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MAJOR ATMOSPHERIC GASES: A SYNOPSIS OF THEIR SOURCES, IMPORTANCE, EFFECTS AND MANAGEMENT

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Abstract

This paper looked at major gases present in the earth's atmosphere. Relevant literatures and internets were consulted to carry out the study. The atmospheric gases were discussed in relation to their sources, importance, effect on humans, animal, plants and environment and their sustainable management. Despite the importance and usefulness of these gases to humanity and eco-system, they still pose serious problems to the environment as a result of human activities that lead to the increase in quantity of these gases in the earth atmosphere. Sustainable management strategies for these gases suggested include avoidance of the consumption of gases dangerous to ozone, minimizing the use of cars through the use of urban mass transit, growing of more trees and plants, use of smokeless sources of energy like solar energy, and biogas, reduction of waste through recycling and composting, capturing of gas flaring among others.

Keyword: Atmospheric gases, Sources, Management.

Introduction

The atmospheric gases are gases located in the Earth's atmosphere and they are held to the earth by force of gravity. The most important of which are nitrogen, oxygen, argon, carbon dioxide, ozone and water vapour. Other gases occur in very small proportions and they include neon, kryton, helium, methane, hydrogen etc. Nitrogen, oxygen and argon are constant in amount but carbon dioxide, ozone and water vapour vary in amount both spatially and temporary (Ayoade, 2004). The table below shows major atmospheric gases and their percentage composition in the dry air.

Gas	Percentage by volume
Nitrogen (N_2)	78.08
Oxygen (O_2)	20.94
Argon (Ar)	0.93
Carbon dioxide (Co_2)	0.03 (variable)
Neon (Ne)	0.0018
Helium (He)	0.0005
Hydrogen	0.00005
Ozone (O_3)	Trace
Krypton (Kr)	Trace
Xenon (Xe)	Trace
Methane (Me)	Trace

Adapted from Ayoade (2004)

Three-fourths of all air resides in the troposphere which is the lowest layer of the atmosphere. The troposphere also contains water in all three phases (liquid, solid and gas) as well as solid particles called aerosols. It is therefore the layer where weather phenomena and turbulence are most marked and has aptly been described as the weather-making layer of the atmosphere (Ayoade 2004). For these reasons, it is of most direct importance to man. Within the troposphere, temperature decreases with height at an average rate of 6.5°C per kilometer.

Sources of Atmospheric Gases

Natural sources of Nitrogen include volcanoes, oceans, biological decay, and lightning strikes. Human activities add another 24million tons of nitrogen oxides to our atmosphere annually. Both Nitrogen and Nitrogen oxides are formed during high temperature combustion in the atmosphere, when oxygen combines with nitrogen. Volatile organic nitrogen compounds are released to the atmosphere during plant decay. Industrial Emissions and fossil fuel combustion contribute gaseous nitrous oxide and nitrate as nitric acid from sources sometimes hundreds of miles distant. Atmospheric nitrogen is delivered to sea and land in rainfall as dissolved compounds ('wet' deposition). Coastal fogs are another source of Nitrogen (Heba, 2020). All of Earth's oxygen does not come from trees, rather, the atmospheric oxygen that we depend on as humans come predominantly from the ocean. More than half of the world's oxygen is produced via phytoplankton photosynthesis. Phytoplankton are one-celled plants that live at the ocean surface. According to John (2004) about 70% of the oxygen in the atmosphere comes from marine plants and plant-like organisms. Forests are responsible for roughly one-third (28%) of the Earth's oxygen. The remaining 2 percent of Earth's oxygen comes from other sources. Ozone on the other hand is formed in the atmosphere through chemical reactions between pollutants emitted from vehicles, factories and other industrial sources, fossil fuels, combustion, consumer products, evaporation of a paints, and many other sources, Hydrocarbons and nitrogen oxide gases react in the presence of sunlight to form ozone. Hot, sunny, and calm weather promotes ozone formation (CARB, 2020). The formation of ozone can occur both near the ground and high in the atmosphere. Most of the ozone that is found near the ground comes from vehicle exhaust and emissions from factories, power plants and refineries.

Argon is industrially extracted from liquid air in a cryogenic air separation unit by means of fractional distillation. When nitrogen gas present in the atmosphere is heated using hot calcium or magnesium, a nitride is formed leaving behind small amount of argon as an impurity. It can also be obtained as a by-product while purifying natural gas (Thomas, 2012). Argon is an odourless, tasteless and colourless inert gas. Atmospheric carbon dioxide comes from two primary sources- natural and human activities. Natural sources of carbon dioxide include most animals, which exhale carbon dioxide as a waste product. Human activities that lead to carbon dioxide emissions come primarily from energy production, including burning coal, oil, or natural gas and deforestation (CO_2 Human Emissions, 2017). The main source of water vapour in the atmosphere is the process of evaporation and transpiration. Water vapour is the ultimate source of all forms of condensation and precipitation. Water vapour enters the atmosphere primarily by the evaporation of water from the Earth's surface, both land and sea. About 90 percent of water in the atmosphere is produced by evaporation from water bodies, while the other 10, percent comes from transpiration from plants (USGS, 2019). On earth, helium is relatively rare- 5.2ppm by volume in the atmosphere. Most-terrestrial helium present today is created by the natural radioactive decay of heavy radioactive elements such as uranium and thorium. The alpha particles emitted by such decays consist of helium-4 nuclei. Some of this helium find its way to the surface and enters the atmosphere, where it quickly rises and escapes into space. The rest becomes trapped under impermeable layers of rock and mixes with the natural gases that form there.

Krypton is a rare atmospheric gas and as such is non-toxic and chemically inert. Although traces are present in meteorites and minerals, krypton is more plentiful in Earth's atmosphere, which contains 1.14 parts per million by volume of krypton. Molecular hydrogen is a natural component of our atmosphere due to the breakdown of formaldehyde, but it is also a byproduct of fossil fuel combustion, especially from automobile exhaust and biomass burning. It is also found in the sun and most of the stars, and the planet Jupiter is composed mostly of hydrogen. On earth, hydrogen is found in the greatest quantities as water. It is present as a gas in the atmosphere only in tiny amounts - less than 1 part per million by volume. Methane gas is emitted from a variety of anthropogenic (human influenced) and natural sources. Anthropogenic emission sources include landfills, oil and natural gas flaring, agricultural activities, coal mining, stationary and mobile combustion, waste water treatment and certain industrial processes while natural sources include decay of plant material in wetlands, the seepage of gas from underground deposits, termites, oceans, volcanoes e.t.c. Although neon is a rare gas in the Earth's atmosphere (about 0.0018 percent by mass), it is the fifth most abundant element in the universe (one part per 750), where it is produced during alpha process in stars. The sole source of neon is from extraction from liquefied air. It is produced from air in cryogenic air separation plants (Wikipedia, 2022). Xenon is present in the atmosphere at a concentration of 0.086 parts per million by volume. It can be found in the gases that evolve from certain mineral springs. It is obtained commercially by extraction from liquid air.

Importance of Atmospheric Gases

The plants are the main users of nitrogen gas in the soil, they can take in the nitrates through their root system, the nitrates are used in the organic compound that let the plant survive. Nitrogen gas contributes in the composition of all living tissues of living organisms, and it is used as a biological nitrogen source by a certain bacteria. Nitrogen gas exists in the legumes (such as the clover, the peas, and the soya bean) that contain the protein, where their roots contain the nodular bacteria that takes the atmospheric nitrogen and converts it into the protein. Nitrogen gas is a very important gas as it forms the protein substances that build up the body of all the living organisms, it exists in all the protein substances as it is the main component of protein (Heba, 2020). Some forms of Nitrogen fixing bacteria are able to bind the Nitrogen gas into Nitrates (No_3^{-1}) and Nitrites (No_2^{-1}). These molecules can be further processed into amino acids necessary for proteins and DNA. The nitrates and nitrites are needed by plants to grow and produce the nitrogen molecules used by animals (David, 2017). For animals, breathing is the most important use of oxygen and in terms of physiology, our respiratory system and circulatory system carries oxygen to our cells and organs. Oxygen is essential for respiration because the body uses it to 'burn' food molecules. Oxygen is necessary in combustion, without oxygen, burning cannot take place. It is also used as fuel along with hydrogen in space programs. Earth reminder (2020) posited that oxygen is an indispensable part of our life. Decomposers need a preferable amount of oxygen to carry out the process of decaying the waste material. This, oxygen helps in the process of decomposition. Ozone as earlier stated occurs both in the Earth's upper atmosphere and at ground level. It can be good or bad, depending on where it is found. It forms a protective layer that shields us from the sun's harmful ultraviolet rays. This beneficial ozone has been partially destroyed by manmade chemicals, causing what is sometimes called a "hole in the ozone" (EPA, 2021).

The major application of argon include; electric lamps as filter gas, welding purpose, discharge tubes and argon lasers and argon - dye lasers. Carbon dioxide is used as a refrigerant, in fire extinguisher for inflating life rafts and life jackets, blasting coal, foaming rubber and plastics, promoting the growth of plants in greenhouses, immobilizing animals before slaughter, and in carbonated beverages (Encyclopedia Britannica, 2020). Plants also use carbon dioxide during photosynthesis processes. Presence of water vapour in the air determines the climatic conditions. It also produced snow, fog, mist, hails and other phenomena, depending upon the temperature. Its presence controls the rate of evaporation and transpiration from plants and animals. The presence of water vapour is very essential for the growth of plants. It is also very essential for the health and comfort of animals. Helium is used as an inert-gas atmosphere for welding metals such as aluminium; in rocket propulsion (to pressurize fuel tanks, especially those for liquid hydrogen, because only helium is still a gas at liquid-hydrogen temperature). In meteorology (as a lifting gas for instrument-carrying balloons); in cryogenics (as a coolant because liquid helium is the coldest substance); and in high-pressure breathing operations (mixed with oxygen, as in Cuba diving and caisson work, especially because of its low solubility in the bloodstream) Encyclopedia Britannica (2020). Krypton is used in certain electric and fluorescent lamps and in a flash lamp employed in high speed photography. Radioactive krypton-85 is useful for detecting leaks in sealed containers, with the escaping atoms detected by means of their radiation. In addition, hydrogen is essential to our life. It fuels the sun, which converts hundreds of million tons of hydrogen into helium every second. And two hydrogen atoms are attached to one oxygen atom to make water. These make our planet habitable. Hydrogen is also used in industrial processes, for exploring outer space, for production of electricity, use in automobile industries.

Methane is used primarily as fuel to make heat and light. It is used as cooking gas because it produces more energy per unit weight in comparison to oil and coal. Neon is used in vacuum tubes, high-voltage indicators, lightning arresters, wave meter tubes, television tubes and helium-neon lasers. Liquefied neon is commercially used as a cryogenic refrigerant in applications not requiring the lower temperature range attainable with more extreme liquid-helium refrigeration (Wikipedia, 2022). Xenon is used in the manufacturing of headlamp and ion drive engines. Xenon is used for photographic flash lamps, bactericidal lamps (because it produces ultraviolet light), various lasers, moderate nuclear reactions, and motion picture projectors. Xenon can also be used as a general anesthetic gas (Heimenstine, 2019) (Gorski, 2014) asserted that Xenon might improve athletic performance in endurance sports. The gas may also erase traumatic memories. The element also has a number of well-established users, from acting as a neutron absorber in nuclear reactions to applications in astronomy research and anesthesia.

Effects of Atmospheric Gases

Excesses nitrogen in the atmosphere can produce pollutants such as ammonia and ozone which can impair our ability to breathe, limit visibility and alter plant growth. When excess nitrogen comes back to earth from the atmosphere, it can harm the health of forests, soils and water ways. Windevries (2021) asserted that nitrogen oxide has adverse effects on the growth of natural vegetation and agricultural crop yield in high concentration areas. WHO (2013) pointed that, there is direct effects of nitrogen dioxide (NO_2) on human health. Several studies, published since 2004 as reviewed by the WHO (2013) have documented association between NO_2exposure and hospital admissions with respiratory symptoms and mortality. Side effects of oxygen in oxygen therapy include a dry or bloody nose, tiredness and morning headaches. Oxygen also poses a fire risk, so one should never smoke or use flammable materials when using oxygen. Symptoms of oxygen toxicity also include, chest pain, trouble breathing, muscle twitching in face and hands. Severe cases of oxygen toxicity can lead to cell damage and death. Breathing ground-level ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ozone also can reduce lung function and inflame the lining of lung tissue. Repeated exposure may permanently scar lung tissue. When ozone layer is depleted, it exposes human to harmful ultraviolet radiation which result in serious health issues such as skin diseases, cancer, sunburns, cataract, quick ageing and weak immune system. On the environment, the effects of ozone on individual plants can have negative impacts on ecosystems, including loss of species diversity (less variety of plants, animals, insects and fish) changes to the specific assortment of plants present in a forest as well as changes in habitat quality.

Argon on the other hand when contact with eyes may cause burns or frostbite. When inhaled may cause dizziness, vomiting, rapid breathing, headaches, unconsciousness. During welding, if there is no enough ventilation, toxic fumes of argon can be much stronger, it can displace the oxygen and kill. While carbon dioxide exposure has several benefits to plant and human life, too much carbon dioxide can affect human health negatively. That includes dizziness, headaches, restlessness, difficulty in breathing, tiredness, convulsion, elevate blood pressure and increased heart rate. An increase in the atmospheric carbon dioxide levels can also result in more devastating effects to the environment. An increase in atmospheric carbon dioxide causes climate change. The more carbon dioxide is trapped in the atmosphere, the more heat will be trapped in the environment that contributes to the rise in global temperatures and influences climate change. That results in extreme weather events like wildfires, tropical storms, heat waves and severe-drought, negatively affecting crop production and disrupting the animals' natural habitats (Emilie, 2021). Direct skin contact with Neon can cause frostbite. High exposure can cause fatigue, vision disturbance, headache, confusion, dizziness and suffocation from lack of oxygen. Exposure to Neon is dangerous because it can replace oxygen and lead to suffocation. Neon as a rare atmospheric gas is non-toxic and chemically inert, as a result, it poses no threat to the environment and can have no impacts at all because it is chemically unreactive and forms no compounds. Exposure to high levels of helium can cause headache, dizziness, and lightheadedness. Very high levels can cause passing out and even death due to suffocation from lack of oxygen. Contact with liquid helium can cause frostbite. Weatherspoon (2020) posited that inhaling helium can be dangerous and deadly because, when you inhale helium, it displaces oxygen. This means that as you inhale, your body is only getting helium. High concentrations of hydrogen gas can cause an oxygen-deficient environment. Individuals breathing such as atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting and depression of all the senses. The skin of a victim may have a blue colour. Under some circumstances, death may occur. Also, pre-existing respiratory conditions may be aggravated by over exposure to hydrogen. Krypton gas is inert and is classified as a simple asphyxiant. Inhalation in excessive concentrations can result in dizziness, nausea, vomiting, loss of consciousness, and death. Death may result from errors in judgement, confusion, or loss of consciousness which prevent self-rescue. Exposure of krypton container to prolonged heat or fire may cause it to rupture violently and rocket. While xenon itself is not toxic, its compounds are strong oxidizing agents that are highly toxic. Many compounds of xenon are created principally with fluorine or oxygen. Both oxides, xenon trioxide (XeO_3) and xenon tetroxide (XeO_4) are highly explosive, (Shaw, 2020). Inhalation of xenon in excessive concentrations can result in dizziness, nausea, vomiting, loss of consciousness, and death. However, High levels of methane gas can reduce the amount of oxygen breathed from the air. This can result in mood changes, slurred speech, vision problems, memory loss, nausea, vomiting, facial flushing and headache. In severe cases, there may be changes in breathing and heart rate, balance problems, numbness and unconsciousness (Nevadanano, 2020).

Sustainable Management of Atmospheric Gases

The purpose of Nitrogen management in agriculture is to increase crop and animal productivity and nitrogen use efficiency, and to decrease nitrogen losses to acceptable levels. Thereby, applying nitrogen fertilizer in the proper amount, at the right time of year and with the right method can significantly reduce how much fertilizer reaches water bodies. Keeping animals and their waste out of stream keeps nitrogen and phosphorus out of the water and protects stream banks. Delvin, Whitney and Lamond (1996) opined that best nitrogen management practices include setting realistic yield goals, soil testing, nitrogen timing, site specific management, nitrification inhibitors, manure management, careful handling and mixing practices and buffer zones. In management of oxygen, procedures should be developed for the safe use and handling of oxygen in all applications. Bulk oxygen supply location must be outside building. Gas should be piped pressure. Extra oxygen cylinders should be stored in well ventilated outdoor location away from flammable and combustible material. Oxygen cylinders must be stored at least 20 feet from all flammable gases or be separated by a non-combustible, fire resistant barrier with at least a half-hour rating. Permanently installed containers must have substantial non-combustible support on firm non-combustible foundations. All fittings for oxygen service must be oil and by grease free to prevent fire or explosion (SLAC, 2013)

Strategies to prevent the formation of tropospheric Ozone are primarily based on methane reductions and cutting the level of atmospheric pollution arising from man-made sources, such as agriculture and fossil fuel production and distribution. Sustainable management of Ozone layer include avoidance of the consumption of gases dangerous to the ozone layer, minimizing the use of cars through the use of urban mass transit, walking and use of bicycles. Cleaning products that are harmful to the environment should not be used and maintenance of air conditioners as their malfunctions cause CFC to escape into the atmosphere. As we know that carbon dioxide is one of the greenhouse gases that cause global warming and unbalanced ecological system, serious efforts should be made to balance the percentage of carbon dioxide in the atmosphere. some of these steps include: Growing more trees and plants, using smokeless sources of energy like solar energy, biogas, direct air capture (DAC) e.t.c. General precautions when handling hydrogen gas is to avoid cracking hydrogen cylinder valves to remove dust or dirt from fittings as this practice (though acceptable for other gases) could result to self-ignition. Hydrogen gas cylinders must be secured in an upright position to avoid being knock over.

Methane emissions from agriculture would likely be reduced if farmers produced more food from plants and less from livestock, or if they switched to more productive cattle herds. When organic materials in landfills and in waste water decompose, it releases methane. Sustainable mitigation strategies include reducing waste that ends up in landfills, such as by recycling and composting, capturing methane gas and burning methane gas which is known as flaring among others.

Conclusion and Recommendation

Major atmospheric gases and their compounds play significant role in the development of science and technology which makes life more easier and better for human race. Because, their discovery and uses contribute immensely to industrial and scientific revolutions. However, in the process of harnessing these gases for the use of man they still pose threat to the well beings of human race. Therefore, efforts need to be intensified by individuals, governments, corporate organisations and international communities to revive mitigating strategies already adopted to minimize the negative effects of these gases.

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