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Air Pollution”**

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Some thoughts on indoor air quality

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I have been intrigued by some problems for several years. We measured indoor air quality in low income homes heated by coal or paraffin stoves, and found as much as 1600ppmv CO. Now EPA standards are around 50ppm for 1h; we were talking 8h average. Question 1 was how did the occupants survive? There were widespread reports of headaches and other symptoms. The only hypothesis we could come up with was that they must have adapted to this condition, but nowhere in the literature could we find any reference to such an adaptation. We then tried to find statistics on death rates under these conditions, and failed. All such deaths would be recorded as “accidental” and there is no way to distinguish between automobile accidents and gassing. A study of community papers did however reveal that in winter there were typically three deaths of whole families per week in Soweto, a town of around 1 million souls. It is reasonably rare for a whole family to die, and inquiries we made tended to reinforce the feeling that the cause was likely to be CO poisoning, but we never managed to prove it.

A deeper question was the impact such CO levels might have on the development of children. Clearly the CO is going to tie up a lot of haemoglobin, and reduce oxygen flows. Would this impact physical or mental development? The literature suggested it would, but there was no experience of such extreme levels.

A related problem was the presence of a very fine soot fraction produced by wick-type paraffin/kerosene stoves. Some measurements we carried out, condensing pyrolysis products on the base of clean, very cold pots, indicated that around 4% of the fuel was turning up as condensibles. Some of it was a very fine soot, probably less than 1 micron because it was not visible in air. The condensibles had a strong “burned” smell, probably due to the presence of free radicals. The size would indicate that it would probably be precipitated in the deep lung, and its origin would suggest carcinogenicity, but we have not yet characterised it.

Some work we have done on emissions from paraffin/kerosene stoves have shown that pressure (“Primus”) type stoves give reasonably complete combustion, but many cheap wick stoves give high levels of CO and unburned hydrocarbons. The levels are higher the longer the appliance is used, which seems to be related to the ageing of the (cotton) wick. Some recent work with ultraclean kerosene (zero sulphur, zero aromatics) has shown significant improvement in the levels of unburned hydrocarbons even in these cheap wick stoves, but the CO levels remain high. A disadvantage of the pressure type of stove is the difficulty of simmering during cooking. Many of our grain staples are burst in rapidly boiling water, then cooked by slow simmering, and one need to be able to do both.

We determine the CO:CO₂ ratio rather than the pure CO concentration. This allows us to compare appliances of differing power output, because the CO₂ is directly determined by the stove power. This allows us also to show that, for instance, a 1kW appliance in a Ym³ cooking area ventilated at X air changes per hour should be safe (<50ppm) if the CO:CO₂ ratio is less than 0.02.

A recent bit of work has concerned ethanol gel appliances. Most that we have studied fail to mix the fuel and air, so you land up with a diffusion-type flame and HUGE CO and unburned fuel levels. It came as a real surprise that ethanol could give thick soot! CO:CO₂ ratios as high as 1 were observed (with a correspondingly low efficiency).

Any inputs to any of these aspects would be welcomed.