

## A STUDY ON INDOOR AIR POLLUTION BY KITCHEN FUELS IN KHALISHPUR, KHULNA

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### ABSTRACT

*Indoor air pollution by kitchen fuels (wood, coal) is a global problem especially for developing countries. Because 80% people of developing countries depend on solid or biomass fuels. Many developed countries have reduced their population's reliance on solid fuels, but for developing countries it's not an easy task. In our country 90% population depend on biomass fuels for their domestic energy needs. There is enough evidence found that indoor air pollution increases the risk of acute respiratory infections for children and chronic obstructive pulmonary disease for adults. The main victims of indoor air pollution are women and children because they expose to smoke of biomass fuels for long time. Despite the harmful effects of this problem, people in our country also concern about the outdoor air pollution. This study investigates the present condition of indoor air pollution by kitchenfuels of 100 households in ward number 10 of Khulna City Corporation. It also represents the relationship between indoor air pollution and respiratory health problem with types of cooking fuels. A questionnaire survey and air quality determination test was conducted on study area. The study reveals that about 70% people of ward no.10 depend on biomass fuels; where the percentage of biomass users are higher, the health problems (especially respiratory) are also higher. And the suspended particulate matter contains in smoke resulting from burned biomass exceeds the standard level. Finally, a proposal is given for reducing indoor air pollution by household fuels.*

**Keywords:** *Indoor air pollution, kitchen fuels, respiratory health, relationship, air quality*

### 1. INTRODUCTION

Air is indispensable for the survival of all living organisms on earth, including human beings. It is even more important than water - without water a person can survive for days, but without air no more than a couple of minutes. Now-a-days air pollution is one of the major problems of the world. It is a manmade environmental disaster. There are two types of air pollution and one of them is outdoor air pollution and the other is indoor air pollution. Different policies have been taken for stopping outdoor air pollution whereas indoor air pollution remains as unknown factor. According to Italian ministry for environment, (1991), Indoor pollution is defined as "the presence of physical, chemical or biological contaminants in the air of confined environments, which are not naturally present in high quantities in the external air of the ecological systems." So indoor air pollution means the presence of excess level of pollutants (such as CO<sub>2</sub>, CO, SO<sub>x</sub>, NO<sub>x</sub>) in the air.

Indoor air pollution is a significant concern, because people on average spend the vast majority of their time indoors where they are repeatedly exposed to indoor air pollutants. In fact, the US Environmental Protection Agency (USEPA) estimates that the average person receives 72 percent of their chemical exposure at home, which means the very places most people consider safest paradoxically exposes them to the greatest amounts of potentially hazardous pollutants. The air in our homes can be 2 to 5 times more polluted, and in some cases 100 times more polluted, than outdoor air. One of the important sources of indoor air pollution is smoke which is result from burning solid fuels. Incomplete combustion of solid fuels contains different types of pollutant which pollutes the indoor air. Incomplete combustion of biomass is the main source of indoor air pollution worldwide (WHO, 2011) and in most developing countries; it is burned in open that produces a lot of smoke (Akunne, Louis & 2006). Bangladesh is a densely populated country where majority of the population relies on biomass fuels for cooking food and heating in cold weather. About 90% people of our country depend on biomass fuels for their household energy need. Despite their dependence on solid fuels, little attention has given to problems occurred by indoor air pollution resulting from smoke of burning biomass fuels (wood, crop, sawdust, tush cath, etc). From a health perspective, acute respiratory infections (ARI) are one of the leading causes of under-five deaths in the country, which has an under-five mortality rate of 77 per 1,000 live birth (Mortality Country Fact

Sheet, 2006) .The Bangladesh Country Environmental Analysis (2006) states that respiratory infections and diseases from indoor air pollution result in 17 percent of Disability Adjusted Life Years lost per capita. The CEA found that reduced exposure to environmental health risks could result in economic savings equivalent to 3.5 percent of GDP. So it is important to know household indoor air condition, air quality of household and find out measures to reduce indoor air pollution.

## 2. METHODOLOGY

In order to find out the general scenario of indoor air pollution of Khalishpur, Khulna and to establish a relationship between indoor air pollution and respiratory health, the following works are done such as conduction of questionnaire survey and air quality parameter test. The overall works are based on several steps as shown in the flow diagram:

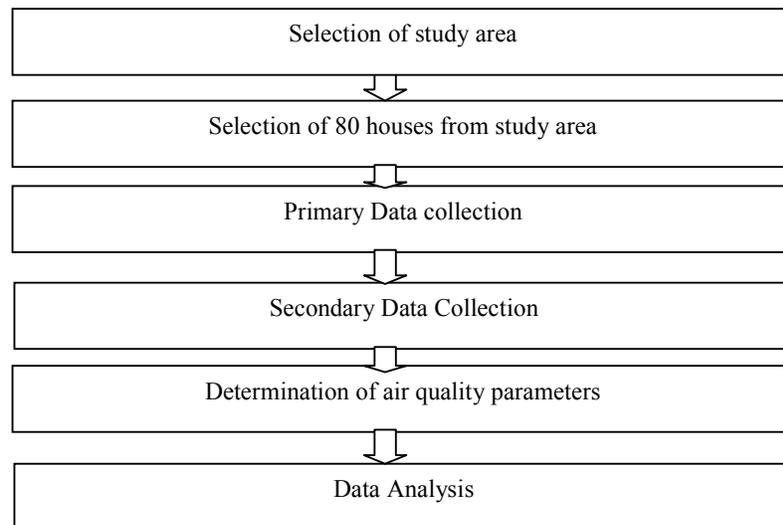


Figure 1: Steps of the study

### 2.1 The Study Area

Khulna, the south-western divisional city in Bangladesh, is situated between 21.38' and 23.1 north latitude and 88.58 east longitude and is 12 ft above mean sea level. . It is the divisional headquarters of Khulna division and a major industrial and commercial centre. The city currently covers an area of 46 sq. km and the population of the city, under the jurisdiction of the city corporation, was about 1 million in 2010 estimation Khulna is the 3rd largest city in Bangladesh. Total area is about 45.65 Km<sup>2</sup> and 31 Wards. Total population is 1500689 and population density is 67,994 per km<sup>2</sup>.The word no 10 of Khulna city corporation(KCC) was selected as study area because-:(i)The location should be 10 km away from the national high way to minimize the effect of vehicular pollution, (ii) No air-polluting industry like thermal power plant, cement factory, sponge iron factory, rice mill within 10 km radius in order to control the impact of industrial pollution (iii) Only biomass fuel and LPG gas should be used by the people for domestic cooking.(iv)People of different occupation live in this area. (Fig 2.2) . It is consists of DakshinKashapur, Khalishpur H.E. East, Khalishpur H.E (PaschimBlock) & Nayabati. It has 27947 population and 6713 households. Study was conducted on 80 households.

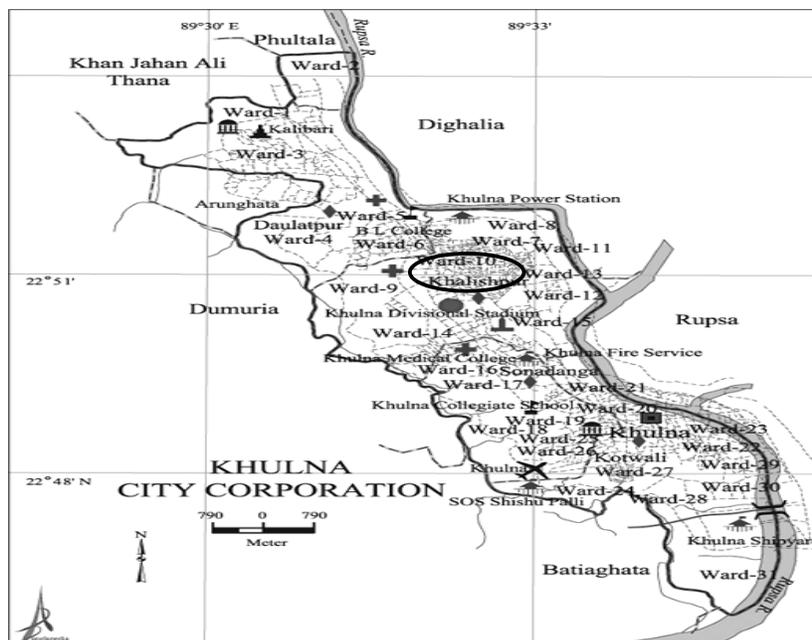


Figure 2: Map of Khulna City Corporation

## 2.2 Methods

At first reconnaissance survey was conducted to select suitable site. The study area was selected based on four criteria. After that 80 households, 20 from each location such as Dakshin kashpur, khalishpur H.E (east & pachim block ) and nayabati was selected for questionnaire survey. This households were selected based on some criteria- (i) people of the house use biomass or LPG gas to cook their food. (ii) They cook regularly. Then primary data was collected by conducting questionnaire survey on 100 households of Ward no.10. The survey was carried out from September 20, 2014 to April 5, 2015. The survey work was done mainly in 11.00 am to 1.00 pm while most of the women cook. Various information about household and family was collected by the personal interview. For example; age, education, occupation, average income, family member, cooking place, cooking hour, ventilation, fuel type, stove type, etc. Secondary data was collected from different journals, newspapers dailies, official reports, publications and web sites. In order to determine air quality parameters a High Volume Sampler ( Envirotech APM 415) was used. After data data analysis was conducted. Data analysis involves interpreting the data in a simple way. The data was arranged by pic chart, bar diagram, figure, etc. Comparisons of various data were also included.

## 2.3 Instrument

In order to determine air quality parameters a High Volume Sampler (Envirotech APM 415) was used. The machine was run for 8 hours and continuous power supply was provided. It is lighter, more compact, can be carried in a car dickey and is ideal for field use. It can be used either by mounting it on Roof Tops of van or building or separately outside as necessary. Its design allows change of brushes without requiring blower assembly to be dismantled.

## 3. RESULTS AND DISCUSSION

### 3.1 General

In this chapter the information found by questionnaire survey are represented by different bar diagrams, pie charts and tabular form. The value of air quality parameters of ward no.10 along with the standard value are represented in tabular form. Thus the relationship of indoor air pollution and respiratory health can be developed based on these data.

### 3.2 Data of questionnaire survey

After selecting ward no.10 of Khulna City Corporation as study area, 100 households from 6713 households are marked for survey. Then a structured questionnaire is made based on socio-demographic characteristics,

cooking history, cooking fuel type, ventilation system and other factors. Questions also included the number of meals cooked per day, time spent in cooking, time spent near stove. A series of questions on symptoms experienced in the last two weeks (cough, eczema, shortness of breath, etc.) are also in the survey.

Table 1: Household demographic

Head of household illiterates	3%
Household has electricity	100%
Mean family size	4.2
Monthly expenditure on fuels (highest)	1200-1500TK (33%)
Monthly expenditure on fuels (lowest)	250-300TK(77%)

Table 1 presents the basic statistics on demographics from the sample. Here literacy rate is quite high though monthly expenditure of fuels is quite low. Here only 33% people have capability to spend o1200-1500 tk on cooking fuels. Where 77% either have no capability to expend or don't want to spend cooking fuels. Almost all the house has electricity.

The survey result present that almost 54% people use firewood followed by LPG, sawdust, charcoal. People partially use electricity for cooking food through rice/curry cooker or electric stove. But basically they avoid it for its high price. Now a day's rice cooker has been used by most of the women. Some people use both firewood and LPG gas for cooking their food. Some people use LGP gas for day to day cooking, they also use firewood to cook in traditional Chula occasionally. However some households own LPG gas, they do not use it. So it is not necessary that all clean fuel owner only use LPG gas or electricity only, they use solid fuels also. About 27% of households that owns LPG gas stove still use traditional cooking stove. Now people hardly use kerosene. The percentage of using different types of fuel is shown in Fig 3

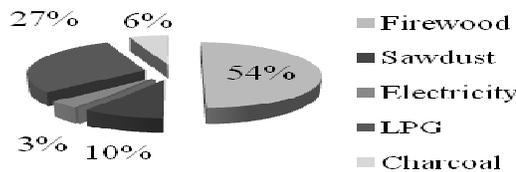


Figure 3: Types of fuel used

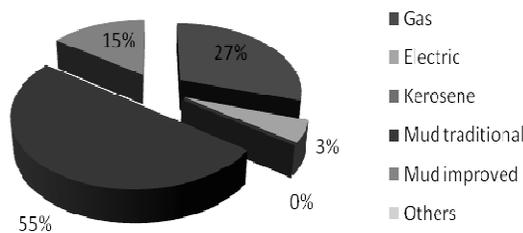


Figure 4: Types of stove used

Fig 4 shows the percentage of using traditional mud stove is high. About 55% people use traditional mud stove instead of improve mud stove. 27% people use gas stove.

Women usually cook two times a day and spend around 4-5 hours in kitchen. However the cooking frequency depends on the number of family member, their nature and job

Table 2: Monthly expenditure and choice of fuels

	Monthly Expenditure <10000tk	Monthly Expenditure >10000tk
Number of meals per day	2	2-3
Percentage of solid fuel users (traditional cooking stove)	77.78%	62.5%
Percentage of solid fuel users (improved cooking stove)	11.11%	25%
Percentage of lpg gas user	11.11%	12.5%
Percentage of electric stove user	0	25%

Table 2 shows various type of fuel along with monthly expenditure. From the table it can be seen that people having monthly expenditure less than 10000 taka prefer cooking in solid fuels than non solid fuels (LPG gas, kerosene, electricity). On the other hand the percentage of non solid fuel users are high among the people whose monthly expenditure more than 10000tk. On the other hand the percentage of improve cook stove users is very low. It is about 11.11% for low income people.

From the survey the cost of different fuel per unit can be found. In Table 4.3 the type of fuel along with their average cost is given

Table 3: Cost of different fuels

Fuel name	Total expenditure	Unit of quantity (kg, stick, etc)	Price per unit
Firewood	630	60-70kg	9
Tush kath	120	60-70	2-3
Sawdust	230	40	5-6
Kerosene			92
LPG/LNG	1100-1400	12kg	93.33
Electricity			5

From the above data a energy ladder can be made. The ‘energy ladder’ model has been used to categorize energy sources along a hierarchy according to their cost, ease of use, technological advancement and, importantly for this work, the concentrations of air pollution they produce (Smith et al.1994). Here electricity is at top and animal dung or crop at bottom. Electricity is considered as safest fuel in terms of indoor air pollution as there is no chance of incomplete combustion. And it is known to us that incomplete combustion contain carbon monoxide. Animal dung is usually not for sell. Low income people use it for cooking food. LPG (Liquefied petroleum gas)/ LNG (Liquefied natural gas; although it is not available in Khulna) is the second highest position. As the cost of fuel increase, the fuel becomes safer. The bottom fuels are coal, wood, crop residue.etc. LPG (Liquefied petroleum gas)/ LNG (Liquefied natural gas; although it is not available in Khulna) is the second highest position. As the cost of fuel increase, the fuel becomes safer. The bottom fuels are coal, wood, crop residue.etc.

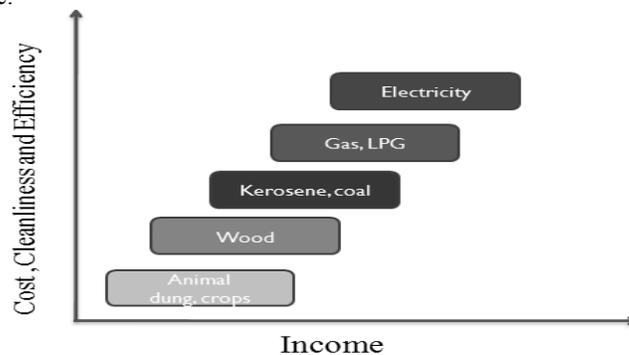


Figure 5: Energy ladder

Study results also show that the 35.65% population cook in the separate building used as kitchen, 46.81% in a separate room used as kitchen. Whereas 13.33% people cook in outdoor and only 4.21% people have no kitchen. They cook in a room used for living/sleeping Fig 6 shows different types of cooking places .

Ventilation plays an important factor. Because through ventilation smoke resulting from burning biomass fuel can escape. In this study area most of the kitchen has window but the position of window and cooking place is not right. So smoke can't escape from the cooking place easily. Here availability of cross ventilation is very low. Only half of the houses have it . Because of the shortage of roof the upward direction smoke can't move from the place..

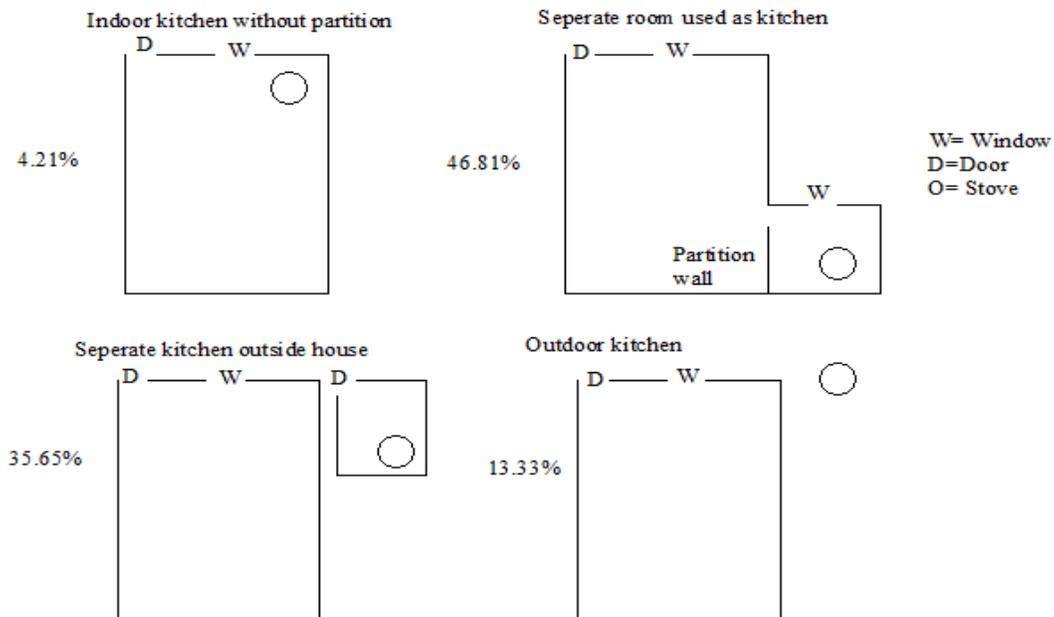


Figure 6: Types of cooking places

### 3.3 Problems of indoor air pollution

Different health problems people face in Ward no.10 people. For example eye irritation, eczema, headache etc. In fig 7 the percentage of different problems faced by the people while or after cooking is shown. From the graph it can be seen that problem of eye irritation is on the highest rate among the other problems. It's about 58 % where eczema 29 % and shortage of breath 8%.

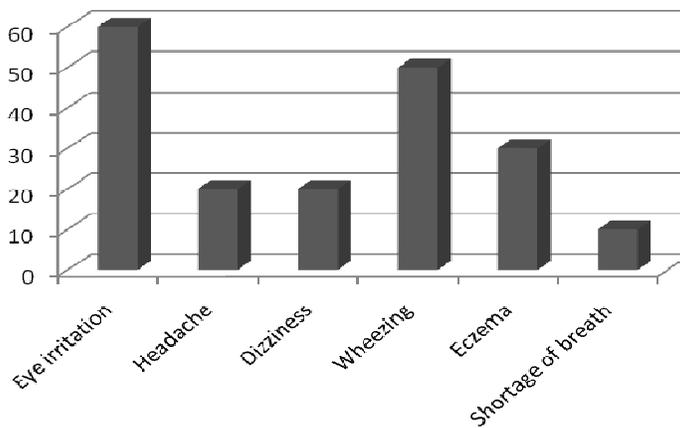


Figure 7: Problems faced due to use of solid fuels

Fig 8 the black bars represents the percentage of using solid fuel in different location and the grey bars for different health problems (eye irritation, wheezing, shortness of breath, eczema, headache, dizziness, etc) are faced by the people. In the graph A, B, C, D, represent Dakshin Kaipur, Khalishpur H.E (East block), Khalishpur H.E (Paschim block) & Nayabati respectively. From the graph it can be seen that health problems are higher at Nayabati where the percentage of solid fuel users are also high. Whereas Dakshin Kashpur has low solid fuel users and health problems are also low comparatively to other areas as shown in

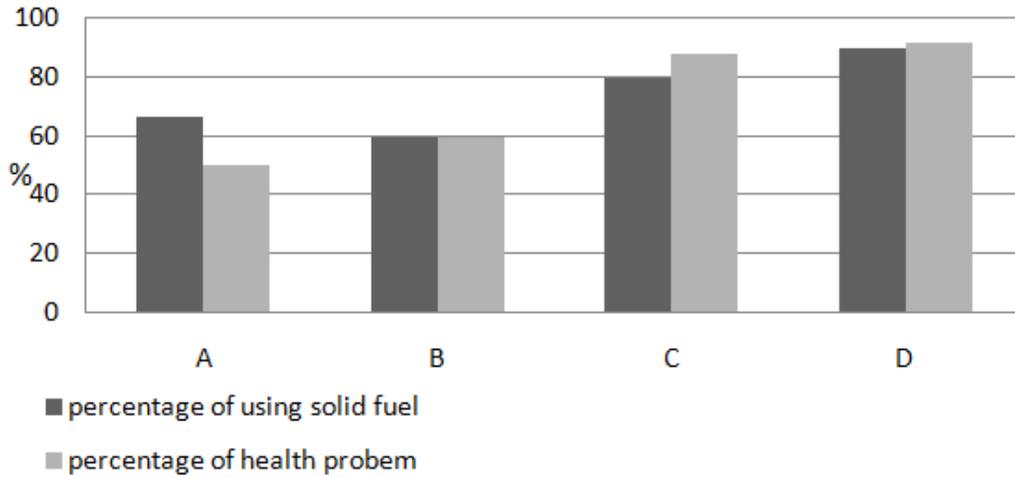


Figure 8: Percentage of solid fuel user and their health problems

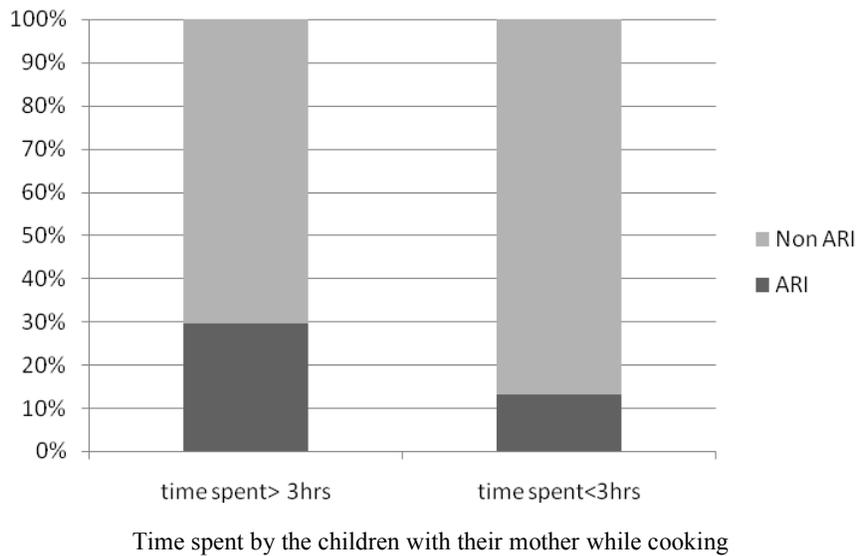


Figure 9: Time spent by the children with their mother and percentage of children faced ARI problems

80% children stay with their mother while cooking. Among them 42.45 have ARI symptom (Cough, runny nose, sore throat, wheezing, dizziness, difficulty with breathing, etc). It was found that among the children showing (ARI) symptoms, 3 or more hours spent by the mother were 29.41% and less than 3 hours was 13.04% (Fig 9)

### 3.4 Air quality parameter determination

After conducting the survey, the indoor air quality parameters are determined. The high volume sampler is placed 2ft from the cooking stove and it ran for 8hrs continuously. This experiment is conducted by experts of Department of Environment (DOE) of Khulna. Because of defects in the smoke meter, the value of CO (carbon monoxide) couldn't be found. Then the remaining parameters (NO<sub>x</sub>, SO<sub>x</sub> and SPM) are compared with the

standard values provided by DOE. In Fig 3 there is picture of filter paper before and after the test. The values of air quality of the study area is given below in table

Table Error! No text of specified style in document.: Air quality value

Air Parameter	Quality	Spm ( $\mu\text{g}/\text{M}^3$ )	Sox ( $\mu\text{g}/\text{M}^3$ )	Nox ( $\mu\text{g}/\text{M}^3$ )	Remarks
Test value		372.0	13	22	Spm exceeds the normal limit
Bangladesh Standards		200	80	100	

### 3.5 Proposal for reducing exposure to indoor air pollution

Proper measures can reduce exposure to indoor air pollution. The following steps can be used to reduce indoor air pollution by biomass fuel

Firstly: The simplest way to reduce indoor air pollution is removal of smoke from households. This can be done by switching cleaner fuels such as kerosene, LPG gas, etc.

Secondly: As most of the people in our country are poor, switching to cleaner fuel is difficult for their high cost. In that case improve cooking stove can be an alternative way to reduce indoor air pollution. Improved cooking stoves attempt to use traditional fuels in a more efficient manner and, therefore, do not impose a large cost on poor households. Often including a chimney, they are designed to remove harmful pollutants from the kitchen. Unlike the traditional cooking stove in improved cooking stove smoke create from burning of fuels escape through the pipe to outside. So the pollutant exist on the smoke doesn't harm the cook.

Thirdly: to convince households to increase ventilation within the household. Several studies have stated that the kitchen location, ventilation, and permeability of roofs and walls significantly affect smoke exposure (Dasgupta, M.Huq, Khaliqzaman, Pandey & Wheelles, 2004a). Fourthly: Behavioral change can plays an important role in reducing indoor air pollution such as

- Using of dry wood or animal dung
- Using of smaller pieces of wood
- Using of pots lit
- Keeping door and windows open while cooking
- Keeping children away from stoves
- Cleaning and maintaining stoves and flumes

Fifthly: Creating awareness among the mass people about the risks associated with exposure to indoor air pollution from the use of solid fuel for cooking. The message can be consist of following topic

- the adverse health impacts of exposure to smoke
- ventilation in kitchens
- hygiene and cleanliness in kitchens
- fuel use

Promotional activities: to raise awareness among a broad audience that included households, school students and teachers, health workers, and other local government representatives

Household meeting: Arranging household meeting

School sessions: for students and teachers at local schools and colleges

Film show: Film screenings for communities, including household members, local government representatives (i.e., Ward Commissioners)

## 4. CONCLUSIONS

From the above study it is found that on ward no.10 50% of house hold use solid fuel for their energy need and among them only 15% use improve cooking stove and half of the household have cross ventilation and screen window. Here air quality parameter SPM exceeds the standard limit where as Sox & NOx are within the limit.

Study reveals that Health problems are greater where the number of solid fuel users is large. And no steps have been taken for the reduction of indoor air pollution. Actually here people are ignorant of the harmful effect cause by biomass fuels. So proper measures such as improve cook stove, behavioral change and creating mass awareness about the harmful effect of indoor air pollution by fuels should be taken to reduce indoor air pollution by kitchen fuels.

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