

Research Article

Impact of Gas Flaring on the Serum Antioxidant Biomarkers of Eleme Residents in Rivers State, Nigeria

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• Gas flare; Antioxidant; Eleme; Oxidative stress biomarkers; Nkpolu-Oroworukwo community

Abstract

Gas flaring, a common practice in the oil and gas industry prevalent in the Niger Delta region of Nigeria, constitutes a major source of aerial pollutants with potential health effects. This study evaluated the possible effect of chronic exposure to environmental pollutants from gas flares on the antioxidant biomarkers of inhabitants of Eleme in Rivers State, Nigeria. Volunteer subjects for the study were selected from representative groups resident in Eleme, an oil and gas producing and refining area, for over 15 years while similar volunteer subjects resident in Nkpolu-Oroworukwo, a non-gas flaring community, served as the control. Blood samples were collected from the subjects and analyzed for intrinsic indicators of oxidative stress including Reduced Glutathione (GSH), Glutathione peroxidase (GPX), Glutathione-S-Transferase (GST), Superoxide dismutase (SOD), Malondialdehyde (MDA) and Catalase (CAT) levels using standard methods. The results for GPx, and GSH showed a significant decrease ($p \leq 0.05$) in concentration in the test subjects when compared to the control while MDA increased significantly ($p \leq 0.05$) in the test subjects when compared to the control. Concentrations of GST, CAT and SOD in test subjects also decreased when compared to the control. However, the decrease was not statistically significant ($p \leq 0.05$). These results suggest that chronic exposure to environmental pollutants like gas flares can alter human stress levels and deteriorate endogenous antioxidant status.

INTRODUCTION

Environmental pollution is a common feature in the oil and gas producing communities in Rivers State and other Niger Delta States in Nigeria. Flared gas is the most significant source of air emission from oil and gas installations [1]. During most of the activities in the oil and gas industry, wastes both in solid, liquid or gaseous form are generated and discharged into the environment. Flared gas is one of such wastes. Gas flaring is a common practice of burning off unwanted, flammable gases via combustion in an open atmosphere, non-premixed flame [2]. Gas flaring as one anthropogenic activity defined as the “wasteful emission of greenhouse gases (GHGs) that cause global warming, disequilibrium of the earth, unpredictable weather changes and major natural disasters because it emits a cocktail of benzene and other toxic substances that are harmful to humans, animals, plants and the entire physical environment” [3]. Gas flaring has also been defined as the complex and unscientific burning and emitting of excess hydrocarbons consisting of substantial amount of soot, carbon monoxide and greenhouse gases associated with crude oil and gas production processes [4] (Figure 1).

It has been observed that about 45.8 billion kilo-watts of heat is discharged into the atmosphere from 1.8 billion cubic feet of gas every day in the Niger Delta region, leading to temperatures

that render large areas inhabitable. The heat generated from gas flaring kills vegetation around flaring area, destroys mangrove swamps and salt marshes, suppresses the growth and flowering of some plants, induces soil degradation and diminishes agricultural productivity [5]. Furthermore, increased ambient thermal conditions have also been noted in oil and gas flared environments [6]. Increased ambient temperature can cause chronic and persistent dehydration. Chronic and persistent dehydration can lead to increased serum urea and reduced renal perfusion among other distortions of normal homeostasis [7]. Components of gas flares including noxious gases, hydrocarbons, particulates and heavy metals have been reported to exert varying deleterious effects on human health and the environment [3]. Increases in mortality from renal diseases have been observed among populations living in cadmium polluted areas of Belgium, England and Japan, with elevated levels of renal dysfunction [8].

Eleme is a Local Government Area (LGA) in Rivers State, Nigeria covering an approximately 140 square kilometers of land space. It is bound in the north by Obio/Akpor and Oyigbo LGAs, in the South by Okrika and Ogu Bolo LGAs, in the east by Tai LGA and the west by Okrika and Port Harcourt City LGAs. The Eleme environment host more than six operational gas wells with flare points clustered within the communities. The people of Eleme are traditionally farmers who depend largely on crops



Figure 1 A gas flaring site.

Source: <https://www.dw.com/en/gas-flaring-continues-scorching-niger-delta/a-46088235>

they cultivate for their livelihood. Associated gas from oil and gas exploitation is flared at ground levels within very close proximity of cultivated farmlands in the area [9,10]. Eleme LGA is also host to several heavy industries. There are two major petroleum refineries, two fertilizer plants, a petrochemical plant, a sea port, Federal Lighter Terminal (FLT) and Federal Ocean Terminal (FOT) with associated industrial plants that flare gas in the area [10]. Available records shows that most of the industrial wastes and effluents generated in the area are not discharged and disposed in compliance with established standards and Global Best Practices (Figure 2).

Oxidants are chemical compounds that carryout oxidation reaction in biological systems and these reactions are capable of producing toxic oxygen species or free radicals called Reactive Oxygen Species (ROS). These reactive oxygen species contains one or more unpaired electrons which can easily accept electrons from other molecules. Oxidants are species with very short half-life that have damaging activity towards biological macromolecules [11].

Conversely, antioxidants are compounds that scavenge and dispose of the reactive oxygen species and clean them, therefore preventing their formation and actions [12]. They inhibit oxidation and consequently prevent damages that may occur in the cells of organisms exposed to the free radicals. Anti-oxidants such as thiols or ascorbic acid (vitamin C) terminate the chain reactions of oxidants. To balance the oxidants status, plants and animals have evolved complex systems of overlapping antioxidants such as glutathione, catalase and superoxide dismutase, produced *in vivo*, and dietary anti-oxidants like vitamin A, C and E [13]. Antioxidants exert their effects via several mechanisms including; scavenging the species that initiate peroxidation, quenching singlet oxygen, chelating metals, breaking free radical chain reactions, and reducing the concentration of oxygen [14].

Due to the continuous gas flaring activities in the Niger Delta region of Nigeria, it becomes expedient to assess the levels of

endogenous oxidative stress markers in residents of impacted communities who are constantly exposed to the flared gases, drink from the polluted water, eat plants harvested from the surrounding soil and equally consume aquatic species found in these environments. Bearing in mind the cumulative health effects that may result from exposure to environmental pollutants; this study investigated the impact of gas flaring on the antioxidant status of residents in Eleme communities.

MATERIALS AND METHODS

Ethical approval

Ethical approval for the study was obtained from the Rivers State Ministry of Health (RSMoH), Rivers State Health Research Ethics Committee (RSHREC) and Rivers State Hospital Management Board (RSHMB), Port Harcourt, Nigeria. All test and control subjects for the study duly gave their written consent and filled the requisite questionnaire.

Exclusion criteria

The control population were volunteer subjects aged between 18 and 50 years, had no positive history of any health complications, were not on any special medication for any disease, are not smokers, had no history of alcohol abuse, work or live outside Eleme and have not travelled to Eleme or any other community anywhere in the world where gas flaring and oil and gas exploitation is taking place. Subjects with known illnesses such as cancer, diabetes mellitus and Parkinson's disease as well as tobacco smokers were excluded from this study. This is because cigarette smoke is an exogenous source of oxidative stress [15] while levels of oxidative stress biomarkers are known to be raised in the pathophysiology of cancer, diabetes mellitus and Parkinson's disease conditions [16].

Inclusion criteria

The test population includes healthy volunteer subjects within the age range of 18 - 50 years, with no history of recent blood

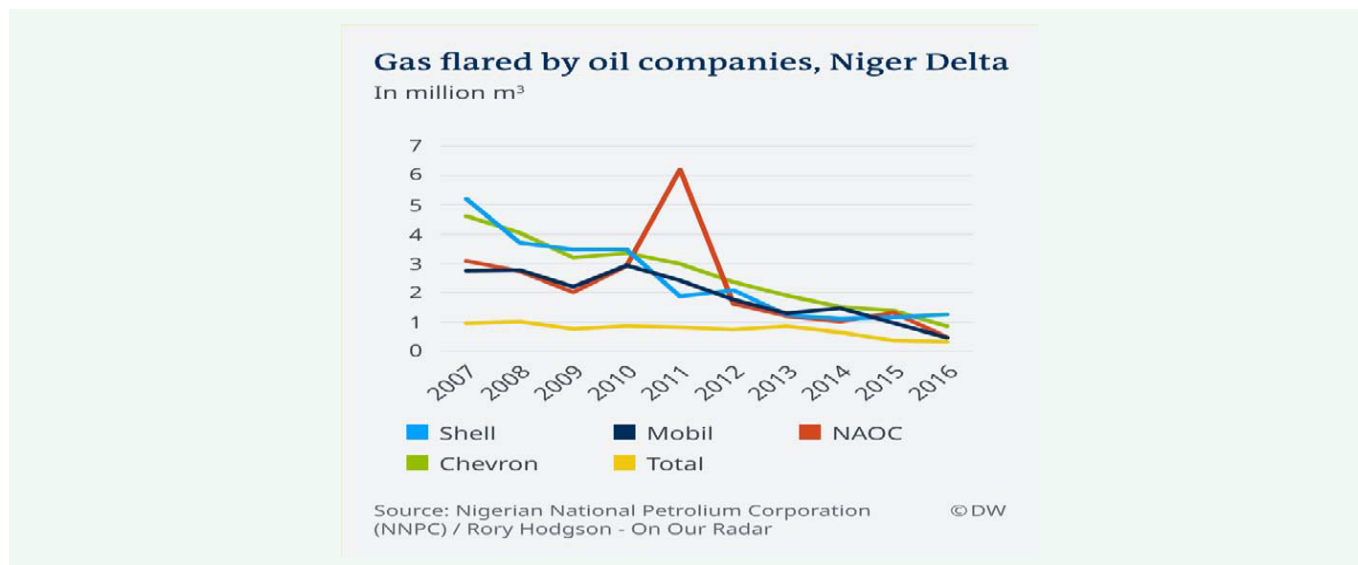


Figure 2 Statistics of Gas flaring by company in Niger Delta from 2007-2016.

transfusion and no clear diagnosis of other known diseases. They reside, work and farm in the study area (Eleme communities) for over 15 years and have been to Eleme communities or any other community anywhere in the world where gas flaring and oil and gas exploration is taking place.

Study area

This study was carried out in two Local Government Areas (LGA) of Rivers State located in the Niger Delta region of Nigeria. Eleme communities, located in Eleme LGA in Rivers East Senatorial District served as the test area while Nkpolu-Oroworukwo community located in Port Harcourt City LGA in Rivers Central Senatorial District served as control

Study population

A total number of 200 male and female volunteer subjects within the ages of 18 and 50 years were recruited for this study. They comprise of 50 males and 50 females (100 subjects) used as test and 50 males and 50 females (100 subjects) used as control. Blood samples were collected from each participants and analysis of the serum Antioxidant status of the subjects were conducted individually.

Specimen collection and processing

Blood specimen was collected from a peripheral vein via antecubital venipuncture from the respective volunteer subjects. This was dispensed into serum separator tubes (SST) and then centrifuged at 1000 rpm for 10 minutes. The serum obtained was transferred into plain sample bottle and stored in a freezer at -20 °C before analysis. All samples were analyzed within 14 days.

Determination of antioxidant biomarkers

Reduced Glutathione (GSH), Glutathione Peroxidase (GP_x), Glutathione-S-Transferase (GST), Superoxide dismutase (SOD), Malondialdehyde (MDA) and Catalase (CAT) levels were determined in the serum samples using standard "Randox"

antioxidant reagent kit (Randox Laboratories, London, UK)

Statistical Analysis

All data generated were analyzed using a one way Analysis of Variance (ANOVA) with the aid of Statistical Package for Social Sciences (SPSS) version 20 running on Windows PC. Data for each parameter were expressed as mean value ± standard deviation. The significant differences between the test means and control means were determined at 95% or p<0.05 confidence level.

RESULTS AND DISCUSSION

The levels of serum antioxidant biomarkers of male and female volunteer subjects in Eleme (test) and Nkpolu-Oroworukwo community (control) are contained in Table 1. Changes in biomarker levels occurred between the test population and control at varied degrees. Whereas the levels of GSH, GP_x, GST, CAT and SOD generally decreased in the test population compared to control, MDA levels increased in the test population compared to control. The increase was more pronounced in the female population compared to males.

Residents of communities where gas flaring occur are constantly exposed to noxious gases, toxic hydrocarbons and heavy metals as well as particulates emitted from such gas flares. These pollutants exert varying health effects including alterations in the endogenous antioxidant status of individuals chronically exposed. The results obtained from this study (Table 1) revealed that Catalase activity in the male and female test subjects (Eleme) decreased when compared to the control subjects (Nkpolu-Oroworukwo community). The Catalase enzyme in humans catalyzes the biotransformation of endogenous peroxides to water and oxygen thus protecting the cells from the inherent reactive oxygen in peroxides. Low level of Catalase is very dangerous as this may expose the cell to oxidative damage arising from the production of reactive oxygen species (ROS) [17]. The result for Catalase activity revealed that exposure to gas flare can lead to a reduction in catalase concentration in the blood. This

Table 1: Levels of Antioxidants in male and female volunteer subjects.

Subjects	Antioxidants					
	GSH($\mu\text{g/ml}$)	GPx($\mu\text{g/ml}$)	GST($\mu\text{g/ml}$)	CAT($\mu\text{g/ml}$)	MDA($\mu\text{mol/ml}$)	SOD($\mu\text{g/ml}$)
Male (control) (n=50)	0.99 ^{ab} ±0.25	0.25 ^a ±0.34	0.11 ^a ±0.03	19.50 ^a ±1.81	0.51 ^{ab} ±0.38	0.20 ^a ±0.10
Male (Eleme) (n=50)	0.61 ^a ±0.19	0.07 ^a ±0.05	0.09 ^a ±0.03	18.24 ^a ±6.83	0.52 ^{ab} ±0.22	0.14 ^a ±0.10
Female (control) (n=50)	1.16 ^b ±0.09	0.94 ^b ±0.65	0.13 ^a ±0.05	22.46 ^a ±6.74	0.33 ^a ±0.26	0.21 ^a ±0.15
Female (Eleme) (n=50)	0.67 ^a ±0.39	0.03 ^a ±0.02	0.08 ^a ±0.02	18.86 ^a ±2.95	0.83 ^b ±0.06	0.06 ^a ±0.02

*Values are expressed as mean \pm standard deviation. Values with different superscripts show significant difference at the 0.05 level.

effect could be attributed to the absorption of toxic hydrocarbons and heavy metals emitted. Hydrocarbons and heavy metals can interfere with metabolic processes, leading to the production of free radicals in the body [18].

The level of GSH and GPx decreased significantly ($p \leq 0.05$) in the test subjects (Eleme) when compared with the control subjects (Nkpolu-Oroworukwo community) in both males and females. An over expression of GPx has been reported by to protect cells against oxidative damage, suppresses apoptosis induced by H_2O_2 , and reverses the malignant phenotype in pancreatic cancer [19]. A decreased concentration of GPx has also been reported to be a contributing factor to vitiligo [20]. GSH aids in neutralizing free radicals by donating their electrons, thus protecting the cells from oxidative stress [21].

MDA increases in the body during excessive oxidative stress [22]. This study (Table 1) showed a significant ($p \leq 0.05$) increase in the concentration of blood MDA in the test subjects when compared to the control, indicating an increase in the oxidative stress status of the subjects in Eleme communities. This may be attributed to the prevailing industrial activities in Eleme, which includes gas flaring that emits aerial pollutants continuously. The constituents of the flared gas have been reported to alter both the environment and human biochemical systems [4].

The GST and SOD levels of the test subjects decreased compared to control (Table 1). Although the decrease is not statistically significant ($p \leq 0.05$), a drop in level of these endogenous antioxidants could exert deleterious synergistic effect. Superoxide dismutase (SOD) and catalase are enzymes that comprise the antioxidant system in the body. SOD constitutes the first line of defense against reactive oxygen specie and it is important in the removal of superoxide ion while catalase is essential for the removal of hydrogen peroxide (H_2O_2) [23]. Under chemical stress, the activity of antioxidant enzymes including catalase, GST and superoxide dismutase (SOD) may be increased or inhibited depending on the level and time of exposure, and the species of organism involved [24,25].

CONCLUSION

From the results of this study, it can be concluded that the chronic exposure to gas flares and oil and gas industrial activities in Eleme environment, is linked to the significant alterations in the serum antioxidant biomarkers status of the residents. This could cause oxidative stress and attendant health complications among residents of the area.

It is important to commence intervention and mitigation measures in order to prevent adverse health effects on individuals living in the impacted communities. It is hoped that this study would serve as a reference for Government and oil firms in delineating the health and environmental implications of gas flaring in communities of the Niger Delta region when formulating policies or initiating actions that would be beneficial to those working and living in the area.

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