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Impact of Gas-Flaring on the Quality of Rain Water, Groundwater and Surface Water in Parts of Eastern Niger Delta, Nigeria

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Abstract The environmental and health impact associated with over 50 years of oil exploration and exploitation in Eastern Niger Delta region of Nigeria is of great concern. Flaring is the controlled burning of the natural gas associated with oil production. This study has clearly shown that gas-flaring constitutes a major source of water pollution in the oil producing region of Eastern Niger Delta. The results of the laboratory analysis of the water samples revealed that the water sources in the area have been negatively impacted acid-rain and NO_2, SO_2 and CO_2 from the burning gas. The sulphate, bicarbonate and nitrate content of rain water samples within the radius of 20 km from the gas-flaring station are high but the concentration decreases away from the gas-flaring stations. It was ascertained that the acidity and hence the nitrate, sulphate and bicarbonate content of rain water is a function of the frequency and duration of the rainfall as well as the direction of the prevailing wind prior to the rainfall and it gives rise to the formation of acid-rain. Corrosion of buildings, the dominance of respiratory problems and skin diseases are some of the signatures of gas flaring on the host communities. However, there may be a serious long term effect on the water resources in region in terms of quality if gas-flaring in the area does not stop.

Keywords: *impact of gas-flaring, Water Quality, Eastern Niger Delta, Nigeria*

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1. Introduction

Globally, gas flaring is one of the hottest debated environmental issues currently and in Nigerian oil producing Niger Delta in particular. Flaring is the controlled burning of the gas associated with oil production. Flaring is a means of eliminating gas when the volume is insufficient in terms of recovery and collecting it would be uneconomical. Gas flaring is a serious contributor to acid-rain, the impacts of which are already being felt in the Niger Delta region in terms of vegetation damage (Plate 1), corrosion and caving-in of roofing sheets (Plate 2) and death of aquatic lives (Plate 3). According to Stan (2002), about 115 billion cubic meters of gas are flared every year world-wide. Similarly, World Bank, (2004), ascertained that gas flaring in Niger Delta had contributed more greenhouse gases to the atmosphere more than all other sources in Sub-Saharan Africa Combined. Oil production in Niger Delta began over 50 years ago and so did the practice of flaring associated gas. In developed countries, the associated gas is re-injected into the ground while in Nigeria it is burnt off into the atmosphere without considering the environmental and health impact. Despite regulations introduced more than 20 years ago to outlaw the practice, most associated gas are flared by the oil companies, causing local pollution and contributing to climate change (TELL Magazine, 2008; Daily Trust Newspaper, 2008).

According to an interview with a village head, from one of the local communities living around the gas flaring station, the unpleasant smell, roaring noise and intense heat emanating from the gas flaring are dehumanizing as many of them are now suffering from skin diseases, cancer, ear problem, respiratory problems such as asthma and bronchitis. He confirmed that these diseases were new to them and are possible caused by continuous flaring of gas in the area. The impact of gas flaring on the environment and health of host communities in Niger Delta, Nigeria is of great concern. In view of the economic activities domiciled in the region, it becomes imperative to undertake a comprehensive study of the effects of gas flaring on the water resources of the area. This study was carried out in order to assess the impact of the gas flaring on the quality of rain water, surface water and groundwater in the vicinity of two representative gas flaring stations in Eastern Niger Delta within a radius of 40km centered at each station.

2. Materials and Methods

2.1. Study Area Description

The study area lies within the Eastern Niger Delta Region of Nigeria between latitude 4°40ᴵN and 5º40ᴵN and longitude 6º50ᴵE and 7º50ᴵE (Figure 1). It covers parts of Port-Harcourt, Aba and Owerri, covering a total area of approximately 12,056 km^2. The area is low lying with a good road network system and is drained by Imo River and its tributaries. The topography is under the influence of tides which results in flooding especially during the rainy season (Nwankwoaloa and Mmom, 2007).

Plate 1. Devastation of the Vegetation in the area due to acid rain

Plate 2. Cluster of zinc roofs with various degree of rusting/caving-in

Plate 3. Death of aquitic animals in the rivers in the area due to acid-rain caused by gas flaring

2.2. Physiography, Geology and Hydrogeology of the area

The area is a low land and characterized by two distinct seasons: a dry season (November to March) and rainy season (April to October). The study area is underlain by the coastal plain sand of Miocene age (Figure 1). The study area is underlain by unconfined aquifer of regional extent. Recharge into the unconfined aquifer is by direct infiltration of rainwater. The formation is made up of friable, fine to coarse grained sands with minor clay intercalations (Onyeagocha, 1980). It consists of water-bearing, porous and highly permeable continental sands. Records from drilled boreholes indicate shallow groundwater table while pumping test analyses show high hydraulic characteristics in terms of yield, transmissivity and storativity. Petrographic study on several thin sections (Onyeagocha, 1980) shows that quartz makes up more than 96% of all the sand grains. The general thickness of the coastal plain sands is variable and ranged from 180 m to 2000 m (Avbovbo, 1978). The annual groundwater recharge ranged between 20% and 30% of the annual rainfall of about 2500 mm (Uma and Egboka, 1987).

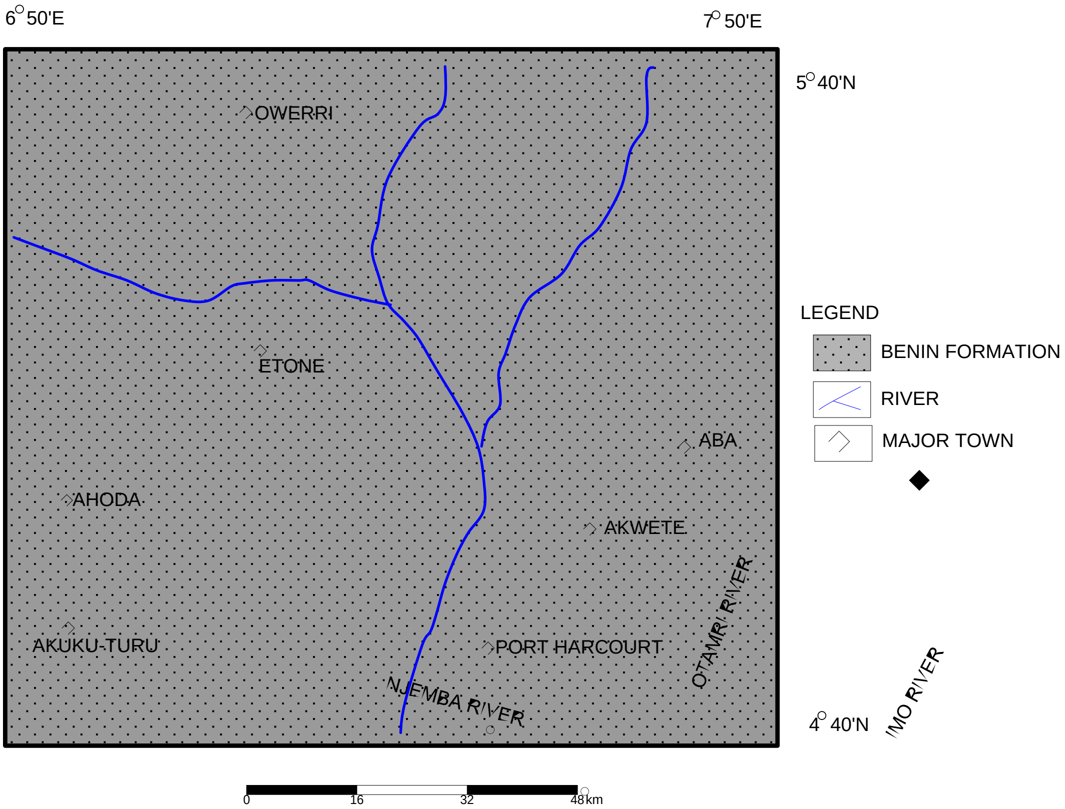

Figure 1. Geology map of the study area

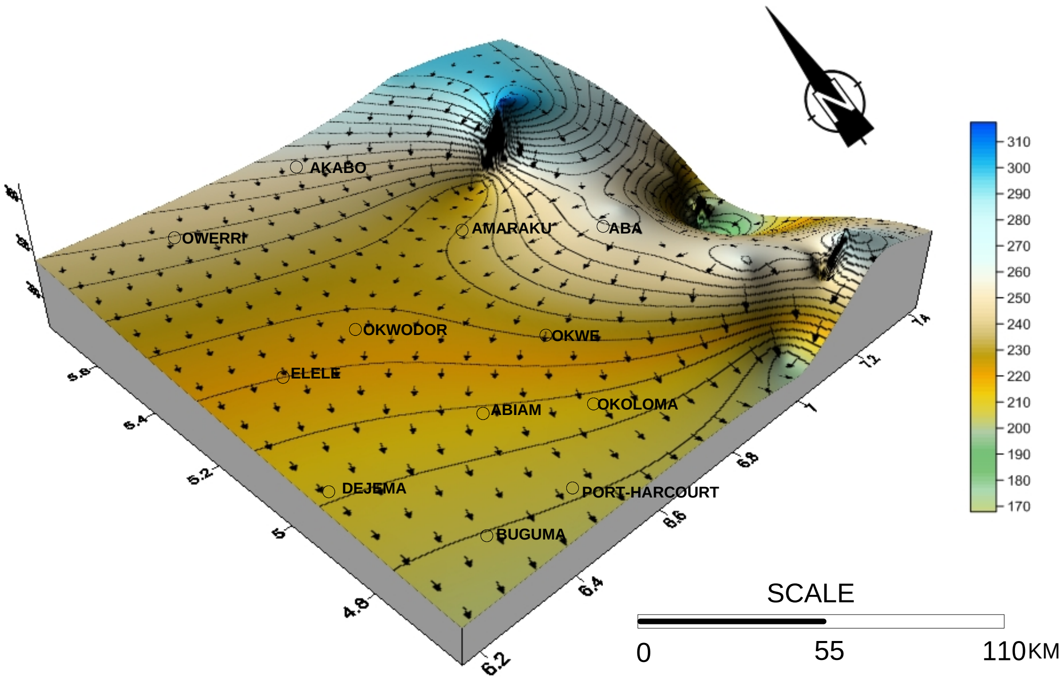

Figure 2. Digital terrain model of the study area overlapped with contour and flow lines

2.3. Sampling and Laboratory Analysis

Altogether 38 samples including 20 groundwater samples, 10 rain water samples and 8 surface water samples were collected and analyzed. All the samples were preserved by refrigeration and analyzed within 24 hours of collection. The water sampling and analyses were carried out in accordance with American Public Health Association (APHA, 1995), standard for sampling and analyzing water and waste water. The physical parameters such as pH and conductivity were determined on the field using a Gallenkamp pH meter and Hach conductivity meter WPA 400 digital model respectively. The coordinates of each samples location was taken using the global positioning system and the data was used to generate the digital terrain model of the area overlap with the contour map and groundwater flow direction (Figure 2). The heavy metal concentrations were analyzed using atomic absorption spectrophotometer (Model: YOUNGLI AAS 8010).

3. Results and Discussion

The mean concentrations of some of the parameters analyzed are shown in Figure 3 and Figure 4 while the scatter plot and correlation graph of the different water sources analyzed are illustrated in Figure 5 and Figure 6 respectively. The Conceptual Model of the environmental and socio-economic impact of acid-rain is illustrated in Figure 7. The effect of gas flaring on the quality of the water sources was studied using hydrochemical data from water samples in the vicinity of the gas flaring stations. The concentration of the major anions (bicarbonate, sulphate and nitrate), temperature, conductivity, heavy metal content (HM) and total hydrocarbon content (TH) increase appreciable in the vicinity of the gas flaring stations and consistently decreased away from the gas flaring points (Figure 3 and Figure 4). Their enrichment in the water sources may be attributed to the gas flaring activity in the area (Uma, 1989; Amadi *et al*., 2012). The rain water samples show concentration and variation trends similar to those of surface water and groundwater (Figure 3). The concentrations of pH, moisture content (MC) and bacteria count (BC) were lowest at vicinity of the gas flaring stations but increases away from the gas flaring points. The increased acidity of the rain water in the gas flaring stations may be responsible for the low pH (5.2) as control samples taken far away the gas flaring stations have higher pH (6.7). Similarly, the low concentration of MC and BC can be attributed to the intense heat emanating from the gas flaring station. Such heat (elevated temperature) may be capable of drying up the soil moisture and kill the bacteria in the soil/water as bacteria cannot withstand high temperature (Figure 4).

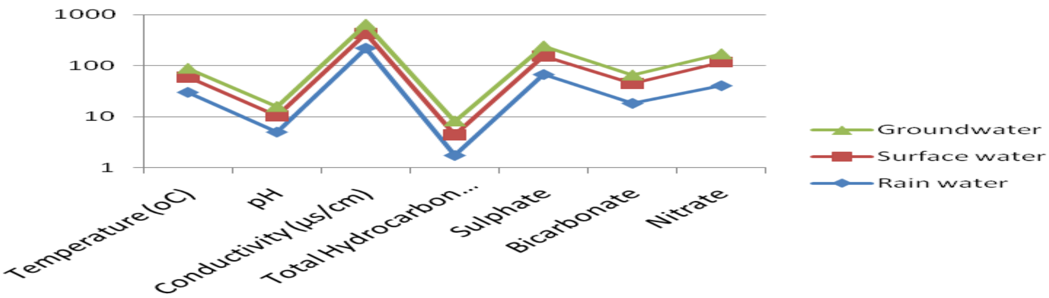

Figure 3. Graph of water sources and their concentrations

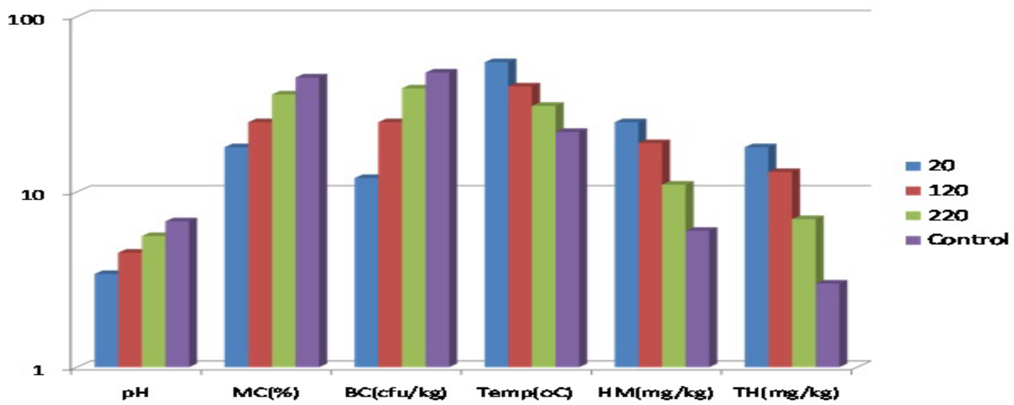

Figure 4. Graph of concentrations versus distance (km) to gas flaring station

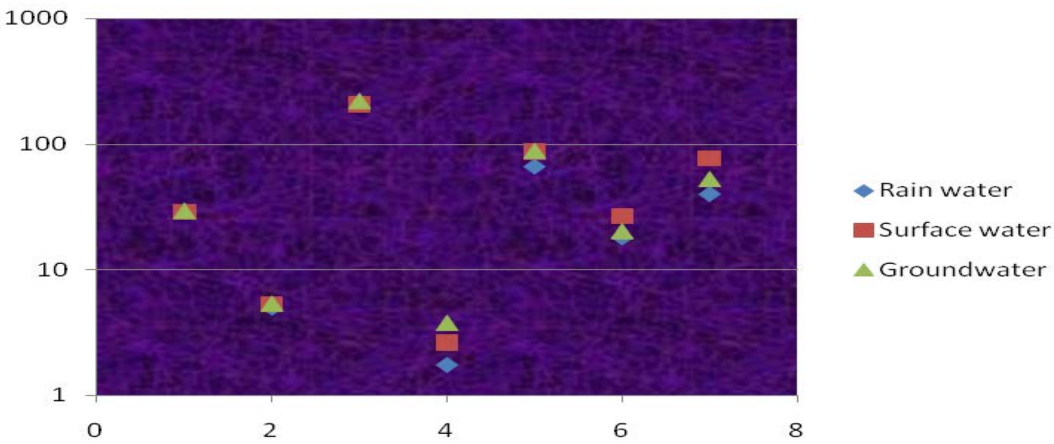

Figure 5. Scatter plot of water sources versus concentrations in mg/l

The similarity in distribution pattern of the geochemical constituents from the different water sources (Figure 5) in the vicinity of the gas flaring stations is a clear indication that that the enrichment of these ions are associated with the gas flaring activity. A comparison of the distribution pattern (Figure 6) and the groundwater flow direction (Figure 2) revealed a striking similarity. The gas flaring station overlies a groundwater recharge zone and the direction of the decreasing ionic concentration is parallel to the direction of groundwater flow away to the discharge zone (Amadi *et al*., 2014). This relationship is an indication that the movements of contaminants (TH, HM, SO_4^{2-}, HCO_3^- and NO_3^-) ions are likely assisted by advection, which is the contaminant transport by the bulk volume of the migrating groundwater. Surface water sampled at the discharge area of the groundwater flow from the gas flaring stations also showed evidence of geochemical enrichment. The results are consistent with the concentration of the ions in the rain water and groundwater samples from the locations.

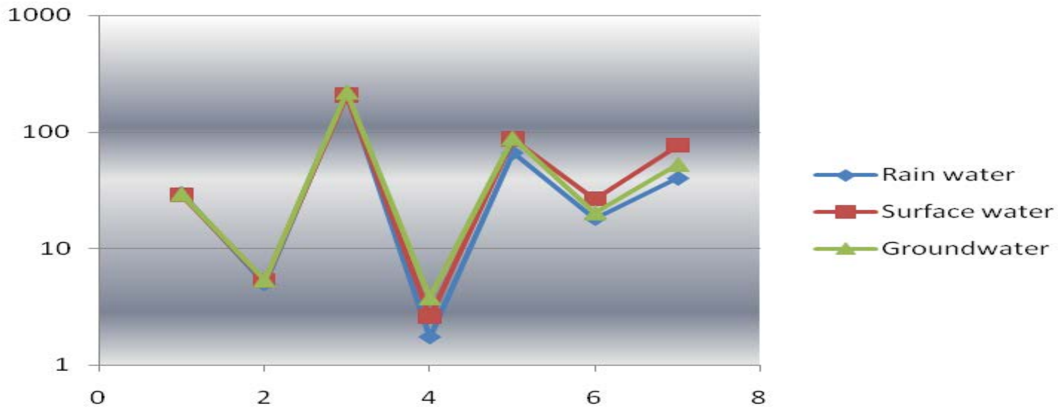

Figure 6. Correlation analyses of water sources versus concentrations in mg/l

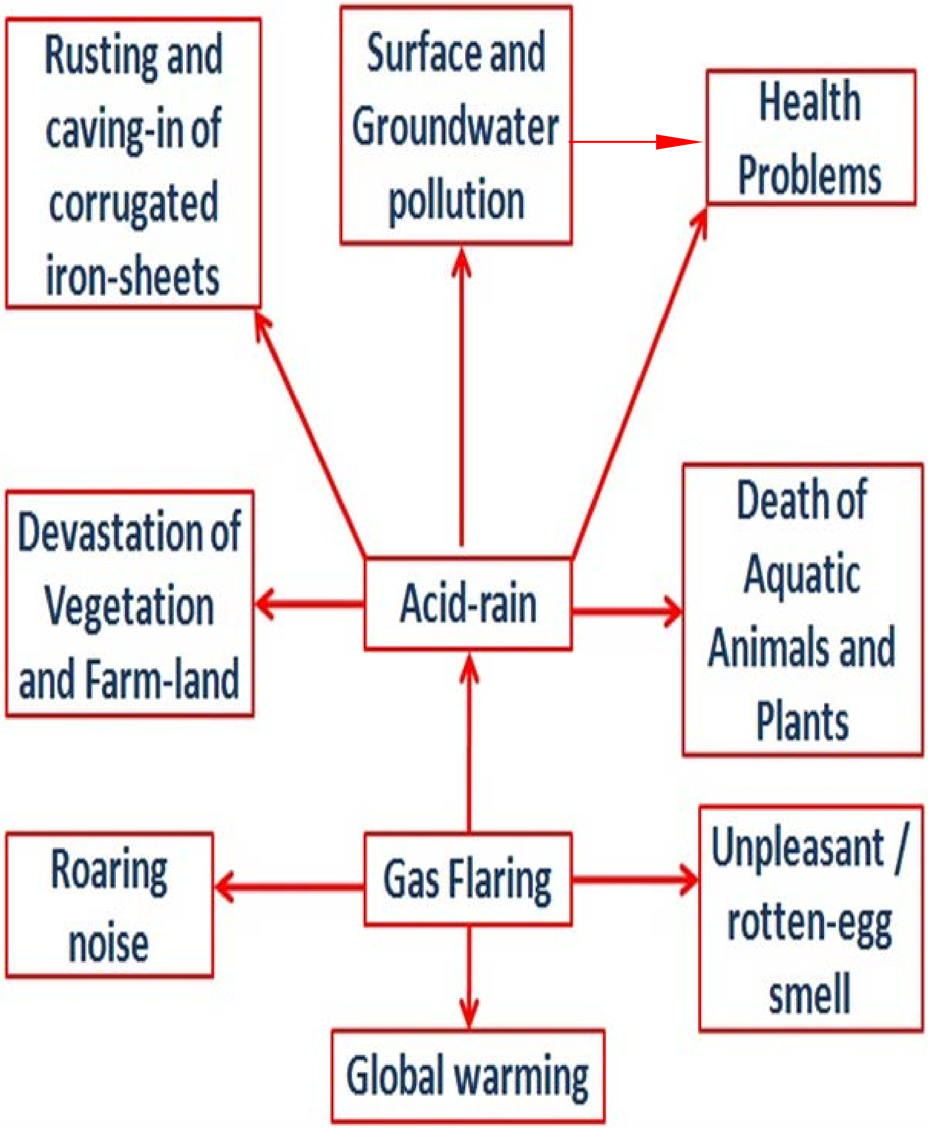

Figure 7. Conceptual Model of the Environmental and Socio-economic impact of Acid-rain (Amadi, 2013)

In Eastern Niger Delta area of Nigeria, the problem of acid-rain is evidenced in the rusting and caving-in of corrugated iron sheet and in the decay of other building materials as well as the devastation of the vegetation, death of aquatic and wildlife (Plates 1-3, Figure 7). These signatures of gas flaring manifesting through acid-rain in the area can be avoided if the associated gases are re-injected in the ground as practiced in developed countries. By so doing, these gases are not wasted and the environment is not polluted. Also, the health and socio-economic impact of gas flaring can be avoided. Therefore, any effort geared toward the eradication of gas flaring in Niger Delta region of Nigeria should be encouraged by all due to its enormous benefits.

4. Conclusion and Recommendations

This study has clearly demonstrated that gas flaring constitutes a major source of water pollution in the oil producing area of Eastern Niger Delta, Nigeria. The signatures are felt heavily on the water sources in the area. The dispersion of the enriched contaminant is heaviest on the direction of the groundwater flow but reduces on the opposite direction. The deterioration of the water resources in region will continue except an end is put to gas flaring in the region. Evaluation of the impact of gas flaring on plants, soil and air should be undertaken in the area in order to have comprehensive baseline information on the impact of gas flaring on the environment.

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