MONITORING INDOOR AIR POLLUTION

Kitchen smoke

Smoke (indoor air pollution) from cooking with wood, dung and crop residues leads to the death of nearly one million children a year and is the fourth greatest risk for death and disease in the world's poorest countries. Tiny particles from burning fuels such as wood and charcoal get into the lungs, leading to respiratory infections such as pneumonia and chronic bronchitis. In addition, there is evidence to link indoor air pollution to asthma, tuberculosis, cataracts, low birth weight and increased infant mortality. Where coal is burnt, there is an added risk of cancers.

In recent years, governments and international organisations have started to take a greater interest in indoor air pollution and are keen to find ways to alleviate it.

Whilst individual technologies can be tested in a laboratory, stoves and other smoke-alleviating products work very differently within a household situation and monitoring methods are needed to identify technologies that are both effective at alleviating smoke and, importantly, are attractive to the user, so that they are in regular use.

Approaches to monitoring

Monitoring approaches vary from very basic surveys, for example, where women report whether they have observed reductions in kitchen smoke, to international large-scale health / pollution studies, which examine the links between smoke and ill-health. The largest of these is nearing completion (May 2007) and results are being analysed and published (WHO, 2007a).

Randomised controlled trial in Guatemala

The links between exposure to indoor air pollution and various forms of ill-health are clear. However, more information is needed on how they relate to each other.

A major study in the rural highlands of Western Guatemala is examining, for the first time, the relationship between childhood pneumonia and reducing pollution levels in the homes through the introduction of improved stoves (Figure1). Other issues that affect women's lives and wellbeing are also being measured.

The 500 households in the study receive either the improved stove, or no stove at all.
A combination of weekly and more infrequent home visits is used to measure exposure to pollution and the health of both children and women of child-bearing age

At the end of the work, the remaining households in the study are provided with stoves.

Figure 1: Woman using improved stove, Guatemala (photo: Nigel Bruce)

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However, this is a unique study, and for most organisations, a decision must be made on what can be achieved realistically. Health studies are complex and expensive. More realistically, measurements of smoke reduction can be made, and their effects on health estimated.

A key to successful monitoring is to decide;

- Who needs the information?
- For what purpose do they need it?
- Is this information needed locally, nationally, internationally?

A book entitled 'Evaluating household energy and health interventions: a catalogue of methods' by the WHO is currently in press to provide guidance on the various approaches to evaluating such interventions (WHO_2, 2007).

This Technical Brief will describe an approach taken by Practical Action to examine the levels of indoor air pollution, and to ensure that the technologies being adopted by households collaborating in their smoke-alleviation research were effective in reducing smoke. The research is based in Kenya, Nepal and Sudan, where various technologies, from smoke hoods to gas stoves are now being used to alleviate kitchen smoke.

The monitoring process

Community participation (Figure 2) is essential from the start. Representative households should be identified by the community themselves, although various criteria can be required - eg children under five; enthusiastic to work with the project. Community meetings and discussion will promote participation and ensure that findings are relevant to the project communities.

Figure 2: Nepal community meeting (photo: Nigel Bruce/Practical Action)

Monitoring is divided into two distinct areas:

- Monitoring indoor air pollution before and after the introduction of a technology
- Monitoring acceptance and benefits. This is important, as the technology will do nothing unless people use it.

Questionnaires can be used to identify aspects of people's lives which impact on their use of household energy. The resource section at the end of this Technical Brief gives information on where these questionnaires can be found.

Monitoring pollution

It is widely agreed that the two major components of biomass smoke that should be monitored are *particulates* and *carbon monoxide*. Particulates are tiny particles of smoke that get deep into the lungs and make people vulnerable to respiratory infections. Carbon monoxide is a colourless odourless gas that can lead to death in a very short period of time at high concentrations. At the lower concentrations commonly experienced in households using traditional stoves and open fires, exposure can lead to headaches, dizziness and nausea, and it is linked to low birth weight. Where coal-burning is common, oxides of sulphur may also be measured

Monitoring particulates

One approach to monitoring particulates is to use a low-flow sampling pump that draws in air, spins off the larger particles and deposits the lighter, more dangerous ones, on a small circular disc of filter paper. The filter is weighed before and after monitoring, and the difference in weight indicates the levels of pollutant in the room http://www.apbuck.com/shop/item.asp?itemid=15 .

Monitoring is usually conducted over a whole day. This type of monitor (made by AP Buck) was used by Practical Action, and is well tried and tested, but only showed the total levels of pollution over the whole day. Some versions of this monitor (Figure 3) now measure the levels of pollution and record them minute by minute over the day (called 'real-time monitoring') http://www.apbuck.com/shop/item.asp?itemid=16 .

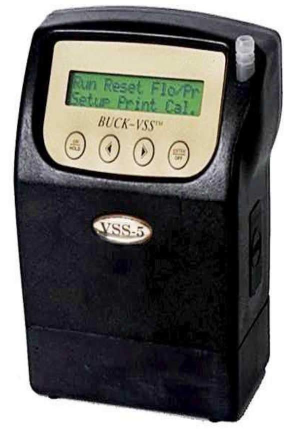

Figure 3: Buck low-flow sampling pump

A big advantage of this type of monitor is that the white filter paper turns completely black during monitoring due to the smoke. This filter can be shown to household members to demonstrate what is happening when they breathe in polluted air. A disadvantage is that the pumping action is audible within the house during monitoring.

More recently, a small silent monitor has been developed by University College Berkeley, USA, which produces real time data.

The UCB monitor (Figure 4) relies on sensors from an inexpensive commercial household smoke detector that combines ionization chamber sensing (ion depletion by airborne particles) and photoelectric sensing (optical scattering by airborne particles) (UCB, 2006).

Figure 4: UCB monitor

Monitoring carbon monoxide

Figure 5: T82 Carbon monoxide monitor

There are two main types of equipment for monitoring carbon monoxide in this type of work. The first is a 'stain tube', which is a small tube, made of robust glass inside which is a sensor which changes colour with exposure to the gas. These tubes are useful if only a small number of measurements are to be made, but as they can only be used once, they are expensive for larger numbers of samples. They give an indicator of CO levels, but are difficult to interpret accurately and do not give real time data. Practical Action uses real time monitoring of carbon monoxide. The equipment is an ISC-T82 single gas monitor made by Industrial Scientific (Figure 5). Once monitoring has taken place, the data can be downloaded to computer using a T82 datalogger to computer. Software enables the user to look at graphs of levels of carbon monoxide with time, as shown in Figure 6.

Data from the CO monitor is downloaded, using a T-82 datalogger for both room and woman. The similarities show that the woman inhales most smoke when the fire is alight. It can also be seen that she was inhaling some smoke around 4.00pm in the afternoon - perhaps she had a visitor who was smoking

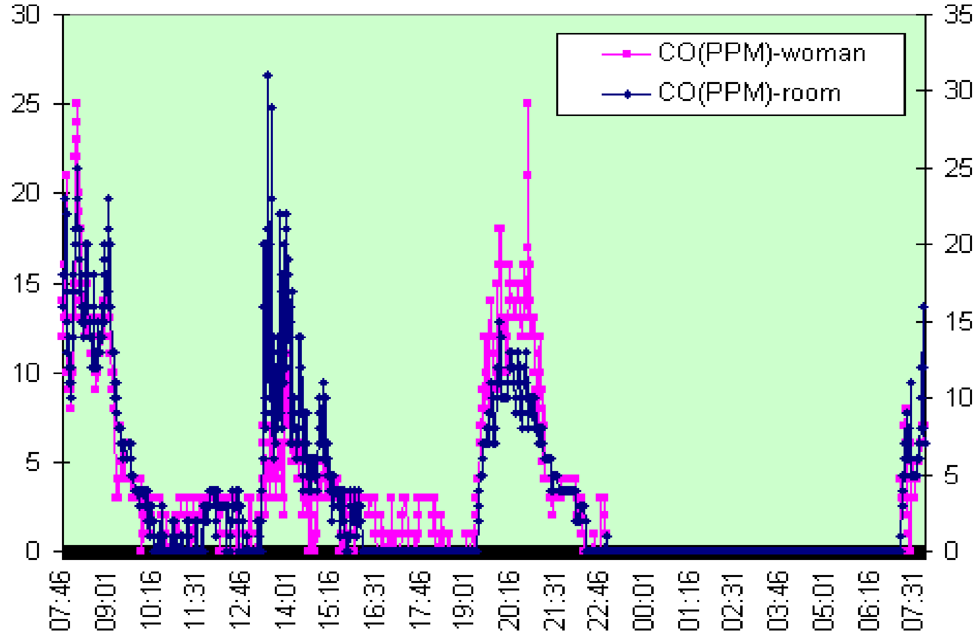

Figure 6: Datalogging using T82 datalogger for both room and woman

Other projects use the less expensive HOBO monitor which has been shown to provide good results. However, the T82 provides an easy and user-friendly download facility, enabling researchers to observe immediately the levels of pollutant as shown in Figure 6. Also, as it is used for safety monitoring in hazardous situations, the build quality and levels of accuracy are high.

Using the equipment in project households

A particulate pump and a CO monitor are set close together 1.3m vertically and 1.3m horizontally away from the stove and monitoring is conducted for 24 hours. Where possible, the equipment is set away from walls and draughts. In Figure 7, from Sudan, it can be seen that all the electrical equipment is housed in locked 'cages' to prevent children from tampering with it.

Figure 7: Equipment in metal cages – Sudan monitoring *(Photo: Practical Action).*

Figure 8: Woman wearing CO monitor around neck *(photo: Practical Action).*

At the same time, the cook is asked to wear a CO monitor round her neck during monitoring: The monitor is attached and a check is made that she feels comfortable. Many people thought the participants were wearing mobile phones.

How many households should be monitored?

Practical Action monitored thirty households in each of the three project countries: Kenya, Nepal and Sudan. Each household was monitored twice before any technology was installed and twice after – reflecting seasonal changes that could affect pollution. As anticipated, particulate and carbon monoxide levels varied widely from household to household. However, households with high levels during the first monitoring tended to have high levels in the second as well.

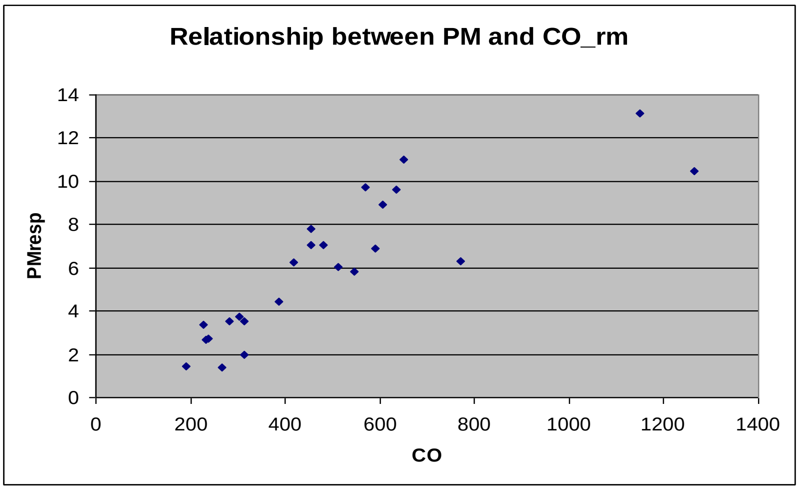

Figure 9: Relationship between mean and median values of particulates and carbon monoxide in three-country study

It was also shown that, when the mean and median of data from each of the three countries and each round was put together, there was a good relationship between particulates (PMresp) and carbon monoxide (CO rm) (Figure 9).

Working with thirty households enabled Practical Action to see if there were substantial changes brought about by the technologies that had been installed. Other factors were checked that could have had a major effect on the results. For some factors, such as a small number of women brewing alcohol in Nepal (part of the usual week's work), it was necessary to compare figures excluding those households who were brewing from both pre- and post- measurements as there was not enough data to account for it in other ways. This exclusion was, of course, recorded as part of the results.

Projects to alleviate smoke should be looking for *substantial reductions* - not just for a few percentage change. Thus the thirty households per country were sufficient to provide a clear picture of whether the changes had been successful in reducing smoke substantially.

Monitoring acceptance

Data should ideally be collected a few months after the technology has been installed. At this time it will be evident whether the switch to the new way of cooking has been continued or not. Questions on the stove and the fuel used on the day and in general will provide information on whether the majority are using the new appliances.

Further questions can be asked about the impacts of the technology on people's lives. Care should be taken that the questions are asked in a way that allows criticism as well as positive change. Particularly in research projects, learning what is wrong is almost more important than finding out the good things.

Group discussions can help people to develop ideas publicly – though care should be taken to ensure that those with the quieter voices also have a chance to express themselves. If the entrepreneur is available to attend some of the group sessions, he/she will be left in no doubt if there are problems that need to be addressed. Otherwise the comments should be fed back from the meetings.

Data analysis
With all this data, statistical analysis is key to examining the findings and reporting them accurately. Practical Action uses a statistical package (SPSS) to look at:

- Baseline data on levels of pollution: respirable PM; CO-room; CO-woman
- Factors which affect concentration of pollutants - weather; number of meals; time spent; size of room; fuel; type of stove etc.
- Time / activity studies which show how long the woman is close to the fire
- Further studies looking at the impact of household interventions on health and well-being, savings and income generation, time and environment.

Reference and further reading

- *Smoke, Health and Household Energy Volume 1: Participatory Methods for Design, Installation, Monitoring and Assessment of Smoke Alleviation Technologies* [Liz Bates, ed] Practical Action 2005
- WHO, 2007 Randomized controlled trial in Guatemala.
- UCB, UCB Particle Monitor, 2006
- Kirk Smith home page
- *WHO, 2007 Evaluating household energy and health interventions: a catalogue of methods.* World Health Organization. Geneva, WHO, in press.
- *Smoke – The Killer in The Kitchen: Indoor Air Pollution in Developing Countries*, by Hugh Warwick and Alison Doig, Practical Action Publishing, 2004

Monitoring tools & questionnaires
Practical Action
Kirk Smith Group
CEIDH

Useful websites
HEDON
The HEDON Household Energy Network is an informal forum dedicated to improving social, economic, and environmental conditions in the South, through promotion of local, national, regional and international initiatives in the household energy sector. It has recently launched a Clean Air Special Interest Group (CleanAirSIG)

PCIA
The Partnership for Clean Indoor Air was launched at the World Summit on Sustainable Development in Johannesburg in September 2002. The mission of the partnership is to improve health, livelihood and quality of life by reducing exposure to air pollution, primarily among women and children, from household energy use.

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Practical Action is a development charity with a difference. We know the simplest ideas can have the most profound, life-changing effect on poor people across the world. For over 40 years, we have been working closely with some of the world's poorest people - using simple technology to fight poverty and transform their lives for the better. We currently work in 15 countries in Africa, South Asia and Latin America.

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