THE IMPACT OF GAS FLARING ON RAINWATER QUALITY AND HUMAN HEALTH IN DELTA STATE, NIGERIA

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Abstract

The paper examines the impact of gas flaring on rainwater quality, and its implication on human health in Delta State. Rainwater was collected in seven different sites at a distance of 500m and I8km (Control) from the bundwalls of the flare stack. The water of the first rain in each month was collected between January and December 2001 for laboratory analysis. The water was analysed for the following parameters: physical, inorganic, metals, and p^H. Reported cases of health problems in Erhorike and the control site (Okpara Inland) between 1996 and 2001 were also collected from the hospitals for analysis. The result shows a high level of acidity with mean pH value of 4.2. It also losses its aesthetic value since the physical parameters such as total dissolved solids (1113.2mg/l), turbidity (6.54 mg/l), and colour (I6.6TCU) were higher than the maximum permissible limit. Only Zn (0.047) among the heavy metals was below the recommended standard, Reported health problems show that the disease pattern in the flare site was significantly different from that of the control site. To be environment friendly and to operate in a sustainable environment, it is suggested that the oil industries instead of flaring the natural gas should process it for domestic and industrial uses and re-inject it into the underground reservoir.

Introduction

Any human activity on a large scale alters the chemistry of the atmosphere (Mesuba and Buadi, 2003). These activities could be industrial, agricultural, mining and settlements among others. Some of the airborne substances introduced into the atmosphere due to human activities are beneficial for life in general and humans in particular (McDonald, 1985). They provide oxygen and other nutrients that are essential for humans and for the growth of crops and forests (Woodan and Cowling, 1987). On the other hand, other substances released into the atmosphere are either inert biologically or detrimental because they cause stress in plants, animals and micro-organisms (Cowling, 1991). They also alter the surface and groundwater quality, aggravate nutrient deficiencies in soils, or accelerate the soiling, weathering or corrosion of engineering and cultural materials (Olaitan and Lombin, 1984; Costa and Forley, 2000; Odjugo, 2002).

In Nigeria, anthropogenic sources of gas emission into the atmosphere are more from the transport sector, bush burning and gas flaring, among others (Okoh, 2000). Nigeria has an estimated 100-120 trillion cubic feet of proven natural gas, making it the 9^{lb} largest concentration in the world (Olagoke, 2001; Buba, 2003). Associated gas with crude oil is routinely Oared in the course of producing and processing petroleum oil. This is a common practice in the oil production process not only restricted to Nigeria. However, the Nigerian case attracts more attention given the volume of gas flared since the beginning of commercial oil production about 50 years ago. Statistics have it that in Nigeria, an average of 4.9 million standard cubic metres of gas are being flared daily out of the 5.6 million standard cubit metres produced daily with crude oil (Otoikiti, 2001; Atevure, 2004). This flared gas volume when translated into crude oil is equivalent of some 259,000 barrels. This means, Nigeria flares more than 76% of its natural gas output, which is highest anywhere in the world (Atevure, (2004).). Libya is a distant second, flaring 21%, Saudi Arabia 20%, Iran 19%, Canada 8% and Britain, Algeria and Mexico flare about 5% each of their natural gas output (Gbafade and Gowon, 2002; Atevure, 2004).

The World Bank in 2000, estimated that gas flaring in the Niger-Delta region of Nigeria where the crude oil is drilled amounted to some 35 million tonnes of carbon dioxide (CO_2) annually into the air, which amounted to Nigeria accounting for 28% of total gas flared in the world (Buba, 2003). Other gases associated with gas flaring include oxides of nitrogen (NOx), Oxide of sulphur (SOx), oxides of carbon (COx), lead (Pb), Nickel (Ni) and Zinc (Zn) among others. The reaction of some of these gases with other airborne chemicals such as oxygen, ammonia and moisture give rise to acid rain - a condition of polluted rainwater, which adversely affects plants, animals and humans (Odjugo, 2000).

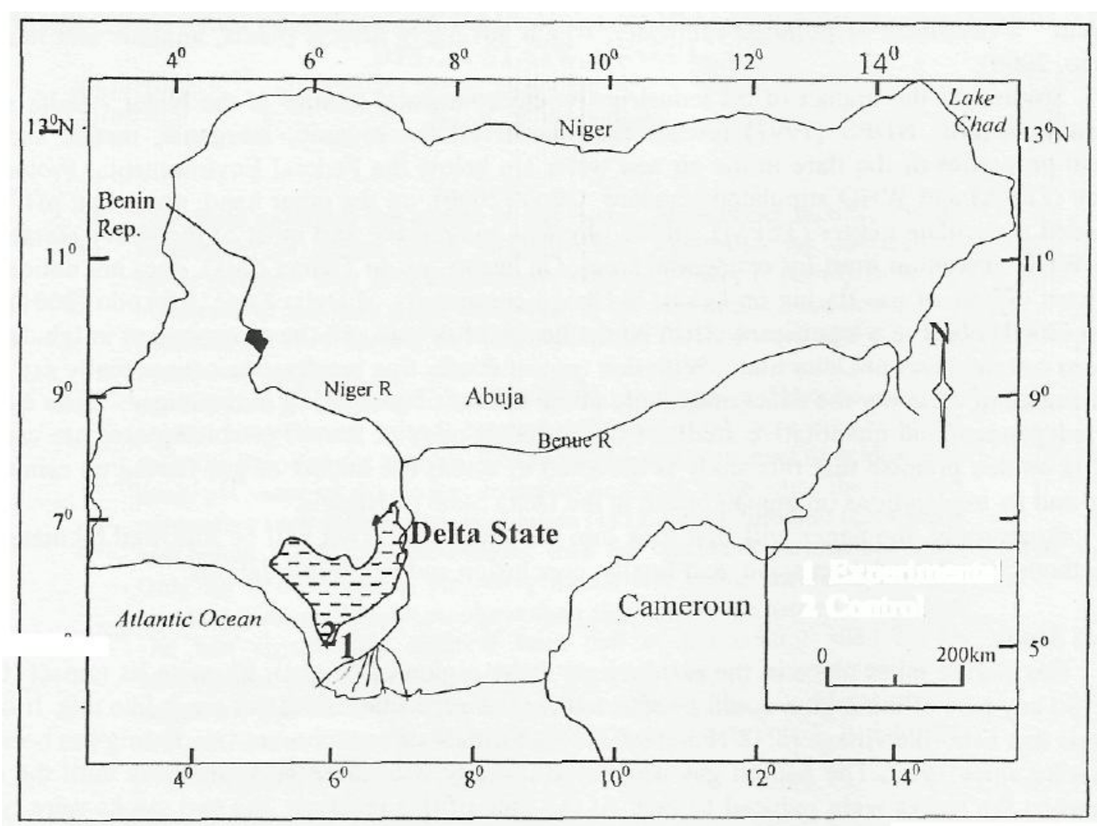
Studies on the impact of oil industries on environmental quality of the Niger - Delta show contrasting results. NDES (1997) reveals that almost all the organic, inorganic, metals and the physical properties of the flare in the air and water is below the Federal Environmental Protection Agency (FEPA) and WHO stipulated standard. Okoh (2000), on the other hand, notes that pH, total suspended particulate matter (TSPM), all the physical parameters, and most of the heavy metals are above WHO maximum limit for residential areas. On health, while Tizhe (2001), does not notice any significant effects of gas flaring on health in Ubogo community of Delta State, Efekodo (2001) and Otuaga (2004) observe a significant effect on the health of people and the environment in Igbide and Olomoro communities in Delta State. With this type of conflicting results, one cannot really say with a high degree of certainty the exact magnitude of the effects of gas flaring in the Niger - Delta except more independent and quantitative studies from different parts of the oil producing area are carried out. It is on this premise that this study is designed to assess the impact of gas flaring on rainwater quality and its implications on human health in the Delta State of Nigeria.

Structurally, the paper will first look into the study area. This will be followed by materials and methods, results and discussion, and finally, conclusion and recommendations.

Area of Study

Gas flaring takes place in the entire Niger Delta region of Nigeria, likewise its impact (Obi, 2003). So any part of the region could be selected for the experimental site of work like this. It is on this basis that Erhorike village (5.38°N and 6.02°E) in Delta State was chosen. Gas flaring has been on in Erhorike since 1967. The natural gas was flared initially with three vertical stacks until the mid 1980s when the stacks were reduced to two. At the time of this research, the two stacks were lying horizontally on the ground.

Erhorike has a population of about 2,500 inhabitants and the major occupation of the inhabitants is farming and fishing. The prevailing climatic condition is that of equatorial type of climate (Koppen's Af climatic classification). With annual mean rainfall of above 2500 mm and temperature of 27°C. The tropical maritime (mT) air mass prevails almost throughout the year concentrating rainfall for 10-12 months (February-November) and the tropical continental (cT) air mass takes over the atmosphere for the remaining 0-2 months (December to January). Relative humidity is high throughout the year with a mean annual value of 80% while sunshine ranges between 3 and 5 hours daily. The soil found in the area is that of riverine and locustrine hydromorpliic type (Areola,



1982). These climatic conditions and soil type give rise to tropical evergreen forest.

Fig. 1: Nigeria - Showing the Study Area

Materials and Methods

Primary and secondary data were collected for this study. The primary data was the rainwater. The first rain in each month was collected between January and December 2001, from seven sites with the raingauge. Out of the seven sites, three were situated on the south-west (Windward, March-October, and Leeward, November-February), three were located on the north-east (Windward, November-February, and Leeward, March-October), while the remaining site was the control located at Okpara Inland 18 km from the flare site. The control distance of 18 km is selected because the results of Onuorali (2000) showed that the impacts of gas flaring on the atmosphere is insignificant at a distance of 15 km from the flare site. The experimental sites were located at 500m" from the bundwalts of the flare. People reside within this distance whereas the minimum limit allowed for by the Environmental Impact Assessment Decree No. 86 of 1992, is 3 km (Okoh, 2000).

The rainwater collected was sent to laboratory for analysis. Parameters analysed for include the pH, physical parameters (total dissolved solids, turbidity, colour, taste and odour); inorganic / organic parameters (CL~, NO_3, SO_4, $P0_4$, Na, K, Mg and Ca); and heavy metals (Pb, V, N and Zn) The laboratory result was compared with the WHO stipulated standards for domestic area in order to determine the level of pollution and the possible effects. The compliance level was computed using Clerk (1984) equation.

$$PC = \frac{N, x P}{N}$$

Where

PC =Percentage compliance
N =Number of times parameter complied with stated standard.
P =100% (Assumed maximum compliance limit).
N =Total number of Measurements.

He concluded that for healthy living compliance level must attain 70% or above.
The secondary data used were the health cases collected from the Health centre at Erhorike and the St Francis Hospital, Okpara Inland. The data were compared with known health problems associated with gas flaring. Five hundred questionnaires were administered to solicit the opinion of the inhabitants on the impact of gas flaring on their health. These were analysed using the simple percentage and Pearson's rank correlation.

Results and Discussion

Physical parameters

Table 1: Acidity and Physical Parameters of Rain Water

	Total Dissolved Solids (mg/l)	Turbidity (NTU)	pH	Colour (TCU)	Taste and Odour (TON)
Jan.	1582	10.8	3.0	25	4.61
Feb.	1391	9.2	3.1	22	3.02
Mar.	1176	6.3	3.6	20	2.40
April	1052	6.1	4.0	16	2.12
May	963	5.2	4.8	12	1.84
June	860	4.3	5.1	9	1.55
July	746	4.0	5.6	7	1.14
Aug	859	3.1	5.2	9	1.30
Sept	863	4.6	5.0	14	1.81
Oct.	1079	5.7	4.5	17	1.88
Nov.	1299	9.3	4.1	20	2.09
Dec.	1488	9.0	3.4	23	2.67
Total	13358	78.5	51.4	199	37.42
Annual Mean	1113.2	6.54	4.28	16.00	2.15
Mean dry Season	1440	9.58	3.4	22.5	2.9
Mean rainy Season	949.75	4.91	4.7	13.00	1.76
Control mean	266	1.1	6.8	2.4	Nil
WHO 1996 Standard	1000	5	6.5-8.5	15	3

Source: Fieldwork, 2001.

The mean total dissolved solid (TDS) of 1113.2 mg/l is 11.3% higher than the WHO 1000 mg/l maximum permissible limit (Table 1). While the rainy season (1440 mg/l) was above the limit. For 6 months (October to April), TDS level exceeded the stipulated limit. The mean turbidity for the year (6.54 NTU) and that of dry season (9.58 NTU) exceeded the acceptable limit of 5 NTU, but the mean rainy season (4.91 NTU) was within the limit. For 8 months (October – May) turbidity was higher than the acceptable limit putting the compliance level at 33.3%. In seven months, (October – March) the colour of the water was higher than the (15 TCU) stipulated limit thus having a Compliance level of 4.6%. While the annual mean (16 TCU) and dry season (22.5 TCU) exceeded This limit, the rainy season (13 TCU) was found lower than the stipulated limits. As for the taste and odour, the annual mean (2.15 TON), dry season (2.9 TON) and rainy season (1.76 TON) were lower than the 3 TON WHO recommended standard. All the physical properties and pH in the control site were within the permissible limit. This implies that outside the flare vicinity, atmospheric quality is within the WHO permissible limit.

It could be deduced from the physical parameters that the water loses its aesthetic value since It is dirty and coloured. This was confirmed 92% of the respondents who revealed that the rainwater was not good for drinking because it was blackish in colour and dirty in nature almost the year round. Although, the test the taste was within the acceptable limit, 86% of the respondents revealed that the water becomes tasty if left for two or more days. This claim was confirmed personally by the researcher who stored the water in stainless steel and drank from it between two and five days of storage.

The permissible pH range for domestic drinking water is 6.5 - 8.5. The annual mean pH for this study was 4.28, while the dry and rainy season were 3.4 and 4.7 respectively (Table I). This shows a high level of acidity especially during the dry season months of November to February. The pH range for the study period (3.0 - 5,6) is an indication of high level of acidity, while the 6.8 pH value recorded in the control site falls within the WHO recommended standard. Ogefere (1999) also noticed coloured and highly acidic waters at Sapele Gas Plant Station.

Chemical Parameters

Table 2: Inorganic Parameters (mg/I).

	Chloric! eCL	Nitrate NO;,	Sulphate $S0_4$	Phosphate PO_4	Sodium Na	Potassium K	Magnesium Mg	Calcium Ca
Jan,	118.6	62^6	326.1	0.82	8.6	0.7	1.38	2.5
Feb.	116.3	64,2	317.4	0.9!	7.4	0.52	1.51	2.27
Mar.	110,9	55.6	266,7	0.83	6.9	0.49	1.27	1.82
April	111.3	58.2	227.3	0.42	6.8	0.43	1.18	1.30
May	109.1	53.0	231.2	0.48	6.5	0.40	0,79	1.80
June	106.4	51.6	203.9	0.24	6.0	0.39	0.73	1.12
July	107.5	48.3	217.4	0.36	4.8	0.41	0.53	0.81
Aug.	101.7	49.7	226.6	0.53	4.9	0.35	0.50	0.99
Sept.	110.9	53.2	233.7	0.59	5.9	0.46	0.57	0.91
Oct.	114.8	50.6	259.5	0.69	5.6	0.59	0.63	1.02
Nov.	112.3	58.9	281.2	0.73	6.2	0.63	0.82	1.48
Dec.	121.7	62.3	220.0	0.83	7.3	0.66	1.42	2.0
Total	1341.5	668.2	3085	7.42	76.9	6.08	11.32	18.0
Mean	111.8	55.68	257.08	0.62	6.41	0.51	0,94	1.5
Dry Season	117.23	62	311.18	0.84	7.3	0.63	1.3	2.06
Rainy Season	109.8	52.53	232.19	0.52	5,9	0,44	0.78	1.22
Control	115.4	42	204	0.28	2.4	0,3!	0.46	0.35
WHO 0 1996	250	50	250	5	200	Nil	3.0	3.0

Source: Fieldwork, 2001 .

Table 2 reveals that the annual mean values of all the organic and inorganic parameters analysed were within the acceptable limit of Wl ID except NQ.i and SO^ that were above the limit. On a seasonal basis, NO^ was above the 50 mg/I maximum limit in both seasons. While SO^ was above the 250mg/l permissible limit during the dry season (257.08 mg/I), it was lower during the rainy season (232.19 mg/I), This puts the compliance level of CL, PO., , Na, K, Mg and C\r to be 100% while that of NO_3 and $S0_4$ were 6.7% and 50% respectively. All the values of the control site were within WHO permissible limit and thus have 100% compliance. Uche (1997) revealed that staying in a region where NO, is above 0.1 PPM (26mg/l) or SU| higher than 0.5 PPM (130 mg/I) for years could result to great risk of deteriorating health. Okoh (2000) specifically stated that living in an environment where NO.i is above 50mg/l (0.2PPM) for a long period leads to infantile methaemoglobJnaemia occurring more for children below 6 months. O'neill (1993) suggested a further potential hazard of forming carcinogenic nitrosomines in the human digestive system by the conversion of nitrate to nitrite and subsequent reaction with amino acids. NRC (1977), NAS (1986) and Cowling (1990) noted that SOx, NOx, and VOC have the highest range of detrimental effects on sanity and for this reason, these three primary pollutants are major keys to the proper management of air quality in most industrial regions of the world.

Table 3: Metals in Rain water (mg/L)

	Lead (Pb)	Vanadium (V)	Nickel (Ni)	Zinc (Zn)
Jan.	0.019	0.0019	0.0211	0.0674
Feb.	0.026	0.0018	0.0220	0.0692
March	0.018	0.0016	0.0203	0.0568
April	0.015	0.0016	0.0201	0.0329
May	0.012	0.0013	0.0197	0.0317
June	0.010	0.001	0.0186	0.0236
July	0.008	0.0008	0.0175	0.0219
Aug.	0.008	0.0008	0.0194	0.0346
Sept.	0.010	0.001	0.0205	0.0432
Oct.	0.010	0.0009	0.0209	0.0586
Nov.	0.012	0.0014	0.0211	0.0618
Dec.	0.015	0.0017	0.0216	0.0638
Total	0.163	0.158	0.2438	0.5655
Mean	0.0135	0.0013	0.02032	0.0471
Dry Season	0.018	0.0017	0.02157	0.0656
Rainy season	0.013	0.0011	0.0196	0.0379
Control	0.006	0.0006	0.009	0.021
WHO 1996	0.01	0.001	0.02	3

Health Implications

Table 4: Reported Cases of Diseases

Diseases	Erhorike	Okpara Inland
Malaria fever	32	27
Respiratory	11	2
Eye	8	4
Hypertension	7	5
Heat related	7	1
Hearing impairment	6	0
Intestinal	5	10
Typhoid fever	5	20
Cardiac	4	3
Measles	4	12

Skin	4	9
Cancer	3	1
Stroke	2	1
Brain disorder	1	1
Others	1	4

Sources: Erhorike health centre and St Francis hospital, Okpara Inland.

Malaria fever (32%) topped the list of diseases that affected the inhabitants of the flare and the control, site. This is the commonest disease in tropical forest area of Nigeria and not peculiar to areas of gas flaring. But gas flaring might have increased the incidence of malaria fever directly and/or indirectly. Odjugo (2000; 2004) revealed that the sporogony of the protozoa causing malaria is guided by temperature. The sporogony accelerates from 25 days at IO"C to 8 days at 32°C and that the activity and rate of mosquito bites increases with increasing temperature until 35°C when a decreasing bite sets in. These favourable temperatures for reproduction and bites are what the flare provides. Moreover, the high temperatures created by the flare make indoors physiologically uncomfortable especially the early hours of the night. This forced the villagers who did not have temperature-modifying gadgets, either due to poverty or lack of electricity to operate them, to stay outdoors till kite at night. This exposes them to more mosquito bites and increased incidence of malaria fever.

The high atmospheric concentration of total suspended particulate matter, N(\ SO_X and heavy metals among others (Tables 1-3) must have accounted for the high incidence of respiratory diseases (11%) such as aggravated asthma and cough; eye diseases (8%) such as eye irritation, cataracts, glaucoma; and high blood pressure with its associated hypertension (7%). The mean day and night noise level measured were 70 and 85 db (decibels) respectively. These were higher than 55 db and 45 db (day and night respectively) for residential areas recommended by Federal Environmental Protection Agency (FEPA). This must have accounted for the hearing impairment complained by 7% of the respondents. The relatively high incidence of intestinal diseases (5%) may be connected with the polluted water that they drink due to frequent breakdown of the only borehole in the village. Heat (7%) and cardiac related (4%) diseases were also common.

Comparing the reported health cases in the flare site (Erhorike) and the control site (Okpara Inland), a reasonable degree of variation is noticed. While the highest six diseases in the flare site were malaria fever, respiratory diseases, eye diseases, intestinal diseases, hypertension and hearing impairment, that of the control site include malaria fever, typhoid fever, measles, intestinal, skin diseases and hypertension. Respiratory and eye diseases common to areas of heavy air pollution (O'neill, 1993, Oke, 1995 and Uche 1997), were evident in a high degree in Erhorike while the percentage was very negligible in Okpara Inland. The variation in the disease pattern between the flare site and the control is further buttressed by Pearson rank correlation value of 0.719, which is statistically significant at $p < 0.01$. At this point, it could not be said categorically that gas flaring is the sole cause of the above diseases, except hearing impairment. However, the pattern displayed could move one to conclude with high level of confidence that gas flaring has directly or indirectly aggravated the magnitude of the occurrence of the diseases.

Conclusion and Recommendations

From the physico-chemical analysis of the rainwater, it was observed that acidity level is high with mean'pH value of 4.2. Apart from the acidic nature of the rain water, it also lost its aesthetic value since the physical parameters such as total dissolved solids, (! 1 13.2mg/l), turbidity (6.54 mg/1) and colour (16.6TCU) were higher than the maximum permissible limit. Only the taste and odour 2.15 (TON) component of the physical parameters were marginally within the permissible limit. The inorganic parameters have higher compliance level. CL<111.8mg/l), PO_4 (0.62mg/l), Na (6.4mg/I), K (0.51mg/l), Mg (0.94 mg/1), (Ca 1.5mg/l) were all within the acceptable limit while only NO.! (55.68 mg/1) and SO* (257.08 mg/1) exceeded the recommended level. Apart from Zn (0.047 mg/1) among the heavy metals which was below the recommended standard, Pb (0,0135 mg/1), V (0.013 mg/1) and Ni (O.02032 mg/1) were greater than the WHO recommended standard. With this result, it is clear that within 500 metres from the bundwalls of the Hare site, the atmosphere is heavily polluted and not conducive for human habitation.

For operations of the oil industry to be sustainable and environment friendly, better environmental and waste management practices are needed. To start with, the atmospheric pollution through gas flaring must be stopped by 2008 deadline of zero gas flaring given by the Federal Government of Nigeria. Instead of flaring, re-injection into the underground gas reservoir should be practised. More gas and petrochemical industries should be established to produce cooking gas. The current arrangement with West African Countries and beyond to supply them their natural gas needs should be intensified since available evidence (Buba, 2003) shows that Nigeria can currently supply the gas need of the entire West African countries if the gas industry is well developed. This will not only cleanse the atmosphere but also provide much revenue to the government and employment to the numerous unemployed and underemployed Nigerians. Moreover, more states in the Niger Delta in particular and the entire nation in general should convert from the current total dependence on hydroelectric power supply to thermal electricity by using gas as currently done by the Rivers State Government..

References

Asiweh, C.P.A. (1999). Environmental and socio-economic implications of the oil industry in Rivers State. Paper presented at the annual conference of the EHOs, held at Asaba, 1 8-21 August, 1999.

Atevure, V. O. (2004). Impact of gas flaring on Nigeria environment and economy. *Journal of Ecosystem Vol. 8(2): 21-35.*

Buba, A. D. (2003). Oil industry and the Nigerian economy. *Environmental Perspective Journal Vol. 15(2): 63-77.*

Clerk, R. T. (1984). *Mining and Environment:* Ibadan: ONAKS Press: Pp 93-97.

Cowling, B. E. (1991). Acid Rain and other Airborne Pollutants: Their Human Causes and Consequences. In Davis K. and M.S. Bernstam-(Eds). *Resources, Environment and Population: A Supplement to Vol. 16, 1990.*

Efekodo, G. (2001). The impact of oil exploration and exploitation in Isoko Land. An. M.Sc. thesis , presented to the Faculty of Social and Management Sciences. Ondo State University, Akungba-Akoko.

Gbafade, U. and P. Gowon (2002): Gas flaring: Why burning the resources? *Atmospheric Review Vol. 14 (2): 82-103.*

McDonald, G. J. (1985). *Climate Change and Acid Rain.* Virginia: Mitre Corp.

Mesuba, C. P. and Buadi, D. A (2003). *Environmental chemistry.* Lagos. Akinlola Pubs. P. 78-81

National Academic of Sciences (NAS) (1986). *Acid deposition: Long-term trends.* Washington D.C.: National Academic Press.

National Research Council (NRC) (1977). Effects of nitrogen oxides on vegetation. In *Nitrogen Oxides.* Washington D. C.: National Academy of Science. 197-214.

Niger Delta Environmental Survey (NDES) (1997). *Environment and socio-economic characteristics:* Vol. 1, Phase 1.

Odjugo, P.A.O. (2000). Global warming and human health: Current and projected effects. *Environmental Analar No. 5 : 428-449.*

----------------- (2002). Health, safety and environment: Challenges of environmental health officers in the present democratic dispensation. Paper presented at the 3rd Delta State Triennial Delegates Conference/NEC meeting, Asaba 13-15, June 2002.

------------------------ (2004). The impact of petroleum oil operations on environmental degradation in Delta State. *Knowledge Review 9(1): 1-9.*

Ogefere, O. C. (1999). "Environmental impact evaluation of the Sapele Flow Station and Gas Plant". Paper presented at the annual conference of the EHOs, held at Asaba, 18-21 August, 1999.

Okoh, N. V. (2000). Environmental impacts of oil exploration. *Atmospheric Review Vol. 12 (1): 68-80.*

Olagoke, C. (2001). Nigeria Economy: II: The oil sector, *OPC: Bulletin No. 12.*

Olaitan, E. O. and G. Lombin (1984). *Introduction to tropical toil science.* London: Macmillan Pubs. Chapter 7.

O'neill, P. (1993). *Environmental Chemistry.* London: Chapman and Hall.

Onuorah, A. O. (2000). T he o il i ndustry a nd e nvironmental d egradation. *Journal of Atmospheric Science. Vo. 10(2): 42-63.*

Otoikiti, S. A. (2001). Economic cost of gas flaring in Nigeria. *Journal of Economic Development 25(1): 18-35.*

Otuaga, C. O. N. (2004). The social perspective of gas flaring and human health. *Environmental perspective Vol. 8(1 and 2): 82-94.*

Tizhe, N. H. (2001). Socio-economic implications of oil exploitation in Ubogo Community. An. M.Sc. Thesis presented to the Faculty of Social and Management Sciences. Ondo State University, Akungba-Akoko,

Uche, J. I. (1997). Air Pollution. In Odjugo, P.A.O. and J.E. Evwoh (Eds). *Physical components of the environment.* Agbor: Pon Pubs.

Woodman, J. N. and E. B. Cowling (1987). Airborne chemicals and forest health. *Environmental Science and Technology* 21: 120-126.