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# The Impact of Gas Flaring from the Kaduna Refinery and Petrochemical Industry (KRPC) on Plant Diversity in Kaduna Northern Guinea Savanna Eco-Region of Nigeria

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## ABSTRACT

50m x 50m plots were laid in each of the two (2) sites, replicated three (3) times to make a total of six (6) plots in all. The plants in all the sites were grouped into four (4) growth forms (trees, shrubs, herbs and grasses) which are evaluated using line transect method. The data were analyzed using student ‘t’ test and biodiversity index was calculated using Shannon Weiner method. The result showed that the population density and biodiversity index of the plant composition in the control site are more than that of the flare site from all the growth forms assessed due to combustion of fossil fuel and the heat generated from the flaring site. The mean of the plant species at the flare site is 663.00 and the control site is 1495.00. The standard deviation for the flare site is 4.32 and that of the control site is 2.51. The paired sample ‘t’ test correlation coefficient showed that there is strongly positive correlation efficient of 0.86 between plant diversity at the flare site and those at the control site. However, from the above analysis, it is concluded that there is statistically significant difference between plant species in the flare site and the control site ($p<0.05$) due to gas flaring that kills and suppress the growth of plants in the flare site. It is recommended that gas should be harnessed for use as liquefied natural gas. Government and NGOs should embark on an aggressive afforestation programme. Government should also enforce law against flaring, major industrial polluters and monitor their compliance with laid down standard.

***Keyword*:** Eco region, Impact, Kaduna Refinery, Northern Guinea Savanna, Plant diversity

## 1. INTRODUCTION

The Kaduna Refining and Petrochemical Company (KRPC) is concerned with the refining of petroleum products at a distillation capacity of 5,000 mt/yr (110,000bbi/d) and petrochemicals at a production capacity of 30,00 0mt/yr of kero solvent (Bureau of Public Enterprises, 2003-2007). Gas flaring is the combustion of associated gas fields (Adole, 2011; Ubani and Onyejekwe, 2013). It is also defined as the process or act of burning away associated gas into the atmosphere during the drilling of the crude oil (Ubani and Onyejekwe, 2013). Nigeria is known to be one of the highest countries on earth for flaring gas (Abua and Ashua, 2015). World Bank (2010) report put the rate of gas flaring in Nigeria at 32 - 6% against 0.6% and 0% by USA and Netherlands respectively. Nigeria flares more natural gas associated with oil extraction than any other country with estimates suggesting that of the 3.5 billion cubic feet (99,000,000 $m^3$) of associated gas (AG) produced annually, 2.5 billion cubic feet (71,000,000 $m^3$) or about 70% is wasted via flaring (Friends of the Earth, 2010). Gas flaring in Nigeria releases large amount of methane which has very high global warming potential. Methane is accompanied by carbondioxide ($CO_2$) of which Nigeria is estimated to have emitted more than 34.38million tons in 2002 accounting for about 5000 of all industrial emission in the country and 30% of the total $CO_2$ emission (Friends of the Earth, 2010). The estimated 84.60% of total gas produced is still flared with 14.86% only being used locally (Ukoli, 2005).

Petroleum is a naturally occurring complex mixture made up predominantly of hydrocarbon compounds and frequently contains significant amount of nitrogen, sulphur and oxygen together with smaller amounts of nickel, vanadium and various elements. Petroleum compounds can occur in solid form as asphalt, liquid form as crude oil and / or gaseous form as natural gas (Uzoma and Mgbemena, 2015). Petroleum hydrocarbons could be divided into four classes: saturates (naphthalene, phenanthene, benzene, cyclohexane); asphaltenes (phenols, fatty acids, ketones, esters and porphyrins); and resins (pyridines, quinolines, carbazoles, sulfoxides and amides) (Colwell and Walker, 1977; Ite and Ibok, 2013, Uzoma and Mgbemena, 2015).

Soil and sediments are the ultimate sink for most petroleum contaminants, such as benzene, toluene, ethylbenzene and xylenes, aliphatic and polycyclic aromatic hydrocarbon (PAHs). Petroleum hydrocarbon contamination of soil and sediment is a global concern because of toxicity (Ite and Ibok, 2013) and refractory character of the aromatic components in the absence of oxygen (Anderson and Lovely, 1997), PAHs, which makes up about 5% by volume, are a widespread class of environmental chemical contaminants of anthropogenic or natural origin. Inadvertent discharges of petroleum hydrocarbons into the environment during gas flaring often pose threats to human health, flora and fauna species, safety and the environment, thus have significant socio-economic consequences. Evidence of acute and chronic toxicity demonstrates the potential toxic and negative impacts of petroleum-derived wastes on the tropical environment (Uzoma and Mgbemena, 2015).

Large volumes of gas from oil wells and refineries have usually been flared into the atmosphere. Besides the toxic contents and air pollution effects of these, the enormous heat released at the flare site results in killing of vegetation around the flaring area, suppresses the growth and flowering of some plants, trigger concentration of trace elements, induces soil degradation and diminishes agricultural productivity (Mba, 1995; UNDP, 2006). Apart from the effect on biodiversity, its toxicity to humans causes respiratory illness leading to kidney diseases, neurological diseases and potential death (Ndubuisi and Asia, 2007).

Consequently, this research was carried out to assess the effect of gas flaring on flora diversity of Kaduna Northern Guinea Savanna Eco-region of Nigeria where data on effect of gas flaring on flora diversity are limited.

## 2. MATERIALS AND METHODS

### 2. 1. Study area

The study was conducted in Kaduna State, Nigeria (Figure 1). Kaduna State is one of the most industrialized States in Northern Guinea Savanna Eco-region. It is located between longitude 06°15'E, 08°5'E and latitude 09°2'N, 11°32'N. It covers an area of about 48,473 sqkm and has a human population of 3.96 million (NPC, 2006).

### 2. 2. Characteristics of the study site

The study sites are located around Brnin Gwari and Kaduna axis. Two (2) sites were selected for the study. Site A, which is Kamaku National Park, Birnin Gwari was used as the control site. Site B is a site behind Kaduna Refining and Petrochemical Company (KRPC).

### 2. 3. Sampling technique

Three (3) replicates of 50m x 50m were demarcated with 30 m enspacement between each plot using subjective sampling method. Each site was evaluated for flora diversity using line transect method. Growth forms of various plant species were identified and recorded as shrubs, herbs, grasses and trees. Mean record for the replicates were used to determine the occurrence.

### 2.4 Analysis of data

The following tools of analysis were used to analyze the data collected:

**(i) Biodiversity Index**

Biodiversity Index was calculated using Shannon-Weiner method.

$$H^1 = \sum_{i=1} PilogPi$$

or

$$H^1 = \sum_i PilnPi$$

where: $Pi = N_i / N$

n = number of individual of species

N = Total number of individual

$H^1$ = measure of diversity

Pi = Proportion of the 1th species in a site (Daniel *et. al.*, 1996)

**(ii) Paired 't' test**

Paired 't' test statistics was employed to analyze the mean differences in plant species between the flare site and the control site.

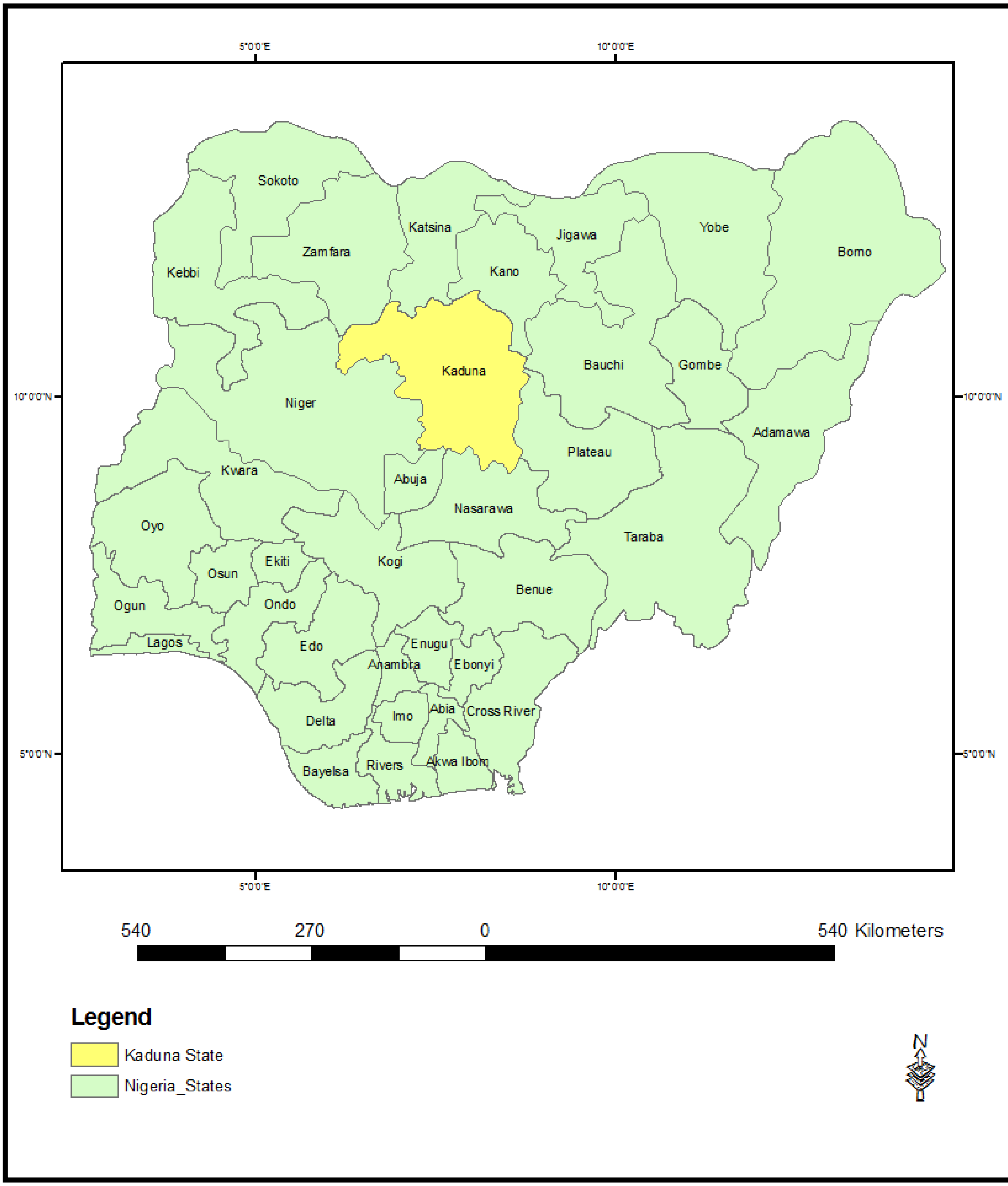


**Figure 1.** Map of Nigeria showing Kaduna State
Source: Field Survey, 2012

## 3. RESULTS AND DISCUSSION

Tables 1, 2 and 3 show plant population densities and diversity index at the flare site and control site. Results showed that a total of two thousand one hundred and sixty two (2,162) plants were recorded irrespective of their growth forms (trees, shrubs, herbs and grasses) with site A (control) having 1,495 species and site B (flare site) having 662 species. The result in table 1 revealed that the family Rutaceae had the highest number of 10 plant species. In the control site *Citrus sinensis* had the highest population density of 10 individual / ha closely followed by *Daniella oliverii* with population density of 6 individual / ha while other species varied between 4 and 2 respectively. In the flare site, *Citruc sinensis* also had the highest population density of 10 individual / ha closely followed by *Eucalyptus cammadulensis* and *Ficus thonningii* with population density of 6 individual / ha while others varied between 4 and 0. Diversity index was 2.52 in the control site and 1.57 in the flare site. This implies that tree species diversity are lower in the flare site than the control site.

**Table 1.** Available Tree Species in the Study Sites.

| S/No | Species | Family | Site A Population Frequency | Piloginpi | Site B Population Frequency | Piloginpi |
|---|---|---|---|---|---|---|
| 1 | *Vitex doniana Sweet* | Verbaneacea | 02(4.35) | 0.1364 | - | - |
| 2 | *Khaya senegalensis Ders.* | Meliaceae | 04(8.70) | 0.2124 | - | - |
| 3 | *Eucalyptus cammadulensis L.* | Myrtaceae | 04(8.70) | 0.2124 | 06(18.75) | 0.3139 |
| 4 | *Tamarindus indica L.* | Fabaceae | 02(4.35) | 0.1364 | - | - |
| 5 | *Adansonia digitata L.* | Bombeceae | 02(4.35) | 0.1364 | - | - |
| 6 | *Azadirachta indica L.* | Meliaceae | 02(4.35) | 0.1364 | - | - |
| 7 | *Ficus exasperata Vahl* | Moraceae | 02(4.35) | 0.1364 | - | - |
| 8 | *Ficus thonningii Blume* | Moraceae | 02(4.35) | 0.1364 | 06(18.75) | 0.3139 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | *Jacaranda mimosifolia D.Don* | Bignoniaceae | 02(4.35) | 0.1364 | - | - |
| 10 | *Daniellia oliverii Rolfe* | Leguminiaceae | 06(13.04) | 0.2656 | - | - |
| 11 | *Raphia sudanica A. Chev.* | Arecaceae | 02(4.35) | 0.1364 | 04(12.5) | 0.26 |
| 12 | *Delonix regia Boj. Ex Hook* | Fabaceae | 02(4.35) | 0.1364 | - | - |
| 13 | *Dalbergia sisso Roxb* | Fabaceae | 02(4.35) | 0.1364 | - | - |
| 14 | *Citrus sinensis L* | Rutaceae | 10(21.74) | 0.3318 | 10(31.25) | 0.3635 |
| 15 | *Psidium guajava L* | Myrtaceae | 02(4.35) | 0.1364 | 06(18.75) | 0.3139 |
| | | | 46(100) | 2.5226 | 32(100) | 1.5652 |

Source: Field Survey, 2016
Tree Species Diversity = 2.5226 (Site A)
Tree Species Diversity = 1.5652 (Site B)

Table 2 revealed that in the control site, *Cassia occidentalis* had the highest shrub population density of 193 individual / ha followed by *Sida acuta* with 162 individual / ha while other species varied between 146 and 12. In the flare site, *Lantana camara* had the highest population density of 164 individual / ha closely followed by *sida acuta* between 100 and 6 respectively. The species diversity index are 2.35 (control site) and 1.38 (flare site). This implies that site A, the control site is significantly higher in shrub diversity than site B, the flare site.

**Table 2.** Available Shrub Species in the Study Sites**.**

| S/No | Species | Family | Site A Population Frequency | Piloginpi | Site B Population Frequency | Piloginpi |
|---|---|---|---|---|---|---|
| 1 | *Combetum sericeum* | Combretaceae | 22(2.41) | 0.0897 | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | *Hyptis suaveolens Poit* | Labiateae | 24(2.63) | 0.0952 | 14(3.27) | 0.1119 |
| 3 | *Urena lobata Linn* | Malvaceae | 16(1.75) | 0.0708 | - | - |
| 4 | *Sida acuta Burm.f.* | Malvaceae | 162(17.72) | 0.3067 | 124(28.97) | 0.359 |
| 5 | *Blepharis maderaspatensis L.* | Acanthaceae | 24(2.63) | 0.0955 | - | - |
| 6 | *Acalypha hispida Burm.f.* | Euphorbiaceae | 30(3.28) | 0.1123 | - | - |
| 7 | *Jatropha curcas L.* | Euphorbiaceae | 44(4.81) | 0.1461 | - | - |
| 8 | *Lantana camara L.* | Verbenaceae | 116(12.70) | 0.262 | 164(38.32) | 0.3675 |
| 9 | *Thevetia peruviana (Pers.)* | | 134(3.72) | 0.1224 | - | - |
| 10 | *Piliostigma thonningii (Schum)* | Caesaliniaceae | 12(1.31) | 0.0569 | - | - |
| 11 | *Aloe buettneri A. Berger* | Liliaceae | 21(2.50) | 0.0867 | - | - |
| 12 | *Callotropis procera L.* | Apocynoceae | 25(2.74) | 0.0984 | 06(1.40) | 0.0598 |
| 13 | *Sida garckeana Polak* | Malvaceae | 28(3.06) | 0.1068 | - | - |
| 14 | *Senna occidentalis Linn* | Caesalpinioldeaea | 193(21.12) | 0.3283 | - | - |
| 15 | *Senna tora L. Syn.* | Caesalpainadeae | 146(15.97) | 0.293 | 100(23.37) | 0.3397 |
| 16 | *Physalis angulata Linn* | Solanaceae | 17(1.86) | 0.0741 | 20(4.67) | 0.1432 |
| | | | **914(100)** | **2.3449** | **428(100)** | **1.3811** |

Source: Field Survey, 2016
Shrub Species Diversity = 2.3449 (Site A)
Shrub Species Diversity = 1.3811 (Site B)

Table 3 revealed that in the flare site, *Achyranthesi aspera* had the highest herb population density with 10 individual / ha; *Nelsonia canescanes* had the least population density of 2 individual / ha while in the control site, *Nelsonia canescenes* had the highest population density of 261 individual / ha; *Euphobia heterophylla* had the least population density of 14 individual / ha. The species diversity index are 1.36 (control site) and 0.92 (flare site).

**Table 3.** Available Herb Species in the Study Sites.

| S/No | Species | Family | Site A Population Frequency | Piloginpi | Site B Population Frequency | Piloginpi |
|---|---|---|---|---|---|---|
| 1 | *Nelsonia canescences laim* | | 26(32.50) | 0.3653 | 02(11.77) | 0.2517 |
| 2 | *Euphorbia heterophylla linn* | Euphorbiaceae | 14(17.50) | 0.305 | - | - |
| 3 | *Polycarpaea corynbasa linn* | Caryophyllaceae | 20(25.00) | 0.3466 | - | - |
| 4 | *Achyranthesi aspera L.* | Amaranthaceae | - | - | 10(5882) | 0.3122 |
| 5 | *Vernonia ambigua Kotschy & Pery* | Asteraceae | 20(25.00) | 0.3466 | 05(29.41) | 0.36 |
| | | | **80(100)** | **2.3635** | **17(100)** | **0.9239** |

Source: Field Survey, 2016
Herb Species Diversity = 1.3635 (Site A)
Herb Species Diversity = 0.9239 (Site B)

Table 4 showed that in the control site, *Cynodon dactylon* had the highest grasses population density of 130 individual / ha with *Imperata cylendrica* having the least of 67 individual / ha while in the flare site, *Hyperthalia dissolute* had the highest population density of 106 individual / ha and *Cynodon dactylon* had the least population density of 20 individual / ha. The species diversity index are 1.58 (control site) and 0.93 (flare site).

Generally, the plant diversity in the control site was more than that of the flare site from all the growth forms assessed. This implies that combustion of fossil fuel and the heat generated from flaring site has a negative impact on the plants population, thus affects the population density and diversity of the plants composition of the site. Similar observations were recorded by Mba, (1995), UNDP, (2006), Bako *et.al*., (2009), Adole, (2011), Raji and Abejide (2013).

Result of analysis with paired sample t-test statistics in Table 5 showed that there is statistically significant difference between plant species in the flare site and the control site

(P<0.05). This occurs as a result of gas flaring activities in the flare site. It was further noticeable that the impact of gas flared was less significant at the control site ($p < 0.05$).

**Table 5a.** Paired Sample Statistics.

| | | Mean | N | Standard Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Flare Site | 663 | 3 | 4.322 | 2.309 |
| | Control Site | 1495 | 3 | 2.51 | 1.451 |

Source: Field Survey, 2016

**Table 5b.** Paired Sample Correlations.

| | | N | Correlation | |
|---|---|---|---|---|
| Pair 1 | Flare Site & Control Site | 3 | 0.855 | 0.002 |

Source: Field Survey, 2016

**Table 5c.** Paired Sample Test.

| | | Paired Differences | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Std. Error Mean | t | Df | S |
| Pair 1 | Flare Site - Control Site | 832 | 3.416 | 1.88 | 399.68 | 2 | 0 |

Source: Field Survey, 2016

## 4. CONCLUSION AND RECOMMENDATION

Plant species are heterogeneously distributed in the eco-region as revealed by the Shannon-Weiner analysis of species diversity. Plants diversity and population density are lower at the flare site that at the control site due to gas flaring that kills and suppress the growth of plants in the flare site. Therefore, it is recommended that gas should be harnessed for use as liquefied natural gas; government and NGOs should embark on aggressive afforestation programme and government should also enforce law against flaring, major industrial polluters and monitor their compliance with laid down standard.

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