THE ENVIRONMENT AND LUNG DISEASES: Clinical Impact of a dysfunctional ecosystem.

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Abstract

In the face of increased air pollution caused by human activities through massive fossil fuel consumption in automobiles, power plants, industrial processes, together with recent historic forest fires in the Amazon forest of Brazil, California and parts of Australia, the atmospheric environment has become a dangerous biome for human habitation. Cases of respiratory tract infections and lung diseases have attained epidemic proportions. The current case of covid-19 which started since December 2019, has added a new name to the list of severe respiratory diseases and has even attained a pandemic proportion, in terms of global spread and impact. This paper attempted an identification of some of the major air pollutants and their sources (both man-made and natural), their impacts on human health and well-being, as well as, proffer possible solutions for achieving a less-polluted atmosphere. Tree planting, clean energy sources and zero gas flaring were some of the remedies put forward.

KEY WORDS: Atmosphere, Air Pollution, Ecosystem, Respiratory Diseases, Tree Planting

Introduction

"In the beginning, God created the heaven and the earth (Genesis 1:1); And God saw everything He had made, and behold, it was very good (Genesis 1:31)".

The quotation above clearly shows that at creation, the Earth was a perfect place for all organisms to dwell and flourish. Indeed, everything that was created was considered excellent. From the sun, the moon, the stars, the galaxies, the constellations, the asteroids, the comets, the meteoroids and the planets (including the Earth), they all glided in their beauty and splendor round the sun. Of all the heavenly bodies, it is only the Earth, which has a distance of one astronomical unit (1AU) from the sun that is livable. The Earth consists of four spheres: the Geosphere, the Hydrosphere, the Atmosphere and the Biosphere. The Biosphere is the environment of mankind and includes the uppermost geosphere (sial), the hydrosphere and the lower parts of the atmosphere. In ancient times, humans were just consumers of fruits, seeds, vegetables and game. Human population was small and people lived in a primitive manner. The wastes produced were biodegradable and were easily returned into the environment without much pollution. Thus, humans lived very close to the environment and their activities had minimal impact on the environment. The Biosphere provided a complete system in which life on Earth was pleasant. Humans depended on the earth's system to provide oxygen, water, nutrients, energy, food, shelter and other materials that supported life. The relationship between man and his environment was cordial and symbiotic. The environment supplied the needs of man and man returned his waste materials to enrich the environment. However, as human populations grew and technology advanced, the harmony between man and his environment was broken. Consequently, large expanse of forests were cleared for farming, pasture, road construction, airfields, schools, hospitals, parks, playgrounds, and urbanization.

In recent times, man has altered his environment (in ways that are not well understood), and virtually all systems and cycles that together make life possible on earth have been disturbed (Ekpoh, 2002, 2009). From the equatorial rainforest to the polar ice caps, and from the depths of the sea to the outer limits of the stratosphere, there are man-made changes on the biosphere which have either aggravated the natural changes and cycles, or led entirely to the creation of new sets of conditions. For instance, the pre-industrial level of carbon dioxide in the atmosphere was 280 parts per million (ppm), while recent measurement shows that the proportion of carbon dioxide in the atmosphere has increased to 412 ppm, a 47 percent increase from the pre-industrial level (Buis, 2019). Equally, new gases such as chlorofluorocarbons (CF_{11} and CF_{12}) have been added to the atmosphere through industrial processes. Global warming, sea level rise, monster windstorms, historic floods, ozone depletion, air pollution, water pollution, wild forest fires and

desertification are some of the consequences of human actions on the environment. Today, it is a fact that man has fundamentally remade the landscape of every area in the quest for survival on planet earth, and has also made significant in-roads into Space.

The fundamental issue in all these environmental changes and alterations is that large-scale and often novel chemical transformations are involved, together with changes in the natural transfers of materials and energy around the earth. Such transformations and changes often lead to environmental crises that human actions are directly implicated. In the man-environment equation, changes which man imposes upon the physical environment, also impose equally important changes upon the ecosystems which humans depend. An understanding, therefore, of the ecological relationships and degree of stability of natural ecosystems, would enhance a rational use of the physical environment and its resources, and subsequently minimize the incidence of dysfunctional ecosystems, especially the atmospheric ecosystem which is global in nature.

This study will highlight human activities that have contributed to the pollution of the atmospheric biome and render it dysfunctional. Pollutant emissions from industrial processes, power plants, automobile exhausts, waste burning and forest fires have made the earth a less pleasant place to live, due to the preponderance of respiratory and lung diseases. Pollutants do not only impact human health and well-being, but have further reduced the beauty of nature around our cities and settlements. The study will further explore ways of making the atmospheric ecosystem functional, so that the earth can be a better place again.

Definition of Terms

Environment: Environment can be considered as an aggregate of all external conditions and influences that affect the life and development of an organism. In other words, it includes everything which surrounds an organism and affects it.

Ecosystem: A biological community of interacting organisms and their physical environment. It is a system where each component is important because of the interrelationships in an ecosystem.

A Dysfunctional Ecosystem: Ecosystem is supposed to be dynamic and alive, where all the component parts are active. Inactivity or malfunction of component parts due to any kind of intervention, be it human activity or natural event, results in a state of dysfunction. For instance, alteration in species composition can affect both the size and stability of an ecosystem.

Pollution: The presence or introduction into the environment (air, land and water) of a substance which has harmful or poisonous effects. In other words, anything that interferes with human health and well-being, as well as, the heath of the ecosystem.

Health: The World Health Organization (WHO) defines health as a state of complete physical, mental and social well-being of a person.

Disease: A deleterious change in the body's condition in response to an environmental factor that could be nutritional, chemical, biological or psychological.

Lung Diseases: Lung diseases refer to many disorders affecting the lungs, such as asthma, influenza, pneumonia, tuberculosis, lung cancer, chronic obstructive pulmonary disease (COPD), covid-19 (a new disease caused by SARS-COV-2 Virus, whose origin is still controversial, with some people suggesting that it originated from dragon bats), and many other breathing problems.

Types of Ecosystems

The Earth, as the biggest ecosystem, is said to contain over 10 million different species in terms of biodiversity. Ecosystems range in size from very small e.g. a pond, to the whole earth. The Earth is made up of three major components, the Atmosphere (air), the Lithosphere (land), and the Hydrosphere (water). The Atmosphere consists of four vertical layers, troposphere, stratosphere, mesosphere and thermosphere. Beyond the thermosphere is space, with zero gravity. The Lithosphere consists of crust, mantle and core. The Hydrosphere consists of streams, rivers, lakes, seas and oceans.

However, in strict ecological sense, there are two broad types of ecosystems in which all other ecosystems are derived: (a) Terrestrial Ecosystems (land-based) and (b) Aquatic Ecosystems (water based). The major types of Terrestrial ecosystems are: forests, grasslands, deserts and tundra. The major types of Aquatic ecosystems are: freshwater and marine.

Characteristics of an Ecosystem

Ecosystem contains the biotic (plants, animals and organisms) and abiotic (rocks, soil, sunlight, heat, water) parts, constituting a community interacting as a system. The life-forms in any given ecosystem is often the product of topography, altitude and climate. For instance, vegetation is sparse in a desert

ecosystem as a result of the temperature extremes and very scanty rainfall. Thus, desert plants such as baobab and cactus are adapted to conserve water. Similarly, desert animals such as camel and addax antelope are adapted to survive in dry conditions.

All ecosystems have a feeding hierarchy called the food chain (and food web), with the sun as the source of energy. In a typical ecosystem, green plants (including algae, lichens and moss) are the primary producers, since they have the capacity to convert atmospheric carbon dioxide (CO_2) and water (H_2O), in the presence of sunlight, to carbohydrate ($C_6H_{12}O_6$), releasing oxygen (O_2) as a by-product (a process called photosynthesis). Herbivores and carnivores serve as consumers in the food chain/food web since they eat what the primary producers produced. Micro-organisms, such as, fungi, worms and bacteria are the decomposers.

A major function of the ecosystem is to keep the component parts running together, through exchange of energy and nutrients in the food chain. In the ecological pyramid (also known as energy pyramid), population at the base is always greater and the pyramid tapers towards the apex. In other words, the primary producers must be greater in number than the primary consumers, and the primary consumers must be greater in number than the secondary consumers, and so on, till it reaches the apex of the pyramid. This is so in order to avoid food crisis in the system. Living organisms within an ecosystem interact in many ways including predation, cooperation, competition and symbiosis. Every species within an ecosystem has a niche. A niche defines the position of a species within an ecosystem. It describes both the range of conditions necessary for the species to survive and the role of the species in the ecosystem.

Nature of the Earth's Atmosphere

The Earth's atmosphere is a unique ecosystem because no other planet in the solar system has an atmosphere with the exact mixture of gases or the heat and moisture conditions necessary to sustain life. Gases make up most of the atmosphere's volume, with dust particles and water droplets suspended in the lower part. The three major gases that make up 99.96 percent of the volume of dry air in the lower atmosphere are: Nitrogen (78.08%), Oxygen (20.95%) and Argon (0.93%) (Fig. 1). The remaining 0.04 percent comprises small amounts of a variety of gases that are often more significant than their proportions suggest (Ekpoh, 2009). Carbon dioxide is the most important member of this group, constituting 0.03 percent of the total volume of dry air. Other minor gases in this group include hydrogen, helium, neon, krypton, xenon, ozone, sulfur dioxide, and methane. New gases, such as chlorofluorocarbons are being added to the atmosphere by human activity. Other constituents of the Earth's atmosphere include particulates and aerosols, e.g. dust, soot and smog.

Fig. 1 Composition of the Earth's Atmosphere

Permanent gases	Percentage (%)	Variable Gases	Percentage (%)
Nitrogen	78.08	Water vapour	0 – 4
Oxygen	20.95	Carbon dioxide	0.038
Argon	0.93	Methane	0.00017
Neon	0.0018	Nitrous oxide	0.00003
Helium	0.0005	Ozone	0.000004
Hydrogen	0.00006	Particles (dust, soot, smog, etc)	0.000001
Xenon	0.000009	Chlorofluorocarbons	0.00000002

Source: Ahrens (2009)

Vertical Structure of the Atmosphere

The atmosphere has four layers; troposphere, stratosphere, mesosphere and thermosphere; but the most important is the troposphere, which is the home of weather and climate, and ranges between 9 to 10 kilometres from the earth's surface. The demarcation of the atmosphere into vertical layers is defined by their temperature behavior and characterized by the reducing concentrations (or density) of the gases away from the earth's surface.

Importance of the Atmosphere

The atmosphere is a delicate life-giving blanket of air that surrounds the earth. In one way or the other, it influences everything we do, since it is intimately connected to our lives. The air we breathe, the type of clothes we wear, the type of house designs, or even the types of crops we cultivate, they all have something to do with the atmosphere.

Ecosystem Disturbance

The Earth's major terrestrial and aquatic ecosystems have been greatly altered by human activities. As shown in Table 2, man has interfered significantly with the different terrestrial ecosystems. For instance, it is estimated that more than half of the Earth's original rainforest has been lost, through clearing for pasture, timber, fuelwood and farming. According to the United Nations Food and Agricultural Organization (FAO), rainforest losses are estimated at more than 50 percent in Africa, more that 40 percent in Asia, and 40 percent in Central and South America (Christopherson, 2003).

Plants are the most visible part of the biotic landscape and they are bona-fide members of the earth's terrestrial ecosystems. In their growth, form and distribution, plants signify the physical systems of the earth in terms of: its energy pattern; atmospheric composition; temperature and winds; air masses, water quantity, quality and seasonal timing; soils; regional climates; geomorphic

processes; and ecosystem dynamics (Christopherson, 2003; Floyd and Ekpoh, 2004).

Like their terrestrial counterpart, aquatic ecosystems are equally important and they influence energy cycles and relationships within the biosphere. Oceans, estuaries and freshwater bodies (rivers, streams, lakes and ponds) are home to aquatic organisms. Aquatic organisms have the same basic needs as their terrestrial counterparts, such as: carbon dioxide, water, and sunlight for photosynthesis; oxygen for respiration; and food and mineral nutrients for energy, growth and maintenance. So, both the terrestrial and aquatic ecosystems enjoy thriving food chains, food webs and energy transfers.

Today, with a world population of about 7.8 billion people (Worldometer, 2020), nearly all parts of the biosphere have been altered in some way by human activity, including even the Polar Regions. Large parcels of pristine forests have been destroyed by human-induced forest fires, releasing tons of obnoxious gases into the atmosphere as pollutants. Many aquatic ecosystems have dried up due to over-exploitation of their water resources for off-channel uses, such as irrigation. Many previously climax vegetation have been significantly modified through bush burning or any other human activity and, changed into a secondary forest.

The conversion of natural habitats to human use is probably the largest single cause of ecosystem disturbance, whereby previously pristine forests are converted to cities, highways, airfields and so on. Pollution is a major factor in ecosystem dysfunction. Whether air pollution, land pollution and water pollution, they all pose serious threat to ecosystem functioning, by damaging or killing organisms that are central to ecosystem balance. The result is a dysfunctional ecosystem once the balance has been altered. Some events and activities that are frequently implicated in ecosystem disturbance include: industrial processes, industrial fumes, automobile fumes, gas flaring and vending, oil spill, deforestation, indiscriminate waste disposal, waste burning, acid rain, ozone depletion, wild forest fires, deliberate bush burning, climate change, historic floods, devastating windstorms, gully erosion and landslides, drought and desertification, volcanic eruption, earthquakes, dust storms, prolonged overgrazing and crop farming. These events and activities will effectively disturb the smooth functioning of the ecosystem through the destruction of habitats and disruption of cycles. Such disturbances and disruptions will then create a dysfunctional ecosystem, be it terrestrial or aquatic.

Fig. 2 Human Disturbance of Natural Ecosystems

Biome	Total Area ($10^6 Km^2$)	% Undisturbed Habitat	% Human Alteration
Temperate Broadleaved Forests	9.5	6.1	81.9
Chaparral and Thorn Scrub	6.6	6.4	67.8
Temperate Grasslands	12.1	27.6	40.4
Temperate Rainforests	4.2	33.0	46.1
Tropical Dry Forests	19.5	30.5	45.9
Mixed Mountain Systems	12.1	29.3	25.6
Mixed Island Systems	3.2	46.6	41.8
Cold Deserts/Semi-Deserts	10.9	45.4	8.5
Warm Deserts/Semi-Deserts	29.2	55.8	12.2
Moist Tropical Rainforests	11.8	63.2	24.9
Tropical Grasslands	4.8	74.0	4.7
Temperate Coniferous Forests	18.8	81.7	11.8
Tundra and Arctic Desert	20.6	99.3	0.3

Source: Adapted from Cunningham and Cunningham, 2002.

Types of Air Pollutants

Air pollutants are airborne substances, which may be solids, liquids or gases that occur in concentrations high enough to threaten the health of humans and animals, or to harm the form and structure of vegetation, or to toxify a given environment, or all of the above (Ahrens, 2009, Ekpoh, 2004). Air pollutants are derived from both natural sources and man-made sources. Example of natural sources include windblown silt (very fine sand) from the earth surface, pollen, volcanic ash and dust, salt spray from ocean water, smoke and soot from wild forest fires (Table 3). Man-made pollutants come from industrial complexes, power plants, homes, office buildings, automobiles (motor vehicles, trains, tramps, etc.), ships, powered balloons and jet aircrafts.

Certain pollutants are called primary air pollutants because they enter the atmosphere directly, for instance, pollutants from industrial smokestacks, home chimneys and exhaust pipes of automobiles. Other pollutants are called secondary air pollutants because they form in the atmosphere only when a chemical reaction occurs between a primary pollutant and some other component of air, such as

water vapour or another pollutant. Pollutants are also categorized on the basis of availability and toxicity, and they are primarily of two kinds: the Conventional Pollutants (widely available), and the Unconventional Pollutant (restricted but very toxic or hazardous). Conventional pollutants include: Sulphur dioxide, Carbon monoxide, Lead, Hydrocarbons, Nitrogen oxides, Photochemical oxidants, and Particulates. The Unconventional Pollutants include: Asbestos, Benzene, Beryllium, Mercury, Polychlorinated biphenyls (PCBs) and Vinyl chloride (largely anthropogenic in origin). Most conventional pollutants are produced primarily from burning of fossil fuel in coal-powered electric plants, cars, trucks and refineries that deal with oil and natural gas.

Pollutants in the Atmosphere: The Cause of a Dysfunctional Ecosystem.

> *"In 1984, Donora was an industrial town of about 14,000 residents, located 50 kilometres south of Pittsburg, Pennsylvania. One large factory in the town manufactured structural steel and wire. A second factory produced zinc and sulphuric acid. During the last week of October 1984, dense fog settled over the town. It was not the normal fog, but a pollutant-laden fog created by the activities of the two industries. After four days of the fog, visibility became so poor that people could not see well enough to drive, even at noon with full headlights. Gradually at first, and then in increasing numbers, residents sought medical attention for nausea, shortness of breath, and constrictions in the throat and chest. Within a week, 20 people had died and about half of the town's population were seriously ill"*

The case of Donora cited above illustrates the situation that we still find today in many industrial cities and urban centres. The earth's atmosphere should compose of nitrogen, oxygen and argon, making up 99.96 percent, with rare gases making the remaining 0.04 percent. However, this is not the case in modern times, as the earth's atmosphere is full of contaminants, such as sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter, volatile organic chemicals, synthetic organic chemicals, and so on, derived largely from human activities. These contaminants are the major culprits in air quality degradation, rendering the atmospheric ecosystem dysfunctional, thereby posing serious threat to human health and well-being (Table 3).

Sulphur dioxide (SO_2): This is a colourless gas that is produced primarily through the burning of sulphur-laden fossil fuels, e.g. coal and petroleum. Sulphur dioxide in the atmosphere oxidizes to form secondary pollutants, such as sulphur trioxide (SO3) and, with water vapour to form sulphuric acid (H_2SO_4), a component of acid rain. These are undesirable atmospheric contaminants. When these contaminants are inhaled into the lungs, they aggravate respiratory problems, e.g. asthma, bronchitis and emphysema. Sulphuric acid is a very corrosive substance that damages plants, animals and physical structures (monuments, tombstones and exposed walls) (Ekpoh and Obia, 2010). Sulphur dioxide and sulphate ions are probably second only to smoking as a primary cause of air-pollution related health damage. In terms of environmental impact, sulphate particles and droplets are known to reduce visibility by 80% in the U.S (Cunningham and Cunningham, 2002). High Sulphur dioxide concentrations have been associated with major air pollution disasters of the type that occurred in Donora, USA. Today, the primary global source of sulphur dioxide pollution include: power plants (especially coal-fired electric generators), heating appliances, smelters, petroleum refineries, and paper mills.

Carbon Monoxide (CO): This is a highly toxic gas produced mainly by incomplete combustion of fuel (coal, oil, charcoal, wood or gas). It is a colourless, odourless, poisonous gas that constitutes a major pollutant of city air, due to its overwhelming proportion among the primary pollutants. The Environmental Protection Agency (EPA) estimates that over 60 million metric tons of carbon monoxide enter the air every year in the United States alone, half of which is caused by motor vehicles (Enger and Smith, 1998). Carbon monoxide is very dangerous in enclosed spaces and, since it cannot be seen or smelled, it often kills without warning. When carbon monoxide is inhaled in large quantities, the brain will be starved of oxygen, leading to headache, fatigue, drowsiness, and even death. Carbon monoxide is created through cigarettes smoking, bush fires, cooking fires and internal combustion engines in transportation. Fortunately, about 90 percent of the carbon monoxide in the air is consumed in photochemical reactions that produce ozone.

Nitrogen Oxides (NOx): Nitrogen is common in living tissue and therefore is found in all fossil fuels. When coal or petroleum is burned, this nitrogen reacts with atmospheric oxygen to form two primary nitrogen pollutants, nitrogen dioxide (NO_2) and nitric oxide (NO), which are simply referred to as oxides of Nitrogen (NOx). These are highly reactive gases that play a lead role in producing ozone and other photochemical smog. Nitrogen oxides combines with water to form nitric acid (HNO_3), a substance that adds to the problem of acid rain. Excess nitrogen in water causes eutrophication of inland waters and coastal seas. It may also encourage the growth of water hyacinth and algae, a development that can block water channels (Ekpoh, 2004; Thompson and Turk, 2005). Nitrogen dioxide is a reddish-brown gas with a strong odour. It has been implicated in the browning and strong odour of some polluted urban atmosphere. High concentrations of nitrogen oxides can cause heart and lung diseases. These pollutants have also been shown to compromise the body's resistance to respiratory infections and

asthma. The primary sources of Nitrogen oxides are automobiles (exhaust pipe emissions), power plants, and waste disposal systems.

Ozone (O_3): Ozone is a noxious substance with an unpleasant odour. Incomplete combustion of petrol in automobile exhaust reacts with nitrogen oxides and atmospheric oxygen in the presence of sunlight to form ozone. The ozone then reacts further with automobile exhaust to form photochemical smog. Ozone plays a double-role in the atmosphere, both beneficial and detrimental. It is a beneficial component of the atmosphere in the stratospheric layer, where it absorbs ultra-violet radiation and protects life on earth. But ozone in the lower troposphere plays a detrimental role in the atmosphere by producing photochemical smog, which is a major air pollutant. Ozone irritates the eyes and the mucous membranes of the respiratory system, aggravating chronic diseases such as asthma, bronchitis, heart disease, and are implicated as possible carcinogens. Even in healthy people, exposure to relatively low concentrations of ozone for six or seven hours during periods of moderate exercise can significantly reduce lung function, accompanied by symptoms such as chest pain, nausea, coughing and pulmonary congestion (Ahrens, 2009).

Toxic Metals and Halogens: Toxic metals are chemical elements of which the principal ones include: lead, mercury, arsenic, nickel, beryllium, cadmium, thallium, uranium, cesium and plutonium. They are derived from mining, and also occur as trace elements in fuels, especially coal. Halogens are reactive non-metallic elements that form strongly acidic compounds; e.g. fluorine, chlorine, bromide and iodine. Halogens and toxic metals are highly reactive, toxic elements which, when concentrated, can damage or even kill organisms in the ecosystem. Most toxic metals and halogens are mined and used in manufacturing. Lead (Pb) and mercury are widespread neurotoxins that damage the nervous system. High environmental levels of lead can cause mental retardation in children. Also, high concentrations of lead in bone and soft tissue can cause brain damage, convulsion and death. Chlorine is a toxic halogen widely used in bleach, plastics and related products. Methyl bromide (a powerful fungicide used in agriculture) and Chlorofluorocarbons are used as propellants and refrigerants in body sprays, air-conditioners and refrigerators, and they are implicated in ozone depletion.

Fig. 3: Some of the Sources of Air Pollutants

Type	Sources	Components	Pollutants
Natural	Volcanic eruptions		Particles (dust, ash), Gases (SO_2, CO_2)
	Forest fires		Smoke, unburned Hydrocarbons, CO_2, NOx, ash.
	Dust storms		Suspended particulate matter
	Ocean waves		Salt particles
	Vegetation		Hydrocarbons (VOCs), pollen
	Hot springs		Sulphur gases (SOx)
Human-induced	Refineries		Hydrocarbons, Sulphur Oxides, (SOx), Carbon Monoxide (CO)
	Power Plants	Coal	Ash, Sulphur Oxides, Nitrogen Oxides (NOx)
		Oil	SOx, NOx, CO
	Paper Mills		Particulate Matter, Sox
	Manufacturing	Sulphuric acid	SO_2, SO_3, and H_2SO_4
		Phosphate fertilizer	Particulate matter, Gaseous fluoride
		Iron and steel mills	Metal oxides, smoke, fumes, dust, organic and inorganic gases
		Plastics	Gaseous resin
		Varnish/ paint	Acrolein, Sulphur compounds
	Automobiles		CO, NOx, hydrocarbons (VOCs), particulate matter
	Home furnaces and fireplaces		CO, particulate matter
	Open burning of refuse		CO, particulate matter

(Adapted from Ahrens, 2009)

Particulate Materials: These are small pieces of solid matter, such as dust, ash, soot, lint, smoke, pollen, spores, algal cells, aerosols, and many other airborne particles. Particulates are often the most visible form of air pollution since they change the colour of air, making it cloudy, with reduced visibility. Particulates also leave dirty deposits on surfaces. Particulates smaller than 2.5 mu-micron are very dangerous to human health because they can damage lung tissues when inhaled during breathing. Asbestos fibres and cigarette smoke are dangerous respirable particles because they are carcinogenic.

Volatile Organic Compounds (VOCs): These are organic gases that evaporate readily and escapes easily into the atmosphere. They include: isoprene (C_5H_8), terpenes ($C_{10}H_{15}$) and methane (CH_4). These gases are derived from refineries, metal extraction from ores, house paints, and pesticides. They are oxidized in the atmosphere to carbon monoxide and carbon dioxide. Carbon monoxide inhibits respiration in humans by binding irreversibly to hemoglobin. Refuse burning is the most common source of dioxin.

Synthetic Organic Chemicals (SOCs): These are dangerous synthetic chemicals, such as: benzene, toluene, formaldehyde, vinyl chloride, phenols, chloroform, and trichloroethylene. They are produced by human activities such as incomplete combustion of fuels in automobiles, power plants and petroleum refineries. Synthetic organic chemicals in the atmosphere produce photochemical oxidants e.g. Ozone.

Indoor Air Pollutants: It is common for people to see air pollution as an outdoor event because of the large number of automobiles on our roads, numerous factories in our cities, big and small power plants, all of which emit countless tons of contaminants into the air. However, studies have shown that indoor air pollution in many homes and offices are 5 to 10 times more severe. For instance, elevated concentrations of synthetic organic chemicals such as chloroform, benzene, carbon tetrachloride, formaldehyde and styrene are more dangerous indoors than outdoors (Ahrens, 2009). Other serious indoor air pollutants include: molds, pathogens and other biohazards. Cigarette smoking constitutes a very disturbing indoor air pollution with respect to public health worldwide. In Africa, Asia and Latin America, organic fuels such as firewood, charcoal, dried dung and agricultural wastes are commonly used as household energy. Under poorly ventilated conditions, cooking fires or room heating with these energy types constitute serious indoor air pollution, especially through smoke inhalation.

Again, the introduction of the pollutants (discussed so far) into the earth's atmosphere has caused serious air pollution in many cities and locations downstream of polluted winds, leading to the creation of dysfunctional atmospheric ecosystems, with severe consequences for respiratory and lung diseases.

Case Studies of Health Impacts of air Pollution
The Nigerian Case:

In 2016, the World Bank reported that 94 percent of the population of Nigeria was exposed to air pollution levels that exceeded the World Health Organization (WHO) limit. It estimated the costs of damage caused by air pollution to Nigerian economy at about 1percent of gross national income (Parke, 2016). In the study, four cities, Onitsha, Kaduna, Aba and Umuahia were shown to have very high particulate matter levels, far above WHO permissible limits. Among the health impacts identified by respondents in the study were: respiratory diseases, such as cough, asthma and lung cancer; cardiovascular diseases; fatigue, headache and anxiety; irritation of the eyes, nose and throat; damage to reproductive organs; harm to the liver, spleen and blood; and nervous system damage (Parke, 2016).

In a recent World Bank study by Kemper and Chaudhuri (2020) on air pollution in Lagos, it was found that illness and premature deaths due to ambient air pollution caused losses of $2.1 billion in 2018, representing about 2.1 percent of Lagos State's gross domestic product (GDP). In terms of human lives, the pollution caused an estimated 11,200 premature deaths. Children under five years of age were the most affected, accounting for 60 percent of total deaths, while adults suffered from heart disease, lung cancer and chronic obstructive pulmonary disease (COPD) (Kemper and Chaudhuri, 2020). Among the pollutants implicated in the 2018 ambient air pollution in Lagos were: nitrogen oxides, sulphur oxides, ozone, air toxics and fine particulate matter of less than 2.5 micrometers. The minute particulates were said to be particularly dangerous since they could pass lung barriers and enter the blood stream, contributing to mortality and morbidity. The major sources of the pollutants included: road transport (including delays caused by traffic hold-ups, preponderance of old vehicles above 15 years, and use of sulphur-laden fuels); emissions from industries; large diesel generators for industries and institutions, waste burning, fuelwood and wood cooking stoves; small private

petrol generators, bush burning for urban agriculture, oil operations, gas flaring.

In an earlier study on the role of gas flaring in the Niger Delta, Ekpoh and Obia (2010) noted that air pollution through gas flaring and vending was alleged to be responsible for various health and environmental problems plaguing the Niger Delta region. Specifically, dry deposition of acidic particulates were responsible for ecosystem poisoning, damage to human health, decimation of aquatic life and the destruction of soil micro-organisms. Still in the Niger Delta, a study by Ana (2011) on air pollution in Eleme and Ahoada East indicated that the respondents blamed contaminated air, resulting from gas flaring, as being responsible for their ill health, especially respiratory disorders.

From the few studies cited above, there is good reason to be worried about air quality in Nigeria, especially as WHO (2016) Environmental Performance Index for Air Quality showed that Nigeria ranked 152nd out of 180 countries.

The 2016 World Health Organization (WHO) Study on Air Pollution Worldwide

In a study that was conducted in 2016, using 4300 cities in 108 countries, the World Health Organization (WHO) arrived at the following findings. (a) That 9 out of 10 people in the world breathe polluted air. (b) Around 7 million people die every year from exposure to fine particles in polluted air that penetrate deep into the lungs and cardiovascular system, causing diseases, such as stroke, heart disease, lung cancer, chronic obstructive pulmonary disease and respiratory infections, including pneumonia. (c) Ambient air pollution alone caused some 4.2 million deaths in 2016, while household air pollution from cooking and polluting fuels and technologies caused 3.8 million deaths in the same period. (d) The study summary submitted that air pollution was a critical risk factor for non-communicable diseases (NCDs), causing an estimated 24% of all adult deaths from heart disease, 25% from stroke, 43% from chronic obstructive pulmonary disease, and 29% from lung cancer (WHO, 2018).

Other examples of the real and potential health impacts of air pollution are listed below:

1. Cunningham and Cunningham (2002) have documented following cases:

(a) United Nations (UN) estimates that at least 1.3 billion people around the world live in areas where the air is dangerously polluted

(b) In the United States, an estimated 430,000 people die each year from cigarette smoking-related diseases such as emphysema, heart attacks, lung cancer and other smoking-complication diseases; and the total cost for smoking related diseases is US$100 billion yearly

© The U.S. Office of Technology Assessment estimates that 250,000 people suffer from pollution-related bronchitis and emphysema in the United States, and some 50,000 excess deaths each year are attributable to these diseases (Cunningham and Cunningham, 2002).

(d) UN estimates that in the highly polluted "black triangle" (i.e. Poland, Hungary, the Czeh Republic and Slovakia), respiratory ailments, cardiovascular diseases and lung cancer are 50% higher than in the cleaner parts of those countries (Cunningham and Cunningham, 2002).

(e) In China, city dwellers are 4 to 6 times more likely to die of lung cancer than village folks due to the level of air pollution in Chinese cities. Also, WHO estimates that 4 million children under age 5 die each year from acute respiratory diseases (Thompson and Turk, 2005).

(f) In Guatemala, the mortality rate among infants due to respiratory diseases (influenza, whooping cough and pneumonia) is estimated to be 1,000 per 100,000 children (Ahrens, 2009).

2. In a fact sheet on air quality and human health impacts, USEPA (2007) noted that respiratory-related diseases ranked top as cause of poor health globally, and their data revealed the following frightening statistics: (a) 6,500 premature deaths (b) 4,000 hospital admission cases for respiratory diseases (c) 3,000 hospital admission cases for cardio-vascular diseases (d) 3,500 asthma attack (e) 2,000 asthma related emergency room visits (f) Reduced lung function growth rate in children [United States Environmental Protection Agency (USEPA), 2007].

3. In another case in Honolulu, elevated temperature due to global warming was implicated in the severe air pollution that led to the prevalence of diseases such as: cough, phlegm, dry/sore throat, sinus congestion, wheezing, bronchitis, emphysema, eye irritation, heart attack, lung cancer, cardiovascular disorders, and death (Hickson, 2000).

4. WHO also estimates that 1% loss of stratospheric ozone could result in about one million extra human skin cancers per year, worldwide (Leaf, 1993).

The Way Forward

Reducing atmospheric pollution and its impacts on human health is not a simple task. It requires that all hands must be on deck. Therefore, response must come from governments, groups, and individuals in order to combat the menace of air pollution. Specifically, the following measures are suggested:

(i) Reduce emissions: Support global efforts to reduce emissions from industries and automobiles, such as international treaties and protocols on gas emissions and environmental sanitation. For instance, the Clean Air Act that was enacted in the United States in 1963 was able to reduce emissions by large proportions. Before the Clean Air Act, most factory smokestacks had no pollution control devices, but after the Act, majority of the industries installed pollution control devices that led to significant reduction or total elimination of emissions.

(ii) Resort to cleaner energy sources, e.g. solar power.

(iii) Install catalytic converters in cars, motor bikes, and other kinds of automobiles.

(iv) Avoid use of Sulphur-laden fuels in cars and motorbikes.

(v) Improve vehicle inspection standards.

(vi) Stop Gas Flaring: According to World Bank recent estimate 2020, Nigeria flares 8 billion cubic meters of gas annually. Between 2012 and 2015 Nigeria made significant progress in reducing gas flaring by 2 billion cubic meters. Such effort should continue so that the country can achieve the Zero Routine Flaring by 2030 Initiative, a global effort to end routine flaring that Nigeria endorsed in 2016 (World Bank, 2016).

(vii) Improve National Power generation and supply, so as to discourage private diesel or petrol generators.

(viii) Encourage afforestation: Reducing air pollution should be everyone's business. Since trees serve as sink for most of the atmospheric pollutants, e.g. carbon dioxide (CO_2), it will be beneficial to have numerous trees, especially in urban environments, to help mop up atmospheric pollutants. Additionally, Nigeria should manage her existing forests sustainably and further pursue massive tree planting throughout the country and, especially in areas of the country that have already been degraded. Deforestation should be discouraged, in particular, bush burning for agriculture and pasture.

(ix) Adopt appropriate waste management methods: Burning of refuse should be discouraged. Open space dumping of refuse should also be discouraged. Modern, environmentally friendly methods of waste management such as recycling and landfills, should be encouraged.

(x) Support healthy lifestyle campaigns, targeting smokers.

(xi) Discourage domestic use of firewood and wood stove for cooking and heating.

(xii) Intensify air pollution monitoring in all cities

Conclusion

Ecosystem dysfunction caused by atmospheric pollutants in the air is a serious and pressing problem of all modern societies, and has severe clinical impacts for lung diseases. The consequences of inhaling polluted air are dire, both for the ecosystem and for human health. It is changing the chemistry of the earth's atmosphere, thus aggravating climate change, as well as, intensifying the prevalence of respiratory diseases, such as cough, asthma, lung cancer, bronchitis, emphysema, heart attack and chronic obstructive pulmonary disease. In our own little ways, we can make a difference by adopting healthy lifestyles and keeping our environment clean. There is no effort too small in "bringing back fresh air" to our cities, as it was in the beginning. In conclusion, the success of the human species now, and in the future, will depend on our ability to alter the environment in a rational, sensible manner, so that we continue to derive basic needs for survival. As the wise saying goes, "Do not bite the finger that feeds you".

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References

Ahrens, D. C. (2009) Meteorology Today: An Introduction to weather, climate and environment. Brooks/Cole, Belmomt, USA.

Ana, G. R. (2011) Air Pollution in Nigeria. https://www.intechopen.com

Baudi, P. V. and Ahmed, A. N. (2006) The impacts of wind related hazards in Southern Cameroon. *Journal of Physical Sciences,* 3(2): 82-88.

Buis, A. (2019) The Atmosphere: Getting a handle on Carbon Dioxide. https://www.ocov2.jpl.nasa.gov/

Christopherson, R. W. (2003) Geosystems. Pearson Education, Inc., New Jersey, USA.

Cunningham, W. P. and Cunningham, M. A. (2002) Principles of Environmental Science: Inquiry and application. McGraw-Hill, Boston, USA.

Cunningham, W. P. and Saigo, B. W. (1999) Environmental Science. WCB/McGraw-Hill, Boston, USA.

Ekpoh, I. J. (2004) Environmental Hazards. St. Paul's Publishing and Printing Co. Ltd., Calabar, Nigeria.

Ekpoh, I. J. (2009) Climate, Society and Environment. St. Paul's Publishing and Printing Co. Ltd., Calabar, Nigeria.

Ekpoh, I. J. and Obia, A. E. (2010) The role of gas flaring in the rapid corrosion of zinc roofs in the Niger Delta Region of Nigeria. *Environmentalist*, 30: 347-352.

Ekpoh, I. J. and Nsa, E (2011) Extreme climatic variability in north-western Nigeria: an analysis of rainfall trends and patterns. *Journal of Geography and Geology,* 3(1) 51-62.

Ekpoh, I. J. (2014b) Slow Response to Climate Change in Nigeria: need for urgent and comprehensive action. *Studies in Social Sciences and Humanities*, Vol.1, No.2: 19-29

Ekpoh, I. J. (2015) Climate Change and Recent Severe Flooding in Uyo, Akwa Ibom State, Nigeria. *Global Journal of Social Sciences,* Vol. 14, pp 23-33.

Ekpoh, I. J. and Bassey, B. J. (2016) Implications of Climate Change for Human Health in Nigeria. *Geosciences Research,* Vol. 1, No. 1: 39-46.

Enger, E. D. and Smith, B. F. (1998) Environmental Science: A study of interrelationships. WCB/McGraw-Hill, Boston, USA.

Epstein, S. (2007) Trends and Temporal Variations of Major Greenhouse Gases. *J. Atmos Environ Science,* Vol. 42, Issue 38: 8707-8716.

Federal Republic of Nigeria (2003) Nigeria's First National Communication under the United Nations Framework Convention on Climate Change. Landmark Publications, Lagos, Nigeria.

Floyd, B. N. and Ekpoh, I. J. (2004) Man and Environment: Crop production in Tropical Africa. St. Paul's Publishing and Printing Co. Ltd., Calabar, Nigeria.

Hickson, J. E. (2000) Air Pollution as a Climate Forcing Factor. Proceedings, Honolulu, Hawaii.

IPCC (2007) Climate Change 2007. Synthesis Report. FAR of IPCC. Geneva, Switzerland. p. 104

Kemper, K. and Chaudhuri, S. (2020) Air Pollution: A silent killer in Lagos. https://blogs.worldbank.org.

Leaf, A. (1993) Loss of Stratospheric Ozone and Health Effects of increased Ultra-Violet Radiation. Reproduced with permission WHO (2016). https://www.ciesen.org/docs/

McMichael, A. J. (2012) Insights from Past Millennia into Climatic Impacts on Human Health and Survival. *Proc Natl Acad Sci USA* 109: 4730-4737.

Mshelia, A. D. (2005) Adaptation strategies to climate change. *Journal of Energy and Environment,* 18(3): 74-81.

Nerlander, L. (2009) Climate Change and Health. Commission on Climate Change and Development. SE 103 39 Stockholm, Sweden.

Odjugo, P. A. O. (2010) General overview of climate change impacts in Nigeria. *Journal of Human Ecology,* 29(1): 47-55.

Parke, P. (2016) The most polluted cities in Nigeria. https://www.edition.cnn.com

Tarbuck, E. J. and Lutgens, F. K. (2000) Earth Science. Prentice Hall, New Jersey, USA.

Thompson and Turk (2005) Earth Science and the Environment. Brookes/Cole, USA.

United Nations (2009) Climate will cost much more than UN thinks. http://www.newscientist.com/article/

United Nations Population Fund (2012) State of World Population 2012. http:/www.unfpa.org

United Nations (2019) Ist Quarter Demography Report 2019. http:/www.independent.ng

USEPA (2007) Health Assessment Document. U. S. Environmental Protection Agency, Washington, DC 20460, USA.

World Health Organization (WHO) (2016) Air Quality Monitoring in Nigeria. https://aqicn.org/country/nigeria/

World Health Organizaton (WHO) (2018) 9 out of 10 people worldwide breathe polluted air. https://www.who.int/item/

World Bank (2016) Nigeria's Flaring Reduction Target 2020. https:/www.worldbank.org

Worldometer (2020) World Population Clocks 7.8 billion People. https://www.worldometer.info/