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Environmental Pollution in Oil Producing Areas of the Niger Delta Basin, Nigeria: Empirical Assessment of Trends and People's Perception

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Abstract: Oil spillage and air pollution, via gas flaring, constitute the major persistent environmental pollution problems affecting oil-producing areas of the Niger River Delta in Nigeria. This study presents a preliminary empirical assessment of the trend and rural community's perception of the problems. About 6133 major oil spill incidences were reported in area between 1976 and 2002. This resulted to the loss of about 2.97million barrels of crude/refined oil or an average of about 1.14×10^5 barrels per year. Between 1976 and 1999 about 94.8 tones of Particulate Matter (PM), 950477.0 tones of Nitrous Oxides (NO_x), 190717.0 tones of Carbon Mono Oxide (CO) and 5462.3 tones of Oxides of Sulfur (SO_x) were recorded from the annual levels of gas flared in the area. Trend equations attempted using statistical method show that the quantity of oil spill is declining, while the number of incidence is on the increase. A linear relationship exists between the components of air pollution. The views of the project-affected communities are quite polarized. One group (about 56% wished to see on-shore oil exploration and production activities cease, while the reminder (44%) does not. The major cause of conflict between the host community and the oil exploration and production company is environmental pollution (51.63%). This is followed closely by youth unemployment (23.96%). The most perceived affected environmental component is rural water supply (85%). Strategies for future management are discussed.

Key words: Exploration effects, oil and gas, environmental pollution, oil producing areas, empirical assessment Nigeria

INTRODUCTION

In today's world, the major challenges facing oil producing developing countries, such as Nigeria, include the following:

- To ensure that the ever growing energy demand can be met by provision of sufficient and timely supply of crude oil and natural gas (Araque, 2001; Newton, 2005).
- To use it's oil wealth wisely without "squandering" the proceed (Sote, 1993; Barrett and Ossawski, 2003; Eifiert *et al*., 2003).
- To ensure waste disposal in an environmentally acceptable manner (Garland *et al*., 1988; Araque, 2001; DPR, 1991; World Bank, 1995, 2003).

The Niger River Delta area of Nigeria lies between latitude 3°N and 6°N and longitude 5° E and 8° E, Fig.1. Previous researchers have identified the major sources, which contribute to environmental degradation in oil producing areas to include the following:

- Drilling waste disposal (Garland *et al*., 1988; Chukwuogo, 2001a).
- Oil spill and leakages (Ojo, 1998; Adejuyigbe, 2001; Nwilo and Badejo, 2001; Momoh and Idenumah, 1999; Bob-Manuel and Johnson, 2001).
- Gas flaring, poor emission control and Noise (Iloeje, 1998; Ojo, 1998; Uma, 1989; Nwagozie and Owatez, 1995; Chukwuogo, 2001b).

It is a recognized fact that environmental pollution problems associated with oil and gas exploration and production exist in the Niger Delta area (Iloeje, 1998; Ojo, 1998; Onosode, 2001; Abam, 2001; Uma, 1989; Akparobi *et al*., 2000; Abare, 2004; Ubong, 2002; Okecha, 2000). Studies have also shown that there are public health, socio-economic and security problem linked to the pollution in the area (Abah, 2004; Nwilo and Badejo, 2001; Adejuyigbe, 2001; SPDC, 2002). There are plans for expansion of oil and gas exploration and production activities in the area (Lukman, 2001; Newton, 2005; Olowo, 2004). Oil prices may remain high and volatile, on the back of continued strong demand from China and the United

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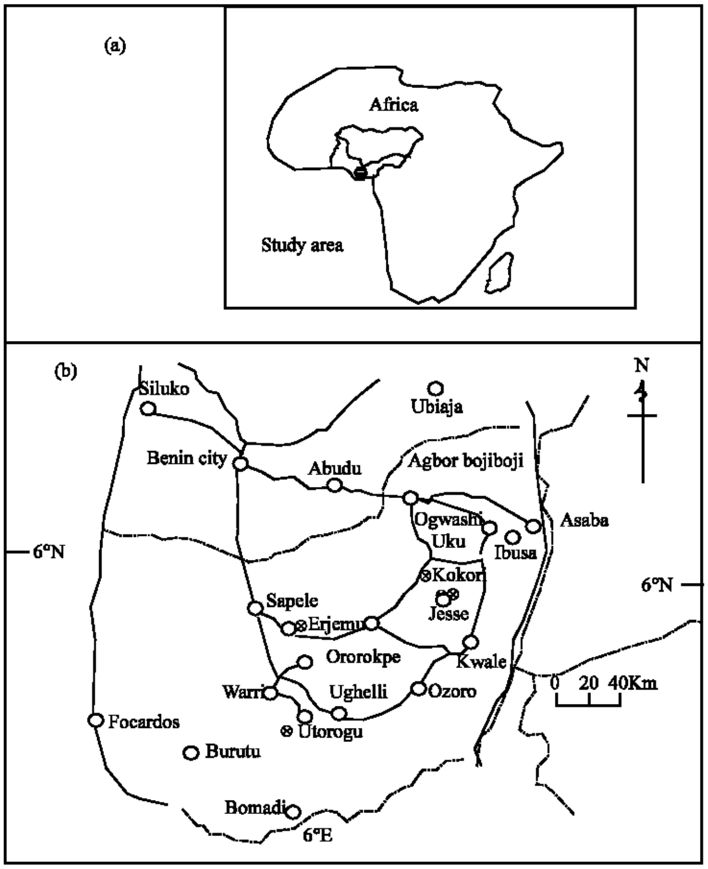

Fig. 1: (a) Map of Nigeria in Africa, (b) Delta State of Nigeria Showing the Study Sites (⊗)

State of America, uncertainties about Organization of Petroleum Exporting Countries (OPEC) production plans and falling non-OPEC supply (Shihab-Eldin *et al.*, 2003; Mutallab, 2005). This may lead to potential increase in pollution concentration. The resultant effects such as health hazards, rural urban migration and social insecurity affects domestic economic development and causes instability in the world's crude oil market. Therefore, there is need for continuous planning and prediction of the environmental pollution. Understanding the trend and relationships between the potential contaminants can serve as the basis for development of models aimed at simulations, predictions, decisions and ultimately policy formulation, improvement and implementation. The two major sources of concern used in this investigation are oil spillage and natural gas flaring.

Oil spillage: Oil spillage (crude and refined) in the study area occurs as a result of many factors such as corrosion of pipes and storage tanks, human error during operations and Sabotage. Nwilo and Badejo (2002) reported that 50% of oil spills are due to corrosion, 21% to oil operations and 1% due to engineering drills. The Shell Petroleum Development Company (SPDC, 2002) attributed 57% of the number of spills to corrosion and 20% to operation equipment failure and human errors. The percentages of oil spillage due to Sabotage are also variable in literature. For example, SPDC (1996) gave 43%, SPDC (2002) 1%, Nwilo and Badejo (2001) 28% and Bob-manual and Johnson (2001) 33%.

The harmful effects of oil spills on the Niger Delta environment are many. Oil spills have destroyed farmlands polluted surface and groundwater caused drawbacks in fishing and killed many rural Nigerians through fire out breaks and explosions in the region (Onosode, 2001). Although it is usually assumed that chemical spills would impact only on the immediate spills sites. It is also expected that contaminants from oil contaminated soils, tank-bottom sludge, waste disposal and landfill sites would be limited to the oil facilities confines (World Bank, 1995; Donigian and Rao, 1989). However, it is a known fact that chemical runoff does occur and spills can move over land and through the soils to contaminate surface and groundwater supplies. Also, hazardous domestic and drilling wastes often tend to migrate away from their storage disposal and treatment

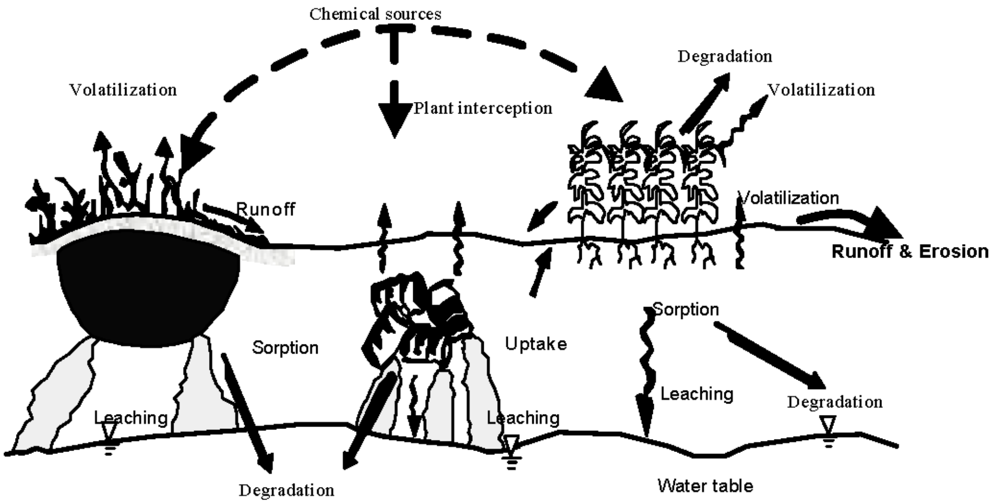

Fig. 2: Oil exploration and production chemicals in the soil environment source: After Doniagan and Rao (1989)

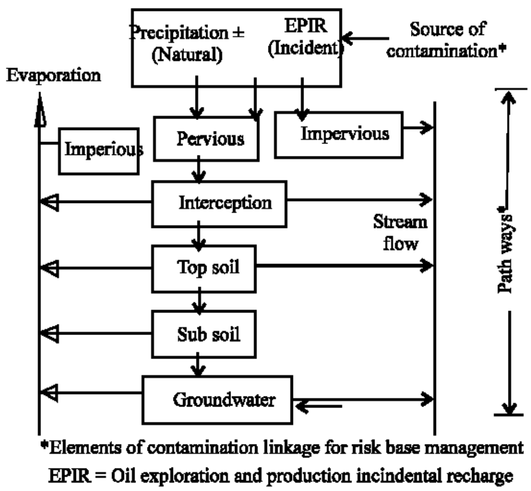

Fig. 3: Flow diagram for hydrogical component

facilities and can subsequently leach to shallow groundwater tables. (Garland *et al.*, 1988; Chukwuogo, 2001b; Ikem *et al.*, 2002).

Most rural inhabitants depend on water from the shallow wells for their domestic needs. Figure 2 and 3 schematically demonstrate the complex and dynamic interaction of processes controlling the fate and transportation of chemical into the soil and groundwater environment, applicable to the oil producing areas of the Niger Delta basin, Nigeria. In Fig. 2 the air polluting chemical sources include NO_x, SO_x, CO and PM, which are washed as acid rain constituents. Leaching activities are mainly from buried domestic and industrial wastes. Figure 3 is a conceptual flow diagram for potential groundwater contermination via recharge (Ndubuisi, 2005). In the figure, there are three components of contamination linkage (Source, pathway and receptor) that are always available in the rural area of the Niger Delta. In risk base management technique (SPDC, 2002), contaminant is only identified, as a risk if the linkages are present. Therefore the risk to groundwater contamination is high (Ndubuisi, 2005).

Gas flaring: In spite of government measures to stop gas flaring by the year 2008 and the existence of monitoring agencies, regulations and standards, the issue of gas flaring is still a problem in the oil producing areas of the Niger Delta. According to Labele-Awala and Hart (2001) about 67% of the associated gas produced per day is flared. Flare reduction is about 1% and it is unlikely to have zero gas flaring by 2015. Thus research on the trend and remedial measure is necessary.

Gas flaring in the Niger Delta is the major source of Carbon, NO_x, SO_x and particulate matter. The cumulative environmental impact of the numerous flares going on within the area will result in contaminant built up into the land and shallow groundwater resources, green house effect and global warning process. CO, SO_x and NO_x are highly poisonous to human. Particulate matters contribute to respiratory illnesses, Lead contribute to kidney problems and mental function (and potential death).

Rural families/communities who reside near the flare stations are at greater risk of exposure because they spend a larger proportion of their day out door, farming or fishing. Children are most vulnerable because chemicals like lead has more neurological impact on the developing brain of children than on developed adult brain. A study reported by the World Bank (1995) on the health out come of environmental intervention in reduction of air borne particulate matter in Port-Harcourt area of the Niger Delta showed that the health effect is 134 avoidable premature death per year, N53.6m @ N400.00 each and N58m saved working days @ N100 each.

Social consequences: In addition to the above environmental health hazards, most communities in the area face the problems of lack of potable water, sanitation facilities, health clinics, access roads and electricity. Graduate unemployment is high while education facilities and housing are often inadequate (Environmental Care, 2000). In spite of being African leading oil producing zone, the world development report (World Bank, 2003) shows that 36.4% of the inhabitants live below poverty live and 70.2% this proportion earn less than US $ 1.0 per day.

This results in an increasing bitterness, protests and growing anger that some times leads to disruption of production and hostage taking. Lives have been lost and these have led to increasing agitation for resource control by oil producing states of Nigeria.

This study focuses on the trend of oil spillage and major air pollutants and the level of rural community's perception on the problem. It will provide a preliminary empirical quantitative assessment of the situation as a base for immediate and strategic environmental management in the area.

MATERIALS AND METHODS

The investigation was carried out through field survey and data collection. The following approach was adopted in order achieve the objective of the research. The data on oil spillage and gas flares were obtained from reports in literature. Spill data for 27years(1976-2003) and gas flared data for 30years (1970-1999) were analyzed using 5 years moving average and least square regression. Assessment of the people's perception lasted from 2001 to 2003 and was executed in stages as follows:

- The first step was to identify areas and environmental components with potential high negative impact magnitude and significance (Glasson *et al.*, 1999). The field survey and data collection included interviews, questionnaires and interaction with stakeholders. Two criteria were used in the selection of the representative community for evaluation of people perception. First, the site should be a rural environment located in a major agricultural area and near oil exploration / production operation facilities. The facility should have potential for spillage, leaks and accidental waste discharges. Examples include, well fields, flow stations, pipelines, flow lines and gas compression stations. Secondly, the site should be accessible and have adequate amount of data (despondence input).
- Using the above criteria, potential onshore communities in Delta State were short listed from topographic and oil facility maps. Delta state was chosen because it is one of the largest oil producing states in Nigeria in which it has been reported that millions of tones of hazardous wastes are added to the soil and groundwater (Akparobi *et al.*, 2000).
- Questionnaire surveys were conducted on community attitudes and perception. The appropriate risks to be assessed were based on previous study in literature (Environmental Care, 2000). The respondent were asked to state and rank the environmental components according to their perception on the frequency of occurrence and magnitude of impact in their community (Glasson *et al.*, 1999) and also to select and rank the major causes of conflict between host community and oil company. The respondents were asked to rate their levels of perception of the environmental risks on a 5 point scale (Nil, Low, Medium, High, Very High). Two hundred questionnaires were allocated and served at each location. Four undergraduate students were employed as research assistance for that exercise.
- The data obtained from the short listed communities were screened and ranked according to number and quality of respondent's input. The 4 non overlapping on shore locations in Fig. 1 namely Jesse, Eriemu, Utorogu and Kokori which were considered to have reasonable amount of reliable input data were used for the analysis presented in this study.

RESULTS AND DISCUSSION

Trends: To obtain a good and realistic result data on 2 principal sources of environmental pollution (oil spillage and gas flaring) are discussed.

Oil spillage: The results obtained from the analysis are presented in Fig. 4-6. The figures indicate that the number of incidence and quantity of spill is essentially similar between 1976 and 2003, with a few years showing big spills (1978, 1979 1981 and 1996). The maximum quantity amounting to 694,117m^3 was recorded in 1979 and the minimum of 7,639 m^3 in 1999.The highest number of incidences occurred in the years 1994, while the lowest

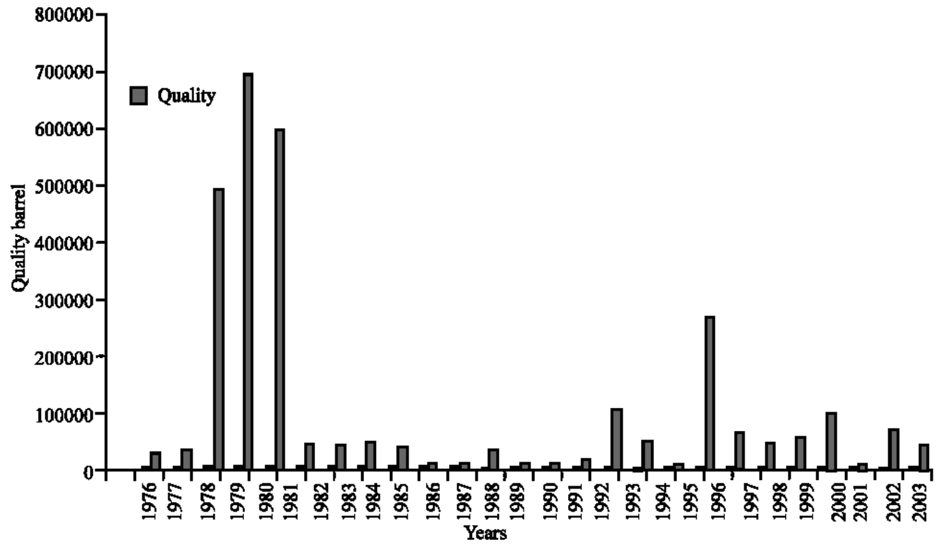

Fig. 4: Annual quantity of spillage

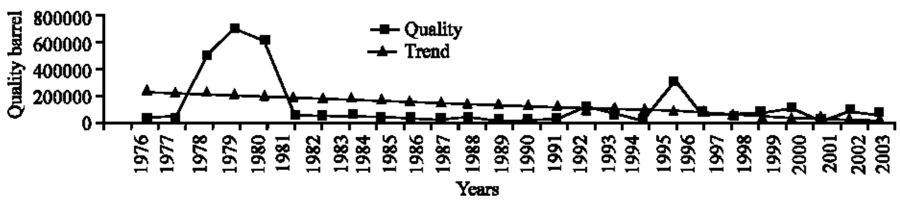

Fig. 5: Annual quantity and trend of oil spillage

was reported in 2003. There are small deviations with large frequency, while the large numbers have small frequency. The trend line in Fig. 5 was found to be in the form of: $Qs = 8811.74 X-233046$. Where: Qs = annual quantity of oil spillage (m^3), X = time in years.

Oil spillage is ordinary assumed or referred to be an irregular, random and sporadic event, which usually produce variations lasting only a short time {hours or days}. Between 1976 and 2003 approximately 6133 major incidences of spills were reported in the area. This resulted in the loss of about $2.95*10^6$ m^3 of crude oil. Assuming a minimum rate of US$28 per barrel (Shihab-Eldin *et al.*, 2003) this amounts to a loss of over US$ 0.52 billion. Excluding the environmental damage, this amount could have made substantial impact if used to provide basic infrastructure in the area.

Pollutants from gas flaring: To investigate this we compared the pollutants NOx, SOx, CO and PM composition recorded in gases flared from 1970-1999 (Fig. 7-9). The trend equation for the regression line in Fig. 7 was found to be in the form: $Vg = 634.0X + 25197$. Where: Vg = Annual volume of gas flared in million m^3.

An attempt was made to find multiple correlations between these variable (contaminant). The result produced linear relationship in the form: PM =73-1.73SOx + 0.0007CO +0.12NOx. The average annual level of PM was found to be 3160.3tonnes, Sox = 182.1, Nox = 31682 and CO = 6357.3 tonnes. The Oxides of Nitrogen, NOx accounted for about 77%, while, Carbon Monoxide was found to be about 15% (in tonnes) of the gas pollutants from gas flaring.

This implies that for any given quantity of gas flared the proportion or % of these contaminants released into the atmospheric environment can be predicted. Figure 9 shows the annual variation of the total volume of gasses flared in the region. Simulations derived from observed historical records are the most wide spread method of developing models for solving environmental pollution (Glasson *et al.*, 1999; Chukwuogo, 2001b; Lebele-Awala and Hart, 2001). Therefore, result from this investigation has provided baseline data for more quantitative simulation in the area and subsequent improvement in flow control designs.

Perception survey: Analyses of the survey results are based on the following:

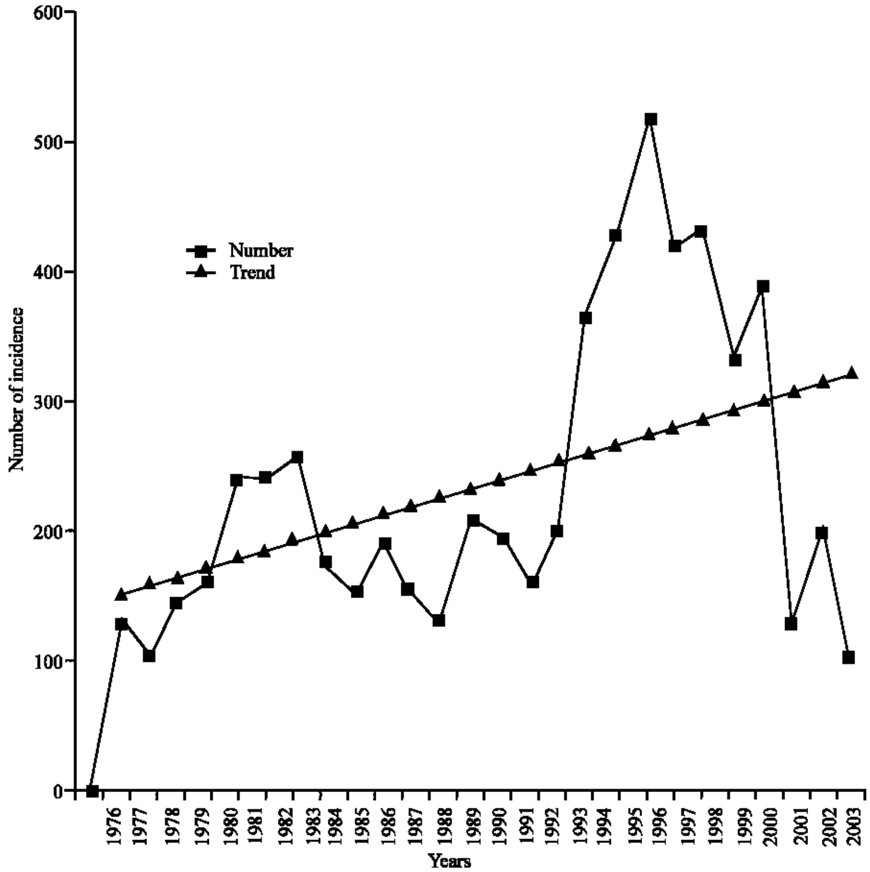

Fig. 6: Number of incidence and trend of oil spillage

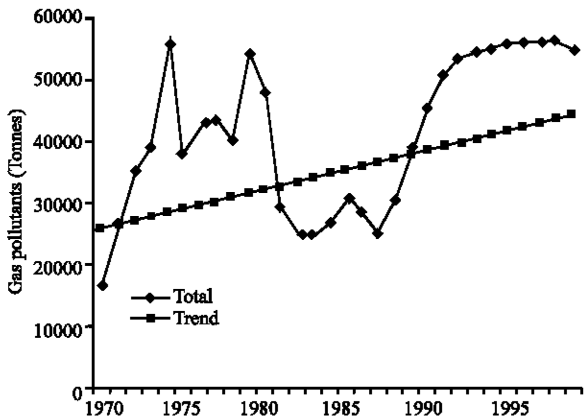

Fig. 7: Annual level and trend of gas polutants from gas flaring

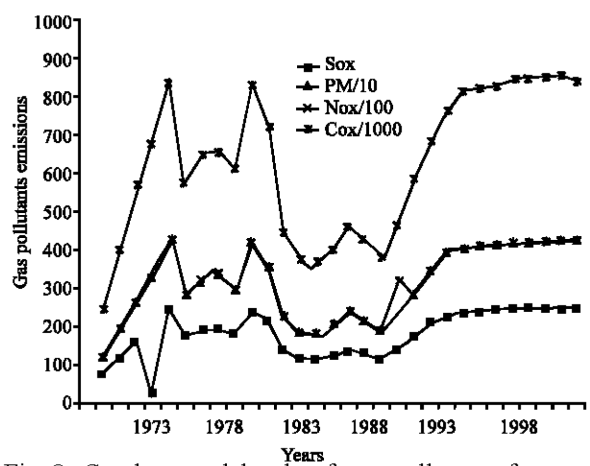

Fig. 8: Graph annual levels of gas pollutants from gas flaring

- Sample from communities adjacent or near to the oil facilities = 75%
- Sample from outside this area = 25%
- Respondents which had been residence in the area for 10 years and above = 76%. This group is believed to be in a sound position to evaluate/comment on local environmental issues.

The respondents were requested to rank the environmental components according their perception on

Table 1: Distribution of major environmental components

Components	Number and % of respondence Utorogu	Eriemu	Jesse	Kokori	Average score (%)
Air pollution (gas flaring)	30 (18.8)	30(17.7)	10 (17.5)	3.0 (6.0)	15.0
Oil spillage	40 (25)	70 (41.2)	15(26.3)	15 (30)	30.6
Surface and ground water contamination	60 (37.5)	40 (23.5)	23 (40.4)	25 (50)	37.8
Land/soil contamination	29 (12.5)	20 (11.8)	6 (10.57)	5 (10)	11.2
Excessive noise	10(6.3)	10(5.9)	3(5.3)	2(4)	5.4
Total	160/200	170/200	57/200	50/200	437 (54.6%)

Table 2: Distribution of major causes of conflict

Major reasons	Number and % of despondences Kokori	Utorogu	Eriemu	Jesse	Average (%)
Lack of employment	12 (24)	40 (25)	40 (23.5)	13 (23.3)	24.0
Environmental pollution	25 (50)	80 (50)	90 (52.9)	30 (53.6)	51.6
Lack of basic social amenities e.g potable water	8 (16)	10 (6.5)	10 (5.9)	3 (5.3)	8.4
All of the above	5 (10)	30 (18.8)	30 (17.7)	10. (17.9)	16.1
Total number of respondents	50/200	160/200	170/200	56/200	54.5

Table 3: Summary of respondents characteristics

Parameter	Characteristic	Proportion (%)
employment status	Skilled and unskilled workers e.g. oils workers teachers, civil servants	72
	Students and unemployed youths	28
Sex	Male	78
	Female	22
Age (years)	12 –35	34
	36 – 55	49
	≥56	17

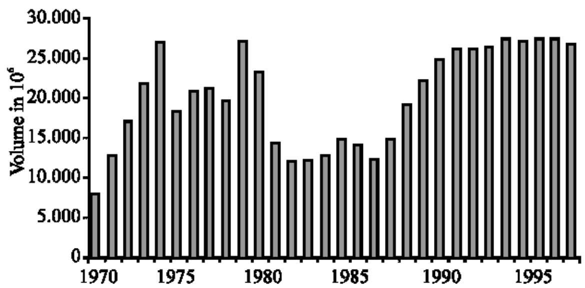

Fig. 9: Annual volume of gas flared (m^3)

their frequency and impact (magnitudes and significance), Glasson *et al.* (1999). Results from the input are presented in Table 1 and 2. In the table, the number (and percentage) represents the respondents who felt that each component was a big problem. Deductions from the investigation found that almost all the respondents (92%) believed the conditions of the rural oil producing communities have deteriorated due to gas flaring (15%), oil spillage (30.63%), water contamination (37.85%), land/soil contamination (11.2%) and excessive noise pollution (5.35%). Table1 indicates that about 55% responded to the questionnaire. This apparently shows that environmental pollution associated with oil exploration and production activities are well established in local perceptions.

There are variations in respondents' answers. For example, Table 1 shows strongest feeling for oil spill at Eriemu (41%) but far less support at Kokori (4%). Surface and groundwater contamination had the strongest feeling this is understandable because most of the rural communities rely on shallow hand dug wells which tap the phreatic aquifers in the superficial deposits that underlie the area (Uma, 1989; Environmental Care Ltd, 2000; Reijers *et al*., 1996).

The principal reasons expressed against oil activities which lead to conflict with the host communities are: Environmental pollution (51.63%), lack of youth employment (23.96%), followed by lack of basic social amenities such as potable water supply, health centers, schools and access reads (8.43%).

When questioned as to how the problem might be tackled, their answers were as follows:

- Stop oil exploration and production activities, 26% (highest in Jesse)
- Wait for what the government can do about it, 04% (highest in kokori)
- Alternative supply of drinking water, 16% (highest in Jesse)
- Quick response to spills, leaks and other environmental issues, 27% (highest in Eriemu).
- Dialogue with companies and government directly, 24% highest at Utorogu.
- Relocate and compensate affected communities, 10%. A majority of 67% wants positive and quick response to halt environmental degradation. However, in some of these communities it seems likely that existing social amenities, such as a borehole water scheme at Jesse, may suffer from maintenance if oil operation activities are stopped or banned in the area.

- Oil workers views: It was found that a general environmental awareness exists among this group to the level that most could distinguish between sustainable and deteriorating environment. Also there is a dominant perception that potential associated impacts can always be controlled/mitigated and that it is the responsibility of the government agencies to monitor and ensure compliance to standards and regulations.

CONCLUSION

Empirical analysis the trend of oil and gas pollution levels in the Niger Delta area of Nigeria has shown that the quantity of oil spill is on the decline, while the number of incidence is on the increase. The Oxides of Nitrogen, Nox, accounted for about 77%, while, Carbon Monoxide was found to be about 15% (in tonnes) of the gas pollutants from gas flaring.

An appraisal of the rural people's perception identified water contamination as the most perceived impacting environmental component and environmental contamination as the major cause of frosty relationship and social instability in the area.

RECOMMENDATIONS

It is recommended that the following areas need immediate attention to prevent spillage, foster good relationship and reduce social instability in the region:

- There is need to regularly monitor pipelines and flow lines and their installation so as to minimize corrosion effects, reduce sabotage and for early detection of spills.
- In the event of oil spillage quick evacuation of inhabitants is necessary to avoid loss of life through fire. Thereafter all efforts should be made to minimize/mitigate the impact.
- The efforts to stop gas flaring, increase natural gas exportation should continue. The relevant authorities should intensify provision of basic social amenities and youth employment.
- Surface and groundwater resources has been identified as the most affected component that has the highest magnitude and significance to the life of the rural communities therefore there is need for research and development of contaminant prediction models.
- The preliminary trends and relationship among air contaminants should be tested and compared with laboratory analytical results.

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