How big is small? Enough to not breathe oil!

The Peruvian case of diesel-fuelled wick lamps for lighting

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Abstract

Health risks due to indoor air pollution from inefficient domestic burning processes for cooking or lighting are not breaking news. The presence of high levels of sulfur dioxide in burnt wood emissions from traditional cookstoves; its remaining high levels in the air after two hours from turning off the source; and the fact that this gets even worse with an oil-fuelled wick lamp that pollutes almost the same as a second traditional cookstove in the same room for at least one hour each day for 20% of the world´s population, maybe are. This paper shows first evidence from Peru´s rural context in the simultaneous lack of modern energy devices for lighting and cooking.

Keywords: sulfur dioxide; indoor air pollution; diesel wick lamp;

Introduction

Worldwide there are about 1,400 million people without access to electricity (OECD 2010). Of these, it is estimated that 500 million people still use fossil fuels, among them mainly kerosene, to produce light (Lam et al. 2012). In Peru, about three million people lack access to electricity (MEM 2013), so need to use traditional wick lamps, candles, and batteries.

Unlike in other countries, in Peru no one is using kerosene-fuelled wick lamps because its use has been prohibited by law since 2010, since it is used in the production of illegal drugs (narcotics). However, there are many families in rural areas of the rainforest which have replaced kerosene with diesel, using it as fuel for wick lamps.

In addition, almost all families using wick lamps cook in open fires (traditional stoves). The negative impact of traditional stoves in open fires has long been researched; however, there is only thin evidence about the exposure to both indoor air pollutants at the same time.

Research Objectives

This paper aims to study health risks created through exposure to the gaseous emissions produced by diesel-fuelled wick lamps (DFWL), as well as the risk of their parallel use with wood burning cooking stoves. The first research question was to discover if the use of DFWL results in high emission levels of the same dangerous gases that traditional cookstoves produce, mainly particular matter 2.5 ($PM_{2.5}$) carbon monoxide (CO).

In addition, it was tested if the sulfur dioxide (SO_2) levels – typical from oil burning processes – are higher than those recommended by the World Health Organization (WHO) as highest exposure limits. The last question was to measure the emission levels of these gases from DFWL in parallel use with a traditional cookstove and evaluate its remaining levels over time after turning off the sources.

Methods

Two DFWL with different types of wick (Type A: cotton and Type B: old cloth) were collected from households in two different towns in the Amazon area (the provinces San Martín and Amazonas, respectively) and used as polluting sources.

Tests were conducted on indoor air pollutant concentration (CO, $PM_{2.5}$, SO_2 and carbon dioxide CO_2), resulting from the use of two types of DFWL with diesel fuel. These tests were conducted in SENCICO's improved cookstove certification laboratory in Lima.

The environment chosen had a ventilation rate of 4.29 h-1, which was determined with the window and door closed, as recommended by the new protocol for IWA (International Workshop Agreement) on improved stoves (February 2012).

During the trials for each type of test, variables were homogenized such as: start and end time of each test, environment, fuel (diesel and firewood), technical evaluation, and the approximate level of light emitted by the DFWL.

The concentration levels of the pollutants mentioned above by each type of DFWL were evaluated for 3.5 hours a day on 3 consecutive days during similar hours respectively (D1-D6).

Similarly, during days D7-D9, the emissions of the traditional stove were evaluated in the mornings, and, in the afternoons, parallel with the most polluting DFWL according to the results of tests on D1-D6. The testing time with the operation of both polluting sources was 1 hour.

To control the environmental variables that could influence the results of the tests, the Davis Vantage Pro Weather Station was used.

To measure the concentration of pollutants generated by DFWL, the following equipment was used:
i) Indoor Air Pollution Meter (IAP, second generation 2012) for measuring $PM_{2.5}$ and carbon monoxide CO.
ii) Aeroqual (NDI sensor and GSE) for the measurement of carbon dioxide CO_2 and sulfur dioxide SO2.

Results

The DFWL type A showed in all test the highest concentration of gases. This DFWL showed the highest fuel consumption with an average of 101 g of diesel versus 55 g for 3.5 hours burning respectively. All the results listed below are taken from the tests conducted with DFWL type A.

The average PM2.5 levels of the most polluting DFWL was around 10,499 µg/m^3. Figure 1 shows PM2.5 and CO concentration levels on D1 as a characteristic curve for the three days of measurement.

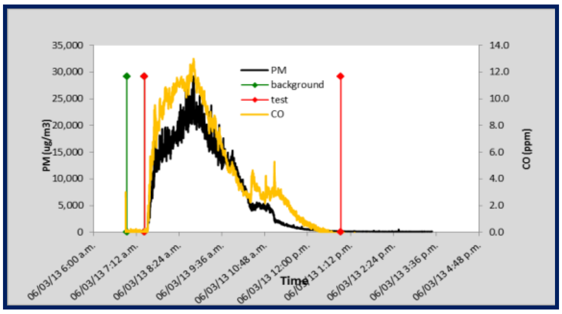

Figure 1: Characteristic curve of PM2.5 and CO for DFWL type A on D1

This concentration of $PM_{2.5}$ particles reaches approximately 60% of the emission levels of a traditional cookstove as the only pollution source, which showed average levels of 15,165 µg/m^3 in this research. The levels of $PM_{2.5}$ for a traditional cookstove as the only pollutant on D7 can be seen in figure 2.

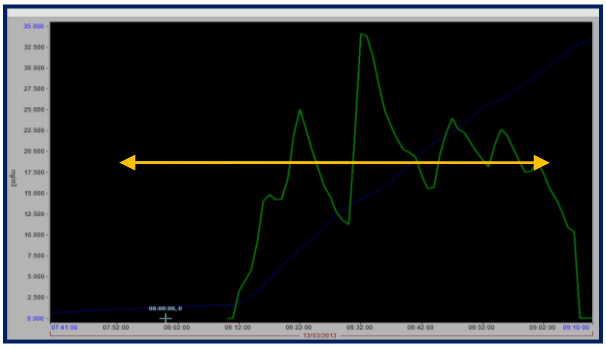

Figure 2: Characteristic curve of $PM_{2.5}$ for DFWL type A on D7

The tests with the same DFWL showed that the average concentration of SO_2 emitted after the first 10 minutes of burning was 1.14 ppm, exceeding almost up to seven times the limit allowed by the WHO for 10 minutes exposure of 0.17 ppm. There were peaks of 1.83 ppm. Figure 3 shows the characteristic curve seen on D3 for SO_2.

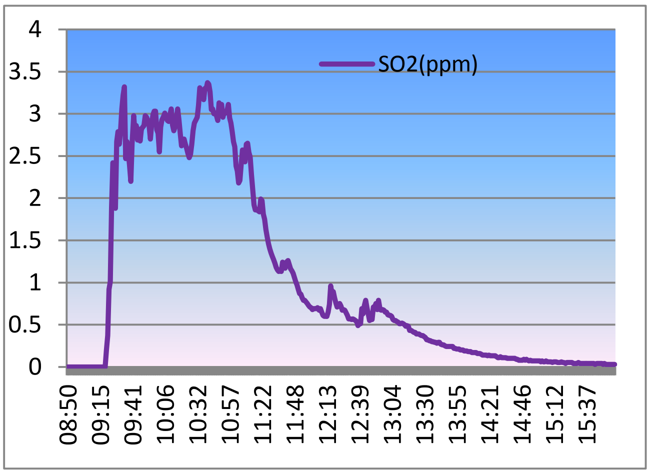

Figure 3: Characteristic curve of SO_2 for DFWL type A on D3

The concentrations of CO and CO_2 from both DFWL didn't show risky levels, neither in tests with only DFWL as with those with the traditional cookstove as well, which can be seen on the characteristic curves in figure 4 and from figure 1 as well.

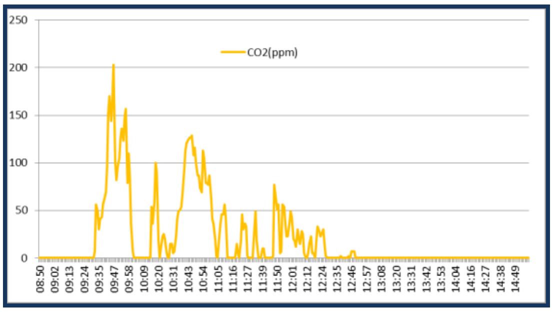

Figure 4: Characteristic curve of CO_2 for DFWL type A on D2

The use of a DFWL simultaneously with a traditional stove regarding $PM_{2.5}$ showed an average level of 19,723 µg/m^3 (with peaks over 43,000 µg/m^3) having an average increase of nearly 30% from the values with a traditional cookstove as the only pollutant. The characteristic curve of the concentration level on D7 with both burning sources can be seen in figure 5.

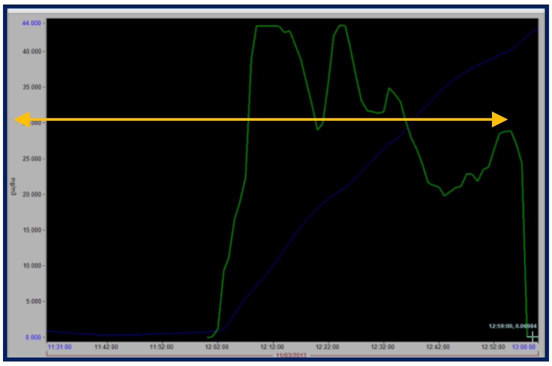

Figure 5: Characteristic curve of $PM_{2.5}$ for DFWL type A and a traditional cookstove on D7

An unexpected result was observed in that a traditional cookstove, as the only source of pollution, reaches levels of sulfur dioxide SO_2 far exceeding the permissible exposure values from various organizations, such as the WHO. SO_2 is not a typical gas taken into account in typical cookstove emission tests.

The intensity of this emissions are so high that they even exceed the maximum possible measurement levels of the instruments (> 15 ppm), hence the concentration levels during the full test couldn´t be monitored for both cases (DFWL alone and in addition with a traditional cookstove). The disrupted evolution on D9 can be seen in figure 6.

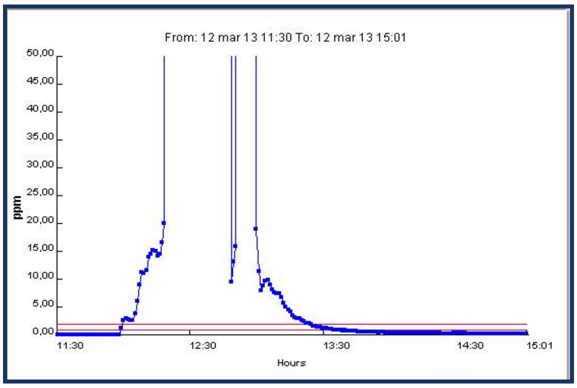

Figure 6: Characteristic curve of SO_2 for DFWL type A and a traditional cookstove on D9

However, SO_2 emission speeds of 0.5 ppm/min and 1.5 ppm/min with a DFWL alone and with both polluting sources respectively could be seen.

High levels of SO_2 still remain in the room after two hours of ventilation without further emissions of both pollutants after one hour of both sources burning. After this time, there were levels of 1.31 ppm and 500 µg/m^3 of SO_2 and $PM_{2.5}$ respectively.

Discussion

This study invites further research on indoor air pollution, taking into consideration sulfur dioxide SO_2 and its health implications, either through DFWL or traditional cooking stoves. In relation to the DFWL, it is suggested to carry out evaluations with the same type of DFWL and with different types of comburent agents (wicks) since it has been observed that different varieties of wicks emit larger or smaller amounts of fine particles.

In the absence of complete simultaneous measurement of pollutants during the tests on DFWL and traditional stoves, it is suggested to perform this test with equipment that allows for a wider range of measurement and records other pollutants, such as nitrogen oxides and sulfur . It is also advisable to measure on different days, following similar time schedules, in order to control environmental variables.

The tests performed have also shown the existence of high levels of SO_2, emitted only by wood burning stoves. For this reason, it is suggested to consider the levels of SO_2 emitted during combustion when validating improved stoves.

It is understood that the high pollutant concentration levels recorded (especially $PM_{2.5}$ and SO_2) pose a risk to people who use these traditional devices for lighting and cooking in their homes. So, being the most likely means of exposure to sulfur dioxide and toxic particles by breathing contaminated air from the burners or traditional stoves, people should be warned about the risk of carrying out activities within a closed environment due to the presence of these polluting sources.

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