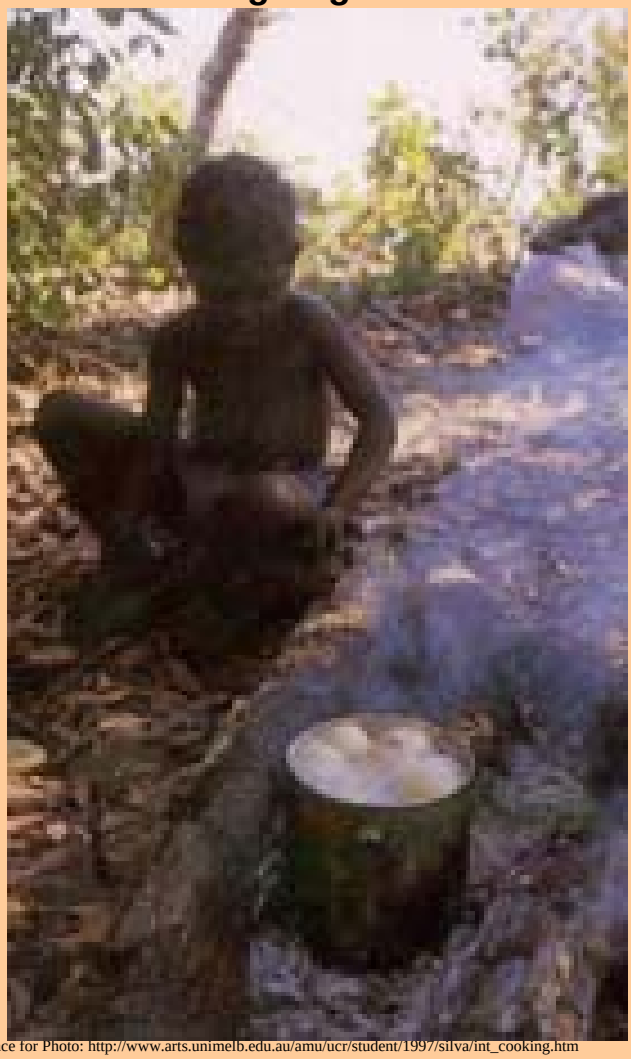
SECURING SUSTAINABLE LIVELIHOODS through appropriate technology

Smoke pollution

at Daguragu



Reference for Photo: http://www.arts.unimelb.edu.au/amu/ucr/student/1997/silva/int_cooking.htm

from cooking fires

A preliminary scoping study

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Photograph 1: Even though people have been cooking with wood for thousands of years, pollutants found in wood smoke can be a major contributing factor to lung, ear and eye diseases. Death rates from respiratory illnesses are four times as high for Indigenous people as for the rest of the Australian population, and the incidence of otitis media in remote communities may be as high as 54%.

ABSTRACT

Pollutants found in smoke from indoor cooking fires are a major contributing factor to eye and lung diseases in developing countries, causing an estimated 2 million deaths every year. To date no research has been undertaken in remote Australian communities to determine whether wood smoke pollutants are likely to cause health problems for people here.

During a recent visit to Daguragu, CAT took the opportunity to carry out a preliminary test of the smoke from cooking fires for emissions of pollutants. Although at this stage it was only possible to take very few measurements from a small sample size, it was found that the nitrous oxide emissions from a smoking fire may be as high as twice what is measured in the sidestream smoke from a cigarette. Carbon monoxide emissions may be almost four times higher. While this is less likely to present a significant health risk for people cooking outdoors in well-ventilated areas, it certainly identifies an urgent need for further research into cooking with wood in enclosed spaces such as inside houses, or on semi-enclosed verandahs.

Anecdotal evidence suggests that residents of at least two Central Australian communities have been cooking *indoors* using wood. Whether or not a stove is used or simply an open fire on the floor of the house, this practice cannot be recommended for health reasons.

TABLE OF CONTENTS

Photograph 2. Many communities in the US are concerned about the adverse health impacts of wood smoke from household heaters. Wood smoke has been found to contain a number of carcinogenic and irritating pollutants, in high enough quantities to significantly contribute to the risk of respiratory illness. Source of graphic: http://www.webcom.com/bi/images/billboard.gif

1.0 INTRODUCTION

Wood smoke is not simply harmless and innocuous, even though people have been cooking with wood for thousands of years. More than half of the world uses biomass fuels, primarily wood, for cooking and heating their homes, and the World Bank estimates that **2 million people die prematurely every year[1] from the inhalation of smoke from indoor cooking fires**. Pollutants from indoor cooking fires are major contributing factors to lung and eye diseases in developing countries[2], and respiratory illnesses are the **leading cause of death** in these countries[3] [4]. In India, it is believed that 18 per cent of blindness is caused by exposure to smoke from cooking with wood and other solid biomass fuels. A reduction in the smoke levels from cooking with wood would have a major impact on reducing the global burden of respiratory disease.

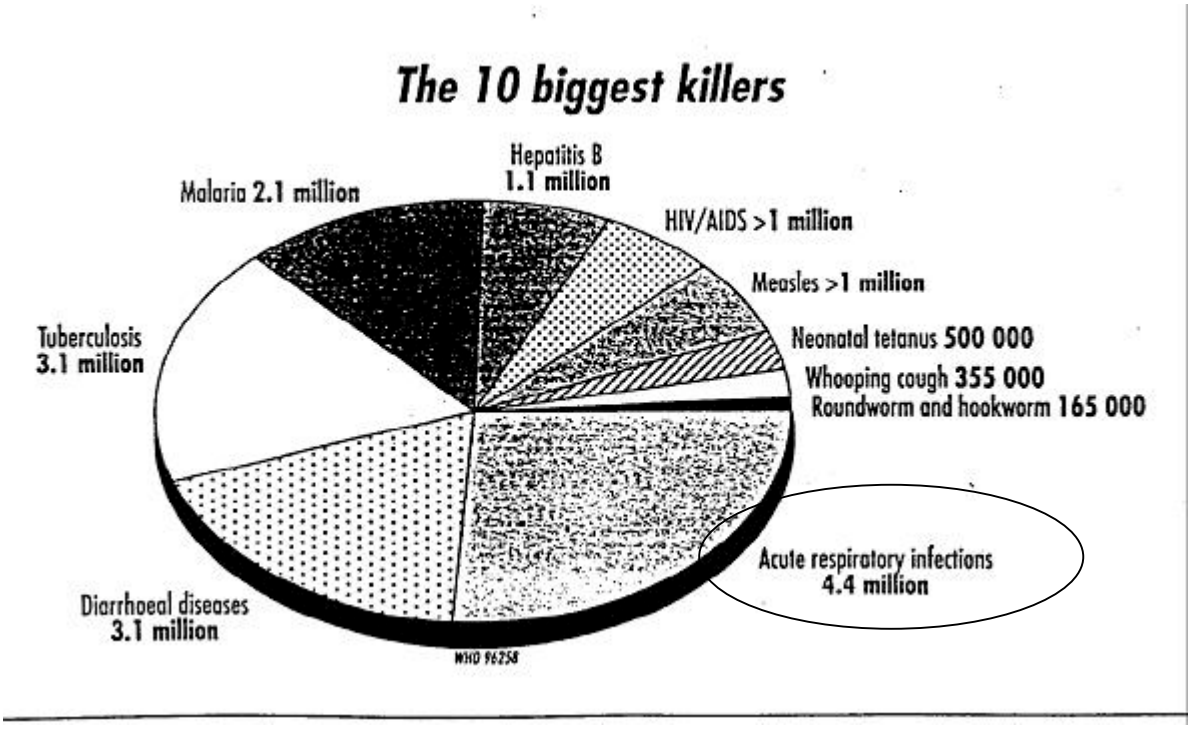

Figure 1. The leading causes of death in developing countries. Source of graphic: Mara,D.D., Tropical Public Health Lecture Notes, University of Leeds, 2000.

Worldwide, acute respiratory illnesses are **the leading cause of death for children under five[5]**, and the lung damage caused by wood smoke is a major contributing factor to the weakness which prevents people from fighting these severe, often fatal infections[6]. For example, the incidence of acute respiratory infection (ARI) was found to be six times as high for children exposed to wood smoke while on their mother's backs, as for children who did not suffer from such exposure[7]. In Tanzania, the under five mortality rate for ARI was three times as high for children sleeping in a room with an open wood stove, than for unexposed children.

The constituents of wood smoke typically include carbon monoxide, nitrous oxides, respirable suspended particulates, polyaromatic hydrocarbons and formaldehyde[8]. Among the polyaromatic hydrocarbons found in wood smoke,

there are many known carcinogens[9]. There is evidence that benzo(a)pyrene, a polyaromatic hydrocarbon found in wood smoke, lowers the response of human immune systems. In a single day, a woman cooking with wood may be exposed to as much benzo (a) pyrene from wood smoke as if she had smoked up to 450 non-filter cigarettes[10]. Wood smoke may also trigger asthma attacks in susceptible individuals. Bladder and lung problems have been found to be caused by polyaromatic hydrocarbons present in wood smoke emissions[11].

Lung function has been found to be greatly reduced in children exposed to indoor smoke from cooking fires, for studies carried out in India and South America[12]. Wood smoke also contributes to low birth weight[13] and stillbirths when pregnant women are exposed to pollutants from indoor cooking. Chronic lung diseases such as asthma and bronchitis among non-smoking women have also been found to be linked to pollutants from wood smoke[14]. There have been numerous studies carried out in Mexico, Colombia, India, Papua New Guinea and Nepal to confirm and document the links between chronic lung diseases and wood smoke. Studies in China[15] and in North American Indian communities[16] confirm the links between wood smoke and acute respiratory illnesses[17]. Other adverse health effects from woodsmoke include cataracts and nervous or muscular fatigue, as well as an increased risk of anemia, lung cancer[1819202122], tuberculosis[23] or pneumonia[24]. Nitrous oxides found in cooking smoke can decrease resistance to tuberculosis infections[2526]and increase the severity of the infection, for those who are already infected. Wood smoke increases the likelihood of coughing which exacerbates the spread of airborne diseases.

To date, there have not been any studies documenting the effects of wood smoke on Indigenous Australians living in remote areas. There have also not been any studies of the pollutant levels found in the smoke from fires used to prepare meals in remote community settings. Pollutants from wood smoke depend on the type of wood which is burnt, and also whether a stove or oven or other cooking device is used, rather than an open fire. Exposure to these pollutants depends on environmental factors such as wind speed, as well as on whether the cooking is carried out indoors or outdoors. Because of these factors, data obtained from overseas studies in developing countries may not be directly transferable to the situation of Indigenous Australians.

Respiratory illness is a significant health problem for the residents of remote communities, being the third leading cause of hospital admissions for Indigenous adult males,[27] and a significant cause of ill health for women and children also. Death rates from respiratory illnesses are four times as high for Indigenous people as for the rest of the Australian population[28]. The incidence of pneumonia, proven by x-rays, causes 80 times as many hospital admissions for Indigenous children as for non-Aboriginal children[29].

Acute respiratory infections account for the most common identifiable cause of infant mortality and under five morbidity in the Northern Territory[30]. For example, an estimated 1-2% of all Indigenous children suffer from a disease which is now rarely seen in developed countries (except for people who suffer

from cystic fibrosis). This disease is called Bronchiectasis, and is characterised by enlarged, thick-walled bronchial tubes, caused by chronic inflammation from viral and bacterial infections [31].

The incidence of bronchiectiasis in Indigenous communities is 40 times greater than that of the most closely related disease affecting non-indigenous people, cystic fibrosis. A recent report on bronchiectiasis recommends that its incidence can be greatly reduced by decreasing exposure to environmental toxicants such as wood smoke.

Woodsmoke may be linked to ear problems also[32]. Otitis media is a significant problem in Australian Indigenous communities[33 34], and also in Canadian First Nation communities, where wood is still used for cooking. Estimates of the incidence of otitis media in the Indigenous population range from 11% to 54%. Otitis media is a major cause of mortality in children in developing countries, causing 51000 deaths in 1993 alone. It has been linked to environmental tobacco smoke[35 36], and also, more recently, to indoor air pollution from wood smoke[37 38]. The incidence of otitis media in Australia's non-Indigenous population, is extremely low. Perhaps this can be partly attributed to the fact that most non-Indigenous people in Australia rarely use wood as a cooking fuel.

The Centre for Appropriate Technology aims to find ways to make stoves and kitchens in Indigenous communities work better for the people who use them. Wood stoves or wood fires typically release up to 50 times more carbon monoxide, particulate matter and hydrocarbons than a gas stove used to prepare an identical meal[39]. The present study aims to investigate whether pollution from wood smoke is severe enough to be likely to be linked to respiratory illnesses in Indigenous communities, and whether the matter should be further investigated to allow Indigenous people to make informed choices about different cooking fuels.

1.1 Aim of the project

The purpose of the research is to find out the levels of different air pollutants in the smoke from a cooking fire used by a typical family for cooking a meal, in a remote community setting. The measured levels can then be compared with recommended maximum exposure levels and with emissions measured elsewhere, to determine whether pollution from wood smoke is likely to contribute significantly to the burden of respiratory illness in remote communities.

The data may be used to enable people to make an informed decision about the use of different cooking fuels. This information may also be used to change housing policy and to design better cooking facilities in remote communities. Ultimately, the research may lead to improvements which will make it easier for people in remote communities to prepare food safely.

1.2 Procedure

Only two households in Daguragu were cooking with wood on the day of the study. Both used an outdoor open fire. The emissions of carbon monoxide and nitrous oxides were measured, as well as carbon dioxide and oxygen levels. A Testo 300M Combustion Gas Analyser, hired from Tech-Rentals, was used to carry out the measurements.

Observations were also made and discussions were held with the community's housing officer and the local environmental health officer from Katherine West Health Board.

1.3 Research Questions

Questions which this research project seeks to investigate are listed below:

> How much carbon monoxide and nitrous oxide is contained in cooking smoke from a "typical" outdoor cooking fire in a remote community? (A future study may consider sulphur dioxide, particulates, polyaromatic hydrocarbons and hydrogen sulphide also)
>
> How do the levels of these chemical pollutants compare with those which have been found to present a significant risk to human health, contributing to eye and lung diseases?
>
> If there is likely to be a serious smoke-related health problem, then how can outdoor cooking be modified and improved to minimise exposure to harmful pollutants? What kitchens or stoves meet the expressed needs of people in remote communities, and minimise any smoke induced impact?

(The present preliminary study has only just begun to address the first two research questions, much more work is needed in the future).

1.4 Sample

The sample which was to be considered is all 40 households of residents of Daguragu community. However, not all residents of Daguragu still cook with wood, and on the day of the monitoring, many householders were not present in their homes due to their attendance at a regional meeting for community councillors, or due to their absence in Katherine on business. Only 2 households, cooking with wood, were able to have the emissions from their cooking fires monitored. It is hoped that more measurements can be made during a future trip to Daguragu. Nevertheless, the results of this preliminary study are being publicised to highlight the need for more research.

2.0 METHODOLOGY

Emissions of chemical pollutants, products of combustion, were measured using a Testo 300M Combustion Gas Analyser, hired for two days from Tech Rentals. The pollutants which were measured included carbon monoxide and nitrous oxides, as well as background oxygen and carbon dioxide levels.

Photograph 3. Measuring emissions from cooking fires using a combustion analyser, similar to the one which was used at Daguragu, but slightly more sophisticated.

3.0 RESULTS

The results obtained from the emissions monitoring are documented below:

House number 1
Time: 8:17 am. The fire had died down a lot and was almost out. They had finished cooking.
21.3% O_2
11 ppm NO_x
1.2% CO_2
0 ppm CO

House number 2
Time: 8:43 am The family were cooking toast for breakfast on a grill over the fire.
322 ppm CO
21.6% O_2
0 CO_2
0 ppm NO_x

The fire was stoked and extra wood was added which made it a lot more smokey.
1051 ppm CO
20.9% O_2
0 CO_2
2ppm NO_x

Cigarette smoke emissions:
Time: 8:52 am
266 ppm CO
21.6% O2
6ppm NO_x
0 CO_2

The air was very still. The wind speed was measured with an anemometer and was found to be 0.2 m/s. Ambient temperature was 24.8°C.

The combustion analyser was used at the homes of two different Daguragu families. One female householder expressed great interest in the readings and asked "what do the numbers mean?" The CAT researcher was making a comparison with cigarette smoking and the householder (who was smoking) held her cigarette against the probe so that the pollutants from her cigarette would be analysed. She was surprised to find that the nitrous oxide emissions from the wood smoke were about three times as high as those from her cigarette. "We usually cook inside on the electric stove anyway", she said.

4.0 DISCUSSION OF RESULTS

The levels of pollutants measured at Daguragu can be compared with the levels which are typically measured in the sidestream smoke from smoking one cigarette, with the recommended exposure limits set by the World Health Organisation[40], and with the limits set in Australia's National Environmental Protection Measure (NEPM)[41]. These results are tabulated below:

	HOUSE 1 WOOD SMOKE	HOUSE 2 WOOD SMOKE -LOW FIRE	HOUSE 2 WOOD SMOKE -HIGH FIRE	CIGARETTE SMOKE	WHO Standards	NEPM Standards
TIME	8:17	8:43	8:48	8:52		
CO	0 ppm	322 ppm	1051 ppm	266 ppm	10 ppm (8 hour exposure limit) 100 ppm (15 minute exposure)	9 ppm (8 hour exposure limit)
O_2	21.3%	21.6%	20.9%	21.6%		
NO_x	11 ppm	0 ppm	2 ppm	6 ppm	0.2 ppm (1 hour exposure)	0.12 ppm (1 hour exposure)
CO_2	1.2%	0 ppm	0 ppm	0 ppm		

Table 1. Comparison of monitoring results with guideline values set by the World Health Organisation and Australia's Commonwealth Department of Environment and Heritage.

Bearing in mind the small sample size, it can be seen that the measured levels of pollutants CO and NO_x are **far in excess** of the recommended maximum levels. This highlights the need for further monitoring to be carried out, especially for communities which are cooking with wood *indoors* where there is limited ventilation. In the light of the above recorded data, which corroborates studies carried out overseas, the practice of cooking with wood *indoors* cannot be recommended, on health grounds.

Many people were missing from the community and were unable to participate in the emissions monitoring. Some had still not returned from Katherine, where they had travelled to attend the Katherine show about a month previously. Almost all of the councillors from the Daguragu Community Council were not present at home due to the fact that a meeting had been called at short notice, to discuss regionalisation. It is recommended that when any subsequent visits are made to the Daguragu community, emissions from cooking fires are monitored to add to the data obtained from the present study, as a larger sample size obviously lends greater validity to the findings of this research.

The levels of particulates have not been monitored as part of the present study, primarily due to a lack of monitoring equipment, and also due to a shortage of time for data collection at Daguragu. However, it is recommended that as part of a future study these particulate levels should be measured. In future, a simple but indicative test for particulates can be carried out *without* the use of expensive and sophisticated monitoring equipment[42], by using a simple sampler manufactured from a strip of filter paper coated with petroleum jelly. (For details see http://www.atec.org/curric/activities/acc44.html). A simple gravimetric method should be used, whereby a filter paper circle can be marked with a grid of 1cm squares and coated with petroleum jelly to allow particles from wood smoke to adhere to the filter paper to allow counting.

It is recommended that particulate levels be measured in future as they are one of the major pollutants in wood smoke[43][44][45][46][47], and have been implicated in a number of diseases[48], including lung cancer[49], increased incidence and severity of upper respiratory tract infection[50] and asthma[51].

Research carried out overseas, (eg. in Kenya[52] and Guatemala[53]) indicates that emissions from wood stoves with chimneys tends to be significantly less than emissions from open fires. CAT manufactures a number of different stoves for cooking with wood, including drum ovens, “bush microwaves”, low stoves and high stoves[54]. The use of any one of these stoves can be expected to reduce the cook’s exposure to harmful pollutants. It is recommended that in future, further research be undertaken to determine the levels of pollutants in the smoke from various stoves manufactured and sold by CAT, and to compare these emissions data with the values recorded for a simple open fire. This may provide evidence to support the purchase of CAT wood stoves on health grounds.

The risks of ill health from cooking over outdoor open fires, while being substantially lower than those associated with indoor woodsmoke, are still

likely to be significant, according to overseas research. No such research has been carried out in Australia, and it is recommended that research comparing emissions from indoor and outdoor woodfires be carried out for the types of fuels and cooking methods used in Australian Indigenous communities.

Insufficient data was obtained in the present study to compare the entire emission spectrum from a typical cooking fire at Daguragu with the sidestream smoke from one cigarette. However, this type of comparison has been made for other situations, and a typical comparison is tabulated below:

CONSTITUENTS OF TOBACCO SMOKE/WOOD SMOKE	LEVELS FOUND IN WOOD SMOKE (g/kg wood burnt)	LEVELS FOUND IN TOBACCO SMOKE (ng/cigarette)
Aldehydes	0.6-5.4	
Formaldehyde	0.1-0.7	70-100
Acetaldehyde	0.03-0.6	18-1400
Benzene	0.6-4.0	12-48
Benzo(a)anthracene	4x10-4 - 2x10-3	20-70
Chrysene	5x104- 1x10-2	40-60mg
Benzofluoranthenes	6x10-4- 5x10-3	4-22
Benzo(a)pyrene	3x104- 5x10-3	20-40
Ideno(1,2,3-cd)pyrene	2xl0-4- 1.3x10-2	4-20
Dibenzo(a,h)pyrene	3x104- lx10-3	1.7-3.2
Dibenz(a,h)anthracene	2x10-5 - 2xl0-3	4
Ca	9xl0-4 - 1.8x10-2	41-62
Cr	2x10-5 - 3x10-3	4-70
Ni	lxl0-6 - lx10-3	0-600

Table 2. Comparison of emissions found in wood smoke with pollutants from environmental tobacco smoke.

References:
URL: http://www.webcom.com/bi/table2.htm Chemical constituents of Wood Smoke
URL: http://www.brown-and-williamson.com/Index_sub2.cfm?ID=18 Approximate Chemical Composition of Whole Mainstream Smoke

This corroborates CAT's (albeit limited) measurements which show that the nitrous oxide emissions from a smoking fire may be as high as twice what is measured in the sidestream smoke from a cigarette. Carbon monoxide emissions may be almost four times higher.

Indigenous people's exposure to wood smoke is influenced by the duration of cooking and cooking methods, and quantity of firewood used, as well as the prevailing environmental conditions such as wind speeds, which affect ventilation rates. These factors have not been considered as part of the present study, which was only a preliminary investigation. However, as the present study highlights the need for further research, it is recommended that a more detailed study be undertaken to determine the influence of these factors, and to obtain an indication of the likely daily/annual exposure of Daguragu residents to pollutants from wood smoke.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This preliminary research, albeit for a limited sample size, shows that the nitrous oxide emissions from a smoking fire may be as high as twice what is measured in the sidestream smoke from a cigarette. Carbon monoxide emissions may be almost four times higher. While this is unlikely to present a significant health risk for people cooking outdoors in well-ventilated areas, it identifies a need for further research for cooking with wood, especially in enclosed spaces such as inside houses, or on semi-enclosed verandahs.

Considering that the incidence of Bronchiectiasis is so high in Australian Indigenous communities, and that overseas studies show the links between wood smoke and respiratory illnesses, it is recommended that further studies be undertaken to establish evidence of the health risks of wood smoke in Australian Indigenous communities. The results of any such studies should be widely publicised to enable Indigenous people to make an informed choice about cooking fuels and cooking technologies.

Photograph 4. Traditional cooking methods used for thousands of years may not be innocuous as believed. The present study reveals high levels of nitrous oxides and carbon monoxide in the smoke from cooking fires. Source of graphic:
http://www.arts.unimelb.edu.au/amu/ucr/student/1997/silva/int_cooking.htm

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