International Journal of Infectious Diseases and Therapy
2023; 8(3): 109-116
http://www.sciencepublishinggroup.com/j/ijidt
doi: 10.11648/j.ijidt.20230803.15
ISSN: 2578-9651 (Print); ISSN: 2578-966X (Online)

Tracking Respiratory Tract Infections Among Residents Due to Pollutant Emissions from Okpai Gas Power Plant in Ndokwa East Local Government Area, Delta State, Nigeria

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To cite this article:
Prince-Mang Ndidi Loretta, Kpang Meelubari BarinuaTsaro, Imiete Godspower. Tracking Respiratory Tract Infections Among Residents Due to Pollutant Emissions from Okpai Gas Power Plant in Ndokwa East Local Government Area, Delta State, Nigeria. *International Journal of Infectious Diseases and Therapy*. Vol. 8, No. 3, 2023, pp. 109-116. doi: 10.11648/j.ijidt.20230803.15

Received: July 5, 2023; **Accepted**: July 31, 2023; **Published**: August 22, 2023

Abstract: As population increases, more buildings for housing, commerce and industry are also required and the resultant effect of this change is a rise in demand for electric power availability accompanied with harmful emissions from power plants installed for electricity generation and other industrial activities. More than 50% of power generated in Nigeria is from thermal power plants (TPP) which utilizes natural gas for their operations. The environmental and health impacts of thermal power plant are quite devastating as it is known for the emission of large amount of CO, CO_2, SOx, NOx and SPMs into the atmosphere responsible for most respiratory disorders. This study was aimed at tracking Respiratory Tract Infections (RTI) among residents of Ndokwa within the vicinity of Okpai gas power plant due to pollutant emissions from the plant. The reported cases of RTI was obtained from the archive of Anieze Primary Health Centre while other relevant data was collected through questionnaire distributed among residents within 200m, 400m, 600m, 800m, 1000m and 2000m distances from the gas plant. The Spearman Rank Correlation coefficient value, r=0.827 revealed that there is a significant relationship between RTI and pollutant emission at ($F= 28.02$, $p<0.05$. It was also found that 68.4% of RTI in the area was due to pollutant emission, though it occurrence varies significantly with distance. Arising from the findings, regular RTI screening and early detection/treatment, investment in alternative environmentally friendly sources of power generation, constant air quality monitoring and enforcement of regulated threshold, installation of gadgets that will ameliorate the level of gaseous emissions at the gas plant were recommended for urgent implementation in order to cause a significant reduction in air pollutant emission and further prune its associated health hazards in the area.

Keywords: Respiratory Tract Infection, Air Quality, Pollutants Emission, Thermal Gas Plant, Residents

1. Introduction

Energy powers productive activities such as agriculture, commerce, manufacturing, industry, and mining. This simply means that inadequate supply of energy is linked to poverty and can contribute to economic decline. According to Pokale [21] in order to improve energy generation, thermal electric plants that burn fossil fuels (natural gas) are adopted to generate electricity and these generate air emissions whose major components include air pollutants such as carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter (PM), sulfur dioxide (SO_2), and volatile organic compounds (VOCs) which are of great concern owing to their environmental and health implications. The WHO (2002) report provide a global estimates of about 2.5 million deaths each year resulting from indoor exposures to particulate matter in rural and urban areas in developing countries, representing 4–5% of the 50–60 million global deaths that occur annually which are not only confined to the local area of production but extend at both regional and global scales as a result of long transportation possibility [16], [7]. Carbon monoxide is readily absorbed from the lungs into the

bloodstream, resulting in competitive binding between it and oxygen to haemoglobin in the red blood cell, forming carboxyhaemoglobin and oxyhaemoglobin respectively. The carboxyhaemoglobin causes decreased oxygen carrying capacity of blood, thus inducing toxic effects which are dangerous to health in man [7].

Energy services that result from electricity are used for lighting, provision of air-conditioned indoor climate, refrigerated storage, and appropriate temperatures for cooking [20]. Thus, power plants play a key role in producing electricity. Meanwhile, power generation in Nigeria is mainly from two sources: hydroelectric power stations and thermal (steam and gas) stations. Nigeria has 25 power plants including the independent power plants (IPPs) out of which 22 are thermal power plants which according to [17] account for about 84% of the country's power supply. Most of these facilities are being managed by Power Holding Company Nigeria Plc (PHCN), a public sector charged by law for the generation, transmission, distribution, or marketing and sales of electricity to the public in Nigeria [10]. Among different kinds of power plants, gas turbine power plants have gained a lot of attention because they are attractive in power generation field due to feature low capital cost to power ratio, high flexibility, high reliability without complexity, compactness, early commissioning, commercial operation, fast starting accelerating and quick shut down and also for its good environmental performance, manifested in its low environmental pollution [22].

Thermal pollution from gas plants also affects the microbial populations, which participate in organic matter decomposition and nitrogen formation process resulting in a decline in organic matter and total nitrogen, as well as microbial populations, humid (top soil) formation, nutrient availability and soil fertility. Essentially, Nitrogen monoxide (NO) which is also one of the oxides of nitrogen generated from natural gas combustion is a harmful pollutant causing direct injuries of the respiratory organs and it is the precursor for acid rain and ground level ozone. Therefore, the operations of Okpai gas power plant resulting in emissions of hazardous air pollutants cannot be without public health effects especially Respiratory Tract Infections within the host communities. It is against this background that this study seeks to evaluate the relationship between exposures to gas emissions from Okpai gas power plant and Respiratory Tract Infections (RTI) across the study area.

2. Materials and Methods

The study area is located in the south-eastern part of Delta State and lies between latitude 5°45' N to 6°01'N and longitude 6°06'E to 6°20'E. Ndokwa East is bounded by the River Niger on the east, Isoko North Local Government Area in the south, Ughelli North, Ethiope West, Ika North and South, Aniocha South and Oshimili South Local Government Areas to the North. The total population for this study was 103,316 households clustered within (200, 400, 600, 800, 1000, and 2000) m from the gas power plant where air quality samples were taken in accordance with Weli, Adegoke and Kpang [26]. While the number of reported cases of Respiratory Tract Infections was obtained from the archive of the Anieze Primary Health Centre, the population within each cluster was divided by an estimated household size of six (6) members being the standard household size stipulated by the National population commission (2006). The number of households in each cluster where air quality samples were taking was proportionally substituted in the Taro Yamane (1967) formula to determine the sample size for this study. The main instrument used for this study was questionnaire and a total of 400 copies of structured questionnaires were designed, validated and distributed within the household's heads in order to obtain relevant information required for the study as shown in Table 1.

Taro Yamane formula

$$\frac{N}{1=N(e)^2}$$

Where n = Sample Size
N = Population Size
e = level of precision = 0.05 at 95% confidence level.

$$\text{Therefore, n} = \frac{103{,}116}{1=103{,}316(0.05)^2} = 400$$

The Spearman Rank Correlation statistic was employed for the analysis between air quality parameters and Respiratory Tract Infections in the area using the formula below:

$$\rho = 1 - \frac{6\sum {d_i}^2}{n(n^2-1)}$$

Table 1. *Sample Size for the Study.*

Distance (m)	Population (P)	Number of Households (P: 6)	Sample Size
200	24,430	4072	95
400	20,600	3433	80
600	17,354	2892	67
800	22,500	3750	87
1000	8100	1350	31
2000	10230	1705	40
	103316	17202	400

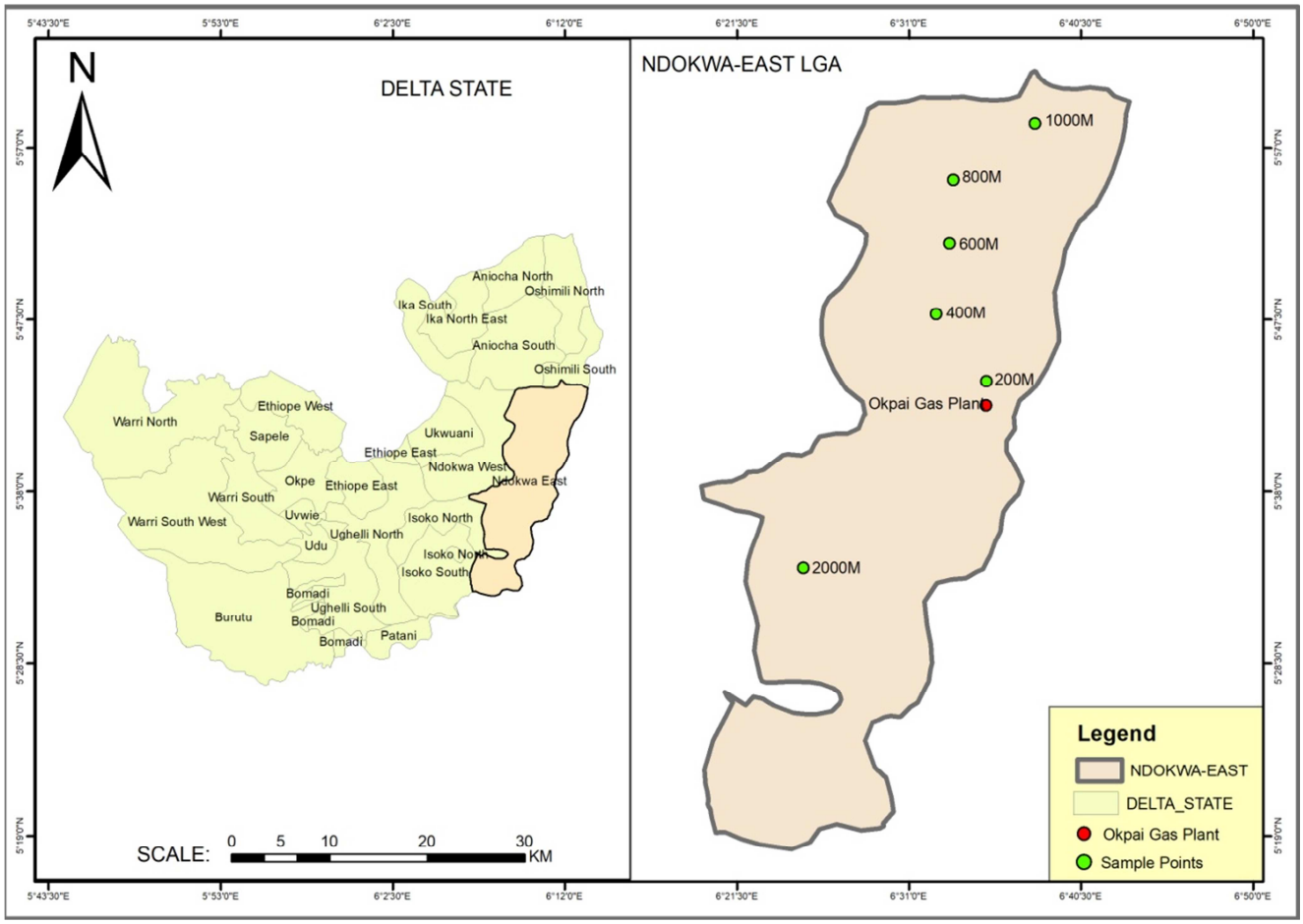

Figure 1. *Air Quality Sample Points from the Gas Power Plant in the Study Area.*

3. Results and Discussions

Table 2. *Socio-economic Characteristics of Respondents.*

Characteristic	Description	Frequency	Percentage (%)
Gender	Male	220	55
	Female	180	45
Age (in years)	20-29	46	11
	30-39	72	18
	40-49	114	29
	50-59	96	24
	60-69	56	14
	70 and Above	16	4
Marital Status	Single	62	16
	Married	225	57
	Divorced	58	14
	Separated	27	6
	Widowed	28	7
Educational Status	Non Formal	46	11
	Primary	48	12
	Secondary	150	38
	Vocational Training	60	15
	Graduate	72	18
	Post Graduate	24	6
	TOTAL	400	100

The socio-economic characteristics of the respondents covering gender, age, and marital status of heads of households as well as the number of years spent in each community by household heads is presented in Table 2. It is revealed that 55% of the household heads were males while 45% were female. In terms of age 11% of them were between

20-29 years and 18% were in the bracket 30-39 years of age. The analysis also revealed that 29% of the people were between 40-49 years of age whereas another 24% where in the bracket 50-59 years of age. On the other hand, 14% of the respondents were between ages 60-69 years while a negligible 4% were in 70-79 years of age category. Another significant proportion of the respondents were those in the married category as a total of 57% of them were in that group while 16% were reported to be singles. Again 14% of the respondents were divorced and another 6% were separated while 7% were found to be widowed. Regarding the educational qualifications, 11% of the entire respondents indicated no formal education while 12% had only primary education; another 38% had secondary education while 15% had vocational training whereas 18% had BSc while 26% had post graduate degrees.

Table 3. *Mean Air Quality in each Distance from the Gas Flaring Point and RTI Cases.*

Gases	200m	400m	600m	800m	1000m	2000m	FME
CO (mg/m^3)	3.30	2.78	2.25	1.64	1.26	1.00	10
SO_2 (mg/m^3)	1.00	0.04	0.02	0.01	0.01	0.01	150
NOx (mg/m^3)	0.09	0.06	0.05	0.017	0.01	0.01	150
H_2S (mg/m^3)	0.08	0.06	0.03	0.033	0.023	0.017	0.2
VOC (mg/m^3)	84.5	75.58	50.48	29.30	20.85	18.04	76
O_3 (mg/m^3)	0.18	0.13	0.10	0.05	0.03	0.017	0.06
SPM ($\mu g/m^3$)	3.29	2.99	2.63	2.26	2.03	1.94	230
Reported RTI Cases	163	121	103	67	42	28	

The mean pollutant concentration in each distance from the Gas Flaring Point in relation the reported cases of RTI in the study area is presented in Table 3 and it is observed that the reported cases of RTI decrease with increase in distance from the gas flaring point. Although among all the pollutants measured which were Carbon monoxide, Oxides of sulphur, Oxides of Nitrogen, Hydrogen sulphide, Ozone, and volatile organic compounds measured at varying distances, only VOC and O_3 particularly at 200m away from the power plant was observed to be higher than the limit specified by the Federal Ministry of Environment and 31% the total reported RTI cases were at that distance. Furthermore, 23% of the RTI cases reported were found within 400m distance from the source of emission where the mean concentration of VOC was 75.58 mg/m^3 which is approximately 76 mg/m^3 being the specified tolerable limit while O_3 measured 0.13 mg/m^3 mean value indicating 217% above the limit. On the other hand, it was also seen that O_3 was 167% higher than the limit at 600m with a mean measurement of 0.10 mg/m^3 and 20% of the RTI cases reported were concentrated within this cluster. All the other gases were observed to be within allowable limit at the different distances and the number of RTI cases reported were observed to decrease with increase in distance as it was observed that13% of the RTI cases reported corresponds to 800m and 8% and 5% of the cases known were reported within 1000m and 2000m from the gas flares point respectively. This observation corroborates with the result established by Nwaichi *et al.* [19] in their investigation of the level and distribution of CO_2 and other associated potential contaminants at some flare sites in the Niger Delta to evaluate possible environmental characteristics and it was found that the concentration of CO_2 and CO particularly alongside other air pollutants were significantly high at study sites when compared to the control site based on regulatory standard. This implies that at 200m distance from flare stack pollutant emission was found to be statistically significant portraying high risk of death from carbon dioxide poisoning except there are interventions. The concentration of VOCs and O_3 at 200m distance from the gas plant portends is highly dangerous for the residents because of their environmental health consequences which include respiratory irritation, swelling of airways, lungs inflammation, breathing, impairment etc. Similarly, the consistent decrease in RTI reported cases with respect to decrease in distance as observed in this study aligns with Abdulkareem *et al.* [2] where the extent of air pollutants particularly CO_2, CO, SO_2, NO_2, and THC were quantified by predictive model for pollutant dispersion from gas flaring and the volume of gas flare, conditions of flare including experimental data on concentration collated and the computer-generated results revealed that the dispersion pattern of pollutants from gas flaring is paramount following the Gaussian principle of distribution. Thus, it will not be out of place to state that meteorological characteristics of the local region have a strong control on the pollutant concentrations at different distances across the study area. It is opine that Nitrogen monoxide (NO), which is one of the oxides of nitrogen generated from natural gas combustion, is a harmful pollutant causing direct injuries of the respiratory organs and it is the precursors for acid rain and ground level ozone. Therefore, the presence of NOx as one major pollutant in the study area is a confirmation that the residents will suffer from respiratory health challenges in agreement with Gobo et al. [11] that examined the relationship between human exposure to toxicological factors in the environment arising from gas flares and the development of various human health related conditions in selected host communities in the Niger Delta and reported disease types such as asthma, cough, breathing difficulty, eye and skin irritation in communities with a long history of gas flaring compared to community with no flaring history. Also identified as major pollutant of the atmosphere are gases which are emitted to the air which are the COx and SOx. The greenhouse gases identified as dangerous gases are CO_2, CH_4 and NO_2 which are considered in the assessment of the Global Warming potential (GWP) of the system. These pollutants emitted from thermal or gas generating stations are grouped as follows oxides of sulphur, oxides of Nitrogen, oxides of carbon, Hydrocarbon and particulates and emphasized that these gases along with a variety of more exotic

hydrocarbons even in small quantities can be harmful to the environment and also cause diseases that are detrimental to human health such as asthma, bronchitis, respiratory and cardiac diseases, sinuses cough and phlegm, hay fever, chronic wheezing pulmonary diseases, malaria, dengue fever, blurred vision, loss of hearing, cancer, sterility, immune system damage and leukaemia, death through direct effect of heat etc. Similarly, this is supported by Kurt et al. [14] who asserted that Ozone (O_3), Particulates matter, dust, benzene and Ozone (O_3) cause serious damage to the respiratory system resulting in respiratory irritation, swelling of the air ways, impaired breathing, emphysema increased sensitivity to allergens; pneumonia, etc. Other linked health effects of particulates to lung damage, asthma, stuffy nose, sore throat, hay fever, burning or red eyes, and shortness of breath, cancer, premature death, and wheezing.

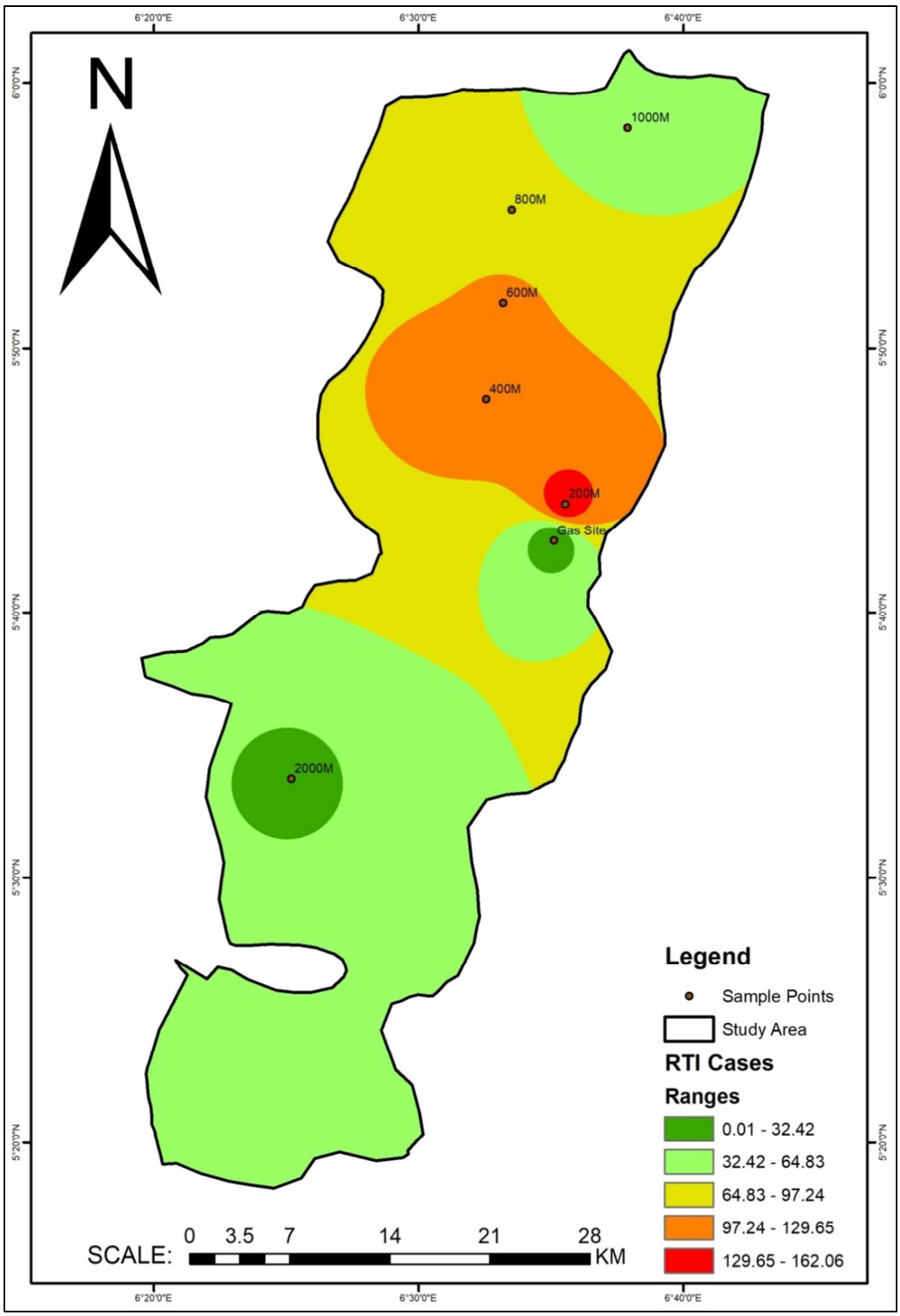

Figure 2. *Reported cases of RTI at different distances from Okpai Gas Power Plant.*

Table 4. *Effects of Emissions from Okpai Gas Power Plant on the Surroundings.*

Description	Distance from the Gas Plant (m)						
	200	**400**	**600**	**800**	**1000**	**2000**	**Total**
Displacement & Relocation of people	8	7	10	5	3	2	35
Increased Work Related Hazards	5	8	5	8	3	5	34
Air Pollution	25	20	15	20	5	8	93
Health Problems	40	30	20	30	10	12	142
Corrosion of Buildings	7	6	7	9	5	4	38
Reduction in Food Productivity	10	9	10	15	5	9	58
Total	95	80	67	87	31	40	400
Percentage (%)	23	20	17	22	8	10	100

The views of the respondents on the effect of emission emissions from Okpai thermal gas plant is presented in Table 4. It is obvious as presented that 23% of the respondents resided at 200m distance away from the gas plant whereas 8% of the entire people in the area believes that the main effect of the gas plant is displacement and relocation of people while another 8% strongly agrees that Thermal gas plants is responsible for increased work related hazards. It is also clear as indicated in the table that 20% of the respondents lived within 400m away from the gas plant whereas 17% of the people are at 600m radius while 23% of the respondents were of the opinion that the gas plant is a major source of air pollution in the area. Again, health problems was identified as another fundamental issue arising from the presence of the gas plant as 36% of the people completely affirm this on their own opinion. From the table, it was found that 22% of the interviewees were located at 800m distance from the plant whereas 1000m and 2000m had 8% and 10% within those distances respectively. According to 8% of the respondents, gas emissions generated from the plant causes corrosion of buildings and other structures in the study area whereas another 15% were of contrary opinion as they strongly assert that the thermal gas emissions reduces food productivity.

Power generating units are not only highly capital intensive investment but also requires various natural resources like fossil fuel and water, thus creating potential significant impacts on the environment and generate tremendous stress in the local ecosystem as it contributes over 60% of SO_2, 20% of NOx, 25% of manmade mercury and over 30% of excess CO_2 to the environment [21]. In general fossil fueled TPP have been globally identified to be among the major contributors of environmental pollution with severe consequences on human health due to increasing concentrations of pollutants and greenhouse gases emitted such as SO_2, NO_2, Suspended Particulate Matters (SPMs), Unburnt Hydrocarbons (HCs), Carbon dioxide and Carbon Monoxides (CO_2 & CO), Chlorofloro-Carbons (CFCs) and Unburnt Carbon particles (Soot) [29]. When petroleum is burned, it releases greenhouse gases into the atmosphere which in turn damages ecosystems (The Hindu, 2011, cited by Numbia, 2014). According to WHO (2006), it is estimated that dirty air kills more than half a million people in Asia each year of which the burden falls more on the poor particularly less developed countries as reported by Ogawa (2006) and cited by Abdul Raheem and Adekola [3]. The consequences of this pollution related problems generated by TPP in Nigeria are worrisome basically because of high population density, large emissions and a very low awareness of the public of the health hazards associated with these pollutants. The study area recorded air pollution as the second highest impact of Okpai gas power plant on the immediate environment after health problems and this corroborate with the opinion of Nriagu [18], who stated that the inefficient technology in the flare systems means that many of them burn without sufficient oxygen or with small amounts of oil mixed in with the gas, creating soot that is deposited on nearby land and buildings and inhaled by local residents and that the mixture of toxic substances emitted from flares contains benzene particles which poses severe health risks to exposed host communities and some of the respiratory diseases associated with long term exposure to atmospheric pollutants emitted during incomplete combustion of gas flare include neurological, reproductive and developmental effects as well as lung cancer, allergies, asthma, chronic obstructive pulmonary disease, and even flu and COVID19 according to Xu et al., Katsouyanni et al., and Arbex et al. [28, 13, 1]. It was revealed from the study that the level of concentration of the air pollutants from the power plant depended on the distance from the source of emission which was evident in the numerous adverse health consequences complaints among several people who live in close proximity to the thermal gas plant in conformity with Edino et al. [9], where it was asserted that most gas flaring systems in Nigeria's Niger Delta are located in close proximity to communities and the residents perceive gas flaring as hazardous to health, environment and general well-being of the community. Additionally, increase in temperature or thermal gradient resulting from the gas flare systems in some communities has undesirable effect on human health in the natural environment and affects the health, physiology and psychology of inhabitants of host communities with close proximity to the flare systems. Similarly, [4] assessed the adverse effect of gas flaring on the environment and the potential benefits of its reduction on the local economy and the environment at large and the data gathered revealed that gas flaring contributes to global climate change and has significant negative impacts on the environment. It was evidently reported that gas flaring has contributed significantly to poor environmental and human health quality around the vicinity of the flares and overall environmental degradation. Ayansina et al. [6] revealed that there is a wide spread acceptance of the fact that power plants, fired by fossil fuels is contributing significantly to global warming through enhanced green house. This suggest that plants as well as people are

damaged by air pollution from power plants and therefore, low levels of such pollutants retard plant growth, thus threatening the productivity of forest and crops. Rains acidified by sulphur chloride, a major pollutant emitted by fossil fuel power plants can cause considerable damage to vegetation, the soil and building. Usually, enough fresh water is required for conversion into steam, which turns the turbine blades, this heating of water can be done by using coal, oil or nuclear fuel. The efficiency of the plant is generally not sufficient since vast quantities of heat are lost in conversion stage. Soil moisture can be reduced by the presence of some of these gaseous emissions in the soil [23], thus affecting crop yield with impacts on nutrients availability for some crops [15]. On the other hand, Sonibare [24] asserted the possibility of sulphur products becoming a route for sulphur migration in the soil plant system and consumption of these gaseous emissions by vegetation affects aesthetic value of plants and reduces their economic value as food and fibre (27). Gas emission from thermal power plants are stationary sources of atmospheric contaminants which produce wasted heats which degrade air quality and several other environmental consequences like greenhouse effect, increase in temperature or thermal gradient, human health problems, poor agricultural yields, acid rain/acidification of aquatic environment and changes in the ecosystem. Also, in the presence of atmospheric compounds such as oxygen (O_2) and water (H_2O), secondary pollutants such as NO_3^- and SO_4^{2-} are formed and they contribute significantly to acid rain which leads to acidification and ultimately causing a reduction in species richness, impact on agriculture and biodiversity, poor public health, and rapid corrosion of corrugated iron roofs (galvanized iron sheet) which aligns with some of the impact of gas emission identified in this study. Also, several farmers have attributed thermal gradient from gas flaring practices to poor agricultural yields and that the affected communities suffer loss of vegetation; and adverse human health as well. Therefore, the consequences of gas flaring in the environment have adverse effects on the inhabitants and also undermine sustainable development of a region [5].

Table 5. *Relationship between pollutant emission and RTI.*

		Correlation Coefficient	0.827* F
R	RTI	Sig. (2-tailed)	0.000 28.02
		N	400

The relationship between pollutant emission and RTI is presented in Table 5 whereby it is revealed that the correlation coefficient r=0.827 and the coefficient of determination (R^2) =0.684 which suggest that 68.4% of RTI in the area is due to pollutant emission. It was also observed that this relationship was significant at $p<0.05$ (F=28.02). However, the reported cases of RTI among residents were observed to vary with respect to increase in distance. Major air pollution sources that contribute to poor air quality include emissions from domestic fuel burning, vehicles, industries, mining operations and waste disposal and incineration. Other sources include airports and railways, biomass burning and illegal tyre and waste burning. Pollutants emitted from these sources include particulates, sulphur dioxide (SO_2), nitrogen oxides (NO_x), ozone (O_3), carbon monoxide (CO) and Volatile Organic Compounds (VOCs) which are significant primarily in terms of local human health impacts and local and regional environmental impacts. Health impacts associated with exposure to poor air quality include cardiovascular and respiratory diseases while environmental impacts include localized effects such as visibility impairment to more global problems such as acid deposition and global warming [8]. The findings of this study corroborates with Hunt and Johnson [12] where it was asserted that electricity generation activities cause increase in temperature of the earth's atmosphere by causing increase in particular gases especially carbon dioxide which has effects on human body. The extremely high levels of Carbon dioxide and methane gases that are released into the atmosphere is suggested to also impact climate patterns beyond the local level. It has been revealed that gas flaring usually lead to ozone layer depletion, climate change, global warming, acid rain and rising sea level. Most of the gases causing the identified situation such as carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NOx), and ozone (O_3), are also emitted to the atmosphere by gas generating stations with poisonous effects like respiratory irritation, swelling of airways, lungs inflammation, impaired breathing [25].

4. Conclusion and Recommendations

The study shows that as air pollutants such as Carbon monoxide, Oxides of sulphur, Oxides of Nitrogen, Hydrogen sulphide, Ozone, Suspended Particulate Matter and volatile organic compounds from Okpai thermal plant over the years has obviously impacted the natural environment of the host community. These pollutants also cause harm to humans, animals and plants and contribute significantly to acidification of streams, thereby harming aquatic life and damage to buildings and other objects of aesthetic value within the region. It is clear as revealed by the study that the environmental hazards and health consequences evident in the number of reported cases of respiratory tract infections associated with these emissions is enormous. Thus, there is a high potential for reductions in air pollutant emissions including the attendant health hazards with the urgent implementation of the following measures:

1. installation of some known gadgets at thermal power plant stations that help to ameliorate the level of emissions of these pollutants into the atmosphere.
2. launching of public enlightenment campaign on the health consequences of emissions from TPP and the need embrace personal safety measures.
3. periodic medical check-up for RTI screening and early detection/ treatment most especially for residents living within 200-600m radius from the gas plant.
4. government should invest in environmentally friendly but sustainable alternative sources of power generation.
5. constant air quality monitoring should be carried out.

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