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Biomass as a Source of Household Energy and Indoor Air Pollution in Nepal

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Abstract: This paper reviews the status of biomass as a source of household energy and indoor air pollution in Nepal. The current statistics show that about 89% of total energy is consumed in residential sector is largely for cooking and heating purpose. The major sources of residential energy are fuel wood (86.5%), animal dung (6.5%) and agricultural residue (3.7%), which clearly indicates a huge demand for biomass as household energy in the country. Several studies have shown that particulate matter (PM_{10}) concentration on cooking place was about 8000 µg/m^3 against the national standard of 120 µg/m^3 in 24 hours average time. Similarly, the total suspended particle (TSP) was about 8,800 µg/m^3 against national standard of 230 µg/m^3, 21 ppm of carbon monoxide (CO) against national standard of 9 ppm in 8 hour average was found where biomass was used as fuel. Moreover, these studies have also shown that mortality and morbidity rates among children and women are extremely high due to acute respiratory infection (ARI) and chronic obstructive pulmonary disease (COPD). This clearly indicates that the major cause behind it is indoor air pollution.

Key words: Biomass % Indoor air pollution % Mortality % Particulate matter % Acute respiratory infection

INTRODUCTION

Nepal is divided in to three different geographical regions; Mountain, Hill and Terai respectively. The mountainous region is least dense populated region and covers 35% of the country. The Hills region covers 42% whereas the Terai region comprises 23% of total land area. The latter is fertile land and has dense forests; it houses 47% of the Nepalese population [1].

Above two thirds of the population depends on agriculture as the main source of income, but contributing only 32.4% of Gross Domestic Product (GDP), whereas the small industrial sector contributes 21%. More than 31% of the population live below the poverty line (i.e. their income is less than 1 $ per day) [2].

The overall energy scenario of the country reflects that traditional energy sources (Fuel wood, dung and agricultural residue) constitute about 87%, commercial 12% and less than 1% alternative sources respectively in fiscal year 2008/09. About 89.1% of total energy is consumed in the residential sector, is largely for cooking and heating. The major sources of residential energy are fuel wood (86.5%), animal dung (6.5%) and agricultural residue (3.7%) [2]. This clearly indicates a huge demand for biomass as household energy in the country. The biogas programme and the national improved cooking stoves (ICS) programme are quite successful in creating demand and controlling quality and are still ongoing to mitigate the unsustainable fuel wood consumption, environmental protection and above all help improve health condition of the people. The number of biogas digesters exceeds 204,069 plants with the aim of expanding it to1 million plants. Similarly, the number of ICS hits 250000 of installations till 2007 and continues to increase [3]. Fuel choice is directly linked with the socio-economic status of the county. Traditional fuel sources are cheap and sometimes free of cost whereas commercial and other fuel source demand high investment to use it as an energy source. Use of biomass fuels as a household energy in traditional way cause indoor air pollution exceeds the standard set by national ambient air quality standards for Nepal. Therefore, the government of Nepal has shown strong interest to work in household energy and reduce infant and child mortality rate and improve women's health condition. The link between household energy and its impact on health of specially child and women's are deep rooted.

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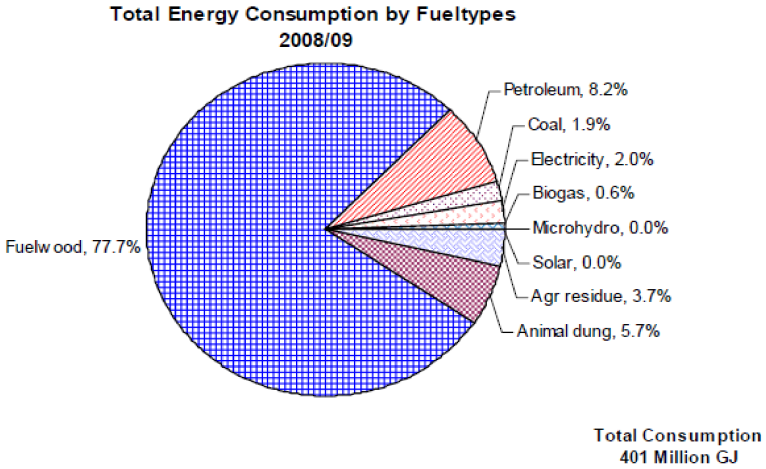

Fig. 1: Share of energy consumption by fuel types [2]

Mortality and morbidity rates among children and women are chillingly high in Nepal. Acute respiratory infection (ARI), Tuberculoses and other chronic obstructive pulmonary disease (COPD), complication in child birth continue to exist at high rate. The survey conducted in 1996, showed that 34% of children under five were infected with ARI [4]. One of the major causes behind it is indoor air pollution. The infant mortality rate was around 64 per thousand in 2001. However, this figure comes down to 9.14 deaths per thousands in 2007 [5]. Among several other factors ARI has been identified as one of the major factors for high infant and under five mortality rates in Nepal.

As of 2006, Nepal's population was 25.8 million of which about 50% are female. Some 3.56 million were under five [5]. The population size of children and women evidently suggests mitigation of indoor air pollution is dire need of the country. The government of Nepal along with several NGO, INGO and donor agency are working together to achieve their goal to maintain indoor air pollution at standard set limit.

An Overview of Residential Energy Consumption: The residential sector consumed almost 89.1% of the total energy consumption of Nepal in 2008/09. This sector consumed about 401 million GJ [2]. Biomass resources were the major fuels used in this sector, namely the fuel wood, agricultural residue and the animal waste. Recently renewable sources like biogas and electricity from micro-hydro and solar home systems are substituting the conventional fuels used mainly for cooking and lighting. The commercial sources of fuel used in nominal amount and is mainly used in the urban centers. The picture below presents the share of different fuels used in the residential sector in 2008/09 [2].

The population growth rates as well as the economic situation of the household are taken as the main driver for the types of fuel and energy consumption in the residential sector of Nepal. In the residential sector, the energy used is mainly for different end-uses: cooking, heating, animal feed preparation, lighting etc. The percentage share of biomass energy in the primary energy consumption of Nepal in residential sector was/is significantly high. The efficiency of biomass energy conversion in traditional way of using it is very low; which is the majority case in Nepal. Also, conventional way of using biomass cause significantly high indoor and outdoor air pollution. The need of study on indoor air pollution and its health impact on especially women and children who are most of the time in the kitchen or inside the house is very important. At the same time it is dire need of developing appropriate technology so that biomass conversion efficiency can be increased while reducing emission. At present there are some suitable technology as biogas and improved cooking stove (ICS) to use biomass efficiently and effectively with minimal indoor and or outdoor pollutants. Nevertheless, this technology has not been able to penetrate the whole region of the country. The governments of Nepal along with several other organizations are working together in this front to make these simple technologies widely acceptable within the country.

Indoor Air Pollution: Very few literatures about indoor air quality in Nepal are available. A study conducted by Nepal Health Research Council and others in 2001 indicated that PM_{10} concentration on cooking place where biomass was burnt was 8207 $\mu g/m^3$ and 3414 $\mu g/m^3$ and 1504 $\mu g/m^3$ at the place where kerosene and LPG was used as fuels respectively [6].

Table 1: Comparison between CO and TSP for traditional stoves and improved stoves

Study location	Pollutants	Exposure on traditional stove	Exposure on ICS	% reduction	References
Gorkha	CO	280 ppm	70 ppm	75	Reid, 1986
	TSP	3170 μg/m^3	870 μg/m^3	73	
Beni	CO	310 ppm	64 ppm	79	Reid, 1986
	TSP	3110 μg/m^3	1370 μg/m^3	56	
Mustang	CO	64 ppm	41 ppm	36	Reid, 1996
	TSP	1750 μg/m^3	920 μg/m^3	47	
Bardibas	CO	82.5 ppm	11.6 ppm	86	Pandey, 1990
	TSP	8200 μg/m^3	3000 μg/m^3	63	

Another study done by Davidson *et al.* [7] in 18 houses in Nepalese villages in 1986 revealed that the total suspended particle (TSP) was 8,800 μg/m^3, 21 ppm of carbon monoxide (CO) and 368 ppb of nitrous oxide where biomass (wood) was used as fuel.

Some other reports of indoor air pollution monitored the personal exposure levels of Respirable Suspended Particulates (RSP), CO and formaldehyde levels during cooking periods in 20 households with traditional stoves (without chimneys) and again after introducing improved cooking stoves (ICS) in rural areas of Nepal's hill region between November 1986 and March 1987. The mean concentration of RSP was found to be 8,200 μg/m^3 for 1 hour and the onehour concentration of CO and HCHO (formaldehyde) were 82.5 ppm and 1.4 ppm respectively for traditional stoves. In the case of ICS, the mean concentration of RSP, CO and HCHO were 3000 μg/m^3, 10.8 ppm and 0.6 ppm respectively [8].

Reid *et al.* [9, 10] monitored personal exposures of women to TSP and CO during cooking periods in 60 households with traditional stoves (without chimneys) and improved cook stoves (with chimneys) in the Middle hills of Nepal. The table summarized findings of different research conducted in different period.

The findings clearly suggest that improved cooking stoves have far less emission of TSP and CO than traditional cooking stoves. However, the emission is not at standard safe level.

Nepal Environment and Scientific Services [10] monitored PM_{10} concentration in different localities of Kathmandu for different fuel type (LPG, kerosene and wood) in 2001. They found that PM_{10} concentrations in wood burning houses are 6 times greater than in LPG-using houses and 2.4 times greater than kerosene-using houses.

All relevant study about indoor air pollution conducted in Nepal at different periods showed that emission levels are much higher than national and international standards. The national ambient air quality standards for Nepal set 230 μg/m^3 for total suspended particles (TSP) and 120 μg/m3 for PM_{10} in 24 hours average time. The carbon monoxide (CO) standard is 9 ppm or 10,000 μg/m3 for 8 Hours average [11]. The ambient air quality standards of US and Europe are stricter than national standards of Nepal. From above fact about indoor air pollution it is evident that large share of Nepalese women and children are still at high risk.

Health Impact of Indoor Air Pollution: It is evident from some of the studies of indoor air quality at different location of Nepal that Nepalese women and children, who are mostly in the kitchen and inside house, have been exposed to unacceptable levels of indoor air pollution. Many investigations consistently show that indoor air pollution increases a risk of chronic obstructive pulmonary diseases and of acute respiratory infections (AIR) in childhood. One of the major causes of mortality for children under five in Nepal is AIR. Similarly, low birth weight, increased infant mortality, pulmonary tuberculoses, nasopharyngeal and laryngeal cancer and cataracts have shown some correlation with indoor air pollution.

Ministry of Health data shows that ARI is the third highest cause of morbidity in Nepal, affecting 3.13% of the total population [5].

Chronic Obstructive Lung Diseases (COLD) is another major risk factor especially among women and has been found strong relation with smoke exposure. Some studies shows in rural Nepal, nearly 15% of non-smoking girl (below 20 years) had chronic bronchitis, a high rate for non-smoker [12]. This is also an evidence of strong relationship of smoke exposure and the COLD since girls in rural Nepal are supposed to help to carry out all indoor household work whereas their father work outdoor to support and sustain the house.

There are some related findings which suggest that smoke exposure cause high risk to human health and increase untimely death toll. There are now various

organizations working together with government of Nepal to help support reducing indoor air pollution. The common agreement on reducing indoor air pollution is to substitute traditional biomass cooking stoves by some improved cooking stoves or biogas stoves or something else, which emits no or less pollutants. There are already over 200,000 domestic biogas plants installed in various parts of the countries and above 250,000 improved cooking stoves are installed. All stakeholders are pushing forward the ICS and biogas programs to attain the goal of reduced indoor air pollution and improved health condition of women and children.

As of now not much study of indoor air pollution after substituting traditional biomass stoves with ICS or Biogas has been done. But informal discussion with beneficiary indicates that it has improved their health significantly. However, scientific investigation and findings are highly awaited so that government and other organization who are working closely for the same mission will decide future action plan based on the scientific evidence. There are some organizations and research institute have been monitoring indoor air pollution at various parts of the country to compare the indoor air pollution of the traditional and improved cooking scenario. Nevertheless, recent health statistics shows that infant mortality rate has been reduced significantly from 64 per thousand in 2001 to 9 per thousand in 2007 [5]; ARI is one of the major causes for infant mortality. The figure suggest that there has been tremendous improvement in health impact after substituting traditional biomass with improved one along with better awareness among household working girls and women.

Mitigation Measures of Indoor Air Pollution: From the available literature and research findings about indoor air pollution and its health impact at various parts of the country proved that conventional approach of using biomass as a thermal energy of the house and prolonged smoke exposure is one of the crucial reasons for indoor air pollution and has harmful health impact especially on women and children. Although there were not sufficient research findings available on improvement of indoor air quality through ICS and biogas, the available studies suggest that there is a tremendous positive impact. Some literature suggests that substituting traditional cooking stoves by ICS can reduce 60-80% TSP and CO, which are the major indoor pollutant responsible for ARI, COPD and other health disorders. Similarly, biogas has numerous positive health impacts on women and children since it reduces smoke to nearly zero level inside the kitchen, meaning a reduction of indoor air pollution significantly. Remarkable improvement on indoor air quality and health of the family has been reported while talking to those families who accepted to substitute their traditional cooking stoves with biogas plant. Nonetheless, scientific research findings have not been reported to date in reference with biogas plants in Nepal.

Based on available scientific and social research findings the governments of Nepal along with various national and international organizations have been working closely in disseminating ICS and biogas all over the country. They also launched several awareness programs for the people of the rural part of society and let them know advantages and disadvantages of having and not having ICS, biogas and other relevant appropriate technologies. There have been several health awareness programs and educational programs for uneducated men and women, going on various parts of the country. It has been perceived that women empowerment is one of the key factors in resolving several problems occurring in remote areas of the country. One of the important feature of people participation program (PPP) in any kind of development projects usually energy generation project like biogas, ICS, micro hydro and so on…is first to aware all stakeholders of the community about pro and cons of the projects, second to create a feeling of sense of ownership of the project so that they will take care of successful operation of the project, last but not the least PPP uses good model of women inclusion in all activity of the project work and community work that help significantly for women empowerment. Once women are aware of indoor air pollution and health impacts due to conventional cooking stoves, ICS and biogas plants can substitute the traditional technologies without creating any hassle.

CONCLUSION

Biomass is a key source of residential energy providing around 85% from fuel wood alone. Large share of residential energy demand is thermal energy for cooking, which means almost all fuel wood is used for cooking purpose. It is obvious that emission from solid fuel is higher than from gas fuel. Many Nepalese still use traditional cooking stoves that produce lots of smoke causing a high degree of indoor air pollution. Especially children and women are exposed to indoor air pollution since most of the time they live inside the house or work in the kitchen. Some results suggest that above 8000 µg/m3 TSP and 82 ppm CO had found in a kitchen where

traditional stoves were used, which far exceeds the national limit of 230 µg/m3 TSP and 9 ppm CO [6, 7, 8]. ARI is commonly found direct consequence of indoor air pollution that toll 64 under five children in 2001. Biogas and ICS are found to be successful technology in intervening residential energy sector. It has contributed significantly in reduction of indoor air pollution. Some research suggests that 60-80% reduction of TSP and CO can be achieved substituting traditional stoves by ICS. The reduction must be higher in case of biogas. The impacts of it have been seen in reduction of ARI caused under five death tools in 2007. It has been reported that 9 under five death tool in 2007 [5]. All scientific and social research finding proves an importance of intervening residential energy sector by ICS and biogas. While implementing ICS and biogas programmes local need and desire is considered as a crucial factor. That is one of the reasons for success story of biogas and ICS. Experience to date shows that people's participation, community based project, social mobilization, social awareness, local need oriented, holistic approach, sustainability and promotional activities are best way of extending and expanding the program to all targeted people of the country.

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