Cooking or being Cooked

The inside Story of Indoor Air Pollution due to Cooking, Health Effects and Interventions

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Ever since the invention of fire, its applications have integrated to human activities, making fire inseparable from humar life. Fire has helped people to process or preserve their food, enabling them to consume much wider varieties of foodstuffs with enhanced food safety. Light from the fires guided them to establish safe shelters, protecting their lives and belongings from hostile environments. Further, heat from the fires allowed people to warm themselves in colder climates and expanded their activities to higher latitudes and elevations. Thus, fire has become an integral part of life, allowing humans to establish their settlements leading to a more civilized society. But with fire also came the first anthropogenic pollution, air pollution, as evidenced by the soot still found in prehistoric caves. Soot found from the ancient caves suggests that the levels of pollutions are very high, presumably due to smoke entrapped in the caves. Ironically, in the 21st Century, people from the developing nations continue the same mistake that their forefathers made. Lack of knowledge and poor socio-economic backgrounds of the people living in developing nations have not changed their customary habits and they are dearly paying for the consequences in terms of health or even in terms of their lives.

Indoor air pollution

Many people perceived that, air pollution is associated with the contamination of urban air from automobile exhausts and industrial emissions. However, in developing countries, the problem of indoor air pollution far outweighs the ambient air pollution. Yet, as the old saying goes, people believe that "*There is no place like home*" and they are reluctant to acknowledge the existence of air pollution in their homes. Knowingly or unknowingly, numerous pollutant sources exist in an indoor environment. These include combustion sources, building materials and bioaerosols. In addition, outdoor pollutants are infiltrated increasing the indoor pollution. Pollutants generated indoors and those infiltrated from outside are entrapped in a limited air space, enhancing residents to their exposure. The risk associated with the indoor pollution is further aggravated, because people used to spend much of their times in the indoor environment with limited air exchange.

A recent report of the World Health Organization (WHO) asserts the rule of 1000, which states that a pollutant released indoors is one thousand times more likely to reach people's lung than a pollutant released outdoors[1]. In developed countries, the most important indoor air pollutants include radon, asbestos, volatile organic compounds, pesticides, heavy metals, animal dander, mites, moulds and environmental tobacco smoke[2]. In developing countries, the most important indoor air pollutants are the combustion products of unprocessed solid biomass fuels utilized by the poor urban and rural folks for cooking and heating.

The scope of this discussion is to create awareness, highlighting investigations on the indoor combustion sources from the rest of the world to stimulate the researchers, relevant authorities and concerned citizens in Sri Lanka. The information in this discussion would be vital to the Sri Lankan public, because nearly 80% of our population, mainly from remote areas, depends on fuel wood for cooking. As far as the health effects are concerned, neither Sri Lankan public nor the authorities know the exact situation in the country, presumably due to nonchalance and lack of interest or availability of funding for investigations. Health statistics in Sri Lanka have ranked the respiratory health problems as the prime reason for hospitalization from 1980 to 1995. Since 1995, traumatic injuries took the lead, shifting the respiratory health problems to the second place[3]. Apparently, Sri Lankan authorities do not believe the noble concept of "*Prevention is better than cure*". They are neither interested in seeking solutions to mitigate the main health problems in the country nor concerned about the loss of productivity. Yet, they are willing to provide free medication when people are unhealthy.

Energy for Cooking and energy ladder

Over the past few centuries, about half of humanity has been able to afford transitioning from traditional biomass fuels, wood, animal dung, crop residues such as rice husks, etc., to fossil fuels such as kerosene or gas, or to electricity. The remaining half of humanity, almost all in developing countries, continues to use biomass fuels or coal, often in open fires or in inefficient, smoky stoves. Consequently, the United Nations Environment Programme/World Health Organization Global Environment Monitoring System (GEMS) has confirmed that the worst overall air pollution conditions and the largest indoor pollutant concentrations and exposures are found in both rural and urban areas of the developing world[4,5].

Compared to developed countries, developing nations use much less total energy per capita. However, because of their much larger populations, they still require a substantial portion of global energy. Less industrialized countries use energy differently, consuming a much higher proportion at the household level, principally for cooking and lighting, and for heating in cooler climates. In fact, household fuel needs continue to make up more than half of the total energy demands in more than 100 countries.

Energy for cooking in less industrialized countries is provided by a heterogeneous mixture of fuels which vary in importance from country to country. The concept of 'energy ladder' is used to rank these fuels based on their cleanliness and efficiency. It is needless to say that the affordability is the most important factor in selecting the type of fuel for the people living in developing countries. In the 'energy ladder', biomass fuels, namely animal dung, crop residues and unprocessed fuel wood, which are the dirtiest fuels, lie at the bottom and are used mostly by very poor people. Electricity, which is the most expensive, lies at the top of ladder, and it is also the cleanest fuel.

Liquid fuels such as kerosene and gaseous fuels including liquefied petroleum gas, LPG, are positioned at higher levels of the energy ladder due to their cleanliness and efficiency. But, their relatively high cost even with government subsidies compel poor peasants to rely on biomass fuels. Further, lack of clean combustion technologies worsens the air quality even with these relatively cleaner fuels. The relatively high cleanliness of these gaseous or liquid fuels is due to the adequate mixing of the fuel with the oxygen in air, leading to a better combustion process. In the case of solid fuels including biomasses, combustion is incomplete, and it restricts only to the surface. Thus, the formation of partially-combusted products, pyrolyzed products and volatilized products are inevitable with the solid fuels.

Though kerosene can be burnt very cleanly in a pressurized burner, it is often used in wick burners which are very sooty and smoky, for cooking or lighting. When burnt well, kerosene produces only negligible levels of particulate matter and less carbon monoxide than wood. There is some concern over these emissions, particularly when burnt with wicks, but little research has been undertaken on this matter. One of the drawbacks of kerosene is that it cannot be produced informally, and has to be purchased, thus implying costs, and it is not always easily available.

LPG, or household cooking gas, is a non-renewable fossil fuel that also achieves nearly complete combustion, making emissions hard to detect from background levels. Like kerosene, the main drawbacks of LPG are cost and availability. The risk factor associated with the use of flammable liquids and gaseous products in poor households is very significant. Incidents such as house fires due to unsafe kerosene lamps or possible explosions of storage tanks are often reported, costing belongings and even life. Like solar power, electricity as a fuel produces no indoor emissions. But, switching to electricity also involves monetary costs and requires infrastructure and power supply.

Cooking in Sri Lanka

A report submitted to the World Bank estimates, that the Sri Lankan fuel consumption in 1999 was 7019 thousand tonnes oil equivalent with an annual increase of 5%. Biomass, mainly fuel wood, is the major indigenous energy source accounting for 53% of the total energy consumption. The household sector accounted for 52% of the total energy consumption while the industrial and transport sector consumed 25% and 23% respectively of the energy. Out of the total biomass energy supply, the household sector consumed 76% and the rest was consumed by the industrial sector. Nearly 80% of the population still relies on the unprocessed fuel wood for cooking and 20-30% of the households utilize fossil fuels such as kerosene or non-fossil fuels including plant-based fuels for illuminating the houses[6].

Customary three stone open fires are the most popular type of stoves that utilize firewood for cooking in Sri Lanka. But the efficiency of these three-stone open fires is only about 10-15%[7]. The consequences of this low efficient, rudimentary stoves with inadequate provisions for smoke removal from the indoor settings are two fold. Firstly, most of the energy content of the fuel is wasted and secondly, the level of exposure is imperative. Both the energy wastage and the exposure can be minimized by introducing proper intervene mechanisms which have been tested and implemented throughout the world including Sri Lanka.

Vulnerability

It has been estimated that unprocessed solid biomass fuels release at least 50 times more noxious pollutants than gaseous fuels. Unfortunately, the victims of the exposure are mainly women and young children in developing countries[8,9]. Traditionally, women are involved in food preparation and cooking activities in most of the developing nations. They are also exposed to frequent, short bursts of high pollutant concentrations during activities such as lighting fires and moving cooking pots. Often the infants and young children are in the company of their mothers in these polluted environments. Since the immune systems of infants are not fully developed, their small airways are more susceptible to the effects of inflammation[10,11]. Young children with developing lungs breathe faster than adults, elevating the intake of pollutants. This results in pollutants accumulating in their respiratory system. Further, malnutrition which goes hand in hand with poverty, may retard the development of the immune system, worsening the health problems. Elderly and expectant women are also more susceptible to chronic conditions resulting from frequent and long periods of exposure[12]. Their susceptibility is exacerbated by malnutrition, poor living standards, overcrowding in limited spaces, and exposure to diseases due to poor sanitation.

It has been estimated that 2.7 to 2.8 million women and children die each year from indoor air pollution in developing nations[8]. India has the largest burden of disease due to the use of dirty biomass fuels, and 28% of all deaths due to indoor air pollution in developing countries occur in India[13]. Only a handful of investigations have been made in Sri Lanka, and they may not be sufficient to confirm or to disregard the possible relationships of indoor smoke to health effects and/or to mortality. Due to similar lifestyles, it is reasonable to assume that casualties in Sri Lanka are congruent to that of India. This sets the limits to Sri Lankans to learn from their closest neighbour, India, in restraining such fatalities and uplifting the healthfulness.

Health effects

There is consistent evidence that exposure to biomass smoke increases the risk of a range of common and serious diseases of both children and adults. It is estimated that indoor air pollution accounts for 4-6 % of the burden of diseases, placing it above tobacco smoking, sexually transmitted diseases, alcohol and homicides as a leading causes of ill health and death[14]. In recent years, new tentative evidence has emerged based on few studies that indoor air pollution in developing countries may also increase the risk of other important child and adult health problems. It includes conditions such as low birth weight, perinatal mortality (still births and deaths in the first week of life) asthma and middle ear infection for children, tuberculosis, nasopharyngeal and laryngeal cancer, and cataract in adults[8,10,11,16,17].

There are several mechanisms by which the above pollutants cause health problems. Broadly speaking, there are two ways in which biomass smoke can affect health. Substances in the smoke can themselves be responsible for a health impact, as is the case with carcinogens or the toxins that cause cataracts. Alternatively, these substances can pave the way for infection by bacteria or viruses by damaging the respiratory system's mechanical and immune defences.

Toxicology, animal studies and epidemiological studies, suggest a number of health problems that could result from exposure to smoke from biomass stoves. Both ambient air pollution and environmental tobacco smoke share many of the constituents of biomass smoke, and they can serve as models for exposure to biomass smoke. However, the health effects of these different types of pollution may differ because of differences in the relative concentrations of their constituents, and because of differences in exposure patterns. The potential health risks which have been identified include acute respiratory infections (ARI), chronic obstructive pulmonary disease (COPD), tuberculosis (TB), low birth weight (LBW), cataract, cancer, asthma, infant mortality and heart diseases[2,8,10-18].

Respiratory infections

Studies in a number of different countries and settings have examined the link between exposures to smoke from cook stoves and the development of ARI in children[4,21-24]. In South Africa, investigators have found that Zulu children living in homes with woodstoves were almost five times more likely to develop a respiratory infection severe enough to require hospitalization[8]. In Nepal, researchers observed a significant relationship between the number of hours spent near the fire and the incidence of moderate and severe cases the among 2-year-olds[24]. Likewise, a recent study in Gambia revealed that children carried on their mother's backs, as they cooked over smoky cook stoves had contracted pneumococal infections, one of the most serious kinds of respiratory infections at a rate 2.5 times higher than non-exposed children[8,9].

Many respiratory infections in the developing world result in death, and evidence shows that exposure to cook stove smoke may contribute

to higher mortality rates. For example, a study in Tanzania found that children younger than 5 years of age who died of ARI were 2.8 times more likely to have been sleeping in a room with an open cook stove than healthy children. Overall, studies indicate that exposure to wood smoke from cook fires in poorly - ventilated conditions may increase the risk of a young child getting a serious respiratory infection from two to six times[24].

Lung diseases

Adults suffer due to the ill effects of severe indoor pollution as well. Several studies found the existence of a strong link between chronic lung diseases in women and exposure to smoke from open cook stoves. One recent Colombian study found that women exposed to smoke during cooking were more than three times more likely to suffer from chronic lung disease[20]. Other studies suggest that this risk increases with the increase of exposure to smoke. A study in Mexico showed that women who had been exposed to wood smoke for many years faced 75 times more risk of acquiring chronic lung disease than unexposed women, about the level of risk that heavy cigarette smokers face[8,9].

Recent research suggests that people living in households that rely primarily on biofuels for cooking are two or three times more likely to have active tuberculosis than those in houses that use cleaner fuels. Cooking smoke can increase the risk of tuberculosis by reducing resistance to the initial infection or by promoting the development of active tuberculosis in people who are already infected, or both. Pulmonary tuberculosis, the most common form of the disease transmitted by coughing is aggravated by exposure to smoke[19]. Benzo(a)pyrene, a known carcinogen, is found in large quantities in cooking smoke, and there is evidence that this can depress immune system responses. Extended exposure to high levels of biomass smoke can impair the clearing ability of the lungs and render them more susceptible to infection. Repeated or severe childhood chest infections can also lead to chronic lung diseases in adults. A number of studies have reported an association between exposure to biomass smoke and chronic bronchitis or obstructive lung disease.

Asthma

Asthma is more likely to aggravated by smoke, triggering an attack, than causing it in the first place. However, repeated attacks due to smoke exposure may leave the person more vulnerable to lower doses and increase the severity of attacks. Exposure to fine particulate matter in smoke has been linked with increased symptoms of asthma and visits to emergency rooms. Evidence of the role of cooking smoke in causing asthma is mixed, but it has some of the same pollutants that are found in ambient air pollution or tobacco smoke, both of which have been linked with the disease[20,21].

Low birth weights

Exposure to high indoor smoke levels has also been found to have a link with pregnancy-related problems like stillbirths and low birth weight. One study in Western India found that a 50 % increase in stillbirths is associated with the exposure of pregnant women to indoor smoke. Indoor air pollution most likely contributes to heart diseases in developing countries. In developed countries, outdoor pollution at levels far below those found in smoky indoor environments has shown a link with heart diseases[8,9].

Smoke from burning biomass contains large quantities of carbon monoxide (CO), which can bind with haemoglobin in the blood to make carboxyhaemoglobin (HbCO), effectively reducing the amount of oxygen reaching the body tissues and causing anaemia[25]. This is particularly important for women because they have less haemoglobin in reserve than men, and because their natural levels of HbCO are greatly elevated during pregnancy. There are no empirical studies linking cooking smoke to anemia, but there is some evidence that links it to reduced fetal growth, low birth weight and perinatal mortality[16].

Cataract

Cataract, the main proximate cause of complete blindness worldwide, is known to be linked among other factors to damage to the eye that can be produced by heavy airborne pollution[27]. A number of studies in humans indicate that tobacco smoke can cause cataract, suggesting that cooking smoke might have a similar effect. Trachoma and conjunctivitis, which also cause blindness, could be aggravated by smoke as well[28].

Cancer

Cooking smoke contains many polycyclic aromatic hydrocarbons, such as benzo(a)pyrene, which can cause cancers. Empirical research has shown an association between exposure to coal smoke and lung cancer, but the evidence linking biomass smoke to lung cancer is limited[14]. Exposure to biomass smoke has also been linked to nasopharyngeal and laryngeal cancers, otitis media (middle ear infection) in children, and cor pulmonale.

It has been estimated that as much as 25-33 per cent of the global disease burden can be attributed to environmental risk factors, and use of unprocessed solid fuels for cooking and heating has been the third important factor, after malnutrition and water/hygiene/sanitation, in causing disability and death in developing countries.

Awareness

The first and the foremost important step in the prevention of health problems and other related issues resulting from biomass fuels is educating the public. Awareness on indoor air pollution due to combustion sources and their health impacts need to be initiated at the school level. The high literacy levels among Sri Lankan public can be facilitated in promoting the awareness campaigns through leaflets and seminars at the community centres. This is essential because people often are unaware of or have lay beliefs about the risks associated with the indoor air pollution. For example in Kenya, it is reported that the women had little notion of the health impacts of indoor air pollution. Although their sore eyes are associated with indoor smoke, they do not consider coughing as a problem, probably, because it is so habitual and widespread. In this regard, our rural housewives in Sri Lanka are not exceptions.

For fuel wood burning stoves, knowledge of the combustion process is fundamental in achieving maximum fuel efficiency with a minimum pollutant production. In fact, the user is a most important determinant of both the fuel efficiency and pollutant production than the cooking stove. It is important to recognize that, knowledge on indoor air pollution must not only be limited to the general public, but the authorities also need to have a proper understanding to ensure their commitment to promoting awareness. This must lead people to find ways of minimizing exposure through better kitchen management and protecting the susceptible individuals

Ventilation

It is believed that inadequate household ventilation seriously exacerbates the concentration of pollutants in homes due to poor exchange of air between indoor and outdoor. The air exchange rate depends on the number and placement of window and door openings. Modifying housing to increase ventilation is another way of dispersing indoor smoke. Modified housing design by installing of new windows or enlarging the existing windows is an intervention to alleviate indoor air pollution.. Similarly, raising the roof height will be beneficial in diluting the pollutants for controlling the exposures.

Addition of a mechanism to remove smoke from the kitchen is one of the most practicable options

in mitigating the indoor pollution. Chimneys and flues are an integrated design feature of many improved stoves, and they can be introduced into the existing kitchens as well. Flues work by providing an extraction mechanism to remove smoke directly from the combustion chamber through a vertical vessel. A further advantage of flues is that, as hot air moves upwards, it draws primary air into the firebox from below to replace it. Thus, the combustion process becomes more efficient and cleaner. Some stoves have been designed for better efficiency based on this principle. There are also several drawbacks with stoves with flues and chimneys. Flues may not perform well if they are not installed properly. Chimneys may be ineffective if smoke is released at lower heights resulting in the infiltration of exhausted pollutants through windows and doors.

Another mechanism of dispersing the pollutants is installation of hoods which works on the same principle as flues and chimneys. The only difference is that they are freestanding and independent of the stove. This is advantageous, as they can be used with both open fires and all types of stoves to remove the pollutants from the indoor environment. There are very few interventions involving hoods because they may present problems of integration into traditional homes, especially small houses. In simple terms, proper air circulation within the cooking area disperses the pollutants minimizing the possible exposures. Whatever, the mechanism that supports the dispersion of pollutants rather than stagnating the pollutants, minimizes the risk associated with this problem.

Cooking habits and Exposure

Domestic behavior can influence both health and conservation practices. Studies showing a significant risk of acute lower respiratory infections in children carried on their mothers back while cooking, suggest that simple childcare modifications have the potential to reduce childhood exposure in such settings[29]. Keeping children away from the fire and smoke is the simplest practical way to reduce children's exposure. Likewise, a reduction of exposure to smoky interiors by pregnant women may be beneficial. Another strategy is encouraging the use of outdoor cooking whenever possible. As our forefathers did, having a separate kitchen minimizes the indoor pollution levels. However, the limited housing spaces and the poor socio-economic backgrounds of the people, particularly those who are living in urban slums, avert such capabilities. Similarly, outdoor cooking is unlikely to be practical with unfavourable weather conditions.

Changing the habitual cooking practices can control the emissions of pollutants to a certain extent. For example, Sri Lankan housewives tend to cook all three meals, provided that they can afford to do so, which automatically prolongs the exposure. In addition, the food preparation process is extraordinarily long. Introduction of quick food preparation techniques and preserving the food for several meals without the introduction of an additional cost can curtail the cooking time and the related problems. Simple interventions such as drying wood prior to burning, cutting wood into smaller pieces, and extinguishing the fire immediately after use can also reduce the emissions.

In the case of indoor cooking, ventilation in the kitchen should be given due priority. Installation of a chimney to release the pollutants above the breathing zone is another mechanism of minimizing the exposure. In the existing houses, measures such as putting a window above the cooking stove and providing cross ventilation through the door may help in diluting the pollutants load.

Although burning wood produces smoky emissions, it can be burnt cleanly by converting to a gas. During gasification, wood is heated in an inadequate oxygen supply and the volatile portion is released as a gas. This gas is called a 'producer gas' and in the presence of sufficient oxygen, it will burn with a smoke free blue flame. Producer gas consists largely of carbon monoxide and hydrogen. Hence, the stove needs to be designed carefully and used correctly in order to avoid the risk of carbon monoxide poisoning.

Interventions on cooking stoves

Stoves occupy a central place in the health, environmental, economic, and social lives of families in developing countries. Improved cooking stoves therefore can provide a number of benefits. They can reduce indoor and outdoor air pollution by providing more complete combustion, decrease indoor exposure by providing better ventilation, and decrease burns by elevating the cooking surface of the floor. Improved stove efficiency can boost household economics and empower women by reducing the time, dangers, drudgery and cost involved in obtaining and preparing fuel, leaving more time for childcare or economic activities. Reduced fuel wood consumption also serves to improve soil fertility and reduce deforestation, soil erosion and desertification. Local economies benefit from jobs associated with stove construction and repair, and national economies from reduced dependence on importation of fossil fuels like kerosene and LPG.

Improved stoves have been a major element of the appropriate technology movement for decades. Hundreds of designs have been produced, adapted and field tested across the developed and developing world. In the improved stoves, keeping the temperature high within the firebox maximizes combustion. Designs also attempt to maximize radiative, convective and conductive transfer of heat to the food pots. These designs can frequently accomplish more than a doubling of percentage of heat utilized. Unfortunately, many improved stove projects have not been able to realise their maximum potential because they focused either on fuel efficiency or on reduced smoke, but often not both[30].

Simple design steps can be taken to improve the burning efficiency of a stove, which helps to achieve more complete combustion and reduce emissions. Adding a grate allows a steady source of primary air to the fire, and holes in the firebox, above the level of the fire, improve the flow of secondary air to the fire. Insulating the firebox can also improve combustion efficiency. Most improved stoves were designed to use less fuel, with emphasis on more efficient combustion but not smoke reduction. Improved combustion is usually expected to reduce emissions, however, where increased fuel efficiency is not achieved through more complete combustion, but through enclosing the firebox and reducing airflow, emissions will be higher. Some improved stoves have been found to significantly reduce emissions of total suspended particulates and carbon monoxide, while others have shown no improvement or even higher emissions. Several other factors influence emissions levels from stoves. Low-cost stoves tend to deteriorate air quality by increased emissions with time due to use of poor quality materials, poor construction and poor maintenance.

The importance of pots and pans in minimising cooking energy consumption is easily overlooked. Using lids is a basic energy conserving measure. Pots, which can be stacked one atop another and pressure cookers, can also significantly reduce fuel expenditure although such simple equipment is not generally available to poor households and may not work well with local food preparation customs. In many improved stove designs, pots are specifically made to suit for the stove design, often fitting snugly into a depression on the cooking surface and thereby minimizing the loss of heat and fumes.

Initiatives in Sri Lanka

Addressing the fire wood - related indoor smoke problem in Sri Lanka dates back to the 1950's,

with the introduction of South Indian *Heri Chulas* to the tea estate workers. The Industrial Development Board involved in the designing of improved stoves in the 1970's. Later, institutions such as Ceylon Institute of Scientific and Industrial Research (now Industrial Technology Institute) and NGOs such as Sarvodaya Shramadana Sangamaya joined the campaign in promoting cooking stoves in the rural areas. The National Fuel wood Conservation Programme commissioned in 1980's by the Ministry of Power and Energy launched a program to distribute the stoves to almost the entire population in the country. However, lack of funds, absence of institutional framework, lack of awareness and commitments from the authorities as well as the general public has hampered the progress. In addition to the stove programs, few scientific discussions have taken place within the island. Yet, the indoor smoke issue remains unanswered, and poor families in rural areas as well as urban slum dwellers experience the problem.

Several surveys have prompted in assessing biomass smoke in relation to the health effects in Sri Lanka. A survey conducted on the disease burden of **COPD** in the respiratory unit of Kandy General Hospital concluded that cooking smoke is a possible contributing factor for COPD in Sri Lankan women[31]. Another survey was focused on assessing respiratory symptoms among children and women from low-income families in suburban Colombo over a period of six months. It was noted that half of women over 40 years and one third of the children below 10 years had at least one recurrent respiratory symptom over the six-month period. The research concluded that inadequate ventilation in the sleeping area and use of fuel wood for cooking were the main risk factors that were associated with developing respiratory symptoms[32].

During the last decade, several research initiatives at the Chemistry Department of the University of Colombo were focused on addressing indoor air quality issues[33-38]. There were strong evidences that the cataract[33], lung cancer[34] and low birth weights[35] have been attributed to the exposure to biomass smoke rather than to other smokes and smoke from richer fuels. Investigations on indoor combustion sources such as burning mosquito coils, joss sticks and tobacco products have revealed that significant levels of hazardous carbonyl compounds[36-38] and carcinogenic PAHs[37-38] are emanating from different indoor combustions. These indoor combustion sources elevate the human exposure posing health risks, but easily they can be controlled or eliminated by changing indoor settings.

Concluding remarks

The current government strategies and public perception of air pollution in Sri Lanka have been concerned about urban outdoor environment only, but some of the highest concentrations of pollutants actually occur in indoor environment. Excessive use of low quality biomass fuels in inefficient traditional cooking stoves with no flue or chimney generates smokes, particulate, carbon monoxide and hundreds of organic compounds including several carcinogens. The information presented in the discussion was largely compiled from the reports cited in the literature and was based on experiments conducted in other countries. Nevertheless, these data can be applicable to illustrate the impact of biomass wood stove on indoor air pollution in Sri Lanka.

The focus of air pollution studies to should be shifted towards rural women and children who comprise it more than half of the population since they spend most of their time indoors. The ever continuing practice of using biomass cooking fuels impacts on several sectors and marginalizes the poorest of the poor, village women. The overall goal of our government and development partners to achieve a higher quality of life for the masses is not certainly compatible with high levels of human exposures to carcinogens during cooking.

In Sri Lanka, I believe that it is possible to improve the healthfulness and comfort of indoor environments with a reasonable expenditure of the resources. I further believe that it is desirable to do so. In order to achieve these targets, a major role needs to be played by relevant governmental and non-governmental organizations. They can sponsor research activities, promote public awareness, contribute to the development of standards and guidelines and set examples at the higher authoritative levels. Architects and other professionals who are directly involved in the housing industry can play a significant role in improving the ventilation practices and designing improved stove systems. Scientists can investigate the fuels having higher efficiencies and low emissions. It may be cost effective for the Sri Lankan government to spend money collectively to avoid soaring health costs incurred due to poor indoor air quality. After all, healthier people are an asset to a country, and the government's goal must be to keep the nation healthy rather than treating them when they are sick.

In conclusion, indoor air quality represents a very important segment of environmental issues. Viewed from the perspective of human health protection it merits as much attention as hazardous waste management, urban air quality and water quality management. Finally, let's not forget that we mainly live indoors and each of us has a personal stake in assuring indoor air quality.

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