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Changes in Liver, Kidney and Atherogenic Indices of Women in Ebocha, Niger-Delta, Nigeria due to Gas Flaring

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ABSTRACT

Gas flaring causes pollution to the environment and also affects the human organs such as the liver and kidneys. The present study seeks to investigate changes in liver, kidney function and atherogenic predictor indices of native women of Ebocha, Niger Delta, Nigeria who have over the years been chronically exposed to the persistent gas flaring in the area. Two hundred (200) healthy and freely consented women aged between 30 to 50 years were recruited; one hundred (100) from Ebocha and one hundred (100) from Uturu the control station. Results revealed that the values of serum activities of alanine aminotransferase (ALT), aspartate transferase (AST) alkaline phosphatase (ALP), and the concentrations of albumin and total protein were significantly ($p<0.05$) higher in Ebocha women when compared to values of women from Uturu. The pollution caused as a result of gas flaring did not affect the concentrations of bilirubin in women from both sites. However, serum creatinine, urea, K^+, Na^+, Cl^- and HCO_3^- concentrations were significantly ($p<0.05$) higher in Ebocha women when compared to values for women from the control station. Ebocha women had significantly ($p<0.05$) reduced concentrations of serum triglyceride, total cholesterol and HDL cholesterol but significantly ($p<0.05$) increased LDL-cholesterol and atherogenic predictor indices in comparison with those from Uturu indicating that chronic gas flaring has negative effects on the liver, renal function, lipid profile and atherogenic predictor indices of women resident in Ebocha.

Keywords: Liver, kidney, atherogenic indices, gas flaring, women, Niger Delta.
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INTRODUCTION

Niger Delta area is located on the Atlantic coast of Southern Nigeria. It is the world's second-largest Delta with a coastline of about four hundred and fifty kilometers (450 km) which ends at Imo river entrance (Aghalino, 2000; Anomoharan, 2012). It consists of diverse ecosystems of mangroves, freshwater swamps and rain forest trees, and is the largest wetland in Africa. Due to pollution caused by oil exploration and production activities, the area is now characterized by polluted streams and rivers, forest destruction and biodiversity loss. In fact, the area is an ecological wasteland (Okeke et al., 2016). The devastation of the ecosystem has affected the livelihood of the indigenous people, who depend on the ecosystem and its resources for survival. Various ethnic nationalities such as the Effiks, Epies, Igbos, Ijaws, Ikwerres, Isokos, Itsekiris, Ofonis, Ogonis, Ogbias, and Urhobos reside in the area (Omajemite, 2008). The area also comprises of diverse species of flora and fauna both aquatic and terrestrial (Adati, 2012). It is surrounded by villages and towns with fishing and farming as the prime industries that support their economy (Kamalu and Wokocha, 2010). But the effects of gas flaring and oil spillages have adversely affected the availability of fish (Nwaogu and Onyeze, 2020). Fruits, vegetables and other agricultural produce have been adversely affected as well. These have taken a toll on the health and well-being of the residents too (Ashton et al., 1999).

Crude oil is associated with the economic development of Nigeria. Between 1976 and 1977, crude oil provided roughly 92% of Nigeria's total export earnings. It has continued to be the major income earner for the country since the shift of attention from the agricultural sector (Beulah and Obot, 2013). The importance and impact of crude oil on Nigeria can be fully appreciated if one realizes the dominant role it plays in the economy by providing job opportunities and economic development. The major bulk of Nigeria's crude oil is sourced from the Niger Delta region of the country. However, the region's potential for sustainable development remains unfulfilled and its future is being threatened by diverse environmental pollution problems (Beulah and Obot, 2013).

According to FEPA (2001), the petroleum industries release hydrocarbons and other harmful effluents into the environment (Smith et al., 1993; Seyyednejad et al., 2011). Through operations such as gas flaring, transportation of products and disposal of liquid refinery effluents, greases, phenols, sulphides, poly-aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and heavy metals are released into the environment of which the soil is the major recipient. These pollutants easily render soil resources infertile for agricultural processes. This is disastrous as the bulk of the populace depends heavily on agriculture as a means of livelihood.

Gas flaring has potential harmful effects on the health and livelihood of the communities in the Niger Delta, as it releases a variety of poisonous chemicals including nitrogen dioxide, sulphur dioxide, carbon monoxide, methane, particulates, and volatile organic compounds like benzene, toluene, xylene and hydrogen sulphide, as well as carcinogens like dioxins (Okeke et al., 2016). Humans exposed to such substances can suffer from respiratory problems such as asthma, breathing difficulties, pain and chronic bronchitis. Occupational exposures to petroleum fumes have been reported to have toxic effects on various organs and systems including the immune and nervous systems (Smith et al., 1993). Also, organs such as the heart, liver, lungs, skin and kidneys are affected by these toxic substances resulting in various diseases and different forms of genotoxic, mutagenic, immunotoxic, carcinogenic and neurotoxic manifestations (Rabble and Wong, 1996; Krisyi and Subhash, 2014).

The volatile nature of petroleum and its constituents makes them readily available in the atmosphere any time they are dispensed, especially at oil refineries, petrol filling stations and depots. Petroleum products contain a mixture of volatile hydrocarbons and so inhalation is the most common form of exposure. At low doses, petroleum vapour is irritating to the eyes, respiratory tract and skin. Exposure to higher concentrations of the vapour affects the central nervous system which manifests in slurred speech and confusion (Okoro et al., 2006). Very high concentrations may result in unconsciousness and death due to respiratory failure (Smith et al., 1993), and may also have an impact on proper organ function such as the liver and kidneys, so further research is needed. Petroleum fumes contain aliphatic, aromatic and a variety of other branched saturated and unsaturated hydrocarbons which are a continual source of pollution. Benzene, toluene, xylene, naphthalene and ethylene are hydrocarbons present in gas flares (Strosher, 1996). Since petroleum contains some of these constituents, chronic or frequent exposure to their fumes may affect the oxidant/pro-oxidant balance in exposed individuals.

An on-site visit to Ebocha in Niger Delta revealed the deteriorating condition of the environment. The free disposal of gas through flaring generates tremendous heat that leads to direct and increased water loss by transpiration in nearby plants resulting in severe wilting and death. Gas flaring causes acid rain which not only tends to collect on plants and grasses growing on the banks of rivers but also interacts with sediments thereby harmfully affecting the aquatic organisms. The soil and water pollution occasioned by gas flaring pollutants result in damage to wildlife and vegetation (Oshwofasa et al., 2012). There is also the presence of soot on water surfaces which deprives the populace of portable water for drinking and household chores. Many communities claim that nearby gas flares cause acid rain that results in premature corrosion of their zinc-based roofed houses and other local structures (Nkwocha and Pat-Mbonu, 2010). These have made some people resort to the use of asbestos-based materials, which are stronger in resisting acid rain deterioration. Unfortunately, this contributes to the decline of personal health, as exposure to asbestos dust increases the risk of lung cancer (Okeke et al., 2016).

Furthermore, discussions with elderly people on their experience in the area revealed that there is the emergence of endangered species of plants such as guava, plantain and banana; animals such as frog, millipede, earthworm, reptiles and grasshoppers due to the effect of the intense heat from the gas flare stations resulting in reduced crop yield (Seyyednejad et al., 2011). They complained that because they live and work alongside the flares with no protection coupled with continuous inhalation of the toxic gas flare pollutants, diverse health abnormalities such as asthma, respiratory difficulty, headache, drowsiness and high body temperature have oftentimes affected them (Audu and Arikawei, 2013). Available records from health institutions in Bayelsa State showed that over 50% of the farmers suffer from various respiratory diseases (Audu and Arikawei, 2013). These negative impacts of gas flaring on this populace have oftentimes caused social tensions among various native groups, companies and government institutions in the Niger Delta (Omajemite, 2008). Thus, the present study was undertaken to investigate changes in liver, kidney function and atherogenic predictor indices of native women of Ebocha, Niger Delta, Nigeria who have over the years been chronically exposed to the persistent gas flaring in the area.

MATERIALS AND METHODS

Study area

The study was conducted in two different locations in the Niger Delta area of Nigeria. Ebocha, an oil and gas producing community with active gas flaring operated since 1975 by an oil company, constitute the test site, and Uturu with no history of petroleum hydrocarbon (PHC) pollution served as control. Ebocha is located at latitude 6^{o} 40’ 0^{o} E and longitude 5^{o} 25’ 0 N with neighboring towns as Omoku and Obido in Rivers State while Uturu is located at latitude 7^{o} 29’ 0^{o} E and longitude 5^{o} 510’ 0^{o} N with neighboring towns as

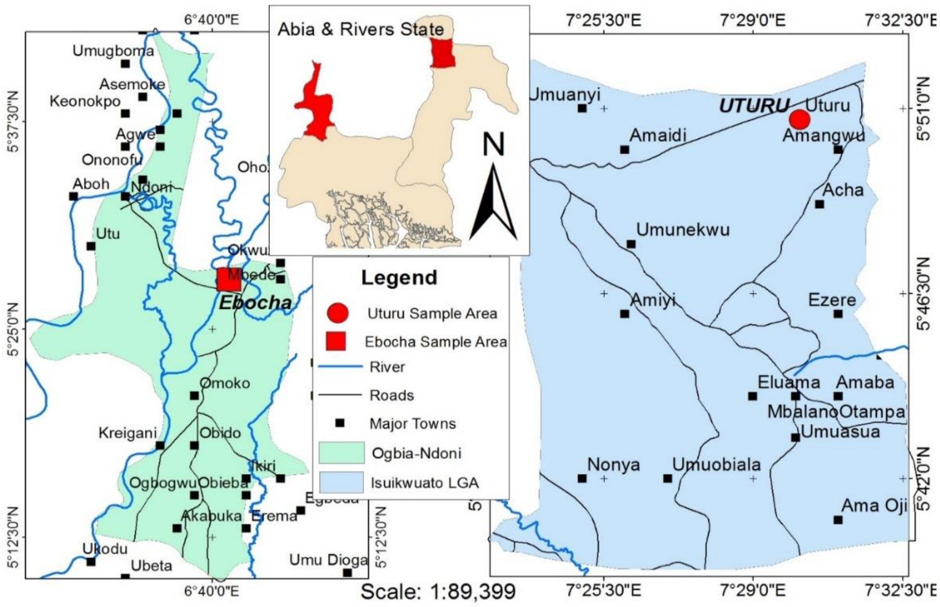

Figure 1: Map of Ebocha and Uturu in Niger Delta, Nigeria.

Amangwa, Amaidi and Acha in Imo State (Figure 1). The residents of both communities are mainly farmers, traders and civil servants and they share many common characteristics. The study was carried out during the dry season between January and March 2017.

Ethical Approval

The research was approved by the Ethical Committee on Human Research of the Department of Biochemistry with Ethical Approval No. FUT/SOBS/BCH/COM.1/012/2017, Federal University of Technology, Owerri, Nigeria and the study conforms to the Helsinki Declaration on Medical Research.

Selection of subjects for the study

Eligible subjects for the study were selected based on the administration of questionnaires and those who were within our inclusion criteria, which include those who were apparently healthy, without any known sickness such as HIV, tuberculosis, malaria, hepatitis B, diabetics and have consistently lived in the study areas for twenty years. The essence and procedures of the study were thoroughly explained to the participants and only those who consented to in writing and /or thumb printed in our questionnaire participated in the study**.**

One hundred (100) apparently healthy women aged 30 to 50 years old, who have lived in Ebocha continuously for at least twenty (20) years within the immediate environment (5 km) from the gas flaring site. The control subjects included another one hundred healthy age-matched women who have lived consistently in Uturu for at least 20 years. Subjects with any identified ailment, those who had traveled and stayed outside their residential study area for more than 48 hours, and those who did not freely give consent were excluded from the study.

Blood specimen collection

Eight milliliters (8ml) of venous blood specimen were collected from each subject and was dispensed into a plain sample bottle and allowed to clot. Thereafter serum was collected from the clotted blood specimen for analyses of liver, kidney and lipid function parameters.

Liver function indices

The serum activities of alanine aminotransferase (ALT: EC: 2. 6. 1. 1), aspartate aminotransferase (AST: EC: 2 .6. 1. 2) and alkaline phosphate (ALP: EC: 3. 1. 3. 1) were assayed. Serum concentrations of albumin, total protein, direct and total bilirubin were determined according to the methods of Balistreri and Shaw (1987).

Kidney function indices

Urea and creatinine concentrations were determined using Urease-Berthelot and Alkaline Picrate-Slotcolorimetric methods respectively (Searcy et al., 1967; Seaton, 1984) with the aid of commercially available reagent kits (Randox Laboratories Ltd, UK). Similarly, sodium and potassium ions concentrations were determined with the aid of proprietary reagent kits using the methods of Maruna and Trinder (1958) and Terri and Sesin (1958). Chloride and bicarbonate ions concentrations were also determined using commercially sourced TECO reagent kit based on the colorimetric method of Skeggs and Hochestrasser (1964).

Lipid profile

Serum triglyceride (TG), total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-c) concentrations were determined using the enzymatic colorimetric

Table 1: Liver function indices of women from both sites.

Liver Function indices	Uturu	Ebocha	Normal Range
ALT (U/l)	8.30 ± 2.01[a]	11.99 ± 1.29[b]	5-40 U/l
AST (U/l)	9.57 ± 1.12[a]	12.23 ± 1.86[b]	11-35 U/l
ALP (U/l)	26.75 ± 1.14[a]	32.80 ± 3.93[b]	30-130 U/l
Albumin	4.29 ± 0.23[a]	3.44 ± 0.43[b]	37-53 g/l
Total protein	8.00 ± 0.40[a]	6.46 ± 0.92[b]	55-89 g/l
Direct bilirubin	0.23 ± 0.07[a]	0.27 ± 0.05[a]	3-18 µmol/l
Total bilirubin	0.89 ± 0.13[a]	0.91 ± 0.10[a]	3-15 µmol/l

Values are mean ± standard deviations. Values with different superscripts per row are statistically significant ($p<0.05$).

Table 2: Kidney function indices of women from Uturu and Ebocha

Kidney function indices	Uturu	Ebocha	Normal Range
Creatinine	0.78 ± 0.08[a]	0.94 ± 0.08[b]	44.2- 194.5 mmol/l
Urea	11.84 ± 1.35[a]	43.48 ± 5.59[b]	2.5- 6.5 mmol/l
Sodium	137.90 ± 4.84[a]	150.00 ± 5.56[b]	135-145 mml/l
Potassium	4.13 ± 0.61[a]	5.23 ± 0.45[b]	3.5-5.0 mmol/l
Chloride	99.87 ± 2.27[a]	102.70 ± 3.24[b]	97-108 mmo/l
Bicarbonate	29.83 ± 3.19[a]	26.88 ± 2.51[b]	24-28 mmol/l

Values are mean ± standard deviations. Values with different superscripts per row are statistically significant ($p<0.05$).

method (Bucolo and David, 1973), phosphotungstate precipitation and enzymatic endpoint methods (Allian et al., 1974) with the aid of commercial reagent kits (Randox Laboratories Ltd, UK). Serum low-density lipoprotein cholesterol (LDL-c) concentration was calculated as previously described by Friedawald et al, (1972).

Atherogenic predictor indices

Serum total non-HDL cholesterol (TnHDL-c) concentration was calculated as total cholesterol less high-density lipoprotein cholesterol concentrations (TC-HDL-c) (BrunzelL et al., 2008), while Castelli's Risk Index I (CRI-I) and Castelli's Risk Index II (CRI-II) were determined as TC/HDL-C and LDL-c/HDL-c respectively (Castelli et al., 1983; Igwe et al., 2010). Atherogenic index of plasma (AIP) and atherogenic coefficient (AC) levels were calculated as log (TG/HDL-c) and [(TC-HDL-c) /HDL-c)] respectively (Brehm et al., 2004; Dobiasova, 2004).

Statistical analysis

Data generated were analysed using 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 ± standard deviation, while significant differences between the test and control means were adjudged at 95% confidence level.

RESULTS

The results in Table 1 shows that serum enzyme activities of ALT, AST, ALP and that of the concentrations of albumin and total protein were significantly ($p<0.05$) higher in Ebocha women when compared to values for women from Uturu.

Table 2 shows that there were significantly ($p<0.05$) higher serum concentrations of creatinine, urea, sodium, potassium, and chloride ions but lower bicarbonate ions in women from Ebocha than those from Uturu.

Results of the lipid profile study showed that the serum concentrations of total cholesterol, triglyceride and LDL-cholesterol of native women of Ebocha were significantly ($p<0.05$) higher than those of the women from Uturu (Table 3).

On the other hand, the serum HDL-cholesterol concentration (1.32 ± 0.08 mmol/l) of the Ebocha women was significantly ($p<0.05$) reduced when compared with that of the Uturu women (6.52 ± 0.06 mmol/l).

Table 3 also shows that there were significantly ($p<0.05$) higher levels of atherogenic predictor indices in the Ebocha native women in comparison with those of the women from Uturu, the control site.

DISCUSSION

Gas flaring following oil exploration over a long period of time has contributed to the petroleum hydrocarbon pollution in Ebocha in the Niger Delta. Definitely, the ecosystem has received the impact of the pollution. Animals and plants growing in that environment have, over the years, taken in a large dose of harmful pollutants (Nwaogu and Onyeze, 2020). When an individual is exposed to a high concentration of xenobiotics especially gas flare, liver and kidney parameters either increase or decrease. The outcome of the measurement determines the extent of the damage caused by the exposure.

The liver is the sole site for xenobiotic detoxification and the synthesis of albumin, which makes approximately 60% of serum protein concentration. Xenobiotic hepatotoxic action is usually expressed by cell respiration disorders that interfere with oxidation and reduction mechanisms; either through impairment in protein, carbohydrate and lipid metabolism or by disturbances in intra and extracellular transport. Consequently, whole-cell or its cytoplasmic organelles can be damaged (Mahmoud et al., 2011). Most frequently, the damage occurs as parenchymal vacuolar degeneration, necrosis of hepatocytes, or disorders in the activity of metabolic enzymes (De Valk et al., 1988) as noticed from this study. The elevation of the activities of these serum enzymes ALT, AST and ALP in the sera of women from Ebocha when compared to those from Uturu, indicate that their hepatocytes were affected due to chronic exposure to gas flaring in that area. These marker enzymes are employed to assess the integrity of the hepatic plasma membrane. The significant ($p < 0.05$) increase in these liver enzyme activities may be attributed to enzyme induction as a consequence of gas flaring which caused these enzymes to leak into the bloodstream thereby increasing their activities.

There were also non-significant ($p > 0.05$) differences in the concentrations of both direct and total bilirubin in women from both locations. This might in part be due to continual utilization of reducing potential NADPH from glucose–6–phosphate dehydrogenase activity by haemoxygenase (HMOX) as a reducing agent for bilirubin synthesis and for reduction of oxidized glutathione to glutathione and for mopping up of free radicals (Olufunsho et al., 2014: Niki et al., 1982).

The kidneys maintain a constant extracellular environment by their involvement in the excretion of catabolites such as creatinine and urea, as well as in the regulation of water and electrolyte balance. This study showed that serum creatinine and urea concentrations of the women from Ebocha were significantly ($p<0.05$) higher than those of women from Uturu. Gas flaring causes increase in ambient environmental temperature (Oseji, 2011). About 45.8 billion kilowatts of heat are discharged into the atmosphere in the Niger Delta area from 1.8 billion cubic feet of gas flared every day (Ukoli, 2005). Increase in ambient temperature can cause persistent and chronic dehydration among residents of gas flared sites. This chronic dehydration can cause reduced blood volume and increase in blood viscosity. Dehydration is further worsened by the poor water quality in Ebocha (Nwaogu and Onyeze, 2020) and Obigbo North (Ekanem, 2001). Persistent and chronic dehydration can lead to reduced glomerular filtration rate (GFR) and increase in serum creatinine and urea concentrations. Elevated concentrations of serum creatinine and urea can arise from reduced kidney perfusion (Rosner and Bolton, 2006). This is because when nephrons and their tubular cells are defective, creatinine, urea and other metabolic products are retained within the bloodstream of living organisms leading to metabolic by-products toxicity (Nwaogu and Onyeze, 2014).

The serum concentrations of sodium (Na^+), potassium (K^+), chloride (Cl^-) and bicarbonate (HCO_3^-) ions of women from Ebocha were significantly ($p<0.05$) higher than those of women from Uturu. Abnormal concentrations of electrolytes in the plasma or serum which might be as a result of several factors are an indication of kidney impairment (Nwankwo et al., 2006). Impairment of kidney function may be elicited via exposure to different nephrotoxic substances (Prasad and Rossi, 1995). The observed change in serum bicarbonate concentration might indicate a primary disorder in the bicarbonate buffering system during metabolic acidosis in which bicarbonate ion (HCO_3^-) is used in buffering hydrogen ions (H^+) more rapidly than it can be generated by normal homeostatic mechanism (Philip, 2002). Consequently, the rise in chloride ion (Cl^-) concentration might be due to over release rather than reduced excretion with simultaneous production of equimolar amounts of hydrogen ion (H^+), resulting in increase of bicarbonate ion (HCO_3^-) because of its use in buffering hydrogen ion (H^+) that accompanies chloride ion (Cl^-) (Philip, 2002).

The study shows clearly that chronic exposure to gas flaring significantly ($p<0.05$) reduced the concentrations of serum triglyceride, total cholesterol and high-density lipoprotein cholesterol (HDL-c) but significantly ($p<0.05$) increased serum low-density lipoprotein cholesterol (LDL-c) concentration and all the atherogenic predictor indices of women from Ebocha when compared to those from Uturu. This could be as a result of hepatotoxicity which has been associated with chronic exposure to gas flaring and environmental pollution. These results corroborate the report of Egwurugwu et al. (2013) who reported a significant increase in the following lipid profiles namely TC, TG, LDL, TC/HDL, LDL/HDL from the blood samples of individuals (both men and women) from the Niger Delta region, Nigeria when compared to the control.

Atherogenic indices are strong indicators of the risk of cardiovascular disease (CVD). The higher their values, the higher the risk of developing CVDs and vice versa (Brehm et al., 2004; Rakib et al., 2014). There were observed significant ($p<0.05$) increases in the Castelli's Risk Index I and II, atherogenic coefficient and atherogenic index of plasma of women from Ebocha when compared to women from Uturu. However, a significant ($p<0.05$) increase in total non-HDL cholesterol was observed in women from Ebocha when compared to women from Uturu. The significant increases in the atherogenic predictor indices observed from this study show that women from Ebocha are more predisposed to CVDs due to chronic exposure to gas flaring.

CONCLUSION

The study revealed that chronic exposure to gas flaring in Ebocha, in the Niger Delta area of Nigeria affected negatively the liver, kidneys, lipid profile and atherogenic predictor indices of women residing in Ebocha who are predominantly farmers as they are constantly being exposed to gas flare. The study calls for immediate governmental policies to reduce gas flaring activity in the area and urgent environmental remedial programmes to make the area habitable for the residents. Also, residents in the area should be enlightened to take antioxidant supplements that will help mop up free radicals that may be released as a result of exposure to gas flare.

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