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INDOOR AIR POLLUTION FROM DOMESTIC FUELS IN MAKURDI L.G.A. OF BENUE STATE, NIGERIA

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Abstract: The concentration of Carbon monoxide (CO), Hydrogen Sulphide (H_2S), Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2) was measured indoors during an average cooking time of 1-hour in ten (10) selected villages of Makurdi L. G. A. using a gasman auto-sampler. Five homes were randomly selected based on need from each of the 10 sampled villages. Two of the selected homes had semi-modern kitchens (with at least a window and a door), one using kerosene stove and the other using locally made charcoal stove. Three of the selected homes use local kitchens without windows and wood as the only source of fuel. A gasman auto-sampler was held 1.0 m above the ground to monitor the concentration of these pollutants at intervals of 10 minutes in all the selected kitchens. Parkiabiglobosa (African locust bean) wood was selected as a fuel-wood in one of the local kitchens, Prosopis Africana in another and a mixed species of wood in the other, in each of the selected villages. The results obtained showed that while the mean concentrations of CO, H_2S, NO_2 and SO_2 in a semi-modern kitchen using kerosene for cooking, from the selected villages was below the maximum permissible limits [10-35 ppm (1-hour average), 0.06 ppm (8-hour average), 1.20 ppm (1-hour average) and 0.01-0.14 ppm (24-hour average) respectively] set by the United States Environmental Protection Agency (USEPA) and other bodies like the World Health Organizations (WHO), the values from the use of charcoal and fuel-wood in poorly ventilated rooms are higher that the permissible limits and not safe for humans, since people exposed to these pollutants are at risk of public health hazards. The mixed species of wood produced the highest values, followed by Parkiabiglobosa (African locust bean) wood and Prosopis Africana wood having the least values. Although there were no significant variations in the concentration of these gases in the local kitchens in all the selected villages, they were all outstandingly higher than the recommended National Ambient Air standards.
Keywords: Biomass, fuel-wood, indoor air quality, pollutants.

Introduction

Indoor air pollution refers to chemical, biological and physical contamination of indoor air. It may result in adverse health effects. In developing countries, the main source of indoor air pollution is biomass smoke which contains suspended particulate matter (5PM), nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), carbon monoxide (CO), formaldehyde and polycyclic aromatic hydrocarbons (PAHs)[1]. In industrialized nations, in addition to NO_2, CO, and formaldehyde, radon, asbestos, mercury, human-made mineral fibres, volatile organic

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compounds, allergens, tobacco smoke, bacteria and viruses are the main contributors to indoor air pollution.

The fact is, you cannot escape air pollution, not even in your house. According to Malik, the environmental protection agency (EPA) reported in 1985 that the air in most American homes contained toxic chemicals that are three times more likely to cause certain cancers than outdoor air pollutants. EPA also reported that the indoor air pollution is 100 times more than outdoor air in some office buildings. Half of the indoor air pollution problems is due to poor ventilation. The rest comes from sources like coping machines, electrical cables, telephones wires, mold and micro-harboring air conditioning systems, cleaning fluids, cigarette, carpet paints vinyl molding etc.[2]

The World Bank in 1998 estimated that about half of the world population and 90% of those in developing countries rely on fossil fuels: wood, animal dung, crop residues, coal etc. for domestic energy needs. Even where stoves are used, in most instances, the combustion capacity of the stoves is poor. As a result of this, they produce heavy smoke and release a number of harmful pollutants indoor, since they only make use of a fraction of the available fuel energy [3]. Cooking and other heating activities using biomass is usually done in poorly ventilated rooms[4]. Although, an average cooking time may be taken to be one hour, the occupants are exposed to years of daily smoke since cooking is done a number of times in a day. Air pollution levels have being investigated in such homes and the report indicates that the pollution levels are up to 200 times higher than the recommended levels[5][6].

The determination of health effect due to indoor air pollution is not just by the pollution level. It is also by the time people spend breathing polluted air[7]. This shows that people who are exposed to polluted air arising from the burning of biomass fuels, predominantly rural dwellers in developing countries are at risk of public health hazards [8]. Exposure to indoor air pollution is linked to a number of respiratory illnesses, these include; acute respiratory infection, chronic bronchitis, asthma and possibly lung cancer etc.[9][10][11][12][13]. Other health problems among the rural dwellers include sneezing, nausea, headache, dizziness, eye irritation, and catarrh etc. [7], which are largely due to the exposure of humans to high concentration of gaseous pollutants in the air. In 2002, the World Health Organization (WHO) estimated that 67% of Nigerians use biomass fuel, with up to 79,000 deaths due to indoor air pollution from biomass smoke[14]. There is an urgent need to preserve the health of teeming rural inhabitants and safeguard the overall environment by controlling indoor air pollution in the rural areas.

In continuing search for a lasting solution to air pollution problems in Nigeria, one important approach is to obtain accurate and reliable data on the air quality in the country. This work was undertaken against this background.

Study Location

Makurdi Local Government Area is one of the 23 local government areas of Benue State, North-central, Nigeria. It is also the capital of the state. The city is located along the Benue River. As of 2007, the World Gazetteer estimated Makurdi population to be 500,797 with about 50% living in the rural areas[15]. It has an area of 840 km^2 and lies on latitude 7^o 38' to 7^o 50' North and longitude 8^o 24' to 8^o 38' East. The State is predominantly an agricultural area, specializing in cash crops, subsistence crops, and a variety of potentials. Parkiabiglobosa (African locust bean) and Prosopis Africana amongst several other species of trees are the two predominant commercial trees in the local government. The urban area is made up largely of people who engage in civil service duties, commercial activities and agrarian peasantry. There is also little fishing activities at the river banks.

Materials and Method

First, ten villages namely; Achusa, Adaka, Agan, Agbadu, Anter, Apir, Beetseh, Chekwar, Kanshio and Yaiko were selected randomly from the list of villages in Makurdi L. G. A. The target was on areas that depend largely on fuel-wood for energy supply. Secondly, five homes were randomly selected based on need from each of the 10 sampled villages for indoor air quality monitoring. Two of the selected homes had semi-modern kitchens (with at least a window and a door), one using kerosene stove and the other using locally made charcoal stove. While three of the selected homes use local kitchens without windows and wood as the only source of fuel. These local kitchens are round huts constructed with dried mud bricks with a thatch roof, with an average diameter of 6 m with a door, but no windows.

In the semi-modern kitchens (with at least a window and a door), using a kerosene stove, a gasman auto-sampler held 1.0 m above the ground was used to monitor the concentration of Carbon monoxide (CO), Hydrogen sulphide (H_2S), Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2) at intervals of 10 minutes for an average cooking time of one hour. Each parameter was measured in parts per million (ppm). Also, in the other semi-modern kitchens, using locally made charcoal stoves, and the three (3) local kitchens, using fuel-wood, the concentration of these gases were monitored using the same procedure for an average cooking period of one hour at 10 minute intervals. Parkiabiglobosa (African locust bean) was the fuel-wood used in one kitchen, the others used Prosopis Africana wood and mixed species, in all the selected villages.

Results and Discussion

The mean concentrations of CO, H_2S, NO_2 and SO_2 in a semi-modern kitchen using kerosene for cooking, from the selected villages ranged from 0.15 ppm to 0.20 ppm, 0.009 to 0.014 ppm, 0.012 to 0.016 ppm, and 0.010 to 0.016 ppm respectively as presented in table 1. These values are either below or within the maximum permissible limits [10-35 ppm (1-hour average), 0.06 ppm (8-hour average), 1.20ppm (1-hour average) and 0.01-0.14 ppm (24-hour average) respectively] for these pollutants set by the United States Environmental Protection Agency (USEPA)[16] and other bodies like the World Health Organizations (WHO)[14]. The low concentrations of these pollutants could be as a result of sufficient ventilations and the use of stoves with good combustion capacity and cleaner source of fuel.

In the case of a semi-modern kitchen where charcoal is used for cooking, the mean values of CO, H_2S, NO_2 and SO_2 ranged from 57.68 to 62.25 ppm, 0.14 to 0.18 ppm, 0.018 to 0.024 ppm, and 0.10 to 0.14 ppm respectively as shown in table 2. The mean concentrations of CO (from 57.68 to 62.25 ppm for 1-hour average) measured among the villages was beyond the USEPA Air Quality Standard of 10-35 ppm 1-hour average. The mean concentration of H_2S and SO_2 are also higher than the permissible limits of 0.06 ppm and 0.01-0.14 ppm respectively. People who are expose to this pollutants are at a serious risk of being affected by low birth weight [7], pulmonary tuberculosis [9]. The concentration of NO_2 is below the permissible limit of 1.20 ppm and safe. All the mean concentrations in table 2 are higher than those in table 1. This is because of a poor source of fuel (charcoal). These values though high and beyond the permissible limits are less than those in tables 3-5. This could be due to good ventilations.

Tables 3 and 4 show high mean concentrations of CO ranging from (168.60-208.56 ppm), H_2S ranging (0.14-0.22 ppm), NO_2 (0.18-0.28 ppm) and SO_2 mean concentrations (0.18-0.30 ppm), measured from local kitchens using Parkiabiglobosa (African locust bean) wood and Prosopis Africana in the selected villages. These concentrations are higher than the permissible limits [10-35 ppm (1-hour average), 0.06 ppm (8-hour average), 1.20 ppm (1-hour average) and 0.01-0.14 ppm (24-hour average) respectively] set by USEPA [16] and WHO [14]. While Prosopis Africana wood (Table 4) produced more concentrations of NO_2 that Parkiabiglobosa wood (Table 3), Parkiabiglobosa (African locust bean) wood produced more concentrations of CO, H_2S and SO_2 than Prosopis Africana wood in all the selected villages. These outstandingly high concentrations could be due to insufficient ventilations.

In the case of using different types of wood to cook in local kitchens from the selected villages, the mean concentrations of CO, H_2S, NO_2 and SO_2 ranged from 208.30 to 247.33 ppm, 0.18 to 0.27 ppm, 0.28 to 0.36 ppm, and 0.25 to 0.32 ppm respectively. These values are also outstandingly higher than the USEPA and WHO permissible limits.

The high concentration of the measured gases in local kitchens that use fuel-wood agreed with the findings/observations of [7][17][18][19] and [20] who also showed high concentration of these parameters and other pollutants in rural areas where biomass energy is the major source of energy.

Conclusion/Recommendations

The result of this study reveals that the use of kerosene fuel in a good stove and a well ventilated kitchen is safe during an average cooking time of 1-hour, while the use of fuel-wood as a source of energy in poorly ventilated room is the primary cause of indoor air pollution in the rural areas of Makurdi L. G. A. Continuous intake of these gases have negative effects on humans health.

It is recommended that drastic measures be put in place to curb the negative consequences of indoor air pollution in rural areas; Kitchens in the rural areas should be adequately ventilated or cooking probably done outside. Other sources of energy, for example renewable solar energy which is readily available in the study area should be developed for the use of rural dwellers. Alternatively, the use of kerosene cooking stove that have efficient combustion should be encouraged in the rural communities. These steps could reduce the emission of pollutants during cooking. Finally, the ministry of environment and other agencies should organize awareness campaigns to educate the rural dwellers on the dangers posed by their exposure to high levels of air pollutants within their houses.

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Table 1: Mean Concentration of CO, H_2S, NO_2 and SO_2 while using kerosene in a Semi-Modern Kitchen A

Village	**CO (ppm)**	**H_2S (ppm)**	**NO_2 (ppm)**	**SO_2 (ppm)**
Achusa	0.18	0.010	0.015	0.012
Adaka	0.20	0.012	0.016	0.015
Agan	0.17	0.014	0.012	0.014
Agbadu	0.20	0.013	0.014	0.016
Anter	0.18	0.011	0.015	0.013
Apir	0.16	0.014	0.014	0.013
Beetseh	0.15	0.009	0.012	0.015
Chekwar	0.17	0.010	0.016	0.010
Kanshio	0.16	0.012	0.015	0.011
Yaiko	0.19	0.013	0.013	0.012

Table 2: Mean Concentration of CO, H_2S, NO_2 and SO_2 while using Charcoal in a Semi-Modern Kitchen

Village	CO (ppm)	H_2S (ppm)	NO_2 (ppm)	SO_2 (ppm)
Achusa	58.83	0.15	0.020	0.13
Adaka	61.00	0.17	0.024	0.12
Agan	60.20	0.18	0.022	0.11
Agbadu	58.64	0.15	0.018	0.12
Anter	62.25	0.16	0.020	0.11
Apir	61.50	0.14	0.021	0.10
Beetseh	60.08	0.16	0.019	0.13
Chekwar	57.68	0.17	0.018	0.14
Kanshio	58.20	0.15	0.023	0.10
Yaiko	60.00	0.18	0.022	0.11

Table 3: Mean Concentration of CO, H_2S, NO_2 and SO_2 while using Wood (ParkiaSpp) in a Local Kitchen

Village	CO (ppm)	H_2S (ppm)	NO_2 (ppm)	SO_2 (ppm)
Achusa	204.67	0.19	0.22	0.28
Adaka	208.56	0.21	0.20	0.24
Agan	198.60	0.18	0.24	0.27
Agbadu	196.04	0.20	0.21	0.28
Anter	200.00	0.19	0.23	0.30
Apir	212.83	0.18	0.20	0.25
Beetseh	188.78	0.20	0.22	0.26
Chekwar	204.52	0.21	0.21	0.24
Kanshio	194.44	0.22	0.18	0.29
Yaiko	199.80	0.18	0.22	0.26

Table 4: Mean Concentration of CO, H_2S, NO_2 and SO_2 while using Wood (Prosopis Africana) in a Local Kitchen

Village	CO (ppm)	H_2S (ppm)	NO_2 (ppm)	SO_2 (ppm)
Achusa	171.83	0.16	0.28	0.25
Adaka	176.00	0.16	0.25	0.20
Agan	172.24	0.12	0.24	0.22
Agbadu	170.00	0.16	0.23	0.26
Anter	174.44	0.15	0.26	0.23
Apir	168.60	0.14	0.25	0.24
Beetseh	173.28	0.15	0.23	0.29
Chekwar	172.68	0.13	0.28	0.22
Kanshio	175.42	0.12	0.24	0.24
Yaiko	174.38	0.11	0.28	0.23

Table 5: Mean Concentration of CO, H_2S, NO_2 and SO_2 while using Wood of several species in a Local Kitchen

Village	CO (ppm)	H_2S (ppm)	NO_2 (ppm)	SO_2 (ppm)
Achusa	230.33	0.23	0.32	0.29
Adaka	240.10	0.25	0.34	0.32
Agan	235.36	0.22	0.30	0.28
Agbadu	228.30	0.20	0.31	0.30
Anter	236.40	0.24	0.33	0.29
Apir	232.33	0.23	0.30	0.27
Beetseh	237.33	0.26	0.29	0.28
Chekwar	234.34	0.25	0.33	0.29
Kanshio	235.50	0.23	0.32	0.30
Yaiko	231.30	0.25	0.30	0.27