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Kitchen Air Pollution in India

Malavika Sinha
Department of Geography, Chatra Ramai Pandit Mahavidyalaya, Bankura
West Bengal – 722141, India
✉ malavikasinha@yahoo.co.in

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Abstract: The discussion about the kitchen is tiny one but most effective. The function of a domestic kitchen is quite restless because it operates almost 365 days in a year. In India total number of domestic kitchens is quite higher than total Indian households. These kitchens are small food preparing industry where energy used in terms of kitchen fuel and matter in terms of food and industrial sewage occurs in the form of pollutants. Indian women on an average spend two hours per day and minimum 75 minutes per day in kitchen. This paper covers the most focal aspect of realistic picture of domestic kitchen air pollution in Indian middle class families. The exposure of air pollution is vast one. The preventive measure to combat air pollution in the kitchen is the first foot stepping of it. Here the effort has been made to make aware about the exposure of kitchen air pollution in India. This is just like the concept of charity begins at home. This paper depicts the clear picture of preventive measures to combat air pollution in a developing country (India) which has to be started from domestic kitchens.

Key words: Indoor kitchen air pollution, biomass fuel, health significants.

Objective

There is a proverb ‘charity begins at home’. This is a famous quotation of a lady addressed to her brother to make him home-oriented. All are well familiar with different sorts of pollution as well as physical environments like air pollution, surface and ground water pollution, noise pollution and also social pollution like poverty, crime as social pollution and so on. People from rural or urban background all are familiar with kitchen. The World Health Organization reports that in 23 countries 10% of deaths are due to just two environmental risk factors: unsafe water, including poor sanitation and hygiene; and *indoor air pollution* due to solid fuel used for cooking (Osseiran, 2007).

The basic objective of the work is to sketch the realistic picture of kitchen air pollution in the Indian middle class families.

Methodology

Here the discussion covers only the domestic family kitchen of middle class families and not the commercial restaurant or sophisticated modular domestic kitchen. The information about time spent in kitchen is derived from questionnaire survey. The basic method is the empirical and analytical. The basic information related to kitchen is derived from little measurement technique and then results have been plotted in graphs.

Air Pollution in Domestic Kitchen

The kitchen is a tiny topic but not negligible in number in totality. The number of total Indian domestic kitchens is higher than the total Indian households. In India, households arrange their kitchen according to their own convenience (may be indoor or separate kitchen). They use the fuel and prepare food by their own convenient method. These kitchens are small and ever functioning food repairing industry where energy is used in terms of kitchen fuel and matter in terms of food and industrial sewage occurs in the form of pollutant. It runs for 365 days in a year after years. Indian women on an average spend two hours per day and minimum 75 minutes per day in kitchen.

Sources of Pollutants

The pollution means the degradation of the standard of inhaling air quality. Here in kitchen air pollution occurs through two processes:

a. Through the energy sources used for cooking (kitchen fuel)
b. Through the matter (food substances prepared in kitchen)

The kitchen fuels are basically of two types in India: first is biomass fuel and other is the LPG (liquid petroleum gas). One-third of the world's population burns organic material such as wood, dung or charcoal (biomass fuel) for cooking, heating and lighting. Biomass fuel is massively used in rural India.

The cow dung and wood burning are quite common in rural India and both are responsible for high emission of carbon monoxide, hydrocarbons, ultrafine particles and highly carcinogenic polycyclic organic hydrocarbons (Larson, 1993, Table 1, Figure 1).

Most of the Indian women prepare food for the whole family. If in a family kitchen, food have been prepared for two hours the particulate material ejected from the cooking processes vary according to the fuel (Table 2, Figure 2). The concentration of these ejected particulate material are suspended throughout the residential area have their intensities varying from indoor kitchen to outdoor (Figure 2).

Table 1: Kitchen air pollutants by fuel (in grams)

Types of fuel (1 kg substances for 1 hr)	*Carbon monoxide*	*Hydrocarbons*	*Fine particulates*	*Highly carcinogenic polycyclic organic hydrocarbons*
Burning of wood in a new wood stove	130	51	21	0.3
Cow dung	230	45	67	0.9

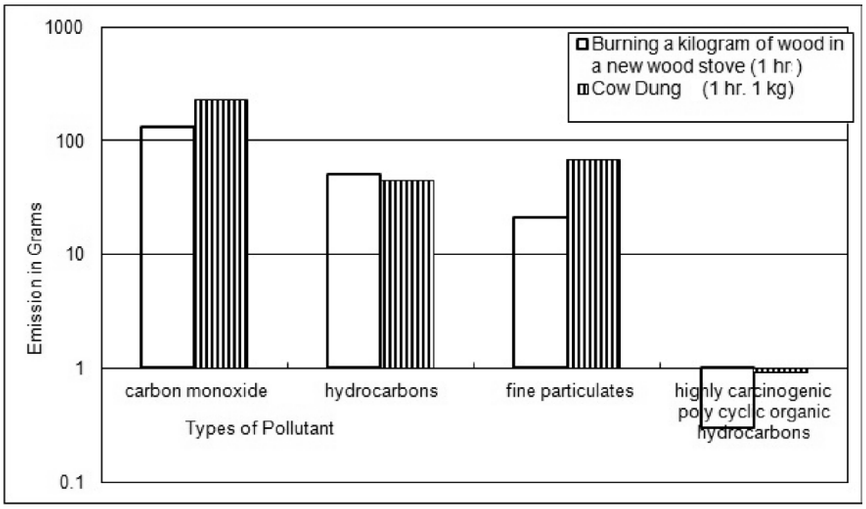

Figure 1: Kitchen air pollutants by different fuels.

Table 2: 24 hours average concentration of pollutants in kitchen (µg/m^3) PM

Type of fuels	*Kitchen*	*Living room*	*Outdoor*
Dung	732	362	99
Wood	500	345	87
Kerosene	203	289	NA
LPG	73	75	114

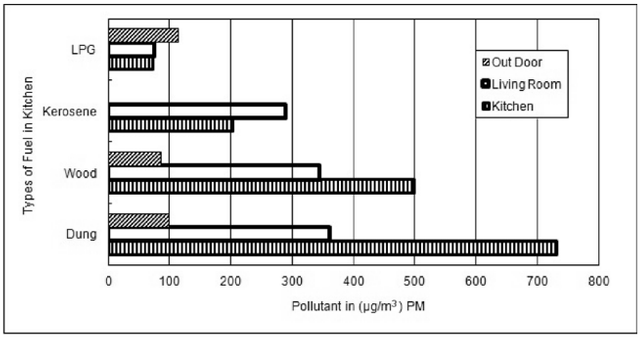

Figure 2: 24 hours average concentration of pollutants in kitchen by different types of fuels.

Table 3: 24 hours average concentration of pollutants in solid fuel in different kitchens (µg/m^3) PM

Type of kitchen	*Kitchen*	*Living room*	*Outdoor*
Kitchen with partition	660	375	90
Enclosed indoor kitchen without partition	652	559	76
Separate enclosed kitchen	575	280	105
Outdoor kitchen	297	215	91

Intensity of kitchen air pollution depends on kitchen types though the same fuel for same duration of cooking process had been pursued (Balakrishnan, 2013). The outdoor kitchen is the safest kitchen (Table 3, Figure 3) for both who cooked the meal and the dwellers of home.

Biomass burning emits many products due to incomplete combustion such as small particles of CO, NO_2, formaldehyde, benzene, butadiene, polyaromatic hydrocarbons etc. All these have an adverse health significance (Balakrishnan, 2011, Table 1).

Liquefied petroleum gas, also called LPG, is simply propane or butane and is a flammable mixture of hydrocarbon gases used as a fuel in kitchen. It is the most safe kitchen fuel in India. The government of India subsidise it to promote more use of LPG in domestic kitchen.

Process of Cooking and Kitchen Air Pollution

Cooking emissions depend strongly on variety of parameters, including ingredients, type of stove and cooking temperature. Cooking style varies with population, culture, climate and geographical location, which complicates the human risk assessment on cooking emissions. Different cooking styles employ different ingredients, cooking procedures and temperatures. The cooking period is divided into four phases:

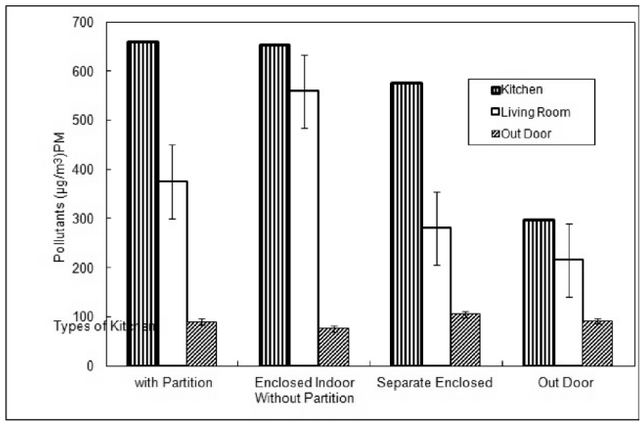

Figure 3: 24 hours average concentration of pollutants in different types of kitchen.

1. Background testing and boiling,
2. Heating of the pan and the oil,
3. frying and
4. Post-cooking decay of emitted particles.

The average background number concentration of all particles was 3.72×10^3 particles/cm^3. It increased rapidly when heating the oil and up to 3.64×10^5 particles/cm^3 after frying. The total particle number concentrations continued to increase for 5 min after the stove was turned off (Table 4).

When used in simple cooking stoves, these fuels emit substantial amounts of toxic pollutants. This pollutant is called solid-fuel "smoke". It includes repairable particles, carbon monoxide, oxides of nitrogen and sulphur, benzene, formaldehyde, butadiene, and polyaromatic compounds, such as benzoic (Smith, 1987). In households with limited ventilation exposures, the pollution is experienced by household members, particularly women and young children who spend a large portion of their time indoors (Bruce et al., 2000; Smith, 1987).

Table 4: Concentration of UFP and PM during and end of cooking

	Food temperature (°C)	*Production rate*	
		UFP (Ultrafine particles/cm^3/s)	*$PM_{2.5}$ (Particulate materials) (µg/m^3/s)*
Pancakes	297	25	0.17
Peppers and onions	336	78	0.13
Vegetable stir-fry	280	31	0.11
Vegetable mix	249	59	Nil
Boil rice	210	34	Nil
Fried egg	271	60	nil
Fried rice	274	06	0.13

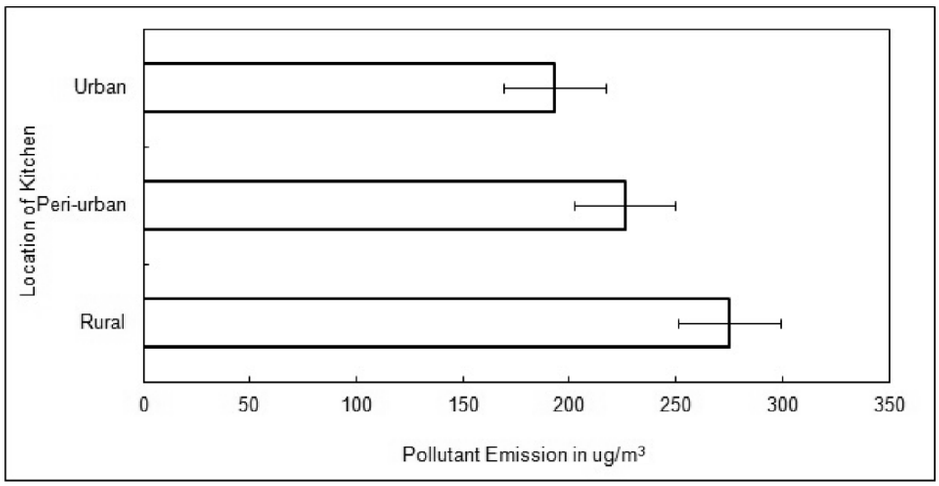

Figure 4: Kitchen air pollution in rural and urban areas.

Carbon monoxide is inhaled and enters the blood stream where it binds chemically to haemoglobin. Haemoglobin carries oxygen to the cells. But when CO binds to it, haemoglobin is unable to bind with oxygen, thereby reducing the amount of oxygen delivered to all tissues of the body. The percentage of haemoglobin inactivated by CO depends on the amount of air breathed, the concentration of CO in air, and length of exposure. The initial symptoms of CO poisoning are similar to the flu (Table 6). They include fatigue, dizziness, irregular breathing, cherry red lips, nausea, headache, paleness, and coughing. Here it is very relevant that most of the Indian women are anaemic (middle class). The haemoglobin percentage varies from 8.5 to 10.5 mg/dl but the standard percentage is 12-16 mg/dl.

To avoid the food diversities in Indian kitchen few basic preparations have been covered to estimate the pollution emission.

It's clear that boiling is the safest mode of cooking because it generates lesser heat and lesser cooking fumes (Table 4 and Figures 5 and 6). But sometimes boiling creates hot vapours containing aerosols. It causes lung problems. But fried and heating of oil is most deadly method of cooking. 'Cooking fumes' or 'cooking oil fumes' is the term commonly used to describe the visible emissions generated during cooking by frying with oil (Evans et al., 2008, Table 4). However, these emissions are not technically 'fumes'. In occupational and environmental hygiene, 'fumes' are defined as submicron-sized solid particles (particulate matter) created by the cooling of hot vapours. During cooking, such vapours are formed when the cooking oil is heated above its boiling point. In addition to this ultrafine particulate matter, cooking, especially frying and grilling, generates aerosol oil droplets, combustion products, organic gaseous pollutants, and steam from the water contents of the food being cooked. This cooking oil fume is responsible for irritation of eyes and asthma. The ultrafine particulate material contains diameter 10 µg and a single hair of a human being contains 70 µg. These particles are so fine that they can very easily enter in lungs and are not visible to open eyes.

Table 5: Kitchen air pollution in rural and urban areas

Area	*Average PM_{10} in kitchen*
Rural	275 µg/m^3
Peri-urban	226 µg/m^3
Urban	193 µg/m^3

Rural Urban Disparities in Kitchen Air Pollution

The rural urban diversity has occurred due to types of fuel used in cooking pattern in India. In rural India more biomasss fuel is used than urban people (Qunfang Zhang, 2010, Table 4).

Kitchen air pollution does not mean to avoid cooking. In India central government and even the state governments are providing subsidies to LPG consumers and, in Gujarat, the R.K. Mission has prepared a sophisticated stove to complete combustion of the biomass. There are various procedures to maintain standard kitchen environment such as use of exhaust fan, chimney and to make kitchen open air circulation too. To enjoy outdoor cooking like cooking in garden and terraces etc. are healthiest method of cooking.

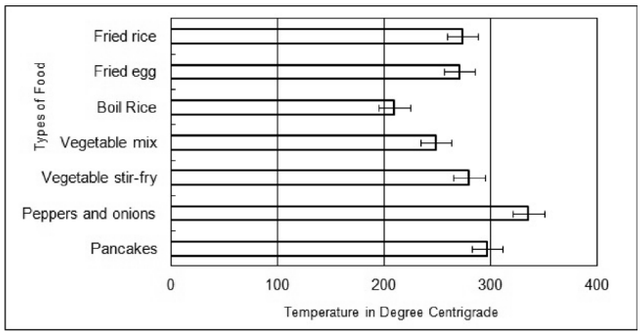

Figure 5: Concentration of heat at the end of cooking.

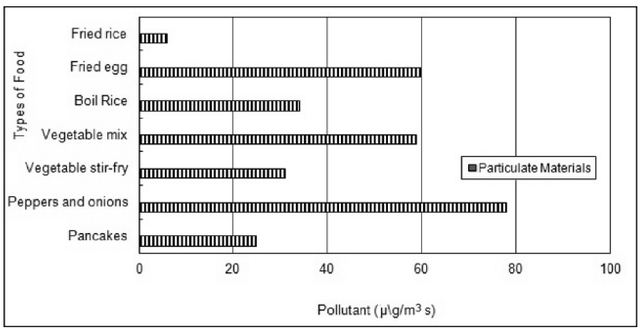

Figure 6: Concentrations of PM at end of cooking.

Table 6: Kitchen air pollutants and health significance

Kitchen air pollutants	*Potential health effects*	*The women who are engaged in domestic cooking by the biomass fuel continuously since following years*	
Carbon dioxide (CO_2)	Headache, dizziness and nausea at high concentration	5 years	8-10 Haemoglobin
		5-15 years	8-9 Haemoglobin
		15 years	7-8 Haemoglobin
Carbon monoxide (CO)	Headache, decreased alertness, flu-like symptoms, nausea, fatigue, rapid breathing, chest pain, (Normal range of B_{12} is 189 to 883 pg/ml)	2-5 years	Headache (Vitamin B_{12} is 240 to 263 pg/ml)
		5-15 years	Fatigue (Vitamin B_{12} is 222 to 242 pg/ml)
		15 years	Flu, Vitamin B_{12} is below 220 pg/ml
Respirable suspended particulates (RSP) (diameter lass than 10 microns)	Dry eyes, nose, throat, skin irritation, coughing, sneezing and respiratory difficulties	5 years	Headache
		5-15 years	Fatigue
		15 years	Lungs problems, suffering bronchitis
Nitrogen dioxide (NO_2)	Eyes and throat irritation		
Formaldehyde	Irritation to eyes, respiratory tract and damage to lung tissues at high concentration levels	More than 10 years	(5-30 ppm and higher) can severely irritate the lungs

Preventive Measures

To prevent the pollution from grass route level, kitchen is the starting point particularly for the Indian scenario and prevention must be started from the beginning as the concept of green and clean Indian kitchen.

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