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The Contribution of Power Generating Sets to Gas Emissions in Abakaliki Metropolis, Southeastern Nigeria

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Abstract: At the Department of Soil Science and Environmental Management, Ebonyi State University, Abakaliki we have been monitoring several sources of gases emissions since 2001. Between 2003 – 2015 we started trying to separate the sources of these pollutants namely: power generating sets, traffic, municipal wastes, sewage system. In this report, three business locations that use extensively power generating sets namely: Gunning, Ogoja, College of Agricultural Sciences (CAS), with a suburb non-business area known as Onuebonyi as control were monitored for atmospheric gaseous concentrations arising from these power generating sets. The carbon monoxide concentrations varied from 0.55 – 0.68 mg L^{-1} in all locations, while carbon dioxide concentrations varied from 0.781 – 0.812 mg L^{-1}; nitrogen dioxide from 0.350 – 0.367 mg L^{-1} and ammonia varied in the same proportion with nitrogen dioxide. The CO, CO_2 and NH_3 met the permissible limit set by World Health Organisation and Nigeria Environmental Protection Council.

Key words: Electricity · Power sources · Gas emissions · Business centers · Developed and developing countries

INTRODUCTION

In developing world including Nigeria many public goods like access to regular and affordable electricity is a mere wish than reality. Power supply is not readily available and affordable. Only the rich can afford power generating sets. Many owners and family lives and that of neighbours have been lost due to accidents arising from such power generating sets like fire, fuel leak, explosion, smoke and the notorious carbon monoxide they emit that are silent killer. Apart, from the gases they emit, power generating sets constitute a nuisance and noise pollution if available to every family. They are also expensive to fuel and maintain [1,2].

The gases they emit namely: carbon monoxide, carbon dioxide, nitrogen dioxide, hydrogen sulphide, ammonia are of global concern. They are implicated in many health and environmental hazards such as asthma, catarrh, cough, depletion of ozone layer, global warming, climatic change, melting of arctic ice, rise in sea level, flooding and tsunami [2-4].

At Ebonyi State University we have been exploring the possibility of separating the possible sources of these gases. Hence, the assessment of the roles of power generating sets in this emission scenario. The work presents the findings between 2013 – 2015.

MATERIALS AND METHODS

Geographical and Climatic Information: Abakaliki lies within Longitude 08° 06¹ E and Latitude 06° 19¹ N at an altitude of 128 meters above sea level. It lies within the derived savannah belt of south eastern Nigeria. The mean annual rainfall for 25 years (1977 – 2012) was 154.75 mm spread across April – November; while the mean annual minimum and maximum temperatures for same period were 23.58 and 32.40°C respectively; with higher and lower temperatures during the dry and rainy seasons respectively. On the other hand, the average annual sunshine hours for same period was 5.13, while the mean annual relative humidity@09/15 hrs was 80.2 and 59.93% respectively; with higher and lower relative humidity during rainy and dry season, respectively. The rainfall, temperature and relative humidity of the area are presented in Figures 1, 2 and 3 [5]. The soil belongs to the order (Ultisol) classified as Typic Haplustult [6].

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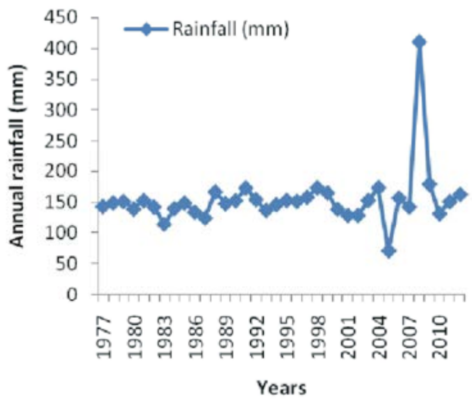

Fig. 1: Annual rainfall for Abakaliki (1977 – 2012) – mm

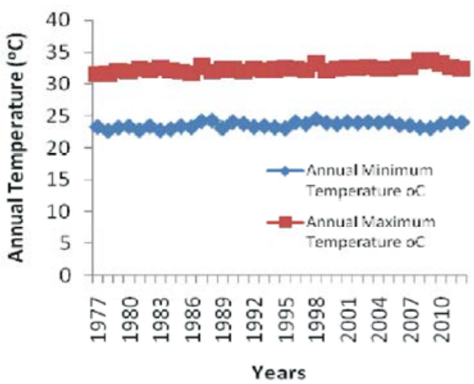

Fig. 2: Annual minimum and maximum temperature for Abakaliki (1977 – 2012) - °C

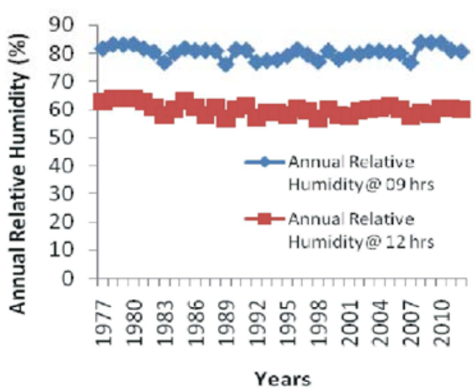

Fig. 3: Annual relative humidity@09/12 hrs at Abakaliki (1977 – 2012) - %

Identification of Power Generating Sets Business Centers: In this study four business locations known for intensive use of power generating sets namely: Gunning Road, Ogoja Road and College of Agricultural Sciences (CAS), with local Onuebonyi neighbourhood as control; were monitored for atmospheric gaseous concentrations between the hours of 07 – 11 am for 5 days a week, for 3 months and for 3 years (2013 – 2015). Each measurement was replicated four times at an equal distance of 10 meters. The CAS business center is located within the school premises of College of Agricultural Sciences, Ebonyi State University, Abakaliki. The major activities that were going on there include: typing, photocopying, lamination, internet services, all sort of computer works with use of power generating sets in view of epileptic supply of electricity. The Gunning and Ogoja Road Business Premises are located close to the biggest market in Abakaliki Metropolis known as Abakpa Main Market where all the commercial services described for CAS are taking place. The last location (Onuebonyi) is a suburb-residential area without commercial activities requiring power generating sets and is 6 miles from Abakaliki Urban.

Measurement Techniques: With the aid of potable hand held gas monitors (GASMAN Model) CO19256H; $CO_2$700IR; $NO_2$19835H; and $NH_3$19736H with detection limit of 0 – 50 ppm and alarm set at 3 ppm, atmospheric concentrations of the following gases were monitored: carbon monoxide, carbon dioxide, nitrogen dioxide and ammonia. The four monitors were hung on a wooden platform raised to a height of 1.5 meters. They were calibrated on each occasion of use due to regular weather changes. The Green Light Emitting Diode (LED) and the sounder operated once every three seconds. The Liquid Crystal Display (LCD) showed zeros. The flashing of red LED is an indicator that concentration of gases has passed alarm range. Hourly timing was done with aid of stop watch. All readings were noted at hourly stability. All protocols for air monitoring were based on World Health Organisation and Nigerian Standards.

Statistical and Data Analysis: For analysis exercise daily values were pooled on fortnightly basis and subjected to analysis of variance for randomized complete block design (RCBD). The values were captured in parts per million (where 1 parts per million (ppm) is equivalent to 1 mg kg^{-1} or 1 mg l^{-1}) – ASA-CSSA-SSSA [7]. Further mean separation and differentiation were done with Fishers Least Significant Difference (FLSD) at 1% and 5% probability levels or 99% and 95% confidence intervals [8]. Correlation and correlation was also done between number of power generating sets and gas emissions as described by Zar [9].

RESULTS

Atmospheric Carbon Monoxide Concentration: The level of carbon monoxide in the atmosphere due to activities of power generating sets was highest at CAS business premises, 0.68 mg L^{-1} and least, 0.59 mg L^{-1} at Onuebonyi (control), with variations between business centers at highly statistical (P = 0.01) level and coefficient of variation of 23.20% (Table 1). Across cumulative monitoring interval, Gunning Road gave highest value of 0.72 mg L^{-1} at 12 weeks, while Ogoja Road gave the same value at 4 and 12 weeks; CAS gave 0.73 mg L^{-1} at 8 weeks; with Onuebonyi (the control) giving 0.72 mg L^{-1} at 12 weeks (Table 2). These values are less than the permissible levels approved by World Health Organization (WHO) and Nigeria Environmental Protection Council (NEPC) of 30 ppm or mg L^{-1} [10,11]. The number of power generating sets were positively correlated (r = 0.63) to carbon monoxide atmospheric concentrations across all locations as expressed by the regression equation, Y = -167.45 + 5.933X (Table 3).

Atmospheric Carbon Dioxide Concentrations: There was no statistical (P = 0.05) differences amongst business centers for atmospheric concentration of carbon dioxide. However, Gunning Road recorded highest value of 0.812 mg L^{-1} and Onuebonyi (control) gave least value of 0.781 mg L^{-1} for the whole periods assessed (Table 1). Across cumulative periods, the highest CO_2 air concentration, 0.89 mg L^{-1} at 2 weeks was at Gunning Road business centers, while it was 0.84 mg L^{-1} at 2 and 12 weeks at Ogoja Road business centers. The CAS business centers gave highest CO_2 air concentration of 0.89 mg L^{-1} at 2 weeks cumulative monitoring; while Onuebonyi (the control) gave 0.83 mg L^{-1} at 12 weeks cumulative (Table 2). These levels are above the permissible level of 0.01 ppm or mg L^{-1} set by the WHO [11].There was positive correlation (r = 0.23) between number of power generating sets and CO_2 air concentration across all locations. The relationship between number of power generating sets and CO_2 air concentration as expressed by regression equation was Y = -1037.2 + 4.48X (Table 3).

Table 1: Effect of power generating sets on gas emission in selected business areas of Abakaliki. Values are means of 5 days x 3 months x 3 years (mg L^{-1}) hourly average. WHO = World Health Organisation and NEPC = National Environmental Protection Council hourly standards.

Locations	CO	CO_2	NO_2	NH_3
Gunning Road	0.55	0.812	0.0367	0.0367
Ogoja Road	0.67	0.798	0.0367	0.0367
CAS	0.68	0.810	0.0367	0.0367
Onuebonyi-control	0.59	0.781	0.0350	0.0350
FLSD(0.05)	0.184*	ns	0.014*	0.022*
FLSD(0.01)	0.192**	ns	ns	0.049**
CV(%)	23.20	5.96	1.40	2.32
WHO	30	0.01	0.12	0.28
NEPC	30	Na	0.12	0.20

Table 2: Effect of power generating sets on gas emissions in selected business areas of Abakaliki. Values are means of 10 days x 3 months x 3 years (mg L^{-1}) for 1 hourly average. WHO = World Health Organisation and NEPC = Nigeria Environmental Protection Council hourly standards.

Gases	CO				CO_2				NO_2				NH_3			
Period	OR	GR	CAS	O	OR	GR	CAS	O	OR	GR	CAS	O	OR	GR	CAS	O
2weeks	0.62	0.61	0.63	0.59	0.84	0.89	0.89	0.781	0.04	0.04	0.04	0.035	0.04	0.04	0.04	0.035
4weeks	0.72	0.68	0.68	0.58	0.75	0.83	0.84	0.699	0.04	0.03	0.03	0.029	0.04	0.04	0.04	0.030
6weeks	0.67	0.68	0.63	0.48	0.78	0.77	0.74	0.721	0.03	0.03	0.04	0.033	0.03	0.04	0.04	0.033
8weeks	0.63	0.58	0.73	0.51	0.79	0.78	0.78	0.674	0.04	0.04	0.04	0.034	0.04	0.03	0.04	0.031
10weeks	0.63	0.58	0.68	0.55	0.79	0.77	0.78	0.711	0.04	0.04	0.03	0.036	0.04	0.04	0.03	0.034
12weeks	0.72	0.72	0.71	0.48	0.84	0.83	0.83	0.700	0.03	0.04	0.04	0038	0.03	0.03	0.03	0.036
FLSD (0.05)	Ns	0.120*	0.90*	ns	0.078*	0.05*	0.07*	ns	0.01*	0.02*	0.01*	ns	0.01*	0.02*	0.1*	ns
FLSD (0.01)	ns	0.166**	0.120**	ns	0.023**	0.07**	0.1**	ns	0.02**	0.02**	0.02**	ns	0.01**	0.02**	0.1*	ns
CV(%)	7	21	5.1	2.2	12	9.1	6.4	1.2	14	14	1.1	5	14	14	14	3.8
WHO	30	30	30	30	0.01	0.01	0.01	0.01	0.12	0.12	0.12	0.12	0.28	0.28	0.28	0.28
NEPC	30	30	30	30	na	na	na	na	0.12	0.12	0.12	0.12	0.20	0.20	0.20	0.20

Table 3: The relationship between power generating sets and gas emissions as expressed by correlation coefficient and regression equations in selected business areas of Abakaliki. Values are means of 5 days x 3 months x 3 years (mg L^{-1}) hourly average. R^2 = Coefficient of Determination; r = correlation coefficient.

Area	Y	X	Intercept	Slope	Req	R^2	r
All locations	Gen. Sets	CO	-167.45	5.933	Y = -167.45 + 5.933X	0.398	0.63
All locations	Gen. Sets	CO_2	-1037.2	4.48	Y = -1037.2 + 4.48X	0.054	0.23
All locations	Gen. Sets	NO_2	71.54	10.43	Y = 71.54 + 10.43X	0.0079	0.09
All locations	Gen. Sets	NH_3	79.11	0.58	Y = 79.11 + 0.58X	0.00164	0.04

Atmospheric Nitrogen Dioxide Concentrations: Similarly, the atmospheric nitrogen dioxide concentration between business centers were statistically (P = 0.05) different; with all centers giving same value of 0.367 mg L^{-1} and 0.0350 mg L^{-1} in control (Table 1). Across cumulative monitoring intervals, the highest NO_2 air concentration was 0.04 mg L^{-1} in all business centers plus control (Table 2). These levels are less than the permissible level of 0.12 ppm or mg L-1 set by WHO and NEPC [10,11]. There was positive correlation (r = 0.09) between number of power generating sets and NO_2 air concentration for all locations as expressed by regression equation Y = 1460.29 + 1826.89X (Table 3).

Atmospheric Ammonia Concentrations: There were highly statistical (P = 0.01) differences in atmospheric ammonia concentration between business centers with same values of 0.0367 mg L^{-1} except in control were 0.035 mg L^{-1} was got (Table 1). Across cumulative times the highest air concentration of NH_3, 0.04 mg L^{-1} was recorded at Gunning Road and Ogoja Road business centers at 2, 4, 6 and 10 weeks; while same values were got at CAS at 2, 4, 6 and 8 weeks and at Onuebonyi (control) at 2, 4, 8 and 12 weeks cumulative (Table 2). These levels were below the permissible levels of 0.28 and 0.20 ppm or mg L-1 set by WHO and NEPC respectively [10,11]. There was positive correlation (r = 0.04) between number of power generating sets and NH_3 air concentration. The relationship between power generating sets and NH_3 air concentrations as expressed by regression equation was Y = 79.11 + 0.58X (Table 3).

DISCUSSION

Atmospheric Carbon Monoxide Concentrations: From the results the order of increasing air concentrations of carbon monoxide were CAS>Ogoja Road>Onuebonyi (control)>Gunning Road. While, this result is very frustrating in view of Onuebonyi (control) where power generating sets were not found, compared to Gunning Road and other places, it shows the difficulty of separating all possible sources of the gas including vehicles, coal, charcoal, firewood and decaying sewage and domestic wastes. The Onuebonyi suburb is a rural area replete with fuel sources like firewood, charcoal, kerosene stoves, coal stoves and Ogoja-Abakaliki Road that traverses them with constant fleets of automobiles (both good and ugly). The urban centers where Gunning, Ogoja and CAS business centers are located are similarly linked by major in and out bound roads with fleets of automobiles (both the good and ugly). Even though no automobile is good when it comes to gaseous emissions except solar or bio-fuelled automobiles which may not be accessible in this part of the world in even two centuries to come. The positive correlation between number of power generating set and atmospheric carbon monoxide is a bit consoling; but traffic (automobiles) and other sources mentioned can be direct and indirect part of the equation. This makes the monitoring and calculation of individual and overall anthropogenic contributions to atmospheric gaseous concentrations so difficult and frustrating. Nevertheless, the business locations passed the limits set by WHO and NEPC [10,11] probably to the interest of citizens who are not directly exposed to these business centers, but may be lethal to their workers and customers who are exposed to the inhalation on daily basis. The accumulations may be deadly and as such there is not much to shout about. The risks are there no matter the level of concentrations. They are variable over time and space. Again carbon monoxide is a silent killer in poorly ventilated places [2,4].

Atmospheric Carbon Dioxide Concentration: The order of carbon dioxide air concentration at the business centers were Gunning Road>CAS>Onuebonyi (control)>Ogoja Road; with all of them passing the limits set by WHO and NEPC. But the fact remains that the correlation of the gas concentrations with number of power generating sets showed that part of the overall carbon dioxide atmospheric budget may be coming from them. In addition, the roles of automobiles and other sources implicated in carbon monoxide are also there. Even though CO_2 is vital for plant photosynthetic capability, including elevated levels which have encouraged flushed vegetations; the gas has also been implicated in depletion of ozone layer, global warming, climate change, melting of arctic ice, rise in sea level, flooding and tsunami [2,3,4,12,13]. The fact that control (Onuebonyi) even exceeded those values got in other places like Ogoja Road that have the largest traffic in the area is another pointer to other sources of the gas. The biomass fuel, firewood, charcoal, coal stove, kerosene stove in this control area may even be giving off more CO_2 than those of automobiles and power generating sets combined. That is why the gases monitoring became imperative. For CO_2 in the control area with many vegetations and woodland for their uptake, the citizens in control area may be more safe compared to urban residents where other business centers are located with little or no trees, vegetations, crowded streets, buildings, automobiles, population bonuses that have no means of sequestering the CO_2 into harmless forms. Hence, the urban citizens are more at risk compared to those at Onuebonyi suburb [1,2].

Atmospheric Nitrogen Dioxide Concentrations: The results showed same levels of nitrogen dioxide in all the business centers except the control. All values were lower than permissible limits set by WHO and NEPC [10,11]. This goes to explain that power generating sets in addition to automobiles may be major source of the atmospheric nitrogen dioxide as emphasized by Holman [14] and RSC [4] and Jackson and Jackson [3]. Other sources include: sewage, domestic wastes, charcoal, firewood, coal, kerosene stoves, biomass-stoves. Atmospheric nitrogen is implicated in acid rain (better known as acid deposition), ozone depletion, global warming, climate change, melting of arctic ice, rise in sea level, flooding and tsunami [2,3,4,12,13]. There is no direct sink for NO_2 except the role they play in global biogeophysicochemical cycling of nutrients and the fact that nitrogen fixing organisms like *Nitrosomonas* and *Nitrobacter* are capable of trapping atmospheric nitrogen and fixing them in the root nodules of leguminous plants. However, they do not utilize nitrogen dioxide directly, but utilize nitrogen generated when it dissociates with other gases like oxygen, ozone, carbon dioxide, carbon monoxide in the atmosphere. Nevertheless, acid deposition or acid and ozone layer depletion has remained the greatest worry of elevated NO_2 concentrations. They may also be implicated in eroding of surfaces like corrugated roofing sheets, metallic surfaces of culverts, bridges, railways, airports, seaports and the entire built environment. Similarly, in other health ailments like catarrh, cough, asthma as suspected for carbon dioxide, carbon dioxide and other similar environmental gases.

Atmospheric Ammonia Air Concentrations: Ammonia is another gas that is highly detested like carbon monoxide because of their poisonous nature especially under pore ventilation. It is very choking and debilitating. In these results, all the business sites had same level of ammonia throughout the study, with little deviation in the control. In this scenario, the factors described for other gases atmospheric levels may have affected the results. However, the burning of fossil fuels is not the major source of atmospheric ammonia concentrations. Their main sources are in feed-lots, decomposing of animal dung's, sewage and domestic wastes. Ammonia is a major metabolite of protein digestion after the release of amino acid. Hence, animal and human urine contain high levels of urea [$CO(NH_2)$] that contains up to 40% nitrogen. Ammonia as a gas is liberated in the decomposition of urea, urine, dead animals and plants [3]. At the Onuebonyi (control) suburb the citizens are safer because the NH_3 can easily be diluted by massive oxygen being produced by the woodlands and vegetations into less harmful gases or translocated down the soil profile in form of ammonium or nitrates for plant nutrition [12,15]. Unlike in the urban, where there are less opportunity for their dilution as described in other gases. Making the citizens in the urban to be more at risk. Nevertheless, the levels of NH_3, just like that of CO and other poisonous gases cannot be compromised be it in the suburb or urban. Even though the values got were below the WHO and NEPC permissible limits, their constant monitoring and evaluation must be a rule rather than an exception.

Scientific Implications of Nitrogen Dioxide and Carbon Monoxide on Human Health and the Environment: Both, nitrogen dioxide (NO_2) and carbon monoxide (CO) are gases released as a result of combustion processes, including those that take place in homes and offices when fossil fuels are burned [15]. According to this worker, indoor concentrations of NO_2 often exceed outdoor values in homes that contain stoves, space heaters and water heaters that are fuelled by gas. The flame temperature in these appliances is sufficiently high that some nitrogen and oxygen in the air combine to form NO, which eventually is oxidized to nitrogen dioxide. The author gave NO_2 levels in homes that use gas for cooking or that have kerosene stove at 24 ppb, compared to 9 ppb for homes that have neither. Peak concentrations near gas cooking stoves can exceed 300 ppb according to this worker.

Nitrogen dioxide, according to Baird [15]is soluble in biological tissue and is an oxidant, so its effects on health, if any, are expected to occur in the respiratory system. Carbon monoxide on the other hand, according to the author is a colourless, odourless gas whose concentration indoors can be greatly increased by the incomplete combustion of carbon containing fuels such as wood, gasoline, kerosene or gas. Higher indoor concentrations usually are the result of a malfunctioning combustion appliance, such as kerosene heater. In developing countries, according to the worker, carbon monoxide poisoning is a serious hazard when biomass fuels are used to heat poorly ventilated rooms in which people sleep. The author gives indoor and outdoor CO concentrations to usually amount to a few parts per million, though elevated values in the 10 – 20 ppm range are common in parking garages due to the carbon monoxide emitted by motor vehicles (inclusive of power generating sets as used in current study). The major danger from carbon monoxide, according to the worker, arises from its ability, to complex strongly with the haemoglobin in blood and thus to impair its ability to transport oxygen to cells. On average, non-smokers have about 1% of their haemoglobin tied up as the complex with CO, popularly called "carboxyhaemoglobin". According to Baird [15] that is why smokers double this value or more because of the carbon monoxide that they inhale during smoking which arises from the incomplete combustion of the cigarettes.

Carbon Dioxide Emission and Trends: Carbon dioxide (CO_2) emissions and estimations, according to Baird [15] has been based on measurements of air trapped in ice core samples from Antarctica or Greenland; that show the atmospheric concentration of carbon dioxide in preindustrial times (before 1750); to be roughly 280 ppm. It was increased by about 30%, rising to 365 ppm by 1998. Currently, it is growing at an average annual rate of 0.4% or 1.5 ppm, almost double that of the 1960s, although there are considerable year-to-year fluctuations of up to ± 1 ppm in the rate of increase. For Baird [15] most of the considerable increase in anthropogenic contributions to the carbon dioxide concentration in air is due to the combustion of fossil fuels – chiefly coal, oil and natural gas, which were formed ages ago when plant and animal matter was covered by geological deposits before it could be more thoroughly broken down by oxidation.

According to Baird [15] the annual per capita release of carbon dioxide in developing countries is about one-tenth as large as it is in developed countries. For the worker, a significant amount is added to the atmosphere when forests are cleared and the wood burned in order to provide land for agricultural use. The author further gives the lifetime for carbon dioxide emitted into the atmosphere as complicated quantity; since in contrast to most gases; it is decomposed chemically or photochemically. On average, within a few years of its release into the air, a CO molecule will likely dissolve in surface seawater or become absorbed by the growing plant. However, according to the worker, many such carbon dioxide molecules are re-released back into the air a few years later, on average, so the disposal is only a temporary sink for the gas. The only permanent sink for it, according to the author is its deposition in the deep waters of the ocean and/or precipitation there; as insoluble calcium carbonate. He notes that the top few hundred meters of sea water mixes slowly with deeper waters, hence carbon dioxide that is freshly dissolved in surface water requires hundreds of years to penetrate to the ocean depths. Consequently, according to the worker, the oceans will ultimately dissolve much of the increased CO_2 in the air, the time scale associated with this permanent sink is very long.

Baird [15] cautions that due to the interchange of carbon dioxide between the air and the biomass and shallow ocean waters and between shallow and deep seawaters, which are complicated, it is not possible to quote a meaningful average residence time for the gas in air alone. Rather we should think of new CO_2 fossil-fuel emissions as being rather quickly allocated between air, the shallow ocean waters and biomass, with interchange among these three compartments occurring continuously. Then, slowly over a period of many decades and even centuries, almost all the new carbon dioxide will eventually end up deposited in the deep ocean. The author gives common quote of 50 to 200 years, required for carbon dioxide level, to adjust completely to its new equilibrium concentration, if a source increases. The worker gives the increase in growth rate of some types of trees, due to the increased concentration of carbon dioxide in the air as CO_2 fertilisation. According to Baird [15] some scientists suspect that the rate of photosynthesis is speeding up as the level of CO_2 and the air temperature increases and that the formation of greater amounts of fixed carbon represents an important sink for the gas. According to him, an increase in the biomass of northern temperate forests is the most likely sink to account for the annual atmospheric CO_2 loss for which scientists had previously been unable to assign a cause.

Nitrogenous Pollutants Including Ammonia: The RSC [4] account for this subject matter is very good. For them it has been long recognized that majority of plants obtain nitrogen through root absorption of the inorganic ions – ammonium (NH_4^+) and nitrate (NO_3^-) from the soil solution. But considerably less is known about how plants are adapted to low nitrogen inputs, particularly those growing in sensitive ecosystems such as forests or heathlands and how they react to additional nitrogen deposition from anthropogenic sources, either as gaseous nitrogen compounds (NO, NO_2, NH_3) or from wet deposition in rain or mist (NO_3^- and NH_4^+). According to these scientists, there has been a great deal of emphasis on studies of the impacts of ammonia (NH_3) pollution, amounts of which have risen alarmingly in some countries where farm animal production is very intensive. For the workers, the precise reasons for the toxicity of NH_3 are not fully understood, but are likely that the protons released when NH_3 assimilation becomes intensive can cause cellular acidosis. They also report evidence that uptake of excess N into leaves can cause mineral nutrient imbalances in plants.

CONCLUSIONS

The role of carbon monoxide, carbon dioxide, nitrogen dioxide and ammonia on environmental and human health are alarming. This study is part of global searches towards sources of these pollutants in the environment. It has established that power generating sets, that are common in power epileptic developing countries like Nigeria; contribute to sources of carbon monoxide, carbon dioxide, nitrogen dioxide, but that of ammonia; even though positively correlated with number of power generating sets is still not clear on their major sources in the environment of study. From literature, it can be confirmed that fuel-wood, charcoal, kerosene stove, gas stoves, coal stoves, biomass stove are major sources of CO, CO_2, NO_2 but NH_3 is attributed majorly to livestock enterprises. In the current work, the sources can either be power generating sets, automobiles, sewage system, domestic wastes littered everywhere; while that of ammonia can be from animal rearing, as some Fulani herdmen also have their livestock within these territories and agricultural activities that make use of urea, sulphate of ammonia, NPK fertilizers as applicable in most of the urban farms and that of Onuebonyi (the control), may also have contributed to the gases emitted to the atmosphere. At Onuebonyi is also located a fertilizer blending factory that may also account for most of these gases; even though their values were still less than that of the city business centers; thus confirming the effects of power generating sets and automobiles in particular. Nevertheless, their levels cannot be compromised in Abakaliki Environment in view of a population of over 300,000 people, power generating sets of over 70,000 within a land space of 16 km^2 (1600 hectares).

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