ECOLOGICAL AND HUMAN HEALTH IMPACT OF NATURAL GAS SPILL INTO AYAMASA RIVER, BAYELSA STATE, NIGERIA

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ABSTRACT

Environmental pollution arising from natural resources exploitation in the Niger Delta area of Nigeria is a common phenomenon. Very often, the consequences are multifaceted impinging on both the biophysical environment and humans, dependent on the natural environment for survival. Against this backdrop, this study examined the ecological and health implications of natural gas spill into Ayamasa River that drains communities in Bayelsa and Delta State (Tuomo, Fouto Roigbene, Isreallo, Isampou, Alieibiri and Isampou federated communities). The study analyzed water samples for physico-chemical properties determination against World Health Organization (WHO) standard, tissue section of contaminated fish species (tilapia) and pollution extent of methane hydrates in the acquatic environment. Oral interview and questionnaire survey were conducted to ascertain the health effects of contaminants on affected local population. The result showed higher values of water quality parameters of biological oxygen demand (BOD) and chemical oxygen demand (COD) to range between (2.07-2.09) and (2.20-2.40) respectively. Also, methane concentration recorded (0.4-0.8mg(l), poisonous enough to cause fish migration. The exposed respondent population manifested symptoms of sore throat, itchy skins, sore eyes, cough, nausea and headache. Other long term effects predicted include birth defects, still birth, infertility, bronchitis, and blood related diseases. The inhabitants suffered occupational injuires, which impacted negatively on their socio-economic livelihoods. The study recommended adequate medical care for affected population, environmental cleaning-up and compensation of victims of the disaster by the gas exploring company.

Keywords: Pollution, methane concentration, occupational injuries, natural gas spill

1. INTRODUCTION

Anthropogenic interactions with environmental resources for purposes of survival remain inevitable in a way that any action perceived to be unfavorable to biophysical life forms conveys potent signals of endangering earth's biological species including man, the causal agent. Natural gas resources play a positive role in the economy of nations where such resource exists, but could also cause disastrous and adverse toxicity effect on flora and fauna organisms. An observation has been made by Brent (2004).that drilling, extraction and transport of gas deposits from the sea floor

and their accidental release into the environment has been reoccurring during field operation by multinational companies engaged in these activities. Goldstein and Kriesky, (2012) remarked that pipeline buried in the sea may leak easily during catastrophic blowout, explosion, equipment failure, corrosion and human error.

Studies by Ordinioha and Birisibe, (2013) showed that an average of 24,000 barrels of crude oil and gas are spilled in the Niger Delta every year mainly due to unknown causes which account for 31.385 per cent, while third party and mechanical failure are responsible for (20.74 per cent) and (17.04 per cent) respectively. The spills contaminate surface water, ground water, ambient air, crops, and marine life forms easily affected by hydrocarbons and methane hydrates also known as carcinogens.

In Nigeria, the environmental impact assessment decree No.86 of 1992 requires that all major actions that could possibly alter the quality of the human environment be preceded by evaluation of such activities, projects and their impacts on the environment determined. Moreso, section 11(5) of oil and pipeline Acts, Cap 07, LFN 200 under environmental law, policies and management as contained in 1999 constitution creates a civil liability on persons who own or is (are) in charge of an oil pipeline to pay compensation to anyone who suffers physical or economic injury as a result of break or leak in the pipeline. There is a growing misconception among stakeholders that natural gas bubbles to water surface and evaporates during spill, but a significant portion of it always dissolves in water which may be highly toxic to marine life. Studies by Howarth, Santaro, & Ingraffea, (2011); Perry, (2013) showed that gas can rapidly penetrate the bodies of fish and do direct damage to gills, skin, chemoreceptor's and eyes, filling up the gas bladder, making the fish unable to gain its buoyancy. Other consequences on human health abound sometimes not properly catalogued in the literature.

Besides most gas leak scenarios frequently suffer under reporting by multinational companies and federal government agencies in attempt to evade adequate compensation commensurate with environmental harm done. This translates to outright repudiation of corporate responsibility to the detriment of impacted population. Against this background, this study was set to unravel the causes of gas spill and its consequences on the biophysical environment, human health and their well being.

Therefore, the objectives were to examine the cause of gas leakage into River Ayamasa, estimate the quantity of gas leaked and duration, examine the toxic components of natural gas associated with such leakage, establish the immediate and potential effects of gas toxins on plants, aquatic life, human health and wellbeing, predict long term health impact of the spillage on affected population and suggest remediation and mitigation measures to forestall future occurrence.

Ayamasa is located on long 5^0 56`$00^0$.E and lat $5^0$ 08` 00^0 N with it's adjoining communities along the river course which include. Foutorugbene, Isreallo, Angala Oweigbene, Albebiri, Isampou and Harama-Ama Federated communities of Burutu and Bomadi L.G.A of Delta/Bayelsa States. These communities are drained by river (Ayamasa) which serves as a natural resource support of their livelihood.

The indigenous people are of Ijaw extraction whose major occupation is fishing. About 95 per cent of the population engages in artisanal fishing involving the use of local fish gears as hooks, nets and, hand paddle canoes. Various fishes are caught and sold to earn income and also used for domestic consumption as source of protein. Other sea foods gathered and sold include mollusks, shellfish, prawns, and crabs. The estimated population of this impacted communities is a little above 9,000 persons. Farming is a secondary occupation among the rural folks. Most farming activities take place by the river banks on exposed and fertile alluvial soils commonly termed "Levees".

Being a riverine area with low-lying topography; it is prone to flooding and inundation. Crops grown include maize, pepper pumpkin, cassava. The area is characterized by

swamp forest with the distribution of tree determined by hydrology; with drier remnants of levees being more diverse than the water logged back swamps. The forest is dominated by tree species as euphorbiaceous, climbers, herbaceous plants, palm trees species, obeche and interspersed by saprophytes, tall grasses and perennial weeds. The obvious drainage pattern of this locality is dendritic with the divergence of River Niger distributaries into the Bight of Bony and the Atlantic Ocean. The drainage system defines settlement pattern of the inhabitants which is typically on interfluves in nature and traversed by various water bodies such as creeks, streams and rivulets. The drainage setting criss-crossed communities and form natural connectivity that predisposes inhabitants to water pollution effect beyond source region at the slightest event.

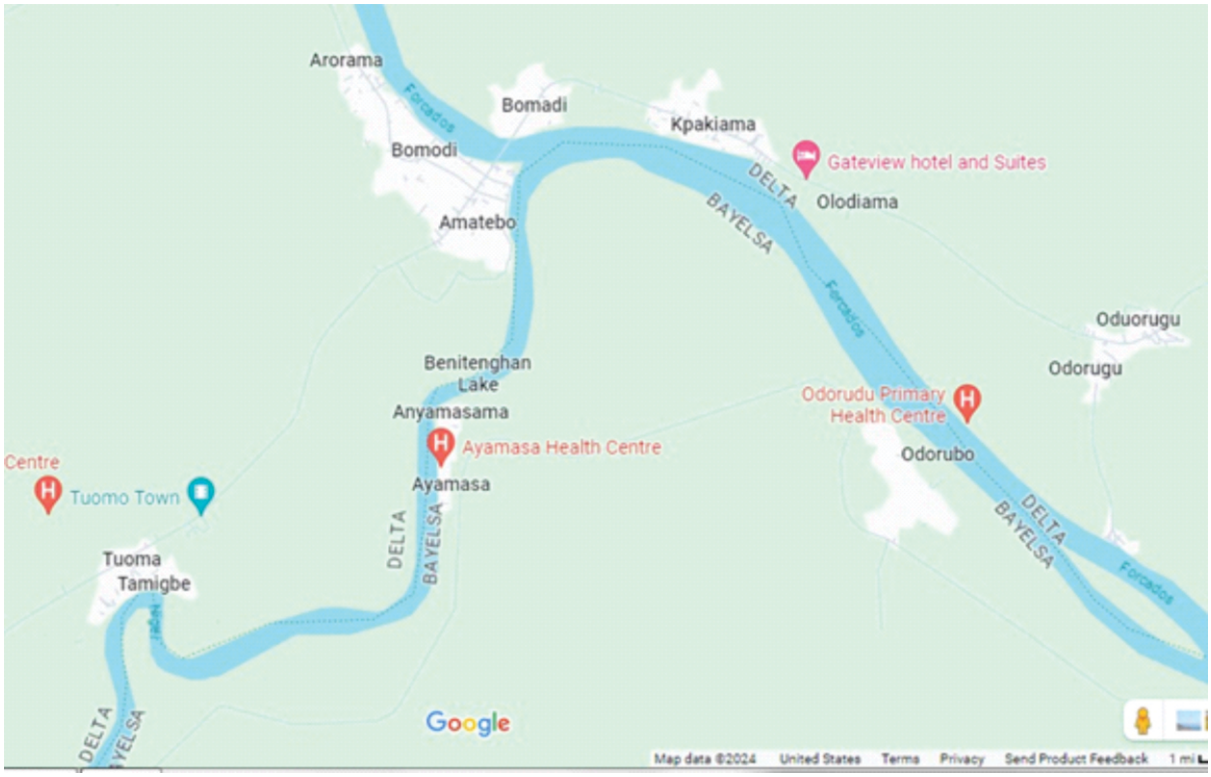

Fig. 1: The Study Area
Source: www.google.com/maps

1. MATERIALS AND METHODS

From the background knowledge of the impact of gas spills into water environment, this study integrated survey design, oral interview and observation, to elicit information from the respondents on the scale of the problem. Water samples and species of marine organisms (flora and benthic organisms) were collected for laboratory analysis. Impacts on plant were observed physically in the field.

Eleven (11) water samples were collected using polypropylene bottles (100cm^3) and specialized glass wares to test for Biological Oxygen Demand (BOD) Dissolve Oxygen (DO) and the presence of heavy metals (Cadmium, lead, nickel, sodium, nitrous oxide, chlorine). All samples were transported to a laboratory in an ice packed cooler kit and analyzed within 24hrs.

Temperature was measured with a thermometer, pH with a pH Kit, electrical conductivity with a WTW-Multine P4 universal meter, these measurement were done in-situ (in the field). Sampling was done at three points (A

control) (B) from the point source (C) downstream, 500 meters away from pollution source. The essence was to accurately compare levels of concentration of experimental parameters.

The measurement of methane concentration in water environment was determined by headspace equilibration (HE) techniques followed by laboratory analysis. To arrive at accurate result, the (HE) method was combined with the use of infrared tunable iodide lesser absorption spectroscopy (HE-TDLAS) that allows immediate determination of dissolved gas concentrations in water environment. Samples of fish caught by the local fishermen (tilapia) downstream of the impacted area was transported to a laboratory for analysis. The gills were examined, tissue sections cleared in 2 changes of Xylene mounted with Canada balsam of sectioning and subsequent microscopy.

2. RESULTS AND DISCUSSION OF FINDINGS

Cause of the leakage/estimated quantity released: The leakage, from investigation was due to equipment failure triggered by cracks (brittle fracture due to tidal effects and high pressure on the gas pipeline. The quantity of gas wastage through leakage varies between 12,000 and 14,000m^3 per hour depending on the size of the pipe source (Enuyuiagha and Nnanna, 2014). Given this, an average of 13,000m^3 x 24hr x 7 days before shut down of facility generated an estimated 2,184000m^3 of gas substances into Ayamasa River between 1st-8th of November, 2014. Where there was no immediate cleanup operation, the consequences of such discharges will linger on.

Toxic components of natural gas released during the incidence**:** It is disheartening and a crime to humanity to conclude during field investigation that natural gas spills into water bodies have no biophysical, health and socio-economic impact on man, flora and fauna. Various case studies on the matter, indicate that natural gas contain chemicals even more harmful than hydrocarbons in crude oil since they possess a more enduring life span than crude oil carcinogens (Howarth, Santaro,Ingraffea, 2011).

Natural gas contain methane which gives it a blue flame colour as it does in propane as an 'asphyziant". It contains impurities and additives such as random and other radioactive materials tagged Btex-Benzene, touene, ethylbenzene and xylene, organometalic compounds such as methyl mercury, organoarsernic and organolead.

Impact on marine life: Studies by Davis, (2011) showed that at a concentration of 0.02-0.055mg/l gas will be sensed by fish which will cause their forceful migration. If however, fish is exposed above 1mg/l, it will become excited within seconds of contact then disoriented and unable to flee. Within 15-20 minutes, fish exposed to such conditions show signs of acute poisoning and can die within 1-2 days of exposure. Shellfish are also killed by exposure to gas. Zooplanktons and phytoplanktons also die at gas concentration of 2-5mg/l. The impact on plants includes smothering of plant leaves, bioaccumulation of methane hydrates on leaf curticles, disruption in photosynthetic activities, sudden death.

The results of water, methane concentration and marine organism analysis are given as follows:

Table 1. Physico-chemical parameters of water

Parameter	Control	Experiment points	Maximum tolerable limit (WHO)
pH	5.0-7.3	5.2.7.9	6.5-8.6
BOD (Biological Oxygen Demand)	0.02-0.04	2.07-2.09	0
DO (Dissolved Oxygen)	0.02-0.4	2.42-3.01	5.0
COD (Chemical Oxygen Demand)	0.0-0.0	2.20-2.40	0
Major ions/nutrients			
Sodium(Na^+) mg/l	0.1-2.1	0.4-5.7	200
Phosphate (p_{40})mgl/l	0.02-0.04	0.21-1..38	5.0
Nitrite (NO3)mg/l	2.60-4.00	3.75-5.3	10
Sulphate (SO4)mg/l	0.20-5.8	1.95-3.16	400
Heavy metals			
Iron	0.1-1.0	0.1-0.1	1.0
Manganese	0.001-0.1	0.01-0.07	0.05
Nickel	0.02-0.07	0.04-1.00	0.05
Chromium	0.02-0.70	.04-0.53	-

Source: Field survey, 2014

Table 1, shows the result of water quality analysis from the gas spill area. Physico-chemical parameters, of pH, biochemical oxygen demand (BOD), Dissolved oxygen and chemical oxygen demand that regulate aquatic life were tested. Other parameters fell below the world health organization standard except for (BOD) and (COD) implying that fishes and other marine flora and fauna were seriously endangered or died during the spill. The same is applicable to major nutrients that were altered in their composition. There was no significant deposit of heavy metals since the chemical constituents of the leakage where not from crude oil.

Ecotoxological assessment of potential impact of natural gas spill into the water environment: It has been established through studies that at a methane concentration of 0.02-0.5mg/l gas will be sensed by fish forcing them to migrate and further exposure to concentration above 1mg/l within 15-20 minutes, an exposed fish will show signs of acute poisoning and die between 1-2days (Osborn, Vengosh, Warn, and Jackson, 2011). By implication, this incident drastically disturbed the composition and biomas of the water fauna and caused mortality of many organisms as reported by local fishers including benthic mollusks.

Toxicological studies of different gases including methane and its derivatives must take into consideration the fact that the influence of other factors (especially temperature and oxygen regime) can radically change in the direction and symptoms of the effect. In particular, increasing temperature usually intensifies the toxic effect of practically all substances on fish because of the direct correlation between the level of fish metabolism and water temperature. Thus, toxicant concentrations that do not cause any effect under low temperature (rainy season) can become lethal with increasing water temperature (dry season) due to the presence of methane condensates and hydrates on the bodies and tissues of plants, animal and even man.

Table 2. Symptoms reported by respondents by exposure categories and associations

Variable	Exposed (%) N=204	Unexposed (%) N=204	O/R	P-value
Sore eyes	68(1.85)	8(4.28)	9.94	<0.001
Headache	76(36.14)	25(22.80)	4.84	<0.001
Sore throat	62(4.0)	12(7.20)	7.50	<0.001
Cough	56(26.61)	28(7.5)	5.12	<0.001
Itchy skin	101(52.08)	16(7.77)	14.57	<0.001
Rashes	82(24.89)	14(6.17)	11.39	<0.001
Nausea	58(24.86)	12(5.27)	6.34	<0.001
Malaise	32(18.28)`	38(14.76)	1.60	<0.001
Diarrhea	92(31.80)	11(12.11)	3.04	<0.001
Asthma	87(41.12)	12(11.21)	2.04	<0.001
Occupational injuries	50(21.30)	14(5.29)		<0.001

Source: Field survey, 2014

Table 2 indicates results of questionnaire data administered to exposed population of affected communities, randomly, in a survey manner. It shows exposure with significant prevalence of diseases such as sore eyes, sore throat, headaches, cough, itchy skin, and occupational injuries. This survey indicates acute health risk the inhabitant of the riverine communities earlier mentioned are exposed to. To be mostly affected are the people of Ayamasa community as victims at the source of pollution.

The release of noxious gases of sulphur, nitrogen oxides, benzene (a) pyrene, dioxin, and unburned fuel components such as touene, benzene and xylene have both immediate and long term impact on human health exposed to such contaminants. If proper and adequate medical care is not given to pregnant women, the consequence in the long term shall be noticed in birth defects such as oral cleft, congenital heart defects (CHD) disability, stillbirth, neural tube defects (NTDS) and gene mutation. These defects are thought to originate in the first trimester as a result of polygenic inherited disease or gene-environment interactions (Brent 2004). Associations between particulate matter (PM) and nitrous gases and low-birth weight and preterm birth have been reported (Ballester, Estarlic, Truguez, and Esplunngues, 2010). According to Eni, Michael, Uquetan, Obiefuna, Asor, Egbe (2023); Obiefuna, Obiefuna, (2023); Eze, Obiefuna, and Inah (2025); Obiefuna, Inah, Nkong, Ekong (2025); Obiefuna, Ekaji, Iwuanyanwu, Eludire, Adedoyin (2023), urbanization, industrial activities and other forms of economic activities contribute to the release of toxic gasses into the atmosphere. This also pollutes the environment, which ultimately gets washed into the river bodies.

Other anticipated health problems common to all populations affected by the impact include, asthma, bronchitis, infertility, shock, acute renal failure, extensive epidermolysis, conjuntivities, milcosites, esophatis, chemical pneumonites, lymphocytic leukemia and a variety of other

blood related disorder in human.

Long term impact on fish population: A general effect typically for all fish is gas emboli. These emerge as different gases (including the inert ones) over saturate water. The symptoms of gas emboli include the rupture of tissues (especially in fins and eyes) enlargement of swim bladder, and disturbance of circulatory system. Given this, it means that, there is going to be a high decimation of fish species population with the juvenile and fingerlings at a higher risk. The secondary impact will be on local fishermen/women, whose occupational fortunes will dwindle overtime.

Impact on air quality: Methane, sulphur, nitrogen oxygen, carbon (iv) oxide have the properties of green house gases that can alter the microclimate of a region by introducing extreme weather events as heat waves, intensive sun burn, and skin cancer. The totality of this leads to global warming and sudden climate change likely to affect agricultural production of the people. Besides, population living near the area of incidence reported odors which expose them to the inhalation of timethylbenzenes, and xylene capable of initiating the respiratory system with long term effects ranging from eye and impaired lung function. Inhalation of xylene affect the nervous system resulting in dizziness, limb numbness, lack of muscle coordination, tremors, temporal limb paralysis and unconsciousness at high level (Perry, 2013).

4. RECOMMENDATIONS

The study recommended adequate medical care for affected population, environmental cleaning-up and compensation of victims of the disaster by the gas exploring companies.

5. CONCLUSION

Gas spill into a water environment produces hazards that have both immediate and long term effects on impacted environment including all entities of flora, fauna and human population. This study was conducted to access the impact of hazards generated by the spilled natural gas on the physical environment and human health. The findings revealed adverse consequences on humans and the biosphyical environment that require urgent attention and mitigation.

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Declaration of Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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