IMPACT OF GAS FLARING ON THE BUILT ENVIRONMENT : THE CASE OF OGBA/EGBEMA/NDONI LOCAL GOVT AREA, RIVERS STATE, NIGERIA

Iyorakpo, Julius
Facilitator, School of Science and Technology, National Open University of Nigeria, Yenagoa Study Center, Bayelsa State-Nigeria
Odibikuma, P. Wagio

Abstract

This research was conducted to determine the Impact of Gas flaring i.e. Associated Gas (AG) on the built environment by Oil and Gas production and prospecting companies operating in Ogba/Egbema/Ndoni Local Government Area (ONELGA), Rivers State of Nigeria. Data for the study was obtained from both primary and secondary sources. Instruments such as Questionnaire, Interview and Observation methods were used for data collection from individuals and Oil and Gas companies in the area while simple percentage and tables were used for data analysis. The study came up with the following findings that; Ogba/Egbema/Ndoni area is immensely polluted with various pollutants ranging from acid rain, carbon monoxides, heavy metals and lead compounds. The impacted variables include corrosion, leakage, staining and cracking on buildings/structures, artifacts, monuments, human health among others. However, given these findings, the study has been able to proffer recommendations which if taken into effective practice will help mitigate the consequences on the people and the built environment.

Keywords: Impact, Gas Flaring, Built Environment

Introduction

In the Niger Delta region of Nigeria, one of the major sources of air pollution is the flaring of associated gas from the activities of oil exploration. Nigeria notably the World's biggest flarer of associated gas has over 1000 gas flaring points (ERA & CJP; 2005; Friends of the Earth, 2004). Gas flaring is the controlled burning of waste (Natural gas) associated with Oil

production. One of the main sources is the 'Solution Gas' trapped underground oil supplies which is released when oil is brought to the surface. Gas flaring is used to eliminate gas when the volume is insufficient to warrant recovery or collecting it would be uneconomical (Evoh, 2002; USEPA, 2006).

Worldwide, some 115 billion cubic meters of Gas are flared or vented into the atmosphere every year (Shewehuk, 2002) and of this quantity, Nigeria alone flares about 23 billion cubic meters every year (Olukoya, 2008). The consequence of this act of excessive gas flaring is a large contribution to global warming and climate change caused by emission of large quantities of two of gas flaring or the incineration of sour gas (hydrogen sulphide-AG). The gas flaring and incineration produces Sulphur dioxide, which is released into the atmosphere. The end result of these compound (Sulphur oxides) when combined with other atmospheric component namely Oxygen and water are what is called Acid Rain. Acid rain produces several negative effects on the environment in which we live (Evoh, 2002).

Gas flaring in Nigeria also has other direct consequences in the local environments. This can easily be seen as all the surrounding vegetation is damaged and some are completely destroyed for as much as 50 meter or more from the pint of gas flaring (Efe, 2003). The increase in temperature as well as soothe and other gases emanating from the flare sites cause immense health problem and infrastructural damage to the environment. Air pollution has been observed to cause death and respiratory diseases to human as well as damage to monuments and other archaeological structures in the past (Watson, 1997). The major sources of air pollution are transportation engines, power and heat generators, industrial processes, the burning of solid waste and the flaring of Associated Gas.

Air pollution has been a household term among environmentalists around the world since 1928. It refers to the degradation of something that was initially good, clean or healthy (Nkwocha, 2008). Air pollution can simply be define as the human introduction into the environment of chemicals, particulate matter or biological materials that causes harm or discomfort to human or other living things or damage to the environment.

Conceptual framework and literature review

Gas flaring, simply, is a means of safely disposing of waste gases through the use of combustion (Evoh, 2002). The ENS (2005) described gas flaring as the use of open flare to burn off unwanted Associated Gas (AG) that are extracted from the earth along with the Crude Oil. These definitions are most commonly used today due to the fact that, this mode of flaring (combustion) is most prominent and largely in use around the World. This is

quite unlike the other type of Gas flaring called 'VENTING'. Venting is the disposing of the AG without burning (ERA & CJP, 2005). The act of burning AG called Gas flaring, results to the addition of end products to the environment. Some of the products of the combustion or venting of AG includes oxides of Nitrogen, Carbon and Sulphur (NO_x, CO_2, CO and SO) particulate matter, photochemical oxidants, hydrocarbons and ash, and hydrogen sulphide as well as sound (noise) and energy (heat) (Gabriel, 2004).

Quantity of Gas Flared in Nigeria:

Traditionally, Oil companies do not like to find AG together with oil field. They prefer to fine gas without it being mixed up with non-associated gas (non-AG). Finding AG means they have to find ways to dispose it in order to profit from the oil. Whereas, finding non-AG, gives them the freedom to control their gas production without reference to production. So flaring of AG has traditionally been much more common generally because it is cheap (ERA & CJP, 2005). The gas flaring act is done at both elevated and non-elevated bearing points. With an elevated flare, the combustion is carried out through the top of the pipe or stack where the burner and lighter are located (Evoh, 2002). In the oil industry, AG from oil wells is collectively discharged by flaring mainly at flow stations (ERA & CJP, 2005).

The quantity of gas flared is very much important because, flaring at small scales can hardly cause environmental problems. When large volumes of gas are flared, there can be serious environmental problems. When gas flared in Nigeria is compared with oil production flares in advance countries from data collected by the Alberta Energy and Utilities Board (AEUB) in Canada shows that in 1996 about 92 percent of gases produced were conserved or used in some manner. The remaining eight percent of gases was flared. This is socially responsible towards gas conservation as demanded partly by environmental requirements in Canada and other countries do not apply in Nigeria (Evoh, 2002).

Nigeria has an estimated 19 billion cubic feet of proven natural gas, making it the largest concentration in the World. Due to unsustainable practices coupled with lack of gas utilization infrastructures in Nigeria, the country flares 75 percent (or more) of the gas produced and re-injects only 12 percent to enhance oil recovery. It is estimated that about two billion standard cubic feet (bcf) of gas is currently being flared in Nigeria; the largest in any member nation of the Organization of Petroleum Exporting Countries (OPEC). Consequently, going by the current statistic, Nigeria accounts for about 19 percent of the total amount of gas flared globally (Evoh, 2002). In table 1, the total quantity of associated gas produced in

Nigeria is shown as produced by a joint venture of UNDP and the World Bank below.

Table 1: Associated Gas Production in Nigeria.

S/N	COMPANY	YEAR OF PRODUCTION		
		2000 (bcf)	2001 (bcf)	2002 (bcf)
1.	Shell Joint Venture (JV)	1.371.535	1.465.057	1.598.837
2.	Exxon Mobile JV	740.751	740.751	740.751
3.	Chevron Texaco JV	741.262	711.757	708.218
4.	Agip JV	502.731	516.163	530.419
5.	Total Final Elf JV	147.092	142.794	124.919
6.	Big 5 Total	3.476.371	3.596.522	3.703.144
7.	Others	69.339	106.398	123.572
TOTAL AG PRODUCTION		**3.545.710**	**3.702.020**	**3.826.716**

Source: UNDP/WORLD Bank (2010)

In addition, the global trend in gas flaring as produced by World Bank (2004) showed that Nigeria is currently flare 75 percent of the gas it produces which verifies the ERA and CJP reports that Nigeria flares around or more than 2.5bcf/d of AG. Further, the ERA and CJP report (2005) also verified that Nigeria accounts for 19 percent of the global amount of gas flared. This translates to about 16.8bcf/y of gas flared as proposed by OPEC (2001) for Nigeria and global amount by volume of gas flared stood at 84.87cm as shown in the Table 2 below.

Table 2: Trends of Gas Flaring in the World (2000)

S/N	Country	Gas Flared	Share of World Total (%)[(a)]	Ratio of Gas flared to Oil produced (m/tone)	
				1990	2000
1.	Algeria	6.8	6	79	101
2.	Angola	4.3	4	N/A	118
3.	China	3.2	3	N/A	74
4.	Egypt	0.9	1	37	23
5.	Indonesia	4.5	4	66	66
6.	Iran	10.5	10	70	56
7.	Nigeria	17.2	16	250	166
8.	Mexico	5.6	5	N/A	33
9.	North Sea	2.7	3	18	9
10.	Russia	11.5	10	N/A	77
11.	Venezuela	4.5	4	30	27
12.	United States	2.8	3	10	22
13.	Other countries	33.0	30	--	--
14.	World	107.5	100	--	--

Source: Cedigaz USEIA; OPEC; ERA; WORLD BANK; HIS Energy Group (2000)

Effects of Gas Flaring on the Environment

The effects of gas flaring on the environment are negative. The main impact that sour gas has on the environment comes in the form of acidic precipitation. The incineration of sour gas (Hydrogen Suphide) produces Sulphur oxides, which are released into the atmosphere. The end result of these compounds, when they combine with other atmospheric components such as Oxygen and Water is what is called Acid rain. Acid rain produces several negative effects on the world in which we live (Evoh, 2002). Another major impact of gas flaring on the environment is climate change as observed and projected by the Inter-governmental Panel on Climate Change (IPCC).

Statement of the research problem

In the Niger Delta region of Nigeria, gas flaring has cause a lot of problems to the environment. Some of these problems have been identified and analyzed by many researchers and scholars like; Isichei and Sanford (1976); Odu (1995); ECLONES (1993); Oyelunle (1999); Uzuukwa (1999); Onier and Aborio (2000); Okocha (2000); Efefaroro (2001) and Efe (2003). In all these researchers however, there has been little or no research work on the impact of gas flaring on the built environment made up of buildings, roads and other structures. These problems are obviously important since the inhabitants and most of their activities as well as their cultural heritage and associated economic values are dependent on the built environment. The degradation of the quality of such structures could also lead to the destruction of valuable lives, machineries, cars, buildings and other sources of livelihood.

There have been several recorded cases of health hazards associated with problems of Lungs and other related cases which were diagnosed in some patients. Some of these cases were proved to be caused by acid rain water consumed by patient from the area where Gas flaring has been on over the years. In addition, unhealthy effects of gas flaring within the study area associated with increased risk of dermatological problems, spontaneous abortion and numerous kinds of Cancer. From the foregoing it is pertinent that gas flaring if not mitigated shall bring about catastrophic health and other problems to the inhabitants living close to the gas flaring points. Hence, this study is to find out the impact of gas flaring on the environment using ONELGA for the study.

Purpose of the study

This study is aimed at assessing the impact of gas flaring on the built environment with reference to Ogba/Egbema/Ndoni Local Government Area

(ONELGA) of Rivers State, Nigeria. Specially, the objective is to assess the level of impact of gas flaring on the Environment.

i. To determine the impact of gas flaring on the built environment of Ogba/Egbema/Ndoni Local Government Area.
ii. To assess the level of impact of gas flaring on human health as well as artifacts and monuments.
iii. To assess the impact of gas flaring on Metallic Objects and Structures.
iv. To assess the impact of gas flaring on Buildings/Structures and water bodies from acid rain.

Research questions

The following research questions are put forward in order to help find answers or solution to the research problem.

i. What are the environmental impacts of gas flaring on the built environment of Ogba/Egbema/Ndoni Local Government Area?
ii. What is the level of Gas flaring on human health as well as artifacts and monuments?
iii. What are the impact of gas flaring on Metallic Objects and Structures?
iv. What are the impact of gas flaring on Buildings/Structures and water bodies from acid rain?

Scope of the study

The scope of the study is the level of impact of gas flaring on the environment in Ogba/Egbema/Ndoni local government area. The study is delimited to the factors that constitute the impact of gas flaring on the environment considered in this study are: impact on the environment, human health, metallic objects, building structures and water bodies. Impact of gas flaring on the environment is enormous (covering a wide range of environmental components). Any attempt at covering all aspects of such impacts in one research may produce imperfect results. This is obvious since the research team for such a complete impact would require experts from a wide range of disciplines and of course, with huge (government) funding. That not withstanding, not all impacts can be anticipated and subsequently studied. Therefore, considering the resources and time available for this research, this study has been limited to the identification and estimation of the magnitude of particular impacts gas flaring has on the various materials used for the construction of buildings and other permanent structures as clearly stated above.

The scope of the study took into considerations of the built environments spanning from 1995 to 2014 as most of the structures in the area are of 10 to 15 years and above.

Methodology

This study is designed as a descriptive survey to simply observe and record the results on the impact of gas flaring on the environment in terms of the conditions of buildings in this area and then compared to other settlements with the same geological and metrological conditions few meters away from the study area.

Data Collection and Analysis

There are two gas flare points in Ogba/Egbema/Ndoni Local Government Area and Omoku gas plant. The sampling sites are labeled A Omoku. Site A is the most polluted/impacted area under study and site B is the control (less impacted) area having the same geological and metrological conditions as site A. The data was collected in two phases. The first phase involved the observation of series of impacts on a hundred (100) buildings in the main study site – A; starting from the building closest to the flare (approximately 1km) and up into the area. In the second phase, approximately 5km measured from the end of Omoku community from there; 50 buildings were analyzed. The second site provides data on the control site. No special preference was given to buildings but shops made from wood and other synthetic materials were particularly left out.

Few instruments were used for the collection/and analysis of data. The various objects that make up the built environment, such as building, roads, artifacts and monuments etc were scrutinized and carefully observed. Various changes were observed to have occurred on these objects as a result of gas flaring were noted. A digital camera was used to collect a few pictures of severe damages caused by the impacts of gas flaring on the observed buildings. The statistical technique of percentages is used to estimate the overall impact of each of the impact parameters (corrosion, leakage, staining and cracking) examined in this study. The results are presented on pie charts and bar charts both statistical methods referring to the percentage of buildings affected by each impact parameter to the total number of buildings in each area of the study.

The data collected for this study were analyzed using simple percentages in order to appreciate relevant inferences from the data relating to the actual impact of gas flaring on the built environment in Ogba/Egbema/Ndoni (ONELGA) area. The statistical method of percentages is used to estimate the overall impact of each of the impact parameters (corrosion, leakage, staining and cracking) examined in this study. The

results are presented on pie charts and compared using bar charts both statistical methods referring to the percentage of buildings affected by each impact parameter to the total number of buildings in each area of the study. The information in the table above can be illustrated in a clearer way for speedy comprehension using a bar chart.

Table 3: Site A

Settlement	Impact Variables	No. of Buildings observed	No. of impacted Buildings	%
Omoku	Corrosion	150	130	87
	Leakage	150	125	83
	Staining	150	135	90
	Cracking	150	100	67

Source: field work (2015)

Table 4: Site B

Settlement	Impact Variables	No. of Buildings observed	No. of impacted Buildings	%
Obrikom Ebocha	Corrosion	150	100	67
	Leakage	150	80	53
	Staining	150	90	60
	Cracking	150	60	40

Source: field work (2015)

From the above tables, one could find out that the difference in the impact variables at the various sites is due to the proximity to the gas flaring site. For instance, Omoku site A which is the closest settlement to the gas flaring site is more impacted negatively than site B which is far away about 1km from the flare site in all the variables (i.e. corrosion, leakage, staining and cracking) as clearly shown on the tables 3 and 4 respectively.

Sources of Data

The data used in this study includes both Primary and Secondary. Data acquired by field observation and recording through the use of open/close ended questionnaire from dwellers within Communities in Ogba/Egbema/Ndoni showing effects of gas flaring on building roofs and walls make up the primary data used in this study. Moreso, oral interviews were also carried out in areas were the use of the organized questionnaires proved abortive. Some of the secondary data used were sourced from the Internet, most especially search engines-http://www.google.com, http://www.ask.com and Library materials such as published journals, articles and textbooks in order to conduct a complete and reasonable study/research of the topic.

The study area

Niger Delta is the most pollution prone area in Nigeria. It cuts across various locations with a good number of industries and Oil exploration companies. It is on a wetland of about 60,000km^2 spreading over a number of ecological zones; sandy coastal ridge barriers, brackish or saline mangroves, freshwater, permanent and seasonal forests and low land rainforest. The area belong to the Exclusive Economic Zones (EEZ) of Nigeria and located between latitude 4^{o}50' and 4^{o}55' N and longitude 7^{o}05' E inhabited by some 1600 long settled Communities. Economic activities, mostly of Oil industries have caused significant migration of people to the area bringing the population to about 3 million people. The first noticeable features in the area are gas flares that dots the landscapes; acid rain increases the devastation with all kinds of pollution ranging from Land, Water, Air and Noise. The climate of the area is characterized by high temperature, rainfall, relative humidity and low wind velocity.

Ogba/Egbema/Ndoni Local Government Area (ONELGA) in Rivers State is a typical example of an area ravaged by pollution especially from industrial emissions emanating from industries such as Oil and Gas Production Plants, Gas Recycling Plant, Natural Gas Liquids Plant and other related industries. It has a population density of 371 persons per sq/km and total population of 41,228 with 8,547 households spreading over an area of 13,8040km^2 according to the Local Government records. The Map of Nigeria showing Rivers State and Map of Rivers State showing the Study Area; Ogba/Egbema/Ndoni Local Government Area as shown in fig. 1 and fig. 2 below respectively.

Fig. 1: Map of Nigeria Showing Rivers State

Fig. 2: Map of Rivers State Showing Study Area

Source: http://www.google.com (2015).

Results/findings and discussion

The results obtained above show that the impact parameters analysed have greater magnitudes in the study area, site A (Omoku) which is closest to the flare site than site B control area. The impact parameters termed staining for instance, showed the highest variance between both sites up to 35%. This is supported by the results of the analysis above and can be largely related to low wind speeds and high humidity of the Ogba/Egbema/Ndoni Local Government Area (ONELGA) environment.

Generally, the impact of gas flaring on the built environment is such that the impact is greater on buildings and structures closest to a flare site. This study has the following findings; corrosive impacts on metallic parts of buildings such as roof and railings were observed to increase by as much as 23% as gas flares are approached with impact getting as high as 97% of total buildings in Omoku (the closest community to a flare site) the observed corrosive impact were found to cause about 6% of the entire population of buildings within Omoku to have leakage were observed on aluminum roofed buildings. This impact also increases with closeness to the flare site by a calculated 2%. Buildings sited close to gas flares showed 35% more staining impacts on their walls and even roofs. Staining impacts were as 99% in Omoku area, which is closest to flare sites. In Omoku, buildings sited close to gas flares showed 6% more cracks to their walls (their age notwithstanding), 16% of buildings in Omoku have cracks on their walls despite their ages.

The rate of deterioration of buildings within one kilometer of a flare site is quite high compared to buildings outside this range. This is due to the observation that corrosion impacts increased by 23%; leakage impacts increased by 2%; staining impacts increased by 35% and cracking impacts increased by 6% in Omoku; five kilometers away or 1.2km (approx.) from the site. In site A, it was observed that 99% of the buildings were stained with some blackish, powdery formations on the walls and other exposed surfaces, even aluminum roofs has stains on them. These stains are suspected to be as a result of the reaction between Hydrogen Sulphide (H2S2) and chemical compounds in the paint used for coating such surfaces. Some others that occur on painted or unpainted surfaces may also be attributed to fungal formations due to the successive acid deposition and hydrolysis of such acids, thereby creating a suitable environment for fungal growth on the surfaces.

The huge difference observed between the level of staining impact at site A and B can be related to the presence of hydrogen sulphide at higher concentrations at site A. this may be due to its closeness to the source of the gas, which may be due to leakages on the pipes carry the gas being flared. On the other hand, it could also be due to other chemical reactions

encouraged by the high relative humidity of the area as well as the high cluster-intensity of the buildings. Others include; the reaction of carbonic acid (HCO_3) produced in the atmosphere by the reaction of carbon dioxide and water and limestone (C_aCO_3) in the cement used to build the wall.

The impact may have been heightened in the study area by the observed higher concentrations of acidic oxides of sulphur, nitrogen and hydrocarbons (the principal corrosive agents) in the area (Ejimogu, 2003). In his study of the concentrations of these gases, it was discovered that sulphur dioxide and hydrocarbons concentrations in the atmosphere were well above Federal Environmental Protection Agency (FEPA) standards. This implies that, the possibility of acidic deposition, both dry and wet (acid rain) is very high; especially when the meteorological conditions of the area are considered. Such acidic deposition on metallic surfaces lead to the corrosion of the metal (corrugated or not) in the presence of oxygen and water which is usually very much available surfaces in Ogba/Egbema/Ndoni local government area, with a very large concentration of the corrosive agents.

The rate of corrosion in the control area (site B) which is approximately 4.5 kilometers away from the site may be due to dispersion of the pollutants (corrosive agent) as they move further into the atmosphere. Turbulence in the atmosphere may be said to force the dispersion of the pollutants leading to the slight reduction of concentration of the corrosive substances. The difference in the percentage of leakage occurrence at both sites can be associated with the age of the building and rate of corrosion. This is quite ironic as while leakage occurrence at site A can be mainly associated with accelerated rate of corrosion, the occurrence can be associated with mainly the aged buildings at site B. this is because the building at site A are much newer (younger, averaging 5-10).

Conclusion and recommendations

Gas flaring is a globally unaccepted act which has a great number of implications on the environment. This study has revealed yet another aspect of pollution on our environment the built environment (our homes, industries, factories, laboratories, offices etc) that has been negatively impacted by gas flaring. The impacts that gas flaring has on buildings are chronic and present a major problem which becomes too costly to recover or repair the affected building parts. Where recovery or repair attempts are made, they amount mostly to net loss to the economy. The acceleration of the natural process of corrosion, decay and other processes, which naturally degrades the quality of buildings, makes gas flaring a formidable enemy of man. This is simply because it does not only affect human health but shelter, as well as sources of food supply, land, vegetation and water.

This study has therefore recommended some measures to mitigate or reduce the various impacts identified to the barest minimum as follows:

1. Efforts should be made to reduce the quantity of gas flared at source coupled with other strategic and stringent legislative and administrative measures to be adopted and implemented by local and national authorities in order to protect life and property in the affected areas.
2. Buildings should not be sited within a kilometer of flare site and vice versa. If buildings must be sited closer than a kilometer to a flare site, such buildings should be designed to have aluminum roofs windows, rails and every other metal requirement should be done with aluminum to reduce the impact of acid depositions; walls should be plastered with cement mortar, which is less susceptible to cracking.
3. Buildings should be painted with high quality paints with effective resistance to wearing and staining (routine repainting plan created with not more than two years interval) to reduce all impacts to the minimum. Aluminum building materials should not be painted to avoid staining impacts.
4. Gas flares currently located within one kilometer of settlements should be switched off and piped further away from settlements. Otherwise the settlers should be moved elsewhere.
5. Government should treat gas flaring as a matter of national security because the deterioration of buildings can lead to collapse of buildings and distorts habitants. In places where gas must be flared for whatever reason, the best technology for incineration such as state-of-the-art burners with 98% or more Methane conversion rate should be used. This study supports the bid for complete stoppage of the act of gas flaring in Nigeria.

References:

Alakpodia, J.I. (1995) 'The Environment of the Niger Delta in B.U. Uweru and J.O. ubrurbe (ed.) 'Readin in general studies Niger People and Culture. About Research Public, Warri.

Efe, S.I. (2003) 'Effects of Gas Flaring on Temperature and Adjacent Vegetation in Niger Delta Environment, international journal of environmental issues volume 1 number 1 2003 pp. 91-101.

Efefarroro, E.W. (2001) 'Effects of Gas flaring on the Vegetation and Climate' A case of Utorgu, Erhioke and Egwa field of Delta State. Unpublished B.sc Thesis, Delsu-Abraka

Ejimogu, C.E. (2003) "Analysis of industrial Emission in Nigeria Industrial Zones (A case study of Eleme industrial zone) unpublished B.Tech. thesis, FUT-Owerri.

Ens-newwire.com (2005) "Nigeria judges rules Gas flaring violates constitutional rights' http://www.ens-newwire.com/2005-11, 15-04 asp. Ppl.

ERA & CJP (2005) Environmental Rights Action and the climate justice programme Gas flaring in Nigeria: A human rights, Environmental and Economic Monstrosity, Netherlands pp. 4,7,11,12,20,21,22,23,24,25.

Evoh, C. (2002) Gas flares, oil companies and politics I Nigeria, http://www.waado.org/environmental/oil companies/gasflarespolitics. Html

Gabriel A.O.I. (2004) Woman in the Niger Delta: Environment issues and challenges in the third millennium pdf. 1.

Hamilton, R.S and Mansfield, T.A. (1992) 'The Soiling of materials in the Ambient Atmosphere Environment, 26A 3291-3296

Hansard (2005) see Tables provided by the UK minister in a parliamentary answer, showing annual UK offshore association and non-association gas production and the percentage and amounts of gas vented and flared since 1979, Hansard: 10th February 2005, column 17792 http://news.bbc.co.uk/1/sci/tech/3381425.stm, www.epa.gov/urbanair.htmi, www.ipcc.ch

Impacts, adaption and vulnerability, executive summary, IPCC third assessment report, working Group 2, http://www.grida.no/climate/ipcc/wg2/378/htm Inventory of U.S. greenhouse Gas Emissions and Sinks: 1990-2004, US Environment Protection Agency, http://www.epa.gov/globalwarming/publication/emissions (2006) Isiechei, A.O and Sanford (1976) 'Effects of west gas flares on the surrounding vegetation in south west Nigeria of applied Ecology, vol. 13; pp. 177-187.

Kucere V., Henriksen J., Knotkova, DSjostrom, Ch. (1993b) 'Model for Calculation of corrosion cost caused by air pollution and its application in three cities report No. 084, Swedish corrosion institute, Roslagsvagen, 1993.