Mitigating Air Pollution in Nigeria through Effective Tree Planting

By

Ojule, Emmanuel S.C.
Department of Geography and Environmental Studies
Faculty of Social Sciences
Ignatius Ajuru University of Education
Rumuolumeni, P.M.B 5047 Port Harcourt
Tel: 08029797039 E-mail: esc_ojule@yahoo.com
&
Orisa-Ubi, Charity
Department of Human Kinetics, Health and Safety Education
Faculty of Natural and Applied Sciences
Ignatius Ajuru University of Education
Rumuolumeni, P.M.B 5047 Port Harcourt
Tel: 08038882944 E-mail: charilove75@yahoo.com

Abstract

This paper investigated mitigating air pollution in Nigeria urban centres through effective tree planting. The paper observed that Nigeria as a major developing country is experiencing an increasing air and noise pollution just like any other third world nation in the world. This pollution is as a result of the expansion of automobiles/tricycle/motorcycle ownership, resulting to vehicular traffic; industrial growth and develop generating set ownership as a result epileptic power supply and the increasing affluence of city residents. As a result of this, air pollution over the nation's urban centres has reached a critical stage and efforts must be made to combat this environmental challenge. Thus one of the cheapest and cleanest ways of addressing this problem is by massive planting of trees across the length and breadth of the nation. This is because; the importance of trees in mitigating urban air pollution cannot be

overemphasized. Trees can remove pollutants especially ozone (O_z) nitrogen dioxide (n_2o), particulate matters such as $P_{m2.5}$, P_{m10} and other particles from the air which makes the atmosphere cleaner. It should be noted that the removal of pollutants by trees is a local effect whereas the formation of pollutants from compound emitted by trees happen downward of trees themselves. Thus the cumulative and interactive effects of trees on meteorology pollution removal and volatile organic compounds (VOCs) and power plant emission determine the overall impact of trees on air pollution. This is because trees are an integral part of the urban environment affecting communities ecologically, socially, economically and physically and they can benefit human health. Thus sustainable urban tree development could be a vital tool for providing a wealthy and sustainable living environment in the urban centres. Thus through effective tree planting in the Urban areas is one of the ways of realizing the urban forestry programme and the National tree planting campaign programme of the 2006 National Forest Policy of Nigeria.

Keywords: Air Pollution, Air Quality, Trees, Urban Forestry, Particulate Matter, Urban Centres

Introduction

Towns and cities are centres of urbanization. Simply put, urbanization is the process of an increasing concentration of people and economic activities in towns and cities. According to Mayhew (2009) urbanization is the increase in proportion of the population residing in towns, brought about by migration of rural population into towns and cities and/or the higher urban levels of natural increase resulting from the greater proportion of people of child bearing age in cities. In both developed and developing nations of the world there is an increase in the percentage and in the number of people residing in urban settlements (Lodha, 2007).

Mayhew (2009) further posits that urbanization indicates a change of employment structure from agricultural and cottage industries to mass production and service industries. This backs up the view among regional geographers, urban geographers and even urban sociologists that urbanization results from, rather causes, social change and changes in land use patterns and land use intensification.

Urban centres are centres of high residential, commercial and industrial activities. One of the environmental problems associated with urban centres is air pollution which results to poor air quality. Air pollution occurs when harmful substances including particulates and biological molecules are introduced into Earth's atmosphere. It may cause disease, allergies or death of humans. It may also cause harm to other living organisms such as animals and food crops and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. Nigeria and other developing countries in the world is witnessing a significant growth in population size and rate of urbanization especially in the last two decades. According to the Federal Ministry of Environment (2015) despite this increase, there appears to be imbalance between urban growth and availability of such infrastructure to reduce the impact of urbanization on the environment. The ministry further observed that one of the consequences of this imbalance is the emergency of accelerated urban air pollution which is most dominant in emerging potential mega cities in the country.

Air pollution results from the introduction of harmful substance into the atmosphere. Mayhew (2009) defined air pollution as the presence of substances in the air in quantities which can affect animal or plant life, human health and welfare, or can unreasonably interfere with life or property; and that common pollutants include carbon dioxide (CO_2), carbon monoxide (CO), lead (P^b), nitrogen oxide (n_2o), ozone (O_Z), smoke, and sulphur dioxide (S_2O). Air pollution may cause disease, allergies or death of humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment.

Human activity and natural processes can both generate and as well as accelerate the rate of air pollution. Indoor air pollution and poor urban air quality are listed as two of the World's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted places report. According to the 2014 World Health Organization (WHO) report, air pollution in 2012 caused deaths around 7million people worldwide an estimate roughly echoed by one from the International Energy Agency (IEA) (WHO, 2004, IEA, 2016).

Air pollution all over the world is measured by a method known as Air pollution index (API). Air quality index is a number used by government agencies (International Air quality 2015) to communicate to the public how polluted the air currently is or how polluted it is forecast to become (National Weather Service, 2015). Air quality index is used to report air quality. Thus, as the air quality increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. It should be noted that different countries have their own air quality indices, corresponding to different natural air quality standards (https://www.en.wikipedia.org.airpollution) Some of these are Air quality Health index (Canada) the Air Pollution Index (Malaysia) and the Pollutants Standards Index (Singapore). Air Quality Index measurement is between 0-300 and is divided into six categories indicating increasing levels of health concern. The air in the city is rated as follows with their colours: 0 to 50 (Good/Safe-Green), 51-100 (Moderate-Yellow), 101-150 (Unhealthy for sensitive groups-Orange), 151-200 (Unhealthy-Red), 201-300 (Very unhealthy-Purple) and 301 to 500 (hazardous-Maroon)

In Nigeria the Federal Ministry of Environment (2015) opines that Nigeria is among the most intensive atmospheric aerosols in the world and that the two main pollutants and sources in the country are particles from desertic zones of sahara and biomass burning that constitute huge amount of black and organic carbon; and these account for over 70% of air pollution in the country. The Ministry further noted that the sources of this air pollution are associated with combustion from vehicles, domestic power

generations and industrial plants, increase in population density resulting in incident transportation emissions, road traffic system, weak legislation and lack of effective enforcement; and lack of control measure.

The problem of air pollution in Nigeria has been receiving much attention locally and globally. Not long ago (in 2016), the World Health Organization (WHO) listed four Nigerian cities (Onitsha, Kaduna, Aba and Umuahia) among the world's most polluted cities. According to the report, Onitsha was rated as the world's most polluted city for air quality when measuring small particulate matter concentration (PM_{10}). Kaduna came fifth in the world and it is a major transport hub in the North; and Aba and Umuahia came sixth and sixteenth respectively. Both cities are major trade centres in Southern Nigeria. The report explained that "reliance on using solid fuels for cooking, burning waste, and traffic pollution from very old tyres" were contributory factors to the pollution in these cities. This calls for a serious concern for both the government and environmental right groups to deal with this problem. To arrive at the ranking, WHO compared a total of 795 cities in 67 countries for levels of small and fine particulate matter (PM_{10} and $PM_{2.5}$) during the five year period, which started from 2008 to 2013. Thus PM_{10} and $PM_{2.5}$ include such pollutants as sulphate nitrates and black carbon, which penetrate deep into the lungs and into the cardiovascular system posing the greatest risk to human health (Uwaegbulam, 2006). Data were then analyzed to develop regional trends.

A tree is a noble organism, unique in its beauty and home and refuge for birds, insects and small animals. Just as we do breathe oxygen (O_2) into our lungs and exhale carbon dioxide CO_2), so trees breathe carbon dioxide into their leaves and exhale oxygen. Trees are really upside-down lungs: their trunks are equivalent to the trachea, their branches to the rights and left main bronchi and all their branching twigs and leaves to small bronchi and alveoli, air sacs, where the exchange of oxygen and carbon dioxide takes place. Tree trunks and branches may appear solid, but they are really rigid channels that transmit water and nutrient to the leaves the way the trachea and air passages transmit air to the alveoli. (Caldicott, 1992)

One of the ways to mitigate the problem of air pollution in urban centres is by planting of trees by the residents of the city. Beckett, Freer-Smith and Taylor (1998) Opine that trees provide many beneficial characteristics that enable them to capture pollutants particles and hence reduce their concentration in the air. According to researchers (Tucker, 2000, Molders, 2013, Pui, Chenani & Zuo, 2014), the conventional measures for controlling $PM_{2.5}$ pollution focus on reducing emissions from sources. These measures alone cannot deal with the $PM_{2.5}$ already in the air. Thus urban trees, an unconventional solution to the problem, have been shown to remove $PM_{2.5}$ from the air (Nowak, Hirabayashi, Bodine and Hoehn, 2013). Urban trees reduce $PM_{2.5}$ pollution both directly and indirectly (Yang, Obang and Yan 2015). In direct reduction, tree canopies intercept $PM_{2.5}$ with their branches and leaves. (Beckett, Freer-Smith, and Taylor, 1998, Freer-Smith, B-Khatib, and Taylor, 2004 and Saebo, Hanslin, Baraldi, Rapparini and Gawronska, 2013). In a study of ten United States Cities, Nowak, et al (2013) found that the amount of $PM_{2.5}$ removed from urban air by trees varied between 4.7t/year and 64.5t/year in different cities. Indirectly, trees lower air temperatures through shading and evapo-transpiration. According to Yang *et al* (2015), the cooling effect reduces the need for energy-using fans and air conditioners which further lowers emissions from power plants. Also, the rates of photo chemical reacting to the urban atmosphere are slowed by the lowered air temperature resulting in decreased production of secondary air pollutants (Nowak, Verolo, Rao, Sistla, Iluley & Orane, 2000).

In Nigeria therefore, one of the easiest and cheapest means of mitigating urban air pollution in our towns and cities and which will directly involve everyone in the urban center is the planting of trees in the urban environment. This is the policy thrust of this paper as it will enhance air quality in the nation's urban centres. The subject of air pollution is a topical issue which has received much attention across the world. There have been several ways of tackling air pollution including using trees to improve air quality in urban centres. Thus while much research have been

done on trees and air quality in the advanced countries of the world (Beckett, Freer-Smith, & Taylor 2000, Hewith, n.d., Nowak, 1991, Nowak, 2002, Harvey, 2016, and Beckett, Freer-Smith & Taylor, 1998) but not much study have been done in the developing countries. This study therefore hopes to investigate the effects of urban trees on urban air quality in Nigeria which is a branch of forestry known as urban forestry.

Air pollution and Degradation of Air Quality over Nigeria

One vital element of healthy living is clean air the air that we breathe daily is a mixture of gases which comprises 21% oxygen, and 78% nitrogen, with the remainder consisting of trace amounts of rare gases such as argon. According to American Space Agency NASA (National Aeronautics and Space Administration) "the air we breathe is changing" and "the burning of fossil fuel and biomass is producing pollutants that are transported large distance and are degrading air quality globally". The agency further observed that the "concurrent long-term buildup of chemically active gases such as methane, provides an additional stress on air quality worldwide". Generally, the contamination of air is from anthropogenic activities and natural events (e.g. Volcano) which has been on increase in recent times due to industrialization and human quest for development (Akinfolarin, Bolsa and Obunwo, 2017). According to Rai, Rajpur and Agawal (2011), these activities release some gaseous emissions such as Sulphur dioxide (So_2) Nitrous oxide (NO_2) Carbon monoxide (CO), Hydrogen sulphide (H_sS), Volatile Organic compounds (VOC_s) and Hydrocarbons and Particulates (smoke, soot, metallic, dust, fumes and aerosols) that contaminate air and when in high concentrations could cause damage to environment and human health. There is a wealth of evidence regarding the effects of long-term exposure to human health. According to Olowoporoku (2011), various studies have indicated that areas of high background concentrations of particles (Fine dust) in the air are associated with increased numbers of primate deaths in people with long term residence in such areas.

Air pollution affects all of us, 24 hours a day, directly or indirectly all over the world. Air pollution is caused by air pollutants. Air pollutants are air borne substances (solids, liquids or gases) that occur in concentrations high enough to threaten the health of people and animals, to harm vegetation and structures, or toxify a given environment (Weli & Utang, n.d.) Air pollutants come from both natural sources and human activities. Examples of natural sources include wind picking up dust and soot from the earth's surface and carrying it aloft, volcanoes belching tones of ash and dust into our atmosphere, and forest fires producing vast quantities of drifting smoke.

Human induced pollution enters the atmosphere from both fixed sources and mobile sources. Fixed sources encompass industrial complexes, power plants, homes, office buildings and so forth. A mobile source includes motor vehicles, motor cycles, tricycles, ships and jet aircraft. Certain pollutants are called primary air pollutants because they enter the atmosphere directly from smokestacks and tail pipes. For example, other pollutants known as secondary air pollutants enter the atmosphere from only when a chemical reaction occurs between a primary pollutant and some other components of air, such as water vapour or another pollutants. Examples of well-known pollutants are Carbon dioxide (CO_2), Carbon monoxide (CO), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Nitric oxide (NO), Ozone (O_3), Lead (P^b), and volatile organic compounds (VOCs). VOCs represent a class of organic compounds that are mainly hydrocarbons-individual organic compounds composed of hydrogen and carbon.

The term particulate matter (PM) represents a group of solid particles and liquid droplets that are small enough to remain suspended in air. Collectively known as aerosols, this grouping includes solid particles that may irritate people but are usually not poisonous, such as soot (tiny solid carbon particles), dust, smoke, and pollen. Some of the more dangerous substances include asbestos, fibres and arsenic. Thus tiny liquid droplets of sulphuric acid, PCBs, Oil and various pesticides are placed in

this category. Because it often dramatically reduces visibility in urban environments, particulate matter pollution is the most noticeable. Some examples of particulate matter are PM 2.5 and PM_{10}. PM 2.5 are atmospheric particulate matter that have a diameter of less than 2.5 micrometry which is about 3% the diameter of human hair. PM 2.5 is so small that they can only be detected with an electron microscope. They are even smaller than their counterparts PM_{10}, which are particles that are 10 micrometers or less, and are also called fine particles.

The likely sources of PM 2.5 are combustion resulting from power plants, smoke and soot from wildfires and waste burning, vehicular emission and industrial processes involving chemical reactions between gases (sulphur dioxide, nitrogen oxides and volatile organic compounds). Studies have shown that PM 2.5 is dangerous. Since they are so small and light, fine particles tend to stay longer in air than heavier particles. This increases the chances of humans and animals inhaling them into the bodies owing to their minute size. Particles smaller than 2.5 micrometers are able to bypass the nose and throat and penetrate deep into the lungs and some may even enter the circulatory system. Studies have found a close link between exposure to fine particles and premature deaths from heart and lung disease. Fine particles are also known to trigger or worsen chronic disease such as asthma, heart attack, bronchitis and other respiratory problems. An association between mother's exposure to fine particles and birth defects has also been established by several reports. Thus children, older adults and those who are suffering from lung and/or heart disease are especially vulnerable to adverse effects of fine particles in the air and should take special precautions when ambient $PM_{2.5}$ crosses unhealthy levels.

Air pollution according to available statistics from the World Health Organization (WHO) shows that nine out of ten people globally are breathing poor air quality, while pollution is responsible for more than six million deaths annually. WHO also estimates that more than six million deaths were linked to exposure to outdoor and indoor air pollution related deaths occur in low and middle-income countries. In 2016, the World Bank

said that air pollution was the deadliest form of pollution and the fourth lead risk factor for premature deaths worldwide. In a joint study with the United States Institute of Health Metrics and Evaluation (IHME), the bank claimed that an estimated 5.5 million lives were lost in 2013 to diseases associated with outdoor and household air pollution. It said that deaths arising from air pollution in 90 percent of the population in low and middle – income countries cost the global economy about $225 billion lost labour income in 2013

In Africa, scientists have found dirty air caused more premature death than unsafe sanctification and malnutrition in Africa in 2013. The data by the Organization for Economic Cooperation and Development (OECD) observed that in 2013, air pollution killed 712, 479 people, unsafe water, 542, 857; unsafe sanitation 391, 613 people. In kazzem (2017) new, Nigerians are particularly at risk as a 2016 World Health Organizations report on air pollution named four Nigerian cities (Onitsha, Aba, Umuahia and Kaduna) among the 20 world worst ranked cities for air quality.

Air pollution is a major environmental hazard in both developed and developing countries in the world. Air pollutants such as dust and smoke have serious impact on human health and also on public health. There is a clear correlation between the incidence of respiratory diseases and air pollution. Cardiovascular diseases are also associated with air pollutants, as are irritation and general discomfort (Olowoporoku, 2011). According to the Federal Ministry of Environment (2015) the two main pollutants and sources of air pollution in Nigeria are particles from desertic zones of Sahara and biomass burning that have huge amount of black and organic carbon. These account for over 70% of air pollution in the country. Thus the use of bio fuels usually results in concentration of gaseous air toxics notably NO_x, CO, volatile organic compounds (VOC_s) and SO_2, associated with combustion from vehicles, domestic power generations and industrial plants. Furthermore, the Ministry observed that the effect of the concentration of these gases with respect to human health, protection of

natural resources and the socio-economic development of the country can become an increasing challenge to science and technology.

Some of the factors affecting air pollution in Nigeria observed by the Federal Ministry of Environment are:

- Increase in population density resulting in incident in transportation emissions/square kilometers
  Increase in the number of family used vehicles (These vehicles are imported from overseas and are called "Tokunbos"
- Increase in the number of household power generators
- Road traffic system
- Maintenance system
- Control measures in place
- Weak legislation
- Lack of effective enforcement

The Federal Ministry of Environment (2015) in the bid to fight air pollution in the country adopted the following strategies for achieving a clean air situation include:

- Designating and mapping of National Air Control Zones (NACs) and clearing air quality objectives for each designated Air control zone
- Establishing ambient air quality standards and monitoring stations at each designated zone.
- Licensing and registering of all major industrial air pollutants and monitoring their compliance with laid down standards
- Provision of guidelines for the abatement of air pollution
- Establishing standards for the control of fuel activities with respect to trace elements especially lead (Pb) and Zinc (Zn)
- Prescribing stringent standards for the level of emission from automobile exhausts and energy generating plants and stations.
- Monitoring and minimizing the incidence of "acid rain"
- Promoting regional co-operation aimed at minimizing the atmospheric transportation of pollutants across national boundaries.

Concept and Biology of Tree

A tree is a noble organism, unique in its beauty and home and refuge for birds, insects and small animals. Trees are more than just heavens for animals, birds, insects and humans. They are also the lungs of the Earth just as we breathe oxygen into our lungs and exhale carbon dioxide, so trees breathe carbon dioxide into their leaves and exhale oxygen. Trees are really upside down lungs, their trunks are equivalent to the trachea , their branches to the right and left main bronchi and at their branching twigs and leaves to small bronchi and alveoli or any air sacs, where the exchange of oxygen and carbon dioxide takes place. Tree trunks and branches may appear solid but they are really rigid channels that transmit water and nutrients to the leaves the way the trachea and air passages transmit air to the alveoli.

Trees are woody plants but not all woody plants are trees. Ekeke (2014) opines that a tree usually grows upright to at least 15 metres at maturity and has a unique stem called bole or trunk. The stem supports limbs and leaves forming the crown or top. Trees generally develop typical shapes when they are grown in an open area. Ekeke (2014) further stated that trees that grow in crowded forests usually grow singly in open spaces. These open space trees tend to have larger crown and shorter boles.

A tree means different thing to different people. For instance, to our ancestors, a tree is a source of fuel and shelter and occasionally, an object of worship to their gods. To an average man in the street, a tree may be a source of pleasant shade in a sunny day. On the other hand, it becomes a nuisance when it shades it leaves on the lawn. To an arborist, it is an ornamental object in the landscape. To a botanist, a tree is a perennial plant with an elongated stem or trunk, supporting branches and leaves in most species. To a forester, a tree is the product of timber and pulpwood. To a plant physiologist, a tree is complex bio-chemical factory which starts from a seed and literally builds itself up. To a climatologist, a tree is an object which purifies the air and moderates the earth's climate; and finally to a hydrologist, it is a material for checking flood and erosion in an area.

Trees may be divided into two main groups called angiosperms and gymnosperms (Ekeke, 2014). The angiosperms (flowering plants) are mainly hardwoods and the gymnosperms (non-flowering plants) are mainly softwoods. The angiosperms have broad leaves and the gymnosperms have needle like or scale leaves. The angiosperms are generally deciduous (shedding leaves) and the gymnosperms bear hard seeds from flowers and inside fruits but the gymnosperms bear seeds on cones (naked fruits) or cone like structures.

For centuries, trees have been attracting the attention of all categories of people including the growers (Silviculturists), scientists and environmentalists. Trees are multi-purpose in their utility to all living matter including flora and fauna. Their benefits are endless and they are always in the service of mankind. Thus trees being perennial plants, are the main source of providing green cover to the soil; they bind the soil and provide more biomass to the soil than other sources (Sharma, 1998). The green parts of the trees, particularly, the foliage converts the solar energy into real energy carbohydrates, sugar, fats, proteins, vitamins, hormones, wood, charcoal, petrol, jems, diamonds, etc. According to Caldicott (1992), trees are an energetic necessity to the biological health of the planet. Thus as human beings fill the air with carbon dioxide and destroy the ozone layer with man-made chemicals (Chlorofluorocarbons), trees offer an excellent means of buffering these effects. It has been calculated that if an area the size of Australia or the continental United States were planted with trees, the air could be cleared of carbon dioxide related from fossil fuels (Corson, 1990).

The importance of trees in the urban environment cannot be over-emphasized. Thus trees can improve the urban environment in the following ways: increasing biodiversity, benefiting human health, increasing a sense of community, affecting air quality, providing shade and humidity, increasing property prices and, having aesthetic qualities (Ekeke, 2014). Besides these benefits, it should also be noted that trees can also damage property and require maintenance. Furthermore we should also be

aware that people plant trees for so many reasons that it is not possible to produce a scoring system that considers all the factors.

The biology of tree cannot be fully understood without making reference to the tree prayer. The tree prayer according to Ekeke (2014) is more like a poem in which the tree is calling all and sundry to its importance in the society by recognizing its multiple uses.

The Tree's Prayer (ANON-PORTUGUESE)

Ye who would pass by and raise your hand against me;
Harken ere you harm me.
I am the heat of your heart in the cold winter nights
The friendly shade screening you from the summer sun
And my fruits are refreshing droughts,
Quenching your thirst as you Journey on
I am the bean that holds your house,
The board of your dining table
The bed on which you lie and the timber that builds your boat
I am the handle of your hoe and the door of your homestead,
The wood of your cradle and the shell of your coffin
I am the gift of God and the friend of man.
Ye pass by listen to my prayer. Harm me not

Forest Policy and National Tree Planting Campaign

Forest policy is a plan of action designed to indicate what proportions nation's land area should be allocated and allotted (Adekunle, n.d.). It could also be considered as consisting of those principles which govern the action of the people with respect to forest reserves. One of the principles of the 2006 National Forest policy is to "mobilize the community and civil society in forestry development (FME, 2006) which implies that the citizenry are encouraged to plant trees in the urban areas. The policy objectives focus on managing the nation's forestry sector in a way that the forestry would continue to deliver goods and services in perpetuity

(Federal Ministry of Environment, 2006). The Urban Forestry Policy Statement in the National Forest Policy states that "urban forestry will be promoted in order to provide aesthetics, recreational, social and economic values and benefits for the people" and its objectives is to promote and maintain the greening of the urban environment and to meet the increasing demand for forest products by urban centres" and one of its strategies is to "encourage roadside and amenity planting, (FME, 2000).

The National Tree Planting Campaign (NTPC) was first introduced in 1981 to mark the world environment day which is observed on June 5th every year. The ceremony involved the planting of commemorative tree at the launching site by the highest office of the land (Mr. President). There is a general public misconception that NTPC is a programme for the establishment of large-scale forest plantation all over the country. The position is that NTPC is a strategy devised by Government to sensitize the people and create public awareness on the need for forest conservation and to impact tree planting culture in the citizenry in recognition of the roles forest and trees play in their environment, and in the general wellbeing of our people. It was therefore not designed to replace the actual plantation programmes of federal, state and local governments. It is also to serve as a vehicle to give support and impetus to natural afforestation efforts. The policy statement of NTPC is that the NTPC Programme shall be reviewed from time to time to ensure that the citizenry imbibe the culture of tree planting in their homesteads, farmlands and developmental areas.

Objectives

1. To conserve and protect the environment
2. To produce raw materials for forest based industries
3. To create awareness on the effects of deforestation, erosion, desertification and the need to plant more trees.
4. To massively re-vegetate the environment.

Strategies

1. Provision of adequate quantities of quality seedlings of economic and ornamental tree seedlings
2. Enforce that each urban household plants a minimum of two trees in addition to planting ornamentals
3. Effective extension services delivery
4. Enlightment programmes
5. Development of maintenance culture for planted trees.

Effects of Trees on Urban Air Quality

Urban centres have vegetation both natural and man-made. This vegetation can either directly or indirectly affect local and regional air quality by altering the urban atmospheric environment. Most people assume that trees only benefit air quality. In fact, some tree species can have negative effects and actually help to form pollutants in the atmosphere according to Hewit (n.d.)

Negative Effects: Trees can emit gases known as volatile organic compounds (VOCs). These are what you can smell in the forest. VOCs in the combination with man-made oxides of nitrogen (NO_x) can contribute to the production of other pollutants especially ozone and particles, which damage human health when in lower atmosphere.

Positive Effects: Tress can remove pollutants especially ozone, nitrogen dioxide and particles from the air which makes the atmosphere cleaner. Trees also remove carbon dioxide, from the atmosphere. Carbon dioxide is a greenhouse gas which is having effects on the earth's climate (Hewit, n.d). It should be noted that the removal of pollutants by trees is a local effect, whereas the formation of pollutants from compounds emitted by trees happen downwards of trees themselves.

Furthermore, Burch (n.d.) noted the following to be some positive effects of trees on air quality in urban centres:

- All trees enhance deposition of particulate matter and gaseous air pollutants like ozone and nitric oxide
- Trees also absorb carbon dioxide which is a significant greenhouse gas.
- Trees provide shade and cooling through evapo-transpiration. This is local cooling from trees reduces the need of air conditioning which helps reduce nitrogen oxide (NO_2) from power plants. Urban scale cooling also helps to reduce evaporative emissions from cars, trees and other sources.

In a similar vein, Nowak (2002) observed that urban forest management strategies to help improve air quality include:

- Increase the number of healthy trees (increases pollution removal).
- Sustain existing tree cover (maintains pollution removal).
- Maximize low VOC emitting trees (reduces ozone layers and carbon monoxide formation)
- Sustain large healthy trees (reduces long term pollutants emissions from maintenance activities).
- Use long lived trees (reduces long term pollutants emissions from planting and removal)
- Use low maintenance trees (reduces pollutants emissions from maintenance activities).
- Reduce fossil fuel use in maintaining vegetation (reduces pollutant emissions).
- Plant trees in energy observing locations/reduces pollutant emissions from power plants
- Plants trees to shade parked cars (reduces vehicular VOC emissions)
- Supply ample water to vegetation (enhances pollution removal and temperature reduction)
- Plant trees in polluted areas or heavily populated areas (maximizes tree a quality benefits)

- Utilize evergreen trees for particulate matter reduction (Year –round removal of particles)
- Avoid pollutant sensitive species (increases tree, health).

According to Nowak (2002) and the United Kingdom's Department of Environment, Food and Rural Affairs (2010), the following are the ways in which trees affect air quality in an urban centre:

- Temperature Reduction and other Microclimate Effects
- Removal of Air Pollutants
- Emission of Volatile Organic Compounds
- Tree Maintenance Emission
- Energy Effects on Buildings

1. Temperature Reduction and Microclimatic Effect:

Tree transpiration and tree canopies can affect air temperature, radiation absorption and heat storage, wind speed, relative humidity, turbulence, surface albedo, surface roughness and consequently the evolution of the mixing-layer height. Such changes in local meteorology and microclimatology can have an effect on local pollutant concentrations in urban areas. Urban trees are generally associated with contributing to cooler summer air temperature; however in some instances they may have the opposite effect causing an increase in air temperature. Where tree stands consists of scattered tree canopies, radiation can reach and heat ground surfaces; at the same time, the canopy may reduce atmospheric mixing preventing cooler air from reaching the area. In such cases, trees shade and transpiration may not compensate for the increased air temperatures due to a reduction in overall mixing. However reduced air temperature as a result of tree planting is believed to improve air quality because emissions of many pollutants and/or bone-forming chemicals are temperature dependent. Decreased air temperature can also reduce ozone formation.

2. Removal of Air pollutants

Trees can remove gaseous air pollution either through uptake via leaf stomata or the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner leaf surface. Recent research suggests that the planting of trees along sides of roads could reduce nitrous oxide (NO_2) concentrations in addition to providing amenity value (XU, 2018). Trees can also remove pollution by intercepting airborne particles. Some particles can be absorbed into the three, though most that are intercepted are retained on the plant surface. The intercepted particle is often re-suspended to the atmosphere, washed off by rain, or dispersed through leaf full. Consequently, vegetation is thought to be only a temporary retention site for many atmospheric particles.

3. Emission of Volatile Organic Compounds (VOCs):

Trees can also have an adverse effect on air quality through the emission of volatile organic compounds (VOCs). VOCs in combination with oxides of nitrogen (NO_X) can contribute to the production of other pollutants, especially ozone and particles. However under low nitrogen oxide concentrations (e.g. some rural environments) VOCs may actually remove ozone because VOC emissions are temperatures dependent and trees generally lower air temperatures, increased tree cover can often lower overall VOC emissions and, consequently, ozone levels in urban areas. VOC emissions rates however also vary by species e.g. Sycamore (*Plantanus, spp*.), popular (populous spp.) and Oak (*Overcus spp*) have some of the highest standardized isoprene emission rate and therefore the greatest relative effect among genera on increasing ozone. However due to the high degree of uncertainty in atmospheric modeling, results are currently inconclusive as to whether these genera will contribute to an overall net information of ozone in cities (i.e. ozone formation from VOC emissions are greater than ozone removal).

Trees that don't emit the most reactive volatile organic compounds (VOCs), but do not have large leaf surface areas have the best effect on air quality (Hewit, n.d.). Trees generally remove airborne pollutants at three times the rate of grassland. Trees at the edge of woodland are more effective at removing atmospheric pollutants than trees in the center of the woodland. This is due to both large leaf areas and greater exposure to the wind.

4. Tree Maintenance Emissions:

Because urban trees often receive relatively large inputs of energy, primarily from fossil fuels to maintain vegetation structure, the emissions from these maintenance activities need to be considered in determining the ultimate net effect of urban forests on air quality e.g. equipment used, vehicles, shredders, clippers and leaf blowers may all contribute to concentrations of CO_2, VOCs, carbon monoxide, nitrogen, sulphur oxides and particulate matter.

5. Energy Effects on Buildings

Additional effects of urban trees can be through energy conservation from buildings. Trees reduce building energy use by covering temperatures and shading buildings in winter, and may increase or decrease energy use by blocking summer breezes. Thus proper tree replacement near buildings is critical to achieve maximum building energy conversation benefits. When building energy use is lowered, pollutants emissions from power plants are also lowered. Pollutants emissions generally improve air quality, lower nitrogen oxide emissions, particularly ground level emissions may lead to a local increase in ozone concentrations under certain conditions due to nitrogen oxide scavenging of ozone.

Cumulative Effects of Urban Trees on Ozone

Changes in urban micro climatology can affect pollution emission and formation, particularly the formation of ground-level ozone. Nowak (2000) observed that a model stimulation of a 20 percent less in the Atlanta area

forest due to the urbanization led to a 4-percent increase in ozone concentrations for modeled day. Although there were fewer trees to emit VOCs an increase in Atlanta's air temperatures due to urban heat island, which occurred concomitantly with tree loss, increased VOC emissions from the remaining trees and anthropogenic sources and altered ozone chemistry such that concentrations of ozone increased. Interactions of the effects of trees on the physical and chemical environment demonstrate that trees can cause changes in pollution removal rates and meteorology, particularly air temperatures, wind fields and mixing-layer heights, which in turn, affect ozone concentrations (Nowak, 2000).

Tree Species Selection to Improve Air Quality

According to Urban Foresters and Silviculturists, tree species selection within urban areas can influence the overall forest effect on air quality. In addition to choosing species that are well adapted to the site to reduce maintenance needs and increase longevity, tree species characteristics can influence chemical removal, chemical emissions, urban microclimate, and building energy conservation.

Urban foresters observed that some of the best tree species to improve air quality generally have large leaf surface areas at maturity, leaf characteristics amenable particles collection (e.g. hairy, stick, low VOC emissions, and /or relatively high transpiration rates (relatively high in temperature reduction) Although these species may be the best for improving air quality, other species characteristics used to be considered when selecting urban trees (e.g. adaptation to site, maintenance needs, sensitivity to pollution, rooting habit, etc).

In Nigeria, tree species selection and design in urban forestry is getting more attention from specialists. According to Larinde (2010), some common tree species used in this direction is listed in the table below according to regions.

Table 1: List of Species Use in Various Urban Forestry Programmes According to Sub-Regions

S/n	Description	Rain Forest	Mangrove Forest	Sahel Savannah	Sudan Savannah	Guinea Savannah
1.	Windbreak	Pinus Caribbean casuarinas Spp.	Eucalyptus Spp. Gmelina aboreapinus Spp.	Azadiracta indicia Eucalyptus camadulensis	Azadicta indicia Eucalyptus camadulensis	Cassia siemea Tectona grandis
2.	Orchads	Teminala catapa Chrisophyllum albidum	Irvingia gabonensis, Cola pachycarpa Psidium guyva	Acacia nilotica, parkia biglobosa Vitelleria paradoxum	Acacia nilotica Psidium aleofera	Citrus sinensis
3.	Woodlots	Cassia siemea Tectona grandis	Gmelina arborea	Azadiracta indica Delbegia Sisso	Azadiracta indicia Eucalyptus camadulensis	Azadiracta indicia Eucalyptus camadulensis
4.	Amenity Planting	Delonix regia plumeria lubra	Jacaranda mimosi Folia Sena Siamea	Azadiracta indicia Eucaliptus camadulensis Casuarinas equsetilopia	Azadiracta indca	Delbegla sisoo Casuarina equisetlofia
5.	Homestead	Anacardium occidentale Citrus sinensis Mangifera indica	Dry codes edulis Treculia africana Anonia muricata	Acacia nilotica Mangifera indica	Moringa alofera Tamarindus indica	Acacia nilotica Citrus sinensis
6.	Borderline Planting	Glincodia Sepium New bouidia lavis	Fiscus benjamina Rumex abyssinicus	Moringa alofera Faidherbia albida	Tamarindus indica	Moringa aleofera

			Acacia holoserica			

Source: Larinde, (2010)

Urban Forest Design and Management to Improve Air Quality

In addition to species selection, design of the urban forest structure can influence local air quality according to urban foresters. Thus increasing urban tree and shrub cover (both horizontally and vertically) can improve air quality by increasing leaf surface area through which the polluted air will pass (increased removal), and by deflecting pollutants away from receptors beneath or downward of the canopy. Nowak (2012) observed that estimates of air quality improvement due to pollution removal (which can reach up to 13%) likely underestimates the total effect of the forest on reducing ground-level pollutant concentrations from reaching below canopy (ground-level) air space.

Colbeck and Harrison (1985) opine that under normal daytime conditions, atmospheric turbulence mixes with the atmosphere such that pollutant concentrations are relatively consistent with height. In this respect, it can be observed that forest canopies can limit the mixing of upper air with air below the canopy and lead to significant below canopy air quality improvements. However, if there are numerous pollutant sources below the canopy (e.g. automobiles), the forest canopy could have the increase effect by minimizing the dispersion of the pollutants away from the ground level (Nowak, n.d.). Some studies have shown that designing vegetation near the source or receptor can have increased effects on improving air quality because pollutant concentrations are higher at the source, which will lead to increased pollutant uptake by the vegetation. Also, vegetation close to the receptor can have local impacts that reduce pollutant concentrations at the ground level near the receptor.

Conclusion and Recommendations

Environmental issues are of critical concern/importance in all countries of the world and one of such is air pollution. Trees could be used in addressing this problem. The beneficial effects that trees have on air quality cannot be over emphasized. Trees are an integral part of the urban environment affecting communities ecologically, socially, economically, and physically and they can benefit human health. Thus, sustainable urban tree development could be a vital tool for providing a healthy and sustainable living environment in the urban centers. Trees along with other plants can make living in our cities more enjoyable and comfortable. Trees help in absorbing noise, reducing air pollution and help to reduce human stress. Urban trees also help in conserving household energy, aid in wind control, land reclamation, wastewater and affect carbon storage and sequestration.

There is need in Nigeria to have adequate legislation and an evidence-based government policy framework that will form the foundation for air quality management in the country. Thus while the framework should go beyond setting the technical standards for emissions limit, it should establish the links between the technical procedures and governance policies to enforce them. There should be a management framework with clear roles and responsibilities for actions by the government, industrial operators and the civil society.

Thus while there are various complex political and economic issues in need of urgent attention by the Nigerian Government, there are opportunities for the Federal Ministry of Environment to be visionary and proactive in establishing an effective air quality management framework for millions of Nigerians living in its urban centres across the nation. It should be noted that establishing such a framework within the next few years in the country will require that a series of specific environmental policy reform and legislative changes that must be put in place. In the first instance, there is need for the federal government to facilitate joint-working and collaboration between the academic and non-academic experts to

establish evidence for wealth-based air quality standards and limit values for individual pollutants whose exposure will compromise public health in Nigeria. The report from this collaboration should then form a basis for a legislative reform process for new and amended regulations regarding all aspects of the atmospheric environment and possibly climate change. The federal government should encourage the various state governments in the federation through their state Ministry of Environment to key into it. The Federal Government should the Federal Ministry of Environment establish a National Centre for Atmospheric Research (NCAR) to embark on research activities on the Nation's atmosphere especially on air pollution, aeronomy, aerology, micro climatology, micro meteorology and lower boundary meteorology. The center should have offices in all the states of the federation and an aeronomy laboratory at Abuja, the Federal Capital Territory. Such a center will enhance easy collection of atmospheric pollution data across the nation.

The National Tree Planting Campaign should be revisited and reviewed in order to achieve its own, objectives and strategies. In addition to observing the world environment day on June 5th of every year, the tree planting campaign should be enforced that day. The Federal Government should make it mandatory for the educational institutions at the nursery, primary, secondary and tertiary levels to embark on tree planting on that day and as well as encouraging forestry club and environmental society in their areas of operation. This will help to create awareness of tree planting in our nation.

References

Abali, H. (2018): Seasonal particulate pollution in Port Harcourt Nigeria. *Journal of Environment pollution and Human Health.* Vol.6 no7. (2018): 20-26. doi.10.12691.Ijephh. 6-1-3

Adekunle, M.F. (n.d.). *Lecture note on Forrest Policy, Law and Administration*. National Open University of Nigeria (NOUN), Abuja FCT

Akinfolarin, O.M., Boisa, N. and Obunwo, C.C. (2017): Assessment of particulate matter Based Air quality Index in Port Harcourt Nigeria. *Journal of Environment Analytical Chemistry*. 4. 224. doi:10.4172/2380-2391.1000224

Backett, K.P, Freer-Smith, P.H and Taylor G. (1998). Urban woodlands: their role in reducing the effects of particulate pollution. *Environment Pollution*. 99.347-360

Backett, K.P, Freer-Smith, PH and Taylor G. (2000) Effective tree species for local air quality management *Journal of Arboriculture*. Retrieved from: https//:www.research-gate.net/publication/238753397

Burch, D. (n.d.). *Trees and air quality.* Bay Area Quality Management District San Francisco, California. Retrieved from:

Caldicott, H. (1992): *If you love this planet: A plan to Heal the Earth*. New York. W.W. Norton & Company

Colbeck, I and Harrison, R.M. (1985): Dry deposition of ozone: some measurements of deposition Velocity and of Vertical Profiles to 100 metres. *Atmos Environment 19(11): 1807-1818*

Corson, W.H. (1990) *The global ecology handbook: what you do about the environmental crisis.* Boston, Beacon Press

DEFRA (2010): *What impacts do trees have on air pollutant concentrations*? UK Department of Environmental, Food and Rural Affairs. Retrieved from: https://laqmdefra.gov.uk/laqm-fags/faq105.html

Ekeke, B.A. (2014) *Fundamentals of Nigeria forest resources management* Port Harcourt. PreJoe Publishers.

Federal Ministry of Environment (2006). *National Forest Policy.* Abuja. Federal Capital Territory.

Federal Ministry of Environment (2015a): *National policy on the environment*. Revised Edition. Abuja, Federal Ministry of Environment

Federal Ministry of Environment (2015b) *Fuel quality progress in Nigeria for Nigeria National Air Quality Management Programme.* Abuja

Hewitt, N. (n.d.) *Trees & sustainable urban air quality.* Lancaster University, Lancaster, UK. Department of Environmental Science

International Energy Agency. (2018). World Energy Outlook. Special Report, Retrieved from http://www.iea.org/publications.

Kazeem, Y. (2017). *A mystery soot has set off an air pollution panic in Nigeria's oil hub city*. Retrieved from https://qz.com/912374/nigerian-city-of-port-harcourt-is-dealing-with-a-mystrey-soot-air-polution-paric

Konijenendijk, C.C., Richard, R.M., Kenny, A. and Randrup, T.B. (2008) Defining urban forestry- A comparative perspective of North America and Europe. *Urban Forestry & Urban Greening* 4: 93-103

Larinde, S.L. (2010): Practical issues in urban forest establishment and management In: Ijeoma, H.M. and Aiyeloja, A.A. (Eds). *Practical issues in forest and Wild life Resource management.* Port Harcourt. Green canopy consultants

Lodha, R.M. (2007): *Academic's dictionary of geography.* New Dehli. Academic (India) publishers

Mayhew, S. (2009) *Oxford dictionary of geography*. Oxford University Press

National Aeronautics and Space Administration (NASA) (n.d.) *Global tropospheric experiment: probing the chemistry/climate connection.* Washington, D.C. USA

New York Times (2018): Study links 6.5 million deaths Each Year to Air pollution New York Times, New York

Nowak, D.J. (1991) *Urban forest development and structure: analysis of Oakland, California* Ph.D Dissertation. University of California, Berkeley, USA

Nowak, D.J. (1994) Air pollution removal by Chicago's urban forest. In Mcpherson, E.G., D.J. Nowak and R.A. Rowntree. Chicago's urban forest Ecosystem: Results of the Chicago urban Forest climate project. *USDA Forest Services General Technical Report* NE 186.

Nowak, D.J. (1995) Trees pollute? A tree? Explains it all. In Proc. 7th National Urban Conference (C. Kollin and M. Barrat; eds) *American Forests* Washington, D.C. pp. 28-30

Nowak, D.J., McHale, P.J. Ibara, M,. Crane, D., Stevens, J. and Lulley, C. (1998). Modeling the effects of urban vegetation on air pollution. In:

Air Pollution Modeling and its Application XII (s.Grying and N. Chaumeriliac, eds.). New York, Plenum Press. Pp. 399-407

Nowak D.J. (2000) *Tree species selection, design and management to improve air quality*. A paper presented at the 2000 American Society for Landscapes Architects (ASLA) Annual Meeting. Washington D.C.

Nowak, D.J, Civerolo, K.L., Rao, S.T., Sistia, S. Luley, C.J. and Crane, D.E. (2000). A modeling study of the impact of urban trees on ozone. *Atmos Environ.* 34: 1601-1613.

Nowak, D.J. (2002): *The effects of urban trees on air quality.* USDA Forest Service, Syracuse, New York. Retrieved from

Olowoporoku D. (2011) *How clean is the air we breathe*? *A case or National Air Quality Management Framework*. Depart of Geography and Environmental Management, University of the West of England, Bristol, UK.

Owen, D.L. (2000) The glossary of forestry terminology. In: Owen D.L. *South African Forestry Handbook 2000.* SAIF, Pretoria. pp 724-734

Reports (2010). *Worst polluted Org*. retrieved from https//www.wpo.org

Sharma, V.K. (1998): *Trees and the environment*. New Dehli. S.B. Nangia., A.P.H publishing cooperation

Weli, V.E. and Utang, P.B. (n.d.) *Essentials of climatology: An introduction to the atmosphere.* Port Harcourt Arnajov and Coy, Nig.

Wikipedia, the Free Encyclopedia. https://en.wikipedia.org/w/index-php?title=Air-quality-index&solid=825820845

Wikipedia, the Free Encyclopedia. https://en.wikipedia.org/wiki/Air-pollution

World Health Organization (2014): *7 million premature deaths annually linked to air pollution*. WHO. Geneva.

Xu, Y. (2008): *Modeling the effects of roadside trees, results and conclusions.* Report for the London Borough of Harrow. AEA. Harwell, Oxon