ENVIRONMENTAL IMPLICATIONS OF SOURCES OF COOKING ENERGY: A CASE FOR AN ALTERNATIVE IN ABRAKA, DELTA STATE, NIGERIA

Atubi, Augustus O. (Ph.D.) and Uzu, Esther U.
Department of Geography and Regional Planning,
Delta State University, Abraka, Nigeria
Tel.*: +234-803-745-0078;* Email*: atubigrp@yahoo.com*

Abstract
This study used both primary and secondary data to examine the implications of sources of cooking energy in Abraka, Delta State, Nigeria. The study also examined how readily available these energies are in terms of price, time and labour and proffered alternative cooking energy that is more environmentally friendly. The findings revealed that the major sources of cooking energy in Abraka, Delta State, is fuel wood and other unprocessed biomass, which led to more than 100µg/m3 of smoke volume - a very high negative impact on the environment. Based on the findings recommendations were proffered.

Introduction
Early in human history, people used energy to make their lives more comfortable. In addition to gathering wild plants and hunting wild animals for sustenance, they domesticated plants and animals to provide a more dependable supply of food. Domesticated animals also furnish a source of energy for transportation, farming and other tasks. Wood provided a source of fuel for heating and cooking. Eventually, this biomass was used in simple technologies, such as shaping tools and extracting metals.

Project Gaia (2005) reports that about two third of the estimated 84 million rural dwellers, mostly women and children, live in a community experiencing severe energy crisis due to deforestation. They rely on inferior agricultural residues, such as cornstalk, maize cob, barks, animal dung, etc. as well as other unprocessed biomass.

According to Bates (2000), household energy comprises all the ways in which energy is used on a small scale within the family for cooking, heating and lighting purposes and this includes physical exertion as well as fuel generated energy. Households are dependent on unreliable and unpredictable sources of income and have various needs of which energy is only one which had to be met within these constraints. Poor families, generally spend proportionally more on satisfying their energy needs than the richer ones, because of the types of fuel that are used and pattern of income and expenditure. Low and unreliable income perpetuate a dependence on energy sources that are either free or can be purchased in small quantities on daily basis (Hooper-Box *et al*, 1997; Obueh, 2004)

The developed countries of the world have succeeded at different levels to provide sustainable and accessible sources through knowledge, skills and constructions, bringing about increased level of human comfort. Rational energy use embodies the idea of balancing human comfort with reasonable energy consumption levels by research and implementing effective and sustainable energy harvesting and utilization measures.

In developing countries, high percentage of the people experience energy scarcity and still rely on low quality fuel/ energy or unprocessed biomass (dung, wood, crop residue, etc) for cooking as a result of their poverty level (Obueh, 2004, Bilgen, 2004). Nigeria with her vast resources and population depend on crude oil (petroleum) - a fossil fuel - for foreign exchange and domestic use, neglecting the fact that crude oil is not an inexhaustible resource. Kerosene, commonly used in cooking, has become unaffordable and people prefer the use of fuel-wood (locally called firewood) and other air polluting cooking energies and technologies.

Cooking energy sources and environmental implications

The United Nations Millennium projects highlight the role of energy services as a pre-requisite for development. To achieve the Millennium Development Goals (MDGS), nearly 500,000 people will need to gain access to cleaner fuel or modern cooking technologies everyday between now and 2015, for the target to become a reality. About 1.7 billion people will need to gain access to liquefied petroleum Gas (LPS), biogas, alcohol fuels and other modern fuels (WHO, 2006). Yet, in the year 2003, about 42 per cent of the world population (more than 3 billion people) used solid fuels for cooking (Rehfuess and Bruce, 2006).

The environmental implications of sources of cooking energy are overwhelming, as indoor and outdoor air pollution has grown to its worst dimension. The use of energy from sources like twigs, animals dung, sawdust, leaves, etc. has promoted pollution at different levels, causing health hazards. Traditional cooking fuels/energies, along with kerosene, impose heavy tolls on health via smoke emissions and fire hazards (Project Gaia, 2005).

Cooking energy is a part of household energy with domestic scale or level, while, according to Bates (2000), household energy (HHE) comprises all the ways in which energy is used on a small scale within a family for cooking, heating and lighting purposes and includes physical exertion as well as fuel generated energy. Most households in Nigeria depend on unreliable and unpredictable sources of income and have various needs of which energy is only one, which have to be met within these constraints. Poor families, generally spend proportionally more in satisfying their energy needs than richer households because of the types of fuel that are used and pattern of income and expenditure.

Compared to developed countries, developing nations use much less total energy par capita. However, because of the much larger population, substantial portion of global energy is required. Less industrialized countries use energy differently consuming a much higher proportion at household level, principally for cooking and lighting, but also for heating in cooler climates (Donna and Marcus, 2000; Yakubu and Zagga, 2006).

Methodology

The experimental research design was adopted. Both primary and secondary data were used. The primary sources of data included observation, personal interview, use of questionnaires and readings/records from the air pollution gadget. The sample was drawn from the villages in Abraka through stratified random sampling. The choosing of homes/households was based on income levels and kitchen types. A total of two hundred (200) questionnaires were administered.

The study area was divided into 4 zones (A, B, C and D). Comprising Zone A were Urhuoka, Ekrejeta, and Abraka P.O villages; B were Ajalomi, Urhuovie, and Erho villages; C were Orhia, Ugolo, and Urhogbesa village; and D were Abraka Inland, Agbareje, and Abraka town. Fifty (50) questionnaires went to each zone. To gather data on the effect of smoke on the immediate cooking environment, an air pollution smoke volume/recorder was systematically mounted in strategic positions in the four zones. Reading was taken on daily basis for 3 weeks, considering the thickness of the smoke. The regression analysis statistical technique was used for analysis of the data collected.

Results and Discussions

Table 8.1 shows the sex, age and marital status of respondents. Twenty-eight (28%) were males and 72% females. The modal ages were 0-20, 21-30, 31-40, 41-50 and above. None of the respondents was below the age of 18 years. Majority of the respondents' were aged 31-40 years, and the mean age was 44.94 years. About 82% of the respondents are married, 13% were divorced, 8% were widows, and 1% were single.

Table 8.1: ***Sex, Age and Marital Status of Respondents***

Variable (Sex)	Frequency	%
Male	56	28
Female	144	72
Total	200	100
Age (yr)		
0-20	16	8
21-30	54	27
31-40	101	50.5
41-50 and above	29	14.5
Total	200	100
Marital Status		
Widow	8	4
Single	2	1
Married	164	82
Divorced	26	12
Total	200	100

Source: Authors Field work, 2009.

Table 8.2 shows the types of fuel (energy used by respondents).

Table 8.2: ***Types of Fuel (Energy used by Respondents)***

Energy Type	**Frequency**	**%**	Stove type	Freq. %
Fire wood	57	28.5	Mid Stove	25
			Open wood	3
			Stone Steel	32
Sawdust	23	11	Cut paint cans	23
Charcoal	51	25.5	Coal pot stand	51
Kerosene	45	22.5	Wick stove	45
Agric. Residue	18	9	Agric Residue	18
L.P.G.	6	3	L.P.G cooker	6

Source: Authors field work, 2009

About 28.5% and 25.5% of the respondents use fuel-wood and charcoal respectively for cooking and processing. Out of the other fuel 57 firewood users, 12.5% used mud stove, 32 (16%) used open wood fire (Aducan tripod steel) as stove. Charcoal users used charcoal pot stand. About 22.5% respondents used kerosene with the wick stove. About 11% make use of sawdust and cut paint cans. These they use as stove technology. About 18% used agricultural residue in either mud stove or open fire stove technology, while only 6% used L.P.G. and its cooker. Respondents in the study area did not use animal dung found in Northern Nigeria.

Table 8.3 shows the peak periods of fuel use. About 72% of the bulk of cooking activity and fuel use is concentrated between 4 and 8 p.m. This is attributed to the custom of the people. Easily prepared food and light food serve as their lunch, which in most cases required little or no use of fuel. Only 7.5% of respondents make use of fuel for activities between 12 noon and 2 p.m., while 20.5% engage in active cooking of breakfast in the morning hours.

Table 8.3: ***Responses on peak periods of fuel use***

Peak Periods	Frequency	%
6am-8am	41	20.5
12noon-2pm	15	7.5
4pm-8pm	144	72

Source: Field work, 2009

Table 8.4 shows respondent satisfaction with fuel energy and stove. Majority of respondents were not satisfied with the type of energy and stove used for cooking. Majority were fire wood users because mud stove, open fire and sawdust operate with the help of firewood. The users of these fuels and stove were not satisfied because it often led bad source of heat, produced soot, affected food, and occasionally resulted in burns and other accidents. But for the charcoal/coal pot stand, users (21%) indicate their satisfaction, while only 4.5% indicated dissatisfaction. The latter needed replacement often as cooking progresses. The pot also frequently broke down, produced smokes and soot and caused burns and accidents.

About 0.5% of L.P.G. users were not satisfied due to its high price and tendency to explosion, while other users were satisfied especially because of its very clean nature. About 18% kerosene users were not satisfied because of its frequent adulteration predisposing it to explosion, scarcity and high price, smokiness and attendant soots. Only 4.5% of kerosene users were satisfied with the energy and stove. Hence, majority of respondents were not satisfied with the type of fuel (energy) and stove they were using.

Table 8.4: ***Data on Satisfaction with Fuel Energy and Stove***

	Satisfied	%	Unsatisfied Frequency	%	Reasons for unsatisfied
Kerosene stove	9	4.5	36	18	1 HED
Charcoal	42	21	9	4.5	ABDG
L.P.G	5	2.5	1	0.5	H,I
Mid stove	9	4.5	28	14	A,B,C,D,G
Open wood fire	5	2.5	33	16.5	A,B,C,D,F,G
Cut paint cans	3	1.5	20	10	A,B,C,D,F,G
Total	73	36.5	127	53.5	

Source: Field work, 2009

Table 8.5 shows the kitchen characteristics. The location of a kitchen for a good flow of smoke and heat is one of the factors considered in erecting a residential structure. A kitchen could either be located indoor on a separate room within the building or outdoor (built with mud, block, sticks with thatch roof).

Table 8.5: ***Data on Kitchen Characteristics***

Kitchen location	**Frequency**	**%**
Outdoor/mud/block/sticks with/windows/without	98	49
Indoor (separate room) with window Roof type	102 200	51
Thatch	92	46
Zinc	102	51
Open	6	3
Total	200	

Source: Field work, 2009

Analysis

For the regression analysis, the dependent variable chosen was RD. The explanatory variables chosen were types of fuel, location of kitchen, number of meals cooked per day, type of stove and respirable dust in ambient air (RD3). The value RD1 to RD3 were used to deduce the level of pollution during one cooking period. Regression Analysis was done to estimate the effect of the various factors on the level of pollution, i.e. the level of respirable dust (volume of smoke).

The basic equation estimated is,

RDX= Constant + X Lockit + 1+ Lockit2+Y lockit3+S meals / day +n stove+$fuel+RD3+EX…Equation (1)

Where,

X=1,2

RD1=volume of smoke /respirable dust while cooking in ug/m^3

RD2=Area measurement for respirable dust inside the house while cooking in ug/m^3

RD3=respirable dust in ambient air in ug/m^3

Mean location lockit 1= when cooking is done inside kitchen without partition

Lockit 2 = if cooking is done in separate kitchen inside house.

Lockit 3 = if cooking is done in separate kitchen outside house.

Lockit 4 = if cooking is done in open air.

Stove = 1 if cooking is done in traditional kitchen

Fuel = 1 if biofeul is used for cooking
EX = error term

The least personal exposure for respirable dust occurs when cooking was done in an open air using clean fuel, and efficient stove and this was obtained by:
RD1=constant + 0 meals /day+ RD3 +E... Equation (2)

Maximum personal exposure occured when cooking was done inside kitchen without partition using traditional stove and biofuels, and this was obtained by:
RD1 =constant + a Lockit 1+0 meals/ day +n stove + Pfuels + RD3 + E… Equation (3).

Result of respirable dust/volume of smoke measurements (RD) showed that the concentration of RD was the highest during cooking with inferior fuels. The volume ranged from 80µg/m^3 for houses using clean fuels to around 2000µg/m^3 for houses using inferior (unprocessed biomass/Biofuels). The volume and concentration of smoke depended on the types of kitchen. For subsequent regressions, natural log of RD1 was used as an explained variable because the variations in RD1 were considerably higher and with this transformation the adjusted R^2 increased from 0.35 to 0.67. The location of kitchen was an important explanatory variable given the fact that most of them used biofuels. The exposure of the cook increased as one shifted from location 4 (cooking in the open air) to location 1, where cooking was done inside a kitchen which had no partition. Therefore, when cooking was done inside a house without partitions using biofuels and traditional stove, this was derived:

Ln RD1 =3.499 +0.435 Lockit 1 +2.62 stove + 1312.91 ug/m^3 … Equation (4).

On the other hand, if cooking was done in open air using clean fuel and efficient stove, the concentration/volume of respirable dust was 63.52ug/m^3 which was 21 times less. However, the latest WHO air quality guideline prescribes no threshold for health effects associated with particular exposure, while the National Air, Quality standards from Central Pollution Control Board (CPCB) on respirable dust for 24 hours in rural areas is 100 µg/m^3 (Santa *et al*, 1991; Umar & Wamakko, 1990).

It was observed that for various kitchen types (Lockit 1, Locket 2, Lockit 3, Lockit 4), the pollution level is much above the specified standard during cooking hours and only less when clean fuels was used for cooking. The implications of this result to the study area was that the level of pollution was very high, judging from the regression result of 0.67. With the constant use of fuel with poor quality, there is therefore, high emission rate. The maximum concentration of smoke is observed when cooking is done inside the kitchen. The result revealed that there is a strong relationship between cooking energy and the environment. The type of fuel and type of stove used were also related

Development Implications and Recommendations

It is obvious that energy crisis is a major problem facing Abraka town, Delta State in particular and Nigeria in general. An estimated 88% of household in Abraka lack access to quality cooking and lighting energy. This situation compels families to depend wholly on inferior unprocessed biomass, which is environmentally and health damaging

It is, therefore, recommended that the government of Delta State and the Ministry of Power and Energy work in collaboration towards providing an alternative non-polluting and accessible fuel for cooking. It is also recommended that sustained effort must be evolved to design and effect integrated energy development programmes that would raise the standard of living of the inhabitants of the area.

About 80% of the standard cubic feet of natural gas is flared daily from gas field of Delta state. Methanol (an alcohol) can also be harnessed from the flared gas, and can be used as a cooking fuel in a specially designed stove for alcohol fuels. It is recommended that this flared gas be put into use for methanol, to be used alongside with ethanol, instead of being wasted daily. This will be better, as alcohol fuels burn with negligible amount of sooth (i.e. it is cleaner when it burns). Alcohol fuels can serve as a better alternative or replacement for kerosene, fuel, wood, sawdust, etc.

The price of commercial energy (electricity from natural grid as well as kerosene), where available, is generally beyond rural people's purchasing capacity, whereas traditional energy is free of cost. Therefore, people continue to use the unprocessed traditional energy, even where commercial energy is available. Thus, renewable alternative energy can play a significant role in remote, rural and even urban areas. For Abraka, Delta State in particular and Nigeria in general, ethanol is a good alternative for unprocessed traditional biomas and other expensive energy for cooking. Ethanol and suitable modernized improved clean cooking stove (as used in Ethiopia) is suitable for cooking and will help reduce pressure on the forest.

Conclusion

Civilization and development of science are closely linked to the availability of energy in useful forms. The rate at which energy is produced and used is called "power" although the term is sometimes used in common speech as energy. The developed countries of the world have succeeded at different levels to provide sustainable and accessible energy source through knowledge, skills and constructions bringing about increased level of human comfort. Rational energy use embodies the idea of balancing and implementing effective and sustainable energy harvesting and utilization measures.

References

Bates, C. (2000), "Energia Now," International Programme: the Household Development Organization, Network.

Bilgen, S. and Kaygusuz, P. (2004), "Renewable Energy for a clean and sustainable future, *Energy Sources*, 21: 11-19.

Donna, K. and Marcus, C. (2000), "Health and Environmental Effects of cooking stoves used in Developing Countries," *Journal of National Institute for Resource and Environment*, 1: 12:3.

Hopper, B. Mabuse C and Rauters, K. (1997**),** *A Conceptual Review and Reassessment of South Africa Energy Policy Research Method: Toward Expanded Framework*, Pretoria: Department of Mineral.

Obueh, H.O (2005), "Improving Gender Impacts in Household Energy Technology for sustainable Development," *COBEN Journal of Science Education,* 3(12): 31-42.

Project Gaia (2005), "Household Energy Development in Delta State," Unpublished Research Studies.

Rehfuses, E. and Bruce, N. (2006), "Household Energy for Life," *Boiling Point,* 521: 1-2.

Santa, A.U, Sambo, A.S abd Mika'ilu, A.S (1991), Fuelwood consumption pattern in Fakai District: A lesson for rural energy Planning and Policy in Nigeria. *Northern Journal of Renewable Energy*: 2(1&2): 54-59.

Umar, B.F. and Wamako. M.M (1999), "Domestic Energy Consumption pattern in Sokoto Metropolic," *Northern Journal of Renewable Energy,* 7(182): 35-40.

World Health Organization (2006**)**, "Fuel for Life: Household Energy and Organization," Geneva: WHO.

Yakubu. A.A and Zagga.A.D (2006), "Use of Fuelwood and Health Hazard in Sokoto city, Nigeria, *International Journal of Environment Issues*, 2(1): 78-92.