crop residues. Author's have minutely observed when cooked by the dung cake having the low level of emission particulate matters in comparison to combined wood and crop residues even in morning and evening times. Besides the above , considerable readings variation of particulate emission level in morning and evening in low and high concentration respectively have recorded .It is also observed the same condition in seasonal variation particulate levels in the winter as high and in summer having low concentration due to the difference in wind velocity. In winter season, more than 90% of the rural villagers burns the traditional biomass fuels mostly wood and crop- residues out side the house in evening time and also same time have been cooking inside the house generating two-tier heat island pollution dome trapping the pollutants resulting high concentration of particulate matter because the wind velocity is very slow and also high terrestrial heat radiation occur. After the sun-set, high terrestrial radiation near the ground, where evening ground level inversion (- ve lapserate) had formed and also less pollutants mixing resulting to high pollutions level.

Table 1. Shows the monitoring of indoor air pollutants based on traditional fuel combustion in Jhansi district, Bundelkhand region.

S.No	Study Area Block(village)	No.of household	No. of Family member	Fuel use Kg/day	TSPM(µg/m^3)				SOx (µg/m^3)				NOx (µg/m^3)				Per Capita Consumption kg/day	Range Of cooking Time hr/day
					Winter season		Summer season		Winter season		Summer season		Winter season		Summer season			
					Mo.	Ev.	Mo.	Ev.	Mo.	Ev.	Mo.	Ev.	Mo.	Ev	Mo	Ev.		
1	Baragaon (Digara)	7	15	11 D.C+W+CR	562	578	439	489	21	26	16	23	47	50	41	46	0.76	4-5
2	Chirgaon (Gulara)	6	12	10.6 D.C+W+CR	502	543	543	470	22	24	15	19	46	51	39	43	0.88	3-4
3	Moth (Bamhroli)	5	8	8.5 D.C+W+CR	432	498	420	480	14	19	10	18	38	42	32	37	1.06	2-3
4	Gursarai (Asta)	4	7	7.2 D.C+ W+CR	370	410	350	391	17	20	11	17	45	52	40	47	1.03	2-3
5	Mauranipur (Basari)	3	6	6.3 D.C+W+CR	330	402	310	390	28	33	19	25	33	39	28	34	1.05	2-3
6	Bangara (Chaukri)	2	10	9.1 D.C+W+CR	490	532	479	502	24	30	21	17	55	58	49	55	0.91	3-4
7	Bamaur (Dundi)	1	5	5.9 D.C+W+CR	320	395	290	360	26	28	17	25	30	35	25	29	0.91	2-3
8	Babina (Sarvo)	1	4	5.5 D.C+W+CR	346	390	335	360	20	23	14	19	25	29	19	23	1.38	1-2
	Range	---	----	5.5-11.4 D.C+W+CR	320-562	390-578	290-479	360-502	14-28	19-33	10-21	17-25	25-55	29-58	19-49	23-55	0.76-1.38	1-2 4-5
	Mean	----	-----	8.06	419	468	383	430	21.5	25.4	12.7	18.2	39.8	44.5	34.1	39.2	1.0	2.87

Mo: Morning; Ev: Evening; D.C: Dung cakes; W: Wood; CR: Crop residues; TSPM: Total Suspended Particulate Matters

Due to these phenomenon , difference in temperature and pressure existence inside and outside of the houses have been noted. Surrounding the houses, high pressure is developed by comparatively more cooler condition than the more heat with low pressure inside cooking house where no mixing of pollutants present within the houses but increases further could be the result of the infiltration of outside air-born particulate into the houses.

Gaseous Pollutant

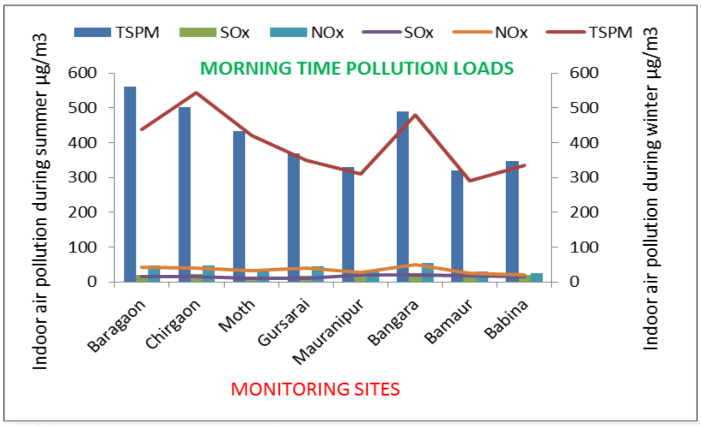
Samples were collected in the impingers one to four hours monitoring basis from biomass fuel based open chulhas in rural household kitchens for a period of 8 hours per day. Tetrachloro mercurate solution was used to absorb SOx and its concentration was measured colourimetrically and expressed as micrograms per cubic meter of air. The monitored air sampled in morning and evening time specially in the winter season, it observed in the ranges 14-28(Av 21.8 µg/m3) and 19-33 µg/m3 (AV.25.4 µg/m3) respectively. In summer season, morning time SOx has ranges between 10 to 21 µg/m3 (Av.12.7 µg/m3) whereas in evening ranges from 17 to 25 (Av.18.2 µg/m3). In both the seasons, readings mentioned above ,author's have opinions that the evening time having the more SOx than the morning time due to the micro-climatic variation at micro scale wind velocity relating to inversion phenomenon outside the surrounding houses of the village cause high gaseous pollutants within the kitchen with neighboring rooms.

The degree of gaseous pollution level of the NOx specially in both the seasons in winter and summer,their alternate morning and evening range averages 39.8-44.5 µg/m3 and 34.1-39.2 µg/m3 emission concentrations were recorded respectively in somewhat higher level than the SOx(average range 21.5-25.4 µg/m in winter 3and 12.7-18.2 µg/m3in summer season) during monitoring.

The whole monitored of the TSPM SO_X and NO_X based on traditional biomass fuels with thermally insufficient open chulhas in rural households indicate the higher level concentration than the permissible limit recommended by the WHO and others organization standards of the air quality relating to human health risks.

A number of rural households in the study area in terms of daily using consumption of total biomass fuels have been observed in eight villages at each block level ranges from 5.5-11.4 kg per day (Av. 8.06 kg/day) and also calculated per capita consumption per day in the range between 0.76-1.06 kg /person/day(Av.1.0kg/person/day) with the range of total cooking time per/day estimated from minimum to maximum ranges 1-2 to 4-5 hours/day(Av.2.87 hr/day). It is already estimated in the world's households where cooking with tradition biomass fuels use approximately 1 kg of fuel wood equivalent per person per day (approximately 15 megajoules heat content).In general, the range of cooking times in the rural areas of developing countries would seem to be 8-25% of the year (Smith and Colfer,1983).

The dose-response relationship in terms of exposure emission concentrations for particulate matters, SOx and NOx from the traditional biomass fuels would seem to a point to high degree of human health risks having positive correlation response where higher concentration produce more human health damage per unit dose than low concentration dose based on common rural people survey.



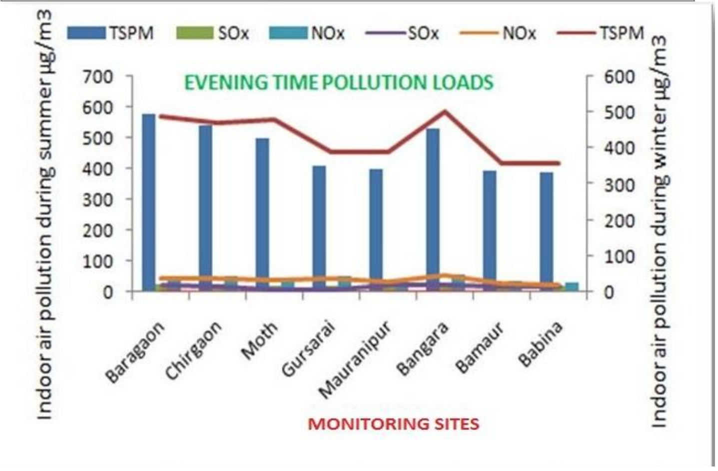


Fig 2. [A] Shows indoor air pollution status during summer and winter in morning time; [B] Indicate indoor air pollution status during summer and winter in evening time.

Assessment of Human Health Problems

In Jhansi district of Bundelkhand region, most of the poor rural communities have exposes the highly smoke bearing biomass combustion having the emission product inhaled as a pollutants in relation to health risks .It is usually seen that the women seem to be the main sufferers as compared to men from smoky indoor fire which follow most cultures and also traditional because of their role as family cook. In Indian culture, women learn to cook while in young age and also particularly small children suffering from acute and sub-acute respiratory infections due to long time spent with mother during cooking. Most of time women were cooking, they tended to be seated on the floor near to the cooking open chulhas . It is known that the smoke is an aerosol of very fine carbon particles of size ranges from 0.5-1.0 micron which are produced by incomplete combustions of organic particles such as dung cakes, wood and crop- residues.

Heavy exposures to varying types of toxic bearing woody smoke from different types of biomass fuels were impact on infant and small children results respiratory disease. In the study area ,identified a number of human risk factors when living in room made high smoky in long time exposures by the biomass fuels. This recurrent respiratory infection , attributable to impaired pulmonary defence mechanism, lead to chronic bronchitis and emphysema and finally chronic pulmonale, where highest prevalence of abnormal pulmonary signs was detected mostly in youngest and oldest age groups. In central India ,high mortality rates from chronic pulmonale have been reported, accounted for 10-30% of hospital admissions, where represent the highest rates of any non-industrial population in the world. It is surprising to note that the domestic air pollution is thought to be an important contributory cause of chronic pulmonale.

In addition to, the sub acute inflammatory reactions were caused by recurrent exposure to irritant and cilia- toxic and mucus –coagulating emissions make the trachea, bronchi and bronchioles, especially in infants, susceptible to infection which may manifest itself as acute infective bronchitis, bronchiolitis or pneumonia. The National Institute of Occupational Health (NIOH) in India surveyed 150 women who cooked with biomass fuels and 75 women who used kerosene (NIOH Annul Report,1979).Medical examinations showed that the incidence of cough, cough with expectoration and dyspnoea was considerably higher among women using traditional biomass fuels. X-ray examinations revealed that respiratory abnormalities were more common among these women (18%) than in the control group. Most of the housewives are exposed to dense toxic gaseous pollutants bearing smoke suffers of pain, headache , watering in the eyes and lung cancer disease.

Conclusion

In the study area relating to the epidemiological studies, the indoor air pollution from biomass combustion cooking on open chulhas in the poorly ventilated kitchen of the rural households has revealed excessive concentration emissions like TSPM, SOx and NOx that are quite large by recommended global standards which concerned to the high human health risks. Exposure to biomass smoke emissions increases the risk of acute respiratory infections (ARI) where mostly affected women and their children due to close proximity to the source of indoor air pollutants exhibit a higher prevalence of chronic obstructive pulmonary diseases (COPD) like asthma, chronic bronchitis and also some other disease extent to ear infections.

Exposure to high indoor smoke levels by the use of biomass fuels is associated with pregnancy related problems such as still births and low birth weight as well as blindness and changes in the immune system of new born. Author's have opinion for this study in rural areas, where indoor air pollution is responsible for much greater mortality than ambient outdoor air pollution. A recent report of WHO asserts the "rule of 1000" which states that a pollutants released indoor is one thousand times more likely to reach the lungs than pollutant released outdoor.

Appendix (Ansari et al., 2009)

The questionnaire for survey of biomass fuel use in domestic cooking

Questionare

No.:

Date:

Name of Village:

Name of home owner with age:

Name of cooking member with age:

Location of home in village:

No. of family members:

Occupation:

Monthly Income:

Details of home: Kitchen separated and or/ with living room: Yes/No

Details of kitchen: Size: Ventilation:

Type of fuel used:

Quantity of fuel used:

Source of fuel: Procured: Collected:

Daily cooking time:

Daily period of cooking:

Morning (Hours): Evening (hours):

Type of stove used for cooking:

Mud (Chulhas) and or/ Other one:

Other possible source of pollution:

Willingness to participate in sampling program:

Yes/No

(Signature with date)

References

[1] Aggarwal, A., L. (1983). Air pollution and rural biomass fuels in developing countries, Abstract of selected Solar technology, 5:18-24.

[2] Ansari, A., F., Khan, H., A., Patel ,K, D., Siddiqui, H., Sharma, S., Ashquin, M., and Ahmad, I. (2009). Indoor exposure to respirable particulate matter and particulate-phase PAHs in rural homes in North India, Environ Monit Assess, DOI 10.1007/s10661-009-1249-2

[3] Balkrishnan, K. J., Parikh, S., Shanker, R., Padmavathi, R.. (2002). Daily average exposure to respirable particulate matter from combustion of biomass fuels in rural home holds of Southern India. Environmental Health Perspectives, 110, 1069–1975.

[4] Bhargava, A., Khanna, R., N., Bhargava, S., K., & Kumar, S. (2004). Exposure risk to carcinogenic PAHs in indoors-air during biomass combustion whilst cooking in rural India. Atmospheric Environment, 38, 4761– 4767.

[5] Bruce N., Perez-Padilla, R., Albalak, R. (2000). Indoor air pollution in developing countries: a major environmental and public health challenge. Bull. World Health Organ. 78:1078–1092.

[6] Devakumar, D., S., Semple., D., Osrin., S., K., Yadav., O., P., Kurmi., N., M., Saville., B., Shrestha., D., S., Manandhar., A., Costello and Ayres, J., G. (2009). Biomass fuel use and the exposure of children to articulate air pollution in southern Nepal, Environment International, 66 ; 79–87.

[7] Ezzati M., and Kammen, D.(2001). Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure–response study. Lancet. ;358:619–624.

[8] Hughart, D. (1979). Prospects for traditional and non conventional energy sources in developing countries, World bank staff working paper No. 346, World bank Washington, DC.

[9] Koning, DE, W., H., Smith, K., R., and Last, J.,M.(1985).Biomass fuel combustion and health.Bulletin of the World Health Organization, 63(1):11-26.

[10] Mishra, V., K., Retherford, R., D., and Smith, K., R. (1999). Biomass cooking fuels and prevalence of blindness in India. Journal of Environmental Medicine, 1, 189–199.

[11] Naeher, L., P., Brauer, M., Lipsett, M., Zelikoff, J., T., Simpson, C., D., Koenig, J., Q. (2007). Wood smoke health effects:Areview. Inhalation Toxicology, 19, 67–106.

[12] National Institute of Occupational Health (1979). Domestic source of air pollution and its effects on high risk population groups in Ahmedabad. In the 1979 Annual Report NIOH. Indian Council for Medical Research Ahmedabad India.

[13] Norman, R., Barnes, B., Mathee A., Bradshaw, D.(2007). Estimating the burden of disease attributable to indoor air pollution from household use of solid fuels in South Africa in S. Afr. Med. J. 2007;97:764–771.

[14] Peabody, J., W., Riddell, T., J., Smith, K., R., and Liu, Y. (2005). Indoor air pollution in Rural China: Cooking fuels, stoves and health status. Archives of Environmental and Occupational Health, 60, 86–9

[15] Regalado J., Perez-Padilla, R., Sansores, R., Paramo Ramirez, J.,I., Brauer, M., Pare, P., Vedal, S.(2006). The effect of biomass burning on respiratory symptoms and lung function in rural Mexican women. Am. J. Respir. Crit. Care Med. 174:901–905.

[16] Robin, L., F., Less, P., S., J., Winger, M., Steinhoff, M., Moulten, L., H., Santoshom, M. (1996). Woodburning stoves and lower respiratory illness in Navajo children. Pediatric Infectious Disease Journal, 15, 859.

[17] Smith, K., R., and Colfer, C.,P. (1983). Cooks on the world stage: the forgotten actresses. East-west Resource systems institute, Honolulu, Hawaii, Working paper WP-83-2.

[18] Smith, R., K., Aggarwal, L., A., and Dave, M.,R.(1983).Air pollution and rural biomass fuels in developing countries: apilot village study in india and implication for research and policy. Atmospheric Environment ,17 (11) ,2343-2362.

[19] Smith, K., R.(1993). Fuel combustion, air pollution exposure, and health: the situation in developing countries. Annu. Rev. Energy Environ. 18:529–566.

[20] Smith, K., R., and Mehta, S. (2003). The burden of disease from indoor air pollution in developing countries: comparison of estimates. International Journal of Health and Environmental Hygiene, 206, 279–289.

[21] Smith, K., R., Mehta, S., Maeusezahl, F., M. (2004). Indoor smoke from home hold solid fuels. In M. Ezzati, A. D. Rodgers, A. D. Lopez, & C. J. L. Murray (Eds.), Comparative quantification of health risks: Global and regional burden of disease due to selected major risk factors (Vol. 2, pp. 1435–1493). Geneva: World Health Organization.

[22] Smith, R., K., Aggarwal, L.,A., and Dave, M., R. (1983).Air pollution and rural biomass fuels in developing countries: apilot village study in india and implication for research and policy. Atmospheric Environment ,17 (11) ,2343-2362.

[23] Smith, K., R.., Samet, J., M., Romieu, I., and Bruce, N. (2000). Indoor air pollution in developing countries and acute lower respiratory infections in children. Thorax, 55, 518–532.

[24] World Health Organization (2002). Indoor air pollution.

[25] World Health Report. Available at: World Resources Institute (WRI), 1998–99. United Nations Environment Programme, United Nations development programme and World Bank. 1998–99 World Resources: A Guide to the global environment, Oxford University Press, Oxford.

[26] World Health statistics Annula (1983). Geneva , World health organization.

[27] WHO, 2006b. Air Quality Guidelines. Global Update 2005.

[28] World Health Organization Europe (1997). Air quality guidelines for Europe. Series no. 23. Copenhagen: World Health Organization Europe, Regional Office for Europe.

[29]Retrievedfrom;
http://www.ncbi.nlm.nin.gov/PMC/articles/PMC2568866 .