Air Pollution in the Niger Delta Area: Scope, Challenges and Remedies

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1. Introduction

Air pollution is one of the major environmental problems confronting the Niger Delta Area (NDA) yet information regarding this is very scanty. Aside from data collected by a few individuals and corporate organizations at scattered locations, there is no comprehensive and empirical database on the magnitude of the hazard and its deleterious effects on the ecosystems and people in the region. Also the existing network of meteorological stations is too coarse to provide data covering the whole of the region. The NDA is Nigeria's most endowed region in terms of oil mineral reserves and one of the most industrialized after Lagos, Nigeria's former administrative capital. The operations of these industries especially the upstream and downstream petroleum sectors as well as a variety of other anthropogenically related activities including biomass combustion, refuse burning and traffic emissions releases a barrage of substances like volatile organics, oxides of carbon, nitrogen, sulphur, particulate matter, heavy metals and other toxics at levels that most times exceed both the national and international guidelines. Apart from compromising the quality of the atmosphere most of the air pollution in the region is observed to have local and regional effects such as the formation of acid rain, water pollution, soil pollution, impacts on plants and wild life, effects on materials and artifacts and recently contributing to the global warming effects. While most of these claims may be true a great majority has not been substantiated scientifically and is rather based on assumptions or being speculative. There are numerous challenges facing air quality studies in NDA. Like in most developing nations the issues are multifaceted and the most acute have been lack of equipment, inadequate expertise, lack of infrastructure and weak policy frame work. This and many other factors has been the bane to achieving the much desired goals towards preserving the quality of the ecosystems and safeguarding the health of the public in the region. In this chapter a conscious effort has been made to give a brief description of the Niger delta area, the possible sources of air pollution in the region with highlights of a few case scenarios of air pollution from community automobile traffic and industries as well as common related health problems. Again as a way forward to most of the problems and drawbacks hitherto mentioned several models and schemes have been advocated.

2. The Niger Delta area

The Niger Delta area in Nigeria (Fig 1) is situated in the Gulf of Guinea between longitude 50E to 80E and latitudes 40N to 60N.It is the largest wetland in Africa and the third largest in the world consisting of flat low lying swampy terrain that is criss-crossed by meandering and anastomosing streams, rivers and creeks. It covers 20,000 km² within wetlands of 70,000 km² formed primarily by sediment deposition. It has an equatorial monsoon climate influenced by the south west monsoonal winds (maritime tropical) MT airmass coming from the South Atlantic Ocean. It is home to 20 million people drawn from nine states namely Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers states with 40 different ethnic groups. This floodplain makes up 7.5% of Nigeria's total land mass. The Delta's environment can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests. This incredibly well-endowed ecosystem, contains one of the highest concentrations of biodiversity on the planet, in addition to supporting abundant flora and fauna, arable terrain that can sustain a wide variety of crops, lumber or agricultural trees, and more species of freshwater fish than any ecosystem in West Africa. The vegetation of the Niger Delta consists mainly of forest swamps. The forests are of two types, nearest the sea is a belt of saline/brackish Mangrove swamp separated from the sea by sand beach ridges. Numerous sandy islands occur with fresh water vegetation. Fresh water swamps gradually supersede the mangrove on the landward side. More than 70% of Nigeria's crude oil and gas production is from the area. The region produces over 90% of Nigeria’s foreign earnings through oil exploration activities. It plays host to most of the upstream and downstream oil related industries and non oil related industries that release tons of pollutants into the ecosystems. The pollution from the Niger Delta on a scale could be regarded as one of the worst among similar delta areas in the world.

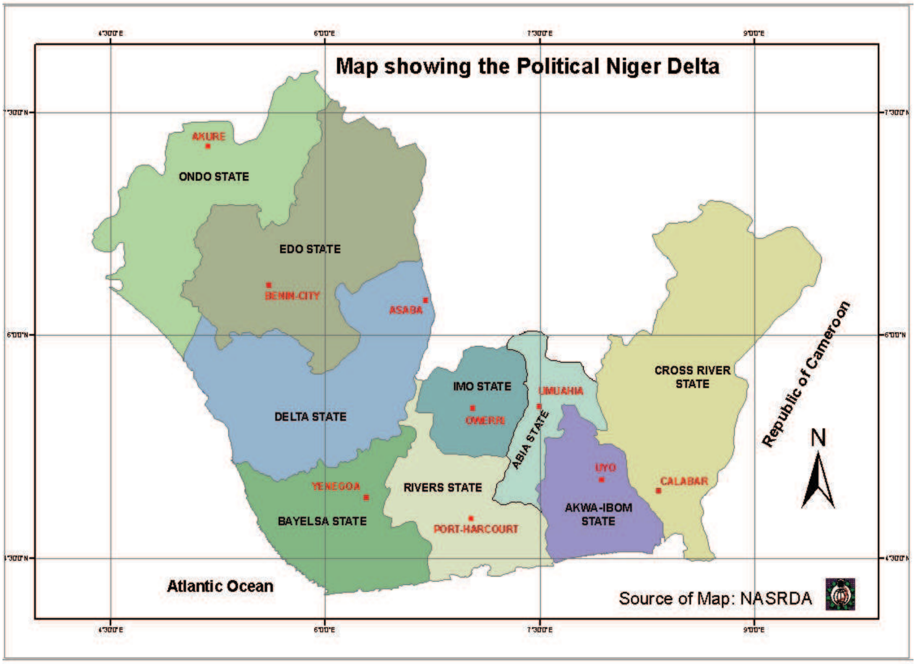

Fig. 1. Political Map of the Niger Delta Area

3. Air pollution sources

3.1 Biomass combustion

Biomass in form of firewood, coal, bamboo trunks and dead leaves are commonly used sources of cooking fuel in the region. Of all these the most frequently used is firewood. This fuel woods are usually logged from nearby bushes and forests or are collected as dead branches within the residential vicinities by the women and sometimes children and are used to generate energy for cooking(Pate 1). The combustion of firewood releases gaseous pollutants and particulate matter. From literature the gaseous pollutants from cooking emissions are carbon monoxide CO, carbon dioxide CO_2, sulphur dioxide SO_2, nitrogen dioxide NO_2, volatile organic compounds VOCs and particulate matter. The particulate matter generated is in the form of carbon black, sooth and fly ash which are major components of smoke and are most often within the 10µm size range.

Plate 1. Cooking Fuel emissions from biomass combustion

3.2 Bush burning

Bush burning is a common phenomenon in the Niger delta communities. Most times the burning of bush is done prior to land cultivation as one of the initial steps of land preparation. This constitutes part of the pre planting preparation. 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 oxides of carbon (COx), sulphur(SOx) and nitrogen(NOx) depending on the fuel composition and intensity of the flame. Particulate matter usually within the 10µm size range is also produced in the course of the combustion process.

3.3 Refuse burning

Refuse disposal is a major environmental problem in the Niger delta communities particularly in the urban areas (Plate 2). The refuse is usually from multiple sources including domestic, municipal, agricultural and industrial sources. 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. 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 VOCs, COx, SOx, NOx, total hydrocarbons(THCs), as well as various classes of toxic and hazardous compounds viz polycyclic aromatic hydrocarbons(PAHs), dioxins, PCBs(Polychloro Biphenyls) and heavy metals such as lead, nickel and mercury.

Plate 2. Emissions from open burning of solid waste

3.4 Traffic emissions

Over 600 million people globally are exposed to hazardous level of traffic – generated pollutants UN, (1998). Human exposure to these air pollutants is believed to have posed severe health problems especially in urban areas where pollution levels are on the increase. Pollution due to traffic constitute up to 90 – 95% of the ambient CO levels, 80 – 90% of NOx, hydrocarbon and particulate matter in the world, posing a serious threat to human health Savile, (1993). Research has shown that transportation sources in the USA were responsible for 77% of CO levels, 80 -90% of NOx, 36% of volatile organic compounds and 22% of particulate matter USEPA, (1993). Similarly, in UK the average concentration of NO_2 was found to increase by 35% from 1986 to 1991 due to increase in vehicular emission CEC, (1992). On the global scene, Seneca and Tausig, (1994) concluded that transportation is the major culprit of air pollution accounting for over 80% of total air pollutants.

In Nigeria much attention is focused on general industrial pollution and pollution from the oil industries, with little attention on the effects of air pollution from mobile transportation sources (Faboye, 1997; Iyoha, 2000 and Magbabeola, 2001).Increased pollution from mobile

Plate 3. Traffic emissions from busy urban roads

sources is on the increase with per capita increase in vehicle ownership(Plate 3). The consequence of this is the congestion of most Nigeria city roads and a corresponding increase in the burden of air pollutants and their associated effects. Studies conducted by Akpan and Ndoke, (1999) in Northern Nigeria show higher values of CO_2 concentration (1780ppm- 1840ppm) in heavily congested areas in Kaduna and (1160ppm-1530ppm) in Abuja. A study of the impacts of urban road transportation on the ambient air was conducted by Koku and Osuntogun, (1999) in three cities in south western Nigeria. Air quality indicators namely CO, SO_2, NO_2, and total suspended particulates (TSP) were determined. The highest levels obtained for the air pollution indicators were CO- 233ppm , SO_2-2.9ppm , NO_2-1.5ppm and total particulates 852ppm in Lagos . In Ibadan the highest levels obtained were CO-271ppm, SO_2 -1.44 ppm and NO_2- 1.0ppm. In Ado-Ekiti the highest levels obtained were CO-317ppm, NO_2 -0.6ppm and SO_2-0.8ppm. These results were found to be higher than FEPA limits for CO-10ppm, SO_2-0.01ppm, NO_2-0.04-0.06ppm.

A comparative study of emission levels in Lagos and the Niger Delta area was reported by Jerome, (2000). Two major cities, Port-Harcourt and Warri were considered for the NDA. The results obtained showed that the concentrations of TSP, NOx, SO_2, and CO in Lagos and the Niger Delta communities were above the FEPA recommended limits. The CO levels for Lagos 10 – 250ppm were higher than the levels 5.0 – 61.0ppm and 1.0 – 52ppm recorded in the two selected communities in the Niger Delta. The TSP concentrations were also high for both locations when compared to WHO standard. A similar traffic related emission study was carried out in Calabar, a major city in NDA and the results presented in the box indicate that the overall average value(OAV) of each pollutant for the 72 hours experimental duration was found to be in the following range: CO :5.0 – 6.1ppm, NO_2 :0 -0.05ppm, PM10: 202 - 230μg/m^3.

Lagos Area Pollutant	Non-Traffic Urban zone	Traffic Zone	Niger Delta Area Oil Communities	Cities	FEPA Standards
TSP μ/m^3	31.4 -746.5	72 – 950	92.2 – 348.5	396.8 – 583.3	250
NOX(ppm)	81 – 81.5	34 – 131.6	22.0 – 295.0	35 – 370	40 – 60
SO_2(ppm)	0.5 – 43	20 – 250	7.0 – 97.0	16 – 300	100
CO(ppm)	0.5 – 3.9	10 – 250	5.0 – 61.0	1.0 – 52	10
CO/NO_X(ppm)	0.0 – 6.0	50 – 200	20	15 – 130	-

Source: Jerome 2000

Table 1. Ambient air pollutants in Lagos and Niger Delta Area

At the National level, available data on the total number of vehicles registered in Nigeria shows an increase from 38,000 to 1.6 million between 1950 and 1992(Enemari, 2001). Data from the Federal Road Safety Commission (FRSC) of Nigeria however, indicates that between 1999 and 2004 about six million vehicles (6,000,000) were registered in Nigeria (Fig 2) of which 70% of the registered vehicles were cars and 30% busses and trucks. The reason for the large increase of registered vehicles in 1999 was due to the deadline given for the registration of all vehicles in the country by FRSC. The subsequent years indicate vehicles coming in for the first time into the country. The increase recorded in 2002 was the climax due to favourable government policies on importation of fairly used vehicles at the inception of democratic rule in Nigeria. Although there was a decline in 2004, it is obvious that the number of vehicles plying Nigerian roads had continued to increase. In Lagos alone about 223,764 vehicles were registered in 2008 compared to 160,134 vehicles registered in 2007. Also in the first quarter of 2009 more than 58,000 vehicles were registered and a total of 27,587 motorcycles were also registered between July 2006 and July 2009 (http//alafrica.com/stories). From the above data it is apparent that the average emission concentration from motor vehicles and motorcycles in the country is in the increase.

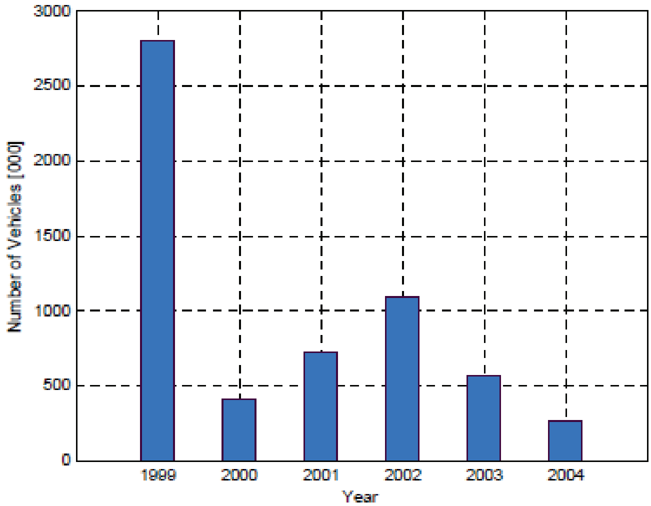

Fig. 2. Total number of vehicles Registered in Nigeria (1999-2004)

Box 1: Traffic Emission Scenario in Calabar

The overall average values (OAV) of each pollutant for the 72 hours experimental duration was found to be in the following range: CO: 5.0-6.1ppm, NO2 – 0 -0.05ppm, PM10 – 202 – 230 μg/m^3 and noise level was 60.5 – 63dB. Comparing these values with AQI CO, range from moderate to very poor; PM10 and SO_2 were very poor. The OAV value of NO_2 is constant for the three experimental days comparing with AQI rating the value is still poor. The reason for this constant OAV value of NO_2 could be the recent government policy of replacing the intercity transport system with new efficient cars with catalytic reduction system. The overall AQI rating for ambient air quality data indicates that the air quality standard in Calabar is below the USEPA standard for ambient air quality rating. .

3.5 Industrial emissions

Apart from Lagos which was the former political capital but still regarded as Nigeria's economic capital, the next most industrialized part of the country is the Niger Delta Area. The region boasts of oil and non oil related industries including refinery, petrochemical, liquefied natural gas, chemical fertilizer, aluminum smelter, paper, cement, flour, wood, battery and textile industries etc which emit various kinds of air pollutants (Box 2). The pollution from these industries adds to the burden of gaseous and particulate pollutants in the air. In this chapter information regarding air pollution from three of these industries namely the chemical fertilizer plant, petroleum refinery plant and the petrochemical complex would be reported.

Box 2: Major Air pollutants in NDA

Gases: CO_2, CH_4, SO_2, N_2O, NO_2, NH_3 VOCs

Particles: PM10, PM2.5, PAHs, Dioxins PAHs, Heavy metals

3.5.1 Chemical fertilizer industry

The chemical fertilizer industry in Nigeria is still in its infant stage. The National Fertilizer Company of Nigeria (NAFCON) described here is located at Onne (4.49^0 and 4.50 N and 6.59^0 and 7.00 East of Greenwich Meridian), 30 km away from Port Harcourt in the Niger delta area. It utilizes a variety of raw materials such as natural or synthetic gas (methane), atmospheric nitrogen, steam and sand as filler material in the production of various formulations. The major products (per day) are ammonia (1,000 tonnes), urea (1,500 tonnes), and NPK formulations (1,000 tonnes).The main sections where gaseous and particulate emissions are reported are the ammonia plant, urea plant, NPK plant, bulk blending plant, bulk storage plant, and the bagging area. Potential sources for leaks in the ammonia plant are the refrigeration loop, storage areas, flanges, valve packing, and the pump and compressor seals. The gaseous emissions from the ammonia plant include reformer and boiler flue gases, excess carbon dioxide, condenser stripper vapour and ammonia discharge. The gases coming from the reformer are vented into the atmosphere with a mixture of CO_2 (20%) and O_2 (3-4%). Most of the CO_2 is recovered and recycled in the process. The condensate of the process water contained some CO_2, methanol and other dissolved gases, which are usually stripped. In the urea plant there are two possible sources of emissions, viz. the high-pressure scrubber and the granular stack. Some amounts of methane, hydrogen, ammonia and CO_2 are released. The wet scrubbers also release some particulate urea through the vent. In the NPK plant the tail gas scrubber is the only source of emission of ammonia, particulates and small quantity of fluoride. In various operations, e.g. granulation, drying, mixing and cooling, some amounts of dust and fumes are generated. In a study carried out by Ana et al,2005 the highest mean levels of ammonia (459.1ppm), was recorded at the Urea synthesis plant and the lowest levels (7.29ppm) recorded at a control point about 5km away from the point. For particulate matter, the highest concentration of 260875.7 $\mu g/m^3$ and the least concentration of 7.29ug/m^3 were recorded.

3.5.2 Refinery and petrochemical complex

The quality of air in Nigeria's largest oil refinery (PHRC) and petrochemical complex (EPCL) was assessed based on key priority pollutants in a study carried out by Ana et al(2009)(Plate 4).Three points each were observed per industrial location At the refinery, the highest PM10 level (130.3$\mu g/m^3$) was recorded while at the petrochemical complex the highest PM10 level (81.3 $\mu g/m^3$) was recorded. The study indicated that the average PM10 levels at PHRC were higher than that recorded at EPCL .In terms of the level of heavy metals, the highest Pb and Ni levels of 0.20 mg/m^3 and 0.86 mg/m^3 respectively was recorded at the PHRC. At the petrochemical complex, the highest Pb and Ni levels of 0.16 mg/m^3 and 0.05 mg/m^3 respectively was recorded at EPCL. Overall, the average heavy metal concentrations were higher at PHRC.The highest concentration of benzo (a) pyrene (1.63x102ng/m^3) was recorded at PHRC compared to (1.61x102 ng/m^3) that was recorded at EPCL. However, the total PAH concentration taken as the sum of benzo(a)pyrene and indeno(123)-cd pyrene was found to be higher at EPCL when compared with PHRC(Table 2).

3.6 Gas flaring

According to Cedigaz (2000), Nigeria holds the highest record (19.79%) of natural gas flaring globally and is responsible for about 46 % of Africa's total gas flared per tonne of oil produced(Plate 5). Until present there are not less than 123 flaring sites in the region making Nigeria one of the highest emitter of green house gases in Africa (Uyigue and Agho, 2007). Similarly, analytical assessment of the statistical bulletin of the Central Bank of Nigeria, (2004) showed that the average rate of gas flaring in Nigeria during the period 1970-1979 stood at 97%, while 97% and 95% were flared between 1980 and 1989, and 1990 to 1999 respectively. Between 2000 and 2004 51% was flared. In the same vein, between 1970 and 2004 Nigeria has flared an average of 76% of the total gas produced. Much of the natural gas extracted in oil wells in the Niger Delta is immediately flared into the environment at a rate that approximates 70 million /m^3 per day. This is equivalent to 40% of African natural gas consumption and forms the single largest source of greenhouse gas emissions on the planet (Wikipedia 2007, Moffat and Linden, 1995). Orubu, (2002b), who undertook a comparison of concentrations of ambient air pollutants in the region and Lagos State concludes that

Plate 4. Emissions form a Petrochemical plant

Parameter	PHRC1 (Mean ± SD)	PHRC2 (Mean ± SD)	PHRC3 (Mean ± SD)	Average/ Location	Guideline Limits
PM_{10} ($\mu g/m^3$)	130 ± 3.32	36.5 ± 1.27	27.9 ± 2.33	64.8	100(FMENV)
Pb (mg/m^3)	0.16 ± 0.12	0.20 ± 0.03	0.11 ± 0.10	0.16	–
Cd (mg/m^3)	0.008 ± 0.002	0.003 ± 0.001	0.009 ± 0.006	0.007	–
Ni (mg/m^3)	0.004 ± 0.002	0.009 ± 0.004	0.86 ± 0.34	0.291	–
Benzo (a) pyrene ng/m^3	–	–	1.63×10^2	54.3	<0.1–100ng/m^3 (WHO, 1997)
Indeno (1,2,3–cd) pyrene ng/m^3	1.53×10^3	2.53×10^3	–	0.0014	<0.1–100ng/m^3 (WHO, 1997)
TPAH* (ng/m^3)	1.53×10^3	2.53×10^3	1.63×10^2	54.3	<0.1–100ng/m^3 (WHO, 1997)

* Total PAH (sum of benzo(a)pyrene + indeno(123-cd)pyrene)

Table 2. Levels of Priority Air pollutants in Nigeria's Refinery and Petrochemicals

pollutant concentrations are highest in the Niger Delta and argues that some of the green house gases (such as methane and carbon dioxide) emitted at flare sites contribute to global warming. The largest proportion of these flare sites are located in the Niger Delta.

Plate 5. Gas flaring from an oil exploration process

3.7 Pipeline explosion

The explosion of pipelines occurs either accidentally or by sabotage(Plate 6). In the Niger Delta area 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 COx, NOx VOCs, THCs, carbon black, soot and some heavy metal residues.

3.8 Multiple air pollution sources

Within the Niger delta communities there are diverse sources of air pollution. The common air pollution sources are biomass combustion, bush burning, automobile emissions, generator emissions, pipeline explosions, industrial emissions and gas flaring. The measurement of air quality for some specific priority pollutants viz ammonia, particulate matter and Polycyclic aromatic hydrocarbons at specific locations within the communities has been carried out using standard procedures (Ana et al, 2005, 2009). The mean values of the parameters are presented in Table 3.

3.9 Meteorological conditions in the Niger Delta

The Niger Delta has a humid, semi-hot equatorial climate. Temperature ranges are small and constant throughout the year. It's hottest month records 28 °C (82.4 °F) and its coolest month 26 °C (78.8 °F) with the temperature range of not more than 2 ºC (5 ºF). Precipitation

Plate 6. Emissions from fire outbreak following pipeline explosion

Air quality at Eleme and Ahoada East

Sample Parameter	Eleme Mean ± SD	Range	Ahoada East Mean ± SD	Range	National Guideline Limits	*t*-statistic	*p*-value
TSP(mg/m^3)	123.4 ± 14.9	37.2–260.6	53.5 ± 26.3	8.84–161.4	100 (mg/m3)	–6.118	0.0001**
Fe (mg/m^3)	0.09 ± 0.06	0.09–0.10	0.027 ± 0.006	0.01–0.05	None	–2.764	0.0171*
Zn (mg/m^3)	0.05 ± 0.03	0.02–0.10	0.05 ± 0.02	0.03–0.42	-do-	0.000	1.000
Pb (mg/m^3)	0.06 ± 0.03	0.03–0.10	0.14 ± 0.03	0.03–0.13	-do-	4.939	0.0003**
Cd (mg/m^3)	0.009 ± 0.01	0.002–0.02	0.006 ± 0.003	0.004–0.01	-do-	–0.760	0.4618
Ni (mg/m^3)	0.03 ± 0.02	0.02–0.05	0.03 ± 0.02	0.01–0.05	-do-	0.000	1.000
†PAH(ng/m^3)	7.99×10^3	3.48×10^{-1}–	1.21×10^{-3}	2.50×10^{-5}–	<0.1 –	7.62×10^6	0.000**
	$\pm 1.31 \times 10^4$	1.88×10^4	$\pm 2.77 \times 10^{-3}$	7.49×10^{-3}	100 ng/m^3		
	(1.91×10^2)		(6.43×10^{-4})				

* Significant ** Highly Significant

† Values in brackets represent median values for PAH in the various locations

Table 3. Levels of Air Quality Parameters in Two Niger Delta Communities

is heavy, between 1824 millimeters to over 4000 millimeters along the coast. Rain falls throughout the year with a short break in August and a longer break from December to January. The heavy rainfall experienced in the area leads to floods in urban areas and communities along the rivers. Also due to the heavy and frequent rainfalls, soils consisting mainly of silt and clay become saturated, reducing infiltration to the barest minimum and encouraging run-off. Rainfall induced run-off is directed mainly to the back swamps in the upper and middle parts of the delta. In the coastal zone, there is an even smaller topographic gradient that makes run-off difficult.

4. Environmental and health problems associated with air pollution in the delta area

4.1 Environmental problems

4.1.1 Formation of acid rain

From the release of large concentration of oxides of nitrogen and sulphur in the Niger delta environment it is glaring that some cases of acidified rain occur in the region. Although literature is deplete in this area it is obvious that such phenomenon is experienced. Olobaniyi and Efe (2007) also show elevated levels of lead (0.56 mg/l) and low pH values ranging from 5.10 – 6.35 in rain water collected in Warri and environs. Akpoborie, *et al*, (2000) also report low pH values from water obtained from shallow hand dug wells in Ughelli, Warri, and Okurekpo all in Delta State.

4.1.2 Visibility Impairment

Most combustion processes lead to the release of oxides of nitrogen and lower fractions of hydrocarbons and in the presence of uv radiation the resultant smog could lead to decrease in visibility. Although not readily reported this is a common phenomenon in a region like the Niger delta that has large hydrocarbon deposits and various episodes of combustion processes.

4.1.3 Ambient thermal conditions

Some 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger-Delta from 1.8 billion cubic feet of gas everyday (Aaron, 2006). Ogbuigwe (1998), reports that temperatures produced at flare sites could be as high as 1,600^{o}C. Temperature as high as 400 ^{o}C at an average distance of 43.8metres from flare sites in Isoko, Delta State have been recorded.

4.1.4 Effects on vegetation and animal life

Studies by Alakpodia (1989, 1995) showed that flares have negative effects on vegetation growth, animal life and ecological equilibrium in the Niger Delta area. Heat Production kills vegetation around the heat area. It suppresses the growth of flowering plants and reduces agricultural productivity and wild life biodiversity.

4.1.5 Corrosion effects on materials and other artifacts

The presence of acidified rain water in the environment increases the corrosion rate of roofing sheets, monuments and other economic structures. In the Niger delta area there is glaring evidence of the impacts of corrosion on several building structures and arts work and these cases have been observed to deteriorate at rather alarming rates.

4.1.6 Coastal erosion and flooding

Awosika and Foluronsho, (2006) documented projected impacts of sea level rise SLR on the Nigerian coastal area and resources to include: large scale inundation, increased coastal erosion, salt water intrusion into coastal aquifers, habitat modification with direct effects on wild life distribution, increased frequency of high intensity rainfall events and associated increased run off, elevated erosion rates, flash floods and increased frequency of ocean storm surges. Other models projected a loss of up to 15,000 km^2 by the year 2100 as a result of a 1m (SLR) while Magbagbeola, (2002) projects flooding of over 18,000km^2 land area within the delta in an SLR of 1m in the next 100 years.

4.1.7 Air quality impairment

Oluwole et al.(1996) in a typical air quality assessment of the Niger Delta showed that the levels of volatile oxides of carbon, nitrogen and sulphur and total particulates exceed existing Federal Environmental Protection Agency's (FEPA,1991) standards. Also Olobaniyi and Efe (2007) showed elevated levels of lead at concentrations of 0.56 mg/l in the atmosphere.

4.2 Health effects

4.2.1 Common health problems in the general population

A survey was carried out on the health conditions of populations' resident and working in the Niger Delta communities (Ana et al, 2009).A summary of the prevalent air pollution-related morbidities is shown in Box 3. Two communities, one with high industrial presence, Eleme and the other, Ahoada East, with low industrial presence were selected. Questionnaire and hospital records were employed for this survey and morbidities that have direct bearing with air pollution were focused on. The questionnaire survey indicated that at Eleme (39, 60.9%) as compared to Ahoada East (10, 4.5%) reported contaminated air as the major reason for ill health among the residents. Also there were more reported cases of skin outgrowths among Eleme residents as compared to Ahoada East. The morbidity conditions from hospital records for respiratory disorders showed 3.85% in males and 4.39% in females (Fig 3a). At Ahoada East respiratory disorder was(3.68% male; 4.18% female) (Fig 3b). In terms of respiratory disease, there was a high significant difference ($p < 0.0001$) between the male and female population at Ahoada East only. Also between Eleme and Ahoada East there was a significant difference among the male population ($p = 0.04$) and the female population ($p = 0.05$) (Figures 4 and 5).In addition the results indicated that for the combined male and female population, there was a significant difference between the two communities for skin disorders ($p = 0.023$) and disease of the respiratory tract ($p = 0.045$).

Box 3: Prevalent Air Pollution related Morbidities
Breathing Difficulties
Bronchitis
Aggravation of Asthma
Cardio-respiratory disorders
Pulmonary edema
Eye disorders
Skin disorders

4.2.2 Common health problems in the industrial community

In a study carried out by Ana et al (2005) in which 384 plant workers were interviewed in a chemical fertilizer industry at Onne in the Niger Delta, 70.5% spend 8 hours per day at work. 66.1% reported respiratory disorders, 24.4% reported skin disorders and 22.6% reported eye disorders. There were strong associations ($p < 0.05$) between eye and respiratory disorders and the industrial activities carried out by the workers. Also Ana et al (2009) in another survey carried out among refinery (PHRC) and petrochemicals (EPCL) plant workers reported that 70.8% workers at PHRC as compared to 67.2% at EPCL reported various health problems related to poor air quality conditions. In both cases, the major cause was attributed to gas flaring. Symptoms associated with exposure to fumes and sprays such as respiratory disorder were widely reported among 40.8% PHRC and 27.6% EPCL workers. There were reports of respiratory symptoms associated with exposure to dust and smoke, leading to irritation among 65.7% PHRC and 57.1% EPCL workers. Both the eyes and the skin were among other parts of the body also affected by the irritants. Further statistical analysis indicated that the duration of stay of PHRC workers in their residential communities was significantly associated with respiratory health problem ($p=0.000$), with Cancers ($p=0.000$). At EPCL, the duration of residence in the community was significantly associated with miscarriages ($p=0.000$), with deformed children ($p=0.000$) and with symptoms related to health effects from air contaminants ($p= 0.000$).

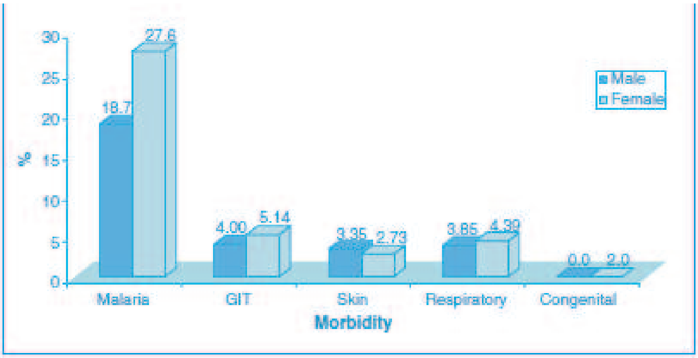

Fig. 3a. Typical morbidity pattern in a more industrialized NDA community

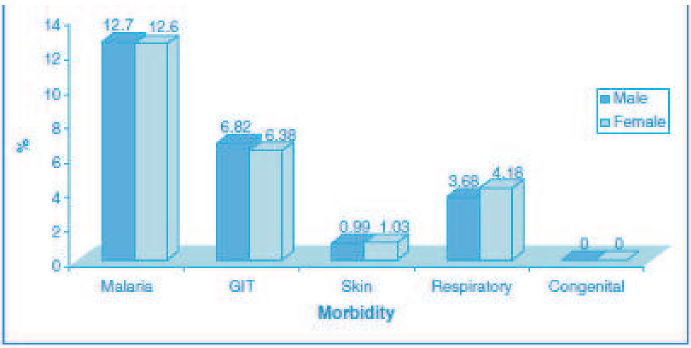

Fig. 3b. Typical morbidity pattern in a less industrialized NDA community

4.2.3 Emerging health problems

The exposure of populations to a barrage of pollutants and pollution episodes in the Niger delta area is believed to cause several health problems, of which etiologies of most cannot be ascertained. Cancer prevalence is believed to be on the increase. Studies by Ana et al(2010) revealed that of the two cancer reference centres Ibadan in the South west and Port Harcourt in the Niger delta the ratio of reporting was 1:4 for UPTH (904) and UCH (3521) respectively. The results indicate that apart from prostate and breast cancers that were higher in Ibadan (79.1%) than in Port Harcourt (75.4%) both the lung and skin cancers were more prevalent in Port Harcourt than in Ibadan(Table 4). This observation is consistent with studies by Ana et al.(2009) which indicated increased lung cancers in the Port Harcourt environment due likely to exposure to atmospheric insults. Similarly, the higher percentage of skin cancer in Port Harcourt above that recorded in Ibadan could be explained though with some degree of uncertainty by the increased environmental risk factors in the more industrialized Port Harcourt area.

Cancer types	Port Harcourt (N=904)	Ibadan(N=3521)	X^2	p- value
Lung	33(3.7)	113(3.2)	0.44	0.508
Skin	172(19.0)	365(10.4)	50.59	<0.001
Eye	15(1.7)	258(7.3)	39.92	<0.001
Others	684(75.4)	2787(79.1)	5.18	0.023

Table 4. Comparison of Cancer cases between two prominent cities in Nigeria

5. Challenges of air quality studies in the Delta area

Air quality studies in Nigeria and particularly the Niger Delta area is still in its infant stage and encumbered with several challenges. According to Taiwo (2005) air pollution studies in Nigeria are few and independently carried out. The same author also indicated that government is not involved in systematic and consistent air quality assessment programmes as is being done in other parts of the world such as that carried out by the Environmental Protection Agency (EPA) in the United States. There is the problem of insecurity and difficulty in terrain that militates against most community based air sampling initiatives and then the lack of requisite and adequate technical manpower to carry out the multifaceted and complex air quality studies in the region. Other obvious and prominent drawbacks are as follows

- Lack of emissions inventory/database due to lack of consistent and systematic measurements
- Unavailability of air pollution and GHG monitoring stations in the Niger Delta. This is based on information from World Data Centre for Greenhouse Gases
- Few independent and research-based measurement data are not readily available for general public use
- Lack of collaboration between key regulatory authorities
- Laxity in the enforcement of emission regulations
- Air quality assessment and air pollution studies have focused mainly on urban centres (Ajao& Anurigwo, 2002)

6. Conclusions

Air pollution has been identified as one of the most critical environmental problems confronting the Niger delta Area. Traffic, industry and gas flaring are the major air pollution sources in the region. Impact on socioeconomic, ecosystems health, properties and climate have been linked with the pollution episodes in the area but which requires substantial scientific and empirical evidence. Multiple factors especially lack of equipment, inadequate skilled personnel and poor policy frame work has militated against effective and qualitative air quality studies in the area. To achieve long term goals for the region in this regard that would lead to the overall benefit of the people in the area, there is need therefore to employ a holistic and integrated approach to air pollution management that will involve all the stakeholders.

7. Future directions

In order to improve on the current air quality monitoring and assessment programmes in the Niger Delta area there is need to embark on the following:

- Develop monitoring mechanisms, regulations and enforcement measures
- Institute planning policies to minimize pollution that may be caused by future development.
- Government agencies such as the Niger Delta Development Commission(NDDC) should collaborate with other multinationals and stakeholders in air pollution management to come up with a comprehensive AQM scheme for the region.
- There should be a focus on the reduction of pollution levels from vehicles, industry, gas flaring and domestic burning of timber, to permissible levels as defined in national and international standards.
- The impact of air pollution from industrial and vehicular sources on the health of the communities in the region and its biodiversity needs to be researched in-depth.
- Existing air quality monitoring programmes should be re-examined and new ones introduced to determine the most effective means of mainstreaming national programmes with regional projects to improve air quality.
- Research on air quality should focus on source apportionment of the pollutants in the region
- Indepth epidemiological and toxicological studies using risk and exposure assessment tools need to be carried out to establish causalities between the air pollution exposure factors and the associated health problems.
- Motor vehicles annual testing and other regulations must be created or re-introduced and strictly enforced.
- Focus should be on air pollution models, real-time monitoring of pollutants and speciation of pollutants from the particulate matter.
- There is a need to engage in renewable energy, clean energy and cleaner air initiatives.
- Usage of emissions abatement control mechanisms by polluters should be enforced.

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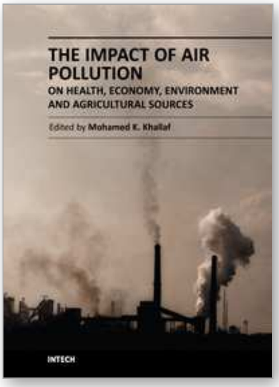

The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources

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This book aims to strengthen the knowledge base dealing with Air Pollution. The book consists of 21 chapters dealing with Air Pollution and its effects in the fields of Health, Environment, Economy and Agricultural Sources. It is divided into four sections. The first one deals with effect of air pollution on health and human body organs. The second section includes the Impact of air pollution on plants and agricultural sources and methods of resistance. The third section includes environmental changes, geographic and climatic conditions due to air pollution. The fourth section includes case studies concerning of the impact of air pollution in the economy and development goals, such as, indoor air pollution in México, indoor air pollution and millennium development goals in Bangladesh, epidemiologic and economic impact of natural gas on indoor air pollution in Colombia and economic growth and air pollution in Iran during development programs. In this book the authors explain the definition of air pollution, the most important pollutants and their different sources and effects on humans and various fields of life. The authors offer different solutions to the problems resulting from air pollution.

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