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Sources of Carbon Monoxide (CO) Pollution in the Niger Delta area of Nigeria

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Abstract

The Niger Delta in the Southern part of Nigeria had been captioned 'a region of environmental degradation' including carbon monoxide (CO) pollution in the World Bank study of the region in 1995 and in the UNEP Environmental assessment of Ogoniland in 2011. The objective of the study was to ascertain the sources of CO production in the Niger Delta, the availability of Nigerian national guidelines on CO pollution, Nigerian national and regional register of CO poisoning and air quality check for CO in the region. A mixed method study (observational-descriptive and systemic review was carried out. Sources of CO production were visited, guidelines on environmental protection, CO and its register and data on daily air monitoring were looked for in Rivers State and the Nigerian Federal Ministries of Environment, Health and Justice. The result showed that there were no guidelines on environmental protection against CO pollution, no register of its poisoning and no monitoring of its ambient and indoor air concentrations in the Niger Delta. Sources of its pollution were tobacco fumes, generator, firewood, kerosene, bush and refuse burning, fire out-brake, barbecues, burning of fossil fuels in old vehicles, crude oil and gas industry (three refineries, oil wells, flow stations and gas flaring, crude oil and condensate spills, vapours from crude and refined oil storage, processing and transportation facilities, petrochemical plants and gas liquefaction plants). In conclusion the Niger Delta was plagued with numerous sources of CO emission and ineffective environmental protection laws. There was therefore urgent need for revival of regional and national environmental laws, maintenance of registers for CO poisoning and conduct of daily air quality check for CO and other gases in the Niger Delta and in Nigeria at large.

Keywords: Sources, Carbon monoxide, Pollution, Niger Delta, Nigeria.

INTRODUCTION

The Niger Delta area in Nigeria is situated in the Gulf of Guinea between longitude 50E to 80E and latitudes 40N to 60N. It is a home to more than 20 million people drawn from nine states namely Rivers, Bayelsa, Akwa Ibom, Cross River, Delta, Abia, Edo, Imo, Ondo and Rivers States, with the first two States called the 'Core Niger Delta. The region produces over 90% of Nigeria's foreign earnings through oil exploration and production activities. It therefore plays host to most of the upstream and downstream oil related and non-oil related industries that release tons of pollutants including CO into the ecosystems.

Unfortunately, there is no collated data on the sources of air pollution in the region, including carbon monoxide. The environmental terrain in the Delta has led to series of scientific research projects, the most notable ones of which were the World Bank study of the region and the Environmental Assessment of Ogoniland in the core Niger Delta which delivered a catalogue of devastation due to oil pollution in the region [1, 2]. Ogoniland in Rivers State was tagged 'a region of environmental disaster [2].'

Carbon monoxide (CO) is an inorganic colourless, odourless and non-irritating gas produced from the incomplete combustion of carbonaceous compounds. It is a primary pollutant as it is emitted from a source directly into the atmosphere. It enters into the body primarily through inhalation, though there is also nominal endogenous production of the gas. CO inhalation is the most common cause of poisoning in the industrialised world. It can cause multi-organ dysfunction and frequently necessitating admission to intensive care units.

In pregnancy its presentations ranges from flu-like symptoms, headache, gastrointestinal, neurological and psychiatric symptoms and signs to maternal Death [3]. Maternal period exposure to the gas during the period of ontogenesis is associated with abnormalities of organs and systems including the central nervous system [4-6], skeleton and face [7], and the heart [8, 9]. Other toxic effects include intrauterine growth restriction [9], preterm labour [10], intrauterine foetal death [11, 12], and sudden infant death [13]. Knowledge of the sources of CO pollution should help the Government to strategize on environmental protection and also medical personnel on management of its poisoning.

Aim

The primary aim of the study therefore was to ascertain the sources and burden of carbon monoxide production in the Niger Delta while the secondary objectives were as follows:

a. To review the Nigerian national guidelines on carbon monoxide pollution,
b. To ascertain the availability of Nigerian national and regional register of CO poisoning and
c. To confirm the availability of air quality check for CO in the Niger Delta

MATERIALS AND METHODS

It was a mixed method study – observational descriptive and systemic review. We reviewed published studies on the sources of carbon monoxide contamination of the Niger Delta and regional variations in the sources. We also looked for Nigerian national register of CO poisoning, the federal Government guideline on CO pollution and also availability of organized monitoring of ambient air quality in the Delta. Literature search was carried out, using Pub med (MEDLINE), Biomed central, Google and Cochrane database. Keyword search statements used were 'Environmental pollution in the Niger Delta,' 'Sources of carbon monoxide pollution,' 'Sources of CO pollution in the Niger Delta,' 'Gas flaring in the Niger Delta,' 'Produced environmental pollutants during gas flaring,' 'Petroleum production and CO production,' 'Environmental protection laws in Nigeria,' 'CO register in Nigeria,' and many other search phrases and sentences.

Literatures published in English language for the past 20 years were included in the study; the figure was chosen because of the rapid development in the science of environmental studies for that period. Studies carried out in other parts of the world were also included, especially if the studied region has similar environmental terrain like the Niger Delta. The literatures were synthesized by two researchers and relevant information was retrieved from them and agreement on inclusive data was reached by dialogue. The Nigerian and WHO normal ambient and indoor CO concentrations were also reviewed. Where the regional concentration is significantly more than the norms, detail investigation was carried out on the sources of CO in that area.

So, in other to confirm the sources of CO pollution, the following facilities were visited: the two oil refineries in Eleme and one in Warri, the petrochemical plants in Eleme, the oil and gas plants in Bonny, the flow stations in Ogoniland and other parts of Rivers State. Farms were visited to witness mass conflagration of bush as a means of land cultivation for agricultural purposes. Houses were visited to confirm the use of biomass and kerosene for generation of light for cooking and other domestic purposes. We also visited the Rivers State and the Nigerian Federal Ministries of Environment, Health and Justice to look for guidelines on environmental protection, carbon monoxide poisoning and its register and data on daily air monitoring in the Niger Delta and Nigeria at large.

RESULT

Review of literatures

Number of articles identified through search = 110. Number of articles dropped for duplication = 7. Number of articles screened = 103. Number of articles that did not meet the inclusion criteria and therefore dropped = 56. Number of articles that met the inclusion criteria = 47.

Nigerian national guidelines and laws on environmental protection

There were well articulated laws in Nigeria on environmental protection. Unfortunately, there were no specific guidelines on the protection of the environment against air pollution, including pollution with CO.

Nigerian national and regional register of CO poisoning

There was no such register in the Niger Delta or in Nigeria in general. There was no publication on CO poisoning and treatment in adults or in pregnancy. The Federal Ministry of Environment, Housing and Urban Development (FME & UD) adopted the WHO standards as the national standards for gaseous emissions against which air quality parameters monitored were compared in order to ascertain its cleanliness (14). CO = 11-14 (µg/m3) or 10 (ppm)

The WHO guideline on CO

The guideline was based on the exposure levels of CO to which a normal adult under resting conditions can be exposed for various intervals without exceeding 2% of maternal carboxyhaemoglobin (COHb) [15-21]. The WHO Guidelines for Europe takes into account periods of exposure to the gas: 15 minutes – 100 mg/m^3, 1 hour – 35 mg/ m^3, 8 hours – 10 mg/ m^3, 24 hours – 7 mg/m^3 [22]. A guideline for 24 hours (7 mg/m^3) was added to the WHO 2000 guidelines to address the risk of long-term exposure [22].

Conversion factors

At 760 mmHg and 20 ^{O}C, 1ppm CO = 1.165 mg/m3 and 1 mg/m3 = 0.858 ppm.

At 25 ^{O}C, 1 ppm = 1.145 mg/m3 and 1 mg/m3 = 0.873 ppm. Parts per million (ppm) by volume (100 ppm = 0.01% of CO in the air = 0.076 mmHg partial pressure of CO gas).

Endogenous production of carbon monoxide

Endogenous production of carbon monoxide by the body results from degradation of blood pigments. 75% of endogenous carbon monoxide arises from the degradation of heme in haemoglobin (the transformation of protoporphyrin into bilirubin liberates an atom of carbon monoxide), and *25%* is due to degradation of other blood pigments [23]. A normal man produces about 0-42 mL of carbon monoxide per Hour [23]. In women this production is identical during the follicular phase of the menstrual cycle, but doubles during the luteal phase [24].

During pregnancy the rate of endogenous production of carbon monoxide increases substantially, then drops rapidly after delivery. The increase in the erythrocyte mass in the pregnant woman accounts for about 30%-40% of the increase in carbon monoxide during pregnancy. Endogenous fetal production also plays a role, representing 15% of the increase and *5%* of the endogenous production of the mother [25].

Exogenous production of carbon monoxide

There are several sources of CO that affect the air quality in the Niger Delta region. Anthropogenic sources include economic and industrial activities especially in large urban centres and industrial complexes. Some of the sources are deliberated upon below.

Exposure to tobacco fumes – Smoking

Household exposure to carbon monoxide is the most frequent cause of poisoning during pregnancy [26]. Cigarette smoke contains on average 4% carbon Monoxide [27]. One cigarette smoked in 7-10 min releases 40 mL of carbon monoxide. The intra-alveolar concentration of carbon monoxide in a person who is in the process of smoking is between 400 and 500 ppm [28]. In a smoke-filled room a non-smoker is exposed to 25-100 ppm carbon monoxide. Chronic carbon monoxide poisoning from tobacco is usually well tolerated by pregnant women, but it may be very dangerous for the woman and her fetus when associated with any other source of carbon monoxide. In pregnant smokers the concentration of carboxyhaemoglobin in the blood is about 3%. Its level in the blood of the new-born infant of a non-smoking mother is about 2% [29]. It increases to 6%-9% if the mother is a smoker. Fortunately, in comparison with women that live in the developed world, women in sub-Sahar Africa rarely smoke cigarette.

Domestic sources of CO in the Niger Delta

They include domestic lighting (using generators) and domestic cooking (using firewood and kerosene). They emit 70 kt./year of CO and other gases [30]. Other domestic sources of CO are the use of dichloromethane in poorly ventilated locations (paint strippers, varnish removers), wallpaper stripping and indoor braziers and barbecues.

Biomass (Firewood) and Kerosene

Majority of both the rural and urban populace in the Niger Delta depend on the use of biomass (firewood, bamboo trunks) and kerosene for domestic cooking and lighting. This results in indoor and ambient air pollution with CO [31]. It is particularly so for those who live out of the cities and they constitute the majority in the Delta. Generally 70.0% of Nigerians rely on firewood for cooking. 26.6% depend on the use of kerosene or oil, while 0.52% and 1.11% use electricity and gas respectively [32].

The combustion of firewood releases gaseous pollutants namely CO, carbon Dioxide CO_2, sulphur dioxide SO_2, nitrogen dioxide NO_2, volatile organic compounds VOCs and particulate matters 2.5 and 10. The particulate matters generated are in the form of carbon black, sooth and fly ash which are major components of smoke.

Burning of fossil fuels in old vehicles

This is another major source of CO pollution in the region. It constitutes up to 90- 95% of the ambient CO levels, 80-90% of NO, hydrocarbon and particulate matter in the world, posing a serious threat to human health [33, 34]. Majority of Nigerians cannot afford new vehicles due to prohibitive costs and, as a result, use old cars. Such vehicles can emit five times more hydrocarbons and carbon monoxide and four times more nitrogen oxides than vehicles commonly found in developed countries [35].

Poor electricity supply and use of generators

Nigeria achieved a 46% electrification rate between 2000 and 2005, with an estimated 71.1 million people out of the estimated total 2005 population of 141.4 million without access to electricity [36]. The Nigerian Electricity Power Authority (NEPA) that produces electricity in Nigeria has not been effective and power generation is epileptic. Consequently, most industries in the Niger Delta depend on the use of petroleum- and diesel-fuelled generators. Some rural communities also depend solely on the use of an industrial generator for electricity supply. Unfortunately, the generators generate high concentrations of CO and other gases.

Agricultural causes of CO pollution - Bush burning

Many people who live in the Niger Delta are farmers. They engage in bush burning as part of preparations for farming and also palm oil production

both of which are associated with significant gaseous emissions [37]. The process of bush burning leads to the release of various types of gaseous pollutants and particulate matter. Very often the gas stream is inundated with volatile organics and CO, SO_2 and NO_2 depending on the fuel composition and intensity of the flame.

Refuse burning

Refuse disposal is a major environmental problem in the Niger Delta. One of the environmentally unfriendly methods of managing the waste is by open burning either on nearby lands or open dumps within the residential vicinities in both rural and urban areas. The composition of the refuse, age of the dump and intensity of the flame usually determines the nature of the air pollutants. Often times the air within refuse burning sites is inundated with CO, CO_2, VOCs, SO_2, NO_2, total hydrocarbons(THCs), as well as various classes of toxic and hazardous compounds like polycyclic aromatic hydrocarbons (PAHs), dioxins, PCBs (Polychlorobiphenyls) and heavy metals such as lead, nickel and mercury. All the chemical substances have implications for both mother and the foetus.

Sources of CO pollution from petroleum industry

The sources of air pollutants from petroleum production include three refineries (two in Eleme in Rivers State and one in Warri in Delta State), oil wells with flow station that are scattered all over the Niger Delta with some within rural dwelling environment, crude oil and condensate spills (both iatrogenic and through vandalism). Others are gas flares in the refineries, vapours from crude and refined oil storage, processing and transportation facilities, two petrochemical plants (one in Eleme and the other in Bonny), 6 gas liquefaction plants [32], fertilizer plant also in Eleme and many others.

Pollution from gas flaring in the Niger Delta

Since June 1956 when commercial oil exploration started in Oloibiri, Bayelsa State, the gas associated with oil production has been flared (Figures 1and 2).

Nigeria is responsible for 19.79% of natural gas flaring globally and 46% of Africa's total gas flared per tonne of oil produced [38]. There are more than 123 flaring sites in the Niger Delta [39]. Typical example is as shown in Figure 1 and Table 1.

Figure 1: Flaring Scene in the Niger-Delta Nigeria

Due to efforts by the Nigerian government at utilising the associated gas with crude oil through the development of liquefied natural gas (LNG) plant in Bonny, the volume of gas flared in Nigeria was reduced to approximately 23.0 million cubic meters, representing 39% of total gas produced in 2004/2005 [40]. Apart from CO, other pollutants from gas flaring include SO_2, non-methane volatile organic carbons (NMVOC), NO_2 and methane.

Six flow stations situated in the Niger-Delta were monitored daily for four consecutive months for concentration of CO at certain distances from the Stations [41]. Some of them were onshore while others offshore. The result is as shown in Table 1.

Table 1: Concentration of CO around the Flow Stations [41]

Flow Station	Concentration (µg/m^3)					
	Distance (Morning Sampling Period)			Distance (Afternoon Sampling Period)		
	60 m	200 m	500 m	60 m	200 m	500 m
1	300-2350 (1800±1000)	750-850 (800±50)	450-2750 (1100±1130)	400-3750 (2800±1580)	400-3750 (2800±1580)	500-3250 (1200±1380
2	2100-2350 (2300±130)	750-850 (800±50)	500-550 (500±30)	3550-3850 (3700±130)	2450-2650 (2600±90)	500*
3	980-5350 (3400±2180)	750-1370 (1190±300)	100-900 (500±450)	1150-2350 (1700±700)	190-1960 (1150±750)	100-1140 (400±490)
4	630-1740 (1200±610)	300-3850 (2800±1680)	400-750 (400±250)	750-2200 (1700±660)	900-6530 (4600±2650)	450-1100 (500±290)
5	2300-2350 (2500±380)	700-1100 (900±220)	100-2360 (1300±1120)	100-2140 (900±890)	750-1100 (1000±180)	100-850 (500±310)
6	100-2710 (800±1270)	100-430 (250±140)	100-1710 (500±540)	100-2550 (700±1230)	100-170 (140±30)	100-1850 (500±880)

Another source of gas flaring in the Niger Delta is explosion of oil pipelines which occurs either accidentally or by sabotage. Much of the pipeline explosions are a product of the later and they are usually accompanied most times with fire outbreak. The burning flame and smoke from the oil pipelines releases large concentrations of gaseous substances and particulate matter. The substances in most cases include CO, NO, VOCs, THCs, carbon black, soot and some heavy metal residues. Sometimes, the pipelines are located in residential areas as in Figure 2.

Figure 2: Crude and refined oil piles and flaring in residential area

Co pollution from power plants

The location of a specific activity is likely to be associated with the potential air quality of its immediate vicinity and even beyond [42, 43]. There are over 14 public power plants in operation or under construction located in Adam I and II, Eleme, Port Harcourt, Saelee, Uphill, Kale, Garran, Aba, Ormolu, Iota A base, Dupain, Awaji and Azure-Edo, all of which are in the Niger Delta. Many oil companies and heavy industries use private gas turbines to power their production facilities and residential quarters; for instance, the petrochemical plant in Eleme has four gas turbines and the liquefied natural gas complex in Bonny has ten gas turbines.

DISCUSSION

The study showed that although there were well articulated laws in Nigeria on environmental protection, there were no specific guidelines on the protection of the environment against air pollution, including pollution with CO. That is paradoxical given the volume of economic activities with associated environmental degradation in the region. Furthermore, not only was there no register of CO poisoning in the Niger Delta and in Nigeria in general but there was also no specific Nigerian national guideline on ambient or indoor CO concentration except the one that was adopted from the WHO guideline of 2000. We cannot therefore quantify the possible impact that CO pollution in the Niger Delta can have on the mother and fetus.

Pockets of studies that were reviewed in the study showed that the Delta was under profound siege of CO pollution. Nigeria is the leading gas flaring country in the World [44].

Heavy industries contribute immensely to CO pollution of the Niger Delta. 3 of the four Nigerian refineries are located in the Niger Delta. Warri refinery produces 67,117.96 Tons of CO / year, Port Harcourt (PH) Refinery phase 1 - 12,973.20 Tons of CO / year while PH refinery phase 2 - 104,230.14 Tons / year. Worse still, the PH refineries 1 and 2 are confined to a village called Alesa in Rivers State in the Niger Delta. It means, the inhabitants of the village and its surrounding have been living in high concentrations of CO for several years and therefore may suffer significant adverse health impact.

Furthermore, production of CO from flaring flow stations and refineries is another big problem in the Niger Delta. In many places, inhabitants of the Delta live on the right of ways of oil pipes and as near as 500 metres to crude oil flow stations, causing exposure to high doses of CO [45]. The problem is further compounded by Smoking vehicles which ply on Niger Delta roads. Roadside ambient CO concentrations ranged from 100 -191 µg/m3, with few towns having 50-100 µg/m3 [45].

Inhabitants of the Delta are also exposed to high indoors concentrations of CO because of using firewood, kerosene as biofuel and generators as source of light. Levels of 19.05- 33.0 ppp in living rooms and 23.85 – 38.55 ppp in kitchens have been recorded [46].

RECOMMENDATIONS

Firstly, the Nigerian environmental protection laws should be revived, and measures should be put in place to actualise its implementation. Secondly, the full

WHO guideline on CO should be adopted so that accurate and unified comparison can be achieved. A register of CO poisoning should be maintained in the Niger Delta so that the true burden of the problem can be ascertained. Furthermore, there is need for unified Niger Delta ambient air quality assessment as practised in developed countries. This will go a long way to identify those regions that are worse affected. It is imperative that the use of generators for energy supply is banned in Nigeria and the National grid decentralized to State governance with a view of eradicating the epileptic electric supply that strangles all spheres of human endeavor in the Delta. Vehicles on the roads should be certified yearly for road worthiness.

Finally, environment-friendly gas supply should be made available for domestic purposes and use of biomass and kerosene should be abolished. The above measures should a long way, reducing the impact of CO pollution on mothers, fetus and all in general.

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