**FUEL SUBSTITUTION: POVERTY IMPACTS ON BIOMASS SUPPLIERS**

# HEALTH RELATED EFFECTS OF TRADITIONAL BIOMASS FUELS: THE UGANDAN CASE STUDY

**FINAL REPORT**

## 1. Executive Summary

In Uganda the lack of direct scientific data quantifying the exposure to indoor air pollutants from traditional biomass fuel combustion and the consequent health impacts prompted the Fuel Substitution Ugandan team to undertake a field study in three urban divisions of Kampala District. The objective of the study was to find out if a casual link exists between exposure to emissions from biomass and health effects. The study also aimed at emphasizing the links between cooking habits and the livelihood of the household.

The study produced the following outputs:

- Detailed description of the health effects due to exposure to pollutants from domestic biomass fuels in urban households.
- Action plan for alleviating the health problems associated with exposure to biomass fuels emissions.

## 2. Background

For most of the past 20 years the World Health Organisation (WHO) and aid agencies have recognised that the prevalence and severity of Acute Respiratory Infections (ARI) among women and children below the age of 5 in less developed countries is influenced by indoor air pollution among other risk factors. This is mainly due to high levels of particulate matter (respirable suspended particles) and gaseous material (e.g.: carbon monoxide, nitrogen dioxide, formaldehyde, benzene, and poly aromatic hydro carbons) generated by incomplete combustion of biomass fuels that are used for cooking and heating.

ARI account for around 6% of worldwide disease and mortality, especially in developing countries. The direct links between respiratory diseases and exposure to indoor air pollution, especially to particulate matter, from combustion of biofuels (wood, charcoal, agricultural residues, dung) have been highlighted through several studies in many developing countries[1]. All studies undertaken confirm the existence of a causal link and the exposure-response relation for indoor air pollution and ARI in developing countries has been identified. Nonetheless to date no such study has been undertaken in Uganda and therefore no direct data is available in the country.

In order to partially bridge this gap the Ugandan team working on Fuel Substitution undertook a study in three divisions of Kampala District and examined the health impacts arising from exposure to biomass fuels pollutants vis-à-vis poverty. The aim of this survey was to provide a quantitative assessment of the health risks due to exposure to emissions from biomass within individual households. The sample selection was made in order to highlight the urban household energy consumption patterns and to gain an understanding of urban and household cooking processes and practices, attitudes and beliefs across a range of socio-economic groups. In this perspective the Local Council (LC) system was found to be a well functioning administrative approach to both the establishment of zone boundaries and for guidance to various households.

## 3. Methodology

The study was divided into four phases that involved;

- Literature review;
- Interviews with users of biomass fuels and medical personnel;

[1] Ezzati, M and Kammen, D. M. (2001) "Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: and exposure-response study" The Lancet, **358**.
Smith K. R. (1993)"Fuel combustion, air pollution exposure, and health: situation in developing countries. Annu Rev Energy Env; **18**.

- Detailed monitoring and quantitative measurements of indoor pollution and of personal exposure to emissions from biomass in a number of household cooking facilities.

The target groups include mainly urban poor. Interviews were carried out involving 20 households from each one of the three divisions in Kampala where the study was carried out i.e Nakawa, Makindye and Kawempe. A total of 60 households were interviewed. Out of the total number of households, two homes were selected in each of the divisions as case studies, where the scientific quantitative measurements were carried out.

### *3.1. Census Survey*

Based on literature review, key informants interviews and personal observations, census surveys were carried out in order to map the use of biomass fuels among the population of Kampala. The choice of a sample selection depended, above all, on the availability of a suitable sampling frame. Since the survey was to quantify the effect of biomass on health, the frame consisted of households, with the household loosely defined as "a grouping of people who share the same cooking facilities".

The interviews (see Annex 1) with household people highlighted the general lack of awareness among the interviewees of the causal effects between indoor pollution and health effects. The people interviewed also complained mainly of cough, headache, flu, itching of the eyes, no alternative source of energy, loss of breath etc.

Interviews carried out with some medical personnel in Uganda reveal that no available data exists on the relationship between indoor air pollution and the related diseases as reported by patients in hospitals. Most of the doctors interviewed pointed out that the patients' respiratory diseases and illnesses are usually associated with incidences other than indoor air pollution.

Dr. Sewankambo from Masaka hospital in Masaka District pointed out that no cases had been reported of people suffering in any ailment associated with exposure to smoke from biomass but accepts that the problem exists.

Dr. Batwala from the department of community healthy, Mbarara University of Science and Technology said that he accepts the problem exists but there is little interest to fund studies in this particular area since the majority of the people use biomass and hence such a study is not viewed as a priority.

Dr. Sendyona from Bushenyi hospital in Bushenyi District accepts the possibility of the existence of the risk but there is completely no available data and hence the need for research in this particular area to highlight the problem.

Three medical doctors from Mulago hospital who didn't want to be quoted pointed out that the problem exists but there is no linkage between exposure and the related health effects to patients who report to the clinics. A total of 10 medical doctors were interviewed and all accepted the existence of the problem but pointed out that given the socio-economic conditions of the country, little attention had been paid to address the issue and therefore supported the study.

In conclusion the doctors hoped that the results of this study would be used to highlight the problem so that a pilot study is undertaken. The pilot study would involve choosing a set of homesteads and following up the cooking habits and the type of fuel used. This would be compared with the number of times individuals in those particular homesteads report to clinics and the related ailments.

*3.2. Quantitative measurements*

In order to measure the levels of personal exposure to emissions from biomass combustion, sampling was done using personal samplers (SKC 224-PCEX7). This consists of a cyclone respirable dust sampling head fitted with a glass fibre (37 mm) of pore size 1.0mm attached to the individual involved in cooking (see attached photograph). The head is connected to the pump by a rubber tube (SKC 226-03-004) and the pump is clipped on to the belt or hip pocket. The sampling head is fitted with a cover that traps non-respirable dust hence total dust can also be obtained. Air is sampled from breathing zone (10 to 20 centimetres off the nose or mouth of the subject) at a stable rate of 3 litres per minutes for 4 hours.

All the filters used are desiccated over silica gel for 24 hours before weighing. The sampling was done in 2 homesteads per division as a representative of the various households with similar socio-economic conditions.

Dust concentrations were determined gravimetrically using an analytical balance (Mettler AE240). Prior to mounting and subsequent sampling the sampling filters were desiccated over silica gel for at least 12 hours and weighed immediately. After sampling, desiccation is repeated and the dust loaded filters weighed again. The difference in weight is the sample weight of particulate matter (mg). The volume of air sampled (litres) is converted to metres cubed ($m^3$) and corrected using gas laws to standard temperature and pressure (STP). The ratio $mg/m^3$ (STP) is the required concentration.

Photographs were taken during the sample measurements and can be seen in Annex 2.

*3.3. Analysis and Comparison of results*

The results of the measurements[2] are presented in table 1.

Table1: Quantitative measurements carried out in Nakawa, Makindye and Kawempe Divisions of Kampala District

| **Location and date of measurement** | **Measurement conditions** | **Number of measurements** | **Total particulate concentration ($mgm^{-3}$ $PM_{10}$)** | **Respirable particulate concentration ($mgm^{-3}$ $PM_{10}$)** |
|---|---|---|---|---|
| Makindye Division, Parish Luwafu, Bukejje zone, 2nd March 2002 Home 1 | Cooking with semi-dry firewood; measurements carried out from the body of the cook and 1 metre from the ground | 2 | 161.3 | 128.6 |
| Makindye Home 2 | Cooking using firewood. Measurements taken 2m from the ground | 2 | 89.2 | 25.3 |
| Nakawa Division, Banda parish (facility for brewing local brew), 8th March 2002 Facility 1 | Individual exposures during boiling of water for mixing in the brew; measurements carried out 0.7m from the ground due to the height of the kitchen | 2 | 15.7 | 9.6 |
| Nakawa Division Banda Parish (facility for brewing local | Cooking with wood and measurements carried out at 0.5m from the ground | 2 | 19.1 | 13.2 |

[2] It is important to note that the values obtained from the measurement should not be considered 100% accurate due to the age of the instrumentation utilised.

| | | | | |
|---|---|---|---|---|
| brew)<br>Facility 2 | | | | |
| Kawempe Division, Kitambuza zone, Kanyanya village, 9th March 2002<br>Home 1 | Cooking with wood, individual exposures 2-3 hours | 2 | 30.1 | 25.35 |
| Kawempe Division, Kitambuza zone, Kanyanya village, 9th March 2002<br>Home 2 | Individuals exposures during cooking 2-3 hours | 2 | 14.2 | 11.4 |

The results of the household surveys show that Ugandan households like those of most developing countries depend largely on traditional fuels (charcoal and fuel wood) for their domestic needs.

The concentrations of indoor respirable pollutants have been found to be extremely high in households included in the study carried out in the three Divisions of Kampala District. The US Environmental Protection Agency (EPA) recommends a primary standard for $PM_{10}$ of 150$\mu g/m^3$ over 24 hours. On the other hand, although evidence from epidemiological studies consistently points to associations between short-term exposure to particulate matter and adverse effects on human health, the WHO has not published guideline values for $PM_{10}$ to date as it recognises that no judgement can be made about whether biomass $PM_{10}$ is less or more unhealthy than the same exposure concentration of urban outdoor particulate matter.

The measurements taken in the three divisions of Kampala, show considerable variations in the levels of exposure between each sample depending on the design of the kitchen and the quality of biomass (quality of wood, dry or wet). A major factor influencing personal exposure to particulate matter is the ventilation in the cooking area. They also show that exposure to indoor air pollution is a considerable problem. In general, the percent of pollution emitted that actually is breathed in by somebody (the "dose effectiveness") is much higher for indoor sources than outdoor sources, sometimes hundreds of times, simply because people are nearby and pollutants are poorly dissipated due to little or no ventilation.

Furthermore, from direct observations it was possible to highlight the overall poor practice in terms of efficiency in fuel resources utilisation. Most cook-stoves and cooking places were found to waste most of the energy generated by dissipating the heat into the atmosphere rather than utilise it for cooking purposes. All the households where sampling was carried out, were found to be using wood-burning three stone fire cookstoves as shown in the attached photographs. In one case in Kawempe division (plate 12), the mother pointed that she sometimes uses charcoal but when she needs to have the food cooked fast, firewood becomes a better alternative.

In Nakawa Division where the sampling was carried out in a facility for brewing local beer as shown in plate 7, the lady was very reluctant to have the equipment fixed on her and therefore kept on moving in out and out the cooking facility, but overall the facility was well ventilated and allowed good air circulation.

However, the case in Makindye was more reliable (Plate 1) in that the lady found cooking was very receptive and spent most of the time in the kitchen as the biomass being used was not very dry and at some stage, the whole kitchen was filled with smoke as shown in plate 2

which choked even the researchers. This highlights the problem faced by such poor people on a day-to-day basis.

It is important to point out that the Nakawa example for the two facilities for brewing local beer, the results were not very reliable as those in two homesteads in Kawempe and Makindye and Divisions. This is because the people on whom sampling was carried out were very suscipious (Nakawa Division) and kept moving in and out of the facility, but also the facility were well ventilated and air circulation was quite adequate and this could have contributed to the low levels in Nakawa compared to Kawempe and Makindye.

The significant difference in the levels measured in Makindye and Kawempe divisions was also due to ventilation and quality of wood as the wood used in the homesteads in Kawempe at the time of sampling was found to be drier and kitchen were better ventilated.

In general, within the limits of experimental error, the results highlight the existence of the problem.

## 4. Interventions

Tackling indoor air pollution is a formidable challenge. This involves dealing with the difficult question of developing financially viable services for which the poor are willing to pay. Several technical and economic barriers need to be overcome to promote improved stoves and clean fuels as mitigation options. The area is cross sectoral in nature and requires collaboration and commitment between agencies responsible for health, energy, environment, housing and rural development. Other agencies and organisations are strongly encouraged to address the issue and assist in providing possible solutions.

Better infrastructure and energy services for households and communities are key measures in mitigating the most daunting environmental risks to health. Reducing modern risks calls for measures to prevent and abate pollution. These, in turn, require setting and enforcing environmental standards, developing a culture of environmental compliance and creative effective incentives. The National Environment Management Authority (NEMA) is setting standards for exposure in occupational settings but due to limited/absence of data, no measurements were carried out in household kitchen since the choice of fuel depends on economic status, such standards will be difficult to enforce.

### *4.1. Mitigating Risks*

- There is need to make sure that the room in which the fire is burning is well-ventilated.
- The fire should be raised off the ground by means of a grate. This improves overall efficiency without reducing combustion. An improved three-stone fire of this form has an efficiency comparable with enclosed stoves, but with lower emissions.
- Portable stoves without chimneys should be lit and operated out of doors for at least ten minutes. Re-fuelling indoors is dangerous. This is because during stove lighting and refuelling, the pot's cold sides and stove sides cool the flames and result in less complete combustion, and more poisonous gases being emitted.
- No fire should be operated in a poorly ventilated room.
- No assumption should be made to the effect that improved stoves without chimneys are safer than the traditional open fires. Stoves which are 'fed' through the same opening as the one which supplies air for combustion have the danger of being over-stocked in an attempt to prolong burning. Adding a lot of fuel to the combustion chamber reduces the amount of space for air. This leads to more incomplete combustion and increases emissions significantly.

Fuel switching/alternatives/swapping can also have positive impacts. A shift from a wood to a charcoal stove reduces the overall health impacts by a factor of more than four. Liquefied petroleum gas (LPG) reduces the overall health risk by a factor of 100. Similarly, a shift to kerosene results in a reduction by a factor of six.

*4.2. Technical interventions*

- ❖ Smoke removal- flues attached to stoves, hoods and chimneys to remove smoke. Other stove improvements which reduce emissions, through better combustion and more efficient heat transfer. Stoves with longer life-span.
- ❖ Housing design- changes to kitchen design to increase ventilation and control the distribution of pollution.
- ❖ Fuels- methods of cleaning existing fuels, for example bio-gas and other "clean" biomass products, or promoting fuel-switching/swapping to alternatives such as kerosene or LPG.
- ❖ Stove programs: evaluation of Government of Uganda program of improved stoves for market penetration, customer acceptance, institutional set-up and sustainability based on selected case studies.
- ❖ There is need for a co-ordinated and systematic support of NGO's in this particular area.

*4.3. Behavioural Interventions*

- ❖ Promoting awareness of long-term health effects on the part of users including demonstration. This may lead to people finding ways of minimizing exposure through better kitchen management and infant protection. An example is seen in Kawempe Division in Plate 13 where a young girl is seen putting firewood in a three stone cookstove.

*4.4. Policy level Interventions*

- ❖ Local micro-credit facilities for the upfront costs of switching to gaseous fuels, examination of targeted (as opposed to across-the board) subsidies to enable low income households to switch and creation of income generating opportunities.
- ❖ Training -to develop skills and expertise for stove development, improved housing.
- ❖ Clean fuels- preparation of a concept paper on the economic and operational issues and barriers relating to the uptake of LPG and kerosene in rural and urban areas of Uganda.
- ❖ Exposure and health assessment: collection of better and systematic information about actual exposure levels experienced by households in different districts and climatic zones and development of a model for predicting the exposure levels based on fuel use and other household data therein (exposure atlas).
- ❖ Cooperation between formal and informal sector should be sought aggressively.

*4.5. Constraints*

- In some instances some people were not cooperative, this is mainly due to the fact that many studies have been done in such areas (but not on indoor air pollution) where they have been asked to provide information with the pretext that the results will be used to improve their livelihoods but to no avail.

- Suspicion by people to be sampled especially in Nakawa Division in the facilities for brewing local beer as they believed the results would be used to close down their premises if found to be very high.
- The time and resources were not adequate; there is need for a bigger study over a much longer period of time in order to get a real picture of the whole problem scenario.

## 5. Conclusion

The fuel wood crisis exacerbates the problem of indoor pollution from poorly combusted biomass fuels. As dry fuel wood, the preferred fuel for many activities that range from cooking to local beer brewing, becomes scarce, people turn to wood fuels with higher moisture content, and eventually to lower grade biomass fuels, such as agricultural and animal wastes. Since most of these have much higher moisture content and release less energy than dry fuelwood, they not only produce much more smoke, but also require the cook to continuously attend to the fire. The result is that the cook is exposed to more intense smoke for longer periods. This was very evident in Makindye where raw biomass was being used for cooking thereby generating a lot of smoke and hence increasing the chances of indoor air pollution to the cook.

Reducing and eliminating the adverse health impacts of indoor biomass combustion is not impossible. In most cases, the problem is the result of neglecting the development of rural areas, and particularly of women, with preference given to urban and industrial areas. The first step in the resolution of the problem must be its recognition. This implies the need for more extensive surveys to ascertain the extent of the problem so that policy interventions can be custom made.

The exact nature of policy intervention will vary from area to area. Nevertheless, it will have to include various technical, social, and political elements. Generally speaking, all interventions that improve the status of women through education, political change advocacy, and so on help. Many technical interventions, such as the introduction of improved cooking stoves, cleaner fuels and more hygienic dwellings, will be necessary. The most important aspect of all, however, is the general political will to recognise that the problem exists, and that its resolution is an urgent national priority.

Although the indoor air database is weak in Uganda due to the scarcity/absence of monitoring results, these estimates indicate that a serious indoor air problem exists in Uganda. There are no occupational health standards for domestic cooks and there won't by any in the near future because of the problems of enforcing such standards bearing in mind that the choice of fuel to a large extent depends on economic status.

**Annex 1**

**QUESTIONNAIRE ON HEALTH EFFECTS DUE TO EXPOSURE TO EMISSIONS FROM BIOMASS**

Date.....

Name of Interviewee.....

Division.....

Zone.....

Village .....

Number of households.....

Household composition.....

Type of fuel used.....

Any alternative source of fuel used .....

Source of fuel.....

Reason for Choice of fuel.....

Type of cookstove used.....

Frequency of cooking .....

Where is the household food cooked (open air, in the main house or in a separate kitchen.....

House hold income/economy.....

Formal employment of any member of the household.....

Type of ailments commonly affecting members of the household.....
……

Are there any health problems associated with the fuel used in cooking?.....

Any suggestions to government and/or donor agencies .....
……

## Annex 2

## PHOTOGRAPHS TAKEN DURING INDOOR AIR POLLUTION

Figure 1: Personal sample head for measuring respirable particulate matter from the combustion of biomass in Makindye Division. Three stone fire stove being used

Figure 2: Poor biomass combustion in a kitchen in Makindye Division, a source of indoor air pollution

Figure 3: Low volume sample measuring particulate matter from smoke. Makindye Division, Kampala

Figure 4: Kitchen where cooking is taking place. Exposure to pollutants is minimised due to ventilation allowed by the kitchen layout.

Position of sampling head

Figure 5: Boiling water for mixing in local brew. The arrow show a sampler attached to the collar for trapping particulate matter

Figure 6: A kitchen with poor ventilation and poor air circulation. There is a likelihood of indoor exposure to smoke.

Figure 7: Sampler for trapping particulate matter. The lady was busy boiling water for mixing in local brew in Banda

Figure 8: Personal sampler pump attached to the belt of the gentleman putting firewood under a three stone stove for local bier brewing

Figure 9: Personal sampler for trapping total particulate matter from the combustion of biomass. This structure is used to boil water for mixing in local brew

Figure 10: Sampler for trapping total particulate matter from the combustion of biomass from this structure used for boiling water to mix with local brew in Banda

Sampling head for trapping particulate matter

Figure 11: Low volume sampler for measuring particulate matter from the smoke. The mother and child are likely to be exposed to the smoke from combustion of firewood.

Plate 12: Young girl cooking using firewood. Her position and the type of stove (three stone stove) determine high exposure to indoor air pollution

Low volume pump sampler used in measuring particulate matter from smoke in the kitchen