





Review Article

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Electricity Generator Emission and Its Impacts on Air Quality to the Environment

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ARTICLE INFORMATION

Received: 12 March 2023

Received in revised: 12 April 2023

Accepted: 15 April 2023

Available online: 11 May 2023

Manuscript ID: [AJGC-2303-1378](#)

Checked for Plagiarism: [Yes](#)

Language Editor:

[Dr. Fatimah Ramezani](#)

Editor who approved publication:

[Dr. Sobhan Rezayati](#)

DOI: [10.22034/ajgc.2023.389544.1378](#)

ABSTRACT

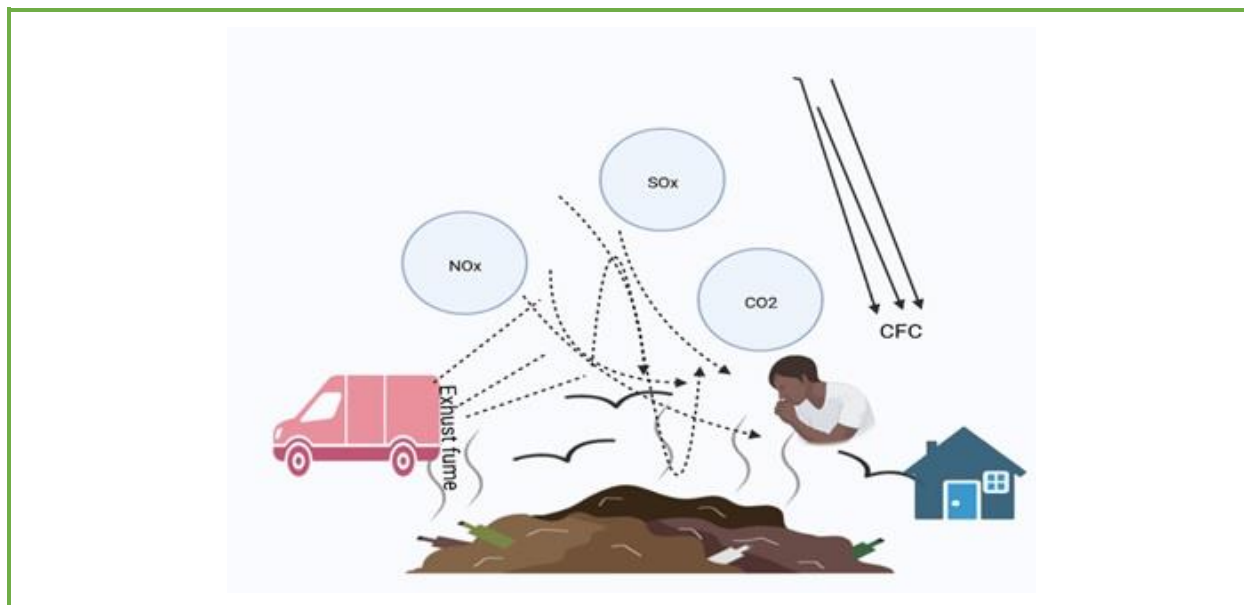
Electricity generator emission is a silent and rampant epidemic due to its chemical constituents which are known to be toxic and carcinogenic to humans. Reports of death through electricity fume and other environmental pollutants have indeed become almost a daily staple in our country, Nigeria. The unreliable and epileptic power supply by the electric power companies has made many people rely heavily on power-generating sets of all kinds with dire implications. Air quality assessment needs to be carried out in both cities and rural areas to make the environment free from toxic contaminants. This work reviews the electricity generator emission and its impacts on air quality to the environment which has caused a growing number of deaths through inhalation of toxic contaminants from the electricity generator.

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KEYWORDS

Exposure
Generator
Fumes
Emission
Pollution

Graphical Abstract



Introduction

It is of immense good to look into the impacts of air quality most importantly in urban areas. Researchers have done extensively well in water quality assessment both in urban and rural areas. There is a need to extend the same to environmental air quality to make the environment free from toxic air contamination. Many researchers have worked for the air quality within the environment and it is the strong proof that some premature deaths, as well as respiratory and cardiovascular diseases suffered by humans, were the result of environmental air contaminants [1]. According to the World Health Organization (WHO) estimation in 2012, 11.6% of the deaths in the world were attributed to the intake of outdoor and indoor air pollution. The representative of deaths per year was estimated to be 6.5 million of which 3 million deaths were attributed to the ambient air pollution. With these figures estimated above, there is an urgent need to properly sanitize the environment via air pollution eradication. In accordance with WHO

in 2016 [2], a total of 88% of these deaths occurred in low and middle-income countries. The Organization for Economic Co-operation and Development (OECD) Center declared that over 700,000 untimely deaths have been related to air pollutants in Africa in 2013 [3]. In the major cities of the World such as Europe, Asia, and America, several studies have been carried out. However, all these studies were pointing out the necessary actions to be taken to reduce and mitigate the emission of these pollutants into the environment. From the review of Kampa and Casanas [4], anthropogenic activities were the main culprits of gaseous and particulate pollutants emission into the air. Very few studies on air pollution have been carried out within the African continent. This is particularly true for the Western African region [5].

An air quality monitoring network does not exist in Nigeria and if it does exist very few do. Many scholars have recorded that air pollution causes more premature deaths per year than either unsafe drinking water or malnutrition [3]. Most of the economic activities in Nigeria

such as industries, trade, and transportation are mainly concentrated in the cities giving rise to high environmental pollution. The reasons the industrialist or the traders move to the urban areas to establish their business is not farfetched. This is because urban areas have road networks, and electricity is better off and more populated. As the population of the city increases the more the customer that patronizes traders increase due to the epileptic power supply by the Electricity Power Distribution Companies (EDC) of Nigeria. 98 % of the traders have their own means of generating electricity which in turn causes nuisance and air pollution in the environment. The exhaust fume has been reviewed by so many scholars to contain toxic chemicals such as oxides of nitrogen (NO_x), oxides of sulfur (SO_x), oxides of carbon (CO_x), and Polycyclic Aromatic Hydrocarbons (PAHs) [6]. These chemicals are mentioned to be toxic and carcinogenic to humans on ingestion/inhalation. Economic activities are associated with rapid economic growth, strong urbanization, and the uncontrolled expansion of cities causing increasingly significant anthropogenic emissions of gaseous and particulate pollutants. These cause deterioration of air quality, which may alter the health of the populace and could cause serious damage to the ecosystem [7].

The health implications of exposure to high concentrations of oxides of sulphur (NO_x) include, but are not limited to the following: Difficulty in breathing, respiratory illness, alteration of pulmonary defense, and aggravation of the existing cardiovascular disease. According to Paerl *et al.* [8], oxides of nitrogen (NO_x) contribute to eutrophication in coastal water. Eutrophication occurs when the body of water lacks nutrients which lead to an insufficient amount of oxygen in the water causing the fish and other aquatic animals to

die. Symptoms include headache, vomiting, dizziness, nausea, fatigue, a feeling of weakness, and an effect on breathing [9]. It can also cause a serious adverse effect on the fetus of a pregnant woman through inhalation [10]. Oxides of carbon are primarily generated through the burning of fossil fuels, wood, and coal by industries. This leads to the release of CO₂ and CO into the atmosphere which CO₂ is the major culprit to global warming. Global warming is a phenomenon brought about by the increase in global temperature mainly due to burning fossil fuels and other energy sources which release greenhouse gases like CO₂, N₂O, CH₄, NO_x, SO_x, etc. Higher energy UV radiation from the sun strikes the earth's surface and is reflected back as lower energy infrared (IR) radiation. The greenhouse gases trap this radiation on Earth and this in turn results in a climatic change with significant consequences to humans, animals, and plants. On the other hand, CO is colorless, odorless, and tasteless but highly toxic. It combines with hemoglobin to produce carboxy-hemoglobin which takes up the space in the hemoglobin that normally carries oxygen and makes it ineffective for delivering oxygen to the body tissues. Tikuisis *et al.* stated that CO concentration as low as 667 ppm can cause up to 50 % of the body's hemoglobin to be converted into carboxy-hemoglobin [11]. 50 % level of carboxy-hemoglobin may lead to seizure, Coma, and fatality in human and animals.

Production and impacts of some constituents of electricity generator emission

Evaporative emission

This produces hydrocarbon pollutants which escape into the air. Petrol evaporation increases as the temperature rises during the day, heating the fuel tank, and releasing petrol vapor. Venting of petrol vapors during the

refueling of tanks is a major source of evaporative emission.

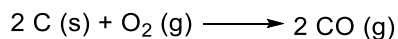
Exhaust emission

I. Particulates: Some particulates are formed during combustion while others are formed in the atmosphere by reactions between the pollutants found in generator exhaust. Particulates contain substances including metals, acids, carbon, and polycyclic aromatic hydrocarbons. Diesel engines emit far greater amounts of particulates compared to petrol engines. Increased amounts of fine particulate matter in the air do contribute to heart and lung problems including asthma and bronchitis [12].

II. Hydrocarbons: These are released when petrol molecules do not burn or burn partially. They react in the presence of NO_x and sunlight to form ground-level ozone (O₃) which is a major component of smog. Ozone is an eye and respiratory system irritant that damages the lungs. Some exhaust hydrocarbons are potentially carcinogenic.

III. Carbon Monoxide (CO): The major industrial source of CO includes producer gas and water gas. Producer gas is formed by the combustion of carbon (coke) in the air at high temperatures. Water gas, which is a mixture of hydrogen and carbon dioxide, is produced via the endothermic reaction of steam and carbon.

Another significant way of producing CO is by direct oxidation of carbon in a short supply of air or oxygen.



CO is conveniently produced in the laboratory by the dehydration of formic acid or oxalic acid with concentrated sulphuric acid. Burning fossil fuels in a limited supply of air or oxygen which occurs in an electricity generator engine produces CO which is lethal for humans upon

inhalation under conditions of insufficient ventilation. Carbon monoxide (CO) is tasteless, odorless, and colorless, but extremely toxic on inhalation. It combines with hemoglobin to produce carboxy-hemoglobin which usurps the space in hemoglobin that normally carries oxygen and makes it ineffective for delivering oxygen to the body tissues. Most symptoms of carbon monoxide poisoning may resemble other types of poisoning resulting from the same mixture of a chemical constituent from exhaust fumes such as NO_x, CO₂, SO₂, and PAHs.

IV. Carbon dioxide (CO₂): Water gas is a major industrial source of CO₂. It is also produced by burning fossil fuels, wood, and coal by industries, vehicles, electricity generators, etc. This leads to the CO₂ release into the atmosphere which is a major source of global warming.

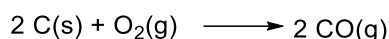
Global warming is a phenomenon brought about by the increase in global temperature mainly due to burning fossil fuel and other energy sources which releases greenhouse gases (GHGs) like CO₂, N₂O, CH₄, NO_x, Sox, etc. Higher energy UV radiation from the sun strikes the earth's surface and is reflected back as lower energy infrared (IR) radiation. GHGs trap this radiant energy which would have escaped into the outer space. This makes warming or the increase of temperatures on earth, and in turn results in the change of climate with significant consequences for humans, animals, and plants. However, climate change does not mean that each part of the world will experience a warm or cold climate. According to Shah [13], as the earth gets warmer, weather patterns change globally at all times of the year leading to increase cold, increase rains, drought, hurricanes, and other extremes in different areas of the world. Thus, the impacts of climate change include:

- i. Rapid change in global temperature leads to heat waves.
- ii. Extreme weather patterns lead

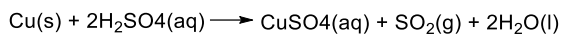
to tsunamis and extreme winter. iii. Impacts on different ecosystems lead to the loss of some species. iv. Rising sea levels leads to the loss of some coastal areas. v. Decrease in food production as a result of drought and floods.

CO₂ is also one of the oxides causing acid rain which negatively affects terrestrial and aquatic animals by increasing the acidity of the environment.

V. Sulphur Dioxide (SO₂): SO₂ is produced industrially by burning sulphur in oxygen or air.

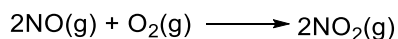


SO₂ can be prepared or produced in the laboratory by heating concentrated sulphuric acid with copper turnings.

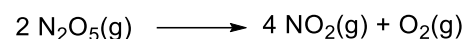
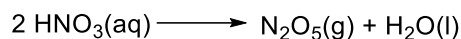


The major health concern with exposure to the high concentration of SO₂ includes difficulty in breathing, illness related to respiratory, alteration in pulmonary defense, and aggravation of the existing cardiovascular disease. Children, the elderly and people with asthma, and cardiovascular and chronic lung diseases such as bronchitis or emphysema are most susceptible to the adverse health effects with exposure to SO₂. It is also one of the oxides that cause acid rain.

VI. Nitrogen Dioxide (NO₂): Nitrogen dioxide (NO₂) can be produced industrially via the oxidation of nitrous oxide by oxygen in the air.



In the laboratory, NO₂ can be prepared in a two-step procedure where dehydration of nitric acid produces dinitrogen pentoxide which subsequently undergoes thermal decomposition.



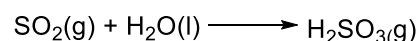
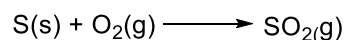
Nitrogen dioxide irritates lungs and lowers resistance to respiratory infections such as influenza. Frequent exposure to concentrations that are typically much higher than those normally formed in the ambient air may cause an increased incidence of acute respiratory illness in children. NO₂ contributes significantly to acid rain formation and eutrophication in the water body [8]. The general symptoms associated with gases ingestion from electricity generator fumes include headache, nausea, vomiting, dizziness, fatigue, the feeling of weakness, respiratory illness, effect on breathing, confusion, disorientation, visual disturbance, and so forth [10]. Furthermore, exhaust emissions have a severe adverse effect on the fetus of a pregnant woman [9].

Acid rain

Acid rain is rain or other forms of precipitation produced when acidic pollutants such as CO₂, NO_x, and SO₂ mix with moisture in the air to form an acid which then falls to earth as rain, snow, or fog. Burning fuels releases acidic pollutants carried far from their sources by the wind.

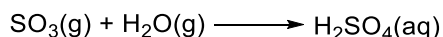
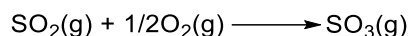
Formation of acid rain and its chemistry

SO₂ produced from the combustion of fossil fuels combines with water to form trioxosulphate (iv) acid.

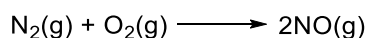


SO₂ is not readily oxidized to sulphur trioxide in dry clean air, but water droplets and dust particulate can catalyze the reaction

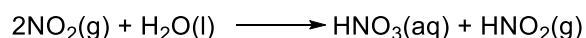
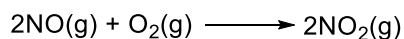
between O_2 and SO_2 in the air producing sulphur trioxide which dissolves in water to produce tetraoxosulphate (vi) acid which is much stronger acid that causes damages to buildings, vegetation, and fish population by destroying fish eggs.



Nitrogen combines with oxygen to form nitrogen monoxide at a high temperature of about $1300\text{ }^\circ\text{C}$ achieved by an internal combustion engine and lightning in the atmosphere.



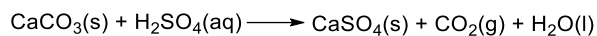
The nitrogen monoxide slowly combines with oxygen to form soluble nitrogen dioxide which readily dissolves in water producing a mixture of nitric and nitrous acids.



Effects of acid rain

Acid rain leads to a pH decrease in water bodies which is directly toxic to fish and other aquatic organisms. Some types of plants and animals are able to tolerate acidic water, but others are acid sensitive and will die if pH declines less than 4. This impacts human populations by creating a risk of consuming contaminated fish, reducing fish availability, and causing an economic impact on people such as fishermen who rely on them for their economic well-being. Acid rain also affects buildings and statues mainly those made of rocks, such as limestone and marble containing the large amounts of calcium carbonate. Acids in

the rain react with the calcium compounds in the stones to create gypsum, which then flakes off.



The effects of this are commonly seen on statues, buildings, and old gravestones, where acid rain can cause the inscriptions to become completely illegible. In addition, acid rain increases the corrosion rate of metals, in particular iron, steel, copper, and bronze.

Volatile organic compounds (VOCs)

VOCs are known to be outdoor air pollutants. It is either methane (CH_4) or non-methane VOCs. CH_4 is a greenhouse gas which enhances global warming. The non-methane VOCs include benzene, toluene, and xylene. They are further referred to as aromatic non-methane VOCs. The aromatic non-methane VOCs are suspected to be carcinogenic and may lead to leukaemia with prolonged exposure.

Particulate matter (PM)

PM is a suspended tiny particle of solid or liquid in a gas. The combination of particles and gases is generally referred to as aerosol. We have anthropogenic aerosol and naturally occurring aerosol. The naturally occurring aerosol comes from volcanoes, dust storms, forest and grassland fires, sea spray, and living vegetation. The anthropogenic aerosol (human activities) includes the burning of fossil fuels, power plants, and various industrial processes. PM either natural or anthropogenic causes health hazards such as heart diseases, lung cancer, and respiratory infection [14].

Chlorofluorocarbon (CFC)

These are gases released from refrigerators, aerosol spray, air conditioners, etc. Whenever

CFCs are released into the air, they rise to the stratosphere. Here they come in contact with other gases and damage the ozone layer. This allows the UV rays from the sun to reach the earth's surface causing damage to the human skin, eyes, plants, and animals.

Ammonia

This is mainly emitted by agricultural waste. Ammonia is a compound having the formula of NH_3 . It is a gas with a characteristic pungent smell and contributes immensely to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia either directly or indirectly is a building block for the pharmaceuticals synthesis. Apart from its wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulphur to form the secondary particles [15].

Odor

Smells coming from garbage, sewage, and industrial processes are very dangerous to humans on inhalation.

Radioactive pollutants (RP)

RP are pollutants produced as a result of a nuclear explosion, nuclear events, war explosions, and natural processes such as the radioactive decay of radon.

Conclusion

Electricity generator fume and its related pollutants are silent killers and many people exposed to electricity generator emissions do not take the necessary precautions. It is recommended that awareness should be created on the environmental impact of electricity generator fumes because it is the

major source of environmental pollution. Electricity Generator House (EGH) should be far from the living house with enough ventilation. Government should have a policy on the importation, sale, use, and disposal of electricity generators since it is the major culprit to environmental contamination. Emission limits for oil and gas companies regarding gas flaring should be further enforced by the government. Researchers are also recommended to work more on environmental quality monitoring through the evaluation of electricity generator fumes and other pollutants to make the environment friendly and free from toxicity.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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How to cite this manuscript: Ogbuewu Ifeanyi, J.C. Nnaji. Electricity Generator Emission and Its Impacts on Air Quality to the Environmen. *Asian Journal of Green Chemistry*, 7(2) 2023, 132-139. DOI:10.22034/ajgc.2023.389544.1378