

Research Paper

Evaluation of health and environmental hazards of poorly refined kerosene from household users in Bayelsa state, Nigeria

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ABSTRACT

This paper assessed the environmental and health hazards emanating from the use of locally refined kerosene in the Niger Delta Region, Nigeria. Pollutants levels of carbon monoxide (CO), sulphur dioxide (SO₂) and NO_x were technically measured using IMR1400 Combustion Gas Analyzer. Users' exposure to fire explosions, health effects and hazard reduction measures were assessed through questionnaire survey. Results showed that pollutant concentrations from poorly refined kerosene at source point were far above WHO limits. The mean at source point concentrations of CO (916.00 ppm), SO₂ (45.16 ppm) and NO_x (0.42 ppm) exceeded the WHO limits of CO (10 ppm), SO₂ (0.01) and NO_x (0.04 to 0.06 ppm) significantly. The questionnaire survey confirmed the widespread use of the poorly refined kerosene (90.7% of the households) and users' awareness of the health and environmental hazard implications of the use of this poorly refined kerosene was significant. Nigerian Government is therefore, called to intensify action towards the eradication of all illegal refineries in the area and also to ensure the provision of a steady electric power source as the primary energy source for household use.

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Key words: Locally (poorly) refined kerosene, conventional refinery kerosene, Niger Delta Region, pollutant emission.

INTRODUCTION

Kerosene has been the most predominantly used energy source for household uses in Nigeria. It is regarded as a "step up the energy ladder" from solid cooking fuels such as wood and charcoal (Smith et al., 1994).

Nationally, representative cooking fuel assessment conducted by Demographic and Health Surveys (<http://www.measuredhs.com>) showed an urban/rural usage pattern for Nigeria (2008) as 51.6 /11.3%. The high level of kerosene usage in Nigeria has increased the demand for kerosene which has imperatively make the cost of the product so high; up to about 164 Naira per litre.

The advent of the locally refining method of crude oil in the Niger Delta region, especially in Bayelsa State has drifted consumers to the poorly refined kerosene, because it is cheap and available. The study became imperative as health effects associated with pollutants are on the increase in the study area. Unlike the conventional kerosene

produced from fractional distillation, which literatures confirmed that combustion pollutants emissions posed threat to the environment and human health, the poorly refined kerosene may pose more threat due to its unstandardized production process.

Local refining process

Petroleum products such as petrol, kerosene and diesel are produced from simple distillation process and the products are collected at discretional intervals. The distillation process is not fractionalized and temperature of the heat source also not regulated.

The process entails the use of metal drum for the heating of crude oil; wood fire is used as the heat energy source, galvanized pipes of about one inch are connected to the

metal drum as conductors immersed in a water bath is used as condenser. The first product that distilled out is collected as petrol, then, kerosene and lastly, diesel and the rest is disposed off as waste.

Therefore, mixtures of petrol in kerosene, diesel in kerosene and diesel in petrol obtained makes it a coloured product, where it is supposed to be a clear liquid. Poorly refined kerosene varies greatly due to the source of crude oil and the refining process.

Refinery Kerosene is a clear liquid fuel with a mixture of hydrocarbon containing 6 to 16 carbon atoms in length. Kerosene is a middle distillate of petroleum refining process, defined as the fraction of crude oil that boils between 145 and 300°C (US Environmental Protection Agency, 2011).

Kerosene is a complex mixture of branched and straight chained compounds: paraffin (55.2% w/w), naphthalene (40. 9% /w/w), and aromatics (3. 9% w/w) (US EPA, 2011).

Exposures to pollutants emitted from kerosene stoves

Most developing countries use kerosene as major household energy sources; it is often burned indoors without chimneys or smoke hoods. Exposure to combustion products from fossil fuels have been associated with a range of health effects, including lung cancer, chronic obstructive pulmonary disease (COPD), low birth weight, cataracts, pneumonia, and tuberculosis (Futteton et al., 2008). Therefore, pollution from fossil fuel has provoked efforts to find alternative energy sources or ways to burning biomass more cleanly (Nicholas et al., 2012).

Kerosene, when burned in stoves or appliance emits many potentially health damaging pollutants, these pollutants emitted include Particulate Matter (PM), Carbon Monoxide (CO), formaldehyde (HCHO), Polycyclic Aromatize Hydrocarbons (PAH), Sulphur dioxide (SO₂) and Nitrogen Oxides (NO_x). Some of these health effects of such pollutants are summarized as follows:

Particulate matter

Exposure to Particulate Matter (PM) increases the risk of respiratory and cardiovascular diseases, cancer, and mortality (Krewski et al., 2005; Samet and Krewski, 2007; Tsai et al., 2012; Yang, 2008). Fine Particulate Matter (PM) is emitted from kerosene as a product of incomplete combustion. The World Health Organization (WHO) has established PM 2.5 guide time for all non-occupational and environmental (indoors and outdoors) of 10 µg/m³ (annual) and 25 µg/m³ (24 h) (WHO, 2006).

Carbon Monoxide (CO)

Carbon monoxide is generated by incomplete combustion.

When inhaled, CO binds to hemoglobin in red blood cells to form carboxyhaemoglobin, reducing the oxygen carrying capacity of the blood and increasing the risk of chronic and acute adverse health effects in adults, children and fetuses (Nicholas et al., 2012).

The effects of acute exposure include dizziness, muscle cramping, loss of consciousness, and in extreme cases, death. Low level chronic developmental effects (Dix-copper et al., 2012; Garland and Pearce, 1967) and cardiovascular diseases (Yang et al., 1998); WHO guideline levels reflect air concentrations at which a normal adult would not exceed 2% carboxyhaemoglobin.

Formaldehyde

Formaldehyde is classified as class 1 carcinogen (IARC, 2006). It is produced by combustion sources. Formaldehyde is absorbed in the up respiratory tract unless it is bound to fine particles which allow deeper penetration into the lungs. A guideline concentration of 0.10 mg/m³ was established by WHO.

Polycyclic aromatic hydrocarbons (PAH)

PAH is a constituent of kerosene and it is produced from incomplete combustion. Benzo (a)Pyrene (BaP) is considered as a class 1 carcinogen (IARC, 2010). There is emerging evidence that phenanthrene, which is present in many petroleum base fuels, is a potent immune-suppressant in animal and possibly humans (Nadeau et al., 2010). Naphthalene is considered by IARC to be a class 2 carcinogen. A guideline level of 0.01 mg/m³ was established by WHO (2010).

Sulphur dioxide

Sulphur dioxide (SO₂) is produced from the sulphur content of fuels during combustion. Sulphur emitted indoors exists as sulphur dioxide (SO₂). Exposure to sulphur dioxide include changes in pulmonary function and respiratory symptoms, while chronic exposure at levels (<20 ng/m³) have been associated with increase in all-age mortality (Nicholas et al., 2012). WHO established precautionary guideline of 24 h indoors level of (20 ng/m³).

Nitrogen oxides (NO_x)

There is a strong evidence linking NO₂ with adverse respiratory health effects in adults and children. These include inflammations, asthma, and reduced immune defenses that lead to exacerbation of new respiratory infections (Nicholas et al., 2012). NO and nitrogen dioxide are formed in reactions between atmosphere nitrogen and

Table 1. Indoor gaseous pollutants concentration from refinery kerosene.

Pollutants	N	Concentration (ppm)				
		Mean	SD	95% CI		WHO/FEPA
				Lower	Upper	
CO concentration at source point	72	39.52	52.63	26.68	52.36	10
SO ₂ concentration at source point	72	1.01	1.95	0.56	1.47	0.01
NO _x concentration at source point	72	0.42	1.03	0.17	0.66	0.14 - 0.06

oxygen during combustion process. WHO guideline is (200 mg/m³) for 1 h and (40 ng/m³) annually (WHO, 2006).

Fire explosions

Kerosene appliances are responsible for many fire explosions and burns, with a variety of contributing factors; as a problem, kerosene related fires and burns has been recently reviewed (Peck et al., 2008). Although, in this study explosion seemed to be mainly caused by poorly refined kerosene.

The use of kerosene stoves has led to major fires and serious burns, often fatal burn (Nicholas et al., 2012). Many devices, particularly those with wicks are mainly used and they are poorly constructed and as such there is always a leakage. The leakage may ignite explosion resulting from the mixing of gasoline and kerosene during the process of collection or production. The amount of gasoline, with its much lower flash point and higher vapour pressure can lead to kerosene devices exploding.

Purpose of the study

The paper assessed the environmental and health hazards from the use of poorly refined kerosene produced from local refineries in the Niger Delta region, Nigeria. It was affected by the several incidences of kerosene appliances explosions, fires, burns and respiratory diseases.

Study design

The treatment approach involved the measurement of air pollutants by means of combustion gas analyzer. A well structured questionnaire was used for establishing the users' complaints.

Study area

The study area is Amassoma and its cluster communities. The area is chosen base on its population as a host to the Niger Delta University, Bayelsa State. It is also a hob of this

illegal petroleum product business with the availability of the product at all time. Amassoma is situated in southern Ijaw Local Government Area, and Bayelsa State, Nigeria. Its geographical coordinates are 4°58'13" North, 6°6'35" East (Google maps, 2012).

METHODOLOGY

The model 1 MR 1400 combustion gas analyzer was used to measure the spot pollutions emitted from stoves. The gas analyzer was held at a height of one meter about the stove for two minutes after which the maximum and minimum reaching were recorded for indoor air pollution concentrations; a total of 432 measurements were at different points, 2 and 4m away from burning stove.

Users' hazards implications

These were ostracized from structured questionnaires. Questionnaires were administered to members using the kerosene as source of cooking fuel. A total of 144 questionnaires were administered and 119 were completed and returned, which is about 83% responses.

- Frequency of kerosene possession.
- Frequency of the type of kerosene possession.
- Health issues associated with kerosene usage.
- Users' awareness of the related hazards.
- Ways of minimizing the hazards.

RESULTS AND DISCUSSION

Comparative measurements in Tables 1 and 2 showed that households using locally refined kerosene as source of cooking energy had higher hazards. Technical measurements of indoor air pollutants concentrations from conventional (refinery) kerosene is CO (39.52 ppm), SO₂ (1.0 ppm), NO_x (0.14) as compared to that of locally, SO₂ (45.16 ppm) and NO_x (1.80).

The result showed that pollutant emission from the locally refined kerosene is so high and are in excess of WHO and FEPA limits which are CO (10 ppm), SO₂ (0.01), NO_x

Table 2. Indoor gaseous pollution concentrations from poorly refined kerosene.

Pollution	N	Concentration (ppm)				WHO/ FEPA
		Mean	SD	95%CI		
				Lower	Upper	
CO concentration at source point	72	916.00	706.99	749.87	1082.14	10
SO ₂ concentration at source point	72	45.16	75.30	27.46	62.85	0.01
NO concentration at source point	72	1.80	3.15	1.06	2.53	0.04 - 0.06

Table 3. Household Kerosene possession frequency and type.

Variable	Option (No.)	Frequency (%)
Possession and use of kerosene as cooking energy source		
Yes	107	89.9
No	12	10.1
Total	119	100
Type of kerosene used		
Refined	10	9.3
Locally	97	90.7
Total	107	100

Table 4. Health hazards associated with the use locally refined kerosene.

Hazard	Total respondents	Frequency of observation	
		Number	Percentage (%)
Skin itching	119	80	67.2
Impaired visibility (interact)	119	66	55.4
Dizziness	119	38	31.9
Nausea and vomiting	119	42	35.3
Increased wheezing	119	72	60.5
Fire explosion	119	16	13.4

(0.04 to 0.06 ppm). There may be variations due to variability in room sizes, ventilation, and contributions of outdoor sources from other result which were substantial in some studies (Raiyani et al., 1993; Saksena et al., 2003).

The high levels of the pollutants emitted may have been responsible for the health implications, such as itching skin, wheezing, dizziness/impaired visibility, nausea and vomiting and fire explosions. Table 3 showed the frequency of possession of the usage and type of kerosene; it indicates that 89.9% of the household uses locally refined kerosene. Only about 10.1% use the refinery kerosene. The results showed that consumers tend to use the poorly refined kerosene because it is cheap and accessible.

Some of the associated health hazards in descending order of agreement to the occurrence are: itching skin (67.2%), wheezing (60.5%), dizziness/impaired visibility (55.4%), nausea and vomiting (35.3%) and fire explosions (13.4%) and potential of occurrence respectively (Table 4).

The high frequency of health effects is in line with the review report by Nicholas et al. (2012). Although, the frequency is higher because the review is of refinery kerosene and the poorly refined one.

Table 5 showed perception of users on ways of controlling hazards from poorly refined kerosene. The highest mean value (3.24) of respondents is on the total ban of the illegal refineries in the Niger Delta Region of the country. Other respondents suggested for reduce in the price/litre of refinery kerosene (3.20), adequate electricity supply (1.18) and improved supply of the refinery kerosene (2.06).

Conclusion

There is a high rate of usage of the locally refined kerosene in Amassoma, Bayelsa State, Nigeria. The high usage has

Table 5. Perceptions on ways of reducing locally refined kerosene related hazards.

Hazards	Weight/frequency					Σf	Mean
	1	2	3	4	5		
Improve supply from National Refineries	11	20	23	35	30	119	2.06
Band of illegal refineries	11	25	27	36	20	119	3.24
Reduce price/litre of kerosene	12	23	25	40	19	119	3.20
supply of electricity (National gride)	65	25	20	5	4	119	1.81

1-strongly agree, 2-agree, 3-undecided 4-disagree 5-strongly disagree.

increased the associated environmental hazards and health implications on household users. In order to control the hailing hazards, users are willing to embrace any measure that will provide a cheaper and safer energy source for their household cooking.

LIMITATIONS

Certain constraints were encountered during the study; limitations included unavailability of accurate analytical equipments for the measurement of particulate matter (PM) and formaldehyde (HCHO).

RECOMMENDATION

While Nigerian Government is making consideration in providing cleaner and safer energy source, in the interim, Government should band the activities of the illegal refineries and make the conventional refinery kerosene available with lower pollutant emission factor. Users should also create enough ventilation in kitchens in their buildings.

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