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The effect of gas flare on the health of schoolchildren in the Niger delta area of Nigeria

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Abstract
The proximity of schools to gas flaring sites and the use of simple ventilation systems in school buildings with currently no regulation or laid down blueprint during design and construction in an environment prone to adverse environmental hazards caused by the continuous exploration of oil in the Niger Delta is worrisome. Although a wide health implication has been associated with inhalation of poor air, its effect on the performance of schoolchildren and staffs is poorly understood. Thus, the aim of this research is to explore from professionals around the region the issues surrounding the provision of clean air indoors even though, most developed and developing world are advancing in newer systems and technologies for clean indoor air. This study adopts both qualitative and quantitative approach using both open-ended and semi- structured interview techniques. This paper finds that indoor air quality is not considered during design, selection, and construction of schools. Analysis showed that rather than consider the health effect associated with the inhalation of ambient air by schoolchildren who spend 80% of their active time in schools due to the use of simple open windows and doors as the source of breathable air. Advanced ventilation systems were therefore recommended to ensure supplying clean air for school buildings.

Keywords: air quality, gas flare, health implication, schools, and ventilation system

1. Introduction
Gases are regularly flared by energy companies exploiting oil in the Niger Delta area of Nigeria causing air pollution. These flared gases release hazardous substances into the atmosphere resulting in adverse impacts on the built environment as depicted by [1, 2]. Flared gases can heat surrounding air and cause poor air quality leading to some health hazards [3]. Thus, the school children who spend most of their time in schools where adverse outdoor air conditions exist become vulnerable. In the meanwhile, this also poses a challenge to their health. The rise in health risks such as cancer, asthma and other diseases are been attributed to gas flaring and subsequent release of hazardous gases inhaled by people that work or live in such areas [4, 5].
According to [6], children require clean air and a safe environment for both health and learning purposes. Studies have also shown that polluted air reduces the level of concentration of children in school [7]; and [8]. Thus advancements have been proposed both natural and mechanical to help schoolchildren breath clean air whilst carrying academic exercise. Against this backdrop, schools constructed in the Niger Delta area of Nigeria require the adoption and reconsideration of the design, material selection process and construction method adopted which can help in the circulation of clean air and possible improvement in the concentration level of pupils.

2. Relevant literature
The internal part of a building seen as a protector of humans from weather and climatic conditions may be more polluted than surrounding outdoor environment [9]. According to Volland [10], humans spend almost all their life time in enclosed spaces both residential and non-residential making it a potential threat to health risk. In addition, [11], affirmed every year IAQ is responsible for 1.6 million annual deaths and 2.7% global burden of disease. Therefore, its importance is vital due to adverse rising health issues as opined by [12]. Yet countries like Nigeria continually carry out an activity that increases health risk of its populace. Even though constant awareness and research have proven that the most affected by the inhalation of poor air are children [13]. This has resulted in developed and some developing countries in providing air quality guideline for schools and monitoring systems, even with the seasonal and yearly examination of such quality of air [14]. Yet this is a mirage in a country with its major economic manpower relies on oil.
The need for clean air quality in schools is vital since children spend more than 30% of their life time in schools more than they spend anywhere else apart from their homes as affirmed by [15]; The impact of indoor air quality and its effect on the performance of children and teachers during school period has been known to show adverse effects including lack of concentration and snoring of children in primary schools [16]. This shows that if there is clean indoor air then students and staffs can work well. Therefore, the possibility of achieving clean indoor in the vicinity of GF depends on the type of ventilation system used and the purification employed during the design and construction of schools.

3. Health implication of air quality on pupils
According to [2], the adverse health effect of air quality has been linked with an increase in the number of lung and skin cancer diagnosis. Many studies and standards have been provided in the developed world to help improve the level of indoor air quality (IAQ) in schools since children are the most vulnerable group of the population [6, 17]. Countries like the UK and US provide guidelines on the limit of gaseous substances that can be tolerated during school hours in school buildings. For instance, in the UK, carbon dioxide concentration in classes should not exceed 1,500 ppm while

the European standards limit it to 3,500 ppm [18,19], and countries like Sweden have their limits set below 1000ppm [20]. According to [21], respiratory and asthma diseases are the major causes of days lost from school and their socioeconomic costs need not be exaggerated. The awareness that IAQ needs to be achieved for the comfort and well-being of users of school buildings is a process that shows an adjustment and readiness in providing clean air space for both present and future generations. Table 1 shows gas flare pollutants, their descriptions, and adverse health effects.

Table 1: Gas Flare Pollutants and Their Adverse Effects

Pollutant	Description	Adverse Effect
Particulate Matter ($PM_{2.5}$ & PM_{10}):	PM effects according to several reports is more prevalent compared to other pollutant. This is because of the multifaceted mixture of compact and liquefied particles of organic and inorganic elements. Comprising of components such as sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water suspended in the air.	The adverse health effect is maximum in PM particles with a diameter of 10 microns or less, ($\leq PM_{10}$), which can infiltrate and lodge deep in the lungs. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer.
Carbon monoxide (CO)	A colourless, odourless gas that interferes with the delivery of oxygen throughout the body.	Carbon monoxide causes headaches, dizziness, weakness, nausea, and even death
Nitrogen dioxide (NO_X)	Colourless, odourless gas	Scientific studies have shown symptoms of bronchitis in asthmatic children rise associated with long-term exposure to NOx. Reduced lung function also associated with NOx causing eye, nose and throat irritation, shortness of breath, in addition, increased risk of respiratory infection is recorded.
Volatile organic compounds (VOCs)	VOCs evaporate into the air when these products are used or sometimes even when they are stored	The adverse effect of these gases on the air causes eyes, nose and throat irritation, cause headaches, nausea, and causes damage to the liver, kidneys, and central nervous system. With the possibility of some these VOCs causing cancerous diseases.
Ozone (O_3)	Unwarranted gaseous substances such as Ozone in the air can have an obvious negative effect on human health.	Can degenerate to difficulties in breathing, triggering asthma, reduce lung function and cause lung diseases
Benzene	Benzene in indoor air can originate from outdoor air. Indoor concentrations are also affected by climatic conditions and the air exchange rate due to forced or natural ventilation	Exposure to benzene has been linked to a range of severe adverse health effects and diseases, including cancer and aplastic anemia. Acute contact to benzene may cause narcosis: a headache, dizziness, drowsiness, confusion, tremors and loss of consciousness, moderate eye and skin irritation.
Sulphur Dioxide (SO_2)	Formulation of SO_2 in the air is due to the incomplete combustion of all types of carbon fuels.	SO_2 affects the respiratory system leading to the inflammation of the respiratory tract causing severe coughing, mucus secretion, aggravation of asthma and chronic bronchitis and the functions of the lungs, and causes irritation of the eyes. It also makes people more prone to infections of the respiratory tract.
Polycyclic Aromatic Hydrocarbons	Chemical organic compounds formed from complex organic substances exposed to high temperatures or pressures produced by incomplete combustion or high-pressure processes. PAHs.	Short-term exposure to PAHs also has been reported to cause impaired lung function in asthmatics and thrombotic effects in people affected by coronary heart disease, eye irritation, nausea, vomiting, and diarrhoea. Long-term exposure to PAHs has been reported to have an increased risk of skin, lung, bladder, and gastrointestinal cancers.
1,3-butadiene	Forms from the incomplete combustion resulting from natural processes and human activity1, 3-butadiene are also a recognised genotoxic human carcinogen, as such, no absolutely safe level can be specified.	The health effect of most concern is the induction of cancer of the lymphoid system and blood–forming tissues, lymphoma, and leukaemia

Source: [22-24]

Various studies have shown that poor IAQ in schools interferes with learning activities and can cause discomfort, irritation, and various short and long-term health problems in students, teachers, and staff [25, 26]. Therefore, design and construction of schools in gas flaring environment require specifications stipulating limits that should be adhered to during design and construction to reduce inhalation of poor air. In addition, specification becomes imperative since field survey shows that a typical public school building is ventilated with an open ventilation system as a design system in the Niger Delta area (see figure).

***Source*:** [27]

Fig 1: Open windows and Door as Ventilation System used in Public Schools

The figure above shows a typical school in the Niger Delta area of Nigeria with open windows and doors as the main ventilation system, which then allows the filtration of poor air quality from gas flaring activities into the building where young children acquire education. Thus, the proposition of design specification for the Niger Delta area of Nigeria will serve as a means to end the infiltration of poor air into the internal study area of pupils.

4. Research Approach Method

Respondents were made up of Architects, Estate Surveyors and Valuers, Land Surveyors, Air Pollution Experts and Quantity Surveyors for this study. They included academic and practicing professionals with over ten years' experience based on the membership of their respective professional bodies. The level of qualification, expertise, and proximity to research study area requires the use of data collection methods that will provide relevant expert opinions on the questions posed. The descriptive interpretation involved will require responses that can be judged based on respondents understanding of the primary aim of the research. The use of both qualitative and quantitative methods provided the necessary advantages and fit for the purpose approach, due to the availability of experts within the study area [28] and helps to reduce the biases of either method if used solely[29, 30].

Open-ended Questionnaires were hand delivered to all respondents giving them an extended time for collection. A total of one hundred and twenty (120) questionnaires were administered from the first week in May to the first week in July 2015 out of which 103 were retrieved. A total of 86% response rate was achieved, which forms a reliable and useful basis for analysis for the study [31]. The Statistical Package for Social Sciences (SPSS) was used for analysis. While 10 experts with over twenty years of experience agreed to an interview which was analyzed using Nvivo 11.

Information gathered from the questionnaires includes the impact of gas flaring on IAQ, its effect on the academic performance of pupils, health impact on pupils and staffs and types of ventilation system used in the school buildings in the ND.

5. Results and Discussions

Table 2 shows the various responses, firstly the responses on gas flare impact on air quality around Gas Flare areas in the Niger Delta, the adverse impact on health, and similarly the impact on the performance of pupils.

Table 2: Impact of Gas Flare

	1 Very low Impact	2 Low Impact	3 Moderate Impact	4 High Impact	5 Very High Impact
Gas Flare Impact on Air Quality	2%	5%	20%	49%	24%
Impact of Gas Flare on Pupils' Performance	6%	11%	28%	35%	20%
Health Impact Associated with Gas Flare	5%	6%	21%	45%	23%

***Source*:** Field Survey

From table 2, the responses showed that continued flaring and open air burning of gases has a substantial impact on schoolchildren and staffs. The analysis revealed that gas flare impact on air quality has a maximum of 24% of very high impact and a minimum of 2% very low impact, while gas flare impact on the performance of schoolchildren and staffs has a maximum of 20% very high impact and 6% very low impact. And finally, its health impact showed a 23% very high impact and a minimum of 5% very low impact. Consequently, from the analysis, it is pertinent that the activities carried out in the ND area cause pollution which affects the health of the children, performance of schoolchildren and staffs.

Furthermore, table 3 revealed the responses gathered after analysing on the question relating to the ventilation system used in school buildings around gas flaring environment.

Table 3: Types of Ventilation systems used in the Niger Delta

	Not Used	Fairly Used	Moderately Used	Frequently Used	Very Frequently Used
Open Windows	0.00%	0.00%	0.00%	21.40%	78.60%
Ceiling Fans	0.00%	14.60%	10.70%	34.00%	40.80%
Air Conditioners	75.70%	24.30%	0.00%	0.00%	0.00%
Air Humidifiers	96.00%	4.00%	0.00%	0.00%	0.00%

***Source*:** Field Survey

From table 3, four ventilation systems were listed and responses revealed that open windows are generally an accepted method of providing indoor air as 21.4% responded indicated that open windows are frequently used and 78.6% very frequently used method with 0% moderately, fairly and not used method. Conversely, ceiling fans had 14.6% as fairly used, 10.7% moderately used, 34.0% frequently used and 40.8% very frequently used showing that ceiling fans were used in combination with the open windows. In addition, the air conditioning had 75.7% as not used and 24.3% fairly used ventilation system and 0% moderately, frequently and very frequently used indications. However, air humidifiers were not used at all as all respondents indicated 0% not used in their respective questionnaires.

Further to the statistical analysis conducted, responded were also asked to further elaborate on their options ticked using semi structured interview and figure 2 summaries comments made by respondents confirming the results of the analysis carriedoutabove.

***Source*:** Field Survey

Fig 2: Gas Flare and Its Impact

From analysis as illustrated in table 3 and figure 2 gas flaring causes health implication also impacting negatively on the academic performance of schoolchildren. Despite these facts, Nigerian has continued to design and construct schools using simple open ventilation system which allows the infiltration of ambient air polluted due to constant flaring. According to [27], the hope that Nigeria will stop gas flaring is the mirage and Thus, the need for the construction industry to explore the use of the advanced system of ventilation that can provide clean has failed to tape into advance natural and mechanical ventilation systems used to achieve clean air.

6. Solution

The health risk associated with air pollution has led to so many innovations such as photocatalytic (TiO_2) construction and building materials used to achieve both aesthetic and environmental advantages as an air depollution substance [32]. Similarly, cladding material, an innovative construction material with modern technology that could clean air around it was invented and used in Mexico [33]. Other strategies include green walls have been studied [34]. This is proven to be efficient in sucking up poor air like carbon dioxide and replace the environment with oxygen. Green facades also are known as 'Living Walls' or 'Vertical Greening Systems is a building façade with the internal and external wall intentionally covered with vegetation providing aesthetic and functional purposes. It could be a modular, or a trellis-type system and can be attached to an existing building façade, or be a free standing structure.

Mechanical systems have continued to make an innovative entry in the construction industry as a means of achieving clean air quality. This is used in buildings where the treatment of air filtration is mandatory due to high levels of noise and air pollution [35]. Its use and reliability were confirmed in the market report of a consumer water and ambient air; Air Purification System [36], observing that air cleaners accounted

for large sales in 2001 with projected increase over coming years. Accordingly, the promoters of well-building standards encourage the use of advanced air purification systems such as spacing and the use of Ultraviolet Germicidal Irradiation and Photocatalytic Oxidation [37]. Nevertheless, Nigeria and in the Niger Delta where surrounding air is polluted with more 250 anthropogenic gases still rely on and use simple ventilation system for construction of schools where the future leaders of tomorrow vulnerable are required to acquire knowledge.

7. Conclusion

Advanced ventilation systems are the best practice for the design and construction of schools in the polluted areas of Nigeria. The continued design and use of simple ventilation system as currently being used will leave a lasting impact on the health of pupils. The use of advanced ventilation system weather natural or mechanical will provide a significant amount of clean air in an area prone to environmental hazards. It is recommended that if design and construction of schools are part of the responsibility of the government and a way of meeting the Millennium goal then the quality of air inhaled by children who spend most of their time in schools should be paramount in the design of schools in the Niger Delta.

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