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Impacts of prolonged exposure to gas flares on some blood indices in humans in the Niger Delta Region, Nigeria

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ABSTRACT

This work was done to evaluate the effects of prolonged exposure to gas flares on some haematological parameters on humans. 790 subjects, drawn from two different communities: a gas flared(test group) and non gas flared (control group) communities participated in this study. Blood samples were collected from each subject and analyzed for red blood cell(RBC), white blood cell(WBC), haemoglobin concentration (HGB), packed cell volume (PCV), mean corpuscular haemoglobin (MCV), mean corpuscular haemoglobin(MCH), mean corpuscular haemoglobin concentration(MCHC), platelet(PLT) count, total protein(TP) and albumin(ALB). The results showed statistically significant decrease in HGB, RBC, MCV,MCH,MCHC, PLT, TP and ALB in the test group when compared with control ($p< 0.05$) However, significant increase was observed in WBC count in the test group, compared with the control group($p<0.05$). The observed effects in all parameters studied were more marked in females than the males. In conclusion, prolonged exposure to gas flares can cause marked decrease in some blood indices in humans.

Key words: gas flares, human, Niger Delta, chronic exposure, blood indices.

INTRODUCTION

Oil and gas exploration (and exploitation) started in the Niger Delta Region of Nigeria in I956, when the first commercial oil well was discovered at Oloibiri, after about half a decade of oil exploration, in the present day Rivers State of Nigeria. The Niger Delta region, encompassing over 20,000 km^2 in Southern Nigeria, is the center of oil and gas production and allied activities in Nigeria [1,2]. It is the richest part of Nigeria in terms of natural resources such as large oil and gas deposits, extensive forests, suitable agricultural lands and abundant fish resources [2]. However, the region's potentials for sustainable development remains unfulfilled and its future is being threatened by diverse environmental problems, of which pollution is the most paramount[3,1,4,5].

Nigeria is the 6^{TH} largest producer of oil in the world and it is endowed with more gas reserves than oil [6,7]. In 2011, total crude oil and condensate production was 866,245,232 barrels, giving a daily average of 2.37 mmb/pd,

while in the gas sector, a total of 2,400.40 Billion Standard Cubic Feet(BSCF) of Natural Gas was produced by sixteen companies; of the quantity produced, 1,781.37 BSCF (74%) was utilized, while 619.03BSCF (26%) flared [7].

Flared gas is the most significant source of air emission from offshore oil and gas installations [8]. During most of these activities in the oil and gas industry, wastes either in solid, liquid or gaseous form are generated and discharged into the environment [9]. Flared gas is one of the generated wastes in the oil and gas industry. Gas Flaring is a common practice of burning off unwanted, flammable gases via combustion in an open atmosphere, non-premixed flame [10]. Gas flaring is 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" [1].

According to World Bank [11], global gas flaring has increased from 138 to 140 billion cubic meter in 2011 and Russia is the largest gas flaring country, followed by Nigeria, Iran and Iraq. Nigeria flared 14.6 bcm of natural gas in 2011 and most of this occur in the Niger Delta region. During gas flaring, incomplete combustion emits various compounds such as methane, propane, and hazardous air pollutants such as volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and soot [12] and also benzene, naphthalene, styrene, acetylene, fluoranthene, anthracene, pyrene, xylene and ethylene [13]. Benzene and toluene in particular are hazardous due to their inherent toxicity in mammals, while their wide use in industry and high volume of production lead to substantial environmental releases. These volatile hydrocarbons, which can be absorbed into the blood via the respiratory tract [14], as well as transfer to man through the food chain [15], have various potential health effects [16].

The frequent spills of crude oil on land, water and gas flaring are the major anthropogenic sources of heavy metal enrichment in terrestrial habitats of oil producing areas of Niger Delta of Nigeria [17]. Nigerian crude oil is known to contain heavy metals such as Al, Zn, As, Ba, Fe, Pb, Co, Cu, Cr, Mn, Ga, Sb, Ni and V [18]. Surface and underground waters in a gas flared environment tend to have more concentrations of heavy metals such as lead, barium, cadmium, selenium and copper than non-gas flared area [8]. There are high concentrations of heavy metals in gas flares, soil and water in the Niger Delta Region [8,18].

Gas flaring affects every system in living things including man, animals, plants and their environment. It affects haemopoeisis [19,20,21]; is carcinogenic [22,23]; immunotoxic [24]; chronic respiratory diseases such as asthma [25,26]; fetotoxic [9,27]; neurotoxic [27]. It also causes increase in temperature(thermal gradient), acid rain, low agricultural productivity [28].

Little research on gas flaring and the associated health impacts in humans residing in the Niger Delta region of Nigeria has been conducted [29] and this effort is our modest contribution in this regard.

MATERIALS AND METHODS

Study areas

The study was conducted in two different communities in the Imo East Senatorial zone of Nigeria. Imo State is one of the nine states in the Niger Delta region of Nigeria. Egbema, an oil and gas producing community with active gas flaring by Shell Petroleum Development Company (SPDC) for more than 40 years, constitute the test group. This community is also located in between many other active oil and gas flaring sites such as Ossu, Oguta and Izombe oil and gas fields operated by Addax and Akri and Ebocha oil and gas fields run by Nigeria Agip Oil Company. Alaoma Owerre-Ebeiri community, a non oil and gas producing area, constitute the control group population. The residents of both communities were mainly farmers, traders and civil servants and share many common characteristics. The study was done during the rainy season, in the months of May and June, 2012.

Selection of subjects

Apparently healthy subjects, between the ages of 18 to 80 years, who consented to in writing and/or thumb printed (after thorough explanation) to participate in the study, were randomly selected. All must have lived in their various communities consistently for more than 5 years. The research was approved by the Ethics Committee on Human Biomedical Research of the University of Port Harcourt, Nigeria and the study conforms to the Helsinki

Declaration on Biomedical Research. A total of seven hundred and ninety (790) subjects of both sexes took part in the study. The test group had 475 subjects(140 males and 335 females) while the control group had 315 subjects(127 males and 188 females).

Collection of blood samples

5ml of venous blood was drawn from a peripheral vein in the upper limb of subjects, 3ml was transferred immediately into sterile EDTA anticoagulant bottles and analyzed same day for haematological indices using an automated hematology Analyzer(KX-21 Sysmex, Japan) at the Imo State University Teaching Hospital, Orlu while the remaining 2ml was put into sterile plain universal containers, allowed to clot and retract properly and then centrifuged at 5000rpm for 5minutes. The supernatant was then stored frozen at -20°C until analyzed for total protein and albumin.

Statistical analysis

Statistical Package for Social Sciences (SPSS) (version 17 for windows, SPSS Inc., Chicago, USA) was used to analyze the data. The differences in the various parameters studied between the test and control groups were evaluated using Kolmogorov-Simirnov Z statistic. Anova was used to assess differences within the groups. Statistically significant values were determined at $p < 0.05$ or 95% confidence level.

RESULTS

A total of seven hundred and ninety (790) subjects participated actively in this study. There were 267 (34%) males and 523 (66%) females.

The study recorded a male:female participation ratio of approximately 1:2.

Table 1: Haematological parameters of the population

Parameter	Control group (n=315)	Test Group (n=475)	Z test result P<0.05)	% Difference
RBC($X10^{12}$/L)	4.77±0.04	4.55±0.03	0.01°	-4.93
Hb (g/dl)	12.59±0.09	12.11±0.07	0.01°	-3.89
PCV(%)	35.98±0.26	35.77±0.19	0.12*	-0.58
WBC($X10^{9}$/L)	5.20±0.07	5.81±0.07	0.01°	+10.91
MCV(Fl)	79.89±0.2	79.86±0.32	0.02®	-0.04
MCH(pg)	28.52±0.22	27.54±0.38	0.01°	-3.49
MCHC(g/dl)	35.48±0.12	33.97±0.07	0.01°	-4.35
PLT($X10^{9}$/L)	231±3.41	193±3.37	0.01°	-17.85
Total Protein(g/Dl)	81.33±0.80	71.28±0.40	0.01°	-13.17
Albumin (g/L)	49.70±0.55	44.49±0.43	0.01°	-11.11

Values are presented as mean±SEM.

° Statistically significant difference observed between the test and control groups.

** No statistically significant difference observed between the test and control groups.*

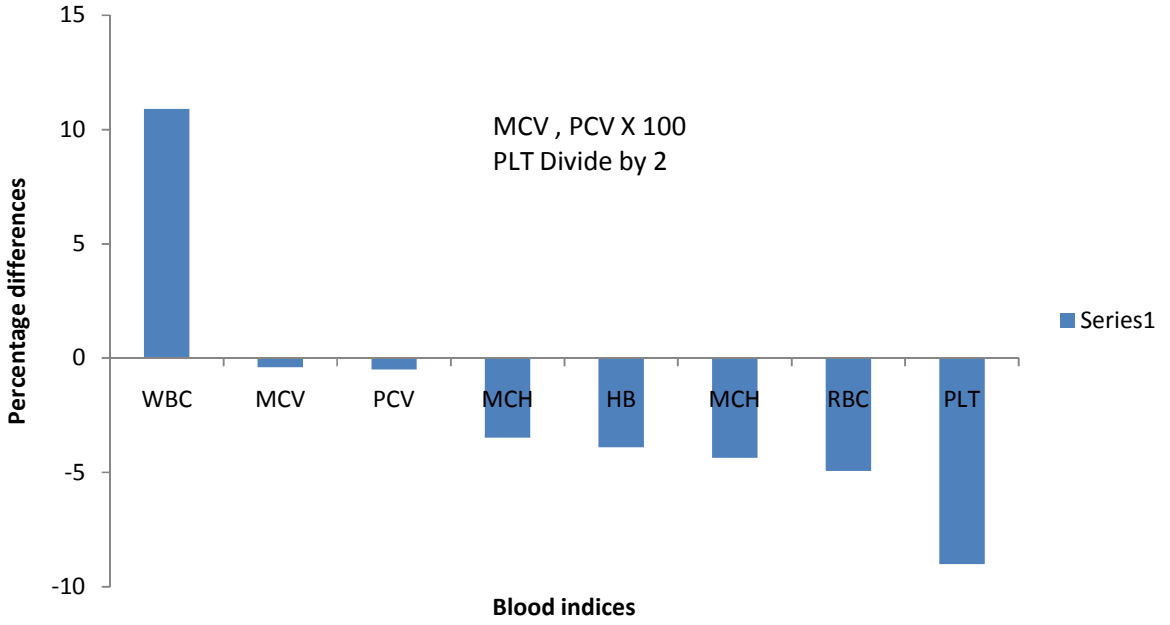

Figure 1 :Percentage differences of the haematological indices

Table 2: Comparison of haematological parameters in males and females

Parameter	Research Group	Male	Female	P value	% Difference
WBC($X10^9$/L)	Control	5.23±0.13 (n=127)	5.18±0.13 (n=188)	1.00°	0.96%
	Test	5.67±0.13 (n=140)	5.86±0.09 (n=335)	0.43°	3.29%
RBC($X10^{12}$/L)	Control	4.84±0.07	4.74±0.06	0.73°	2.09%
	Test	4.80±0.06	4.45±0.03	0.01	7.56%
HGB(g/dl)	Control	12.66±0.15	12.54±0.11	0.55°	0.95%
	Test	12.94±0.14	11.76±0.07	0.01*	9.55%
PCV(%)	Control	36.23±0.39	35.81±0.34	0.99°	1.17%
	Test	38.18±0.39	34.77±0.19	0.02*	9.32%
MCV(Fl)	Control	79.77±0.49	79.99±0.38	0.57°	0.27%
	Test	80.95±0.68	79.41±0.36	0.04°	1.92%
MCH(pg)	Control	28.16±O.24	28.76±0.34	0.48°	2.11%
	Test	27.87±0.49	27.40±0.51	0.04°	1.70%
MCHC(g/dl)	Control	35.20±0.21	35.68±0.15	0.05°	
	Test	33.88±0.15	34.00±0.09	0.99°	0.35%
PLT($X10^9$/L)	Control	232.21±5.34	230.58±4.44	0.96°	0.70%
	Test	185.71±6.52	196.53±3.91	0.09°	5.61%
Total Protein(g/L)	Control	80.42±1.20	81.95±1.02	0.49°	1.88
	Test	71.79±0.78	71.07±0.51	0.97°	1.01
Albumin(g/L)	Control	49.35±0.85	49.93±0.71	0.66°	1.17
	Test	43.87±0.77	44.72±0.52	0.76°	1.92

**Statistically significant*

° Not statistically significant.

This results of this study showed a general statistically significant decrease ($p<0.05$) in RBC,HGB, MCV,MCH,MCHC, PLT, total protein and albumin in the test group subjects when compared with the control subjects (Table 1 and Figure 1). WBC was significantly higher in the test group population when compared with the control subjects ($p<0.05$). There was no significant difference ($p>0.05$) in packed cell volume values between the two groups, though the control subjects had a slight increase with a percentage difference of 0.58%.

Among the control group population, there was no statistically significant($p>0.05$) difference in all the parameters studied (Table 2) between the males and females.

Among the test group, there was statistically significant ($p<0.05$) increase in red blood cell count, haemoglobin concentration, packed cell volume, mean corpuscular volume, mean corpuscular haemoglobin and total protein in males when compared to the females. However, there was no significant ($p>0.05$) gender difference in white blood cell count, mean corpuscular haemoglobin concentration, platelet count, total protein and albumin levels.(Table 2).

DISCUSSION

The observed statistically significant decrease in the measured parameters such as red blood cell (RBC), haemoglobin(HB) concentration, mean corpuscular volume(MCV),mean corpuscular haemoglobin(MCH), mean corpuscular haemoglobin concentration (MCHC), platelet(PLT) count, total protein and albumin may be due to several toxic effects arising from the various pollutants associated with gas flares.

Firstly, Benzene, one of the constituents of flared gas, is a well known systemic toxicant in humans at any concentration and a cause of aplastic anaemia. It is haematotoxic and depresses the bone marrow, leading to pancytopenia (a general depression of erythrocytes(red blood cells), leucocytes (white blood cells) and thrombocytes (platelets) [27,30,31,21,32]. These studies demonstrate that benzene is indeed a haematotoxicant.

Secondly, Naphthalene, another hydrocarbon found in flared gas, is a hemolytic agent that can destroy the membrane of red blood cells with the liberation of haemoglobin. The metabolites are hemolytic, that is, the biologic damage is secondary to the naphthalene [27, 21]. Furthermore, the abundance of naphthalene in flared gases, which causes profuse sweating, nausea, vomiting, abdominal pain and irritation of the bladder [27], may instill fear and apprehension in the exposed, leading to anorexia nervosa, malnutrition and anaemia.

Thirdly, Xylene, another hydrocarbon present in gas flares, can cause central nervous system depression and effects in the liver and kidney [27]. Erythropoiesis is controlled by the hormone erythropoietin that is produced in the kidney [33]. Therefore, prolonged exposure to gas flares with these toxic substances can adversely affect the kidney that blood production may be impaired. For example, this study demonstrated increased serum uric acid levels in the test subjects compared with the control ($p<0.05$) (Not shown in the tables). Hyperuricemia is a known cause of kidney disease and cardiovascular diseases [34-37]. Increased serum uric acid level may be involved in the progression of chronic kidney disease [38] and chronic kidney disease is a known cause of anaemia [33] Elevated serum uric acid level is an independent predictor of the development of renal dysfunction in subjects with normal renal function [39, 40]. Prolonged exposure to lead in petrol can compromise liver and kidney function [41]. This study also showed that prolonged exposure to gas flares can significantly increase blood pressure measures especially systolic blood pressure(134.11 ± 1.1 Vs 129.10 ± 1.4); diastolic blood pressure(89.48 ± 0.69 Vs 82.97 ± 0.70) and mean arterial pressure(104.37 ± 0.77 Vs 98.47 ± 0.91) in the exposed compared with the non-exposed ($p<0.05$). (This is not shown in the table). Hypertension can greatly affect the kidney. It has been observed that increased systolic blood pressure may predict kidney damage [42].

Fourthly, the reduction in the blood indices observed in the test group may be due to oxidative stress as crude oil is known to cause oxidative stress and increased membrane permeability in red cells[43,20]. Furthermore, it has been observed that exposure to or contact with chemicals in oil refining industry have been associated with changes in the red cell adenyl and blood monooxygenase system [44,45].

Fifthly, proteins are essential not only for heamopoiesis but also for other body functions such as body building, cell repairs, blood clotting, hormone and enzyme production [46,47]. The observed decrease in total protein and albumin ($p <0.05$) in this study may also explain the decrease in the measured haemtological parameters.

Sixthly, the test group study area, a predominantly farming rural community in the Niger Delta Region is not devoid of such occupational hazards as helminthiasis. It is a well known fact, that besides malaria and nutritional deficiencies, heavy helminth infections are associated with anemia [48,49,50]. Furthermore, the test community tend to have factors enhancing exposure to helminthiasis such as defecation practices [51],occupational necessities [52,53] and housing conditions [54]. All these factors in addition, can complement the toxic constituents of gas flares to cause reduction in the haematological parameters seen in this study.

The increase in white blood cell count noted in this agrees with earlier findings [21,20]. Elevated WBC count in humans following prolonged exposure to arsenic have also been noted [55]. It may be due to response of the myloid and megakaryotic stem cells to continued exposure to gas flares. And it has been demonstrated that these stem cells can have the selective advantage of proliferation and resistance to toxicity of oil and its metabolites [56, 57, 58].

This study also showed that the effects of prolonged exposure to gas flares were more in the females than the males. This agrees with earlier findings [21]. They noted that the females were more domiciled either at home or in their farms than the more mobile men. The females were thus more exposed to the polluted environment than the males. Furthermore, women may be more exposed to chemical sensitivity due to followings: First, they have a greater total percentage of body fat, which stores chemicals; use more fragrances, hair coloring, hair sprays, lipsticks and other make-ups with known toxic ingredients and women typically do the house cleaning, and are exposed daily to toxic products even in their kitchens [59]. Second, alcohol dehydrogenase which detoxifies carbohydrates, alcohol,and chemicals are greatly reduced in females than males [60]. Third, butylcholinesterases, which scavange chemicals, are lower in females than in males[61].

Physiologically, females tend to have lower haematological indices especially in their reproductive years than males [47].

In conclusion, prolonged exposure to gas flares in humans can negatively affect haemopoiesis leading to reduction in red blood cell, haemoglobin concentration, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration and platelet count.

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