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Investigation of Particulate Matter (PM10 & PM2.5) and Gaseous Pollutants (CO_2 & CO) in Houses Using Kerosene Cooking Stoves & Wood Fire in Attisa 3, Bayelsa State, Nigeria

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Abstract

The essence of this study is to ascertain the possible presence of Particulate Matter (PM 10 and PM2.5) and CO_2 and CO as Gaseous Pollutants emitted to the indoor environment as a result of the use of wood fire and cooking stoves as compared to the WHO standard guidelines as adopted by European Parliament 2008, in three communities in ward 3 in Yenagoa City Council area of Bayelsa State, Nigeria. Samplings were carried out using Dustmate for PM 10 and PM 2.5 and KANE 100-1 Gas Analyser and Logger for CO_2 and CO capturing in 6 hours per day. Each sampled point was randomly selected as houses/kitchens using wood fire and kerosene cooking stoves. The results were compared to WHO Guidelines as adopted by the European Parliament 2008, for the allowable limits of the indoor high and low assessment threshold levels. Sampled results show that gaseous pollutants under investigation in the three communities show that CO recorded high risk in houses/kitchens using Kerosene Cooking Stoves over houses/kitchens using wood fire. That is, it could have resulted in periods of putting off Stoves that produce incombustible CO. However, CO_2 was reasonably in order except for a few cases. In the same vein, PM10 was all within or below the WHO Guidelines, but PM 2.5 recorded very high-risk results on both houses/kitchens using Kerosene Cooking Stoves as well as houses/kitchens using wood fire.

1.0 Introduction

The continued use of wood fuels in domestic cooking as energy is the major source of wood smoke exposure in large populations globally which causes environmental health **[1],** especially in developing nations like Nigeria. It has been estimated that the use of wood fuels for cooking and heating **[2]** which is also very common in developing countries has been estimated to affect about 3 billion people exposed to smoke from these sources **[3]**. On the other hand, many local users, as well as occupational exposure to wood smoke include the use of wood fuels in a majority for household cooking, bakery, fish drying/roasting, cassava (Garri) processing, and charcoal production **[4].** In the decade Past, there has been several research in view of focusing on household solid fuel uses and its effect on human health **[5]**. It is also commonly reported that those exposed to smoke from the burning of biomass as wood fuel at homes are about half of the world's population **[6].** Accordingly **[7]** states that biomass burning from wood smoke exposure is responsible for about 1.5 million early deaths annually **[8].** The firewood combusted releases gaseous pollutants and particulate matter such as PM10 and PM2.5 gaseous pollutants from cooking emissions are normally carbon monoxide (CO), carbon dioxide (CO_2), Sulphur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs) and particulate matter of different micrometers which leads to health risk**[9]** such as headache, dizziness, nausea, cardiovascular and respiratory disease and with prolonged high concentration emanates to premature deaths**[10].** However, there remains a lack of concrete evidence on wood smoke exposure and the associated health effects in the Yenagoa metropolis of Bayelsa State, especially those living in the ward 3 areas in Yenagoa City Council. Hence, this research has proven evidence of exposure to Particulate Matter (PM 10 and PM 2.5) and other Gaseous pollutants, especially CO2 and CO, compared to the WHO standard guidelines **[11]**. Similarly, Kerosene cooking stoves have been an important household source of cooking since the mid-19th century. In developed countries, the use of kerosene cooking stoves has been deliberately reduced to a large estimate because of the different forms of available electrical supplies. Consequently, in developing countries like Nigeria, kerosene cooking stoves have remained in widespread use for cooking and kerosene serves as a spark-up fuel for burning of material and this has been the controversial use of government subsidies to secure kerosene availability, mainly for cooking, by poor populations **[12]**. This, however, is applicable to many homes which used kerosene mainly as their major source of fuel which eventually hand replace the majority using wood fuel by middle income-earners. In the same vein, Kerosene is still associated with emitting hazardous pollutants when used indoors. Though, Kerosene is often advocated as a cleaner alternative to many solid fuels such as biomass as wood fuel, and coal for cooking and heating which are subsequently used when electricity is unavailable. On the global scene, an estimated 500 million households still rely on kerosene or other liquid fuels for lighting, corresponding to 7.6 billion liters consumed annually **[13].** It is reported that Some kerosene cooking stove emits substantial amounts of fine particulates (PM2.5), carbon monoxide (CO), nitric oxides (NOx), and sulfur dioxide (SO2) **[14]**. Studies of kerosene used for cooking or lighting provide some evidence that emissions may impair lung function and increase infectious illness (including tuberculosis), asthma, and cancer risks. Due to the continual use of Kerosene cooking stoves, National and international efforts to promote the advanced combustion of biomass Kerosene cooking stoves with low emissions are now underway which includes the National Biomass Cookstove Initiative of India **[15]** and the Global Alliance for Clean Cookstoves **[16]**. In the same vein, this work has also proven that there is available evidence on exposure to PM 10 and PM 2.5 as well as CO_2 and CO in the use of kerosene cooking stove as compared to the WHO standard guidelines [13], as well as to that of Specified British Standard for Indoor Air Pollutants [17] shown in Table 1. In another word, several other contributions and different activities and operations within the indoor environment may influence particulate and gaseous emissions [11, 13].

2.0. Methodology

2.1. Study Area Description

The communities of Obogoro, Akaba, and Ogu are communities that are part of the designated 25-kilometer development area in the Bayelsa State Capital City developmental plan, yet there are over 80% of low and middle-income-earners living in these communities, as these are old settlements for over ten decades that people are living in a clustered and compact environment. This factor had also given rise to many families still depending on wood fuel and kerosene cooking stoves for their daily living. These 3 communities lie parallel to the river nun by the Ikoli Bridge linking Ward 1 (Atissa

1) and part of Ward 3 (Atissa 3). In the same vein, these communities are in the heart of the Yenagoa Local Government Area, the capital city of Bayelsa State, South-South in the Niger Delta Region of Nigeria. This area is in coordinates of 4°55′29″N 6°15′51″E which is part of the landmark coverage of 706 km² with an increasing population of 2.9% from a projection of 470,800 as at the 2016 Population census **[17].** These communities, though in the heart of the city, they are mostly characterized by rural concern, that is, most of the women are housewives, and petty traders, and the men are peasant farmers, especially fishermen. These settlers are posed to the use of wood fires and kerosene cooking stoves extensively for cooking.

Table 1. Specified British Standard for Indoor Air Pollutants; (European Parliament, 2008)

PM-10	Upper Assessment Threshold	(i). 140 µg/m^3, not to occur above 18 times annually (70% limits value) (ii) 28 µg/m3 (70% of limit value)	24-hour Annually
	Lower Assessment Threshold	(i). 100 µg/m^3, not to occur above 18 times annualy (50 % limit of value) (ii) 20 µg/m^3 (50% limit of value)	24-hour Annually
PM-2.5	Upper Assessment Threshold	(i) 17ug/m^3 (50% limit of Value)	Annually
	Lower Assessment Threshold	(ii) 12 µg/m3 (50% limit value)	Annually
CO_2	Concentration level	(i) not to rise more than 5000 ppm during the teaching hours (ii) At any occupied time, including teaching concentration should be kept below 1000 ppm.	8-hour
CO	Upper Assessment Threshold Lower Assessment Threshold	7 mg/m3 (70% limit of value) 5 mg/ m3 (50% limit of value)	8-hour 8-hour

2.2 Sampling

Selection of houses was made randomly in all three communities, though within a distance of 15 to 20 metres apart, covering about 200-metre square in each community. In each community, houses and kitchen apartments used were both mud houses as well as block-built houses to ascertain the difference in accumulation of the gases and particulate matter. These houses are comprised of some using kerosene cooking stoves and others using wood fires. A total number of ten houses for each community were used for the study which speaks of the widespread capture of the majority of the living homes. The houses that fall under the sampled sites have a minimum of 14 to 17 people (men, women, and children inclusive) who are exposed to wood fire and kerosene stove emissions. In the Obogoro community, six of the houses were those using kerosene cooking stoves, but 2 were mud houses. The rest four were families using wood fire for cooking which comprises 3 mud houses and a block house. In the Akaba community, seven of the houses were those using kerosene cooking stoves, with single mud house. The other three were families using wood fire for cooking which comprises all three mud houses. In the Ogu community, five of the houses were those using kerosene cooking stoves, but 2 were mud houses. The rest five were families using wood fire for cooking which comprises 3 mud houses and 2 blockhouses.

2.3 Sampling Description and Equipment

The main equipment used for the sampling was Dustmate and KANE 100-1 Gas Analyser and Logger. Samplings were carried out for 6 hours per day in each of the randomly selected homes. 3 hours in the morning from 6:00 am to 9:00 am and 3 hours in the evening from 5:00 pm to 8:00 pm respectively. The total sampling period was about 8 months which took from November 2021 to June 2022, and include both the dry season and the early rainy season. The kitchens and houses were fairly ventilated with some having windows and all were without exhausts and fans and with few of them being ceiled. The sampling equipment was situated one metre away and at a height of one metre as well from each cooking stove where particulate (PM10 and PM2.5) and gaseous pollutants ($C0_2$ and CO) were being measured. Though the temperate condition, relative humidity and ventilation were not also taken into consideration during the sampling period. All sampling houses was done for four days, though all communities has days and times for both seasons covered to have an accurate experimental result. The sampled concentration of PM10, PM2.5, CO_2 and CO obtained was compared with WHO guideline limits as adopted by the European parliament 2008, Standard for Indoor Air Pollutants in Table 1.

Table 2: Location/House Type Used in Sampling with Respect to Number of Sampling Time

COMMUNITY	OBOGORO		AKABA		OGU		TOTAL
HOUSE TYPE	BLOCK	MUD	BLOCK	MUD	BLOCK	MUD	
NO OF HOUSES.	5	5	6	4	3	7	30
NO OF SAMPLING HOURS.	30	30	36	24	18	42	180

Table 3: House/Kitchen Types Used in Sampling Locations

S/NO		LOCATIONS OF SAMPLING POINTS			TOTAL
		OBOGORO	AKABA	OGU	

	SOURCE OF ENERGY FOR COOKING	BLOCKS	MUDS	BLOCKS	MUDS	BLOCKS	MUDS	NUMBER OF HOUSES
1	KEROSENE COOKING STOVES	4	2	6	1	1	4	18
2	WOODFIRE	1	3	0	3	2	3	12
3	TOTAL	10		10		10		30

Table 4: Summary of Concentration of Particulate matter, CO2, and CO at Obogoro Community in the total sampled period for Kerosene Cooking Stoves Apartment

Activities	CO_2 (ppm)	CO (ppm)	PM10 (µg/m^3)	PM2.5 (µg/m^3)
First Day	783.4	11	106.50	32.1
Second Day	669.09	08	152.22	41.82
Third-Day	577.43	20	63.65	29.68
Fourth Day	*558.67*	*23*	*78.76*	*43.80*
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

BDL (below detection limit), RCF= reference calibration factor, but CO2 = 5% <400

Table 5: Summary of Concentration of Particulate matter, CO2, and CO at Obogoro Community in the total sampled period for Wood Fire cooking Apartment

Activities	CO_2 (ppm)	CO (ppm)	PM10 (µg/m^3)	PM2.5 (µg/m^3)
First Day	976.4	10	185.50	35.1
Second Day	649.09	BDL	87.22	34.82
Third Day	847.43	20	102.65	40.62
Fourth Day	1011.22	BDL	68.89	35.87
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

BDL (below detection limit), RCF= reference calibration factor, but CO2 = 5% <400

Table 6: Summary of Concentration of Particulate matter, CO2, and CO at Akaba Community in total sample period for Kerosene Cooking Stove Apartments

Activities	CO_2 (ppm)	CO (ppm)	PM10 (µg/m³)	PM2.5 (µg/m³)
First Day	783.4	20	96.50	87.1
Second Day	899.09	BDL	92.22	67.82
Third Day	977.43	30	93.65	52.62
Fourth Day	*678.90*	*14*	*93.34*	*56.55*
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

BDL (below detection limit), RCF= reference calibration factor, but CO2 = 5% <400

Table 7: Summary of Concentration of Particulate matter, CO2, and CO at Akaba Community in total sample period for Wood Fire Cooking Apartments

Activities	CO_2 (ppm)	CO (ppm)	PM10 (µg/m³)	PM2.5 (µg/m³)
First Day	983.4	10	100.50	34.1
Second Day	799.09	BDL	92.22	57.82
Third Day	877.43	BDL	99.65	42.62
Fourth Day	*676.78*	*BDL*	*85.76*	*60.80*
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

Table 8: Summary of Concentration of Particulate matter, CO2, and CO at Ogu Community in total sample period for Kerosene Cooking Stoves Apartments

Activities	CO_2 (ppm)	CO (ppm)	PM10 (µg/m³)	PM2.5 (µg/m³)
First Day	783.4	15	116.50	44.1

Second Day	699.09	22	152.22	57.82
Third Day	677.43	15	133.65	52.62
Fourth Day	774.84	10	90.35	45.90
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

BDL (below detection limit), RCF= reference calibration factor, but CO2 = 5% <400

Table 9: Summary of Concentration of Particulate matter, CO2, and CO at Ogu Community in the total sample period for Wood Fire Cooking Apartments.

Activities	CO_2 (ppm)	CO (ppm)	PM10 (μg/m^3)	PM2.5 (μg/m^3)
First Day	1083.4	BDL	106.50	54.1
Second Day	899.09	BDL	102.22	37.82
Third-Day	877.43	25	83.65	52.62
Fourth Day	889.40	BDL	98.90	53.45
Time (hr)	24	24	24	24
Error	10%		RCF	RCF

BDL (below detection limit), RCF= reference calibration factor, but CO2 = 5% <400

Table 10: Summary of Concentration of Particulate matter, CO2, and CO at Obogoro, Ogu, and Akaba Communities in the total sample period for Kerosene Cooking Apartments

[redacted]				
Obogoro (Average)	507.79	15	100.28	36.85
Akaba (Average)	834.71	16	94.68	66.02
Ogu (Average)	733.67	15.5	123.18	50.11
Total (Average)	692.06	15.5	106.05	50.99

Table 11: Summary of Concentration of Particulate matter, CO2, and CO at Obogoro, Ogu, and Akaba Communities in the total sample period for Woodfire Cooking Apartments

[redacted]				
Obogoro (Average)	871.03	7.5	114.32	36.63

Akaba (Average)	834.18	2.5	96.29	48.84
Ogu (Average)	937.33	6.25	97.82	36.14
Total (Average)	880.83	5.5	102.81	40.54

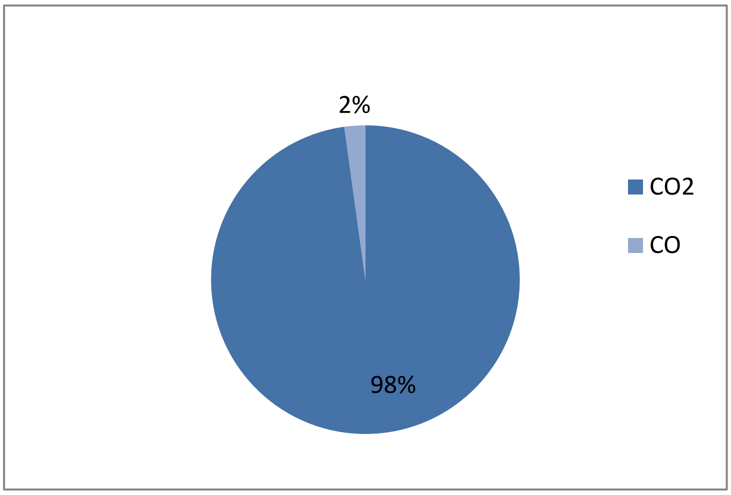

Figure 1: Kerosene Cooking Stoves

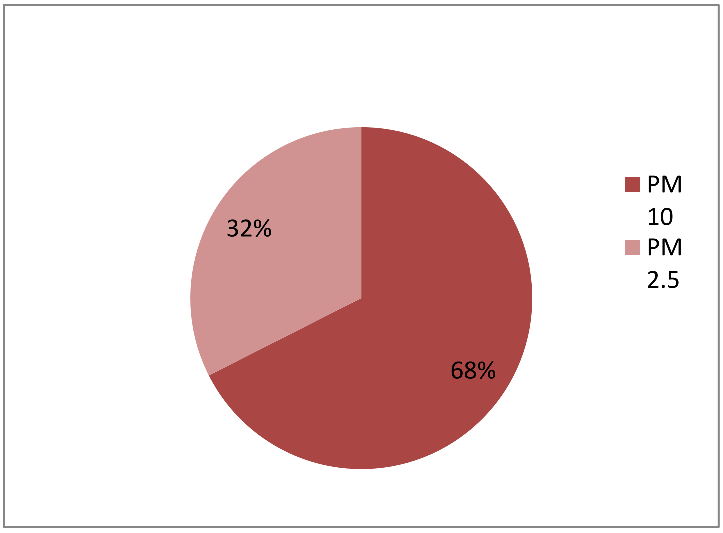

Figure 2: Kerosene Cooking Stoves

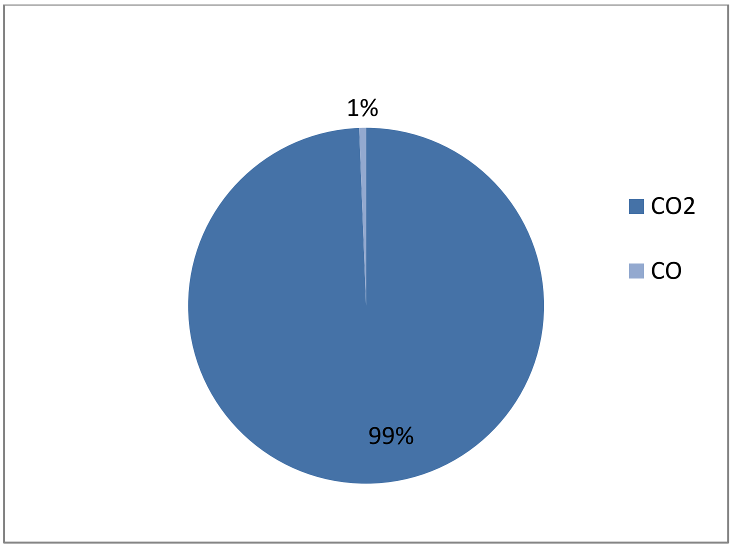

Figure 3: Wood Fire, CO_2, CO

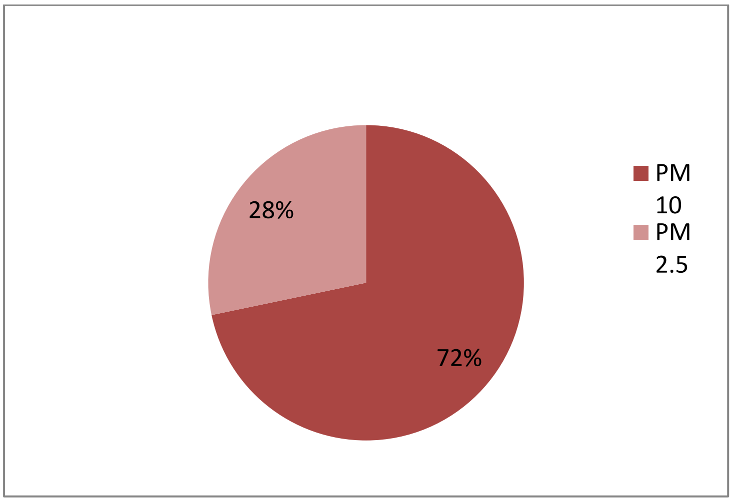

Figure 4: Wood Fire

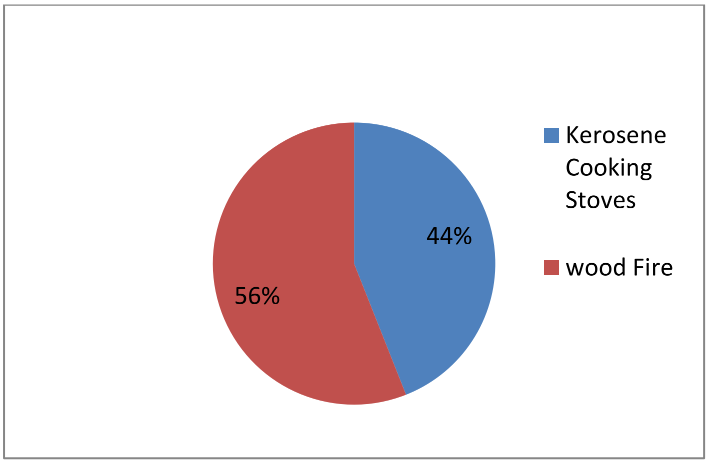

Figure 5: CO_2

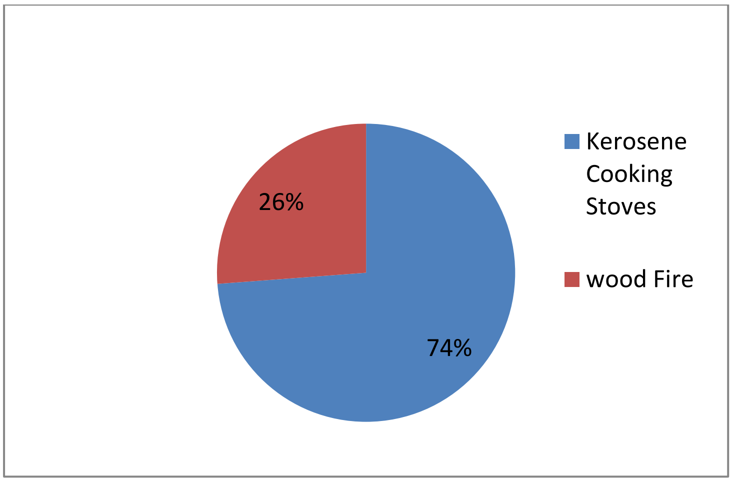

Figure 6: CO

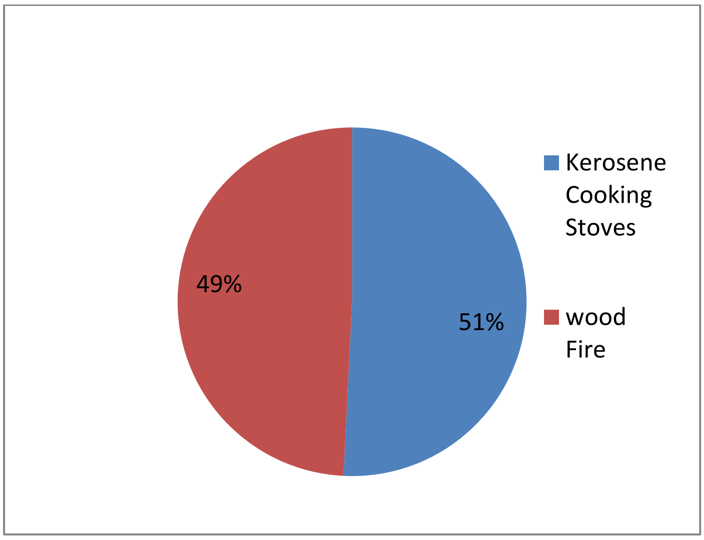

Figure 7: PM10

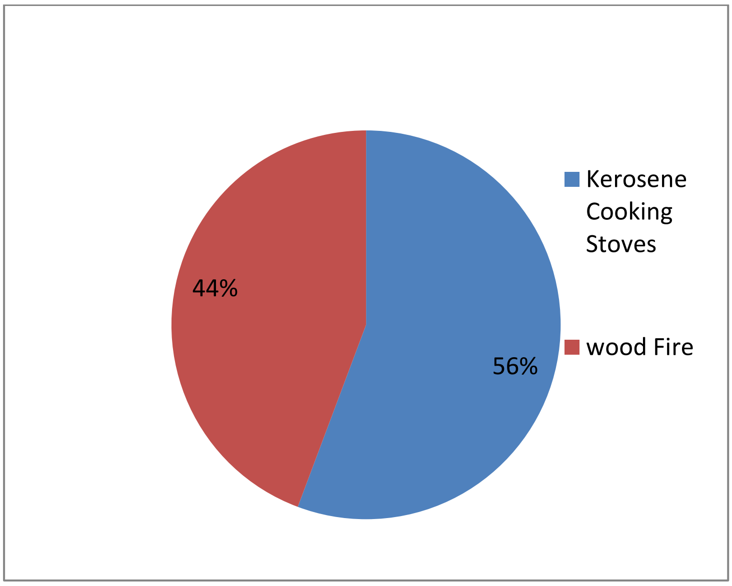

Figure 8: PM2.5

3.0 Results and Discussion

There was a total of 30 houses/kitchens using kerosene cooking stoves and wood fire that were investigated (Table 2.) in three communities (Ogogoro, Akaba, and Ogu) out of the five communities that made up the Attica (3) political delineation in Yelga. These 30 homes were selected randomly and 18 of them were buildings with occupants using kerosene cooking stoves while 12 were using wood fire as the main source of cooking and heating (Table 3). The total number of block-built apartments used for the investigation was 14 while 16 were mud-built houses/kitchens (Table 2). From Table 2, Obogoro Community has 5 block-built houses/Kitchens and 5 mud-built houses/kitchens, Akaba Community has 6 block-built houses/kitchens and 4 mud-built houses/kitchens while Ogu Community has 3 block-built houses/kitchens and 7 mud-built houses/kitchens respectively. Table 4 and Table 5 are summary the results of Obogoro Community showing sampled results from all houses/kitchens using kerosene cooking stoves and wood fires as sources of energy. Comparatively, houses/kitchen using wood was higher for Carbon dioxide (CO_2) at 1011.20 ppm over houses/kitchens using kerosene cooking was highest at 558.67 ppm (Table 4 and 5). Carbon monoxide (CO) was highest in houses using kerosene cooking stoves at 23 ppm (Table 4) over wood fire at 20 ppm (Table 5). For PM10, houses using wood fire were higher with 185.50 μg/m^3 (Table 5) over 152.22 μg/m^3 (Table 4) which was highest with houses/kitchens using kerosene cooking stoves. For PM2.5, houses/kitchens using kerosene cooking stoves were higher with 43.80ug/m^3 (Table 4) over wood fire with 40.62 ug/m^3 (Table 5) as the highest. Furthermore, Table 6 and Table 7 are summaries of results of the Akaba Community showing sampled results from all houses/kitchens using kerosene cooking stoves and wood fire as sources of energy. Similarly, Carbon dioxide (CO_2) is higher in houses/kitchens using wood fire at 983.40 ppm (Table 7) over houses/kitchens using kerosene cooking stoves with the highest at 977.43 ppm (Table 6). Again, Carbon monoxide (CO) has its highest results in houses/kitchens using kerosene cooking stoves at 30 ppm (Table 6) over 10 ppm (Table 7) with houses/kitchens using wood fire, though there was a BDL. For PM10, it has its highest sample result in houses/kitchens using wood fire at 100.50 μg/m^3 (Table 7) over houses/kitchens using kerosene cooking stoves at 96.50 μg/m^3 (Table 6). For PM2.5, it has a higher sampled result of 67.82 μg/m^3 (Table 6) on houses/kitchens using kerosene cooking stoves over wood fires whose highest results occurred at 60.80 μg/m^3 (Table 7). In addition, Table 8 and Table 9 are summary results of Ogu Community showing sampled results from all houses/kitchens using kerosene cooking stoves and wood fire as both sources of energy. Relatively, CO_2 has its highest sampled result in houses/kitchens using wood fire at 1083.40 ppm (Table 9) over houses/kitchens using kerosene cooking stoves having its highest result at 783.40 ppm (Table 8). In the same vein, CO also has its highest sampled result in houses/kitchens using wood fire at 25 ppm (Table 9) over houses/kitchens using kerosene cooking stoves at 22 ppm (Table 8). However, houses/kitchens using wood fire have 3 days resulting in below detection limits (BDL). Again, PM10 has its highest sampled result in houses/kitchens using kerosene cooking stoves as 152.22 μg/m^3 (Table 8) over houses/kitchens using wood fire with its highest sample results as 105.22 μg/m^3 (Table 9). Likewise, 2.5 has its highest sampled result also in houses/kitchens using kerosene cooking stoves as 57.82 μg/m^3 (Table 8) which occurred on the second day over houses/kitchens using wood fire as its highest sampled result as 54.10 μ/gm^3 (Table 9) occurring on the first day. Table 10 and Table 11 are the average overall summary results throughout the sampling period in the three communities in block-built and mud-built houses/kitchens using kerosene cooking stoves and wood fire as their main sources of energy. Comparatively, houses/kitchens using wood fire have its overall total average results for Carbon dioxide (CO_2) as 880.83 ppm over houses/kitchens using kerosene cooking stoves as 692.06 ppm, but for Carbon monoxide (CO), it recorded 15.5 ppm on houses/kitchens using kerosene cooking stoves over on houses/kitchens using wood fire as 5.5 ppm. Furthermore, the overall results for PM10, in houses/kitchens, using kerosene cooking stoves records 106.06 $\mu g/m^3$ over houses/kitchens using wood fire as 102.80 $\mu g/m^3$, and PM2.5 has its overall average results as 50.99 $\mu g/m^3$ in houses/kitchens using kerosene cooking stoves over houses/kitchens using wood fire as 40.54 $\mu g/m^3$. Finally, the overall percentage result for houses/kitchens using kerosene cooking stoves in all three Communities (Obogoro, Akaba, and Ogu), CO_2 was 98% while CO was just 2% (Figure 1), while PM10 was 68% and PM2.5 was 32% (Figure 2). Then for houses/kitchens using wood fire, shows that CO_2 appears 99% while CO was just 1% (Figure 3). PM10 was 72% while PM2.5 was 28% (figure 4). Relatively, the overall percentage results show that CO_2 was 44% in houses/kitchens using kerosene cooking stoves and 56% in houses/kitchens using wood fire (Figure 5). For CO, houses/kitchens using kerosene cooking stove has 74%, and houses/kitchens using wood fire has 26% (figure 6). Then, for PM10, houses/kitchens using kerosene cooking stoves has 51% over houses/kitchens using wood fire with 49% (Figure 7), while For pm2.5 houses/kitchens using kerosene cooking stoves was 56% over houses/kitchens using wood fire as 44% (Figure 8).

Comparing results from this study to the WHO standard guidelines as adopted by the European parliament, 2008, gave the following results: The results show that CO_2 in Akaba Community was highest with 834.71 ppm followed by Ogu with 733.69 ppm and least in Ogbogoro with 507.79 ppm. All results appear to be lower than WHO guidelines; that (i) CO_2 Concentration levels, do not rise more than 5000 ppm during working hours (ii) At any occupied time, concentration should be kept below 1000 ppm for 8 hours. For CO, Akaba Community results were still higher than Obogoro and Ogu with 16 ppm over 15.5 ppm at Obogoro Community and 15 ppm at Ogu Community. The result was above the WHO guidelines of 7 mg/m3 (70% limit of value) for the Upper Assessment Threshold within 8 hours of exposure and 5 mg/ m3 (50% limit of value) for the Lower Assessment Threshold within 8 hours as its equivalent in ppm measures. This, however, shows that all three communities, houses/kitchens using kerosene cooking stoves are at a high level of risk as results appears double of the WHO allowable limits guidelines for Upper Assessment Threshold within 8 hours of exposure and three times over 5 mg/ m3 (50% limit of value) for Lower Assessment Threshold. For PM10, Ogu Community has the highest result at 123.18ug/m3 with Obogoro having 100.23ug/m^3, Akaba Community with the least having 94.68ug/m^3. However, all results were below WHO guidelines for Upper Assessment Threshold for 24 hours annually; that, (i). 140 $\mu g/m^3$, not to occur above 18 times annually (70% limits value), (ii) 28 $\mu g/m^3$ (70% of limit value), and Lower Assessment Threshold for 24 hours annually, that (i). 100 µg/m3, not to occur above 18 times annually (50 % limit of value), and (ii) 20 $\mu g/m^3$ (50% limit of value). For PM2.5, Akaba leads with 66.02µg/m3, Ogu has 50.11µg/m3, and least Obogoro with 36.88 $\mu g/m^3$. The results indicate health threat and serious danger to occupants and users as compared to the WHO Guidelines for PM2.5 Upper Assessment Threshold annually; that (i) 17$\mu g/m^3$ (50% limit of Value) and (ii) 12 $\mu g/m^3$ (50% limit value) for Lower Assessment Threshold annually. Similarly, the total average overall result for houses /kitchens using wood fire, CO_2 for Ogu Community records highest as 937.33 ppm over Obogoro having 871.03 ppm with the least at Akaba as 834.18 ppm. However, all the results were below WHO guidelines on both Upper and Lower Assessment Threshold measures. For CO, Obogoro Community records the highest at 7.5 ppm over Ogu Community with 6.25 ppm with Akaba as the least at 2.5 ppm. These results show that both Obogoro and Ogu Communities fall within the allowable limits of the WHO allowable limit guidelines on both the Upper and Lower Assessment Threshold, however, the Akaba Community was below the WHO Guidelines. For PM10, Obogoro Community has the highest record at 114.3 $\mu g/m^3$ over Ogu Community with 97.82 $\mu g/m^3$ and the least at Akaba with 96.29 $\mu g/m^3$. Relatively, all three Communities' results show that it was below the Upper Assessment Threshold of WHO guidelines, but higher than the Lower Assessment Threshold measures of 24 hours annually. Finally, For PM2.5, Akaba Community has the highest record at 48.84 $\mu g/m^3$ over Obogoro Community having 36.63 $\mu g/m^3$, and Ogu Community the least with 36.14 $\mu g/m^3$.

4. Conclusion

Kerosene cooking stoves and wood fires are sources of energy for both cooking and heating in most families in developing countries, especially Nigeria where a high percentage of people are rural dwellers and live in city suburbs. In this regard, an investigation of houses/kitchens using kerosene cooking stoves and wood fire was carried out in three communities (Obogoro, Akaba, and Ogu) out of five Communities in Attisa 3 in the political delineation in the Yenagoa Local Government Area of Bayelsa. The investigation was to determine some Gaseous pollutants, Carbon dioxide (CO_2) and Carbon Monoxide (CO) and Particulate Matter PM10 and PM 2.5. The results were compared to WHO Guidelines as adopted by the European Parliament 2008, for the allowable limits of the indoor high and low assessment threshold levels. Sampled results show that gaseous pollutants under investigation in the three communities show that CO recorded high risk in houses/kitchens using Kerosene Cooking Stoves over houses/kitchens using wood fire. That is, it could have resulted in periods of putting off Stoves that produce incombustible CO. However, CO_2 was reasonably in order except for a few cases. In the same vein, PM10 was all within or below the WHO Guidelines, but PM 2.5 recorded very high-risk results on both houses/kitchens using Kerosene Cooking Stoves as well as houses/kitchens using wood fire.

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