Original Research Article

Alteration of haematological and renal function parameters of men native to Ebocha, Niger Delta, Nigeria due to chronic exposure to gas flaring

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The impact of pollution due to gas flaring on men native to Ebocha in the Niger Delta Area was investigated. Forty apparently healthy men between 30 to 50 years were screened; twenty from Ebocha and twenty from Uturu a control location with no history of petroleum hydrocarbon (PHC) pollution. Standard analytical procedures were used in the determination of the concentrations of the parameters. Parameters investigated were haematological: haemoglobin (HB) concentration, packed cell volume (PCV), white blood cell (WBC) count, percentage of lymphocytes, monocytes and neutrophils; renal function: urea, creatinine, K+, Na+, Cl and HCO3-. Results obtained revealed that mean values of haemoglobin, packed cell volume, white blood cell counts and neutrophils (10.22±1.40 g/dl, 31.20±4.08%, 2.98±0.16×10³/µl 43.90±2.08%) respectively were substantially lower in men from Ebocha when compared to those of men from Uturu (13.20±1.29g/dl, 39.7±3.84%, 4.6±0.98×10³/ul and 60.00±7.48% respectively. The mean value counts of lymphocytes of the men from Ebocha (55.40±7.87%) were significantly higher than those of the men from Uturu. However, the mean values of monocytes were essentially similar for men from both locations. Of the renal function parameters, only creatinine and urea gave values in mg/dl (1.31±0.38 and 46.41±5.03) respectively that were significantly (p<0.05) higher in men from Ebocha when compared to values in mg/dl (0.81±0.37 and 11.81±2.62 respectively for men from the control location. The mean concentrations of sodium and potassium ions of the men from Ebocha were significantly (p<0.05) higher than those of men from Uturu. However, there was no significant (p<0.05) difference in the mean concentrations of chloride and bicarbonate ions of men from the two sites. Thus, these findings show that haematological and renal function parameters of men from Ebocha were altered, possibly due to chronic exposure to gas flaring in that environment.

Key words: Chronic exposure, haematological, renal, gas flaring, Niger Delta.

INTRODUCTION

Niger Delta Area is located in the Atlantic coast of Southern Nigeria (Aghalino, 2000) and is the world’s second largest delta with a coastline of about four hundred and fifty kilometres (450 km) which ends at Imo river entrance (Awosika et al., 1995). It consists of diverse ecosystems of mangrove, fresh water swamps and rain forest, and is the largest wetland in Africa. A Delta is a region where a river enters into an ocean body with numerous distributaries. Such an ocean is usually low lying periodical inundation. Its vegetation is luxuriant varying from fresh water to brackish
mangrove. The soil is predominantly clayey with low content of organics which invariably makes it highly fertile. Due to its swampy nature, high acidic and sordid condition, it constitutes a regional environmental challenge (Onwuama, 1997). 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, 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 the economy (Kamalu and Wokocha, 2010). But the effects of gas flaring and oil spills have adversely affected the availability of fish (Nwaogu and Onyeze, 2010). Fruits, vegetables and other agricultural produce have been adversely affected as well. They have taken a toll on the health and well-being of the residents too (Ashton et al., 1999).

According to FEPA (2001), the petroleum industry releases hydrocarbons and other harmful effluents into the environment (Smith et al., 1993; FEPA, 2001). 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 resource infertile for agricultural processes. This is disastrous as the bulk of the populace depend heavily on agriculture as a means of sustenance.

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, and these include 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 (Rabbe and Wong, 1996; Krissi 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 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). 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 led 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 by gas flaring pollutants resulted in the damage to wildlife and vegetation (Ikoro, 2003). There was also presence of soot on water surfaces which deprived the populace of portable water for drinking and household processing.

Many communities claim that nearby gas flares cause acid rain that resulted in premature corrosion of their zinc-based roofed houses and other local structures. 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 emergence of endangered species of plants such as guava, plantain and banana; animals such as frog, millipede, earthworm, reptiles and grasshopper due to effect of the intense heat from the gas flare stations resulting to reduced crop yield. They complained that because they live and work alongside the flares with no protection and also the inhalation of toxic gas flare pollutants, diverse health abnormalities such as asthma, respiratory difficulty, headaches, drowsiness and high body temperature have oftentimes affected them.

Available records from health institutions in Bayelsa State showed that over 50% of the farmers suffer from various respiratory diseases (SMH, 2011). These negative impacts of gas flaring on this populace have often times caused social tensions among various groups, companies and government institutions in the Niger Delta. The aim of this study was to investigate the effect of chronic exposure to gas flaring on the haematological and renal function.
parameters of men native to Ebocha, in the Niger Delta Area of Nigeria.

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 area with active gas flaring operated by Agip Oil Company for more than forty years since 1975 constitute the test site and Uturu with no history of petroleum hydrocarbon (PHC) pollution served as control. The residents of both communities were mainly farmers, traders and civil servants and share many common characteristics. The study was carried out during the rainy season, between June and September, 2015.

Selection of subjects for the study

Apparently healthy men who have lived in Ebocha continuously for at least twenty (20) years within the immediate environment (5 km) from the gas flaring sites were eligible as subjects for chronic toxicity study. Also, men of the same age as those of Ebocha, who have not travelled out of Uturu for over twenty years are eligible as subjects. Venous blood samples were collected from men between the ages of 30 to 50 years from each of the test and control sites who consented to after thorough explanation to participate in the study. The research was approved by the Ethical Committee on Human Research of the Federal University of Technology, Owerri, Nigeria and the study conforms to the Helsinki Declaration on Medical Research.

Blood specimen collection

Six millilitres (6ml) of venous blood were collected and separated immediately, then distributed immediately into ethylene diamine tetra acetic acid (EDTA) anticoagulant-containing specimen bottles for haematological parameters; two millilitres (2 ml) into plain sample bottles and allowed clotting to take place. There after serum was collected for renal function and electrolyte parameters and all were analysed the same day.

This was done for both blood specimens from Ebocha in the Niger Delta Area and Uturu, in Abia State. Staff of General Hospital, Egbema in Ohaji/Egbema Local Government Area of Rivers State screened apparently healthy men volunteers with their consent and obtained venous blood from eligible men with no disease condition. A total of forty men with age range of between 30 and 50 years were employed for the study.

Haematological indices

Haemoglobin concentration was determined using the method of Tietz, (1961). Packed cell volume and white blood cell count were determined using the method of Dacie and Lewis (1991).

Renal function and electrolyte indices

Urea concentration was determined using Urease-Berthelot colorimetric method according to Searcy et al., (1967) from Randox urea reagent kit. Creatinine concentration was determined because differences in creatinine concentration could be indicative of kidney dysfunction in the men from Ebocha as a result of stress in their environment. Creatinine concentration was determined using Alkaline Picrate-Slot method according to Seaton, (1984) from Randox diagnostic kit. Sodium ion concentration was determined using method of Maruna and Trinder, (1958) from TECO diagnostic kit. Potassium ion concentration was determined using the method of Terri and Sesin, (1958) from Randox diagnostic kit. Chloride ion concentration was determined using colorimetric method of Skeggs and Hochestrasser, (1964) from TECO diagnostic kit. Bicarbonate ion concentration was determined using the method from TECO diagnostic kit.

Statistical Analysis

All data generated were analysed 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. While the significant differences between the test means and control means were determined at 95% or p<0.05 confidence level (Parker, 1979).

RESULTS

The results of this study revealed a general significant (p<0.05) decrease in haemoglobin, packed cell volume, white blood cell count and neutrophile concentrations of men from Ebocha when compared to those of men from Uturu (Figure 1-4). Though the mean values are within normal range, this indicates that there was a harmful effect on the haemopoietic system of men from Ebocha. This could be attributed to the fact that air pollutants such as benzene, naphthalene, carbon monoxide, toluene, and xylene affect the formation of blood (haemopoiesis) in bone marrow, spleen and lymph nodes. Therefore, the detrimental effect of benzene on the bone marrow or white blood cells impacted negatively on the number of neutrophils.

The results obtained for lymphocyte count (Figure 5) indicated that the mean value was significantly (p<0.05) higher for the men from Ebocha than for the men from Uturu. The resultant mean values are within normal range (20-456 %) which reveals that there was an immune response for long term exposure to the toxic substances from gas flares in men from Ebocha.
The monocyte count results (Figure 6) showed that the mean value of monocyte count obtained for the men from Ebocha and Uturu were similar, though, the values are within normal range of 2 to 10%, the observed result reflected the bone marrow’s depression to replace monocyte that would have migrated from the bloodstream in order to differentiate into resident macrophages with the function to protect tissues from viral or bacterial infection. Hence, there was no significant difference in the mean values obtained for men from Ebocha and Uturu as they were apparently healthy.

The results obtained for urea, creatinine, sodium ion, and potassium ion concentrations (Figures 8-11) indicated that the mean concentrations were significantly ($p < 0.05$)
higher for the men from Ebocha than for the men from Uturu. The mean values obtained are within normal value. The higher mean value obtained for men from Ebocha indicates that the pollution due to gas flaring may be possibly one of the factors that affected the renal function in the men. The results obtained for chloride ion (Cl⁻) concentration (Figure 12) revealed that the mean concentration of chloride ion for the men from Ebocha was similar to that for the men from Uturu. The mean values are within normal range of 98 to 106 mEq/L. This observed similar mean values obtained shows that there might be a mild electrolyte imbalance in the kidneys. This is because chloride ion (Cl⁻) helps in maintaining proper water distribution and acid–base balance in the extracellular fluid.
Figure 4: Mean values of white blood cell count

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant (p < 0.05).

Figure 5: Mean values of neutrophil count

Bars represent mean ± SD of three determinations. Bars with different superscript letters statistically significant (p<0.05).
of the body. Hence, the upset in sodium ion (Na⁺) concentrations shifts chloride ion concentrations slightly as a compensatory anion that is essential for sodium pump. The results obtained for chloride ion (Cl⁻) and bicarbonate concentrations (Fig.11-12) revealed that the mean concentrations for the men from Ebocha and Uturu were essentially similar.

DISCUSSION

Gas flaring following oil exploration over a long period of time has contributed to the extent of 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. Mean values obtained in this study revealed that the mean concentration of haemoglobin and packed cell volume for the men from Ebocha were significantly (p < 0.05) lower than those for men from Uturu (Figures 2 and 3). These observations are similar to reports of Ovuru et al (2004), who noted a decrease in haemoglobin concentration and packed cell volume of rabbits fed with crude oil–contaminated diet. These might be due to the exposure of men from Ebocha, which is a polluted
environment (Nwaogu and Onyeze, 2010). It has been suggested that the effect of flared gas on humans is related to the exposure to hazardous air pollutants emitted during incomplete combustion of the flared gases (Kindzierski, 2000). Benzene and toluene are hazardous due to their inherent toxicity in mammals and can be absorbed into the blood through the respiratory tract with various health effects (Adienbo and Nwafior, 2010). This is because benzene is a known systemic toxicant in humans at any concentration and causes aplastic anaemia (Egwurugwu et al., 2013). It is also haematoxic (Adienbo and Nwafior, 2010). Naphthalene is a haemolytic agent that can destroy the membrane of red blood cells with the liberation of haemoglobin. These effects of benzene and naphthalene might be responsible for the reduced haemoglobin concentration and packed cell volume observed in this study as associated with the men native to Ebocha in the Niger Delta. This observation agrees with the findings of

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**Figure 8:** Mean values of urea concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant ($p < 0.05$).

**Figure 9:** Mean values of creatinine concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant ($p < 0.05$).
Figure 10: Mean values of sodium ion (Na\(^+\)) concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant (p < 0.05).

Figure 11: Mean values of potassium ion (K\(^+\)) concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant (p < 0.05).

Okoro et al (2006), who reported a decrease in haemoglobin concentration and packed cell volume of fuel attendants exposed to petroleum products inhalation.

The mean white blood cell and neutrophil counts for the men from Ebocha were significantly (p < 0.05) lower than those of men from Uturu (Figures 4 and 5). White blood
cells function primarily in body defense against foreign bodies and this is often achieved through leukocytosis and antibody production (Marieb, 1995). Benzene depresses the bone marrow leading to pancytopenia (a general depression of erythrocytes (red blood cells), leukocytes (white blood cells) and thrombocytes (platelets) (Otitoloju and Dan-Patrick, 2010). The decrease in white blood cell counts and neutrophil counts observed could be as a result of pancytopenia and leukocytopenia. These observations are similar to the findings of Ovuru et al (2004), who reported a decrease in white blood cell counts of rabbits fed with crude oil–contaminated diet. These results also agree with those of Mckee and White (2014), who reported that there were statistically significant reductions in red blood cell and white blood cell counts in male rats exposed to polycyclic aromatic hydrocarbons. Also Otitoloju and Dan-

**Figure 12:** Mean values of chloride ion (Cl\(^{-}\)) concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant (p < 0.05).

**Figure 13:** Mean values of bicarbonate ion (HCO\(_3\)\(^{-}\)) concentration

Bars represent mean ± SD of three determinations. Bars with different superscript letters are statistically significant (p<0.05).
Patrick (2010), reported a reduction in white blood cell count among albino mice exposed to gas flaring. These observations further agree with the findings of Okoro et al. (2006), who reported a decrease in white blood cell counts of fuel attendants exposed to petroleum products inhalation. The decrease in WBC counts might be associated with stress-induced changes in the haemopoietic pathway.

Mean of lymphocyte counts for the men from Ebocha was significantly (p<0.05) higher than that of men from Uturu (Figure 6). This observation is similar to the findings of Momoh and Damazio (2014), who reported an increase in lymphocyte counts of rats administered with kerosene. This observation might indicate stress imposed by the effects of hydrocarbon pollution in lymphoid tissues leading to stimulation of antibody production. This was confirmed by the findings of Selye (1963) who reported that a stress stimulus elicits a defence response.

The results revealed that there was no significant (p>0.05) difference between the mean counts of monocytes for the men from Ebocha and Uturu (Figure 7). This observation might be due to absence of any infection in these men, as they were apparently healthy.

The kidney maintains constant extracellular environment by its involvement in the excretion of catabolites such as urea and creatinine; regulation of water and electrolyte balance. The results in this study showed that the mean concentrations of urea and creatinine for the men from Ebocha were significantly (p<0.05) higher than those of men from Uturu (Figures 8 and 9). Gas flaring causes increase in ambient temperature (Oseji, 2011). About 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger Delta 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 and Obigbo North (Nwaogu and Onyeze, 2010; Ekanem, 2001). Persistent and chronic dehydration can lead to reduced glomerular filtration rate (GFR) and increase in serum urea and creatinine. Elevated concentrations of serum urea and creatinine can arise from reduced renal perfusion (Rosner and Bolton, 2006). This is because when nephrons and their tubular cells are not functioning effectively, urea, creatinine and other metabolic products are retained within the blood stream of living organisms (Nwaogu and Onyeze, 2014). These observations agree with the findings of Uboh et al (2009), who reported that exposure to gasoline vapour may cause elevation of serum urea and creatinine in rats.

The mean concentrations of sodium ion (Na⁺) and potassium ion (K⁺) for the men from Ebocha were significantly (p<0.05) higher than those of men from Uturu (Figures 10 and 11). Abnormal concentrations of electrolytes in the plasma or serum are a clear indication of renal impairment. Impairment of renal functions may be caused by exposure to different nephrotoxic substances such as lead (Prasad and Rossi, 1995). Alteration from the normal levels of electrolytes, which might be caused by several factors, is an indication of renal impairment (Nwankwo et al., 2006).

The obtained results revealed that there was no significant (p>0.05) difference between the mean concentrations of chloride (Cl⁻) and bicarbonate (HCO₃⁻) ions for the men from Ebocha and Uturu (Figures 12 and 13). Although there was elevated chloride ion (Cl⁻) concentration and reduced bicarbonate ion (HCO₃⁻) concentration for the men from Ebocha, each value is within the normal range. These observations might indicate primary disorder in the bicarbonate buffer system during metabolic acidosis in which bicarbonate ion (HCO₃⁻) is used in buffering hydrogen ion (H⁺) more rapidly than it can be generated by normal homeostatic mechanism (Philip, 2002). Also the increased chloride ion concentration might be as a result of accumulation of lactate (Philip, 2002).

Consequently, the rise in chloride ion (Cl⁻) concentration might be due to overproduction rather than reduced excretion with simultaneous production of equimolar amounts of hydrogen ion (H⁺); resulting to the reduction of bicarbonate ion because of its use in buffering hydrogen ion (H⁺) that accompanies chloride ion (Philip, 2002).

CONCLUSION

The study revealed that chronic exposure to gas flaring in Ebocha, Niger Delta area, did not affect monocytes in the men native to that environment. However, haematological parameters such as HB, PCV, WBC and neutrophil counts were markedly reduced while lymphocyte count was significantly increased, thereby affecting haemopoiesis negatively. There were marked increases in the concentrations of some renal function parameters: urea, creatinine, sodium, and potassium ions; the concentrations of chloride and bicarbonate ions of men from the two sites were essentially similar. Based on these findings, it could be concluded that chronic exposure to gas flaring in Ebocha, Niger Delta Area induced alterations in some haematological parameters and renal function indices in men in that environment. This observed alteration is possibly due to chronic exposure to gas flaring in that environment.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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