INDOOR AIR POLLUTION FROM FIREWOOD COMBUSTION IN TRADITIONAL HOUSES OF NEPAL

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ABSTRACT
Indoor air pollution was investigated during the winter in traditional houses and personal samplers provided to their residents in the Dhading district of Nepal. Results show that the concentration on each floor varies with the position of the staircase. The maximum CO, CO_2, SPM, NO_2 and HCHO concentrations were 185.5 ppm, 2509 ppm, 11.13 mg/m^3, 84.7 ppb and 166.9 ppb, respectively in the indoor spaces. This pollution is higher than the standard. The concentrations of CO, CO_2 and SPM are highly correlated to the area of the apertures in the kitchen. The iron stove proved highly effective in reducing the indoor air pollution of the investigated house and the residents' samplers.

INDEX TERMS
Nepal, Firewood, CO, SPM, PAHs

INTRODUCTION
In rural areas of Nepal, firewood is the main energy source for cooking, heating and lighting. Generally, firewood is burned in an open-hearth without a chimney, and this situation causes indoor air pollution problems in the rooms, and affects the health condition of the residents. The UNDP and a number of projects are installing improved stoves to improve Indoor Air Quality (IAQ), but only a few research works have been done on IAQ (Reid *et al.*, 1986). An improvement in IAQ is one of the most important contemporary issues in Nepal. A quantitative analysis is necessary to improve the IAQ by the modification of the open-hearth. For the purposes of evaluation and improvement of the IAQ in traditional Nepalese houses, indoor air pollution caused by firewood combustion was measured and investigated in 17 houses and in personal samplers provided to their residents. To improve the IAQ, an iron stove with chimney was installed and investigated in one of the houses. The main objectives of this research are: 1) to evaluate the IAQ of houses and residents; 2) to relate the IAQ to the area of the kitchen apertures; and 3) to evaluate the IAQ using the improved iron stove.

RESEARCH AREA
The research area is in Dhading district, which is located in the middle hills of Nepal (Rijal *et al.*, 2002). It has a temperate climate and is not influenced by any source of industrial or vehicular air pollution. People used to burn firewood for cooking and heating in an open-hearth or semi-open mud stove with only a poor chimney (a small hole for eliminating the smoke), or with no chimney at all. Recently, grass or slate roofs are being converted to corrugated iron. It is believed that corrugated iron roofs are damaged by the smoke. To protect the corrugated iron roof from the smoke, the position of the staircase is being moved from indoors to semi-open spaces. In some houses, they are also moving the kitchen from indoors to semi-open spaces. For the experiments, an iron stove with a chimney was purchased in Kathmandu and installed in one house (Fig. 1). The chimney starts on the first floor and extends to the ridge level (3F) to eliminate the smoke. To improve the thermal environment and reduce firewood consumption, glass was installed in the windows.

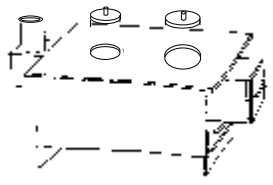

Figure 1. *Iron stove*

METHODS
The investigation was carried out during the winter (December, 2001 to January, 2002). Measurements were made both outdoors (1.5 m above ground level) and indoors (0.6 m above floor level) (Table 1). The indoor

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