TITLE PAGE

INFLUENCE OF SELECTED BOTANICAL GARDEN STRUCTURE, PLANNING AND DESIGN ON ECOSYSTEM SERVICES AND ATMOSPHERIC AIR QUALITY

BY

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CERTIFICATION

I certified that the studies conveyed in this thesis were steered under the supervision of Dr. A.A. AbdulRahaman in the Department of Plant Biology, University of Ilorin, Ilorin, Nigeria. The thesis has been read and accepted as meeting the requirements of the Department and the University for the award of Ph.D. degree in Plant Biology.

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DEDICATION

This work is dedicated to:

The Honour and Magnificence of Almighty God, the sustainer of earth and heaven, who offers life and takes it at, will. He sustained me throughout my research work and even beyond.

My Late Parents Chief (Pa) Micheal Alabi Adeseko and Mrs Abigeal Alabi Adeseko.

My wife, Mrs Grace Bosede Alabi and my loving children: Joseph Oluwatomisin Alabi, Mary Oluwanifemi Alabi and Martha Oluwatobilola Alabi.

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ABSTRACT

Pollution due to smoke, dust and other pollutants posed serious challenges to atmospheric air and human health. The study was to investigate the influence of selected botanical garden structures (BGS), planning and design on Ecosystem services (ESS) and atmospheric air quality (AAQ) in Lagos, Ibadan, Akure, Ilorin, Kano and Jos universities botanical gardens (BG) in Nigeria. The objectives of the study were to: (i) identify and determine landscape status (LS) of tree species (TS); (ii) identify tree crown characteristic indices (TCCI) for shade and shelter; (iii) determine TS air pollution tolerance index (APTI); (iv) determine level of air quality index (AQI); and (v) design BGS prototype with TS that can enhance provision of ESS.

Study areas were divided into several plots using transects lines for TS and lichens (L); samples were collected from each plot, frequency values (FV) for TS and L were used to determine the LS. Cluster analysis (CA) of the TS and tree crown characteristics indices (TCCI) were performed, by assigned codes 1 – 6 to the taxonomic character (TC) in ascending order according to the observation and measurement. Ascorbic acid, relative water content, pH and total chlorophyll were evaluated from fresh leaves; values obtained were used to calculate APTI. Pollutants and metrological parameters were determined using standard methods and weather equipment; validated with LaMotte air-sampler for inside-outside BGs AQI during dry (DS) and rainy seasons (RS), obtained values were used for AQI and correlation analysis. Layout plan (LP) was used to design a complete BGS, planting and leaf morphology (LM) plans, based on computer- aided architectural design (CAAD).

The study revealed that:

i. TS of 180 belonging to 25 families (F) were represented in the study areas, LS showed abundant (16F) and rare (9F). FV ranged from 9.71 to 0.94 TS and 8.95

to 0.01 L of good and moderate level of AAQ. Moraceae has the highest numbers of TS (19) accounting for 10.56% LS of TS;

ii. CA of TS in the 6BGs gave percentage clusters of 63%, outliers 37% and TCCI ranged from 3 to 7 and 1 to 2.67 for shade and shelter respectively;

iii. APTI for *Mangifera indica* has high value of tolerance 29.46 in all the BGs, while sensitive species *Ficus bengamina* has lowest value 5.91;

iv. DS and RS AQI ranged from of 34.49 to 40.47 and 31.36 to 37.52 (inside BGs) and 84.60 to 96.38 and 74.38 to 84.82 (outside BGs). However, significant difference $p \leq 0.05$ existed among the BGs, pollutants and AQI;

v. BGS prototype designed by CAAD ranged from LP, building 9825mm by 19870mm, planting and LM plans for TS family of Apocynaceae, Moraceae, Araucariaceae and Mimosaceae as sensitive species and Anacardaceae, Meliaceae, Annonaceae and Mytaceae as tolerant species.

The study concluded that, TS families of Apocynaceae, Anacardiaceae, Meliaceae, Moraceae, Mimosaceae, Myrtaceae and Araucariaceae out of 25F were good candidates for ESS such as: lichens occurrence, shading, pollutant removal and AQI improvement by BGS. The BGS is therefore, recommended for provision of ESS to the society.

CHAPTER 1

1.0 INTRODUCTION

1.1 Background to the study

The word garden rooted in two Hebrew words “gan” and “oden” meaning to shelter and inclination or utopia when the two words are combined, it means the enclosure of land for inclination and amusement.

A botanical garden (BG) is a well-ordered and staffed establishment for the conservation of plants under scientific administration for purposes of education and research, in association with libraries, herbaria, laboratories, and museums as are essential to its particular enterprise. Each botanical garden generally cultivates its own special fields of interests reliant on its personnel, location, extent, available funds, and the terms of its charter. It may include greenhouse, a herbarium, an arboretum and other divisions of grounds. It maintains a scientific as well as a plant-growing staff, and publication is one of its major means of communication (Bailey and Bailey, 1978).

Botanic gardens were the initially scientific gardens in Europe. The first was set up in Pisa in 1543, followed quickly by another at Padua in 1545. There followed the establishment of gardens in Florence, Bologna, Pavia, Leipzig and then Leiden, in 1590. Botanic gardens did not appear in Britain until 1621, when one was laid out at oxford, followed by Edinburgh 1670, the Chelsea Physic Garden 1673 and Glasgow 1705. All these gardens, during their early years of being, were physic gardens, in which medicinal and poisonous plants were grown as reference gatherings for medical students. This early gathering in which the emphasis was on the correct naming and classification of plant set the design of research in botanic garden thereafter. With the exclusion of the Chelsea Physic Garden, which was outing by the Worshipful Society of

Apothecaries, all were attached to the medical schools of ancient universities. (Bown, 1992; Desmond, 1995; Hill, 1915; Young, 1987)

As time went by, the curators of the botanic gardens, feasibly feeling circumscribed in their nursery by the needs of medicine, began to acquire a much wider range of plants to grow, in part to increase the desirability of their gardens, but also to demonstrate plant diversity. ‘Rare’ and ‘Exotic’ plants were especially valued. With the gradual alienation of the study of botany from medicine in the late eighteenth and early nineteenth centuries, botanic gardens keen to the study of plants and plant diversity in their own right were established in other universities: Cambridge in 1760, Glasnevin (Dublin) in 1796 and therafter in other universities in the UK and around the world throughout the19th and 20th centuries (Oldfield, 2007; Elliott, 2004; Thanos, 2005 and Ingram *et al*., 2008).

Botanical gardens are often run by universities / scientific research establishments and often have linked herbaria and research programmes in plant taxonomy or some other aspect of plant science. In opinion their role is to keep documented groups of living plants for the purposes of scientific research, preservation, demonstration (recreation, outdoor dramatic and musical concerts) and education, although this will depend on the resources available and the special interests trailed at each specific garden.

The“New Royal Horticultural SocietyDictionary of Gardening” 1999 points out that among the various kind of establishments now known as Botanical Gardens there are many public gardens with little scientific activity, and it cited a more abbreviated definition that was published by the world wild fund and IUCN (International Union for Conservation of Nature) when launching the “Botanic Gardens Conservation strategy” in 1989. This has been further reduced by Botanic Gardens Conservation International to the definition which “encompasses the spirit of a true botanic garden (WyseJackson and Suther land, 2000; WyseJackson, 1999), that abotanic garden is a garden enclosing scientifically ordered and conserved collections of plants, usually documented and labeled, and opened to the public for the purposes of recreation, education and research (Huxley, 1992).

Over the years botanical gardens, as cultural/scientific organization, have responded to the interests of botany and horticulture. Currently most botanical gardens show a combination of the themes mentioned and more: ensuring a sturdy connection with the general public. There is outlook to provide visitors with information relating to the environmental issues being faced at the start of the 21st century mainly those relating to plant conservation and sustainability.A botanical garden is an establishment holding documented collections of living plants for the purposes of scientific research, conservation, display and education (WyseJackson, 1999). Green infrastructure (GI) is a term that is appearing more and more frequently in land conservation and development discussions across the country and around the world. It means different things to different people depending on the circumstance in which it is used. For instance, some people refer to "trees" in urban landscape areas as green infrastructure because of the "green" benefits they offer, while others use green Infrastructure to refer to engineered structure (such as water treatment facilities or green roofs) that are designed to be environmental friendly (Benedict and McMahon, 2002). It can take a number of forms, and can offer a wide variety of what is known as Ecosystem Services (ESS). Some of the ecosystem services that can be provided by green infrastructure include the following: Social such as visual and aesthetic value of trees in an urban landscape. Economic values such as tree status in urban landscape. Environmental such as climatic modification which include: temperature reduction, shading, climatic change mitigation, pollutant removal and air quality improvement.

Green infrastructure can be braced through strategic and co-ordinated enterprises that focus on maintaining, reestablishing, improving and linking existing areas and features, as well as forming new areas and features (Naumann and McKenna, 2011). Green infrastructure is an evolving concept, based on the awareness that natural systems can provide a range of engineering and human services to the city, known as “Ecosystem Services” (Bolund and Hunhammer, 1999; Nowak and Dwyer, 2007; Pataki and Carreiro, 2011). The model is thought to have originated from the United State in the 1990s, stressing in the “life support” roles provided by the natural environment. Green infrastructure can provide a range of concrete environmental services, including stormwater management, air quality improvement, carbon sequestration, and mitigation of urban heat effects. However the green infrastructure concept also embraces the more anthropogentric functions of the natural environment, including those related to human social, recreational and cultural values. For instance green infrastructure has been termed as an interconnected network of green space that protects natural ecosystem values and functions, and provides related benefits to the people (Benedict and McMahon, 2002).

Green infrastructure can play a significant role in improving air quality in cities, poor air quality is a concern in many urban areas, due to a combination of population growth and urbanization, and increased pollutant emissions due to industrialization and the use of transport based fossil fuel. Urban heat island effects increase overall electricity demand, as well as peak demand usually occurring on hot summer weekday afternoons. During great heat events (exacerbated by the urban heat island effect) the subsequent demand for cooling can overwork supply systems and lead to blackouts, or controlled blackouts to avoid power outages. Research shows that electricity demand for cooling increases by 1.5-2.0% for every 0.6^{o}C increase in air temperatures suggesting that 5-10% of community demand for electricity is to compensate for the urban heat island effect (Akbari, 2005). Electricity supply normally relies on fossil fuel power plants, which in turn leads to an increase in air pollutant and greenhouse gas emissions. The primary pollutants from power plants include sulphurdioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), and mercury (Hg). These are both dangerous to life and health of the people, and contribute to complex air quality problems including the formation of ground-level ozone (smog), fine particulate matter, and acid rain. Increased use of fossil-fuel by power plants also increases emissions of greenhouse gases, such as carbondioxed (CO_2) which contribute to global climate change (EPA, 2012).

Furthermore, to impacts on energy-related emissions, increased temperatures can also directly increase the rate of ground-level ozone formation (formed when NOx and volatile organic compounds (VOCs) react in the presence of sunlight and hot weather). At large more smog will form as the environment becomes sunnier and hotter. Air quality is the degree to which air is unpolluted enough to fulfill the requirement of various uses, air pollution, and addition of harmful substances to the atmosphere resulting in damage to the environment, human health, and quality of life. One of the numerous forms of pollution, air pollution happens inside homes, schools, and offices; in cities; and even globally. Air pollution makes people sick, it causes breathing problems and promotes skin cancer-and it also damages plants, animals, and the ecosystems in which they live. Some air pollutants return to earth in the form of acid rain and snow, which oxidize statues and buildings, harm crops and forests, and make water in the lakes unsuitable for fish and other plant and animal life.

Pollution is changing earth`s troposphere, stratosphere, mesosphere and thermosphere so that it lets in more injurious radiation from the Sun. At the same time, our contaminated atmosphere is becoming a better heat-proofing, preventing heat from radiating back into space and leading to a rise in worldwide average temperature. Scientists envisage that the temperature increase, referred to as global warming will affect world food supply, alter sea level, make weather more extreme, and upturn the spread of tropical diseases (Hart, 2008).

There are varieties of ideas as to the nature, relevance and purpose of botanical gardens or green infrastructure. Bailey and Bailey (1978) have endeavored to clarify the usage of the term by pointing out the peculiarities implicit in using the word “Botanical Garden” as a concept (controlled and staffed institution), as a scientific idea (collection of plants), and as an educational services (Scientific management and research), (Bolund and Hunhammer, 1999; Nowak and Dwyer, 2007; Pataki and Carreiro, 2011; Benedict and McMahon, 2002). Green Infrastructure is an evolving concept, based on the understanding that natural systems can deliver a range of industrial, technological and social services to the city, known as “ecosystem services”. The concept is thought to have been created in the United States in the 1990s, stressing in the “life support” functions provided by the natural environment. Green infrastructure can provide a range of tangible environmental services, including stormwater controls, air quality improvement, carbon seizure, and mitigation of urban heat effects. However the green infrastructure concept also includes the more anthropogentric functions of the natural environment, including those related to human social, recreational and cultural values. For example, it has been described as a consistent network of green space that preserves natural ecosystem values and functions, and provides allied benefits to human populace.

In recent times, there has been increasing awareness of individuals, stakeholders and governments on the importance of maintaining the biodiversity of plant Earth as well as the promotion of activities that ensures that upcoming generations will inherit a cleaner, greener and more ecologically sustainable environment. The interconnections of universities and research institutions on green infrastructures, especially issues related to botanical gardens chain with the natural world are presently recognized. Accordingly, the breeding of new plant varieties, development of greenhouse and nursery services for rising foliage and flowering plants, food crops, herb crops and their management are presently seen as a hopeful strategy towards saving our green earth in the area of air quality enhancement (Egbule, 2013).

In the story of creation, as recorded in Genesis 1: 8-13

> "Then God commanded, let the water below the sky come
> Together in one place, so that the land will appear and it was done.
> He named the land "Earth" and the water which had come together.
> He named "Sea …. He commanded, let the earth produce all kinds of
> Plants, those that bear grain and those that bear fruit and it was done.
> So the earth produced all kinds of plant, and God was pleased with what he saw".
> And the Lord planted a garden eastward in Eden; and then He put the man
> Whom He had formed… And out of the ground made the Lord God to grow
> Every tree that is pleasant to the sight, and good for food.

Hence, God created the universe and everything including plants before man was introduced on earth to enjoy and maintain them. Therefore, history and every civilization show that plants were the main source of food, clothing, medicine and shelter to man. The botanical gardens of the 16th and 17th centuries were medicinal gardens but the idea of a botanical garden changed to incorporate displays of the beautiful, eccentric, and sometimes economically important plant. Later, in the 18th century they became more educational in function, demonstrating the latest plant classification systems conceived by botanists working in the associated herbaria as they tried to order these new treasures. Then, in the 19th and 20th centuries, the trend was towards a combination of professionalof various groups demonstrating many features of horticulture and botany (Hill, 1915). Ancient Chinese documented the many uses of plants, while the collection of plants was an important activity in Egyptian military, the Christian priest in Europe used plants and flowers as teaching tools and the Greeks excelled in their resourcefulness of plant superstitions. The Victorian times saw the wealth in several countries using flowers and plants for ornamental purposes and often paying vast sums of money to collect, house and use them. Also, the industrial revolution and urbanization saw more people moving toward cities. They began to use plants as adornment for their surroundings, also as reminder of their rural heritage and to improve air quality.

Between 1543 and 1901, botanical gardens became conspicuous magnificent possessions, the current global blowout of Botanical Gardens is very different as displayed left; with over 500 botanical gardens found in Western Europe – 130 of them found in Great Britain, 350 in North America, and around 200 Botanical Gardens in East and Southeast Asia, most of which are found in China and most Southern Asian Botanical Gardens found in India (BGCI, 2010), this spread ambiguously indicates the influence of colonial Britain.

By the early 19th century Europe were receiving a flood of flora from overseases, which were scientifically categorized, grouped in beds according to their families, and beds were sometimes even arranged taking into consideration the line of evolution from one family to another. Likewise, wavy conservatories were designed in order to effectively conserve tropical species; some species were dried, conserved and kept in a building called herbarium. In the 18th century Sir Joseph Bank started the creation of colonial gardens, after the awareness of the economic value of foreign flora, these colonial gardens operated as bases for plant hunting and acted as experimental gardens to find any species which could lead to colonial economic development. By the turn of the 20th century there were four botanical gardens essential to the British Empire: Calcutta, Pamplemousses on Mauritius, Peradeniya on Ceyon and Trinidad. They were part of a botanical network centres across the Royal Botanical Gardens, Kew, across Europe, and other large centres across the globe such as Rio de Janeiro, swapping scientific botany. Kew was the central herbarium for the British Empire, where the majority of flora was named and classified. Behind the public aesthetic value of botanical gardens serious scientific and horticultural work was and is carried out; taxonomy and classification. This work has been vital for the conservation and survival of many flora species and has created a solid foundation for the environmental conservation movement of the late twentienth century. Now botanical gardens take great responsibility in educationg the public on the inter-relations of the world's systems, its brittleness and on conservation issues (Mintz and Rode, 1999; Willison, 1997).

Botanic Gardens Conservation International (BGCI) defines "Botanic Garden as an institution holding standard collections of living plants for the purposes of scientific research, conservation, display and education". John Brookers in his book title "Rooms Outside" painted the picture of early men garden when man first attempt not to be normads and settled in one place that his instinct was to surround himself with protective wall thus he built circular barriers round his abode probably of thorns or shrubs (BGCI, 2010). Later man started grouping of plants into rows and this was followed by crude form of irrigation in linear requirement of his tools and eventually developed his organization into squares and rectangular forms characterized by most early gardens. The real concept of garden as we know today originated from the myth of the society and the real design i.e the layout and organization seems to initiate from ancient cultivation and irrigation practices. With regard to folklore the popular religions both **Christianity and Islam** define garden as a form of paradise. Muslim describes it as the commencement and the end of life on earth. The promised garden of Muhammed was said to be filled with groves of trees and fountains where pleasure which lasted for a brief moment on earth will be prolonged thousand years. The Christian considered that man was created and put in the Garden of Eden a form of worldly paradise. The following section provide an over view of the development of gardens in different cultures such as: the ancient Egyptian, the Persian, ancient Greeks, the Romans, the Italian, the Frence, the Chinese and the English garden style with respect to known civilization and that of the Nigeria. With the colonization of Nigeria by the British has come the infusion of foreign and exotic garden style into the traditional styles. However, the above subject heading proposes that there is truly a Nigerian garden style or styles that could be attributed to the several cultural groups notably the Yoruba, Hausa, Igbo, Kanuri, just to mention a few (Falade and Oduwaye, 1998).

The earliest forms of European gardens in West Africa predate the era of colonization. They were the gardens and plantations developed around the Trading Forts constructed by the European merchants mainly from Holland, Denmark, Sweden, Germany and England, dating from the 15th century. They were mostly serviceable gardens, being devoted mainly to the cultivation of exotic food crops and fruit trees. The few of them established as ornamental gardens had summer houses which were built for the resident governors and on times were used for holding garden parties. During this time, the forces taste influential to the development of Renaissance gardens in Europe were already at work. As such, some of these early gardens had qualities of the garden styles peculiar to the countries of the European merchants who pioneered them. Prominent examples of these gardens were those at Cape Coast Fort and Dixcove Fort. Fragements of these gardens are still preserved in places around the Forts (Falade, 1985). Until the era of colonization, these early European gardens had little influence in most parts of West

Africa except the then Gold Coast (the modern Ghana) where most of the Trading Forts were focused. Thus, the development of modern landscape in Nigeria can be ascribed to the effort of the colonial masters although this might have been inspired by their own selfish desires. Following the ceding of Lagos in 1861, the British colonial masters took over the affairs in Lagos. However, Mr Mckoskry, was to have opened up the prospect of the Lagos Marina towards the lagoon and turned the area into a pleasing and beautiful walk, thus making it very different from other parts of Lagos (Miller, 1963; Falade and Oduwaye, 1998). During the time of Governor Glover he built many fine buildings, established many trees and the foundation of modern Lagos could be ascribed to him. In 1886, Sir Alfred Moloney became the first governor of an independent Lagos colony and the appropriated Southern Protectorate. Governor Moloney was a horticulturist trained at Kew Gardens, Kew, before he became the governor. As a Kew gardener, Governor Moloney had started a model nursery on the sites of the Old Debtors Prison at Okokomaiko, Lagos Island. Here, he succeeded in raising many plants including "*Cacao thebroma*, *Coffee* spp, *Tamarindus indica*, *Mangifera indica*, *Borassus* and the bread fruit". His notable contribution was the establishment of the Lagos Botanical Garden.

Governor Moloney led the establishment of the Lagos Botanical Station in 1887, which was the first of its kind in the then British West Africa and by so doing he made leading contribution to horticulture in Nigeria. Mr. Morris, of Kew gardens London, enthusiastically supported the development of the station. Another active supporter of Sir Moloney in Nigeria was Sir Rowland Ross, the Assistant Colonial Surgeon, who was also a courtesan of gardens (Russel, 1957; Falade and Oduwaye, 1998). The Lagos Botanical Station was developed on a site of approximately 4 acres (1.52ha) being the former complex of Bishop Crowther the present site of Iddo Railway Terminus. Mr. James McNair, a Jamaican, was trained at Kew garden and seconded to the Hope Botanical Gardens, Jamaica as the first administrator of the station. He was assisted by Mr. T.B. Dawodu, a Yoruba man. From the above-mentioned, it is perhaps true to say that the colonial administrators devoted more exertion to the development of private and institutional gardens than public gardens. At first, their contributions were in form of gardens developed around their homes. Later, they extended their efforts to the enhancement of urban landscape and environmental health. Other private club recreation grounds such as race courses, golf courses and polo ground were established in urban centres which accommodated a relatively large population of colonial administrators, European miners, merchants and industrialists. Although the development of public parks was almost intermittence in all towns except in a few selected colonial new towns. The exclusions are the Government Gardens of Sokoto constructed in 1918 and the Lauzu Park, Bida established in 1950. Both stood out as two examples of the early aids of colonial administration to Public Park and garden improvement in Nigeria (Duckworth, 1950a; Mackenzie, 1959 and Falade, 1985).

Nevertheless, the first Botanic garden to be recognized in Nigeria University was in University of Ibadan, established in 1948. Botanical gardens must find a conciliation between the need for peace and solitude, and content the demand for information (Ecosystem Service) and visitor services including restaurants, information centres and sales areas that convey with them pollution, rubbish, noise and hyperactivity. Good-looking landscaping and planting design sometimes vie with scientific interests – with science now often taking second place. Some gardens are now culture landscapes that are subject to continual demand for new exhibits and prototypical environmental management. The concept of ecosystem service is vital to an understanding of botanical gardens/green infrastructure, and is germane at range of scales from the global to the local. Ecosystem services are the benefits provided to humans through the conversions of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of needed goods and services e.g clean air, water, and food (Costanza, 1997). It can also be defined as the circumstances and procedures by which natural ecosystems, and the species that make them up, withstand and satisfy human life (Daily, 1997). A growing responsiveness developed in the 1990s that healthy ecosystem provide goods and services that benefit humans and other life. Work by eminent scientists such as Ehrlich, Daily, Kennedy, Matson, and Costanza helped to support this groundswell of environmental responsiveness (Daily, 1997).

Concern has been growing over the last half century as mark of decline in the world's ecosystems grows and ecologists and other social scientists discuss the underlying socio-economic causes. More than ever before in the history of man, people living in cities have lost their awareness of their dependence on natural ecosystems for food, regulation of air quality, atmosphere and climate, sanitization of water, provision of building and raw materials for industry, protection from pests, diseases and extreme weather, and for cultural, spiritual and intellectual inspiration and contentment. In response to the concerns the United Nations commissioned a global study called the Millennium Ecosystem Assessment (MESA), which was steered by an international consortium of governments, non-profit organizations, universities, and businesses. The group's report, published in 2005, stated that "ecosystems are dire to human welfare, to our health, our prosperity, our security, and to our social and cultural identity" (Millennium Ecosystem Assessment, 2005). Today the relationship between environmental well-being, human well-being, and economic prosperity remains to be part of mainstream political discussion (Mainka and McNealy, 2008). Some of the ecosystem services that can be delivered by the botanical gardens/green infrastructure include: Economic, Environmental and Social. In the last decade, broad research has been undertaken supporting the triple bottom line “economic, environmental and social benefits” (McPherson, 1995; Staley, 2004; McPherson, 2005; Nowak and Dwyer, 2007; Macdonald and Supawanich, 2008; Clark and Matheney, 2009; Bankole, 2000; Kehinde, 2002). A number of studies have endeavored to quantify the economic benefits (Landscape Status) spawned by an individual tree, or the shared value of the ecosystem services provided by an urban forest (Coder, 1996; MacDonald, 2008).

Trees species are essential in Nigeria. There species are widely extent in tropical Africa and grow wild in tropical West Africa (Keay, 1990; White, 1983). In Nigeria, they are frequently found in the southern part of the country where they occur in rainforest, forest environs and derived savanna where the rainfall and relative humidity are mostly high. Most of the uses to which the trees are being put are based on their Landscape status (Morphological and Woody parts). As we cannot study all tree plants, we must select those which are of immediate value; this method involved the use of transect line with thirty (30) different transect lines of 10m x 10m established in each garden. The transect line method, known also as the sample-plot method, is a basic for many types of ecological study. It received the name “transect line method” from the squares used as sample plots by F.E.Clements in 1898. The name “sample plot” is, conversely, the name used more generally by agronomists and other workers, in both the plant and animal field as well as in other forms of statistical work. The basic principle fundamental to the method is the saving of time and labour by selecting, in accordance with a specified plan, sufficient sample plots or quadrats to give data which will depart in no substantial way from the data that would have been obtained if the complete area had been studied. The determination of the best size and the best number of sample plots is an exercise in itself but will need to be made for each type of work, complement a set of listed quadrats there should be a note concerning the general layout of the land, type of soil, slope, and various other features. (Braun-Blanquet, 1932; Gates, 1949; Alabi and Oladele, 2010; Oladele *et al*., 2013; Clements and Weaver, 1938). The presence i.e (occurrence) of the selected species in the quadrats was documented and the frequency distribution of the tree species was determined. Different system of relationship methods that are objectives, obvious and repeatable, based on the thoughts first put forward by Michel Adanson provides the basis for Numerical Taxonomy (Hawksworth, 1988; Rohlf and Sokal, 1981; Carper and Snizek, 1980).

Biologists may have to get the knowledge of using different classification, based upon different sets of characters, each best for its own special purpose, with overall similarities based on the total character set existing at any one time. A major difficult in cluster analysis is that there is no collective agreement on what constitutes cluster, and most sleuths think that clustering methods depend on the cluster to be found. Also, it is important not to cluster one's data dimly, but to improve techniques of clustering which allow one to check the fairness of the clusters for the data to which it is applied, henceforth hierarchic classificatory system as a solution. Cluster analysis is a suitable method for identifying identical groups of objects called clusters. Objects (observations) in a specific cluster share many features, but are very different to objects not belonging to that cluster. Imagine that you are interested in identify your plants base in order to better target them through, for example, classification approaches. The first step is to decide on the characteristic (qualitative or quantitative) that you will use to classify your plants. In order words, you have to select which clustering variables will be involved in the analysis, however an objects in a certain cluster should be as similar as possible to all the other objects in the same cluster, it should also be as dissimilar as possible from objects in different clusters. But how do we quantity similarity? Some approaches – most notably hierarchical methods – require us to specify how similar or different objects are in order to identify different clusters. Most software packages, for example PAST calculate a measure of (dis)similarity by estimating the distance between pairs of objects. Objects with lesser distance between one another are more similar, while objects with larger distance are more dissimilar. Hierarchical clustering measures are characterized by tree-like structure called Dendrogram proven in the course of the analysis (Street, 1978; Sneath and Hansell, 1985; Sneath and Chanter, 1978; Sokal and Shao, 1985; Sokal and Sneath, 1973; Alabi and Oladele, 2010 and Sneath, 1989).

The source of a hierarchic classificatory system from dissimilarity co-efficient is a two-stage process. The study will limit itself to the first stage. First stage is the derivation of a dendrogram; a dendrogram may be described offhandedly as a hierarchy with numerical levels. The points at which each pair of objects meet in a dendrogram, the splitting-levels, are determined by the dissimilarity co-efficient from which the splitting-levels are determined depends upon the cluster method used (Sneath, 1996). Likewise, we may wish to be able to compare the goodness of fit (Economic values and Biodiversity value) of tree species in the Landscape. Accordingly, Roetman and Daniels (2008) defined “biodiversity as a term used to describe all living things and the variant within and between them. It comprises plants, animals, fungi, and micro-organisms, and can be measured at various levels of complexity”. These include: Genetic, Ecosystem, and Species Diversity. Nigeria has over 800 species of algae, about 200 lower plants (bryophytes), 150 ferns and over 5000 higher plants, about 205 of them endemic (FEPA, 1992; Okali, 2010). Plants are the primary sources of food and are central to national food security. Understanding of plants, their habitats, structure, metabolism and heritage is thus the basic footing for human survival and the way people integrate plants into their religions, cultural behaviors and even cosmologies reveals much about the people themselves.

Some environmental crises such as greenhouse effect that leads to global warming and biodiversity loss at their core involve plants. It could be that we are so closely interconnected that humans often take plants for granted. Evolutionarily, plants have defined our “life zones” and through them we continue to have life and it now looks as if we still have to dig deeper (biodiversity conservation) than ever before into them to seek resolutions to our environmental difficulties (Okali, 2004; Isichei, 2010).

1.2 Statement of problems

The significance of botanic gardens lies in the fact that they are the holders of groups of living plants, ideally, but not always, sourced from wild. These collections have been made up for various purposes: medicine, education, display, landscaping, recreational and conservation, but all are buttressed by documentation concerning the origins of plants that comprised them. Nigeria vegetation is one of the most gifted in Africa, as almost all vegetation types that exists in other Africans countries are found broadly distributed in diverse geopolitical zones of the country, this is favoured by the variants in climate and geographic features, which harbours about 7895 species of plants; in terms of biodiversity this makes it as one of the richest nations in the continent (Adeyemi and Ogundipe, 2012; Pelemo *et al*., 2011). Though, these habitats are under threat from evolving civilization and other untenable human activities, the approach of the populace towards conservation is relatively poor; thereby occasioning to inexorable loss of genetic resources at all levels. Unarguably, one of the insistent problems linked with deforestation is the selective utilization of some targerted species for economic, social and spiritual paraphernalia, and trees are frequently targerted. Preferably, conservation of biodiversity is supposed to be fundamental responsibility for all mankind. (Adeyemi and Ogundipe, 2012; Pelemo *et al*., 2011; IUCN, 2010; Alamu and Agbeja, 2011; Kabiru, 2008;

Nodza *et al*., 2014). Thus, to curb this entail scientific tree conservation strategies intended at improved burning of fuel wood and maximized use of timber products as harmonizing efforts to enforced tree planting for conservation of our forests (Ogunkunle and Oladele, 2004).

Protecting our environment is an onus not a choice if man is to continue surviving on the most habitable planet "earth". Pollution is a global problem, to curb it we must think globally but act locally, hence the influence of selected botanical garden structure, planning and design on ecosystem services and atmospheric air quality set the general direction for research thereafter. There is no doubt that the climate is becoming warmer, a warning that changes are taking place in our environment. The world forests and other economic trees are been removed without replacement leading to global warming (Saidu *et al.,* 2007). The average temperature of the earth's surface increased by an estimated $0.6^{O}C$ in the 20^{th} century (Aneni, 2007). Carbondioxide in the atmosphere traps heat and warms the earth surface and other gases also trap heat as do clouds (Magagi *et al.*, 2007). Accumulation of CO_2 and other green house gases lead to increased temperature of the earth. Environmental pollution results from human actions such as industrialization, transportation, improper waste disposal, logging urbanization etc (Mulgrew and William, 2005).

Vehicular releases and air pollutants in Nigeria due to traffic are believed to have instituted severe health problems especially in cities where pollution levels are on the increase. Pollution due to traffic constitutes up to 90-95% of the ambient CO_2 levels, 80-90% of NO_2, hydrocarbon and particulate matter in the world, posing serious threat to human health (Savile, 1993). For example, NO_2 is responsible for immune system impairment, exacerbation of asthma, chronic respiratory diseases, reduced lung function and cardiovascular diseases. Particulate matters are hazardous and are linked as expediters in the development of lung cancer and increase rate of mortality (Lawani *et al.*, 1996). Likewise damage to agricultural crops from air pollution has been projected very high. This does not include the damage done to ornamental plants, which contribute greatly to the quality of the environment.

Air pollution is the fourth highest threat factor for death globally, poor air quality kills 5.5 million worldwide annually and by far the foremost environmental risk factor for diseases (Brauer, 2016). Similarly, the world Health Organization evaluate that PM contributes to approximately 800,000 premature deaths each year and 6.4 million lost years of healthy life in cities (Brauer *et al*., 2012). In Canada, about 10 million people live in areas where they are wide-open to traffic-related air pollution. Assessments suggest approximately 21,000 premature deaths are linked to air pollution each year (Brauer *et al*., 2013). Thus, the need for science entreprenurship and roles of botanical garden structure in reducing air pollution tend to an incredibly efficient way to improve the air quality and cleaning up the air we breathe inorder to prevent noncommunicable diseases as well as reduce disease risks such as cardiovascular diseases, strokes, ischaemic heart diseases and cancer.

1.3 Justification for this study

This work is therefore derived from the fact that although some works had been done on ecosystem services and “air pollution” or quality of air but these are far from being adequate in relation to the enormity of the pollution problems. The persistent emission of various gaseous and particulate pollution into the atmosphere, would gradually reach unbearable levels if some means of “Cleaning the air” is not employed. Under natural conditions smoke, dust and other solid pollutants are removed by dew, rain, as well as by sedimentation and by adsorption of the pollutants into objects such as plants. Gases are enthralled by vegetation, soil and water. It is vital that this means of removing impurities be used or life would soon become impossible over parts of the earth.

Reformative design is the biomimicry of the biological system describing processes that restore, renew or revitalize their own sources of energy and materials, creating sustainable systems that incorporate the needs of society with the reliability of nature. It is also an outline to biological systems that can heal cities and its inhabitants through bioremediation, living architecture (Plant Architecture), and innovative water management with emphasis on an overview of urban toxicology, environmental issues, environmental justice, phytoremediation, biofiltering, use of plant species and tree, grass, plant selection for pollution reduction.(Lyle, 1994; Thayer, 1994; McDonough, and Micheal, 2001)

Though one's first thoughts about air pollution are likely to be of its harmful effects on plants, an ignored aspect of the relation among plants and pollution is the potential controlling effects that plants may have as "natural filter" of the atmosphere. If it can be shown that plants are effective filters, then it would be sagacious to use vegetation in strategic areas as a way of cleaning the air for humans to breathe. Obviously, pollution cannot be permissible to reach toxic levels or the plants would not be able to survive. Hence, plants should be thought of as a primary filter, secondary filters being anti pollution devices installed at the source of release of the pollutant.

Often, we are reminded that plants come from the plants of ocean. However, planting greenbelts around cities or along highways can add significant amounts of oxygen to the immediate environment, which frequently contain a higher level of auto-exhaust fumes than is required. Though, pollutants are usually classified as only those substances which are added in amount adequate to cause determinate effects on human beings, other animals, vegetation or material.

It is estimated that each year between 250 and 300 million tons of air pollutants enter the atmosphere. In the United State of America a direct result of human activities and the annual emission estimate for Sulphur dioxide is put at 130 million tonnes for industrialized Europe, Asia and USA (Foell *et al,* 1975; UNECEP, 1994). Internationally, combustion processes emit an estimated 163 million tons on the basis of NOx while Environmental Protection Agency (EPA) estimates that nearly 23million tons of NO_2 are released annually into atmosphere of United States arising mainly from human activities. The pollutants acting in recital rather than distinctly have been implicated in many forms of damage to vegetation materials, aquatic resources, wild life and human health according to (USEPA, 1971). Sulphur dioxide pollution is known to obstruct photosynthesis in lower and higher plants. Reproductive ailments, respiratory and cardiac problems in humans have also been traced to sulphur dioxide pollution and its main source of acidity in rainfall, which causes a great damage on vegetation and material (Baumbach *et al.,* 1995; Baumbach and Vogt, 2003).

However, studies of botanical garden potential of the indigenous and exotic trees have not been adequately carried out, efforts have been made by some organizations (PROTA , 2012); and individual Foresters, Horticulturists, Plant Architects, Landscape Architects and Botanists (Hawthorn and Gyakari, 2006; Okafor, 2010; Halle *et al*., 1978; Halle and Oldeman, 1970; Gbile *et al*., 1981; Gbile, 1989; Oteng – Amoako, 2006; Isichei, 2010; Mensha, 2010; Adjanahoun *et al*., 1993; Aminu-Kano and Marguba, 2002; Quashie-Sam *et al.*, 2004; Dokosi, 1998; Odugbami, 2008; Abbiw, 1995; Aliyu, 2006a, 2006b; Burkhill, 1995; and Okali, 2004) to largely classify local trees into various landscape uses and ecosystem services in term of functional and aesthetic values for air quality benefit, for example, shade and shelter, avenue, hedges, medicinal, afforestation and erosion control from ethno-botanical methods such as conservation (endangered plants) and users fondness. Yet the works were remarkable, they lacked the proper arrangement of the Taxonomic Element (Botanical garden, Living and Non-living structures, Landscape status, Ecological and Growth characteristics), Design Element (Colour, Texure, Form and Line) and Principle of Design (Balance, Rhythm, Variety, Repetition, Emphasis and Harmony) by Carpenter *et al.* (1990), Frequency analysis and Clustering Algorithm (Hierarchical, Partitioning, Diversity index, Pollution Tolerance Index and Air quality index) which enables one to determine the relevance of a particular operational taxonomic unit (Botanical Garden Structure) to its usefulness in an ecosystem.

1.4 Aim and Objective

There is a need to fill the gaps in the science entreprenenurship, botanical garden structure, planning and design; conservation of tree species for effective ecosystem services in relation to the enormity of the pollution problems in our society. To this end, the present study is to examine the Influence of Selected Botanical Gardens Structure, Planning and Design on Ecosystem Services and Atmospheric Air Quality. Against this backdrop, the study is therefore set to achieve the following specific objectives namely to:

1. identify and determine landscape status of tree species;
2. identify tree crowns characteristic indices for shade and shelter;
3. determine tree species air pollution tolerance index;
4. determine the level of ambient air quality index;
5. design botanical garden structure prototype with tree species that can enhance the provision of ecosystem services;

1.5 Abbreviations and Acronyms

AA	Ascorbic Acid
AM	Architectural Model
AQI	Air Quality Index
API	Anticipated Performance Index
APTI	Air Pollution Tolerance Index
BDI	Biodiversity Indicator
BG	Botanical Garden
BGCI	Botanic Gardens Conservation International
BGS	Botanical Garden Structure
BVOC	Biogenic Volatile Organic Compounds
CA	Cluster Analysis
CAD	Computer Aided Design
CC	Climate Change
CCC	Civilian Conservation Corps
CFC	Chloro Fluoro Carbon
CO	Carbonmonoxide
CO_2	Carbondioxide
COSU	Cabinet Office Strategy Unit
CVC	Crown Volume Coverage
DBH	Diameter at Breast Height
DI	Diversity Index
ESS	Ecosystem Service

Fig	Figure
GBH	Girth at Breast Height
GI	Green Infrastructure
GPS	Global Positioning System
IEC	Indices of Ecological Continuity
IHI	Index of Human Impact
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LAI	Leaf Area Index
LUC	Land Use Consultant
MESA	Millennium Ecosystem Assessment
NAAQS	National Ambient Air Quality Standards
NESREA	National Environmental Standards and Regulations Enforcement Agency
NIPAAH	National Institute of Plant Architecture and Amentity Horticulture
NO	Nitrogen oxide
NOx	Oxides of nitrogen
NO_2	Nitrogen dioxide
NUC	National Universities Commission
O_3	Ozone
OTU	Operational Taxonomic Unit
PA	Plant Architecture
PAST	Paleontological Statistic Software Application Packages
PCA	Principal Component Analysis

PM	Particulate Matter
ppm	Parts per million
PROTA	Plant Resources of Tropical Africa.
RWC	Relative Water Content
SO_2	Sulphur dioxide
Tch	Total Chlorophyll
TEV	Total Economic Value
UCI	Urban Cooling Island
UNECEP	United Nations Economic Commission for Europe Protocol
USEPA	United State Environmental Protection Agency
VOC	Volatile Organic Compounds
WAC	World Agroforestry Center
WHO	World Health Organization
WWB	World Wide Biodiversity

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Biology of study materials

Tree is well-defined as a large, long-lived woody plant that reaches a height of at least 6m (20ft) at maturity in a given area, and generally, but not always it has a single main self-supporting stem called trunk or bole, which gives off spreading outlets, twigs and foliages to make a crown (Seth, 2002; Ihenyen *et al*., 2009; Redhead, 1971).

Tree species like *Gmelina arborea* is a broad utility timber, being used for structural work, cabinet work and furniture (Deschi, 1981). Apart from the primary use of these tree species, some of the stem bark has medicinal properties and consequently, they are constantly being debarked for herbal preparation against ailment. *Acacia moniliforms* belongs to the family Mimosaceae. It is a tree with bilaterally flattened leaves and twisted fruits, it is propagated by seeds, it requires adequate moisture and abundant light supply, and it contains cyanogenic glycosides and aromatic aminetyramine. It is rich in tannin, hereafter useful in leather industry (Oladele, 2015). *Albizia lebbeck* is a tree compound leaf bipinnate, labrous or slightly hairy on the axis; pinnae in 2-4 pairs, each with 2-11 pairs of obliquely oblong leaflets, shortly stalked; glabrous glands are raised, elliptic to circular, on the upper side of the stalk close to the base and between most pairs of leaflets. *Albizia zygia* is a deciduous tree, tall with a spreading crown and an agile architectural form. Bole tall and strong, bark grey and smooth, young branchlets closely to very thinly clothed with minute crisped puberulence, usually soon disappearing but sometimes persistent, leaves pinnate and broading towards the apex, obliquely rhombic or obovate with the distal pair largest, apex obtuse, leaves are glaborous or nearly so.*Anacardium occidentale* is a medium-sized tree, spreading, and evergreen, much diverged with a smaller crown diameter, leaves simple, alternate, coriaceus, glabrous, obovate, rounded at ends with short petiole, pale green or reddish when young and dark green when mature. The inflorescence is a terminal panicle-like cluster usually bearing male and hermaphroditic flowers. *Annona muricata* is a slight, evergreen tree, trunk straight; bark smooth, dull grey or grey-brown, rough and fissured with age; inner bark pinkish and tasteless; branches at first ascending with the crown forming an inverted cone, later spreading; crown at maturity spherical due to lack of apical dominance; twigs brown or grey, flower terminal or lateral, large; stalks stout. *Annona senegalensis* is a shrub or small tree; bark smooth to roughish, silvery grey or grey-brown, with leaf scars and roughly circular flakes divulging paler patches of under bark. Young branches with dense, brown, yellow or grey hairs that are lost later. Leaves alternate, simple, oblong, ovate or elliptic, apex rounded or slightly notched; base square to slightly lobed; margin entire; petiole short. *Azadirachitaindica* is a small to medium-sized tree, generally evergreen, tall, with a round, large crown; branches spreading; bole branchless, sometimes grooved at base; bark moderately thick, with small, dispersed tubercles, deeply fissured and crusty in old trees, dark grey outside and reddish inside, with colourless, sticky foetid sap. Leaves alternate, crowded near the end of branches, simply pinnate, exstipulate, light green with 2pairs of glands at the base, else glabrous; petiole long, subglabrous; rachis channeled above. Inflorescence, an axillary, flowers bisexual or male on same tree. Fruit seeded drupe, ellipsoidal, long, greenish-yellow to yellow or purple when ripe; exocarp thin, mesocarp pulpy, endocarp cartilaginous; seed ovoid or spherical; apex pointed; testa thin, composed of a shell and a kernel (Orwa *et al*., 2009). *Adansonia digitata* is a large, round canopied tree with a swollen trunk; bark is soft, smooth, fibrous, and reddish-brown. Leaves alternate, digitately; leaflets oblong to ovate, flowers a waxy white, axillary, solitary, pendulous, bisexual. Fruit ovoid with a hard, woody shell, covered with yellowish-grey velvety hairs, indehiscent; seed smooth, embedded in a whitish powdery pulp, have little or no endosperm. The name venerates the French botanist Michel Adanson (1727-1806), who lived in Senegal for 6 years and wrote a work on that country's natural history. Linneaus dedicated the genus and species to him; 'digitata' means hand shaped, referring to the shape of the leaf. (Abbiw, 1990).

Balanites aegyptiaca is a multibranched, spiny shrub or tree. Crown rounded, dense (but still seen through) with long stout branchlets. Trunk and bark grey deeply fissured longitudinally. Leaves compound and spirally arranged on the shoots, dark green with coriaceous leaflets; dimensions and shapes varying widely,petiole canaliculated with short rachis, flower buds ovoid and tomentose, fruit ellipsoid.*Bauhinia variegata* is a small to medium-sized deciduous tree with a short bole and spreading crown. The bark is light brownish grey, smooth to slightly fissured and scaly, the twiga are slender, zigzag; when young, light green, slightly hairy, and angled, becoming brownish grey. Leaves have tiny stipules, petiole puberulous to glabrous, flower cluster (racemes) are unbranched at ends of twigs, and the few flowers have short, stout stalks and a stalklike, green, narrow basal tube (hypanthium). *Blighia sapida* has a spreading crown and ribbed branchlets. Leaves oblong or sub-elliptic, acute to round base, flowers bisexual, aromatic and greenish whites in colour, fruit capsule shape, leather like pods, it turns red on reaching maturity and ruptures open with continued exposure to the sun.*Bridelia ferruginea* is a semi-deciduous to deciduous tree with a dense rounded crown and tall, bare stem; bark on young branches grey-brown and smooth, on older branches and minutely appressed-puberulous (hair sometimes visible only with a lens); stipulate, stipules lanceolate-acuminate; blade elliptic, oblong-elliptic or obovate, apex subobtuse to acuminate; base generally rounded; margins entire or slightly wavy. Inflorescence with flowers in axillary clusters containing male and female flowers; fruit black, subglobose to ellipsoid drupe. *Burkea africana* is a deciduous, medium-sized, spreading, flat-topped tree. Leaves are pinnately compound, silvery-pubescent or glabrescent; leaflets are oval and silvery when they are young and marked with brown spots. Flowers are milky white, fragrant and in pendulous racemes. Bark rough, both vertically and horizontally fissured. Twigs with brown-hairy apex, fruits is superficially resemble a terminalia but is readily separated by its compound leaves. *Cassia fistula* is a medium sized deciduous tree with a straight trunk and spreading branches. Stem bark pale grey, smooth and slender when young and dark brown and rough when old. Leaves alternate, pinnate, ovate, flowers bright yellow in terminal, drooping racemes, fruit an indehiscent pod cylindrical, pendulous and terete. *Casuarina equisetifolia* is Pine-like tree flabby and thread-like jointed branchlets. Leaves are reduced to triangular scales arranged in a whorl at the joints of the branchlets. Flowers are small and unisexual with the sexes on separate tree (dioecious conditions), fruits are cluster in globose or ellipsoid cone-like heads. *Chrysophyllum albidum* is a small to medium buttressed tree species. Bole is usually fluted, frequently free of branches; bark thin, pale brownish-green, slash exuding white, gummy latex. Leaves are simple, dark green above, pale tawny below when young and silver-white below when mature, oblong-elliptic to elongate obovate elliptic; apex shortly acuminate, base cuneate; flowers shortly pedicellate, in dense clusters in the leaf axils or from above the scars of fallen leaves. Fruits almost spherical, slightly pointed at the tip (WorldAgroforestry Center, 2015).

Citrus spp is shallow-rooted evergreen shrub or tree with an enclosed conical top and mostly spiny branches. Twigs angled when young, often with thick spines. Leaves smooth, oval, dark green above, glossy, with a unique smell of similar to the fruit, petiole winged. Fruits orange, reddish-green to yellow-green, round, consist of a leathery peel, protecting the juicy inner pulp, which is divided into segements that maynot contain seeds, depending on the species, which can be *Citrus sinensis*, *Citrus paradisi*, and *Citrus reticulata*.*Daniellia oliveri* is a deciduous, medium-sized tree; bole straight and cylindrical without buttresses; bark surface smooth, grayish white, becoming scaly in older trees, flaking off in large, circular patches, inner bark thick, deep red; crown dense, inversely cone-shaped; twigs glabrous. Leaves alternate, paripinnately compound, flowers bisexual, zygomorphic, scented, fruit an obliquely lanceolate, flattened pod. *Delonix regia* is a tree with large trunk, buttressed and angled towards the base; bark smooth, grayish-brown, sometimes marginally cracked and with many dots (lenticels); inner bark light brown; crown umbrella shaped, spreading with the long, nearly horizontal branches forming a diameter that is wider than the tree's height; twigs stout, greenish, finely hairy when young, becoming brown. Leaves are biparipinnate, alternate, light green, feathery; fruit green and flaccid when young, turning to dark brown, hard, woody pod.*Eucalyptus citriodora* is a large, handsome evergreen tree; tall, straight trunk; open, graceful crown of drooping foliage; bark smooth, white, powdery, sometimes pink, red or blue-grey, on large trunks dark or grey and hairy. Juvenile leaves alternate, ovate to broadly lanceolate, sometimes setose, petiolate, and sometimes peltate; adult leaves alternate, lanceolate to intently lanceolate, acuminate, strongly lemon scented when crushed, fruit ovoid or urceolate (Brooker, 2002 and Bean, 2005).*Ficus sycomorus* is a large, semi-deciduous spreading savannah tree, irregularly buttressed. Leaves broadly (ob) ovate or elliptic, base (sub)cordate, apex rounded or obtuse, margin entire or slightly repand-dentate, flowers, unisexual, cyclic and greenish. The species name comes from the Greek 'sykamorea' (sycamore), used in the Gospel according to St. Luke; it was such a tree that Jesus cursed for it was barren. But the word 'sykomorom' had been used to denote the fruit a century before Christ. It has since been applied as a popular name to many sorts of tree, including Acer psedoplatanus and Platanus ocidentalis. (Abbiw, 1990; World Agroforestry Center, 2015)

Gliricidia sepium has a medium crown and may be single or multistemmed. The bark colour is variable but is mainly grayish-brown, and it can be much fissured. Leaves are alternate and pinnate with leaflets, papery, oblong with a distinctive pointed tip. Leaflet size increases towards the distal end of the leaf. At maturity, the upper surface ranges from smooth and hairless to bristly and usually has no tanniniferous patches. The lower surface can also be smooth and hairless or bristly but commonly has purplish tanninferous patches concentrated toward the centre of the lamina. Flowers arranged on conspicuously short, upward-curving to erect inflorescences, which are usually pink, fading to whitish-brown or pale purple with age. *Hildagardia barterii* is spectacular rainforest tree; it belongs to subfamily Sterculiaceae within the mallow family, Malvacea, and is a fast-growing and highly specialized species, inhabiting rock outcrops and exposed areas with shallow soils. The large heart-shaped leaves and green bark aid it to take full advantage of high light levels in these open areas during the rainy season. Then, as temperatures and light levels increase to blistering levels during the dry season, it sheds it leaves but continues to photosynthesize through the resilient bark. It can be propagated by cuttings, bud grafting and by seeds. It has a well-ordered conical habit and does well in cultivation, especially in rocky or stony ground where other trees may not do thrive. The eye-catching show of scarlet flowers and golden pods is a welcome sight over Christmas and New Year. *Irvingia gabonensis* grows high, bole slightly buttressed. It has a dense, compact crown, branchlets ending in a narrow, curved stipular sheath covering the leaf bud. Bark grayish, smooth or very slightly scaly; slash yellowish-brown to light yellow brittle. Leaves elliptic to slightly obovate, one margin often a little more rounded than the other, acute or acuminate, cuneate or slightly rounded at the base; leathery dark green and glossy above. Flowers yellowish to greenish-white, fruits yellowish when ripe, broadly ellipsoid and variable in size, fibrous pulp surrounding a large seed. *Khaya senegalensis* is a deciduous tree, with a clean bole, buttresses not conspicuous or absent; bark dark grey, with small, thin, reddish-tinged scales; slash dark pink to bright crimson, exuding a red sap. Leaves alternate, compound, stipules absent; petiole and rachis long; leaflets usually opposites pairs, oblong to narrowly oblong-elliptic, apex acute to shortly acuminate, base rounded, margins entire, pale green, lateral nerves. Fruit an upright, almost spherical, woody capsule, opening by 4 valves from the apex. Flowers tetramerous, monoecious but with well-developed vestiges of those of the opposite sex with very little external differences between sexes. (Abbiw, 1990).

Mangifera indica is a large, tall, evergreen tree with a dark green, umbrella-shaped crown. Trunk stout; bark brown, smoothish, with many fissures; thick, becoming darker, rough and scaly or furrowed. Leaves alternate, simple, leathery, oblong-lanceolate, fruit an irregularly egg-shaped and slightly compressed fleshy drupe.*Milicia excelsa* is large deciduous tree, high, bark thick, pale, ash grey to nearly black, then brown, and usually fairly rough ad flaking off in small scales, but seldom fissured. Leaves in young trees sandpapery and green above, paler and pubescent below; older leaves often becoming a bright yellow, serrulate at the margin, simple, alternate, broadly elliptic or ovate, very shortly acuminate, usually unequally glabrous above and underneath except for minute hairs between the network of veins. Flowers dioecious, axillary, greenish, fruit arranged along a longitudinal axis. *Moringa oleifera* is a small, graceful, deciduous tree with thin foliage, often resembling a leguminous species at a distance, particularly when in flower, but immediately recognized when in fruit. Bole crooked, often cleft from near the base. Bark smooth, dark grey; slash thin, yellowish. Twigs and shoots shortly but thickly hairy. Crown wide, open, typically umbrella shaped and usually a single stem; often deep rooted, the wood is soft. Leaves alternate, the old ones soon falling off; each leaf large with opposite pinnae. Flowers produced throughout the year, in loose axillary panicles, fruit large and distinctive. Moriga seeds are actual against skin infecting bacteria,which shows is of therapeutic value, also good as ornamental plants, soil improver and pollution control as well (World Agroforestry Center, 2015; Folorunso *et al*., 2012). *Parkia biglobosa* is a perennial deciduous tree, crown large, spreads wide with branches low down on a stout bole; bark dark grey brown, thick, fissured. Leaves alternate, dark green, bipinnate, leaflets held on a long rachis. Hermaphrodite flowers orange or red in colour. Pods are pink brown to dark brown when mature. *Plumeria spp* belong to the family Apocynaceae. A tree with alternate leaf typically clustered near the end of stout branchlets. The flowers of various colour essentially, pink and white. Fruits are pairs of follicles comprising winged seeds. The milky juice is corrosive. The plants contain an antibiotic, plumericin, which is principally active against fungi.*Prosopis africana* has an open crown and slightly rounded buttresses; bark is very dark, scaly, slash orange to red-brown with white streaks. Foliage drooping; leaves alternate, bipinnate, leaflets, oblong-lanceolate, pubescent. Flower greenish-white to yellow. Pods dark brown, cylindrical, thick and hard, shiny with woody walls compartmented. *Spondias mombin* is a tree; bark grayish-brown, thick, rough, often intensely grooved, with blunt, spinelike projections; trunk with branches above ground level to form a spreading crown. Leaves alternate, once pinnate with an odd terminal leaflet; stipules absent; apex long acuminate, asymmetric, truncate or cuneate; margins entire, glabrous or thinly puberulous. Fruit an ovoid or ellipsoid drupe. *Tamarindus indica* is a large evergreen tree, bole usually, crown dense, widely spreading, rounded; bark rough, fissured, greyishbrown. Leaves altenate, compound; leaflets narrow oblong, petiole and rachis finely haired, midrib and net vein more or less obvious on both surfaces; apex rounded on almost square, slightly notched; base rounded, asymmetric, with a tuft of yellow hairs; margin entire, fringed with fine hairs. Stipules present, dropping very early. Flowers attractive pale yellow or pinkish. Fruit a pod, indehiscent, subcylindrical.*Tectona grandis* is a hefty, deciduous tree, crown open with many small branches; the bole is often buttressed and may be fluted. Bark is brown, obviously fibrous with shallow, longitudinal fissures. The very large leaves are shed, leaving the branchlets bare. Fruit is a drupe; round, hard and woody, enclosed in an inflated, bladder-like covering; pale green at first, then brown at maturity.

Terminalia catappa is a tall deciduous and erect tree, often buttressed at the base. Wholes of nearly horizontal, slightly mounting branches spaced in tiers, or storeys, up the trunk. The pagoda-like habit becomes less conspicuous as the branches elongate and droop at the tips. Bark grey-brown, rough with age. Leaves alternate obovate with short petioles, spirally clustered at the branch tips, dark green above, paler beneath, leathery and glossy. They turn bright scarlet, dark red, dark purplish-red, or yellow. Flowers slightly fusty, greenish-white, very small, with no petals but obvious stamens, arranged in several slender spikes in the leaf axils. Fruit hard, green-red, rounded and flattened egg-shaped.*Terminalia superb* is a large tree, bole cylindrical, long and straight with large, flat buttresses. Bark fairly smooth, graying, peeling off in small patches; slash yellow. Leaves simple, alternate, in tufts at the ends of the branches; deciduous, leaving distinct scars on twigs when shed. Fruit a small, diagonally winged, sessile, golden-brown smooth nut.*Terminalia macroptera* is a deciduous small tree; bole often crooked and low-branching; bark surface deeply fissured, brown to black, inner bark thick, fibrous, brown to orange; crown open, with spreading branches; twigs glabrous, grey-brown to purplish black, soon becoming corky. Leaves arranged spirally, simple and entire; stipules absent. Flowers bisexual or male, fruit an oblong to ellipsoid winged nut including the large wing, glabrous, reddish brown, indehiscent. *Treculia africana* is an evergreen forest with a dense spreading crown and fluted trunk. Bark grey, smooth and thick; when cut, exuding white latex which later rusty-red,leaves simple, alternate, flower head brown-yellow, fruit compound, rounded and very large.*Triplochiton scleroxylon* is a large deciduous forest tree, bole of mature trees are often heavily buttressed but typically free from branches, leaves broad and palmate. Fruits brown to reddish-brown. *Vitellaria paradoxa* is a small to medium-sized tree; much branched, dense, spreading, round to hemispherical crown, bark obviously thick, corky, horizontally and longitudinally deeply fissured. The flowers develop in the axils of scale leaves, fruit wide, elliptic. *Vitex doniana* is a medium-sized deciduous tree with a heavy rounded crown and clear bole. Bark rough, pale brown or grey-white, rather smooth with narrow vertical fissures. Leaves opposite, glabrous. Fower petals white except on largest lobe, which is purple, in dense opposite and axillary, fruit oblong, green when young, turning purplish-black on ripening and with a starchy black pulp. *Ziziphus mauritiana* is a spiny, evergreen shrub or small tree, with spreading crown; stipular spines and many drooping branches. Bark dark grey or dull black, irregularly fissured. Leaves variable, alternate with tip rounded or slightly notched base; finely wavy-toothed on edges, shiny green and hairless above; dense, whitish, soft hairs underneath. Inflorescence axillary cymes, fruit a drupe, globose to ovoid, usually much smaller when wild; skin smooth or rough, glossy, thin but tough, yellowish to reddish or blackish; flesh white, crisp, juicy, sub-acid to sweet, becoming mealy in fully ripe fruits. *Lophira lanceolata* is small to medium-sized tree; bole branchless; bark surface corky, grey, very coarsely flaking, inner bark yellow to brownish red; branches ascending, with conspicuous leaf-scars. Leaves alternate but clustered at the end of branches, simple and entire; stipules linear-lanceolate; blade oblong-lanceolate, base cuneate, often asymmetrical, apex rounded and sometimes notched, glabrous, red to bright pink when young, pinnately veined with numerous lateral veins, conspicuous on both sides. Inflorescense a terminal, pyramidal and lax panicle, flowers bisexual, fruit a conical, somewhat woody. *Araucaria heterophylla* is an evergreen tree, conifer (but not a pine). Bark exfoliates in thin layers. Leaves (needles) in two forms, on young plants and side branches needles are soft, awl-shaped, bowed inward, and not overlapping; on mature trees the leaves are scales-like and overlapping. *Bauhinia variegata* is a broadleaf semi-evergreen to deciduous shrub or tree, most often observed as a multi-stemmed, wide-spreading shrub, can be staked so it develops into an attractive tree about 25ft tall and similar width. Leaves simple, alternate, and bilobed to about one-third the blade, lobes obtuse, base subobicular or cordate, light green, sparsely hairy on vies below. Flowers in terminal clusters (racemes), few per cluster, fruit is a flattened, woody pod (Orwa *et al*., 2009).

Eucalyptus cinerea is evergreen tree, to about 20-50ft (6-15m) tall and 20-45ft (6-14m) wide, upright and horizontal branches. Bark rough, fibrous, and red-brown. Juvenile leaves opposite, sessile (without petiole) or short petiole, roundish, more or less clasping the stem, glaucous (bluish waxy coating); intermediate leaves similar but may be green; adult leaves alternate, broadly lanceolate (Brooker, 2000; 2002). *Lonchocarpus cyanescens* is a shrub of twining habit; belong to the tribe *Dalbergiece* of the Natural Order Leguminosae, the branchs glabrous or slightly silky. Petioles firm, the base rounded, the lower ones shorter, coriaceous, upper side smooth, lower side minutely pubescent. Flowers in copious often fascicled panicles, sometimes a foot long, and branches short, spreading, densely flowered but not fascicled. Bracts lanceolate, subulate, deciduous, equaling the pedicels, one line long. *Erythrina sensgalensis* is tree growing tall, with deeply fissured, corky bark. The branches and bark are armed with slightly hooked spines. Leaves are composed of three leaflets; flowers appear in large groups at the end of the branches, when the tree is leafless (in the first half of the dry season). The flowers are bright red. Fruits, is a bent, twisted and slightly hairy pod, it is constricted between the seeds, which are bright red.It is used in traditional medicine; the wood is used for making knife handles, the seeds are made into necklaces and used as game counters, despite being poisonous.*Funtumia africana* is a tropical tree with a straight, cylindrical trunk and a narrow tree crown. Bark brown to dark in colour, thin and slightly fissured becoming granular on old trees. Slash orange exuding latex copiously. Leaves elliptic or ovate, base round or cuneate, apex acuminate with lateral veins on each side; leaf margins wavy, axils on the main lateral veins not pitted, flowers yellow-white; fragrant in dense cymes, fruit; grey-brown, fusiform. *Synsepalum dulcificum* is a plant known for its berry that, when eaten, causes sour foods (such as lemons and limes) subsequently consumed to taste sweet. This effect is due to miraculin. Common names for this species and its berry include miracle fruit, miracle berry, miraculous berry, sweet berry and in West Africa, where the species originates, agbayun, taami, asaa and ledidi. It is a shrub that grows between 1.8 to 4.5m in height and has dense foliage. Its leaves are glabrous below. They are clustered at the ends of the branchlets. Flowers are white, it carries red long fruits. In tropical West Africa, where the species originated from, the fruit pulp is used to sweeten palm wine and in Japan, it is popular among patients with diabetes and dieters (Levin, 2009; Orwa *et al*., 2009).

Ficus benjamina is a tall tree with gracefully drooping branchlets and glossy leaves, oval with an acuminate tip. In its native range, its small fruits are favoured by some birds, such as the superb fruit dove, wompoo fruit dove, pink-spotted fruit dove, ornate fruit dove, orange-bellied fruit dove. The fruit is edble, but the plant is not usually grown for its fruit but ornamentals, as hedges and decorative plant in the gardens (Kwang *et al*., 2008). The leaves are very sensitive to small changes in light.*Ficus capensis* is a widespread Afrotropical species of cauliflorous fig. The large, alternate and spirally arranged leaves are ovate to elliptic with irregularly serrated margins. Fresh foliage is a conspicuous red colour and the papery. The bark of younger trees is smooth and pale grey-white in colour, in contrast to the flaky, yellow bark of *Ficus sycomorous*. With increasing age the bark becomes darker and rough. The wood is light and soft and is not much used commercially. All parts may exude latex, which has some traditional medicinal applications (Lansky and Paavilainen, 2011). *Psidium guajava* is a large dicotyledonous shrub, or small evergreen tree, many branches; stems crooked, bark light to reddish brown, thin, smooth, and continuously flaking. Leaves opposite, simple; stipules absent, petiole short; blade oblong to elliptic, apex obtuse to bluntly acuminate, base rounded to subcuneate, margins entire, somewhat thick and leathery, dull grey to yellow-green above, slightly downy below, veins prominent, gland dotted. Fruit an ovoid or pear-shaped berry, skin yellow when ripe, sometimes flushed with red; pulp juicy, creamy-white or creamy-yellow to pink or red; mesocarp thick, edible, the soft pulp enveloping numerous cream to brown, kidney-shape or flattened seeds. The exterior of the fruit is fleshy, and the centre consists of seedy pulp. *Cynometra ananta* is an evergreen medium-sized to fairly large tree, bole branchless. Bark surface irregularly flaking with small scales, grey with yellowish to reddish marks, inner bark fibrous, reddish, becoming reddish brown upon exposure, exuding a reddish resin; crown rounded or widely spreading. Leaves arranged spirally, paripinately compound with a pair of leaflets; stipules triangular, leaflets opposite, sickle-shaped, acute to acuminate at apex, thin-leathery, glabrous. Inflorescence an axillary or terminals panicle, flower bisexual and fruit an obliquely oblong to obovate (Hawthorrne and Jongkind, 2006). *Acacia gourmaensis* is a shrub or small tree, bark thick, corky, with thine corky scales, grey to brown; twigs (nearly) glabrous, yellowish, turning black when bark scales off, lenticellate; crown narrow and open. Leaves alternate, bipinnately compound, inflorescence an axillary, lax, elongated, fruit an oblong, flat, papery pod (Burkill, 1995).

Cassia fistula is known as the golden shower tree and by other names, is a flowering plant in the family Fabaceae. The leaves are deciduous and pinnate with three to eight pairs of leaflets, the flowers are produced in pendulous racemes and the fruit is a legume with a pungent odor and containing several seeds of medicinal values (Murali, 1993). *Erythrophleum ivorense* is a large tree; bole cylindrical, but sometimes fluted at base, with or without buttresses; bark scaly, often fissured, grey, inner bark reddish, granular; young twigs brown hairy. Leaves alternate, bipinnately compound; leaflets alternate, elliptical to ovate, base asymmetrical, apex shortly acuminate. Inflorescence an axillary or terminal panicle consisting of spike-like racemes which is reddish brown hairy, flower bisexual, fruit a flat, elliptical, dehiscent pod. The bark has several medicinal uses (Cronhund, 1976; Bosch, 2006). *Polyalthia longifolia* is a mast tree belongs to the Annonaceae family, an evergreen tree with narrow, broadly columnar shape. It is much taller than broad; the trunk is straight and rather slender with grey bark. It has a dense crown with drooping branches. The entire length of the tree is covered by dark green leaves. It is a good landscape plants for hedges. The leaves are simple, alternate, and lanceolate with short petiole. The leaf margin is inverted and undulating. Emerging leaves are coppery, soft and delicate to touch. They mature dark green and glossy with a lighter midveins and undersides. The flowers are inconspicuous yellow-green petals, they are arranged in pendulous racemes or umbels, the flowers last only for short period, usually two to three weeks and with no fragrant. Fruits are initially green and turn purple to black; they are ovoid and are clustered in group with single seed. (World Agroforestry Center, 2015 and Oladele, 2015). *Acacia nilotica* is an evergreen, usually moderate-sizeed tree with a short, thick and cylindericalntrunk; bark is grey, reddish-brown or black, rough, furrowed. Leaves are alternate, bipinately compound, flowers many, crowded and stalkless. It has a strong light requirement; it is drought resistant and occurs in plain, flat or gently undulating ground and ravines. The tree is prevalent in the northern savanna regions and of good traditional medicinal value. (World Agroforestry Center, 2015). *Leucaena leucocephala* is a small, variably shrubby and highly branched to medium-sized tree with a short, clear bole, upright angular branching and a narrow open crown. Bark on young branches smooth, grey-brown, slash salmon pink, darker grey-brown and rougher with shallow, rusty orange-brown vertical fissures and red inner bark on oilder branches and bole. This evergreen plant is deep rooted. It often has a combination of flowers, immature and mature pods all present on the tree at the same time. It is a dynamic coppice and responds well to pollarding and pruning, it flourishes on steep slopes and in marginal areas with extended dry seasons, making it a prime candidate for restoring forest cover, watersheds and grasslands. It is good soil improver, erosion control, high nitrogen-fixing potential and suitable as an ornamental and roadside landscaping species. (World Agroforestry Center, 2015 and Oladele, 2015). *Thevetia neriifolia* is a tall shrub with linear, glossy-green leaves. The flowers are golden yellow and funnel-shaped. The plant, when injured, exudes copious milky platex, which is poisonous. The fruit is fleshy. (Oladele, 2015)

The visual and aesthetic which is a social benefit of trees and other forms of Botanical/Green infrastructure have received less attention in recent research, compared with the significant body of research on environmental and economic benefits of urban greening. In part this is because most research into Botanical/Green infrastructure has been quantitative in nature, and has been undertaken within the fields of environmental science, social science and economic modeling (McLean *et al*., 2007). Much less research has been undertaken by those well-versed in aesthetics and visual design principles (such as Landscape Horticulturists, Landscape architects and urban designers) and few studies have adopted a more suitable qualitative or mixed-method research methodology. The visual form and attraction of towns and cities have been found to be strongly influence by the provision of green space (Tibbatts, 2002). Environmental quality has two main mechanisms, the actual 'physical' and the more subjective 'perceived' quality of the local environment (Khattab, 1993). The concept of environmental quality is wide and can incorporate many elements including environmental pollution and cleanliness, and visual quality and personal security.

2.2 Lichens as bio monitoring of air pollution

Lichens are acute factors of many terrestrial ecosystems as primary invaders, nitrogen fixers, and in providing essential habitat and nutritional requirements for a diversity of wildlife (Sharnoff and Rosentreter, 1998) and invertebrates (Sharnoff, 1998). These symbiotic organisms have been popular bioindicator tools for decades, as they absorb pollutants directly from the air around them and usually show sensitivity to these compounds. Factually, they have proven to be effective bioindicators for atmospheric pollution, including primarily sulphur dioxides (SO_2), but also nitrogen compounds, radioactive fallout, and a variety of heavy metals. More recently, the sensitivity of a variety of lichen species to climate has stimulated their use as indicators for climate change in a wide variety of regions around the globe (Sancho *et al*., 2007; Insarov and Schroeter, 2002).

Mapping lichen distributions to deduce environmental quality began in Europe in the 1930s (Hawkworth, 2002). Conceivably most notably, in 1970, a qualitative scale for determining SO_2 deposition was developed for England and Wales (Hawsworth and Rose, 1970), whereby zones of lichen species structure and abundance were correlated with winter SO_2 deposition. This scale was then further adapted by many researchers for a wider applicability throughout Europe (van Haluwyn and van Herk, 2002). Also in 1970, LeBlanc and Desloover introduced the concept of calculating an index of Atmospheric method quickly become popular and widely used throughout Europe, with many subsequent variations and adjustments (Kricke and Loppi, 2002). A great number of superfluous scales and indicator values have since been applied to lichen communities to evaluate a variety of environmental conditions, for example, the Index of Human Impact (IHI) (Gombert *et al*., 2005), and various Indices of Ecological Continuity (IEC) (Rose, 1976; Tibell, 1992; Rose and Coppins, 2002; Selva, 1998).

Since1866, a study was made available on epiphytic lichens used as bioindicators (Nylander, 1866; Cecchetti and Conti, 2001). Lichens are the most studied bioindicators of air quality (Ferry *et al*., 1989). They have been defined as 'long-lasting control systems' for air pollution evaluation (Nimis *et al*., 1989). During the last 30years, many studies have stressed the chance of using lichens as bioindicators of air quality in view of their sensitivity to various environmental factors, which can aggravate changes in some of their mechanisms and/or specific parameters (Brodo, 1961; Rao and LeBlanc, 1966; Schonbek, 1968; Hawksworth, 1971; Gilbert, 1973; Mendez and Fournier, 1980; Lerond, 1984; St. Clair and Fields, 1986; St. Clair *et al*., 1986; Galun and Ronen, 1988; Showman, 1988; Nimis, 1990; Oksanen *et al*., 1991; Loppi *et al*., 1992a; Seaward, 1992, 1996; Halonen *et al.*, 1993; Gries, 1996; Loppi, 1996; Hamada and Miyawaki, 1998; Odukoya *et al*., 2000; Cecchetti and Conti, 2001; Pacheco *et al*., 2002; Oladele *et al*., 2013) for indeed, many physiological factors are used to assess environmental damage to lichens such as: Photosynthesis (Ronen *et al*., 1984; Calatayud *et al*., 1999); Chlorophyll content and degradation (Kardish *et al*., 1987; Garty *et al*., 1988; Balaguer and Manrique, 1991;

Zaharopoulou *et al*., 1993); decrease of ATP; variations in respiration level (Kardish et al., 1987); changes in the level of endogenous auxins; and ethylene production (Epstein *et al*., 1986; Garty *et al*., 1993). In addition, laboratory exposure to SO2 causes significant membrane damage to lichen cells (Fields and St Clair, 1984). Several studies show a positive correlation among the Sulphur content of lichens and SO_2 present in the atmosphere (Takala *et al*., 1985; Rope and Pearson, 1990; Silberstein *et al*., 1996).

Accordingly, the form of plantbody (Thallus) lichens have been categorized into three groups including: Crustose or Crustaceous lichens-which form a thin crust over the rocks, soils and trees on which they grow, they are fairly or completely adherent to the substratum, the colour may be green, orange, black or yellow e.g Graphis, Lecanoria, Lecidea and Haematomma. The Crustose lichens can further be categorized into five groups powdery or Leprose (They are powdery in appearance and very difficult to separate into Phycobiont and Mycobiont e.g Lepraria, Endolithic (They develop inside rock and aid in weathering of rock e.g Buellia), Endophloeodic (They develop on leaves and stems of plants), Squamulose (Scale-like lichens which appears as partially separated from its substrate e.g Catapyrenium), Effigurate (thallus of Effigurate has radially organized and long marginal lobes e.g Caloplaca). Foliose or Foliaceous lichens. They occur as plane and leaf-like lobed thalli attached to the rock and twigs by means of rhizoid-like outgrowth called rhizinae. This develops from the lower surface of the thalli. The common representatives are physcia, parmelia, peltigera and collema. It is one of the most noticeable types of growth of lichens. Occasionally, this type of lichen forms smaller lobes as in physcia or parmelia and sometimes developing huge plates attached to the centre e.g Umbilicaria. Fruticose lichens are shrubby lichens with plant like growth form and also can hang from the substrate. They are round in cross segment with identical top and bottom, that is they are cylindrical or ribbon-like thallus which is either vertical (Evernia, Cladonia) or Pendulous (Usnea) (Dutta, 1981; Ahmadjian, 1993; Nash, 1996; Santis, 2002; Denise and Thompson, 2014).

2.3 Tolerance level of plants due to Air Pollution

According to Roetman and Daniels (2008) biodiversity is a term used to define all living thing and the dissimilarity within and between them. It includes plants, animals, fungi and micro-organisms, and can be measured at various levels of convolution. Issues of biodiversity and ecosystem health have been shown to be essential to the delivery of ecosystem services from the global to the local scale. Biodiversity plays a vital role in the functioning of ecosystem services. World Wide Biodiversity (WWB) loss is therefore an area of great concern (Groombridge and Jenkins, 2002). Links between biodiversity and commercial biodiversity, human health and well-being have been well recognized (Tzoulas and Korpela, 2007; Kate, 1999) and loss of biodiversity impacts the quality of fundamental life support systems, the incidence and spread of infectious diseases and the potential for evolving new treatments and medicines (Chivian and Bernstem, 2004; Ely and Pitman, 2012). Townsend proposes that the effects of the urban forest and other greenery are influenced by the quality, as well as the quantity of the forest cover, which may be an echo of greater biodiversity (Townsend and Sick, 2011).

It is clear that there are short terms and long terms ecological drifts of fallout and implication of pollutants from urban-industrial centers to natural habitats. The pollutants may gradually affect and change the structure and function of an ecosystem by modifying its abiotic and biotic components. Such changes in course of time affect transformation of healthy and fully productive habitat into an unhealthy and less productive one. Therefore, there is need for a constant monitoring of pollution load in an ecosystem. For this purpose plant sensitive to air pollutants may help in the monitoring of air pollution, provided the pollutants concentration and plant response relationships are precisely established with the help of fumigation experiments and physicochemical monitoring equipment. Since plants constitute a living system, it is imperative to have a proper understanding of all the ecological factors influencing the ambient pollution potential and pollution absorption pattern of plants (Satpathy and Usha, 2008).

Plants on the basis of their responses to pollutants under field and laboratory conditions have been classified into sensitive and tolerant species (Jacobson and Hill, 1970). The degree of sensitivity of plant depends on its developmental stage, nutritional status and other ecological factors (Guderian, 1977). Suggestion by (Bressan *et al*., 1978) that differences in the sensitivity levels of different plant species may be due to stomatal resistance to SO_2. (Winner and Mooney, 1980) reported that plants, which lowered the stomatal conductance through; reducing the size of stomatal pore in response to SO_2 fumigation under field conditions, were relatively less affected by SO_2. Also suggested by Sharma and Singh (1989) that decrease of stomatal density may limit gas exchange and thereby may reduce exposure of more susceptible inner leaf surfaces to injurious pollutants. Increased pubescence of leaf surface may act as a filter screening out particulate matter and prohibiting it from entering through the stomatal. Swick *et al.* (1982) suggested that the leaf cuticle-wax perhaps gives resistance to pollutants diffusing through the cuticle. Studies revealed that plants achieve resistance to pollutants either through stress avoidance that is by avoiding the entry of pollutants into the plants body through decreasing stomatal pore size and stomatal density and increasing circular resistance and pubescence or through stress tolerance that is by physiological manipulation of toxic pollutants entering into the plant body (Levitt, 1972). Plants with high number of stomatal complex types like tetracytic and anomocytic types open more often for transpiration as well as to allow influx of carbon (IV) oxide into the leaves for photosynthesis thus cleansing the atmosphere (Obiremi and Oladele, 2001; Oladele, 2002; Oyeleke *et al*., 2004; AbdulRahaman and Oladele, 2008; AbdulRahaman and Oladele, 2009; Saadu *et al*., 2009; AbdulRahaman *et al*., 2010; AbdulRahaman *et al*., 2013) consequently, these plants humidify the atmosphere with water vapour.

Among the physiological detoxificant of pollutants, ascorbic acid has been proposed to be a dependable one (Keller and Schwager, 1977 and Nandi *et al*., 1973). Ascorbic acid, being a resilient reluctant, activities many physiological and defense mechanisms and its reducing power is directly related to its concentration (Lewin, 1975). Based on the SO_2 fumigation studies, Rao (1979) also showed that plants having high ascorbic acid content were less susceptible to SO_2 pollution. Recently Singh and Rao (1983), on the basis of several factors give a method to determine the tolerance indices of plants and call it Air Pollution Tolerance Index (APTI). It is seen that plants having higher index values are more tolerant to air pollution than those having lower index values, that sensitivity level of plants to air pollutions differ from herbs, shrubs and trees. The Air Pollution Tolerance Index (APTI) values may help to ascertain sensitive species to be used for indicating greenbelt development and monitoring of air pollutants and tolerant species to be used as sink or for reducing pollutant levels in the environment (Satpathy and Usha, 2008). The study shows that the evaluation of the APTI value for tree species may not be ideal for recommending trees for ecological purposes, but the combination of the APTI and API (Anticipated Performance Index) can be of vast significance. It is evident from the study that the single measure of the biochemical parameters plays a distinctive role in determining the response of tree species to air pollution but may not be ideal for assessment of plant responses to a variety of pollutants for green belt purposes. However, using the combination of the biochemical parameters (APTI), biological and socioeconomic characteristics has proved realistic for recommending tree species for ecological purposes (Prajapati and Tripathi, 2008; Govindaraju *et al*., 2012; Ogunkunle *et al*., 2015).

2.4 Services Provided by Garden Trees

The role of trees in the Botanical Garden design comprise of both the aesthetic and functional values. Trees are well-known for eliminating a number of air-borne pollutants, including ozone, sulphur dioxide, nitrogen dioxide and particulate matter (Roy *et al*., 2012). Because of their size and longevity, trees have long been a main element in urban landscape design (Dwyer *et al*, 1994). Larger trees have more visual presence than smaller stature trees, and are often more highly valued by residents, especially where 'canopy closure' over the street is achieved (Kalmbach and Kielbaso, 1979; Schroeder and Cannon, 1983; Sommer and Barker, 1989). In one study the single largest factor in determining the desirability of a street scene was the size of the trees and their canopies. This was sustained by a study in which there was a preference for large canopies trees in a tree replacement programme (Heimlich and Syndor, 2008). Trees provide structure, connection, presence and scale, secondary filters in removing pollutants from the atmosphere, betterment of harsh environments and a capacity to link diverse landscapes (Moore, 2000; Mulgrew and William, 2005).

Botanical garden is a place with a lot of green infrastructure (trees), tree planting is a relatively cheap way of refining the amenity and character of an area, for example a clean and green Campus for conducive learning (Alabi and Oladele, 2008). Trees provide soil improvement, shade or shelter (Muoghalu and Awokunle, 1994). They soften the line of the road and infrastructure, and create light and shade, it is also supported by (Marritz, 2012) that the less easily quantifiable 'visual and aesthetic' benefits of trees are in fact the most powerful. It has been shown that Green Infrastructure and green space provision contributions to improving ‘quality of place’ (Forest Research, 2010). Quality of place has been defined as the physical characteristics of a community that affects the quality of life and life chances of people living and working in it (Cabinet office strategy unit, 2009). Research shows that the provision of high quality, well-maintained green space can have a positive effect on local business and improve an area’s image and the confidence of the local population and potential investors (Land use consultants, 2004). Also Swanwick (2000) has noted that highly valued green spaces enhance positive qualities of urban life, offer a variety of openings and physical setting and encourage sociability and cultural diversity. Amenity is a term referring to the pleasurableness or attractiveness of a place or to the ‘desirableor useful features or facility of a place’. Areas with high levels of amenity are more pleasant or attractive place to live, work or visit (Ely and Pitman, 2012). The concept of urban amenity includes not only the visual and aesthetic qualities of a place, but also a variety of more functional considerations such as safety, comfort and convenience. Therefore a well designed botanical garden can add significantly to the amenity of urban landscape. In the study of Zacharias (2001), he reviews the behavior of pedestrian and highlighted the connection between the legibility or visual understanding of the pedestrian network and pedestrian travel on that network. His study suggests that both regular forms and spatial differentiation are important in improving walkability. He also identifies the need for some complexity of space to maintain attention, but avoiding excessive complexity which may be considered dangerous. This reflects the work of Lynch (1960) an early seminal figure in urban planning, whose study of pedestrians led to the concept that places should be ‘imageable’ which is also supported by botanical garden design method that represent the socio-cultural, economic and environmental value of a place. Also the work of Ogunkunle *et al.* (2015) supported the use of tree plants in green belt development based on some of socio-economic and biological characteristics.

Botanical garden element otherwise known as green infrastructure (Trees) can play a significant role in improving air quality. Studies have established links between urban tree cover and air quality (Escobedo and Wagner, 2008). One study shows that a higher street tree density was linked with lower childhood asthma prevalence (Lovasi and Quinn, 2008). A study in Santiago, Chile initiates that urban forestry may be effective in improving air quality, particularly in terms of removing atmospheric particulates (PM_{10}) (Escobedo and Wagner, 2008; Escobedo and Nowak, 2009). Because the filtering capacity of vegetation is closely related to leaf area, trees with larger canopies can provide the most benefits (Treeconomic, 2011).

Air pollution is defined as the impurity of air by discharge of harmful substances, which can cause health problems including burning eyes and nose, itchy irritated throat and breathing problems (USEPA, 1994). It was also reported that some chemicals found in polluted air could cause cancer, birth defects, brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. The concentrations of such chemicals beyond a limit and an exposure over a certain period are extremely dangerous and can cause severe injury or even death. In Nigeria much attention is given on general industrial pollution in oil industries, with little mention on damage of pollution caused by mobile transportation sources of air pollution (Faboya, 1997; Iyoha, 2009; Magbabeola, 2001). This situation of increased pollution from mobile transportation source is on the increase in per capital vehicle ownership, thus resulting to high congestion on Nigeria city roads and increase in the concentration of pollutants in the air, accordingly, increasing health risk on human population (Akpan and Ndoke, 1999; Jimoh and Ndoke, 2000; Koku and Osuntogun, 1999; Enemari, 2001; Faboya, 1997;

Jerome, 2000; AbdulRaheem *et al.*, 2009b). Pearson and Palmer (2008) reported that primary pollutants from power plants include sulphur dioxide (SO_2), nitogen Oxides (NOx), particulate matter (PM), and carbon monoxide (CO). These are both injurious to human health, and contribute to complex air quality problems including the formation of ground-level ozone (Smog), fine particulate matter, and acid rain, increase use of fossil-fuel by power plants also increases emissions of greenhouse gases such as carbondioxide (CO_2) which contribute to global climate change (EPA, 2012). In addition to impacts on energy-related emissions, increased temperatures can also directly increase the rate of ground-level ozone formation (formed when NOx and volatile organic compounds (VOCs) react in the presence of sunlight and hot weather). In general, more gound-level Ozone will form as the environment becomes sunnier and hotter.

A known ecosystem service provided by trees and vegetation is that of improving air qualities in cities. The natural functions of urban trees are known to eliminate atmospheric pollutants, oxygenate the air, and absorb carbon dioxide through photosynthesis (Brack, 2002, Nowak and Crane, 2006). The natural functions of vegetation can directly and indirectly improve air quality in the following ways (Nowak, 1995; McPherson, 2010):

- Direct removal of pollutants through either:
  1. Absorbing gaseous pollutants through the leaf surface (SO_2, NO_2)
  2. Intercepting particulate matter on leaves (PM_{10})
- Reducing air temperatures through shading and evapotranspiration, and thereby lowering ozone level (O_3).
- Indirectly, by reducing air-conditioning use and related energy consumption in buildings (through shading of buildings, air temperature reduction and wind modification) leading to lower air pollutant emissions from power plants (Known as ‘avoided emissions’).

Shade provided by trees on paved surfaces and parked cars decreases evaporativehydrocarbon emissions and ozone formation. It must be accepted however that trees can also impact negatively on air quality through the emission of volatile organic compound (VOC) and from emissions resulting from tree management activities. Deciduous trees emit great amounts of the compound 'isoperene' during a hot day; Coniferous trees emit the volatile organic compounds 'pinene' day and light, the volatile organic compounds emitted can add to ozone formation in the atmosphere (Chameides and Lindsay, 1988). However cumulative studies involving urban tree impacts on ozone have shown that increased urban canopy cover, particularly with low VOC emitting species, leads to net reduced Ozone concentrations in cities (Cardelino and Chameides, 1990; Taha, 1996; Civerolo and Nowak, 2000; Nowak and Dwyer, 2007).

Guideline for Air quality Improvement

Table 1: Urban forest management strategies to help improve air quality

	Strategy	Results
1	Increase the number of healthy trees	Increase pollution removal
2	Sustain existing tree cover	Maintain pollution removal level
3	Maximize use of low VOC emitting trees	Reduced Ozone and Carbon monoxide formation
4	Sustain large, healthy trees	Large trees have greatest per-tree effect
5	Use long-live trees	Reduce long-term pollutant emissions from planting and removal
6	Use low maintenance trees	Reduce pollutants emissions from maintenance activities
7	Reduce fossil fuel use in maintaining vegetation	Reduce pollutant emissions
8	Plant trees in energy conserving locations	Reduce pollutant emission from power plants
9	Plant trees to shade parked cars	Reduce vehicular VOC emissions
10	Supply ample water to vegetation	Enhance pollution removal and temperature

		reduction
11	Plant trees in polluted or heavily populated area	Maximizes tree air quality benefit
12	Avoid pollutant sensitive species	Improve tree health
13	Utilize evergreen tree for particulate matter	Year round removal of particle

(Nowak, 2000).

2.4.1 Climate change

The single most significant factor affecting climate is solar radiation (Amman and Caspar, 2007). Seasonal changes in radiation are due to the angle of the incidence of sunlight and daily variances are due to absorption and scattering of the radiation by the atmosphere and reflection by clouds. The radiation that strikes the earth's surface is largely accountable for temperature of the ground and the air above it. The nature of the soil surface will greatly determine how much of the emission is absorbed and how much is reflected. This in turn determines the soil-surface temperature. The more radiation a surface absorbs the more it heats the surrounding air.

Climate change is a topical issue of global concern and interest. It is a human-induced change in the climate of the world, due to global warming or greenhouse effect, whereby increase of greenhouse gases in the atmosphere causes the temperature of the earth to rise. These gases allow light energy from the sun to enter the earth, but avert the heat energy arising from sun's rays to escape into the outer space. The heat entombed, builds up to cause the earth's temperature to rise. Over the past 100years, the earth has warmed by 0.74^{o}C and about 0.4^{o}C of this warming has occurred within the last 40years. The United Nation Commissioned a global body of scientists called Intergovernmental Panel on Climate Change (IPCC) to observe this issue (Frederick and Rosenberg, 1994). The body confirmed in 1995 that human-induced global, warming had begun. The global community now understood that the world is facing an unprecedented climate crisis caused by human activity.

Air pollution problems are not necessarily restricted to a local or regional area. Atmospheric circulation can transport certain pollutants far away from their point of origin, expanding air pollution to continental or global scales. It can truly be said that air quality problems know no international limitations. It can affect the environment on global scale. This was buttressed by the work of AbdulRaheem *et al*. (2008) where there seasonal variation of the concentration of ozone, sulphurdioxide, and nitrogen oxides were examined within two cities in Nigeria. Greenhouse effects caused mainly by CO_2, ozone depletion mainly by CFCs and acid rain by SO_2 and NO_2 are threating the very existence of mankind.

Even in non-urban areas, man's activities have led to climate effects. Change of forests to pasture has often been followed by over-grazing, with increased soil erosion by water and wind being the end result. Likewise, change of grasslands to agricultural crop production has led to erosion as well (Satpathy and Usha, 2008). Urban microclimates are described by significantly higher temperatures, higher wind speeds and lower net rainfall inputs than rural and natural landscapes (Miller, 1980). The most important environmental benefit of green infrastructure and trees in particular, is probably their ameliorating effect on urban climate and microclimate (McPherson and Rowntree, 1993; McPherson, 1994). Similarly, according to (O'Brien, 1993) trees improve cities climatically; indeed this is probably the greatest benefit of tree planting in a developed area.

2.4.2 Foliage features and heat mitigation

One inventiveness to mitigate extreme summer temperatures in the urban areas is the 'cool cities' strategy .A 'cool cities' strategy aims to reduce the urban heat Island effect by (a)

Promoting tree planting to shade buildings and to cool the ambient environment by evapotranspiration by foliage. (b) Using reflective roof and paving surfaces to reduce heat accumulation due to solar radiation. The surfaces of pavements and buildings can reach very high temperatures lest shaded (Kjelgren and Montague, 1998). By shading ground surfaces, trees can decrease the amount of radiation reaching being absorbed by and then being re-radiated from paved surfaces (Roberts *et al*., 2006). Trees can seize the majority of the sun's energy, and while some of it is reflected, most is absorbed and used in photosynthesis. Research shows that tree canopies can reduce the temperatures of the surfaces they shade by as much as 10-25^{o}C (Akbari and Kurn, 1997; Akbari and Pomerantz, 2001; Livesley, 2010). Shading effects of different tree species vary according to their Leaf area Index (LAI) a ratio of leaf area per unit of ground surface area. It is also known that shading by tree is more efficient than shading by non-natural materials (Georgi and Dimitriou, 2010). Research in the USA shows that increasing the amount of leaf area in urban or suburban area can have a significant effect on surface temperatures (Hardin and Jensen, 2007). Recent research in Melbourne supports these outcomes, with inner city areas and the western suburbs experiencing higher temperatures than the more leafy eastern or southern suburbs (Loughnan and Nicholls, 2010). It seems that leafy suburbs can be 2-3 degrees cooler than new tree- less suburbs. A study by Taha (1996) finds that the addition of a large number of trees to the public realm should result in an air temperature reduction of 1-3^{o}C in the hottest areas.

Information on the performance of specific plants for green buildings is limited. Interms of living walls, Cameron *et al.* (2014) find that plant species different in their cooling capacity as well as their mechanisms for cooling. *Hedera* and the silver-leaved, semi-herbaceous *stachcys* accomplished the best for wall cooling. *Prunus* also provided significant air-temperature cooling but was less efficient in its surface-temperature cooling when equated to *stachys* and *hedera*. When assessed on a per leaf area basis, however, other species revealed greater cooling potential with *fuchia, jasmium* and *lonicera* out-performing others. *Fuchsia* promoted evapotranspirative cooling, whereas shade cooling was more important in *jasminum* and *lonicera* (Zupancic, 2015). In terms of providing thermal comfort in a hot, humid park setting, compact multilayered plants are suggested over large grassy areas for cooling (Cao *et al*., 2010). When comparing trees and grass, grass surface composition is shown to have little effect on globe temperatures whereas tree shading was found to decrease globe temperatures by 5 to 7^{o}C and reported to provide the greatest reduction of heat stress from their shade (Froehlich and Matzarakis, 2013; Armson *et al*., 2012). This suggests that while both grass and trees may help to reduce urban heat island, trees are more efficient in providing relief to metropolitan residents from heat stress. Where possible, trees are suggested over shrubs and grass for cooling as correlation analysis shows stronger correlation coefficents between their pattern metrics and urban cool islands, especially in warm seasons (Chen *et al*., 2014; Zhang *et al*., 2013; Zupancic, 2015). Interm of tree types, deciduous trees have been known as most important for providing thermal comfort in parks since they provide shade in hot months but do not block needed warmth from the sun in cold months (Lin *et al*., 2010; Hwang *et al*., 2011). During summer, both deciduous and evergreen trees provided similar cooling effects, but in winter the evergreen tree park was much cooler and below the ‘neutral’ comfort conditions (Cohen *et al*., 2012; Zupancic, 2015). One study found that species with a lower canopy temperature like *P.nigra*, or *Tiliacordata* are especially suitable for reducing local air temperatures; however, some species such as *Q. robur* and several species of Populus as well as *P.acerifolia* should be circumvented due to their high emissions of biogenic volatile organic compound (BVOC) and potential contribution to ground-level ozone formation

(Meier and Scherer, 2012). A comparison of small trees that grow in warm temperate climates with dry winters found that *Eucalyptus sp*. Had significantly higher cooling effect, followed by *Ole asp*. The species with the least effect on temperature were *Grevillea* and *Cupressus* (Feyisa *et al*., 2014; Zupancic, 2015).

2.4.3 Foliage characteristics and heat

The cooling capacity of green space is affected by many characteristics, including: Density, Size, Shape and Spacing.

Density: Green space density is defined in many different ways by different studies. For example, some studies observe density in term of tree canopy cover (Feyisa *et al*., 2014); others refer to the relative percentage of foliage in a given urban area (Ng *et al*., 2012). In broad-spectrum, many studies report a strong and significant association between various measures of increased green space density and increased cooling effects (Dobrovolny, 2013; Feyisa *et al*., 2014; Hart and Sailor, 2009; Ng *et al*., 2012; Penni and Magliocco, 2014; Vidrih and Medved, 2013; Weber *et al*., 2014; Zhang *et al*., 2013; Zupancic, 2015). In precise, tree density is imperative and very significant negative relationship was observed between temperature and canopy cover where the temperature dropped by 0.02oC for every percentage increase in tree canopy cover (Feyisa *et al*., 2014).

Size: A strong and significant relationship has been reported between green space size and increased cooling effects (Cao *et al*., 2010; Chen *et al*., 2014; Dobrovolny, 2013; Feyisa *et al*., 2014; Hart and Sailor, 2009; Li *et al*., 2012; Onishi *et al*., 2010; Susca *et al*., 2011; Weber *et al*., 2014; Zupancic, 2015). For instance, modelling revealed that an urban cooling island (UCI) was found to increase with the length of the park and larger green space sizes were significantly related with urban cooling islands, either because less heat from built-up areas is radiated to the centre of the green space, or because more of the cool air is built up and sent out from the centre (Vidrih and Medved, 2013). While the size of the green space was found to affect urban cooling islands in all seasons, it appears to be particularly strong in summer (Chen *et al*., 2014; Li *et al*., 2012; Onishi et al., 2010; Susca *et al*., 2011). Although cooling effects have been recognized in small parks, land surface temperature analysis of 92 parks (Cao *et al*., 2010) showed that larger parks have stronger cooling effects and that urban cooling islands only exist when parks are larger than a certain threshold (two hectares in the study). Nevertheless, it is imperative to note that this threshold is for reduction of surrounding surface temperature and parks under two hectares can still offer thermal comfort via shade.

Shape and spatial configuration: Urban heat mitigation may be accomplished by increasing the relative amount of green space, but also by optimizing the spatial configuration of green space (Choi *et al*., 2012; Rinner and Hussain, 2011). For instance, there is some proof that small parks spaced closely together could improve total health of urban areas (Zupancic, 2015).

2.4.4 Taxonomic variables: green space and heat

Many meterological variables, such as wind, temperature, and season, the surrounding built environment and precipitation can alter the cooling influence of green space.

Wind: Trees can decrease wind speeds on streets, leading to increasing temperatures inside street caryons. Though, the benefit of thermal comfort provided by tree shade is believed to outweigh the possible loss of wind speed from trees (Lin *et al*., 2010; Park *et al*., 2012; Shashua-Bar *et al*., 2012). Wind usually increases the cooling effects of parks (Doick *et al*., 2014; Oliveira *et al*., 2011). During light wind conditions, warm air in the streets rises, drawing cool air from the park into the streets, causing cooling. At higher wind speeds, these currents and the related cooling effect of the park are disrupted (Doick *et al*., 2014; Zoulia *et al*., 2009).

Foliage modifies wind patterns by hindering, guiding, deflecting or purifying (Miller, 2007). Tree planting to decrease wind speeds has long been experienced around the world, particularly the planting of semi-porous windbreaks in rural setting. A barrier of nearly 35percent transparent material can create a long calm zone that can prolong up to 30times the windbreak height (Carbon, 1965). In cities tall buildings generate pathways of high wind velocity (wind tunnels) and vegetated buffers can help disorder these straight pathways. Reduced wind speeds can increase human comfort by decreasing wind chill factors and improving human mobility, including walking or cycling in places subject to wind tunnel effects (Trowbridge and Mundrak, 1988).

Evergreen tree species are mostly preferred as wind breaks as deciduous species are only about 60percent efficient in winter compound with summer when they are in leaf (Heisler, 1991). (Heister, 1990), also describes wind reductions due to buildings and trees in residential neighbourhoods. Modification of wind speed and direction can also disturb cooling and heating costs in buildings. Reducing wind speeds can decrease heating costs in winter, but reduce cooling effects in summer (Akbari and Taha, 1992). One study examines the combined effects of increased shade and reduced wind speeds on residential air conditioning costs, giving an annual savings of 2-23% (Heisler, 1989; Ely and Pitman, 2012). Trees can provide shade from UV radiation and reduce its associated health problems such as skin cancer (Heisler and Grant, 1995; Parisi and Kimlin, 2000; Grant and Heisler, 2002; Watson, 2006). It has been shown that shade alone can reduce overall exposure to UV radiation by up to 77% (Parsons and Tassinary, 1998). Shading by urban trees reduce ultraviolent irradiance when they obscure, leaving much of the sky in view, UV irradiance is greater than suggested by the visible shade. A recent study develops a methodology to assessing the amount of protection tree canopies can provide (Grant and Heisler, 2002). The paper suggests a number of improvements to the urban environment including increased tree canopy coverage (Ely and Pitman, 2012).

Africa is gifted with rich supply of green foliage, found in mangrove forests, equatorial forests, tropical rain forests and grasslands. But one of the impacts of global warming is desertification or desert encroachment, whereby forests are progressively being converted into grasslands, which in turn become converted into deserts. This process of desert encroachment can be checked if Africans take some landscape dealings namely:

1. Creation of shelterbelts or windbreak using fast growing, wide-crowned trees (Azadirachita indica) and slow-growing narrow-crowned trees (Citrus species)
2. Developing of shade trees, near houses and offices (Ficus species) which produce large crowns or canopies.
3. Creation of hedge plants and ornamental plants around houses and buildings in schools, campus and work environments e.g Polyalthia longifolia.
4. Formation of children's playgrounds, football fields, nature parks for recreation, using such as lawns and open spaces. The plants also help to keep the environment cool, through the process of stomatal transpiration, whereby large quantities of water vapour are transpired through the stomata into the atmosphere. This process encourages cloud and rain formation, which in turn checks the process of desertification (Oladele, 2002; Keay, 1989), related to the reports of AbdulRahaman and Oladele (2008) on the role of Africans in the Mitigation of climate change, using a well-planned principles of

landscaping is also the use and generalization of this study of garden design in our environment for improving the quality of air.

Temperature and Season: The cooling effects of green space are significantly greater during the hottest temperature months and hottest periods of the day when relief from heat is most needed (Bowler *et al*., 2010; Cao *et al*., 2010; Cohen *et al*., 2012; Hamada *et al*., 2013; Hwang *et al*., 2011; Meier and Scherer, 2012; Lin *et al*., 2012; Oliveira *et al*., 2011; Park *et al*., 2012; Sung, 2013; Zhang *et al*., 2013). Increased temperature was also found to increase the cooling capacity of green walls (Hamada and Ohta, 2010; Koyama *et al*., 2013).

Built environment: Many characteristics of the built environment, such as building density, heights and arrangement, can significantly influence airflow, and thereby the cooling range of green spaces into surrounding urban areas (Li *et al*., 2012; Li *et al*., 2013; Zoulia *et al*., 2009). During the summer the highest temperature values are often found in east-west-oriented street canyons because north-south-oriented street canyons are more shaded throughout the day (Cohen *et al*., 2012). Increased building height and density are strongly correlated with increased land-surface temperatures, which may reduce the cooling effects of the urban forest (Weber *et al*., 2014). In terms of site location, trees along roads or surrounded by impermeable surfaces are relatively warmer than park trees; thus, it is recommended that siting trees to follow the sun to create maximum combined shading from trees and buildings is important to maximize cooling (Lin *et al*., 2012).

Irrigation: Precipitation or irrigation is necessary for green roofs to provide any significant microclimate benefit during the day (Coutts *et al*., 2013; Zinzi and Agnoli, 2012), which may be a challenge since cooling and allevaiation from heat stress are most needed under dry conditions. Consequently, relying on rainfall, particularly in dry climates, may limit the cooling capacity of green roofs. The cooling effect of plants on air temperatures may be strictly limited if ideal water and soil conditions that support evapotranspiration are not met (Vidrih and Medved, 2013).

2.4.5 Foliage features and air quality

Individual plants species display vast differences in their ability to uptake pollutants (Rowe, 2011). Trees and shrubs were more efficient in removing contaminants than herbaceous perennials due to greater leaf surface area; conversely, the added load requirements and costs of tree roofs limit the feasibility of this option. Similarly air quality improvements from green roofs could be maximized through plant selection. For instance, the tobacco plant was found to have 30times more of NO_2 uptake capacity than commonly used sedium-like succulents. More recently, a comparison of four green roof species found that creeping *bentgrass* and red *fescue* had higher particle capture of PM10 than *ribwort* plantain and the more extensively used green roof species sedum (Speak *et al*., 2012). Nevertheless, a study comparing the PM capture of common roadside plants in Berlin, Germany, found the overall amount of PM on the leaves of roadside species varied according to traffic density, particle type and species and initiate that the mitigation of a wider range of particle can be achieved by taking full advantage of both the structural and species diversity of plants (Weber *et al*., 2014; Zupancic, 2015). In terms of aesthetics, a combination of trees and shrubs is found in most urban parks. One of the first in-depth comparisons of eight different tree and shrub species found that they varied significantly in their ability to capture particulate matter. All plant species tested captured particulate matter of large (10 to 100um), coarse (2.5 to 10um) and fine (0.2 to 2.5um) fraction sizes, but *Spiraeajaponica* was the most effective while *Platanus x Hispanica* was the least effective with a more than twofold difference between the two (Saebo *et al*., 2012). The work by (Yin *et.al*., 2011) put forward that in the highly urbanized Pudong District of Shanghi, an urban park patch of 10,000 square meters planted with a combination of 600 medium-sized trees and 10,000 low shrubs could reduce traffic-based on air pollution by 30 percent for PM10, 15 percent for SO_2 and 10 percent for NO_2 from roadside to 100 metres of the park.

The evidence is clear that trees are vital for mitigating air pollution; though, most of the evidence explores the effects of overall abundance and distribution of trees and far less is known about the impacts of specific tree types and species on air quality (Escobedo and Nowak, 2009; Manes *et al*., 2012). Ground-level data collected from 47 different woody plant species in Norway and Poland established that differences in particulate matter accumulation result from complex interactions between plant properties, climate and other environmental factors. For instance, species *Pinus mugo* and *Pinus sylvestris*, *Taxus media* and *Taxus baccata*, *Stephanandra incise* and *Betula pendula* were more effective in capturing PM than other species such as *Acer platanoides*, *Prunus avium* and *Tilia cordata* (Saebo *et al*., 2012). Amongst the studies identified in this review, coniferous trees are found to be the best for capturing PM over evergreen broadleaf and deciduous species (Tallis *et al*., 2011; Tiwary *et al*., 2009). However, evergreen broadleaf and deciduous tree species have been found to eliminate more atmospheric O_3 than confer forests (Alonso *et al*., 2011). In term of BVOC emission, studies in a temperate, dry summer climate found that *Pinus pinea*, *Aesculus hippocastanum* and *Porpulous alba* were the most effective species in removing CO, O_3, NO_2 and SO_2 from the air, while *Aesculus hippocastanum* was the most effective as filter for PM_{10}. Though, *Porpulus alba* was a strong emitter of isoprene (BVOC). The species that showed a high potential of ozone formation were *P.pinea*, *A. hippocastanum*, *Q. robur*, *G. biloba*, *Q. ilex* and mainly *P. alba*, while *Fraxinus ornus and Carpinus betulus* revealed the lowest emission of total BVOCs (Paoletti *et al*., 2011). Notwithstanding the unique differences among tree species**, a diversity of tree species can**

provide the most stable improvements in air quality. A studyof evergreen broadleaf, conifer and deciduous species by (Manes *et al*., 2012) found complementary air-pollution uptake patterns (related to tree physiology and phenology) across the seasons. For instance, in spring, deciduous broadleaves showed the highest and conifers showed the lowest potential O_3 uptake. In summer deciduous broadleaves showed a reduced O_3 uptake while evergreen broadleaves were able to maintain high levels of potential O_3 uptake and conifers showed increased O3 uptake. In fall, it changed again with higher values estimated for deciduous broadleaves and lower values for evergreen broadleaves and conifers. Their results put forward that increased diversity of tree species could provide maximum overall air-quality improvements and resiliency to seasonal and climatic fluctuations. Furthermore, they compared the BVOC emissions of these trees and reported that evergreen broadleaves include both strong and medium monoterpene emitters *(Quercus ilex, Quercus suber*), deciduous broadleaves include both species with negligible VOC emissions (*Quercus cerris)* and medium isoprene emitters (*Plantanus x Acerifolia, Ropinia pseudoacacia*), while conifers are dominated by medium monoterpene emitter Pinus pinea (Manes *et.al*., 2012).

2.4.6 Foliage characteristics and air pollution

Vegetation density: Vegetation density is the major green space characteristic associated with increased pollution mitigation from urban forests (Yin *et al*., 2011; Dzierzanowski *et al*., 2011; Escobedo and Nowak, 2009; Nowak *et al*., 2013; Tallis *et al*., 2011; Tiwary *et al*., 2009; Tsiros *et.al*., 2009; Zupancic, 2015). For air pollution studies green space density is generally described in terms of relative tree cover, which is (crown cover, leaf area density and leaf area index). Tree sizes and density affect pollution mitigation rates. For example increased tree cover is positively associated with increased mitigation of PM, O_3, NO_2 and SO_2 (Escobedo and Nowak, 2009;

Nowak *et al*., 2014; Nowak *et al*., 2013). Paoletti *et al* (2011) reported that the pollutant removal rates of trees increased over time as the tree grew in size. Denser tree canopies were associated with greater air quality reported by Cavanagh *et al* (2009). Crown volume coverage (CVC) of tree according to Yin *et al* (2011) was positively associated with pollution removal rates (PM_{10}, SO_2, and NO_2) and the study suggests that a CVC value of 2.0m3/m2 was a good target threshold for park design. Accordingly Tallis *et al* (2011) larger trees with greater canopies are generally capable of removing more PM10, while according to Tiwary *et al* (2009) younger, smaller trees are still effective in removing PM_{10} due to their greater foliage densities.

Plant height: there is some indication that compact trees and shrubs growing low to the ground (*Spiraea japonica*) are more efficient for PM capture than large, branchy trees *(P. hispanica*) (Saebo *et al*., 2012; Dzieranowski *et al.*, 2011).

Plant leaf characteristics: Evolving evidence shows the importance of plant leaf traits on PM mitigation. Increased PM capture is associated with greater plant hair density (Speak *et al*., 2012), plant leaf density (Speak *et al*., 2012) greater leaf wax and broader leaf surfaces (Hwang *et al*., 2011; Dzierzanowski *et al*., 2011). Leaf surface roughness was not found to be significant to PM accumulation in a study by (Saebo *et al*., 2012). They found that pines species were particularly efficient at capturing PM despite the lack of leaf hair or rough surface. Studies also found that pine foliage ranked the highest in terms of PM accumulation.

2.4.7 Taxonomic variables: green space and air pollution

Many variables such as Plant location, pollution levels, wind, season, temperature and precipitation can all modify the air-pollution mitigating effects of green space.

Plant location: The degree to which plant location affects levels of air pollution mitigation is unclear. Findings generally point to the combined effect of other modifiers such as wind, microclimate and local pollution levels (Saebo *et al*., 2012; Tallis *et al*., 2011). For instance, the deposition of pollutants on plants depends on factors such as the pollution concentration and climatic factors where the plant is located (Tallis *et al*., 2011). Nevertheless, measured particulate matter accumulation on the leaves of 22 trees and 25 shrubs at multiple test field in Norway and Poland over two years (Saebo *et al*., 2012). They found that plant species (and not location) were a better predictor of PM accumulation on plants. Species found to accumulate a relatively high amount of PM (such as *B. pendula*) did so despite different locations and enviroments. However, species accumulating little PM (such as *A. platanoides* and *A. pseudoplatanus*) set in locations with relatively high levels of air pollution were also the less efficient in locations with low levels of air pollution. The authors suggest PM accumulation by plants generally depends more on species-specific properties than plant location (Saebo *et al*., 2012). Although in another studies conducted by (Oladele *et al*., 2013) on tree barks with lichens as bioindicators of atmospheric pollution reveals the positve significance of plant location to atmospheric pollution monitoring.

Pollution levels: As mentioned above, there is debate over whether or not the closer proximity of plants to air pollution results in greater exposure, capture and uptake of air pollutants. For example, whereas some studies report increased particulate matter removal by plants in areas with more air pollution (Tallis *et al*., 2011), other studies report that the plant species (and not pollution levels) are a greater predictor of PM removal rates (Saebo *et al*., 2012). Likewise, in some cases, if pollution levels are too high, plants can be damaged or destroyed (Manes *et al*., 2012; Morani *et al*., 2011; Roy *et al*., 2012).

Wind: Improvements in air quality tend to occur under windy conditions (Alonso *et al*., 2011; Nowak *et. al*., 2013; Srivanit and Hokao, 2013). Conversely, the impact of wind on the pollution mitigating effects of green space is highly complex, mainly in the context of urban streets. Pollutant concentrations in an urban street canyon depend on the amount of wind present to carry pollutants away. For example, a study in Lisbon on the dispersion of traffic-based carbon monoxide (CO) emissions at the pedestrian level found that for an incoming wind direction of approximately 45º on one street, CO concentrations increased by approximately 12 percent due to the effect of trees on the exchange rates with the air above roof levels. Also, a street with parallel winds showed a CO concentration decrease of about 16 percent due to better ventilation (Amorim *et al*., 2013). In case of green roofs, site-specific winds also affected street canyon air quality. PM mitigation effects were significant with a roof located downwind of a major emission source but not significant for a green roof with prevailing winds that crossed the roadway before reaching the roof (Baik *et al*., 2012; Speak *et al*., 2012). In cases of low wind speeds green walls may offer considerable potential for reductions in street canyon air pollution and may act as abuffer against pollution hot spots (Amorim *et al.*, 2013).

Season/Temperature: Average values for seasonal removal of air pollution show a similar pattern across pollutants where uptake was lowest for all pollutants in winter and highest in the spring and summer (Baro *et al*., 2014). Ozone deposition rates may be higher in spring than in summer, showing that drought stress may lower the sink activity for O_3 pollution (Alonso *et al*., 2011; Escobedo and Nowak, 2009; Zupancic, 2015).

Precipitation: Increased precipitation also tends to increase the ability of urban forests to remove PM because it washes particles from the leaf surfaces. Lower removal rates were found in areas with lower precipitation (Nowak *et. al*., 2013). Stomatal conductance of deciduous trees appears to be more affected by drought conditions, and coniferous trees were found to be more drought-tolerant (Manes *et al*., 2012).

2.4.8 Negative impacts linked with green space

Two vital negative impacts were identified in the literature and the first is the increased green density from trees or other plants which may increase street canyon air pollution leading to much higher exposure for pedestrians in the canyon, this could be detrimental to health, mostly in populated areas (Amorim *et al*., 2013; Morani *et al*., 2011). Whereas street trees were found to reduce street-level PM10 they increased NO_2 concentrations in highly polluted canyons in most circumstances (Pugh *et al*., 2012). Though, for streets with moderate or low emissions, trees showed an 'unambiguously beneficial effect' (Pugh *et al*., 2012). The other possible negative impact of green space relates to evidence that some trees emit biogenic volatile organic compounds (BVOC). BVOC emissions can increase levels of ground-level ozone when mixed with NO_2 (form traffic) in the presence of sunlight (Escobedo and Nowak, 2009; Roy *et al*., 2012). Higher BVOC measures are generally found in vegetated urban areas (Bao *et al*., 2010; Baro *et.al*., 2014; Roy *et.al*., 2012) and have been found to contribute to increased ground-level ozone (Bao et.al., 2010). Conversely, green spaces such as forests can also act as sinks for ground-level ozone, even among forests with high BVOC emitting tree species. A study in Madrid found removing a large urban forest led to increased ground-level ozone both within and downwind of the modified areas. The result supports the finding of another researcher that the capacity for urban forests to remove ground-level ozone is greater than the potential ozone production resulting from BVOC chemical interaction (Alonso *et al*. 2011; Nowak, 2000).

2.5 Visualization Skill and Design

The study of visualization ability and its effect has a long history in many professional societies. As reported by Cleveland (1993) and Miller (1996), visualization has been part of the information disseminated throughout the Engineering Design Graphic Journal. One of the most intriguing factors, at least to this author, is the role that imaginations play in visualization ability. Many of the sources discussed by Miller, including prominent historical individuals in the field such as Orth (1941); Blade (1949); and Kliphart (1957) state, that imagination was primary to visualization ability. It would seem natural (and is pointed out by these sources) that the ability to imagine familiar objects such as chair, table or other item is a precursor to being able to visualize an object based on orthographic multiviews. It would also stand to reason that imaginative ability would be a precursor to operating within a CAD 2D and 3D environment which requires spatial visualization and orientation abilities (Mohler, 1997). Within our own decade, the impact of imagination can be seen through suggestions of Architectural model (AM) making for curricula and media tools to aid in the teaching of visualization as a basic concept of Science Entrepreneurship. Science is not just an academic exercise; it should be seen as an avenue for wealth creation. It was suggested by Wiley (1990); Wiebe (1993); Ross and Aukstakalnis (1993) that the use of real models, animations, and virtual environments can aid in teaching or enhancing visualization ability, there will be increase in the imaginative power which will later develop the level of social appreciation for Botanical Garden design interm of visual, functional and aesthetic benefit to the socio-cultural, economic and environmental quality of our societies. The concept of environmental quality is broad and can encompass many elements including environmental pollution and cleanliness, and visual quality and personal security (Mohler, 1997). Trees do provide an incredible number of medicinal, environmental beautification, phytoremediation and economic benefits. Despite this, it seems that it is often more persuasive to use designs (visual) to communicate their values.

Therefore, a central role in building layout is played by the function of individual spaces within the building, and the functional relationships between spaces (Hillier and Hanson, 1989).

In practice, building layout design relies on a deep understanding of human comfort, needs, habits, and social relationship. Numerous guidelines have been proposed for the building layout process (Alexander *et al.*, 1977; Susanka, 2001; Jacobson *et al.*, 2005), and a few are near-universal in practice. One is the privacy gradient, which suggests placing common areas, such as the living room, closer to the entrance, while private spaces, such as bedrooms, should be largely convex and avoid deep recesses, due to the instinctive discomfort sometimes triggered by limited visibility in concave spaces.

2.6 Plant Architecture

The knowledge of Plant Architecture emerged some 40years ago, and derived, in a number of ways, from earlier works on Plant Morphology (Halle and Oldeman, 1970; Halle *et al.*, 1978). A novel feature of plant architectural studies is that they were originated in tropical regions and were, at first, apprehensive with the study of the aerial vegetative structure of tropical trees (Halle and Oldeman, 1970). Since their definition, architectural ideas have provided great tools for studying plant form or even tropical forest structure and the indulgent of its dynamics and functional values (Oldeman, 1974, 1993, 1990; Halle *et al.*, 1978; Vester, 1997). Studies based on these concepts quickly spread to temperate species (Edelin, 1981; Caraglio and Edelin, 1990; Nicolini, 1998; Grosfeld *et al.*, 1999; Millet *et al.*, 1999; Sabatier and Barthelemy, 1999; Stecconi *et al.*, 2000). The architecture of a plant hinges on on the nature and on the relative prearrangement of each of its parts; it is, at any given time, the countenance of equilibrium between endogenous growth processes and exogenous restrictions exerted by the environment. The aim of architectural analysis is to find these endogenous progressions and to distinct them from the plasticity of their expression resulting from external influences by means of observation and investigation. Seeing the plant as a whole, from growth to death, architectural analysis is basically a global, multilevel and dynamic method to plant improvement (Barthelemy and Caraglio, 2007). For each species, at each location and stage of growth and in each environmental circumstance, careful qualitative and quantitative morphological or even anatomical interpretations are made on varying numbers of individuals, liable on the complexity of the architecture.

Plant forms, growth and evolution have been analysed under the functional views of biomechanics (Niklas, 1992, 2005; Rowe and Speck, 2005). Since its intiation and definition by von Goethe (1790), plant morphology has had a fruitful history and it is commonly acknowledged that plants are modular organisms that develop by the replication of basic botanical entities whose morphological, functional and anatomical features change during ontogeny and according to a number of processes variously called heteroblasty, period change, life stages, maturation, ageing, and morphogenetic progression (Goebel, 1900; Wareing, 1959, 1961; Nozeran, 1978, 1984; Gatsuk *et al*., 1980; Greenwood, 1987, 1995; Poethig, 1990; Jones, 1999, 2001; Kaplan, 2001). As Plant Morphology concerns with plant form and structure and with their temporal and topological changes during ontogeny and even phylogeny, it is thus revevant to practically all the disciplines of modern life science-plant biology (Sattler, 1978; Roloff, 1988; Sattler and Rutishauser, 1997; Scotland *et al*., 2003; Wiens, 2004; Mueller, 2006).Plant Morphology, in its historical and broader sense and as a synthetic discipline, may be considered as one of the main 'inspring soul' of plant architecture studies (Barthelemy and Caraglio, 2007). The main morphological traits (characters) that are usually used in plant architectural analysis are well documented in previous works (Troll, 1937; Bell, 1991; Halle *et al*., 1978) and may be grouped according to four major categories:

1. Growth process.

2. Branching process.
3. The morphological differentiation.
4. The position of living reproductive and non-living structures on the site.

2.7 Science Entrepreneurship

The study of Plant Architecture emerged as a new scientific discipline with an notion that science is business and not an academic exercise only; it is also an avenue for making of wealth when plant form, services and function are combined on a fertile soil with enough nutrients and moisture to provide the essential nutrition and aesthetically pleasing environments for the society, Plant health, human health and well-being (Oladele and Abayomi, 2012 Personal communications). Entrepreneurship is often argued under the title of the entrepreneurial feature, function, initiative, and behavior and is even stated as the entrepreneurial spirit (Miller, 1983; Schumpeter, 1934; 1942; Knight, 1921). Consequently, there are three basic thoughts that elucidate the advent of entrepreneurial activity. The first centers on the individual, in other words, entrepreneurial action is regarded as a human attribute, for instance the willingness to face uncertainty (Kihlstrom and Laffont, 1979), the second fundamental idea accentuates economic, environmental factors that inspire and enable entrepreneurial activity (Tushman and Anderson, 1986; Acs and Audretsch, 1990), the third factor is associated with the functioning of institutions, culture and societal values (Eckhardt and Shane, 2003). Entreprenurship is an indispensable element for economic progress as it reveals its fundamental significance in different ways: (a) by identifying, classifying, evaluating and exploiting business opportunities in science; (b) by creating new gardens and laboratories/or renewing existing ones by making them more dynamic; and (c) by driving the economy forward through research, information and communication technology (ICT) enable garden development, invention, competency, job creation and by generally refining the air quality and wellbeing of society.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Description of experiment location

The experiment was conducted in some gardens in the sub-divided vegetation zone of Nigeria in which one major city were purposefully selected from each zone. Purposeful sampling was used because the selection of the locations was based on the fact that they are the botanical gardens of the selected universities (Appendix 1-6) in the state of studies. The purposeful selection adopted as well helped in making available reasonable number of data to work with; the selection was done to ensure that none of the sub- division vegetation zone was left out in the choice of states in the study sites.

Stratified sampling method was used to ensure that tropical rain forest, sudano-guinea savannah and montane vegetation zones in Nigeria were visited for the purpose of sketching and mapping out of garden structure in the selected locations. This was done by selecting one state from each sub – division vegetation zone by balloting. The concentrations of the pollutants were monitored within and outside the gardens during both dry and rainy season with time replications between (6:30am – 6:30pm) for 12months. The sampling experimental stations of universities botanical gardens: Lagos, Akure, Ilorin, Ibadan, Jos and Kano both of tropical rain forest, sudano-guinea savannah and montane vegetation zones in Nigeria were purposefully selected to reflect the influence of botanical garden structure, planning and design on ecosystem services and atmospheric air quality. There are two broad types of vegetation in Nigeria namely forest and savanna. Forest is defined as vegetation dominated by tree species in open or closed canopy from which grasses are virtually absent. Most of the trees are not fire tolerant (Keay, 1959). Savanna vegetation on the other hand consists of woodland dominated by tall grassy ground layer with scattered trees and shrubs, usually with open canopy. Most of the trees are somehow fire tolerant, while Montane is a derived savannah.

Detailed description of the vegetation zones (ecological unit) by structure, floristic composition and physiognomy of Nigerian vegetation types and their zonal and local variations especially in relation to climatic, edaphic andtopographic factors have been given in the past by various workers Richard (1966); Keay (1959); Charter (1970); Onochie (1979); White (1983) based on climatic, edaphic and biotic factors for instance sub-divided the vegetation of Nigeria into:

1. **The Tropical Rain Forest Regions**

a. Rain forest (Lagos State) Latitude 6^0 27’14’’N Longitude 3^o 23’40’’E

i. Lagos (University of Lagos Biological garden and Environs)

Latitude: 6^o 30’ 59.99’’ N

Longitude: 3^o 23’ 5.99’’ E

b. Rain forest (Oyo State) Latitude 7^o 22’ 39’’ N Longitude 3^o54’21’’E

i. Ibadan (University of Ibadan Botanical garden and Environs)

Latitude: 7^o 23’ 28.19’’ N

Longitude: 3^o 54’ 59.99’’ E

c. Rain forest (Ondo State) Latitude 7^o15’ 22’’N Longitude 5^o 11’ 35’’E

i. Akure (Federal University of Technology Botanical garden and Environs)

Latitude: 7º 18’ 18.48’’ N

Longitude: 5º 8’ 20.65’’ E

2. **The Sudano-Guinea Savanna and Montane Regions**

a. Guinean savannah (Kwara State) Latitude 8º29’47’’N Longitude 4º32’31’’E

i. Ilorin (University of Ilorin Botanical garden and Environs)

Latitude: 8.486776 ºN

Longitude: 4.675104 ºE

. b. Sudan savannah (Kano State) Latitude 11º 30’ 0’’ N Longitude 8º 30’ 0’’ E

i. Kano (Bayero University Botanical garden and Environs)

Latitude: 11º 57’ 56.27’’ N

Longitude: 8º 25’ 51.22’’ E

c. Montane (Derived savannah) (Plateau State) Latitude 9º55’42’’N Longitude 8º 53’ 31’’E

i. Jos (University of Jos Botanical garden and Environs)

Latitude: 9º 57’ 1’’ N

Longitude: 8º 53’ 21’ E

Fig 1: Map of Nigeria shown locations of studies.

3.2 Collection of Plant Specimens

Fresh leaves were collected from mature stands of trees at sites of studied fields (Appendix 1-6). The leaf specimens were identified online and as well at the Herbarium of the Department of Plant Biology, University of Ilorin, Ilorin, Nigeria for confirmation of their identity. Voucher specimens of all plants were deposited at the Herbarium of Plant Biology Department.

Table 2: Data on Trees species in University of Lagos Biological Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1	*Tectonia grandis* L	Teak	Tikii	Verbanaceae
2	*Albizzia lebbeck* (Linn) Benth	Silk flower	Igbagbo	Fabaceae
3	*Bauhina variegate* Kurz	Bauhina	Jinga	Caesalpiniacea
4	*Albizzia zygia* (DC.) Macbor	Siris	Ayinre-weere	Fabaceae
5	*Alstonia scholaris* De Wild	Devil's tree	Ahun	Apocynaceae
6	*Erythrina senegalensis* DC	Coral tree	Ologbosere	Fabaceae
7	*Gliricidia sepium* (Jacq) Kunth	Quick stick	Agunmaniye	Fabaceae
8	*Peltophorium pterocapium* (DC) Baker ex Heyne	Golden flame	Abugilasaru	Fabaceae
9	*Treculia africana* Decne	Bread fruit	Afon	Moraceae
10	*Terminalia superba* Engl.et Diels	Shinglewood	Afara	Combretaceae
11	*Ficus diversifolia* L	Fig	Odan	Moraceae
12	*Ficus sycomonis* L	Fig	Obobo	Moraceae
13	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardaceae
14	*Annona muricata* L	Sour sop	Sharp-sharp	Annonaceae
15	*Citrius sinensis* Osbeck	Sweet orange	Orombo didun	Rutaceae
16	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinacea
17	*Azadirachita indica* A Juss	Neem	Dongo-yaro	Meliaceae
18	*Terminalia cattapa* L	Almond tree	Aga	Combretaceae

19	*Mangifera indica* L	Mango	Mangoro	Anacardaceae
20	*Gmelina arborea* Roxb	Melina	Igi-melina	Verbanaceae
21	*Casuarina equisetifolia* L	Whistring pine	Iru Jeki	Casuarinaceae
22	*Hildagardia barterii* Roxb	Hildegardia	Okurugbedu	Malvaceae
23	*Blighia sapida* K. Koenig	Akee apple	Isin	Sapindaceae
24	*Eucalyptus citriodora* Labii	Lemon scented	Gumtriya	Mytaceae
25	*Plumeria rubra* L	Frangipani	Usibaka	Apocynaceae
26	*Acacia moniliformis* Griseb	Acacia Gabarua	Kasia eleti	Mimosaceae
27	*Acacia nilotica* (L) Wild.ex Del	Acacia	Baani	Mimosaceae
28	*Pakia biglobossa* (Jacq) R Br.ex Don	Locust bean tree	Igba	Mimosaceae
29	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
30	*Milicia excelsa* (Welw.) C. Berg	Iroko tree	Iroko	Moraceae

Table 3: Data on Trees species in University of Ibadan Botanical Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1.	*Chrysophyllum albidum* G.Don	Africanstar apple	Agbalumo	Sapotaceae
2.	*Irvingia gabonensis* Baill	Wild Mango	Oro	Irvingiaceae
3.	*Snysepalum dulcificum* Schumach & Thonn	Miracle fruit	Agbayun	Sapotaceae
4.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
5.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae
6.	*Mangifera indica* L	Mango	Mangoro	Anacardaceae
7.	*Citrus sinensis* Osbeck	Sweet Orange	Orombo didun	Rutaceae

8.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardaceae
9.	*Parkia biglobossa* (Jacq) R. Br. Ex Don	Locust bean tree	Igba	Mimosaceae
10.	*Prosopis african* (Guill and Perr)	Iron wood	Kirya	Mimosaceae
11.	*Plumera alba* L	Frangipani	Usibaka	Apocynaceae
12.	*Azadirachita indica* A Juss	Neem	Dongo-yaro	Meliaceae
13.	*Erythrina senegalensis* DC	Coral tree	Ologbosere	Fabaceae
14.	*Gliciridia sepium* (Jacq) Kunth	Quick stick	Agunmaniye	Fabaceae
15.	*Milicia excelsa* (Welw.) C.Berg	Iroko tree	Iroko	Moraceae
16.	*Blighia sapida* K. Koenig	Akee apple	Ishin	Sapindaceae
17.	*Annona senegalensis* Pers	Curstard apple	Abo	Annonaceae
18.	*Ficus trichopoda* L	Hippo Fig	Bauree	Moraceae
19.	*Ficus elastica* L	Assam Rubber	Odin-faa	Moraceae
20.	*Tectonia gradis* L	Teak	Tikii	Verbenaceae
21.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
22.	*Gmelina arborea* Roxb	Melina	Igi-melina	Verbenaceae
23.	*Vitellaria paradoxa* Gaertn. F	Shea butter	Emi	Sapotaceae
24.	*Bridelia ferruginea* Benth	Pyrexia	Ira	Euphorbiaceae
25.	*Burkea africana* Hook	Wild seriga	Apasa	Caesalpiniaceae
26.	*Lophira lanceolata* Tiegh.ex Keay	Chewstick	Kujeme	Ochnaceae
27.	*Casuarina equisetifolia* L	Whisthing pine	Iru Jeki	Casuarinaceae
28.	*Ficus diversifolia* L	Fig	Odan	Moraceae
29.	*Triplochiton scleroxylon* K. Suhum	Obeche	Arere	Malvaceae
30.	*Eucalyptus citrodora* Labii	Lemon scented	Igi-Rosia	Myrtaceae

Table 4: Data on Trees species in Federal University of Technology Akure Botanical Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1.	*Ficus capensis* L	African Mustard tree	Odan	Moraceae
2.	*Ficus bengamina* L	Weeping fig	Obadan	Moraceae
3.	*Alstonia scholaris* De Wild	Milkwood-pine	Egbu	Apocynaceae
4.	*Ficus exasperata* Vahl	Sand paper tree	Epin	Moraceae
5.	*Funtumia elastica* (Preuss) Stapf	Wild rubber	Ire	apocynaceae
6.	*Milicia excelsa* (Welw.) C.Berg	Iroko tree	Iroko	Moraceae
7.	*Leucena leucocephala* (Lam) de Wit	Lead tree	Dandoya	Fabaceae
8.	*Thevetia neriifolia* Juss	Yellow Oleander	Olomiojo	Apocynaceae
9.	*Spondias mombin* L	Hog plum	Iyeye	Anacardiaceae
10.	*Mangifera indica* L	Mango	Mangoro	Anacardiaceae
11.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardiaceae
12.	*Citrus sinensis* Osbeck	Sweet Orange	Osan didun	Rutaceae
13.	*Azadirachita indica* A Juss	Neem	Dongo yaro	Meliaceae
14.	*Parkia biglobossa* (Jacq) R. Br. Ex Don	Locust bean tree	Igba	Mimosaceae
15.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
16.	*Ficus trichopoda* Bak	Fig tree	Obobo	Moraceae
17.	*Annona senegalensis* Pers	Curstard apple	Abo	Annonaceae
18.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae
19.	*Gmelina arborea* Roxb	Melina	Igi-melina	Verbenaceae
20.	*Tectonia grandis* L	Teak	Tikii	Verbenaceae
21.	*Casuarina equisetifolia* L	Whisthing pine	Iru Jeki	Casuarinaceae
22.	*Blighia sapida* K. Koenig	Akee apple	Ishin	Sapindaceae

23.	*Triplochiton scleroxylon* K. Suhum	Obeche	Arere	Malvaceae
24.	*Cynometra ananta* Hutch & Dalz	Ananta	Apome	Caesalpiniaceae
25.	*Erythrophleum* A. Chev	Sasswood	Erun	Caesalpiniaceae
26.	*Ficus diversifolia* L	Mistletoe fig	Odan	Moraceae
27.	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
28.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
29.	*Hildagardia baterii* Roxb	Hildagadia	Okurugbedu	Malvaceae
30.	*Prosobis africana* (Guill & Perr)	Iron wood	Kirya	Mimosaceae

Table 5: Data on Trees species in University of Ilorin Botanical Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
2.	*Vitellaria paradoxa* Gaertn. F.	Shea butter	Emi	Sapotaceae
3.	*Gliricidium sepium* (Jacq) Kunth	Quick stick	Agunmaniye	Fabaceae
4.	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
5.	*Casuarina equisetifolia* L	Whisthing pine	Iu Jeki	Casuarinaceae
6.	*Tectonia grandis* L	Teak	Tikii	Verbenaceae
7.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
8.	*Parkia biglobossa* (Jacq) R. Br. Ex Don	Locust bean tree	Igbaa	Mimosaceae
9.	*Daniellia olieveri* (Rolfe) Hutch and Dalz	Balsam tree	Iya	Caesalpiniaceae
10.	*Prosopis africana* (Guill and Perr.)	Iron wood	Kirya	Mimosaceae
11.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae

12.	*Gmelina arborea* Roxb	Melina	Igi-melina	Verbenaceae
13.	*Plumera alba* L	Frangipani	Usibaka	Apocynaceae
14.	*Azadirachita indica* A Juss	Neem	Dongo yaro	Meliaceae
15.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardiaceae
16.	*Citrus sinensis* Osbeck	Sweet Orange	Orombo didun	Rutaceae
17.	*Bridelia ferruginea* Benth	Pyrexia	Ira	Euphorbiaceae
18.	*Blighia sapida* K. Koenig	Akee apple	Ishin	Sapindaceae
19.	*Annona senegalensis* Pers.	Curstard apple	Abo	Annonaceae
20.	*Lophira lanceolata* Tiegh.ex Keay	Chewstick	Ipawhaw	Ochnaceae
21.	*Burkea africana* Hook	Wild seriga	Apasa	Caesalpiniaceae
22.	*Albizza lebbeck* (Linn) Benth	Silk flower	Igbagbo	Fabaceae
23.	*Eucalyptus citrodora* Labii	Lemon scented	Igi-Rosia	Myrtaceae
24.	*Hildagardia barterii* Roxb	Hildagadia	Okurugbedu	Malvaceae
25.	*Eucalyptus cinerea* F.Muell. ex Benth	Eucalyptus	Igi-Rosia	Myrtaceae
26.	*Acacia moniliformis* Griseb	Acacia	Kasia eleti	Mimosaceae
27.	*Ficus diversifolia* L	Fig	Odan	Moraceae
28.	*Mangifera indica* L	Mango	Mangoro	Anacardiaceae
29.	*Lonchocarpus cyanenscens* Perkin	WestAfrica indigo	Elu	Fabaceae
30.	*Adansonia digitata* A.L	Baobab	Ku'uka	Bombacaceae

Table 6: Data on Trees species in Bayero University Kano Botanical Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1.	*Azadirachita indica* A Juss	Neem	Dogon yaro	Meliaceae
2.	*Vitellaria paradoxa* Gaertn. F.	Shea butter	Kadanya	Sapotaceae

3.	*Albizzia lebbeck* (Linn) Benth	Tongue acacia	Bature	Fabaceae
4.	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
5.	*Annona senegalensis* Pers	Wild custard	Daaji	Annonaceae
6.	*Khaya senegalensis* (Desr.) Juss	Mahogany	Ogangwo	Meliaceae
7.	*Citrus paradise* Macfad	Grape orange	Osan paya	Rutaceae
8.	*Plumera alba* L	Frangipani	Usibaka	Apocynaceae
9.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
10.	*Citrus sinensis* Osbeck	Sweet orange	Osan didun	Rutaceae
11.	*Ficus elastica* L	Indian rubber	Odin-faa	Moraceae
12.	*Citrus reticulata* L	Tangarines	Osan tajarin	Rutaceae
13.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardiaceae
14.	*Mangifera indica* L	Mango	Mangoro	Anacardiaceae
15.	*Tamarindus indica* Linn	Tarmarind	Tsamiya	Caesalpinideae
16.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
17.	*Adansonia digitata* A.L	Baobab	Ku’uka	Bombacaceae
18.	*Ziziphus mauritiana*	Chinese date	Magarya	Rhamnaceae
19.	*Prosopis africana* (Guill and Perr.)	Iron wood	Kirya	Mimosaceae
20.	*Parkia biglobossa* (Jacq) R. Br.ex Don	Locust bean tree	Igba	Mimosaceae
21.	*Blighia sapida* K. Koenig	Akee Apple	Gwanja	Sapindaceae
22.	*Gmelina arborea* Roxb	Melina	Malaina	Verbenaceae
23.	*Vitex doniana* L	Black plum	Dinya	Verbenaceae
24.	*Terminalina macroptera* Guill and Perr.	Kwandari	Daji	Combretaceae
25.	*Acacia gourmaensis* A. Chev	Flat wattle	Kakaya	Mimosaceae
26.	*Lophira lanceolata* Tiegh.ex Keay	Chewstick	Ipawhaw	Ochnaceae
27.	*Casuarina equisetifolia* L	Whisthing pine	Iru Jeki	Casuarinaceae
28.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae

29.	*Balanites aegyptiaca* (L) Del	Desert date	Aduuwa	Zygophyllaceae
30.	*Hildagardia barterii* Roxb	Hildagadia	Kariya	Malvaceae

Table 7: Data on Trees species in University of Jos Botanical Garden and Environs

	Scientific Names	Common Names	Local Names	Families
1.	*Casuarina equisetifolia* L	Whisthing pine	Iru Jeki	Casuarinaceae
2.	*Plumera rubra* L	Frangipani	Usibaka	Apocynaceae
3.	*Plumera alba* L	Frangipani	Usibaka	Apocynaceae
4.	*Eucalyptus citrodora* Labii	Lemon scented	Igi-Rosia	Myrtaceae
5.	*Eucalyptus cinerea* F.Muell.ex Benth	Eucalyptus	Igi-Rosia	Myrtaceae
6.	*Acacia moniliformis* Griesb	Acacia	Kasia eleti	Mimosaceae
7.	*Erythrina senegalensis* DC	Coral tree	Minjirya	Fabaceae
8.	*Delonix regia* (Hook) Raf	Flamboyant tree	Seke-seke	Caesalpinaceae
9.	*Hildagardia baterii* Roxb	Hildargiadia	Kariya	Malvaceae
10.	*Terminalia superba* Engl.et Diels	Shinglewood	Afara	Combretaceae
11.	*Terminalia catappa* L	Almond tree	Igi furutu	Combretaceae
12.	*Bauhinia* spp Kurz	Bauhinia	Jinga	Caesalpiniaceae
13.	*Milicia excelsa* (Welw.) C. Berg	Iroko tree	Iroko	Moraceae
14.	*Polyalthia longifolia* Sonn	Azoka tree	Igunnu	Annonaceae
15.	*Gmelina arborea* Roxb	Melina	Malaina	Verbenaceae
16.	*Mangifera indica* L	Mango	Mangoro	Anacardiaceae
17.	*Anacardium occidentale* Linn De Wild	Cashew	Kasu	Anacardiaceae
18.	*Ficus bengamina* L	Weeping fig	Obadan	Moraceae

19.	*Citrus sinenesis* Osbeck	Sweet Orange	Osan didun	Rutaceae
20.	*Citrus reticulata* L	Tangarine	Osan tajarin	Rutaceae
21.	*Citrus paradise* Macfad	Grape Orange	Osan paya	Rutaceae
22.	*Pisidium guajava* L	Guava	Gweba	Myrtaceae
23.	*Moringa oleifera* Larn	Drum stick	Zogale	Moringaceae
24.	*Parkia biglobossa* (Jacq) R Br.ex Don	Locust bean tree	Igba	Mimosaceae
25.	*Cassia fistula* L	Purging cassia	Bembedo	Caesalpiniaceae
26.	*Prosopis africana* (Guill & Perr)	Iron wood	Kirya	Mimosaceae
27.	*Ficus elastica* L	Indian rubber	Odin-faa	Moraceae
28.	*Azadirachita indica* A Juss	Neem	Dogon yaro	Meliaceae
29.	*Araucaria heterophylla* (Salisb) Franco	Araucaria	Oloke-afiri	Araucariaceae
30.	*Acacia gourmaensis* A. Chev	Flat wattle	Kakaya	Mimosaceae

Experiment 1

3.3 Soil report and analysis base on the ecological zones

The ecological zone soil was evaluated by using the Field Soil Survey done and Published by Soil Survey Division, Federal Department of Agricultural Land Resources (FDALR) Kaduna, Nigeria 1990. The two ecological zones soil determined are:

i. Tropical Rain Forest Region Soil: Very deep well drained and very deep poorly drained soils; sandy loam, sandy clay loam surfaces over gravelly sandy clay loam, loam sand subsoils.

ii. Sudano-Guinea Savannah Region Soil: Deep to very deep well drained; some shallow poorly drained and very deep poorly drained soils; loam to clay loam and sometimes gravelly surfaces over sandy clay loam to clay and sometimes gravelly subsoils (FDALR, 1990).

Soil sampling in each garden was limited to the top 10cm of the soil for the reason that the greatest effects of tree vegetation usually occur in the top soil especially the top 10cm of the soil profile (Hossner, 1996; Aweto, 1981a; Ogunkunle, 2013). The soil samples were air-dried and sieved with 2mm mesh sieve.Samples for total experimental analysis and for total carbon were further grinded to pass through a 100 micron mesh sieve. Care was taken to avoid differential loss of fine dust.The samples were then analyzed for 11 soil variables parameters using standard laboratory procedures and Instruments (Table 8).

Table 8: List of Soil Variables and Procedure for Analysis.

	Soil Variable	Instrument of Determination
1.	% Sand	Hydrometer method (Buoyoucous, 1951; Day, 1965)
2.	% Silt	Hydrometer method (Buoyoucous, 1951; Day,1965)
3.	% Clay	Hydrometer method (Buoyoucous, 1951; Day, 1965)
4.	% Organic matter	(Walkey-Black, 1974; Jackson, 1962)
5.	% Nitrogen	Kjeldahl method (Brenner and Mulvaney, 1982)
6.	Av. Phosphorus	(Bray and Kurtz, 1945)

7.	Exchangeable Mg++ (ppm)	Flame Photometry method
8.	Exchangeable Ca++ (ppm)	Flame Photometry method
9.	Exchangeable K (ppm)	Residual carbonate method
10.	Exchangeable Acidity (ppm)	(in Kamprath, 1984)
11.	pH	Determined Potentiometrically in 0.01$CaCl_2$ solution

(Ogunkunle, 2013)

3.4. Determination of frequency distribution of plant species and associated lichens:

The density and frequency distribution of plant species/lichens were determined using the method described by Brower *et al.* (1998); Shukla and Chandel (2008). Thirty (30) different Transect lines of (10m by 10m) were established for each garden, the occurrence of the selected tree species and associated lichen in each Transect line was recorded. The density and frequency of each species and associated lichen was determined with this formular:

$$\text{Frequency} = \frac{\text{Number of Occurrence of each species}}{\text{Total number of all occurrence}} \times \frac{100}{1}$$

(Brower *et al*., 1998; Shukla and Chandel, 2008)

Tree species Transect line of 10m x 10m (Figure 2)

a. Placement of (10cm x10cm) Transect line on tree bark for the determination of bark lichen (Figure 3)

b. Tree height H = d + h

d = horizontal distance

h =your height to eyes level (Chaturvedi and Khanna, 1982; Yadav, 2012a)

c. Trunk diameter: - diameter at breast height (DBH) or girth at breast height (GBH) and diameter of crownusing rule or tape rule. (Patric, 1999; Civilian Conservation Corps, 2009)

d. Tree crown area (canopy)

$CA= D^{2/4}(3)$ or $D^2 X 3/4$

Where D is the average crown diameter

(Benneth and Humphries, 1974; Yadav, 2012)

Fig. 2: Transect line layouts for trees species

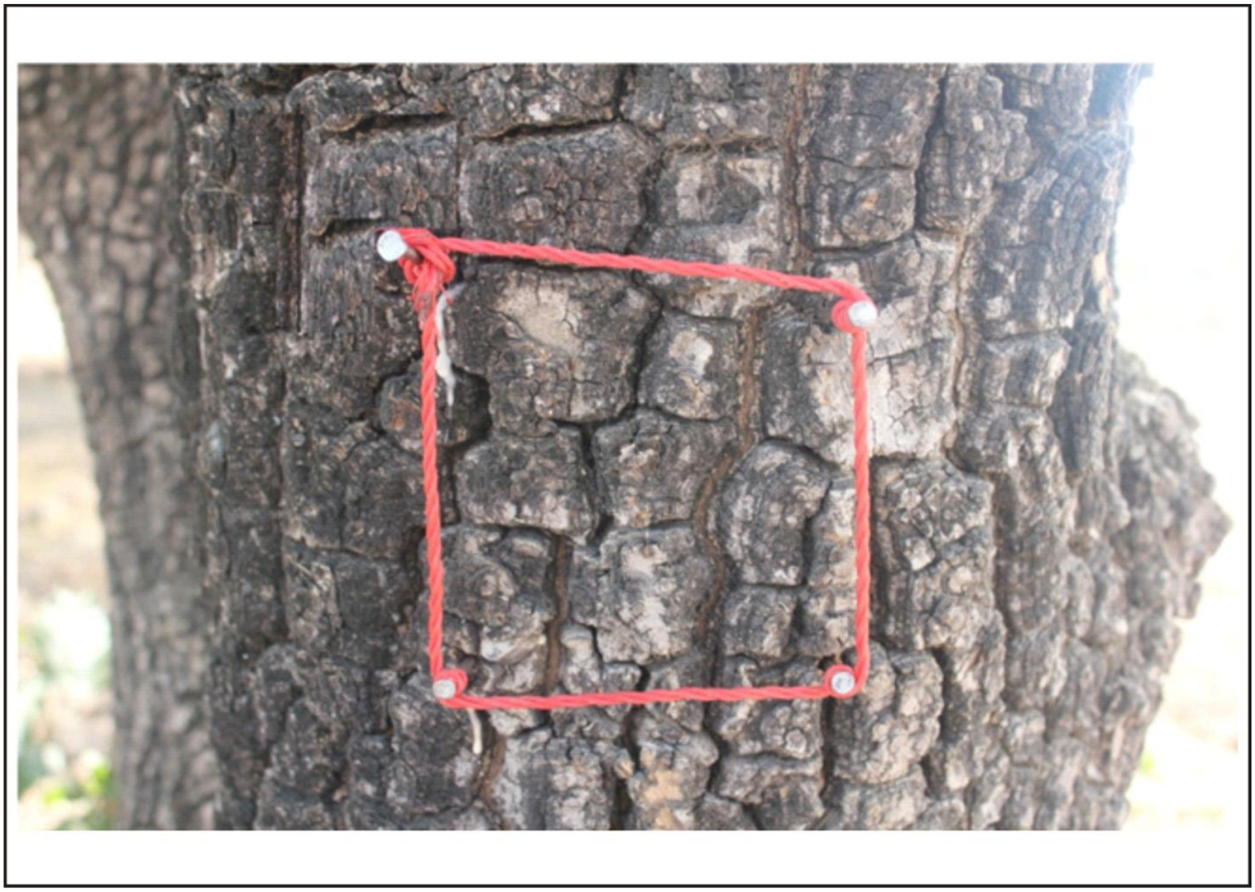


Fig. 3: Transect line layouts for lichens

3.5 Taxonomic Studies of the Foliage Features

Codes (1, 2, 3, 4, 5, and 6) were assigned to the character states (qualitative and quantitative) in ascending order in accordance to the observation, measurement and magnitude of the charactersstates (Tables 9 and 10). The formular according to Hill (1980) was used to determine the character states for the quantitative features only.

$$K = 1.0+3.332 \log n$$

Where K = Number of States

n = Number of species (OTU'S)

(Hill, 1980)

Table 9: Taxonomic Description of Qualitative Characters of Plant species

	Coded Character States					
Qualitative Characters	1	2	3	4	5	6
1. Shape of Crown	Globular	Conical	Cylindrical	Spreading		
2. Shape of leaf	Oval	Lanceolate	Oblanceolate	Linear	Ovate	Obovate
3. Leaf Type	Simple Compound	Pinnate Compound	Bipinnate Compound	Bilobate		
4. Leaf Texture	Thine	Thick	Leathery			
5. Leaf Surface	Glaborous	Pubescent	Floccose	Scabrid	Sericeous	
6. Leaf Apex	Acute	Obtuse	Acuminate	Truncate	Bristle tipped	Apiculate
7. Leaf Margin	Smooth	Serrated	Cuneate	Entire	Undulate	Dentate
8. Leaf Base	Cordate	Obtuse	Cuneate	Oblique	Truncate	Auriculate
9. Petiole	Winged	Puberulous	Glabrous	Cylinderical	Stout	Tomentose
10. Fruit Type	Berry	Drupe	Follicule	Legume	Nut	Capsule
11. Flower Type	Perfect	Imperfect	Radial Symmetry	Bilateral Symmetry		
12. Leaf Form	Conifer	Fascicle	Broadleaf	Narrowleaf		
13. Leaf Arrang.	Opposite	Alternate	Whorled			
14. Anatomy of twigs	Present	Absent	I don’t know			
15. Leaf Colour	Parrot Green	Lime Peel	Deep Mist	Alfalfa	Cadenza	Siamese

Table 10: Taxonomic Description of Quantitative Characters of Plants species

	Coded Character State					
Quantitative Characters	1	2	3	4	5	6
1. Leaf Length	Long	Medium	Short			Measurement Tape
2. Leaf Width	Wide	Medium	Narrow	Small		
3. Stem Height	Tall	Medium	Short			Swedish Stem guage
4. Plant Height	Tall	Medium	Short			Altimeter
5. Freq. Distrn	Large	Small	Medium			Quadrat
6. Blade Length	Long	Medium	Short			
7. Petiole Length	Long	Medium	Short			
8. Leaf Area	Large	Medium	Small			Leaf Area meter- 211
9. Blade Width	Wide	Medium	Narrow	Small		
10. Crown diameter	Long	Medium	Short			Spiegel Relaskope
11. Area of Canopy	Large	Medium	Small			Densiometer- model C
12. Diameter of Trunk	Long	Medium	Short			Diameter Calliper
13. Freq. of Lichens	Large	Medium	Small	Absent		
14. Density of Lichens	High	Medium	Low	Absent	Rare	Occassional
15. Density of Leaves	High	Medium	Low			

3.6 Determination of Diversity Index of the Plant species in the Garden.

Biodiversity Indicator (BDI) or Diversity Index (DI) would show whether the garden is intact or not. The former condition is when garden process is functioning well, while latter condition is when this is not functioning properly due to adverse impact by garden and human activities. The range or diversity indices can be used as a good measure for studying the effect of pollution in any ecosystem. A examination of diversity often provides a better index of pollution than a direct measurement of pollutants, the diversity index in common use in observing environmental monitoring assessment are the "Shannon-Wiener" and "Simpson" diversity index (Simpson, 1949; Shannon and Weaver, 1948; Ubom, 2010; Magurram, 1988; Kent and Coker, 1985), and are used principally to describe the taxonomic diversity of ecological communities.

So, Shannon Wiene Diversity Index, H scaled to the range of 0 – 1 is given below:

$$D = \sum (n_i/N)^2$$

Where:

D = Simpson Index of Dominance.

Simpson Diversity index = 1 - D

Shannon-Wiene Diversity Index, H is given as follows:

$$H = [\sum (n_i/N) \text{ In } (n_i/N)]/\text{In } S$$

Where:

H = Shannon-Wiene

n_i = number of each species

N = total number

n_i/N = probability function for each component of the total

S = Total number of species or component.

(Simpson, 1949; Shannon and Weaver, 1948)

Experiment 2

3.7 Shade and Shelter Characteristics of Tree Crowns

The tree crown characteristics for Shade and Shelter was determined by Tandy (1981) in order to identifying some crown forms (Silhoutte) and branching configuration forms (Picturesques) that can be used as an indices for classification and selection of tree species for suitable purpose such as aesthetic and functional values in the landscape (Fig. 4).The following parameters were determined:

(a) Crown or Canopy forms (Silhouette forms).

- Broad, Round, Square, Tapering, Conical and Columnar

(b) Branching Configuration (Picturesques forms).

- Weeping, Spreading, Contorted, Arrow, Angular and Horizontal Branching

(Tandy, 1981)

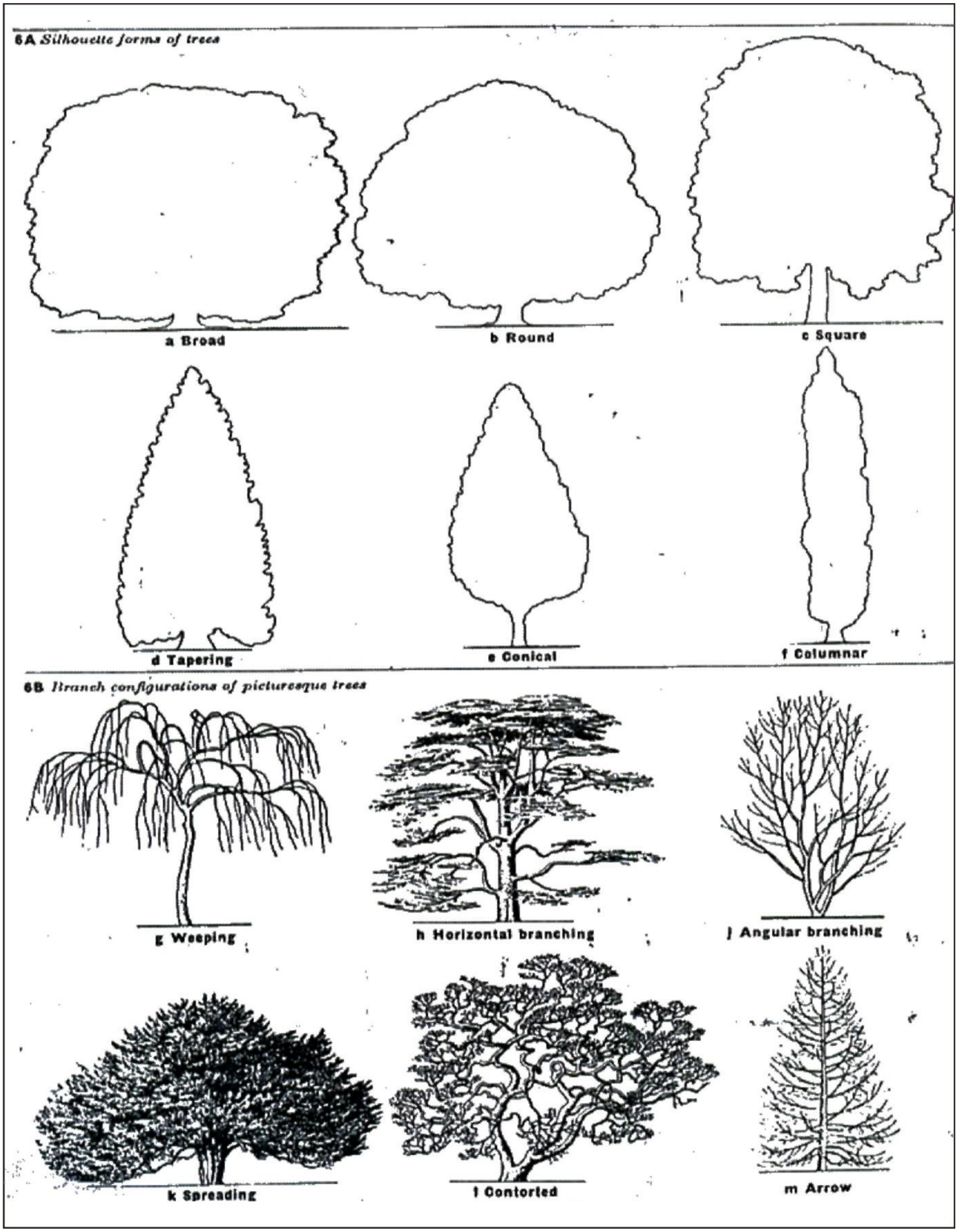


Fig. 4: Tree crowns shown silhouette and branching configuration picturesque forms

(Tandy, 1981)

Experiment 3

3.8 Determination of Biochemical Factors of Garden Plants

3.8.1 Collection of Samples

Leaf sample were collected in triplicates from the selected species in all the six gardens for analytical studies and calculation of Air Pollution Tolerance Index (APTI). The leaf samples were taken from branches at lower most position of canopy at a height of 6-7ft from ground surface of a matured tree girth size in the garden. The leaf samples were wrapped and labeled, brought to the laboratory and stored in the refrigerator for further use.

3.8.2 Determination of Relative Water Content (RWC)

Percentage (RWC) of the leaf was determined using the method of Liu and Ding (2008). It was valued with the help of data on fresh weight, turgid weight and dry weight of the respective leaf samples.

$$RWC = \frac{FW - DW \times 100}{TW - DW}$$

FW = Fresh weight

DW = Dry weight

TW = Turgid weight

3.8.3 Determination of pH of leaf extract

The leaf extract pH was determined using a glass electrode pH meter (PHS-3C model) by homogenizing 2.5g of fresh leaf sample in distilled water; the pH was determined after pH standardization with buffer at 4 and 9.

3.8.4 Estimation of Total Chlorophyll (Tch)

Total Chlorophyll content was determined using the spectrophotometric method (Arnon 1949; Chouhan *et al*., 2012).

3.8.5 Ascorbic Acid (AA) Content Analysis

Ascorbic Acid (AA) content of leaves was estimated using the spectrophotometric method (Begum and Harikrishna, 2010). Four milliliters of oxalic acid-EDTA, 1ml of orthophosphoric acid, 1ml of 5% teraoxosulphate (IV) acid, 2ml of ammonium molybdate and 3ml of water were used as extractants for 1g of the fresh leaves in a test tube. The solution was allowed to stand for 15 min and the absorbance read at 760nm. The concentration of ascorbic acid in the sample was then generalized from a standard ascorbic acid curve.

3.8.6 Calculation of Air Pollution Tolerance Index (APTI)

The Air Pollution Tolerance Index (APTI) was computed using the formula proposed by Singh and Rao (1983). The results of (APTI) obtained were interpreted with the use of Plant categorization scale (Table 11).

$$APTI = \frac{A (T + P) + R}{10}$$

Where A = Ascorbic acid content (mg/g)

T = Total chlorophyll content (mg/g)

P = pH of the leaf extract

R = Relative water content of leaf (%)

Table 11: Plant Categorization Scale

APTI	Value	Response
A	< 11	Sensitive
B	12 – 16	Intermediate
C	17	Tolerant

(Padmavathi *et al*., 2013)

Experiment 4

3.9 Collection of Meteorological Data and Analysis

Four measurements of meterological data were taken at three hours intervals between 6:30am and 6:30pm within the gardens and outside the gardens in each of the vegetational zones.The following factors were measured and analysed:

- Relative Humidity. Hygrometer (Wet and Dry – bulb thermometer)
- Temperature. Thermometer
- Wind speed. Anemometer.
- Solar radiation. Radiometer.

3.10 Determination of Pollutant levels within and outside the Gardens

The air samplings set up used have been described elsewhere by Lawani *et al.* (1996); AbdulRaheem *et al.* (2009). However, a brief overview of the schematic is presented in (Fig. 5). The sampler train is made completely sealed by use of silicon grease at all necessary joints. All the results achieved are correlated and modified with the use of a standard LaMotte air sampling kit and complement reagents (Fig. 6). The concentrations of the following pollutant gases are determined:

- Carbon-monoxide (CO).
- Oxides of nitrogen (NOx)
- Nitrogen oxide (NO,)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2).
- Ozone (O_3)
- Particulates (PM_{10}).

Pollutant gases were monitored within and outside the gardens during both dry and wet season and also the Air quality Index (AQI) was calculated from the observed pollutants using this formular.

$$AQI = \frac{1}{4} \times \frac{\text{(summation of observed pollutants)}}{\text{Standard ambient air quality}} \times 100$$

(Rao *et al.*, 2003)

The air quality index (AQI) results obtained were correlated and corrected also with the use of a national ambient air quality standards (Table 13) and standard air quality index value (Table 12). The ambient air pollutants were classified into categories ranging from good to hazardous, each with different colour code for easy identification.The regulatory framework put in place by government through FEPA is limited to emission generated through stationary source (Abam and Unachukwu, 2009). In the absence of these standards, the data in this research work were compared with the USEPA ambient air quality standards (Table 12).

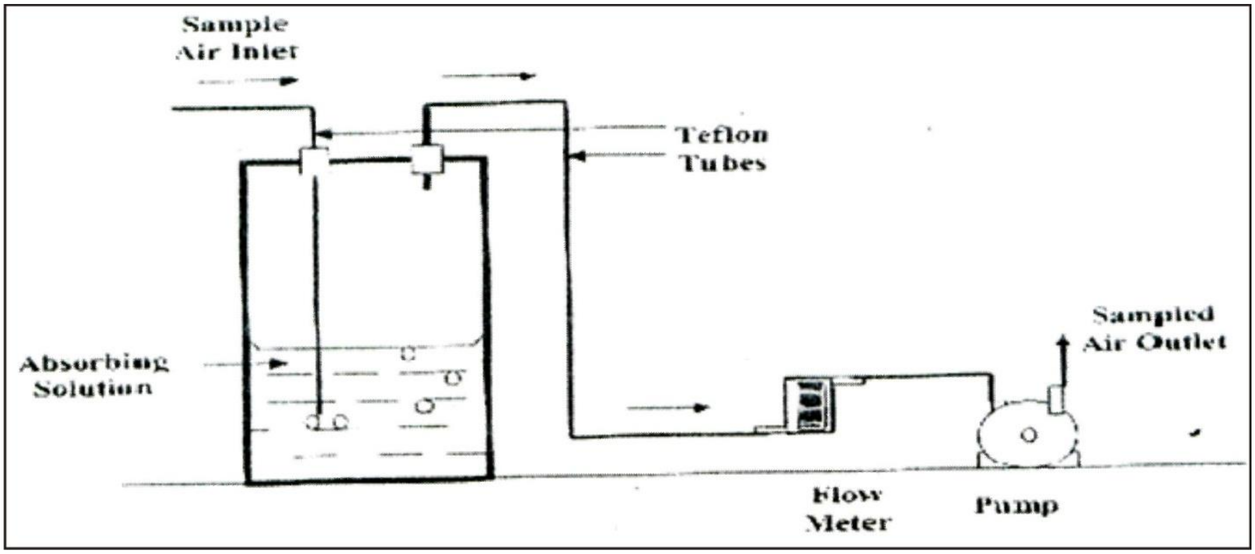


Fig. 5: The Schematics of the air – sampling set - up

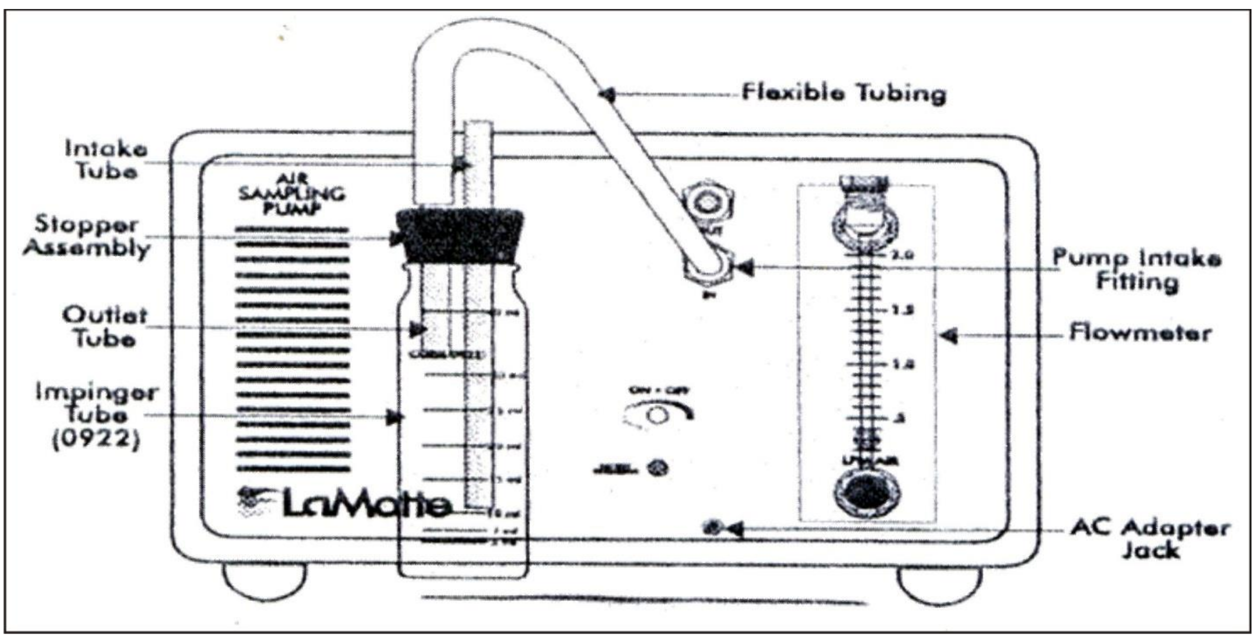


Fig. 6: LaMottee air – sampling set – up

(AbdulRaheem *et al*. 2009a)

Table 12: Air Quality Index Value

Air Quality (AQI) Values	Levels of Health Concern	Colour
when the AQI is on this range	**Air Quality Conditions are:**	**As symbolized by this colour**
0 to 50	Good	**Green**
51 to 100	Moderate	**Yellow**
101 to 150	Unhealthy for sensitive groups	**Orange**
151 to 200	Unhealthy	**Red**
201 to 300	Very unhealthy	**Purple**
301 to 500	Hazardous	**Maroon**

Source: USEPA, 2014

Table 13: National Ambient Air Quality Standards

Pollutants	Type	Standard	Averaging Time
SO_2	Primary	75ppb	1-hour
SO_2	Secondary	0.5ppm (1300μg/m^3)	3-hour
PM_{10}	Primary and Secondary	150 μg/m^3	24-hour
$PM_{2.5}$	Secondary	35 μg/m^3	24-hour
$PM_{2.5}$	Primary	15 μg/m^3	Annual
CO	Primary	35 ppm (40 mg/m^3)	1-hour
CO	Primary	9 ppm (10 mg/m^3)	8-hour
O_3	Primary and Secondary	0.12 ppm (235 μg/m^3)	1-hour
O_3	Primary and Secondary	0.075 ppm (150 μg/m^3)	8-hour
NO_2	Primary and Secondary	0.053 ppm (100 μg/m^3)	Annual
Pb	Primary and Secondary	0.15 μg/m^3	3 months

Source: WHO, 2010.

The detailed of the air sampling set up used has been presented by AbdulRaheem *et al*. (2009). A vaccum pump draws air from the atmosphere into sampling solution in bubbler at a mean flow rate of 1000cm^3 per minute. The volume of absorbing solution used 30cm^3 to ensure that enough sampled dissolved in the absorbing solution based on their low concentration in the atmosphere. All joints in the sampling train were made airtight through the application of silicon grease. Sampling was taken at 60 minute intervals, after which, the bubbler were removed carefully and absorbent solution transferred into sample bottle for analysis (LaMotte, 2005). For oxides of Nitrogen, NO_2, NO, a fitted bubbler was used to improve collection effectiveness, a high volume sampler was used in order to determine pollutant variability over daytime periods, and air samplings wereundertaken at each location over two defined 60 minutes periods for any sampling day.The sampling periods were equitably spaced between 6:30am and 6:30pm; a minimum of 8samples were collected at each site per week for the trace gases monitored on a short term basis for the purpose of mapping, trend investigation and warning. The time of 60 minutes was found from trial sampling to be sufficient for the quantitative sampling of these gases without the absorbing solution being saturated. All samplings were carried out in replicates for reproducibility. The sampling exercise lasted between October 2013 and December 2013 for trial sampling and Mid December 2013 to Mid November 2015 for the rest exercise. The number of the lichen in each of 30Transect line on each tree species were counted in accordance with the work of Oladele *et al*. (2013) in order to determine both the frequency and density of the lichen in study vegetation zone of Nigeria which is the sudano-guinea savannah region, tropical rain forest region and montane.

Experiment 5

3.11 Formulation of Prototype Garden Designs

It was based on the concept of ecological landscape design, which is based on recognizing and mapping natural processes in the landscape and using these as determinants in the design process and animation (McHarg, 1979; Horry *et al.*, 1997). Introduction of shape grammers to computer graphics and developed a system for interactive manipulation of architectural model and plant layouts (Harada *et al*., 1995; Halle and Oldeman, 1970; Liebowitz *et al*., 1999). Shape grammars were sudsequently applied to procedural generation of building facades (Muller, 2006; Golub and Van Loan, 1989). Structural feasibility study has been making known to in the context of masonry buildings (Whiting *et al*., 2009). Techniques were developed for texturing architectural models (Legakis *et al*., 2001; Lefebvre *et al*., 2010), and for generating architectural freeform surfaces; creating animation, leaf morphology plans, building exteriors from photographs and sketches (Muller, 2007; Chen *et al*., 2008; Debevec *et al*., 1996; Horry *et al*., 1997; Pottmann *et al*., 2007; Pottmann *et al*., 2008).

3.12 Statistical Analyses

All the data obtained were subjected to statistical analysis using multivariate analysis and principal component analysis (PCA) of Paleontological Statistics Software Application Packages 3.14 (PAST) for Clustering, Variance – Covariance and Correlation Analyses (Ireland, 2010; Hammer *et al*., 2001; Hair *et al*., 1992; Hammer and Harper, 2006.). Means values were used to perform principal components, correlations and hierarchical cluster analyses. Cluster analysis based on Euclidean distance as similarity measures and Ward's method were used to analyze the grouping relationship among the trees species and other taxonomic characters.

CHAPTER 4

4.0 RESULTS

4.1 Soil under Different Universities Botanical Gardens

The soils underneath diferent universities botanical gardens, in the vegetation zones of Nigeria (tropical rain forest region, sudano-guinea savannah region and montane) were examined for physical and chemical properties. The tropical rain forest region consists of the following selected gardens: university of Lagos biological garden, university of Ibadan botanical garden, and federal university of technology botanical garden, Akure. The sudano-guinea savannah region and montane comprise of the following selected gardens as well: university of Ilorin botanical garden, Bayero university botanical garden and university of Jos botanical garden. The soils were examined and the results were compared (Table 14). Significant differences were found in the soil of each botanical garden in respect of the percentage of sand, silt, clay, total nitrogen and organic matter, different values also occurred in pH, magnessium, calcium, potassium and available phosphorus. The tropical rain forest region soil of the university of Lagos biological garden, university of Ibadan botanical garden, and federal university of technology botanical garden, Akure are sand loam, sandy clay loam surfaces and generally low in exchangeables bases, which were similar to the description of the soils of the region made by federal department of agricultural land resources, Kaduna, Nigeria.The sudano-guinea savannah and montane region soils of university of Ilorin botanical garden, Bayero university botanical garden and university of Jos Botanical garden are loam to clay, sand clay and also low in exchangeables bases, which were similar to the descripition of the soils of the region made by federal department of agricultural land resources, Kaduna, Nigeria. The implication of this analysis is to help in the classification of the land area for judicious use in term of garden design, creation of parkland, layout of road network, walkways and construction of buildings, the fertile area would be used for botanical nursery in raiseing of seedlings for conservation, medicinal and landscaping purposes, since fertility of a soil is governed by its physical and chemical properties, either or both of which may limit productivity and also the botanical identification of plant communities is *sine qua non* to the general soil condition and sampling of garden soil for analysis provide another means by which pollutants are removed out of the air in the gardens because both trees and soil assessment provide a significant effect of botanical gardens in relation to air quality.

Table 14: Soil Physical and Chemical Properties in Selected Universities Botanical Gardens

Botanical gardens	**%Sand**	**%Silt**	**%Clay**	**pH (CH2O)**	**pH (CaCl2)**	**%N**	**%O**	**Ca**	**Mg**	**AvailP**	**K**
Tropical Rain Forest Regions											
Lagos Biological garden	75.7	12.2	22.4	6.1	5.9	61.8	2.21	0.4	0.5	9.22	0.4
Ibadan Botanical garde	85.3	10.4	6.1	6.0	5.4	1.2	3.29	1.9	2.7	12.5	0.17
Akure Botanical garden	43.57	24.92	29.85	5.9	6.2	0.12	1.5	1.1	0.51	10.35	0.32
Sudano-GuineaSavannah and Montane Regions											
Ilorin Botanical garden	82.7	8.7	3.6	5.98	5.2	0.1	3.2	5.9	1.98	8.29	0.15
Bayero Botanical garden	71.8	17.85	11.95	6.3	5.9	0.08	1.35	0.56	19.1	8.46	0.42
Jos Botanical garden	60.1	21.99	19.58	5.7	4.2	0.1	1.01	2.55	0.49	27.18	0.16

4.2 Frequency Analysis and Landscape Status of Tree species

4.2.1 Frequency of Tree species and Associated Lichens

The frequency distribution of tree species examined in the study of the botanical garden and the environs in each of the 6 states of both tropical rain forest, sudano-guinea savannah and motane vegetation zones of Nigeria showed similar trend of value, in which some with high value while some with lower value (Table 15 – 20). This was put forward that sometimes it is difficult to distinguish between the aesthetic and functional characteristic of the plants species inside or outside the garden. The frequency analysis of tree species together with their associated lichens had been determined for 30 different plant species in different botanical gardens located in each of the tropical rain forest, sudano-guinea savannah and montane vegetation zones of Nigeria showed similar roles and functions (Table 15– 20). As shown in the Table 15, the species *Milicia excelsa* and *Blighia sapida* showed high frequency percentage of occurrence (7.45%), while species *Tectonia grandis* is (0.99%) showed low frequency percentage. Likewise, the frequency percentage of the associated lichens was high in species *Erythrina senegalensis* and low in species *Hildagardia barterii*. Table 16 showed species *Plumeria alba* (8.96%) with high frequency percentage of occurrence while species *Snysepalum dulcificum, Ficus elastica* and *Triplochiton scleroxylon* have low frequency pencentage (0.94%) of occurrence. The associated lichens showed the species *Parkia biglobossa* (10.09%) with high frequency percentage, while species *Citrus sinensis, Glicirida sepium* and *Citrus reticulata* have low frequency percentage (0.01%). *Ficus bengamina, Terminalia catappa* and *Polyalthia longifolia* have high frequency percentage of occurrence (6.40%) while species *Ficus exasperata, Ficus trichopoda, Cynometra ananta* and *Erythrophleum ivorense* have low frequency percentage (0.99%). The percentage frequency of the associated lichens (0.08%) were high in the species *Plumeria rubra, Parkia biglobossa* and *Mangifera indica* and low frequency percentage (0.01%) in the species *Ficus capensis, Ficus exasperata, Funtumia elestica, Leucena leucocephala, Thevetia neriifolia, Erythrophleum ivorense* and *Ficus diversifolia* (Table 17). Table 18 showed species *Azadirachita indica* with high frequency percentage of occurrence (9.71%), while species *Bridelia ferruginea, Lophira lanceolata, Hildagardia barterii*, *Adansonia digitata*, *Albizzia lebbeck* and *Annona senegalensis* have low frequency percentage (0.97%). The frequency percentage of the associated lichens showed species *Azadirachita indica* with high percentage frequency (8.95%) and species *Adansonia digitata* with low frequency percentage (0.62%). Table 19 showed species *Khaya senegalensis* with high frequency percentage of occurrence (6.69%) while species *Terminalia catappa, Ziziphus mauritiana, Blighia sapida, Terminalia macroptera* and *Casuarina equisetifolia* have low frequency percentage of occurrence (1.34%). The associated lichens show species *Khaya sengalensis and Blighia sapida* with high frequency percentage of occurrence (0.07%) and species *Adansonia digitata, Delonix regia* and *Hildagardia barterii* have low frequency percentage of occurrence (0.01%). Table 20 showed species *Moringa oleifera* with high frequency percentage of occurrence (7.79%) while species *Eucalyptus citrodora, Terminalia catappa* and *Parkia biglobossa* have low frequency percentage of occurrence (1.29%). The associated lichens show high frequency percentage of occurrence (0.08%) in species *Plumera rubra, Milicia excelsa* and *Mangifera indica,* while species *Gmelina arborea, Ficus bengamina, Citrus reticulata, Pisidium guajava, Cassia fistula* and *Ficus elastica* have low frequency percentage of occurrence (0.01%).

Table 15: Frequency Values of Trees species and associated Lichens inUniversity of Lagos Biological Garden and Environs

	Scientific Names	Frequency of tree (%)	Frequency of lichens (%)
1.	*Tectonia grandis*	7.43	2.67
2.	*Albizzia lebbeck*	2.97	2.34
3.	*Bauhinia variegata*	1.49	1.67
4.	*Albizzia zygia*	1.98	2.34
5.	*Alstonia scholaris*	2.97	2.34
6.	*Erythrina senegalensis*	1.98	8.03
7.	*Gliricidia sepium*	5.45	2.67
8.	*Peltophorium pterocapium*	2.97	3.01
9.	*Treculia africana*	1.49	2.34
10.	*Terminalia superba*	5.94	2.34
11.	*Ficus diversifolia*	2.97	1.33
12.	*Ficus sycomonis*	4.95	2.34
13.	*Anacardium occidentale*	1.98	2.00
14.	*Annona muricata*	1.49	1.33
15.	*Citrius sinensis*	4.95	4.01
16.	*Delonix regia*	6.44	3.44
17.	*Azadirachita indica*	1.98	6.35
18.	*Terminalia catappa*	4.95	5.68
19.	*Mangifera indica*	2.48	7.36
20.	*Gmelina arborea*	4.45	2.34
21.	*Casuarina equisetifolia*	4.45	5.35
22.	*Hildagardia barterii*	1.49	0.66
23.	*Blighia sapida*	0.99	4.68
24.	*Eucalyptus citrodora*	2.97	2.00
25.	*Plumera rubra*	5.94	4.34

26.	*Acacia moniliformis*	3.46	4.34
27.	*Acacia nilotica*	1.49	0.66
28.	*Parkia biglobossa*	3.46	4.01
29.	*Polyalthia longifolia*	3.46	2.34
30.	*Milicia excelsa*	0.99	5.68

Table 16: Frequency value of Trees species and associated Lichens in University of Ibadan Botanical Garden and Environs

	Scientific Names	Frequency of Tree (%)	Frequency of Lichens (%)
1.	*Chrysophyllum albidum*	1.42	0.02
2.	*Irvingia gabonensis*	2.83	0.02
3.	*Snysepalum dulcificum*	0.94	0.005
4.	*Plumera rubra*	2.83	0.02
5.	*Delonix regia*	6.60	0.02
6.	*Mangifera indica*	7.07	0.07
7.	*Citrus sinensis*	1.89	0.01
8.	*Anacardium occidentale*	6.13	0.03
9.	*Pakia biglobossa*	6.13	0.09
10.	*Prosopis africana*	3.30	0.06
11.	*Plumera alba*	8.96	0.06
12.	*Azadirachita indica*	1.89	0.05
13.	*Erythrina senegalensis*	3.77	0.04
14.	*Gliciridia sepium*	2.83	0.01
15.	*Milicia excelsa*	1.42	0.03

16.	*Blighia sapida*	1.42	0.07
17.	*Annona senegalensis*	1.89	0.02
18.	*Ficus trichopoda*	1.42	0.02
19.	*Ficus elastica*	0.94	0.01
20.	*Tectonia grandis*	3.30	0.02
21.	*Terminalia catappa*	6.13	0.05
22.	*Gmelina arborea*	5.19	0.02
23.	*Vitellaria paradoxa*	5.66	0.02
24.	*Bridelia ferruginea*	3.30	0.02
25.	*Burkea africana*	2.36	0.08
26.	*Lophira lanceolata*	3.30	0.05
27.	*Casuarina equisetifolia*	2.36	0.02
28.	*Ficus diversifolia*	2.36	0.02
29.	*Triplochiton scleroxylon*	0.94	0.04
30.	*Eucalyptus citrodora*	1.42	0.02

Table 17: Frequency Values of Trees species and associated Lichens in Federal University of Technology Akure Botanical Garden and Environs

	Scientific Names	Frequency of Trees (%)	Frequency of Lichens (%)
1.	*Ficus capensis*	1.48	0.01
2.	*Ficus bengamina*	6.40	0.02
3.	*Alstonia scholaris*	1.48	0.02
4.	*Ficus exasperate*	0.99	0.01

5.	*Funtumia elastica*	2.46	0.01
6.	*Milicia excelsa*	2.46	0.07
7.	*Leucena leucocephala*	3.94	0.01
8.	*Thevetia neriifolia*	1.97	0.01
9.	*Spondias mombin*	1.48	0.04
10.	*Mangifera indica*	4.93	0.08
11.	*Anacardium occidentale*	5.91	0.02
12.	*Citrus sinensis*	3.94	0.05
13.	*Azadirachita indica*	1.48	0.04
14.	*Parkia biglobossa*	4.43	0.08
15.	*Terminalia catappa*	6.40	0.05
16.	*Ficus trichopoda*	0.99	0.02
17.	*Annona senegalensis*	5.91	0.02
18.	*Delonix regia*	4.93	0.03
19.	*Gmelina arborea*	4.93	0.02
20.	*Tectonia grandis*	4.43	0.02
21.	*Casuarina equisetifolia*	4.43	0.03
22.	*Blighia sapida*	1.48	0.06
23.	*Triplochiton scleroxylon*	2.46	0.05
24.	*Cynometra ananta*	0.99	0.02
25.	*Erythrophleum ivorense*	0.99	0.01
26.	*Ficus diversifolia*	3.45	0.01
27.	*Polyalthia longifolia*	6.40	0.02
28.	*Plumera rubra*	3.45	0.08
29.	*Hildagardia baterii*	1.48	0.02
30.	*Prosopis africana*	3.94	0.08

Table 18: Frequency Values of Trees species and associated Lichens in University of Ilorin Botanical Garden and Environs

	Scientific Names	Frequency of Trees (%)	Frequency of Lichens (%)
1.	*Plumera rubra*	2.91	2.16
2.	*Vitellaria paradoxa*	4.37	7.41
3.	*Gliricidium sepium*	4.37	1.85
4.	*Polyalthia longifolia*	7.28	3.09
5.	*Casuarina equisetifolia*	2.43	2.16
6.	*Tectonia grandis*	2.91	2.47
7.	*Terminalia catappa*	5.34	4.63
8.	*Parkia biglobossa*	2.91	4.32
9.	*Daniela olivieri*	5.83	5.25
10.	*Prosopis Africana*	2.91	4.63
11.	*Delonix regia*	4.37	2.78
12.	*Gmelina arborea*	4.37	2.16
13.	*Plumera alba*	1.94	3.70
14.	*Azadirachita indica*	9.71	8.95
15.	*Anacardium occidentale*	4.85	2.47
16.	*Citrus sinensis*	6.31	6.48
17.	*Bridelia ferruginea*	0.97	1.54
18.	*Blighia sapida*	2.91	5.56
19.	*Annona senegalensis*	0.97	1.54
20.	*Lophira lanceolata*	0.97	1.24
21.	*Burkea africana*	1.46	4.63
22.	*Albizzia lebbeck*	0.97	1.54
23.	*Eucalyptus citrodora*	3.40	3.09
24.	*Hildagardia barterii*	0.97	1.24
25.	*Eucalyptus cinerea*	2.91	2.16
26.	*Acacia moniliformis*	1.94	2.47

27.	*Ficus diversifolia*	1.94	0.93
28.	*Mangifera indica*	4.85	7.41
29.	*Lonchocarpus cyanenscens*	1.94	1.54
30.	*Adansonia digitata*	0.97	0.62

Table 19: Frequency values of Trees species and associated Lichens in Bayero University of Kano Botanical Garden and Environs

	Scientific Names	Frequency of Trees (%)	Frequency of Lichens (%)
1.	*Azadirachita indica*	3.57	0.06
2.	*Vitellaria paradoxa*	5.36	0.06
3.	*Albizzia lebbeck*	3.13	0.02
4.	*Polyalthia longifolia*	5.80	0.02
5.	*Annona senegalensis*	3.57	0.02
6.	*Khaya senegalensis*	6.69	0.07
7.	*Citrus paradise*	4.02	0.02
8.	*Plumera alba*	3.57	0.03
9.	*Plumera rubra*	4.46	0.05
10.	*Citrus sinensis*	2.68	0.03
11.	*Ficus elastica*	4.02	0.02
12.	*Citrus reticulata*	4.91	0.06
13.	*Anacardium occidentale*	2.68	0.02
14.	*Mangifera indica*	4.91	0.06
15.	*Tamarindus indica*	5.36	0.05
16.	*Terminalia catappa*	1.34	0.03
17.	*Adansonia digitata*	1.79	0.01

18.	*Ziziphus mauritiana*	1.34	0.02
19.	*Prosopis africana*	5.36	0.06
20.	*Parkia biglobossa*	1.79	0.03
21.	*Blighia sapida*	1.34	0.07
22.	*Gmelina arborea*	2.68	0.03
23.	*Vitex doniana*	1.79	0.04
24.	*Terminalia macroptera*	1.34	0.05
25.	*Acacia gourmaensis*	3.57	0.03
26.	*Lophira lanceolata*	2.68	0.04
27.	*Casuarina equisetifolia*	1.34	0.02
28.	*Delonix regia*	4.02	0.01
29.	*Balanites aegyptiaca*	1.79	0.02
30.	*Hildagardia barterii*	3.13	0.01

Table 20: Frequency Values of Trees species and associated Lichens in University of Jos Botanical Garden and Environs

	Scientific Names	Frequency of Trees (%)	Frequency of Lichens (%)
1.	*Casuarina equisetifolia*	3.03	0.02
2.	*Plumera rubra*	5.63	0.08
3.	*Plumera alba*	2.59	0.06
4.	*Eucalyptus citrodora*	1.29	0.02
5.	*Eucalyptus cinerea*	2.16	0.03
6.	*Acacia moniliformis*	1.73	0.02
7.	*Erythrina senegalensis*	2.59	0.03
8.	*Delonix regia*	3.46	0.03

9.	*Hildagardia barterii*	3.46	0.02
10.	*Terminalia superba*	3.89	0.03
11.	*Terminalia catappa*	1.29	0.03
12.	*Bauhinia* spp	2.16	0.02
13.	*Milicia excelsa*	3.46	0.08
14.	*Polyalthia longifolia*	6.93	0.03
15.	*Gmelina arborea*	2.16	0.01
16.	*Mangifera indica*	4.33	0.08
17.	*Anacardium occidentale*	1.73	0.02
18.	*Ficus bengamina*	3.46	0.01
19.	*Citrus sinensis*	4.33	0.03
20.	*Citrus reticulate*	3.46	0.01
21.	*Citrus paradise*	4.76	0.02
22.	*Pisidium guajava*	3.03	0.01
23.	*Moringa oleifera*	7.79	0.02
24.	*Parkia biglobossa*	1.29	0.06
25.	*Cassia fistula*	4.33	0.01
26.	*Prosopis africana*	1.73	0.06
27.	*Ficus elastica*	3.89	0.01
28.	*Azadirachita indica*	2.16	0.07
29.	*Araucaria heterophylla*	4.76	0.02
30.	*Acacia gourmaensis*	3.03	0.07

4.2.2 Biodiversity Management and Ecosystem Firmness

Each tree species occupies a particular space and serves a particular function in a landscape (Table 21 – 26). Table 21 shows leaf form taxonomic variable with high diversity index in both Simpson Index (0.9655) and Shannon Wiener Index (3.382) and low diversity index in leaf margin taxonomic variable of both Simpson Index (0.9473) and Shannon Wiener Index (3.198). Table 22 shows an anatomy of twigs with high diversity index in both Simpson Index (0.9667) and Shannon Wiener Index (3.401) and low diversity index in leaf colour taxonomic variable of both Simpson Index (0.9552) and Shannon Wiener Index (3.26). Table 23 shows an anatomy of twigs taxonomic variable with high diversity index in both Simpson index (0.9667) and Shannon Wiener Index (3.401) and low diversity index in leaf margin taxonomic variable of Simpson Index (0.9509) and Shannon Wiener Index (3.194). The diversity index of the anatomy of twigs as a taxonomic variable shows similar result of high value in both Simpson Index (0.9667) and Shannon Wiener Index (3.401) in the Table 24, 25, and 26 respectively and low diversity index of leaf margin taxonomic variable in both Simpson Index (0.9503) and Shannon Wiener Index (3.179) in Table 24, while the low value of leaf colour taxonomic variable in Simpson Index (0.9541) was similar in both the Table 25 and 26. In Table 25 low diversity index of Shannon Wiener Index (3.238) was obtained and (3.243) was obtained in Table 26.

Table 21: Diversity Index of Selected Trees species Taxonomic Characters in University of Lagos Biological garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.03822	0.9618	3.331
2.	Shape of leaf	0.04004	0.96	3.286
3.	Leaf type	0.04512	0.9549	3.25
4.	Leaf texture	0.03686	0.9631	3.346
5.	Leaf Surface	0.04395	0.956	3.263
6.	Leaf Apex	0.04018	0.9598	3.301
7.	Leaf Margin	0.05269	0.9473	3.198
8.	Leaf Base	0.03906	0.9609	3.314
9.	Petiole	0.0373	0.9627	3.332
10.	Fruit Type	0.0394	0.9606	3.301
11.	Flower Type	0.04	0.96	3.309
12.	Leaf Forms	0.03446	0.9655	3.382
13.	Leaf Arrangement	0.03472	0.9653	3.381
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04783	0.9522	3.213
16.	Leaf Lengths	0.04	0.96	3.305
17.	Leaf Widths	0.04204	0.958	3.268
18.	Stem Heights	0.0388	0.961	3.319
19.	Plant Heights	0.03901	0.961	3.321
20.	Frequency Distribution	0.03843	0.9616	3.321
21.	Blade Lengths	0.03934	0.9607	3.311
22.	Petiole Lengths	0.03835	0.9617	3.315
23.	Leaf Areas	0.03944	0.9606	3.305
24.	Blade Widths	0.04067	0.9593	3.289
25.	Crown Diameters	0.03627	0.9637	3.355
26.	Area of Canopy	0.03909	0.9609	3.315
27.	Diameter of Trunk	0.03653	0.9635	3.351
28.	Frequency of Lichens	0.03765	0.9623	3.326

29.	Density of Lichens	0.03765	0.9623	3.326
30.	Density of Leaves	0.04132	0.9587	3.296

Table 22: Diversity Index of Selected Trees Taxonomic Characters in University of Ibadan Botanical garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.04062	0.9594	3.284
2.	Shape of leaf	0.0404	0.9596	3.278
3.	Leaf type	0.0432	0.9568	3.271
4.	Leaf texture	0.03603	0.964	3.359
5.	Leaf Surface	0.04114	0.9589	3.289
6.	Leaf Apex	0.03821	0.9618	3.325
7.	Leaf Margin	0.04918	0.9508	3.184
8.	Leaf Base	0.03936	0.9606	3.311
9.	Petiole	0.03779	0.9622	3.323
10.	Fruit Type	0.04313	0.9569	3.253
11.	Flower Type	0.04056	0.9594	3.306
12.	Leaf Forms	0.03434	0.9657	3.384
13.	Leaf Arrangement	0.03472	0.9653	3.381
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04482	0.9552	3.26
16.	Leaf Lengths	0.0408	0.9592	3.297
17.	Leaf Widths	0.04152	0.9583	3.279
18.	Stem Heights	0.03847	0.9615	3.322
19.	Plant Heights	0.03848	0.9615	3.326

20.	Frequency Distribution	0.0385	0.9615	3.319
21.	Blade Lengths	0.04023	0.9598	3.30
22.	Petiole Lengths	0.04022	0.9598	3.289
23.	Leaf Areas	0.0388	0.9612	3.319
24.	Blade Widths	0.03902	0.961	3.319
25.	Crown Diameters	0.035	0.965	3.375
26.	Area of Canopy	0.03772	0.9623	3.334
27.	Diameter of Trunk	0.03574	0.9643	3.364
28.	Frequency of Lichens	0.03913	0.9609	3.306
29.	Density of Lichens	0.03929	0.9607	3.305
30.	Density of Leaves	0.0384	0.9616	3.33

Table 23: Diversity Index of Selected Trees species Taxonomic Characters in Federal University of Technology Akure Botanical garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.03775	0.9623	3.33
2.	Shape of leaf	0.03937	0.9606	3.296
3.	Leaf type	0.04253	0.9575	3.33
4.	Leaf texture	0.03653	0.9635	3.351
5.	Leaf Surface	0.04207	0.9579	3.28
6.	Leaf Apex	0.03843	0.9616	3.321
7.	Leaf Margin	0.04912	0.9509	3.194
8.	Leaf Base	0.04047	0.9595	3.296

9.	Petiole	0.03817	0.9618	3.318
10.	Fruit Type	0.04339	0.9566	3.248
11.	Flower Type	0.04	0.96	3.316
12.	Leaf Forms	0.03417	0.9658	3.386
13.	Leaf Arrangement	0.03508	0.9612	3.375
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04537	0.9546	3.256
16.	Leaf Lengths	0.03993	0.9601	3.308
17.	Leaf Widths	0.04166	0.9592	3.284
18.	Stem Heights	0.04047	0.9595	3.295
19.	Plant Heights	0.03948	0.9605	3.318
20.	Frequency Distribution	0.03827	0.9617	3.326
21.	Blade Lengths	0.03868	0.9613	3.32
22.	Petiole Lengths	0.04022	0.9598	3.289
23.	Leaf Areas	0.0388	0.9612	3.319
24.	Blade Widths	0.03944	0.9606	3.314
25.	Crown Diameters	0.03521	0.9648	3.372
26.	Area of Canopy	0.03906	0.9609	3.338
27.	Diameter of Trunk	0.03736	0.9626	3.338
28.	Frequency of Lichens	0.03856	0.9614	3.314
29.	Density of Lichens	0.03856	0.9614	3.314
30.	Density of Leaves	0.04064	0.9594	3.301

Table 24: Diversity Index of Selected Trees Taxonomic Characters in University of Ilorin Botanical garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.04091	0.9591	3.285
2.	Shape of leaf	0.04218	0.9578	3.255
3.	Leaf type	0.04321	0.9568	3.267
4.	Leaf texture	0.03611	0.9639	3.358
5.	Leaf Surface	0.04114	0.9589	3.289
6.	Leaf Apex	0.03934	0.9607	3.311
7.	Leaf Margin	0.04972	0.9503	3.179
8.	Leaf Base	0.03844	0.9616	3.326
9.	Petiole	0.03796	0.962	3.322
10.	Fruit Type	0.03951	0.9605	3.304
11.	Flower Type	0.0421	0.9579	3.286
12.	Leaf Forms	0.0344	0.9656	3.383
13.	Leaf Arrangement	0.0344	0.9653	3.382
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04498	0.955	3.252
16.	Leaf Lengths	0.0396	0.9604	3.31
17.	Leaf Widths	0.04054	0.9595	3.29
18.	Stem Heights	0.0389	0.9611	3.316
19.	Plant Heights	0.03802	0.962	3.333
20.	Frequency Distribution	0.03902	0.961	3.31
21.	Blade Lengths	0.03847	0.9615	3.322
22.	Petiole Lengths	0.03868	0.9613	3.31
23.	Leaf Areas	0.03821	0.9618	3.325
24.	Blade Widths	0.04041	0.9596	3.295
25.	Crown Diameters	0.03521	0.9648	3.372
26.	Area of Canopy	0.03724	0.9628	3.34
27.	Diameter of Trunk	0.03587	0.9641	3.361
28.	Frequency of Lichens	0.0376	0.9624	3.331

29.	Density of Lichens	0.0376	0.9624	3.331
30.	Density of Leaves	0.03901	0.961	3.321

Table 25: Diversity Index of Selected Trees species Taxonomic Characters in Bayero University Kano Botanical garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.03972	0.9603	3.295
2.	Shape of leaf	0.04327	0.9567	3.239
3.	Leaf type	0.04308	0.9569	3.27
4.	Leaf texture	0.03669	0.9633	3.347
5.	Leaf Surface	0.04191	0.9581	3.279
6.	Leaf Apex	0.03802	0.962	3.33
7.	Leaf Margin	0.04776	0.9522	3.191
8.	Leaf Base	0.03868	0.9613	3.319
9.	Petiole	0.03964	0.9604	3.292
10.	Fruit Type	0.04198	0.958	3.267
11.	Flower Type	0.04017	0.9598	3.318
12.	Leaf Forms	0.03434	0.9657	3.384
13.	Leaf Arrangement	0.0351	0.9649	3.374
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04592	0.9541	3.238
16.	Leaf Lengths	0.0404	0.9596	3.301
17.	Leaf Widths	0.04095	0.9591	3.292
18.	Stem Heights	0.03763	0.9624	3.334

19.	Plant Heights	0.03733	0.9627	3.34
20.	Frequency Distribution	0.03804	0.962	3.326
21.	Blade Lengths	0.03952	0.9605	3.309
22.	Petiole Lengths	0.03918	0.9608	3.302
23.	Leaf Areas	0.03802	0.962	3.33
24.	Blade Widths	0.03902	0.961	3.319
25.	Crown Diameters	0.03574	0.9643	3.366
26.	Area of Canopy	0.03729	0.9627	3.34
27.	Diameter of Trunk	0.03581	0.9642	3.362
28.	Frequency of Lichens	0.03987	0.9601	3.296
29.	Density of Lichens	0.03987	0.9601	3.296
30.	Density of Leaves	0.03926	0.9607	3.319

Table 26: Diversity Index of Selected Trees species Taxonomic Characters in University of Jos Botanical garden and Environs

	Taxonomic Characters	Dominance	Simpson Index	Shannon Index
1.	Shape of Crown	0.03871	0.9613	3.313
2.	Shape of leaf	0.04363	0.9564	3.234
3.	Leaf type	0.0466	0.9534	3.233
4.	Leaf texture	0.03704	0.963	3.342
5.	Leaf Surface	0.04348	0.9565	3.267
6.	Leaf Apex	0.03902	0.961	3.313

7.	Leaf Margin	0.05047	0.9495	3.17
8.	Leaf Base	0.03854	0.9615	3.317
9.	Petiole	0.03883	0.9612	3.307
10.	Fruit Type	0.04045	0.9595	3.286
11.	Flower Type	0.04601	0.954	3.249
12.	Leaf Forms	0.0349	0.9651	3.373
13.	Leaf Arrangement	0.03503	0.965	3.376
14.	Anatomy of twigs	0.03333	0.9667	3.401
15.	Leaf Colour	0.04592	0.9541	3.243
16.	Leaf Lengths	0.0392	0.9608	3.316
17.	Leaf Widths	0.0409	0.9591	3.285
18.	Stem Heights	0.03746	0.9625	3.337
19.	Plant Heights	0.03819	0.9618	3.33
20.	Frequency Distribution	0.04	0.96	3.305
21.	Blade Lengths	0.03954	0.9605	3.307
22.	Petiole Lengths	0.04012	0.9599	3.289
23.	Leaf Areas	0.03746	0.9625	3.337
24.	Blade Widths	0.03906	0.9609	3.317
25.	Crown Diameters	0.03574	0.9643	3.366
26.	Area of Canopy	0.03763	0.9624	3.335
27.	Diameter of Trunk	0.03542	0.9646	3.369
28.	Frequency of Lichens	0.03905	0.961	3.304
29.	Density of Lichens	0.03905	0.961	3.304
30.	Density of Leaves	0.03875	0.9612	3.324

4.3 Multivariate analysis of Taxonomic Characters of Tree species

4.3.1 Hierarchical Clustering Tree species Dendrogram

Another commonly used approach in multivariate analysis (hierarchical clustering) is the Ward's method dendrogram (Fig. 7a – b). Column dendrogram shows the distance (or similarity) between the variables (the selected cell value column). Dendrograms are made up of clades and leaves which is the terminal end of each clade, it also consist of trees species as either outliers or clusters.

Lagos: 8 outlier's species (5, 29, 10, 19, 18, 3, 21 and 7).

11 clusters species (8 and 16; 24 and 26; 15 and 17; 20 and 25; 11 and 27; 23 and 30; 6 and 28; 12 and 14; 1 and 12; 9 and 13; 2 and 4)

Ibadan: 5 outlier's species (8, 9, 23, 14 and 27)

12 clusters species (15 and 16; 26 and 6; 10 and 13; 25 and 12; 29 and 18; 2 and 24; 3 and 17; 30 and 5; 20 and 21; 7 and 19; 4 and 11; 22 and 28)

Akure: 8 outlier's species (1, 23, 3, 10, 13, 28, 21, and 7)

11 clusters species (4 and 16; 5 and 9; 24 and 25; 11 and 29; 15 and 20; 16 and 22; 2 and 12; 26 and 19; 14 and 30; 17 and 27; 8 and 18).

Ilorin: 4 outlier's species (25, 2, 4 and 11)

13 clusters species (23 and 26; 1 and 13; 12 and 27; 6 and 7; 24 and 15; 18 and 28; 16 and 14; 8 and 10; 21 and 9; 5 and 22; 30 and 20; 17 and 19; 3 and 29)

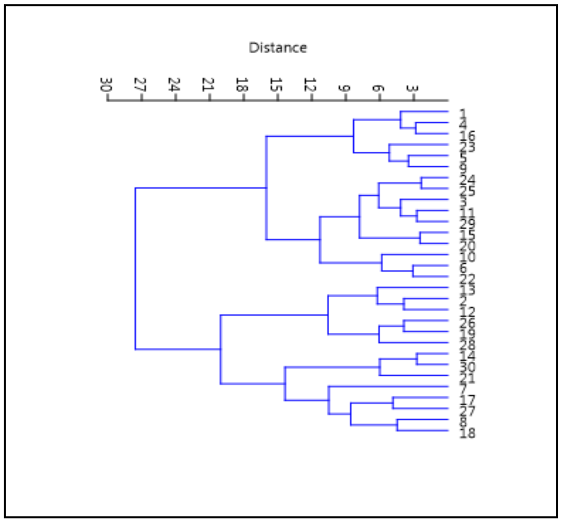
Kano: 6 outlier's species (22, 7, 29, 2, 25, and 14)

12 clusters species (1 and 15; 8 and 9; 10 and 12; 18 and 11; 19 and 20; 3 and 27; 28 and 4; 5 and 17; 13 and 30; 16 and 23; 24 and 21; 6 and 26).

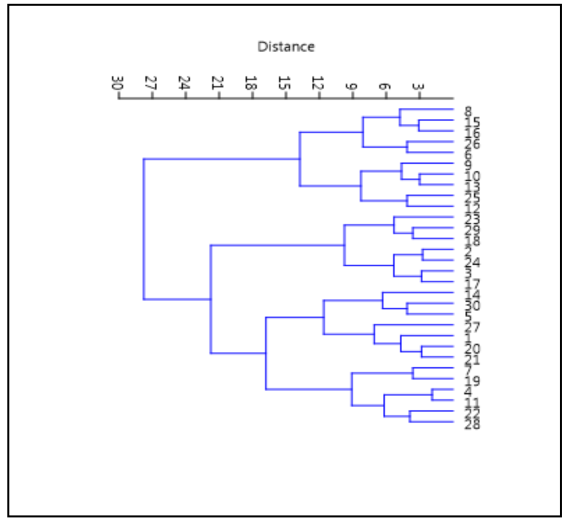
Jos: 10 outliers species (16, 21, 28, 11, 12, 23, 10, 1, 8, and 7)

10 clusters species (18 and 27; 19 and 20; 2 and 3; 5 and 15; 4 and 6; 14 and 29; 9 and 17; 13 and 30; 22 and 25; 24 and 26).

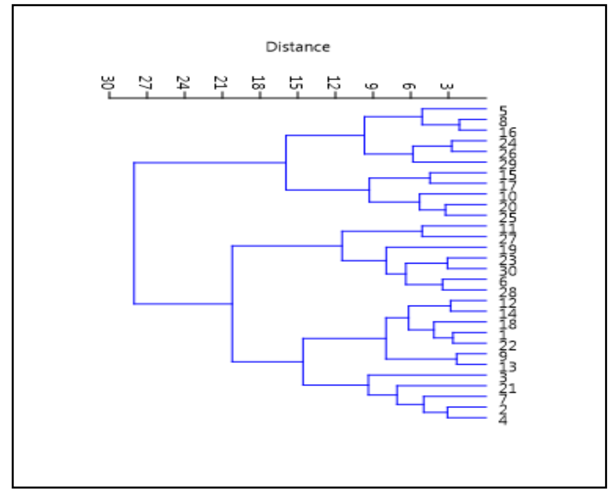
The inferences are highly revelatory, as they could be picked out from the species themselves in the landscape. The landscape status of the species either as outliers or clusters within the operational taxonomic unit (OTU's) was a fair representation of these points interrelationship.



Akure

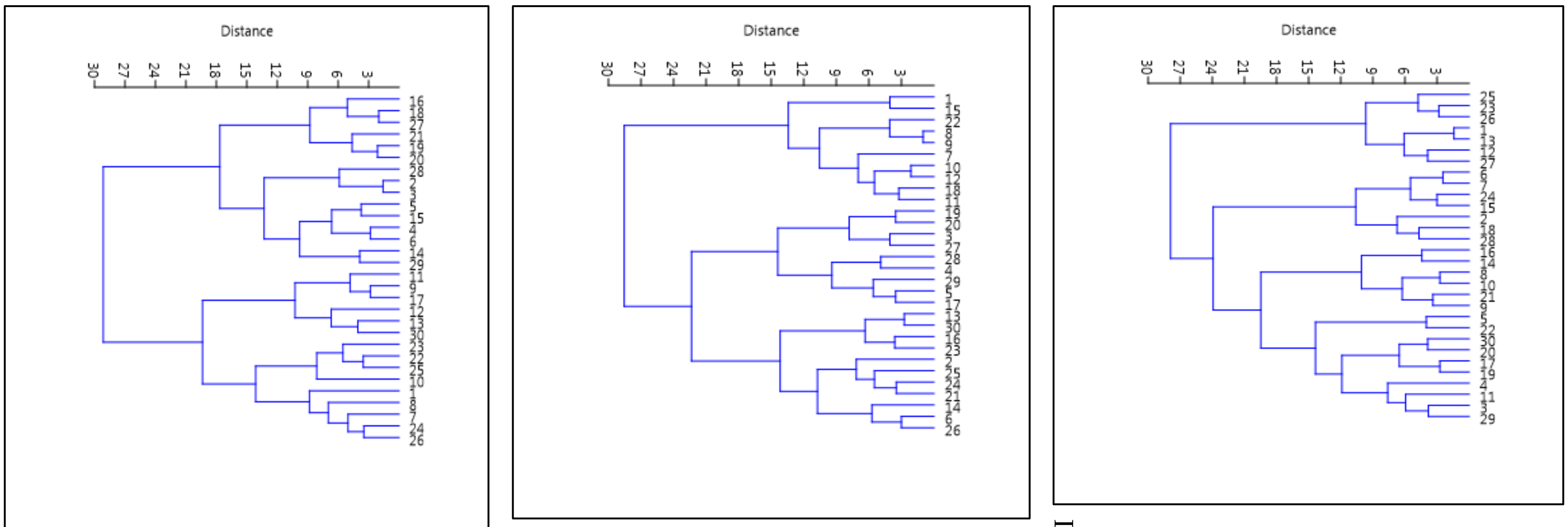


Ibadan



Lagos

Fig. 7a: Ward's Linkage Dendrogram Hierarchical Clustering of Trees species in the selected Botanical Gardens and Environs

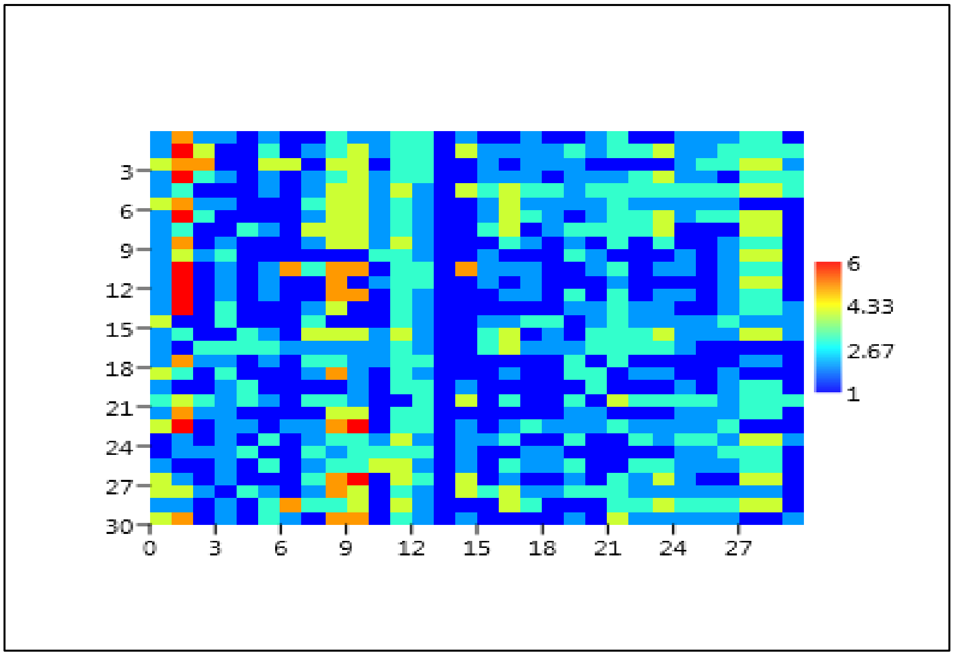


Jos Kano Ilorin

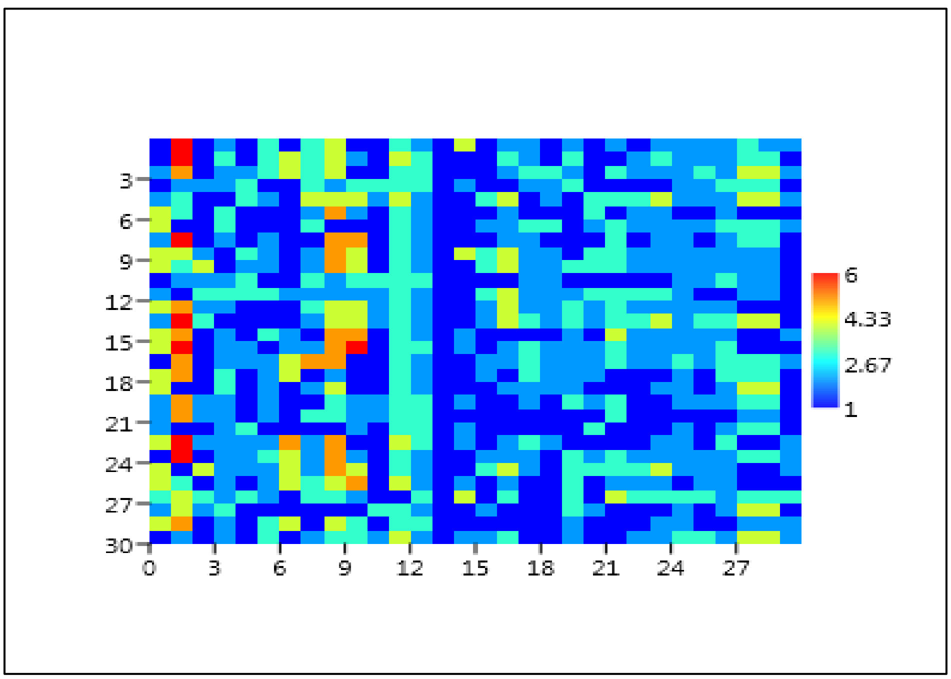
Fig. 7b: Ward's Linkage Dendrogram Hierarchical clustering of Trees species in the selected Botanical Gardens and Environs

4.3.2 Trees species Matrix Plots

Matrix plot (Heat map) is a common method of visualizing or display data. It may also be combined with clustering method above which group samples together based on the similarity of their taxonomic characters expression pattern (Fig. 8a – c). The colour key (1 – 7) ranges from minimum data value as outliers (cool blue) to maximum data value as clusters (hotter orange and red tones). Hence the landscape status of equal rows and columns which could be of either trees species or taxonomic variables within the operational taxonomic unit (OTU's) was a fair representation of these points interrelationship.

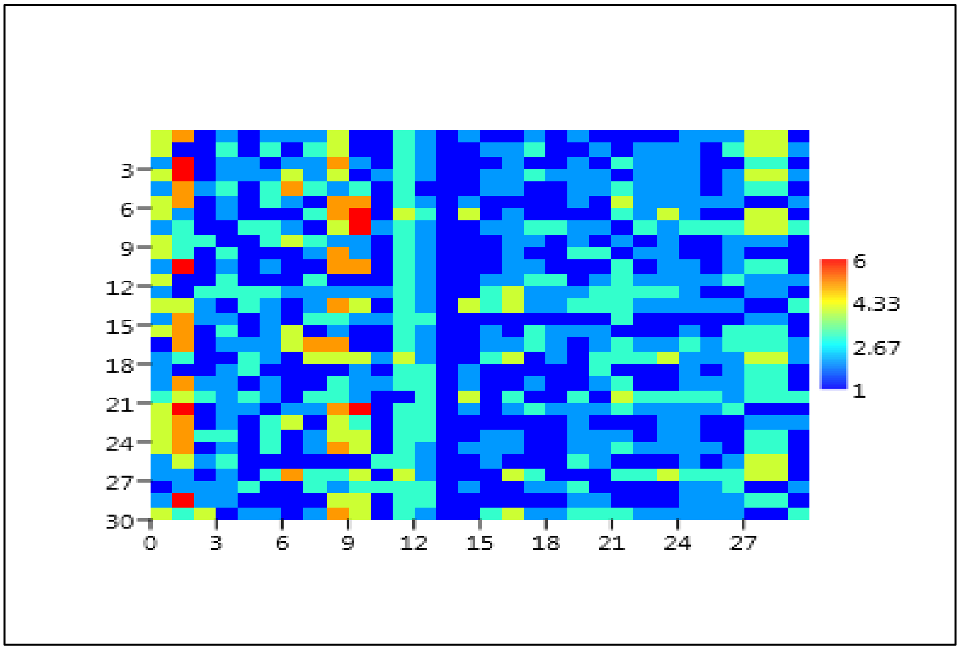


Lagos

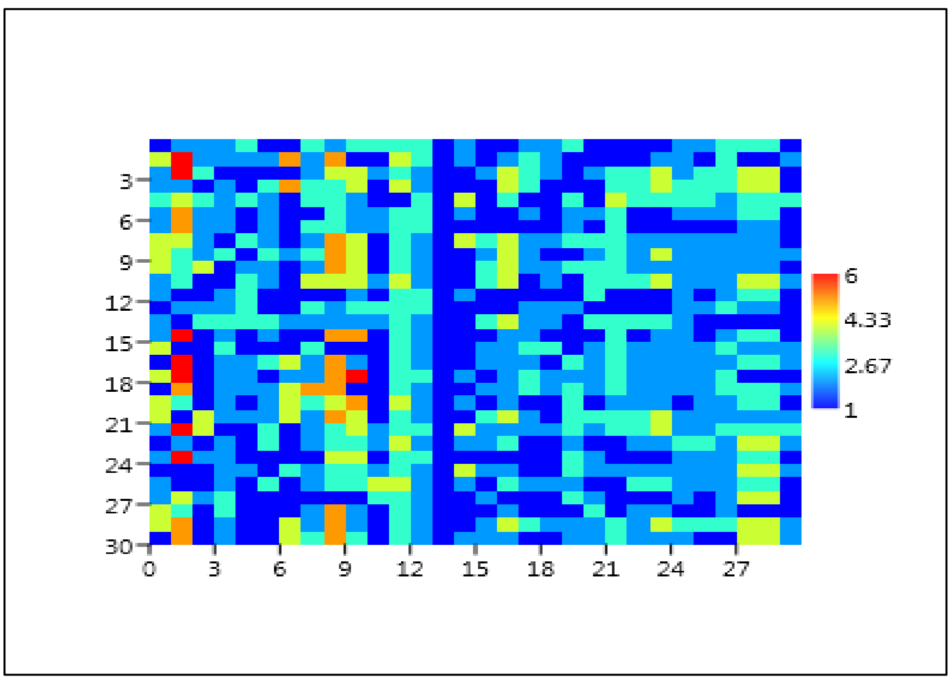


Ibadan

Fig. 8a: Matrix Plot Shown the Significant Effect of Taxonomic Characters of each Tree species in the Selected Botanical Gardens and Environs

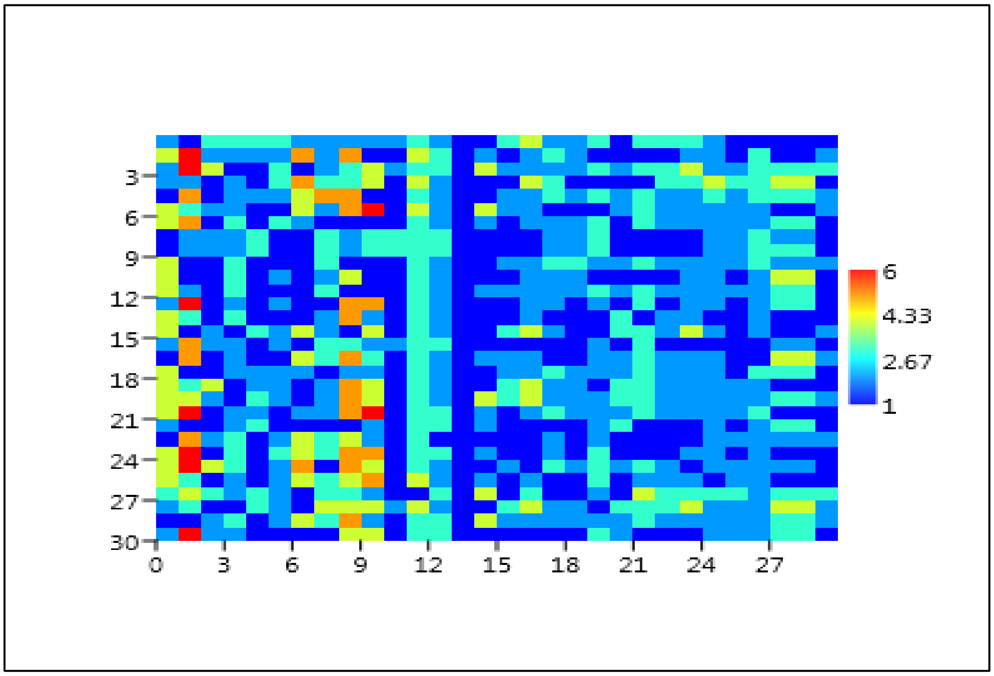


Akure

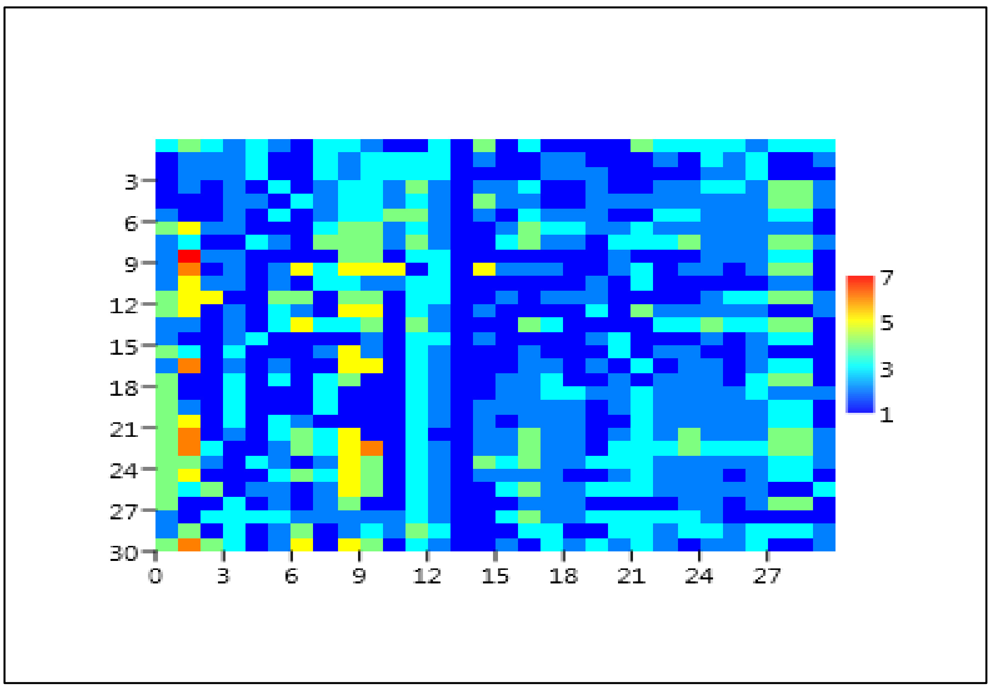


Ilorin

Fig. 8b: Matrix Plot Shown the Significant Effect of Taxonomic Characters of each Trees species in the Selected Botanical Gardens and Environs



Kano



Jos

Fig. 8c: Matrix Plot Shown the Significant Effect of Taxonomic Characters of each Trees species in the Selected Botanical Gardens and Environs

4.4. APTI Values of Plant species

The APTI of trees species has been determined in the universities botanical gardens and environs located in different vegetation zones of Nigeria and the results showed the tolerance and sensitive level of each trees species (Table 27 – 32).

Lagos: Sensitive trees species (9 – 11) scale value

(1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 16, 20, 25 and 26)

Intermediate trees species (12 - 16) scale value

(6, 15, 18, 21, 22, 27, 28 and 30)

Tolerant trees species (17 – 30) scale value

(9, 13, 14, 17, 19, 24 and 29)

Ibadan: Sensitive trees species (9 – 11) scale value

(2, 4, 5, 10, 11, 14, 20, 22, 23, 28, and 29)

Intermediate trees species (12 – 16) scale value

(1, 3, 7, 9, 13, 15, 16, 17, 18, 19, 21, 24, 25, 26 and 27)

Tolerant trees species (17 – 30) scale value

(6, 8, 12 and 30)

Akure: Sensitive trees species (9 – 11) scale value

(1, 2, 3, 8, 18, 19, 20, 23, 26, 28, and 30)

Intermediate trees species (12 – 16) scale value

(4, 5, 6, 7, 9, 12, 14, 15, 16, 17, 21, 22, 24, 25 and 29)

Tolerant trees species (17 – 30) scale value

(10, 11, 13 and 27)

Ilorin: Sensitive trees species (9 – 11) scale value

(1, 2, 3, 6, 10, 11, 12, 13, 22, 26, 27, and 30)

Intermediate trees species (12 – 16) scale value

(5, 7, 8, 9, 16, 17, 18, 19, 20, 21, 24 and 29)

Tolerant trees species (17 – 30) scale value

(4, 14, 15, 23, 25 and 28)

Kano: Sensitive trees species (9 – 11) scale value

(2, 3, 8, 9, 15, 17, 19, 22, 25, 28 and 29)

Intermediate trees species (12 – 16) scale value

(5, 6, 7, 10, 11, 12, 16, 20, 21, 23, 24, 26, 27 and 30)

Tolerant trees species (17 – 30) scale value

(1, 4, 13, 14 and 18)

Jos: Sensitive trees species (9 – 11) scale value

(2, 3, 6, 8, 12, 15, 18, 23, 26, 29 and 30)

Intermediate trees species (12 – 16) scale value

(1, 7, 9, 10, 11, 13, 14, 19, 20, 21, 22, 24, 25 and 27)

Tolerant trees species (17 – 30) scale value

(4, 5, 16, 17 and 28).

The inferences are highly revelatory, as they could be picked out from the species themselves in the landscape. The landscape status of the species either as outliers (sensitive trees species) or clusters (tolerant trees species) within the operational taxonomic unit (OTU's) was a fair representation of these points interrelationship.

Table 27 APTI Values of Selected Trees species in University of Lagos Biological Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Tectonia grandis*	9.89	Sensitive
2.	*Albizzia lebbeck*	8.80	Sensitive
3.	*Bauhinia variegate*	10.91	Sensitive
4.	*Albizzia zygia*	6.91	Sensitive
5.	*Alstonia scholaris*	9.63	Sensitive
6.	*Erythrina senegalensis*	14.92	Intermediate
7.	*Gliricidia sepium*	9.95	Sensitive
8.	*Peltophorium pterocapium*	8.84	Sensitive
9.	*Treculia africana*	19.42	Tolerant
10.	*Terminalia superba*	12.0	Sensitive
11.	*Ficus diversifolia*	7.33	Sensitive
12.	*Ficus sycomonis*	7.64	Sensitive
13.	*Anacardium occidentale*	25.34	Tolerant
14.	*Annona muricata*	23.16	Tolerant
15.	*Citrius sinensis*	12.57	Intermediate
16.	*Delonix regia*	10.43	Sensitive
17.	*Azadirachita indica*	27.33	Tolerant
18.	*Terminalia catappa*	12.89	Intermediate
19.	*Mangifera indica*	29.46	Tolerant
20.	*Gmelina arborea*	9.74	Sensitive
21.	*Casuarina equisetifolia*	13.64	Intermediate
22.	*Hildagardia barterii*	12.0	Intermediate
23.	*Blighia sapida*	12.0	Intermediate
24.	*Eucalyptus citrodora*	25.23	Tolerant
25.	*Plumera rubra*	10.59	Sensitive

26.	*Acacia moniliformis*	10.35	Sensitive
27.	*Acacia nilotica*	13.27	Intermediate
28.	*Parkia biglobossa*	11.26	Intermediate
29.	*Polyalthia longifolia*	17.0	Tolerant
30.	*Milicia excelsa*	15.75	Intermediate

Table 28 APTI Values of Selected Trees species in University of Ibadan Botanical Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Chrysophyllum albidum*	11.15	Intermediate
2.	*Irvingia gabonensis*	9.60	Sensitive
3.	*Snysepalum dulcificum*	12.0	Intermediate
4.	*Plumera rubra*	10.59	Sensitive
5.	*Delonix regia*	10.43	Sensitive
6.	*Mangifera indica*	29.46	Tolerant
7.	*Citrus sinensis*	12.57	Intermediate
8.	*Anacardium occidentale*	25.34	Tolerant
9.	*Pakia biglobossa*	11.26	Intermediate
10.	*Prosopis africana*	8.10	Sensitive
11.	*Plumera alba*	10.36	Sensitive
12.	*Azadirachita indica*	27.33	Tolerant
13.	*Erythrina senegalensis*	14.92	Intermediate
14.	*Gliciridia sepium*	9.95	Sensitive

15.	*Milicia excelsa*	15.75	Intermediate
16.	*Blighia sapida*	11.90	Intermediate
17.	*Annona senegalensis*	11.07	Intermediate
18.	*Ficus trichopoda*	12.0	Intermediate
19.	*Ficus elastica*	11.58	Intermediate
20.	*Tectonia grandis*	9.89	Sensitive
21.	*Terminalia catappa*	12.89	Intermediate
22.	*Gmelina arborea*	9.74	Sensitive
23.	*Vitellaria paradoxa*	7.44	Sensitive
24.	*Bridelia ferruginea*	12.76	Intermediate
25.	*Burkea africana*	15.19	Intermediate
26.	*Lophira lanceolata*	12.98	Intermediate
27.	*Casuarina equisetifolia*	13.64	Intermediate
28.	*Ficus diversifolia*	7.33	Sensitive
29.	*Triplochiton scleroxylon*	6.82	Sensitive
30.	*Eucalyptus citrodora*	25.23	Tolerant

Table 29 APTI Values of Selected Trees species in Federal University of Technology, Akure Botanical Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Ficus capensis*	8.48	Sensitive
2.	*Ficus bengamina*	5.91	Sensitive
3.	*Alstonia scholaris*	9.63	Sensitive
4.	*Ficus exasperate*	11.62	Intermediate
5.	*Funtumia elastica*	11.33	Intermediate

6.	*Milicia excelsa*	15.75	Intermediate
7.	*Leucena leucocephala*	14.16	Intermediate
8.	*Thevetia neriifolia*	10.84	Sensitive
9.	*Spondias mombin*	12.49	Intermediate
10.	*Mangifera indica*	29.46	Tolerant
11.	*Anacardium occidentale*	25.46	Tolerant
12.	*Citrus sinensis*	12.57	Intermediate
13.	*Azadirachita indica*	27.33	Tolerant
14.	*Parkia biglobossa*	11.26	Intermediate
15.	*Terminalia catappa*	12.89	Intermediate
16.	*Ficus trichopoda*	11.61	Intermediate
17.	*Annona senegalensis*	11.07	Intermediate
18.	*Delonix regia*	10.43	Sensitive
19.	*Gmelina arborea*	9.74	Sensitive
20.	*Tectonia grandis*	9.89	Sensitive
21.	*Casuarina equisetifolia*	13.64	Intermediate
22.	*Blighia sapida*	12.0	Intermediate
23.	*Triplochiton scleroxylon*	6.82	Sensitive
24.	*Cynometra ananta*	12.0	Intermediate
25.	*Erythrophleum ivorense*	14.44	Intermediate
26.	*Ficus diversifolia*	7.33	Sensitive
27.	*Polyalthia longifolia*	17.0	Tolerant
28.	*Plumera rubra*	10.59	Sensitive
29.	*Hildagardia baterii*	11.64	Intermediate
30.	*Prosopis africana*	8.10	Sensitive

Table 30 APTI Values of Selected Trees species in University of Ilorin Botanical Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Plumera rubra*	10.59	Sensitive
2.	*Vitellaria paradoxa*	7.44	Sensitive
3.	*Gliricidium sepium*	9.95	Sensitive
4.	*Polyalthia longifolia*	17.0	Tolerant
5.	*Casuarina equisetifolia*	13.64	Intermediate
6.	*Tectonia grandis*	9.89	Sensitive
7.	*Terminalia catappa*	12.89	Intermediate
8.	*Parkia biglobossa*	11.26	Intermediate
9.	*Daniela olivieri*	13.02	Intermediate
10.	*Prosopis africana*	8.10	Sensitive
11.	*Delonix regia*	10.43	Sensitive
12.	*Gmelina arborea*	9.74	Sensitive
13.	*Plumera alba*	10.36	Sensitive
14.	*Azadirachita indica*	27.33	Tolerant
15.	*Anacardium occidentale*	25.34	Tolerant
16.	*Citrus sinensis*	12.57	Intermediate
17.	*Bridelia ferruginea*	12.76	Intermediate
18.	*Blighia sapida*	12.0	Intermediate
19.	*Annona senegalensis*	11.07	Intermediate
20.	*Lophira lanceolata*	12.98	Intermediate
21.	*Burkea africana*	15.19	Intermediate
22.	*Albizzia lebbeck*	8.80	Sensitive
23.	*Eucalyptus citrodora*	25.23	Tolerant
24.	*Hildagardia barterii*	12.0	Intermediate
25.	*Eucalyptus cinerea*	19.74	Tolerant

26.	*Acacia moniliformis*	10.35	Sensitive
27.	*Ficus diversifolia*	7.33	Sensitive
28.	*Mangifera indica*	29.46	Tolerant
29.	*Lonchocarpus cyanenscens*	12.02	Intermediate
30.	*Adansonia digitata*	10.93	Sensitive

Table 31 APTI Values of Selected Trees species of BayeroUniversityof KanoBotanical Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Azadirachita indica*	27.33	Tolerant
2.	*Vitellaria paradoxa*	7.44	Sensitive
3.	*Albizzia lebbeck*	8.80	Sensitive
4.	*Polyalthia longifolia*	17.0	Tolerant
5.	*Annona senegalensis*	11.07	Intermediate
6.	*Khaya senegalensis*	15.24	Intermediate
7.	*Citrus paradise*	15.93	Intermediate
8.	*Plumera alba*	10.36	Sensitive
9.	*Plumera rubra*	10.59	Sensitive
10.	*Citrus sinensis*	12.57	Intermediate
11.	*Ficus elastica*	12.0	Intermediate
12.	*Citrus reticulata*	15.22	Intermediate
13.	*Anacardium occidentale*	25.34	Tolerant
14.	*Mangifera indica*	29.46	Tolerant

15.	*Tamarindus indica*	10.89	Sensitive
16.	*Terminalia catappa*	12.89	Intermediate
17.	*Adansonia digitata*	10.93	Sensitive
18.	*Ziziphus mauritiana*	23.73	Tolerant
19.	*Prosopis africana*	8.10	Sensitive
20.	*Parkia biglobossa*	11.26	Intermediate
21.	*Blighia sapida*	12.0	Intermediate
22.	*Gmelina arborea*	9.74	Sensitive
23.	*Vitex doniana*	12.23	Intermediate
24.	*Terminalia macroptera*	13.18	Intermediate
25.	*Acacia gourmaensis*	10.63	Sensitive
26.	*Lophira lanceolata*	12.98	Intermediate
27.	*Casuarina equisetifolia*	13.64	Intermediate
28.	*Delonix regia*	10.43	Sensitive
29.	*Balanites aegyptiaca*	7.57	Sensitive
30.	*Hildagardia barterii*	12.0	Intermediate

Table 32 APTI Values Values of Selected Trees species in University of Jos Botanical Garden and Environs.

S/N	Scientific Names	APTI	Responses
1.	*Casuarina equisetifolia*	13.64	Intermediate
2.	*Plumera rubra*	10.59	Sensitive
3.	*Plumera alba*	10.36	Sensitive
4.	*Eucalyptus citrodora*	25.23	Tolerant
5.	*Eucalyptus cinerea*	19.74	Tolerant
6.	*Acacia moniliformis*	10.35	Sensitive
7.	*Erythrina senegalensis*	14.92	Intermediate
8.	*Delonix regia*	10.43	Sensitive
9.	*Hildagardia barterii*	12.0	Intermediate
10.	*Terminalia superba*	12.0	Intermediate
11.	*Terminalia catappa*	12.89	Intermediate
12.	*Bauhinia spp*	10.91	Sensitive
13.	*Milicia excelsa*	15.75	Intermediate
14.	*Polyalthia longifolia*	17.0	Intermediate
15.	*Gmelina arborea*	9.74	Sensitive
16.	*Mangifera indica*	29.46	Tolerant
17.	*Anacardium occidentale*	25.34	Tolerant
18.	*Ficus bengamina*	5.91	Sensitive
19.	*Citrus sinensis*	12.57	Intermediate
20.	*Citrus reticulata*	15.22	Intermediate
21.	*Citrus paradise*	15.93	Intermediate
22.	*Pisidium guajava*	12.39	Intermediate
23.	*Moringa oleifera*	7.86	Intermediate
24.	*Parkia biglobossa*	11.26	Intermediate
25.	*Cassia fistula*	13.08	Intermediate
26.	*Prosopis africana*	8.10	Sensitive

27.	*Ficus elastica*	12.0	Intermediate
28.	*Azadirachita indica*	27.33	Tolerant
29.	*Araucaria heterophylla*	10.17	Sensitive
30.	*Acacia gourmaensis*	10.63	Sensitive

4.5 Seasonal Ambient Air Quality

4.5.1 Air Quality Index Inside selected Universities Botanical Gardens

Seven air pollutants: SO_2, NO_2, NOx, NO, CO, Ozone and PM10 were critically monitored as part of the air quality index. The air quality index (AQI) is a rating scale for outdoor air. The lower the AQI value the better the air quality. The results obtained after the analysis of air pollutants and the AQI was calculated for both dry and rainy seasons inside the selected Universities Botanical gardens (Table 33) with the correspondence air quality conditions. In terms of seasonal air quality index, the AQI rating for selected universities botanical gardens were tabulated in (Table 33). The results of the AQI for dry season are in the range of (34.49 – 40.47) which was below the permissible limit of USEPA ambient air quality standard. The same similar trend was also recorded in the range of (31.36 – 37.52) for the rainy season which was also below the permissible limit of USEPA ambient air quality. The overall air quality conditions interpreted according to USEPA ambient air standard as 'Good' with green colour codes which also refer to the positive relevance of Botanical Garden structure to air quality.

4.5.2 Air Quality Index Outside Universities Botanical Gardens

Seven air pollutants: SO_2, NO_2, NOx, NO, CO, Ozone and PM_{10} were critically monitored as part of the air quality index. The air quality index (AQI) is a rating scale for outdoor air. The lower the AQI value the better the air quality. The results obtained after the analysis of air pollutants and the AQI was calculated for both dry and wet seasons outside the universities botanical gardens are given in (Table 34) with the correspondence air quality conditions. In terms of seasonal air quality index, the AQI rating for selected locations outside universities botanical gardens were tabulated in (Table 34). The results of the AQI for dry season are in the range of (84.60 – 96.38) which was not too high above the permissible limit of USEPA ambient air quality standard. The same similar trend was also recorded in the range of (74.38 – 84.82) for the rainy season which was also not too high above the permissible limit of USEPA ambient air quality. The overall air quality conditions interpreted according to USEPA ambient air standard as ‘Moderate’ with Yellow colour codes which also refer to the reduction in pollution levels of the surroundings as moderate for people to live in but not as save as that of the inside universities botanical gardens. This also supports the influence of botanical garden structure, planning and design on ecosystem services and atmospheric air quality.

Table 33: Seasonal Air Quality Index inside Selected Universities Botanical Gardens

	Seasonal Air Quality Index		
Inside Botanical Gardens	Dry	Rainy	Air Quality Conditions
Lagos	39.27	35.97	Good
Ibadan	37.73	34.87	Good
Akure	38.16	34.83	Good
Ilorin	37.95	35.89	Good
Kano	40.47	37.52	Good
Jos	34.49	31.36	Good

Table 34: Seasonal Air Quality Index in Selected Locations outside Botanical Gardens

	Seasonal Air Quality Index		
Outside Botanical Gardens	Dry	Rainy	Air Quality Condition
Lagos	94.59	82.32	Moderate
Ibadan	92.85	81.56	Moderate
Akure	90.69	81.02	Moderate
Ilorin	88.30	77.78	Moderate
Kano	96.38	84.82	Moderate
Jos	84.60	74.38	Moderate

The Principal Component Analysis of Dry Season Pollution and Meterological Parameters Inside Universities Botanical Gardens

Multivariate analysis was used for data classification based on the botanical gardens and seasons. PCA was employed as a method of extraction of the principal components. Three principal components were extracted, which accounted for about (92.79%) variance of dry season pollution parameters inside the universities botanical gardens (Table 35) and (93.53%) variance of dry season meterological parameters inside the universities botanical gardens (Table 36).

Table 35: PCA Value of Dry Season Pollution Parameters Inside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	4.66389	92.785
2	0.357134	7.105
3	0.005523	0.10987

Table 36: PCA Value of Dry Season Meteorological Parameters Inside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	122.677	93.531
2	6.27841	4.7867
3	1.82567	1.3919

The Principal Component Analysis of Dry Season Pollution and Meterological Parameters Outside Universities Botanical Gardens

Multivariate analysis was used for data classification based on the botanical gardens and seasons. PCA was employed as a method of extraction of the principal components. Three principal components were extracted, which accounted for about (97.85%) variance of dry season pollution parameters outside the universities botanical gardens (Table 37) and (96.06%) variance of dry season meterological parameters outside the universities botanical gardens (Table 38).

Table 37: PCA Value of Dry Season Pollution Parameters outside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	21.5326	97.847
2	0.31226	1.4189
3	0.16161	0.73437

Table 38: PCA Value of Dry Season Meterological Parameters Outside Universities Botanical Gardens

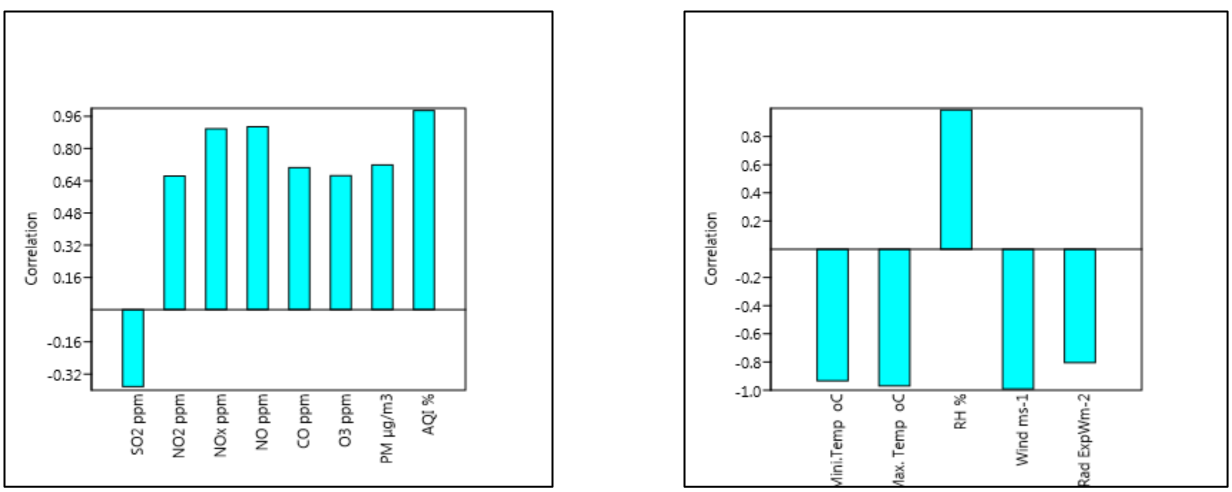
PC	Eigenvalue	% Variance
1	241.002	96.058
2	9.038	3.6024
3	0.773159	0.30817

Modelling of Dry Season Data Inside University of Lagos Biological Garden

The correlated loadings plots are positive for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI and RH (increases the amount of ozone formed during dry season), but negative for SO_2, Temp., Wind and Solar radiation 'reduces the value of ozone formed' (Fig. 9a).

University of Lagos Biological Garden

(Inside)



Pollution Parameters

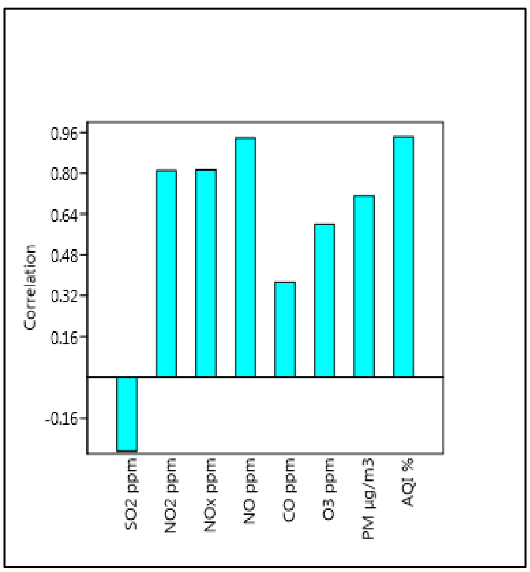
Meterological Parameters

Fig. 9a: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

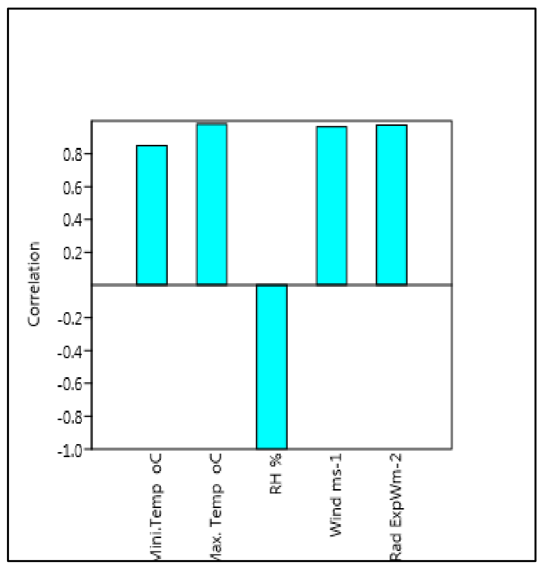
Modelling of Dry Season Data Outside University of Lagos Biological Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of SO_2 and RH are negative 'decreases the value of ozone formed' (Fig. 9b).

University of Lagos Biological Garden
(Outside)



Pollution Parameters



Meterological Parameters

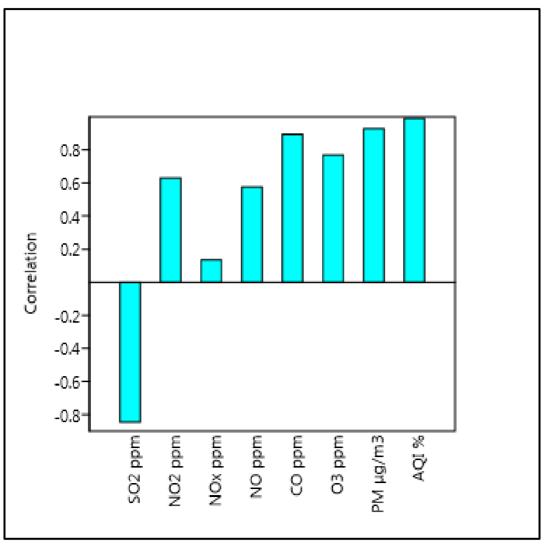
Fig. 9b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

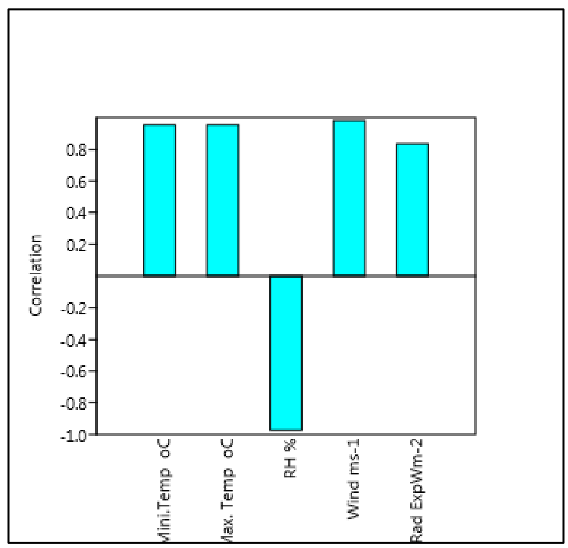
Modelling of Dry Season Data Inside University of Ibadan Botanical Garden

The correlated loadings plots are positive for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the amount of ozone formed during dry season), but negative for SO2 and RH 'reduces the value of ozone formed' (Fig. 10a).

University of Ibadan Botanical Garden

(Inside)





Pollution Parameters

Meterological Parameters

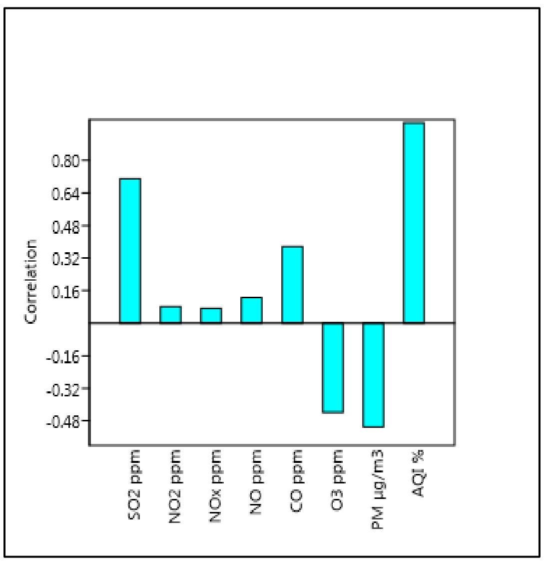
Fig. 10a: Correlated Loadings Plot shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

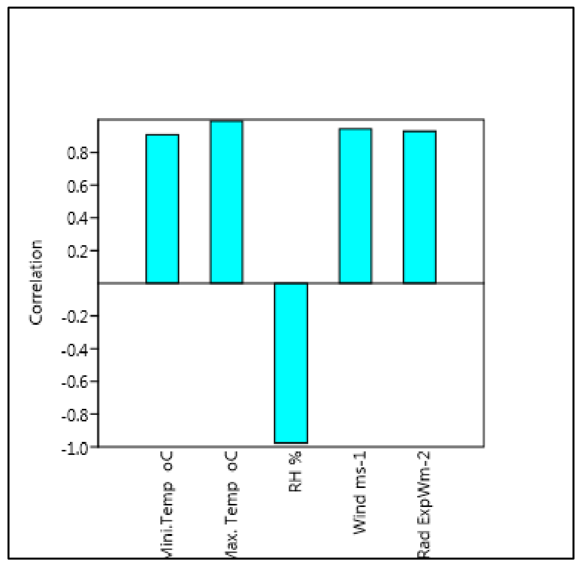
Modelling of Dry Season Data Inside University of Ibadan Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, CO, AQI, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of O_3, PM_{10} and RH are negative 'decreases the value of ozone formed' (Fig. 10b).

University of Ibadan Botanical Garden

(Outside)





Pollution Parameters

Meterological Parameters

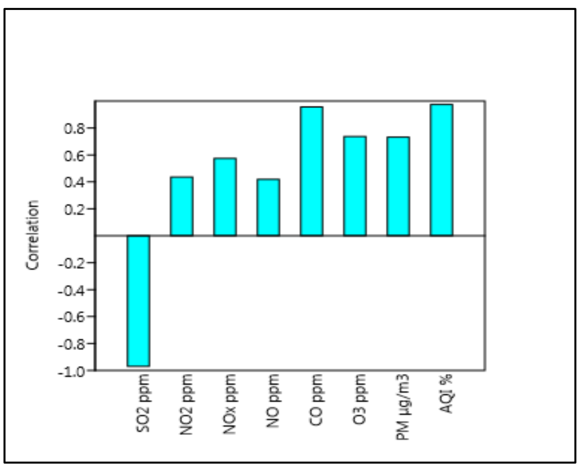
Fig. 10b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

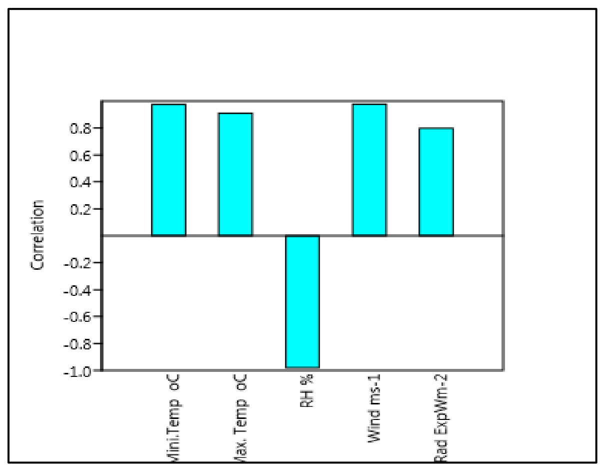
Modelling of Dry Season Data Inside FUTA Botanical Garden

The correlated loadings plots are positive for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the amount of ozone formed during dry season), but negative for SO_2 and RH 'reduces the value of ozone formed' (Fig. 11a).

Federal University of Technology Akure Botanical Garden

(Inside)





Pollution Parameters

Meterological Parameters

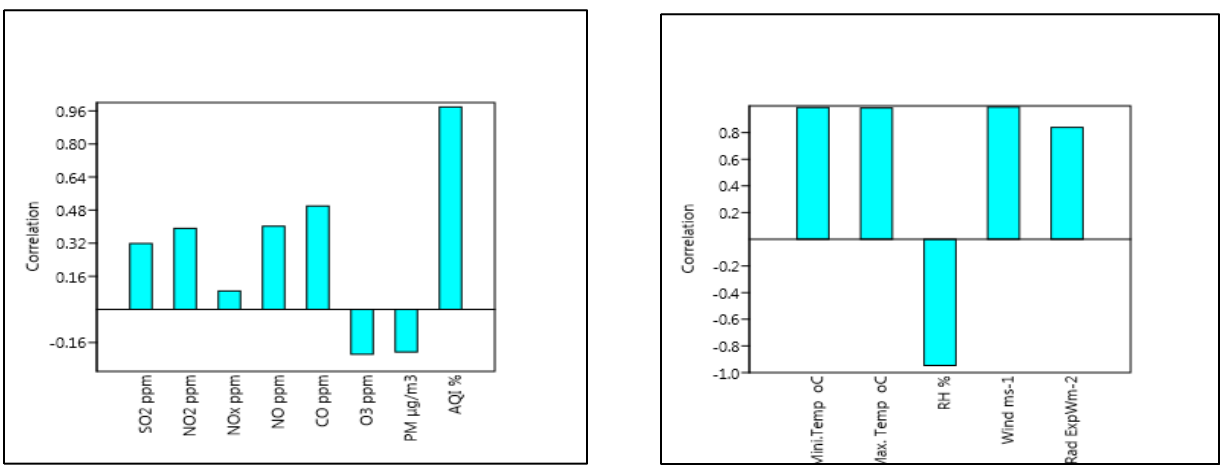
Fig. 11a: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

Modelling of Dry Season Data Outside FUTA Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of O_3, RH, PM_{10}, SO_2, Temp., Wind and Solar radiation are negative 'decreases the value of ozone formed' (Fig. 11b).

Federal University of Technology Akure Botanical Garden

(Outside)



Pollution Parameters

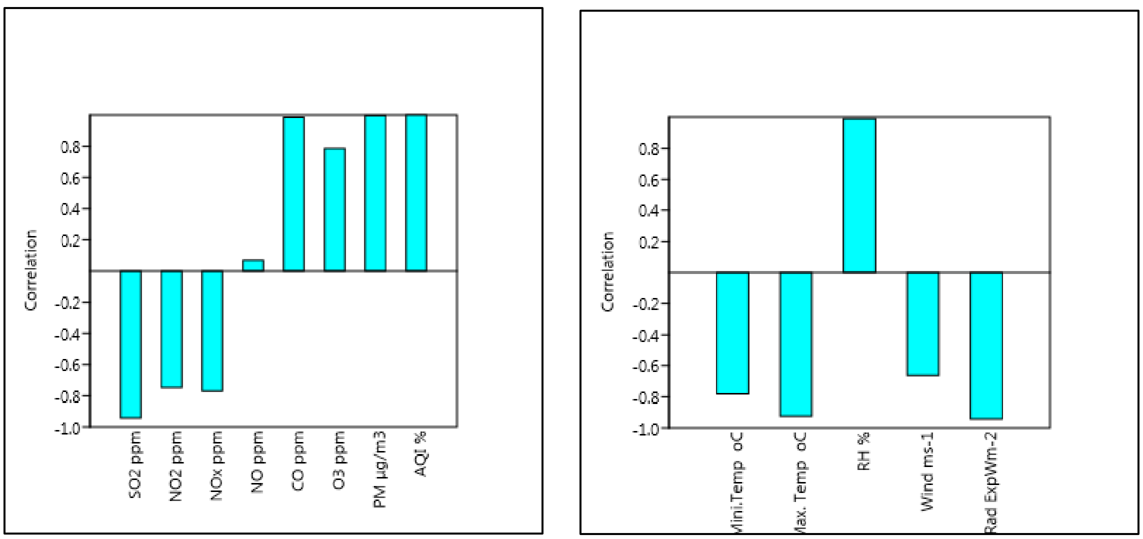
Meterological Parameters

Fig. 11b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

Modelling of Dry Season Data Inside University of Ilorin Botanical Garden

The correlated loadings plots are positive for, NO, CO, O_3, PM_{10}, AQI and RH (increases the amount of ozone formed during dry season), but negative for SO_2, NO_2, NOx, Temp., Wind and Solar radiation 'reduces the value of ozone formed' (Fig. 12a).

University of Ilorin Botanical Garden
(Inside)



Pollution Parameters

Meterological Parameters

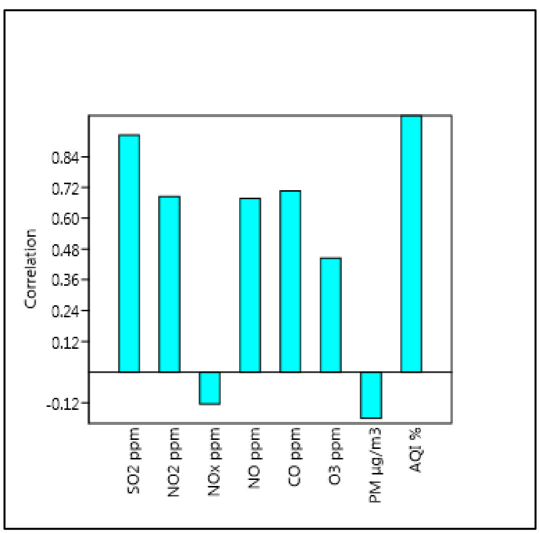
Fig. 12a: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

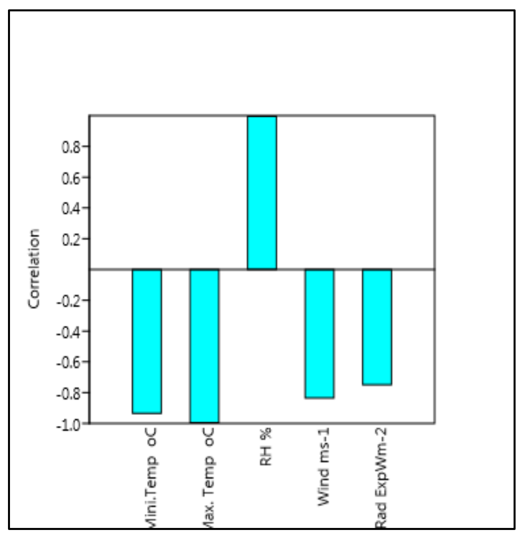
Modelling of Dry Season Data Outside University of Ilorin Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, and RH (increases the values of ozone formed during the rainy season), while only those of NOx, Temp., Wind and Solar radiation are negative 'decreases the value of ozone formed' (Fig. 12b).

University of Ilorin Botanical Garden

(Outside)





Pollution Parameters

Meterological Parameters

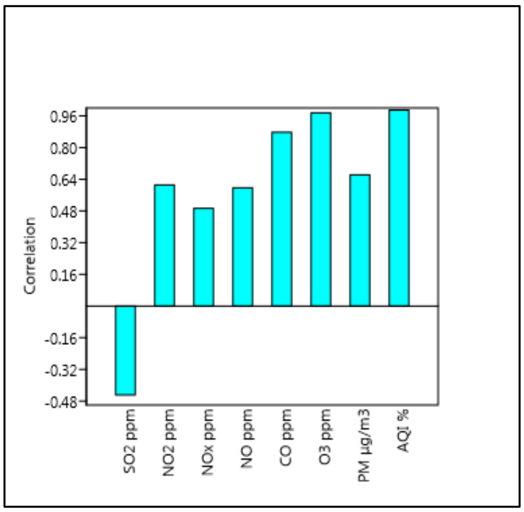
Fig. 12b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

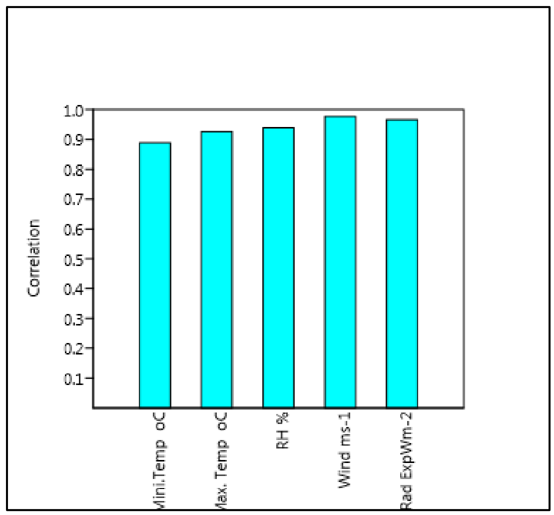
Modelling of Dry Season Data Inside Bayero University of Kano Botanical Garden

The correlated loadings plots are positive for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the amount of ozone formed during dry season), but negative in SO_2, ‘increases the value of ozone formed’ (Fig. 13a).

Bayero University of Kano Botanical Garden

(Inside)





Pollution Parameters

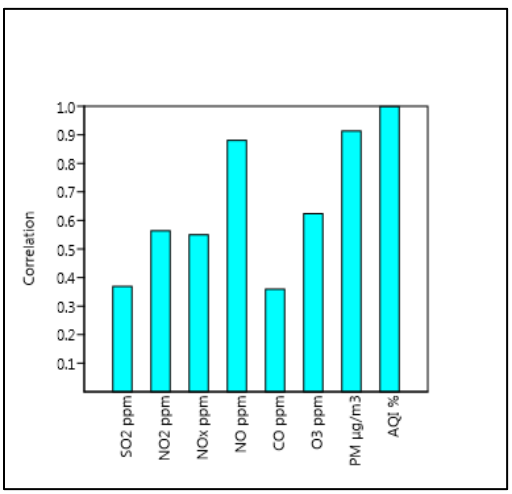
Meterological Parameters

Fig. 13a: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

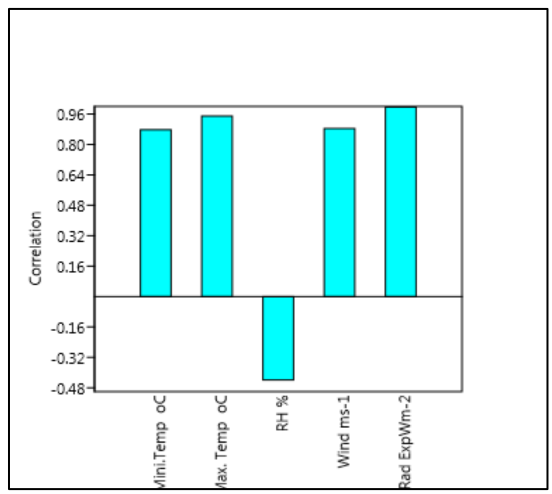
Modelling of Dry Season Data Outside Bayero University of Kano Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, and RH Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only RH is negative ‘decreases the value of ozone formed’ (Fig. 13b).

Bayero University of Kano Botanical Garden
(Outside)



Pollution Parameters



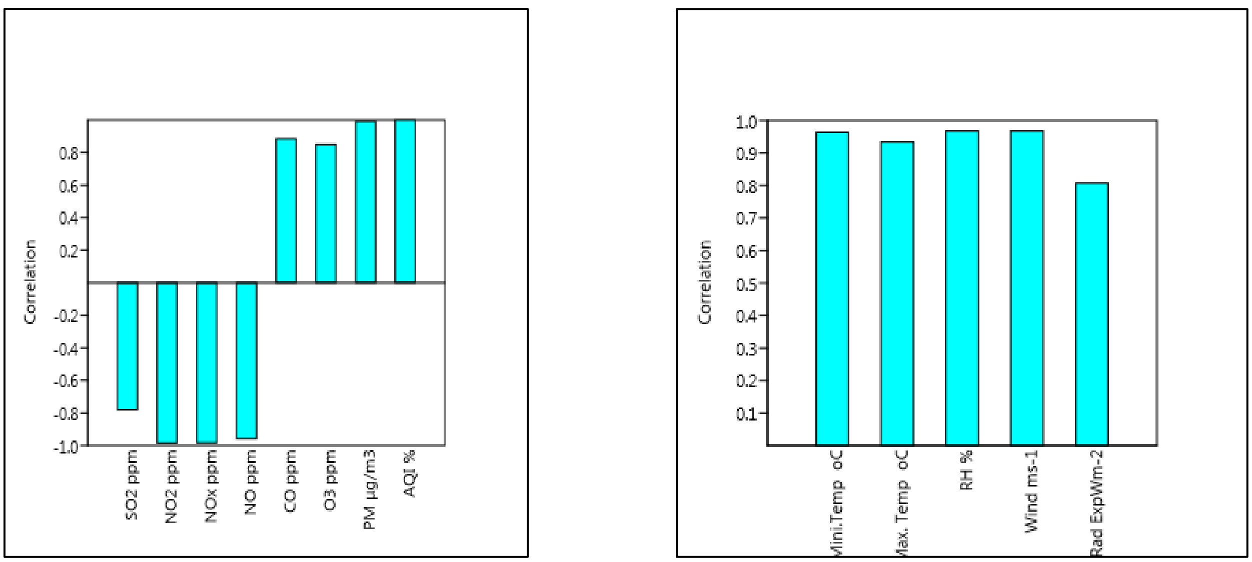
Meterological Parameters

Fig. 13b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

Modelling of Dry Season Data Inside University of Jos Botanical Garden

The correlated loadings plots are positive for CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation and RH (increases the amount of ozone formed during dry season), but negative for SO_2, NO_2, NOx, NO, RH, Temp., Wind and Solar radiation 'increases the value of ozone formed' (Fig. 14a).

University of Jos Botanical Garden
(Inside)



Pollution Parameters

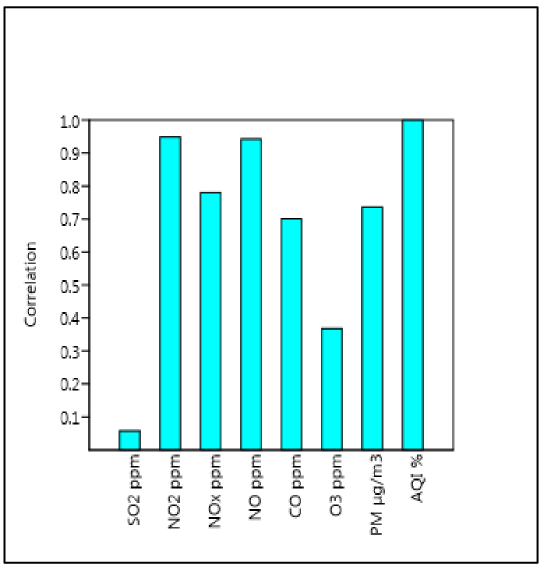
Meterological Parameters

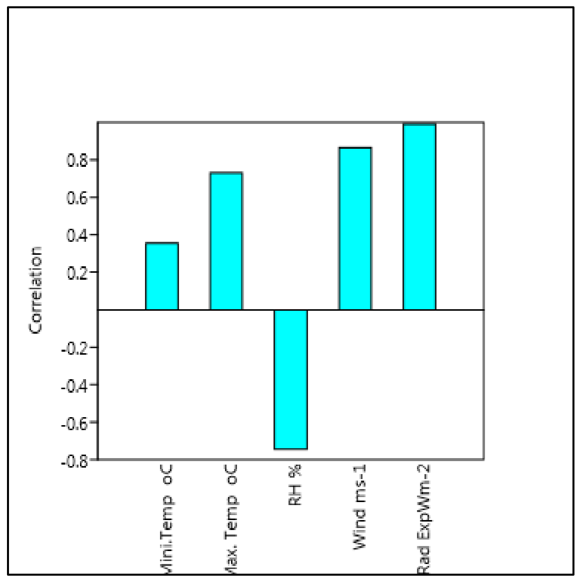
Fig. 14a: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

Modelling of Dry Season Data Outside University of Jos Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, and RH Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only RH is negative 'decreases the value of ozone formed' (Fig. 14b).

University of Jos Botanical Garden
(Outside)





Pollution Parameters

Meterological Parameters

Fig. 14b: Correlated Loadings Plot Shown Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters

The Principal Component Analysis of Rainy Season Pollution and Meterological Parameters Inside Universities Botanical Gardens

Multivariate analysis was used for data classification based on the botanical gardens and seasons. PCA was employed as a method of extraction of the principal components. Three principal components were extracted, which accounted for about (95.49%) variance of wet season pollution parameters inside the universities botanical gardens (Table 39) and (93.86%) variance of wet season meterological parameters inside the universities botanical gardens (Table 40).

Table 39: PCA Value of Rainy Season Pollution Parameters Inside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	5.15604	95.487
2	0.167768	3.107
3	0.075354	1.3955

Table 40: PCA Value of Rainy Season Metrological Parameter Inside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	122.58	93.858
2	6.12044	4.6863
3	1.52114	1.1647

The Principal Component Analysis of Rainy Season Pollution and Meterological Parameters Outside Universities Botanical Gardens

Multivariate analysis was used for data classification based on the botanical gardens and seasons. PCA was employed as a method of extraction of the principal components. Three principal components were extracted, which accounted for about (97.25%) variance of wet season pollution parameters outside the universities botanical gardens (Table 41) and (93.86%) variance of wet season meterological parameters outside the universities botanical gardens (Table 42).

Table 41: PCA Value of Rainy Season Pollution Parameters Outside Universities Botanical Gardens

PC	Eigenvalue	% Variance
1	16.3271	97.246
2	0.441467	2.6294
3	0.020977	0.12494

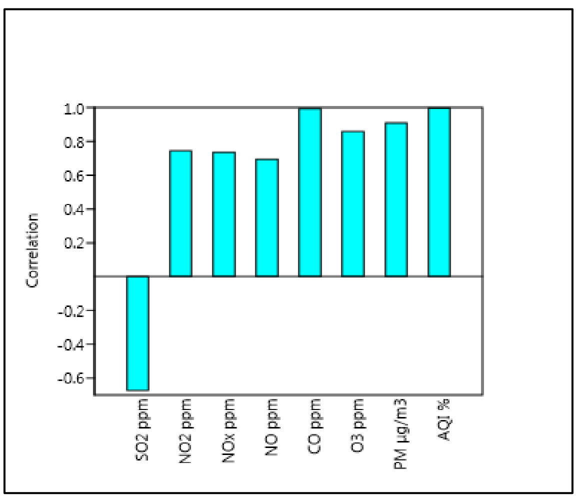
Table 42: PCA Value of Rainy Season Meterological Parameters Outside Universities Botanical Gardens

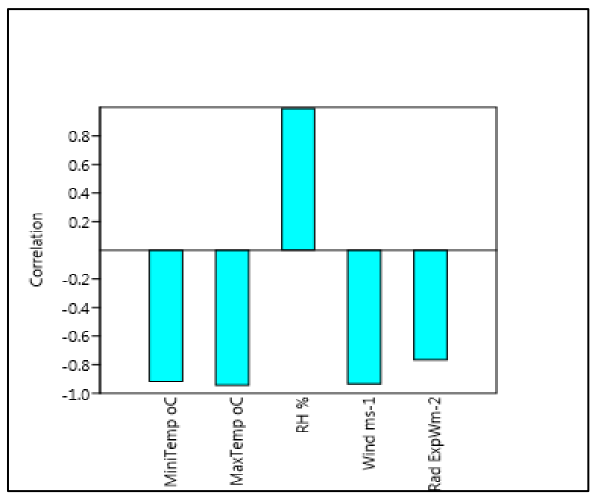
PC	Eigenvalue	% Variance
1	122.58	93.858
2	6.12044	4.6863
3	1.52114	1.1647

Modelling of Rainy Season Data Inside University of Lagos Biological Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI and RH (increases the values of ozone formed during the rainy season), while only those of SO_2, Temp., Wind and Solar radiation are negative 'decreases the value of ozone formed during the rainy season' (Fig. 15a).

University of Lagos Biological Garden
(Inside)





Pollution Parameters

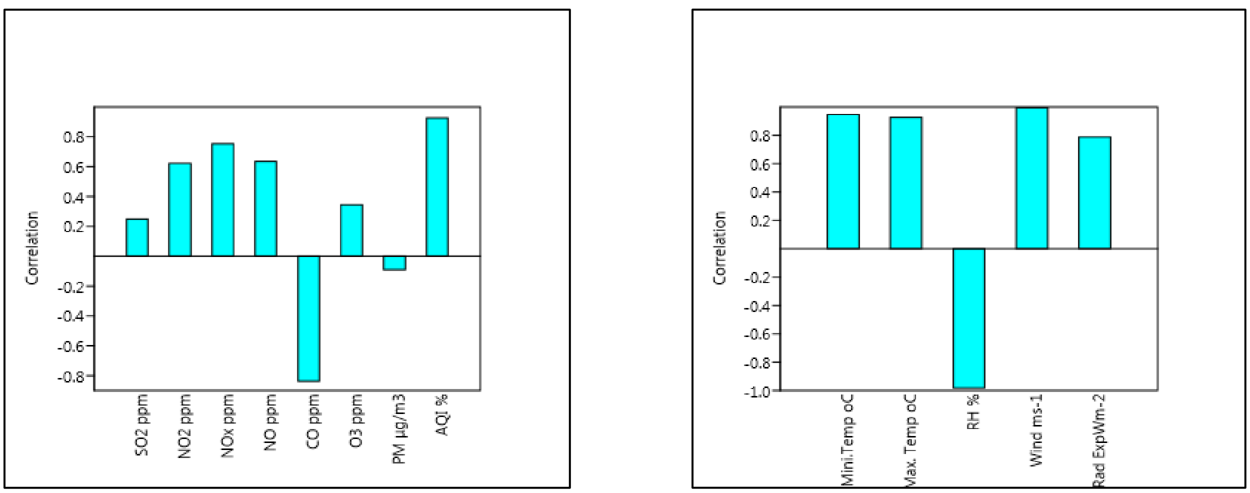
Meterological Parameters

Fig. 15a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

Modelling of Rainy Season Data Outside University of Lagos Biological Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of CO and RH are negative ‘decreases the value of ozone formed during the rainy season’ (Fig. 15b).

University of Lagos Biological Garden
(Outside)



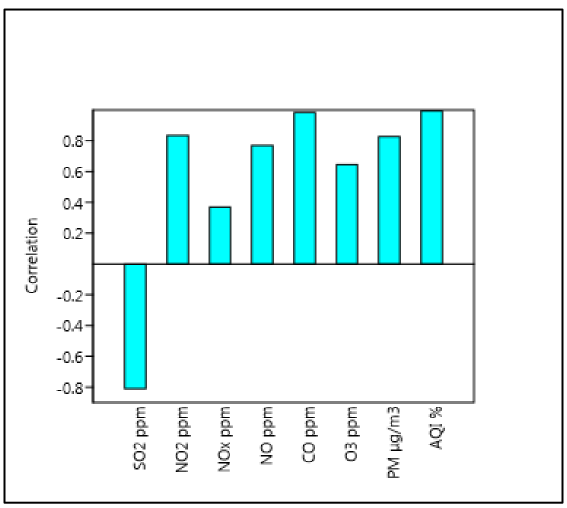
Pollution Parameters   Meterological Parameters

Fig. 15b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

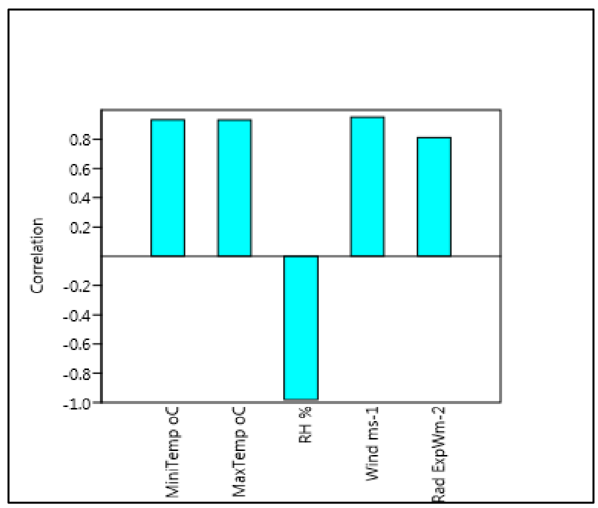
Modelling of Rainy Season Data Inside University of Ibadan Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of SO_2 and RH are negative 'decreases the value of ozone formed during the rainy season' (Fig. 16a).

University of Ibadan Botanical Garden
(Inside)



Pollution Parameters



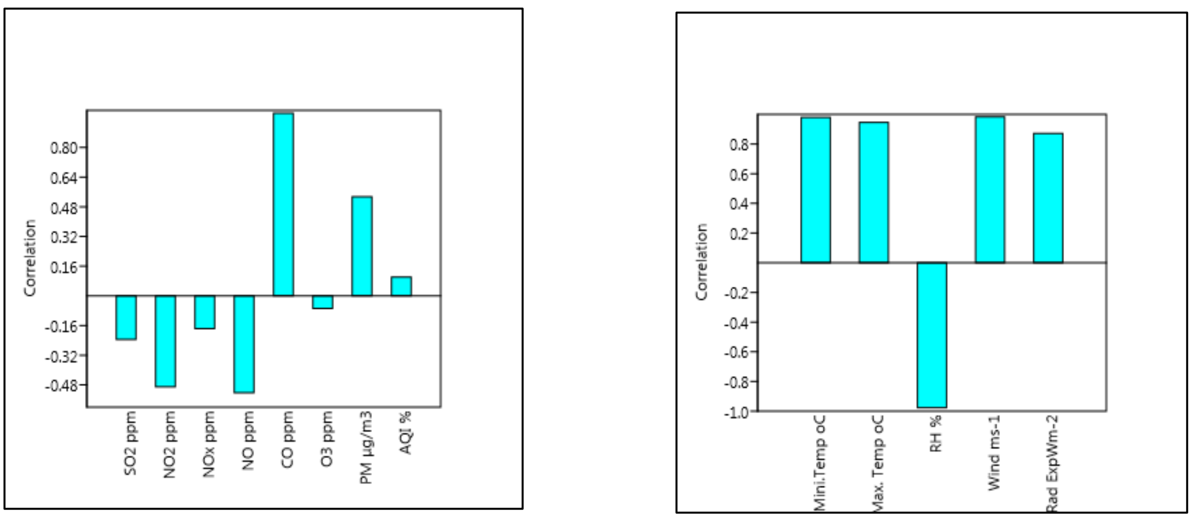
Meterological Parameters

Fig. 16a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

Modelling of Rainy Season Data Outside University of Ibadan Botanical Garden

The correlated loadings plots are of positive correlation values for CO, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (Increases the values of ozone formed during the rainy season), while only those of SO_2, NO_2, NOx, NO and O_3 are negative 'decreases the value of ozone formed during the rainy season' (Fig. 16b).

University of Ibadan Botanical Garden
(Outside)



Pollution Parameters

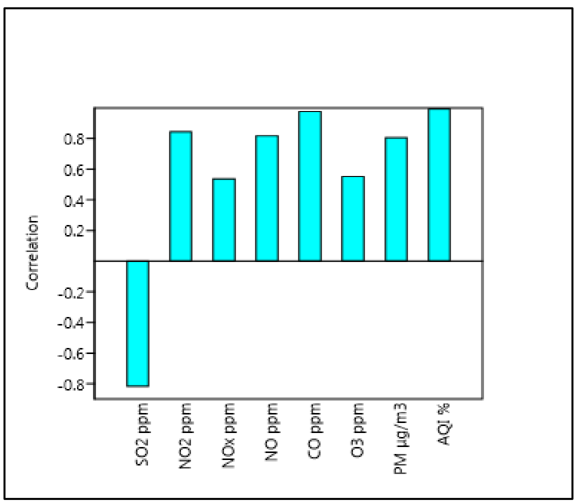
Meterological Parameters

Fig. 16b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

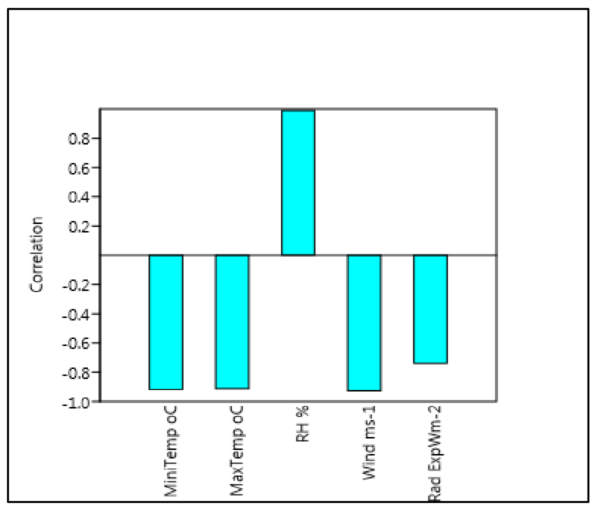
Modelling of Rainy Season Data Inside FUTA Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI and RH, (increases the values of ozone formed during the rainy season), while only those of SO_2, Temp., Wind and Solar radiation are negative ‘decreases the value of ozone formed during the rainy season’ (Fig. 17a).

Federal University of Technology Akure Botanical Garden
(Inside)



Pollution Parameters



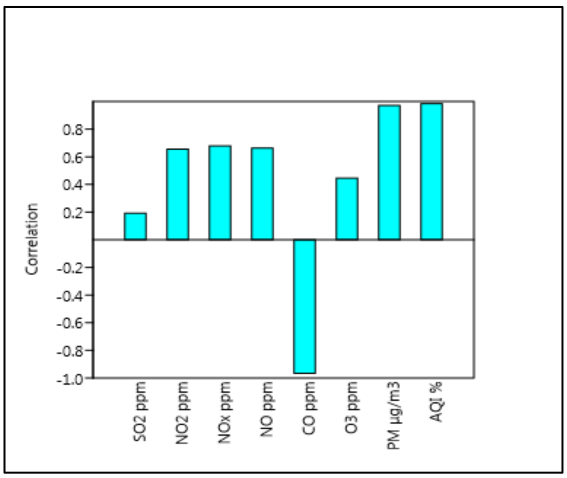
Meterological Parameters

Fig. 17a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

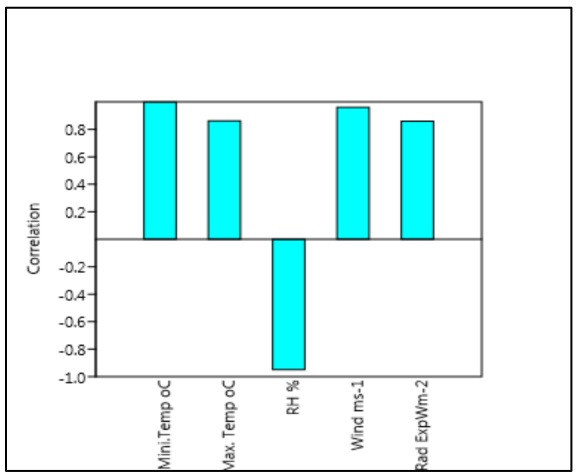
Modelling of Rainy Season Data Outside FUTA Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of CO and RH are negative 'decreases the value of ozone formed during the rainy season' (Fig. 17b).

Federal University of Technology Akure Botanical Garden
(Outside)



Pollution Parameters



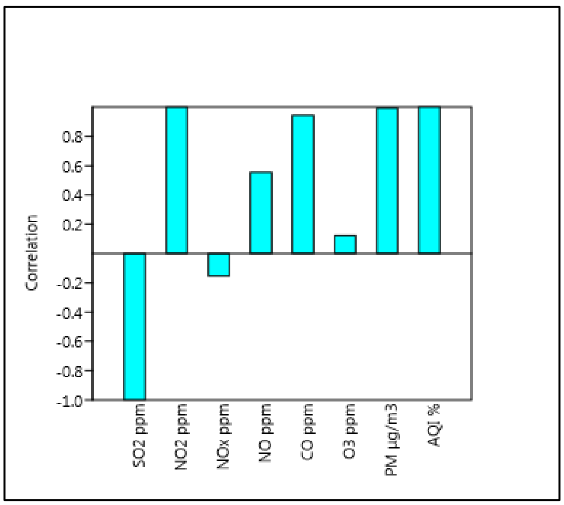
Meterological Parameters

Fig. 17b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

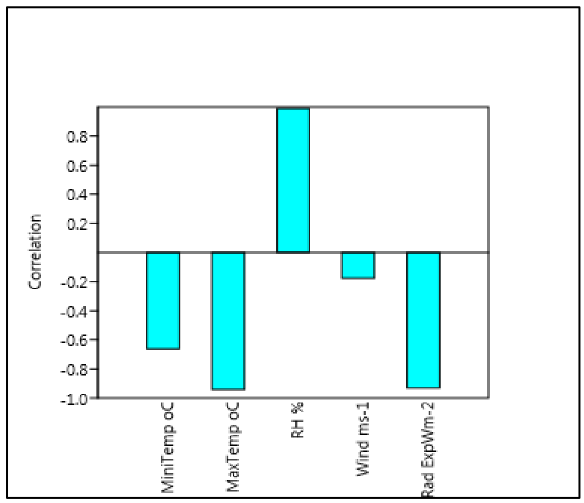
Modelling of Rainy Season Data Inside University of Ilorin Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NO, CO, O_3, PM_{10}, AQI and RH (increases the values of ozone formed during the rainy season), while only those of SO_2, NOx, Temp., Wind and Solar radiation are negative 'decreases the value of ozone formed during the rainy season' (Fig. 18a).

University of Ilorin Botanical Garden
(Inside)



Pollution Parameters



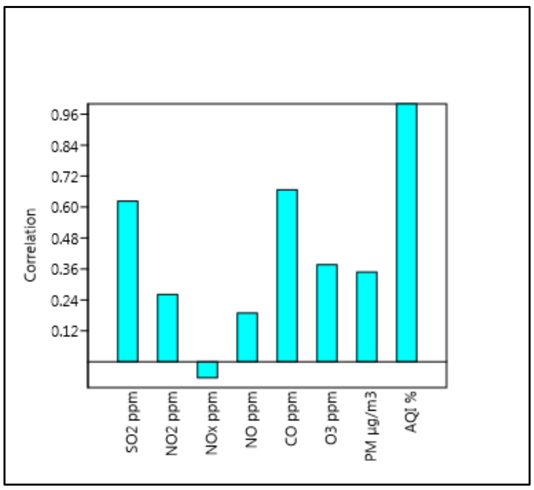
Meterological Parameters

Fig. 18a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

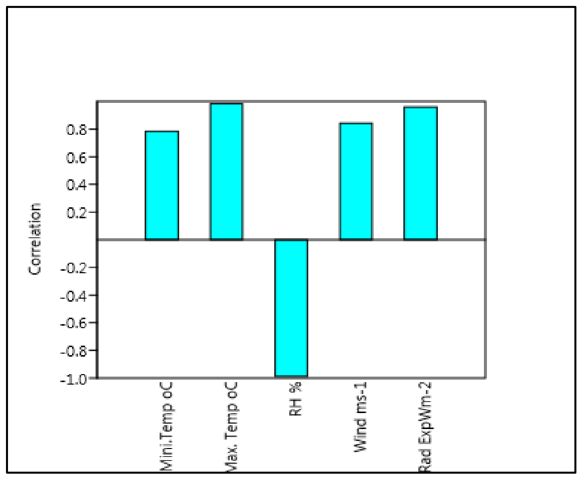
Modelling of Rainy Season Data Outside University of Ilorin Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NO, CO, O_3, PM_{10}, AQI, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of NOx and RH are negative 'decreases the value of ozone formed during the rainy season' (Fig. 18b).

University of Ilorin Botanical Garden
(Outside)



Pollution Parameters



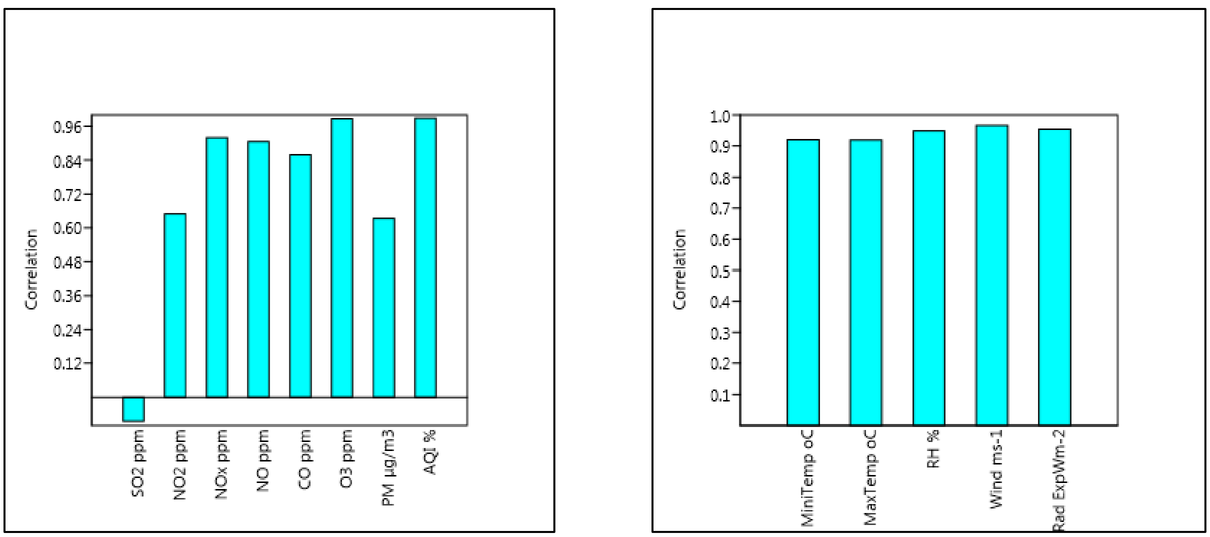
Meterological Parameters

Fig. 18b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

Modelling of Rainy Season Data Inside Bayero University of Kano Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only SO_2 is negative 'increases the value of ozone formed during the rainy season' (Fig. 19a).

Bayero University Kano Botanical Garden
(Inside)



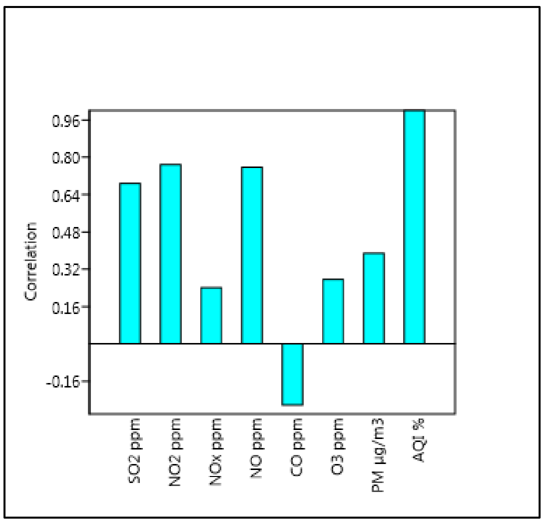
Pollution Parameters　　　　Meterological Parameters

Fig. 19a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

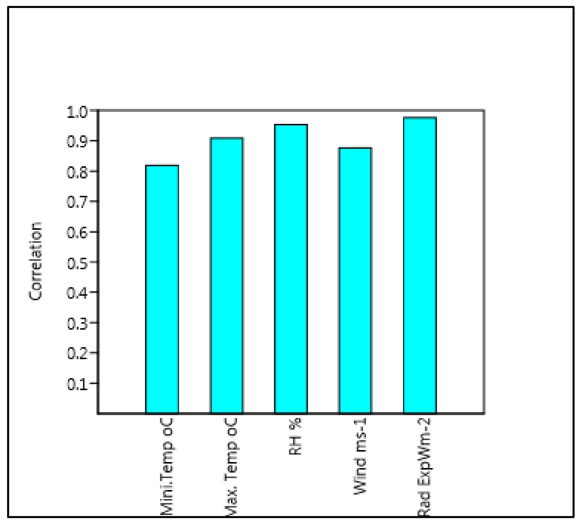
Modelling of Rainy Season Data Outside Bayero University of Kano Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while CO is negative 'decreases the value of ozone formed during the rainy season' (Fig. 19b).

Bayero University Kano Botanical Garden
(Outside)



Pollution Parameters



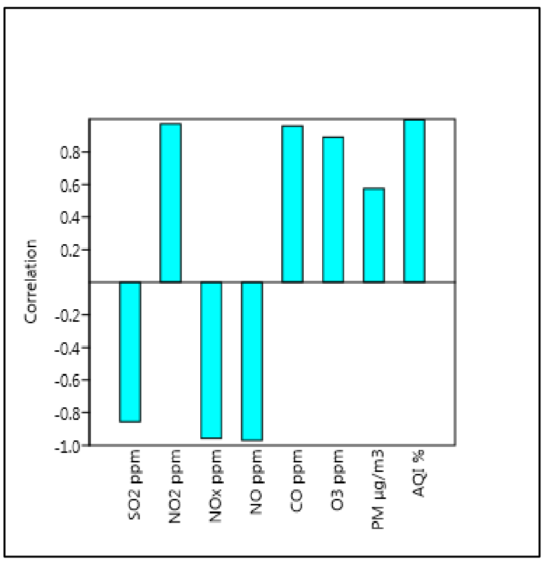
Meterological Parameters

Fig. 19b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

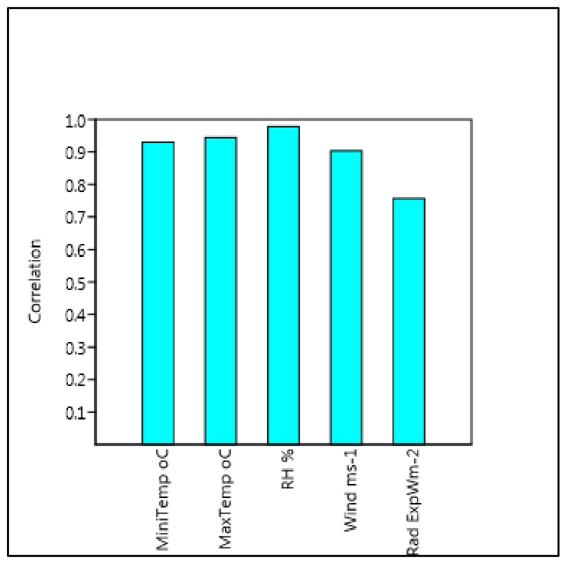
Modelling of Rainy Season Data Inside University of Jos Botanical Garden

The correlated loadings plots are of positive correlation values for NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while only those of SO_2, NOx, NO, Temp., Wind and Solar radiation are negative 'increases the value of ozone formed during the rainy season' (Fig. 20a).

University of Jos Botanical Garden
(Inside)



Pollution Parameters



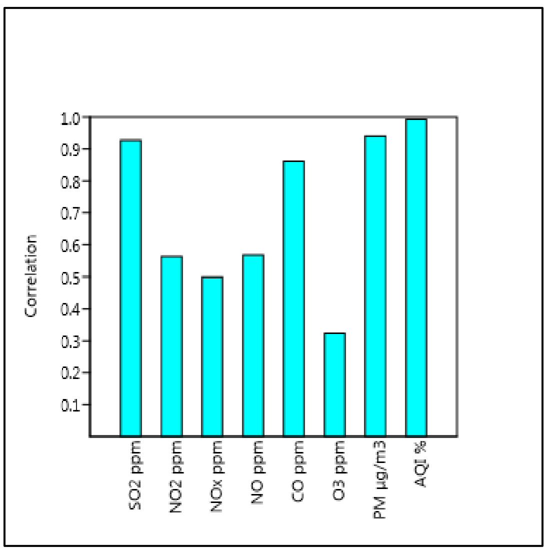
Meterological Parameters

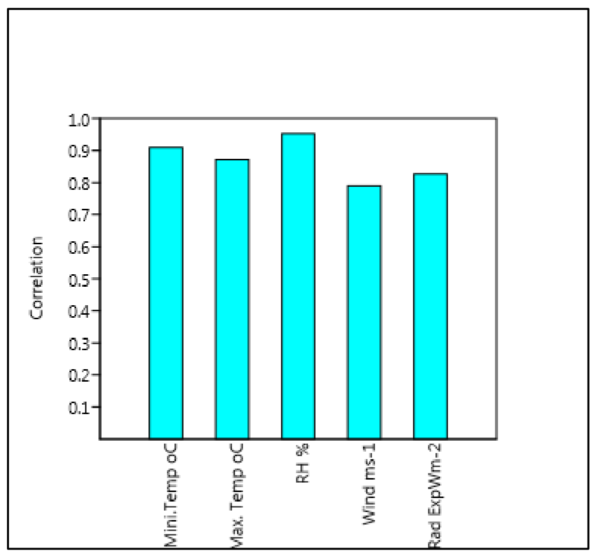
Fig. 20a: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

Modelling of Rainy Season Data Outside University of Jos Botanical Garden

The correlated loadings plots are of positive correlation values for SO_2, NO_2, NOx, NO, CO, O_3, PM_{10}, AQI, RH, Temp., Wind and Solar radiation (increases the values of ozone formed during the rainy season), while the rainfall leads to 'decrease in the value of ozone formed during the rainy season' (Fig. 20b).

University of Jos Botanical Garden
(Outside)





Pollution Parameters

Meterological Parameters

Fig. 20b: Correlated Loadings Plot Shown Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters

4.6 Prototype Design of Botanical Garden Structure

The shape grammers to computer aid design were used for interative manipulation of the architectural layouts. The techniques were also developed for texturing architectural models, animation and for creating leaf morphology plans and architectural model, building exteriors from photographs and sketches. Through prototyping, the schematic plans are refined into a detailed floor plan for each floor, at this stage wall classifications are pinned down and doors, windows and open walls are precisely specified. The individual components of the present design are: the prototype botanical garden structure site layout plan (Fig. 21); it was followed by (Fig. 22 – 23) the floor plan organization, ground floor (9825mm X19870mm), first and second floor (10800mm X 19870mm). The prototype botanical garden structure building section and schedule plan consist of the staircases, windows and doors (Fig. 24). The prototype botanical garden structure office building back and left elevation, right elevation and roof plan (Fig. 25 – 27). It also contains the parking lots and fountain, green house, tennis courts and recreation areas (Appendix 7 – 11). In practice, the layout design plans rely on a deep understanding of human comfort, needs, habits, and social relationship. Exterior trim (heat map), as well as distinctive windows and entrances used in the perspective drawings help in the customizing the building (Fig. 28).

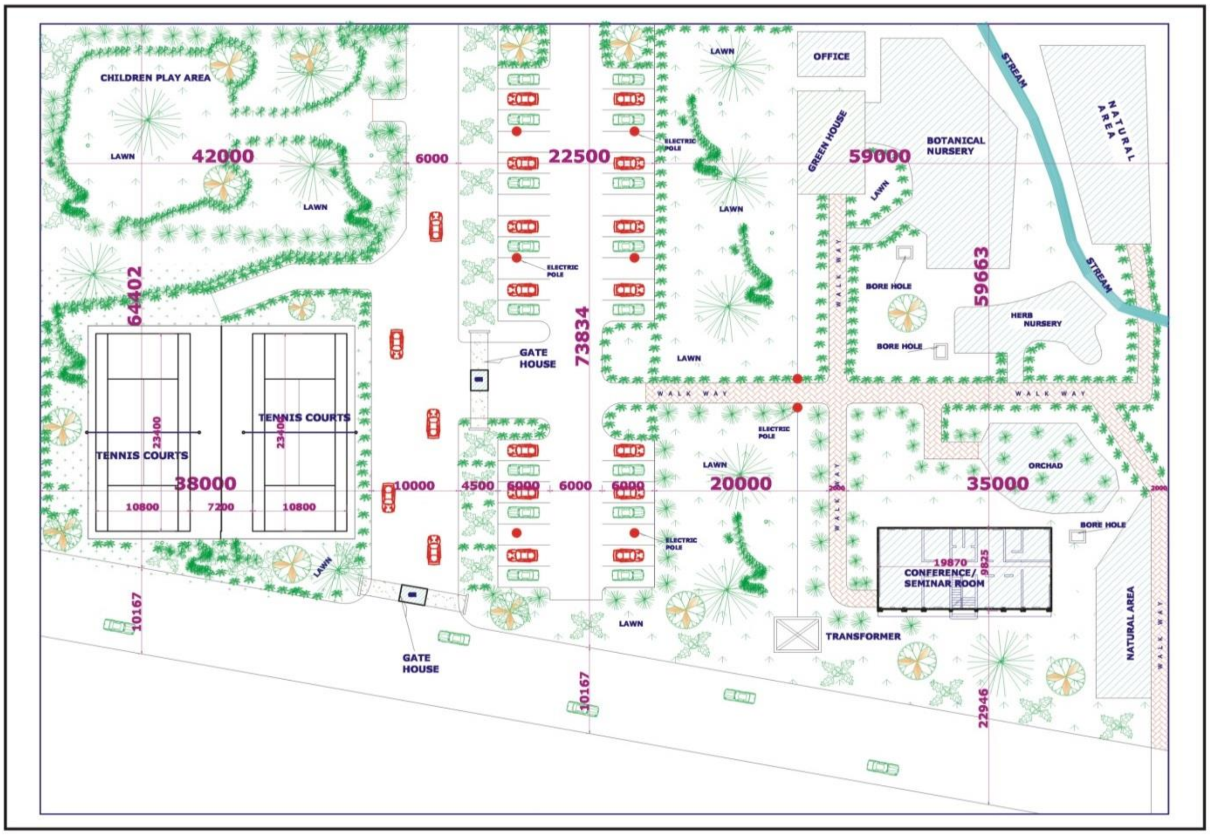


Fig. 21: Prototype Botanical Garden Structure Site Layout Plans

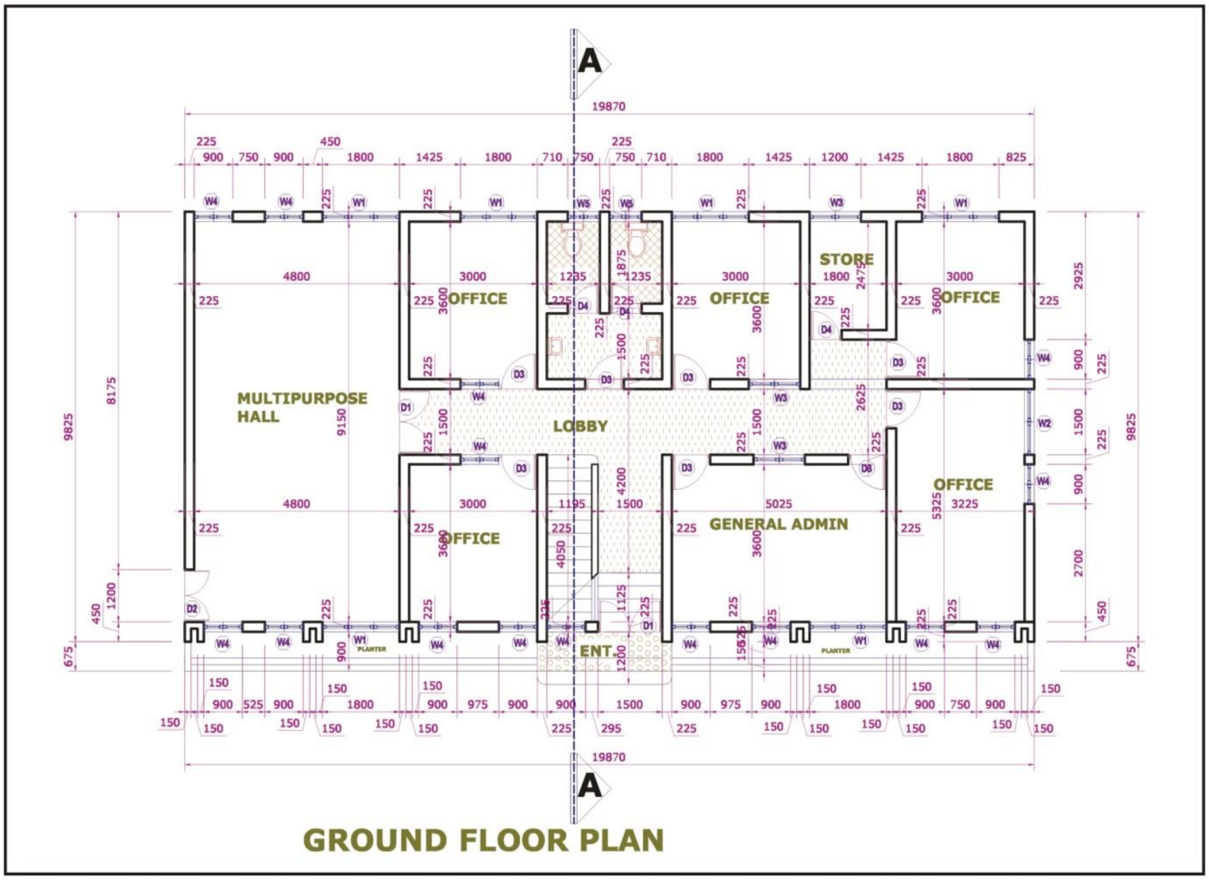


Fig. 22: Prototype Botanical Garden Structure Office Building Ground Floor Plans.

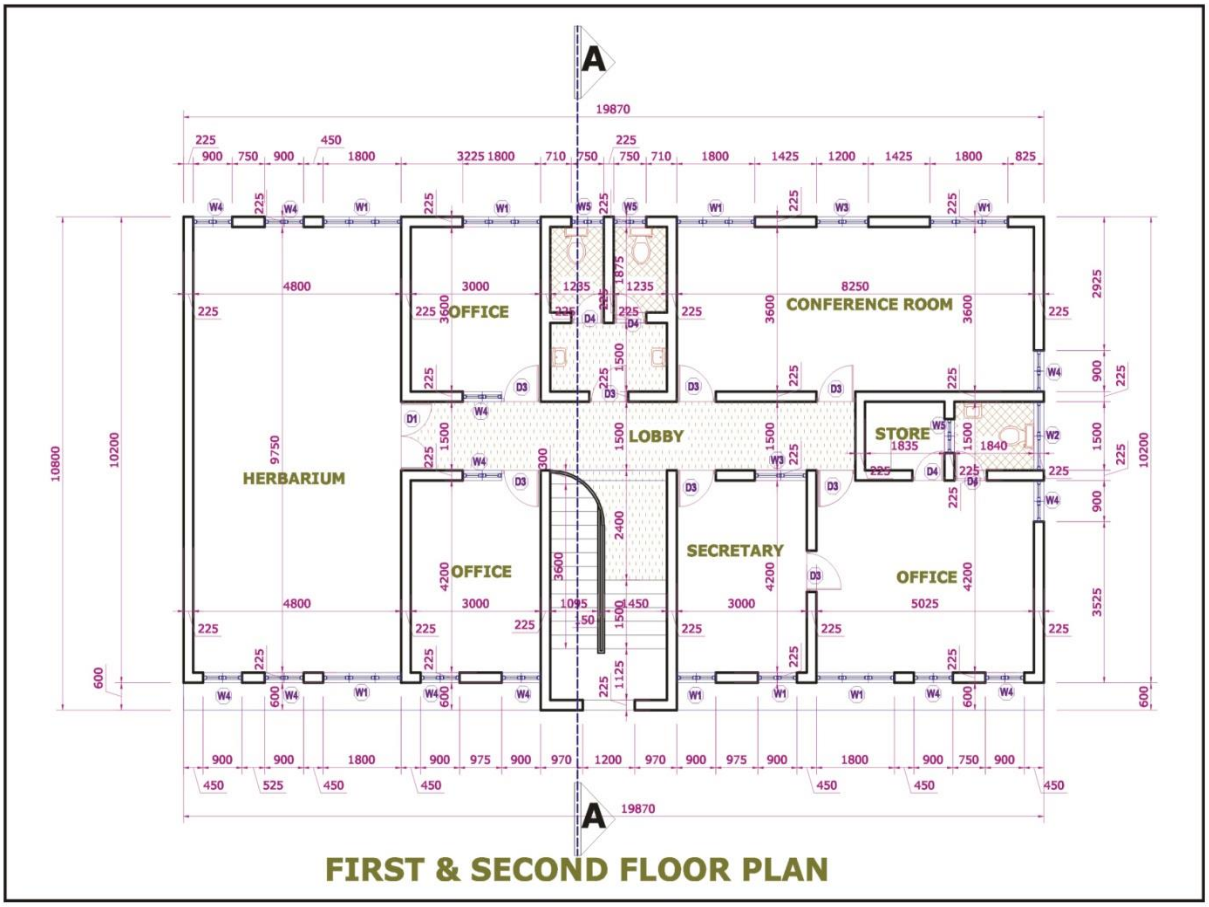


Fig. 23: Prototype Botanical Garden Structure Office Building First and Second Floor Plans

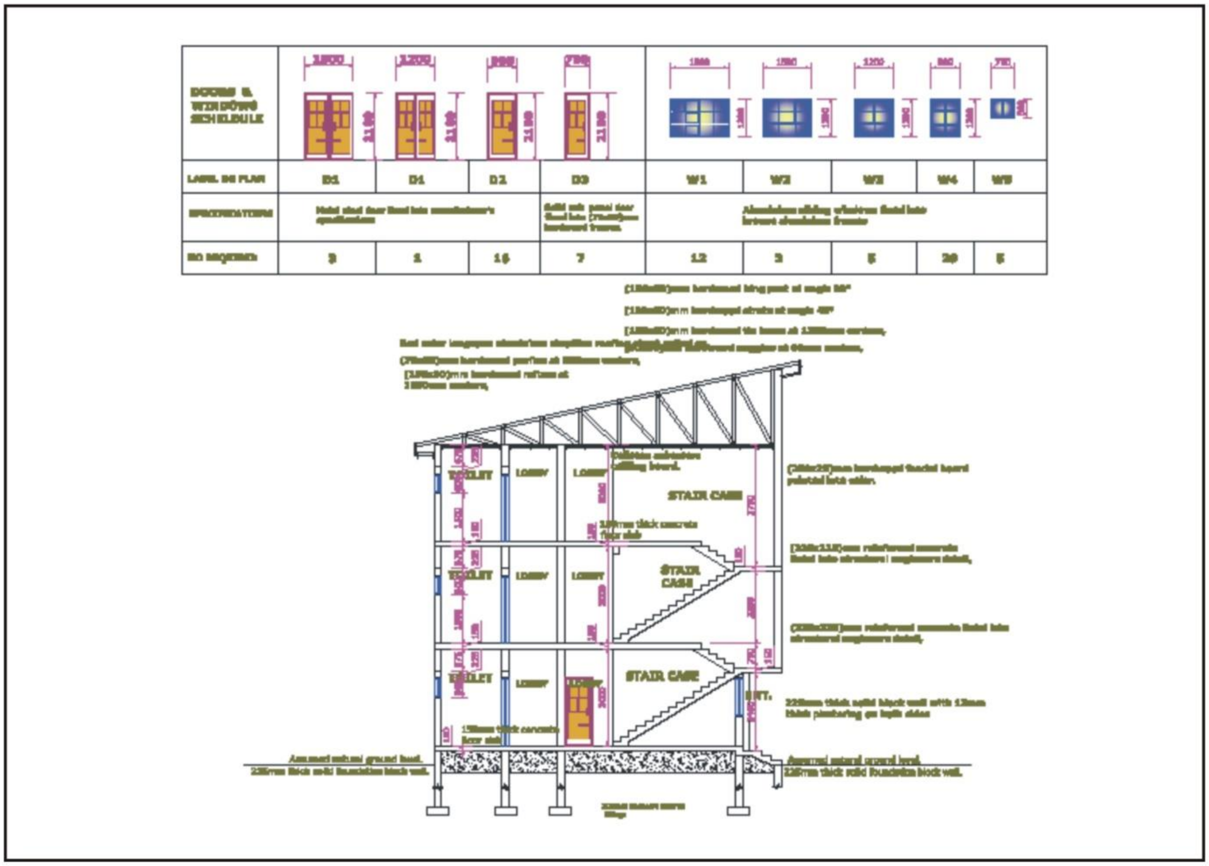


Fig. 24: Prototype Botanical Garden Structure Building Section and Schedule Plans.

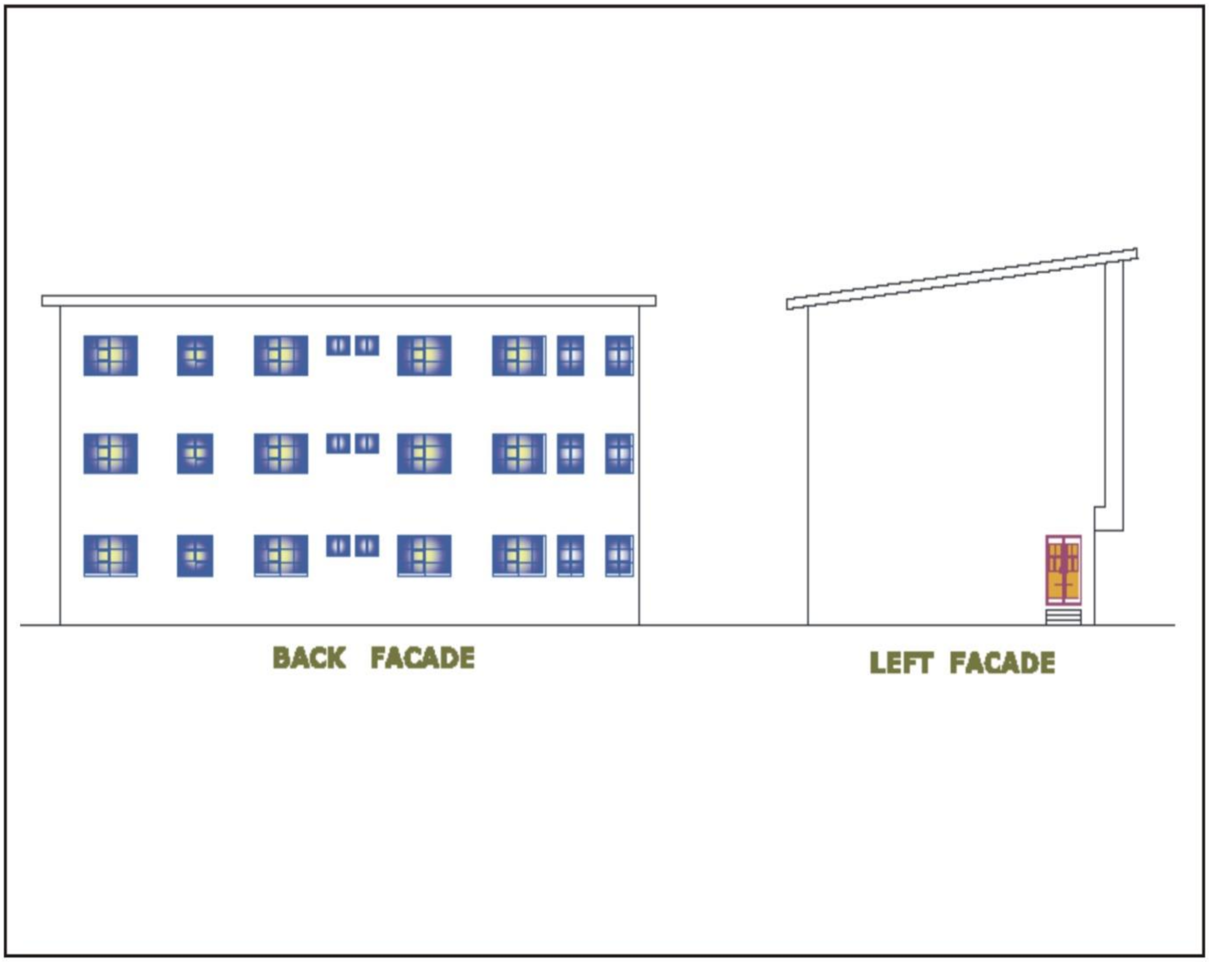


Fig. 25: Prototype Botanical Garden Structure Office Building Back and Left Elevations Plans.

Fig. 26: Prototype Botanical Garden Structure Office Building Front and Right Elevation Plans.

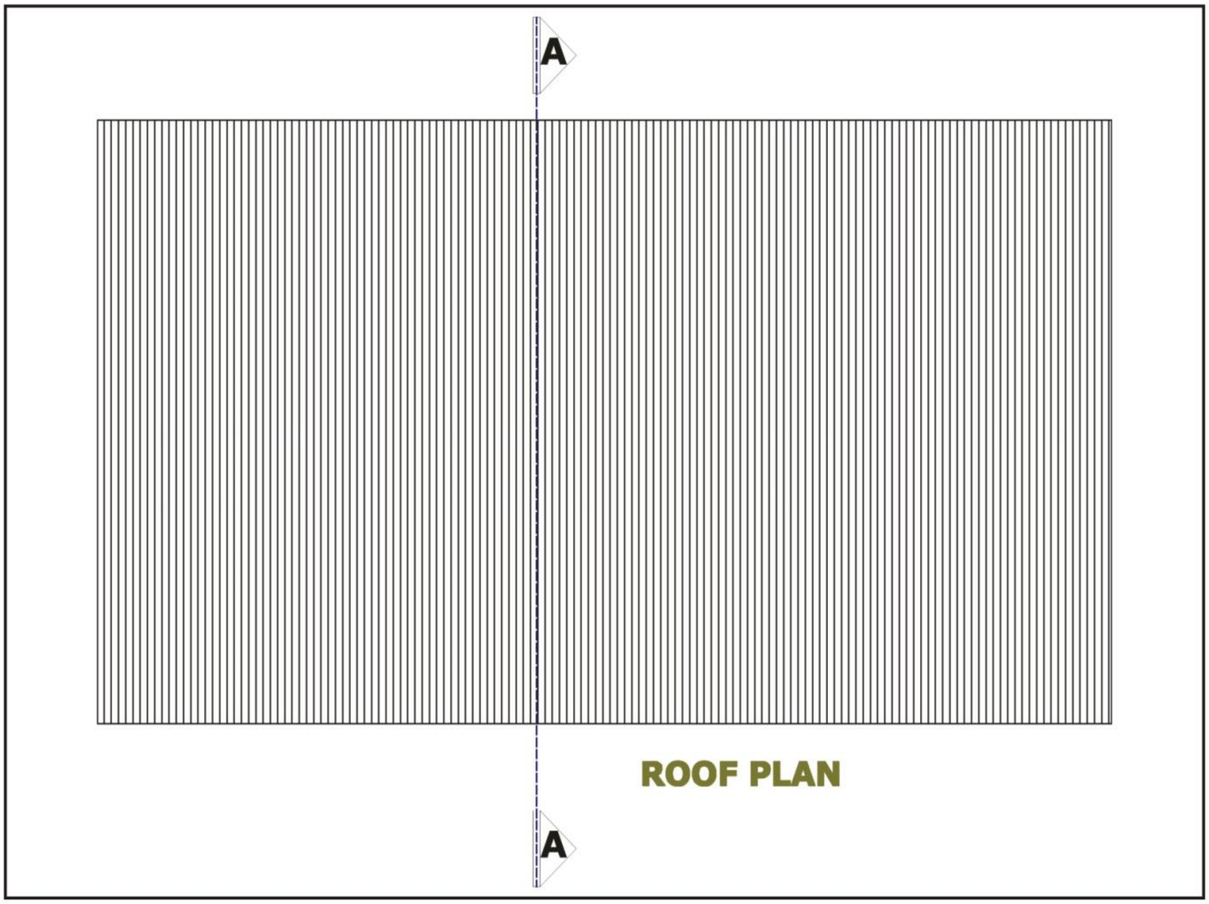


Fig. 27: Prototype Botanical Garden Structure Office Building Roof Plans.

Fig. 28: Front View Perspective of the Prototype Botanical Garden

4.6.1 Leaf Morphology Plan

Taxonomy relies significantly on morphology to differentiate groups; plant leaves are commonly used in taxonomic analysis and are particularly suitable to innovatory basedcoreldraw leaf morphology. In plant architecture and taxonomy, coreldraw leaf morphology plans and architectural model generated by shape grammer method in which the technique was developed for model and creating leaf shapes from photographs and sketches were shown in the results (Fig. 29 – 101). The application and implication of this red background computer pasting of leaves contributes to less scientific rigour in the description of the important aspect of morphology and plant architectural dimension of biodiversity which help in the artistic presentation of plant species to the client that may require using them for either aesthetic or functional purposes.


Fig. 29: ***Acacia macroptera***


Fig. 30: ***Acacia nilotica***


Fig. 31: ***Acacia gourmaensis***


Fig. 32: ***Acacia moniliformis***


Fig. 33: ***Adansonia digitata***


Fig. 34: ***Albizzia lebbeck***


Fig. 35: ***Albizzia zygia***


Fig. 36: Anacardium occidentale


Fig. 37: ***Annona muricata***


Fig. 38: ***Annona senegalensis***


Fig. 39: ***Auricaria heterophylla***


Fig. 40: ***Azadirachita indica***


Fig. 41: ***Balanites aegyptiaca***


Fig. 42: ***Bauhinia variegata***


Fig. 43: ***Blighia sapida***


Fig. 44: ***Bridelia ferruginea***


Fig. 45: ***Burkea africana***


Fig. 46: ***Cassia fistula***


Fig. 47: ***Casuarina equisetifolia***


Fig. 48: ***Chrysophyllum albidum***

Fig. 49: ***Citrus paradisi***

Fig. 50: ***Citrus reticulata***

Fig. 51: ***Citrus sinensis***

Fig. 52: ***Cynometra ananta***

Fig. 53: ***Daniellia oliveri***

Fig. 54: ***Delonix regia***

Fig. 55: ***Erythrina senegalensis***

Fig. 56: ***Erythrophleum ivorense***

Fig. 57: ***Eucalyptus citrodora***

Fig. 58: ***Eucalyptus cinerea***


Fig. 59: ***Ficus capensis***


Fig. 60: ***Ficus benjamina***


Fig. 61: ***Ficus trichopoda***


Fig. 62: ***Ficus sycomorus***


Fig. 63: ***Ficus elastica***


Fig. 64: ***Funtumia elastica***


Fig. 65: ***Gliricidia sepium***


Fig. 66: ***Gmelina arborea***


Fig. 67: ***Hildagardia barterii***


Fig. 68: ***Irvinga gabonesis***

Fig. 69: ***Khaya senegalensis***

Fig. 70: ***Leucena leucocephala***

Fig. 71: ***Lonchocarpus cyanescens***

Fig. 72: ***Lophira lanceolata***

Fig. 73: ***Milicia excels***

Fig. 74: ***Moringa oleifera***

Fig. 75: ***Parkia biglobossa***

Fig. 76: ***Petrophorium pterocapium***

Fig. 77: ***Plumeria rubra***

Fig. 78: ***Plumeria alba***

Fig. 79: ***Polyalthia longifolia***

Fig. 80: ***Prosopis africana***

Fig. 81: ***Psidium guajava***

Fig. 82: ***Snysepalum dulcificum***

Fig. 83: ***Tamarindus indica***

Fig. 84: ***Tectonia grandis***

Fig. 85: ***Terminalia superba***

Fig. 86: ***Thevetia neriifolia***

Fig. 87: ***Triplochiton scleroxylon***

Fig. 88: ***Vitellaria paradoxa***

Fig. 89: ***Vitex doniana***

Fig. 90: ***Ziziphus mauritiana***

Fig. 91: ***Ficus exasperata***

Fig. 92: ***Alstonia scholaris***

Fig. 93: ***Ficus diversifolia***

Fig. 94: ***Terminalia macropetra***

Fig. 95: ***Spondias mombin***

Fig. 96: ***Terminalia catappa***

Fig. 97: ***Mangifera indica***

Fig. 98: ***Treculia africana***

Fig. 99: ***Vernonia amygdalina***

Fig. 100: ***Tectonia grandis***

Fig. 101: Proposed Botanical Garden Model

CHAPTER 5

5.0 DISCUSSIONS

5.1 Frequency Analysis and Landscape Status of Plants species

Subsequently, during the conception of the world in the Garden of Eden, God declared everything was ‘very good’ (Gen. 1:31). However, it’s obvious nowadays that everything in the world is not ‘very good’. Notwithstanding, several optimism and ideas , over centuries, have tried to make our environment veracious, our world environment lingers toward disorder, uncertainty, viciousness, war, health challenges and pollution which this study centres round.

If the 20th century began with all kinds of optimism about the environment future benefit and what humans could do to develop the consequence of pollution in our future environment, the 21st century has certainly lost that optimism and with good intention too. Power plants, industrial manufacturing, vehicle dissipate and charcoal and firewood all release small particles into the air that are hazardous to human’s health.

Air pollution is the fourth premier risk factor for death worldwide and by far the foremost environmental risk factor for diseases (Brauer, 2016). Therefore, biological means of decreasing air pollution is an incredibly efficient way to increase the air quality. A conception of ecosystem service is essential to an understanding of botanical garden structure, planning and design as a green infrastructure in our communities and is applicable at scope of thinking globally but act locally. Taxonomic characters of the plant species were measured for conservation purposes in the botanical gardens. A total of 180species belonging to 25 families was represented in the study area. The family Moraceae has the highest numbers of trees species (19 species) representing (10.56%) of the total species encountered in all the botanical gardens followed by Mimosaceae which consist of (17 species) representing (9.44%). While Irvingiaceae, Lamiaceae, Rhamnaceae, Zygophyllaceae, Moringaceae and Araucariaceae have low number of trees species of (1 species) respectively representing (0.56%). This result reveals high rate of degradation on the plants species, as a result of unselective felling of trees species and reclamation of mangrove forest for improvement of several infrastructure facilities particularly in Lagos biological garden in order to satisfy the development of campus building infrastructures. Hence, these botanical gardens now require high conservation of biodiversity of trees species in terms of ex-situ for ecosystem sustainability. Conversely, it was very evident that in-situ conservation is no longer effective to conserve the trees species as a result of unselective felling and various forms of degradation processes exacerbated by population growth and also plants species were very important in montoring air pollution, mitigation of climate change and conservation of biodiversity. This was in support of the findings of AbdulRahaman *et al.* (2013); Nodza *et al.* (2014); AbdulRahaman and Oladele (2008).

Similar results have been described for the sensitivity of a diversity of lichen species to climate and used as a pointer to climate change (Sancho *et al*., 2007; Insarov and Schroeter, 2002), shade plants in combating environmental menaces (AbdulRahaman *et al*., 2013; AbdulRahaman and Oladele, 2008), frequency of lichens to deduce environmental quality (Oladele *et al*., 2013; Hawksworth, 2002; Hawksworth and Rose, 1970; Ferry *et al*., 1973), biodiversity index for biodiversity conservation and ecosystem stability (Simpson, 1949; Shannon and Weaver, 1948; Okalis, 2010), Air pollution tolerance index values help to classify sensitive species to be used for indicating and observing air pollutants and tolerant species to be used as sink or for reducing pollutant levels in the environment (Ogunkunle *et al*., 2015; Agbaire *et al*., 2015; Otuu *et al*., 2014; Gosh, 1992).

In the study, it was established that lichens are commonly found on the bark of trees species within the garden than the one outside garden, with high frequency value on the trees species within the garden. The results suggest that lichens on tree barks are possibly good entrants for monitoring atmospheric air pollution, since atmospheric pollution is expected to be higher outside the gardens due to heavy vehicular traffic, and other pollutant activity by the the people. Lichens are mostly studied bioindicators of air quality.

The significance of botanical garden structure, planning and design together with its effect on the society serves as an eye opener to the link between environmental plant well-being, human well-being, socio-cultural and economic prosperity which emerged frequently among our politicians in the national assembly main political discussions on how our people could live in a pollution free environment. The major advantage of biodiversity is the firmness and reliability of ecosystems in terms of controlling erosion and monitoring nutrient cycling, productivity, tropic dynamic and other aspects of ecosystem services and function. A stable botanical garden can tolerate some external stress, such as pollution, construction, or foxhunting without being completely disrupted or damaged. The result of the diversity indices in the range of (0.6 – 0.9) in a (0 -1) scale in each of the botanical garden studied shows a similar trend, which indicates that the different botanical gardens were intact, mature and stable and can be used to designate the taxonomic diversity and montoring of environmental pollution, hence their landscape status for trees species (180) of 25 families in all the selected botanical gardens out of which 16 families were recognized as abundant and 9 families were identified as rare, likewise 95 tree species were identified with moderate lichens and 85 species were identified with good lichens for montoring of environmental pollution. Botanical gardens must find a concession between the need for peace and seclusion, and satisfy the demand for “plant information system”, ecosystem services and visitor services including restaurants, information and communication centres and sales areas that bring with them pollution, rubbish, noise and hyperactivity. Observation also makes it possible from the taxonomic characters of the trees species that occurred within the line transects in the gardens. The results of the study serve as indices for selecting each of the trees species as either shade or shelter purposes, which could be of help to mitigate harsh weather condition and climate change. Accordingly, there is need to infer an effective means of conserving the species through ex-situ method, by upgrading the botanical garden in tropical rain forest, sudano-guinea savannah and montane vegetational zones through science entrepreneurship dexterity.

5.2 Taxonomic Description and Cluster Analysis of Plants species

The roles of botanical gardens which is also known as 'ecosystem service' and its effect on air quality such as exclusion of a number of air-borne pollutants, ozone, sulphurdioxide, nitrogen dioxide and particulate matter (Roy *et al*., 2012; Rowe, 2011; Nowak *et al.*, 2014) and natural functions of vegetation which can unswervingly and circuitously improve air quality and shade plants for mitigation of climate change have long been recognized (AbdulRahaman and Oladele, 2011; Nowak, 2000; Nowak, 1995). Some of the ecosystem services provided by the botanical gardens are grouped into socio-cultural, economic, and environmental benefit. In the last decade, extensive research has been commenced authenticating the "triple bottom line" (economic, environmental and social) benefits of green infrastructure (McPherson, 1995; Staley, 2004; McPherson, 2005; Nowak, 2000; Nowak and Dwyer, 2007; Macdonald and Supawanich, 2008; Clark and Matheney, 2009; Bankole, 2000; Kehinde, 2002).

Confirmation for this observation was found in this study with a significant effect of plants species according to cluster analysis in each of the botanical gardens. The results showed 2 taxonomic groupings of 110 species classification, the total outlier's plants species (41) and the total clusters plants species (69) in all the botanical gardens gave a percentage outliers of (37%) and a significantly increased percentage clusters of (63%) and tree crown characteristic indices ranged from 3 to 7 and 1 to 2.67 for shade and shelter respectively;. This technique does not combine the two most similar trees successively. Instead, those trees whose merger increases the overall within cluster variance to the smallest possible degree are combined. It gives cluster with equal distance of measurement and very sensitive to outliers. The cluster is of taxonomic significance in the shade and shelter characteristic of tree species while the outlier is very significant in the monitoring of environmental pollution. Other workers have also reported that trees provide soil improvement, shade and shelter (Muoghalu and Awokunle, 1994), also Swanwick (2000) has observed that highly valued green spaces enhance positive qualities of urban life, offer a range of opportunities and physical setting and encourage civility and cultural diversity.

Matrix plot (Heat map) is a graph that can be used to evaluate the relationship among several pairs of variables at the same time. It is a set of discrete scatter plots, with colour map and colour bar. It is important in Plant Architecture and Amenity Horticulture to assess the aesthetic value of the trees species taxonomic characters and as well as building architecture and other related interior decoration design for visual and aesthetic assessment. It was also reported by Marritz (2012) that the less easily assessable 'visual and aesthetic' benefits of trees are in fact the most powerful. The results showed a similar trend of significance in each of the botanical garden studied and explain better the biodiversity, conservation status, socio-cultural and science entrepreneurship benefit of botanical garden structure, planning and design to the society.

Application of dendrogram and heatmap generated from the cluster analysis also showed a significant effect of economic importance of botanical garden structure. It was also supported by Manes *et al.* (2012) that the economic benefits of the botanical garden structure, planning and design influence on ecosystem services and atmospheric air quality have long been recognized.

The grouping of the trees species in the various gardens studied into shade or shelter have been shown to be proportional to the ecosystem services provided by the gardens. However, earlier report showed that shading effects of different trees species vary according to their crown or canopy forms, branching configuration and leaf area index, a ratio of leaf area per unit of ground surface area (Tandy, 1981). This was also support by the results of the present study of cluster analysis generated from taxonomic variables (qualitative and quantitative). It was also known that shading by tree is more operational and effective than shading by non-natural material (Georgi and Dimitriou, 2010). Plants improve air circulations, provide a cooling, shading effect and help to lower air temperatures. Therefore, this study also propose a well designed prototype botanical garden structure which is significant and can boost the economic benefit of increase property value of the botanical garden, create improved opportunities for employment, research, tourism and economic regeneration with minimum pollution levels.

The number of ecosystem services and benefits provided by botanical garden in term of economic value can also be calculated by the summation of the value from ecosystem services (ESS), amenity horticultural values and landscaping attractiveness commercial precints, increases the value of the botanical garden and creates measure for eco – tourism and economic developmental advantages. For instance, the study is asking for creative ideas for a botanical garden model for plant – loving university communities in Nigeria which could conceivably become an entrepreneurial plant architectural Model for an innovative solution to most atmospheric air pollution related diseases in our communities.

5.3 Plants species as a Bioindicator of Environmental Air Pollution

In the experimental research reported here, the responses (sensitive, intermediate and tolerant) and APTI outcome of the selected trees species increased with tree positions regardless of the location of the botanical gardens, similar results have been reported for plants on the basis of their responses to pollutants under field and laboratory conditions which have been classified into sensitive and torerant species (Jacobson and Hill, 1970). These results therefore support the hypothesis by Guderian (1977) that the degree of sensitivity of plant depends on its developmental stage, nutritional status and other ecological factors so also the environmental benefit of botanical garden structure was confirmed in the experiment reported in frequency of lichens, diversity index, and air pollution tolerance index.

The effectiveness of trees species as bioindicator/biomonitors depends on proper selection based on their tolerance and sensitivity to atmospheric air pollution, which is usually evaluated by the air pollution tolerance index (APTI). Sensitive species are mostly useful as bio-indicators and tolerant species are mostly appropriate as phyto-remediating agents in polluted environments while the bio-indicators help in planning and design of pollution free gardens. However, some workers reported and concluded that APTI of some selected trees species that using the combination of biochemical parameters (APTI), biological and socioeconomic characteristic has proved feasible for recommending trees species for ecological purposes (Prajapati and Tripathi, 2008; Govindaraju *et al.*, 2012; Ogunkunle *et al.*, 2015).

Tolerance and sensitive levels to air pollution varies from tree species to species. Air pollution tolerance index (APTI) is a distinctive index because it integrates four different biochemical parameters: total chlorophyll, pH of the leaf extract, ascorbic acid and relative water content. Plants with high ascorbic acid content are generally sturdy and tolerant to air pollution while those with low ascorbic acid content are sensitive and non tolerant species. Chlorophyll content in plants is indicative of their photosynthetic acitivity, Water in plant is essential for the physiological activities in plant while the pH is an indicator of pollution since it disturbs the conversion of hexose sugar of ascorbic acid. The APTI value for trees species were gotten from the results of the study with *Mangifera indica* shows high rate of tolerance (29.46) in all the Botanical Gardens, while the low rate of APTI value of the trees species include the following: *Albizzia zygia* (6.91), *Triplochiton scleroxylon* (6.82), *Ficus bengamina* (5.91), *Ficus diversifolia* (7.33), *Vitellaria paradoxa* (7.44) and *Moringa oleifera* (7.86) are obtained and they are all sensitive species. The results of this experiment suggest, family of Apocynaceae, Moraceae, Araucariaceae and Mimosaceae as sensitive species and Anacardaceae, Meliaceae, Annonaceae and Mytaceae as tolerant species out of the 25 families, that thespecies with higher value of APTI results were grouped into tolerant trees species, while low rate species resulted into sensitive trees species.

5.4 Seasonal Ambient Atmospheric Air Quality

The data with the seasonal air quality at different botanical gardens are arranged in a matrix form and summarized in the modelling of dry season and rainy season data in various botanical gardens. The following variables are used as columns , concentrations of ozone (O_3), oxides of nitrogen (NOx), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Nitrogen oxide (NO), Carbon monoxide (CO), Particulates Matter (PM_{10}), Temperature (T), Wind speed (WS), Solar radiation (SR) and Relative humidity (RH). The periodic samplings are arranged in row, as their average values are taken hourly. The correlated loadings plot was used for data classification and visualization (interpretation) based on seasons and botanical gardens. PCA was employed as a method of extraction of the principal components. Three principal components were extracted from the plots, which accounted for percentage variance of about 92.79% PCA value of dry season pollution parameters inside universities botanical gardens, 95.49% PCA value of rainy season pollution parameters inside universities botanical gardens, 97.85% PCA value of dry season pollution parameters outside universities botanical gardens and 97.25% PCA value of rainy season pollution parameters outside universities botanical gardens. Likewise the percentage variance of about 93.53% PCA value of dry season metereological parameters inside universities botanical gardens, 93.86% PCA values of rainy season metereological parameters inside universities botanical gardens, 96.06% PCA value of dry season metereological parameters outside universities botanical gardens and 93.86% PCA value of metereological parameters outside universities botanical gardens. The same was used for the correlated loadings plot values, the consequence of the modelling results is that any reduction in the level of SO_2 will be accompanied by an increase in the level of ozone, the amount of ascorbic acid and stomatal complex density. This could be explained by the interconversion between NO_2 and O_3 as described by AbdulRaheem *et al.* (2009). The opposing trends of dependence of SO_2 and NOx on O3 could be due to the level of ascorbic acid, shade and shelter of tree crown, wind modification continual accumulation of SO_2 on one hand and interconversion of NO_2 into O_3 on the other hand (AbdulRaheem *et al.*, 2008; Abam and Unachukwu, 2009; AbdulRaheem and Adekola, 2013; AbdulRaheem *et al.*, 2006 AbdulRaheem *et al.*, 2012; Jimoh and Ndoke, 2000; AbdulRaheem *et al.*, 2006; Ramoni, 2016: USEPA, 2014). Studies shown that plants achieve resistance to pollutants either through decreasing stomatal pore size and stomatal density and aggregate circular resistance and pubescence or through stress tolerance that is by physiological influence of toxic pollutants entering into the plant body, also plants with high number of stomatal complex types like teractytic and anomcytic types open more often for transpiration as well as to allow influx of carbondioxide into the leaves for photosynthesis thus cleasing the atmosphere (Levitt, 1972; AbdulRahaman *et al.*, 2010; Saadu *et al.*, 2009). Consequently, these plants moisten the atmosphere with water vapour. Confirmation for this observation was found in this study with significant relationship between seasons and pollution parameters, seasons and metereological parameters in each of the botanical gardens located in tropical rainforest, sudano-guinea savannah and montane vegetation zones. Similarly, the air quality are classified into good (0 – 50), moderate (51 – 100), unhealthy for sensitive groups, unhealthy (101 -150), unhealthy (151 -200) very unhealthy (201 – 300) and hazardous (310 -500) based on the (USEPA, 2014) Air quality index rating in the range of (0 – 500). The seasonal air quality index inside selected universities botanical gardens during the dry and rainy determine the air quality circumstances listed above. The inside air quality index values during the dry season for the various universities botanical gardens were: Lagos (39.27%), Ibadan (37.73%), Akure (38.16%), Ilorin (37.95%), Kano (40.47%) and Jos (34.49%). While the inside air quality index values during the wet season for various universities botanical gardens were: Lagos (35.97%), Ibadan (34.87%), Akure (34.83%), Ilorin (35.89%), Kano (37.52%) and Jos (31.36%). However, seasonal air quality index outside universities botanical gardens during dry and rainy season gave the following dry season values for: Lagos (94.59%), Ibadan (92.85%), Akure (90.69%), Ilorin (88.30%), Kano (96.38%) and Jos (84.60%). While the outside air quality index values during the rainy season for various universities botanical gardens were: Lagos (82.32%), Ibadan (81.56%), Akure (81.02%), Ilorin (77.78%), Kano (84.82%) and Jos (74.38)Therefore, the overall air quality conditions of the gardens inside and outside resulted into ‘good’ and ‘moderate’ respectively according to the USEPA ratings.

The correlated loadings plot results of the monitored air pollutants and meterological parameters within the botanical gardens in the tropical rainforest: Lagos, Ibadan, and Akure. Montane and the sudano-guinea savannah region: Ilorin, Kano and Jos were given in the modelling structures. Comparing, the value of the correlated loadings plots of the air pollutants and meterological parameters during, the dry and rainy seasons inside the selected universities botanical gardens. The highest value gotten during the dry season was as a result of dry weather conditions of either positive or negative correlation value of wind, solar radiation and maximum temperature which ensued in each of the studied site. The rainy season correlated value was also high but not as high as that of the dry season, the reason was also based on the influence of the weather conditions resulted at that time of taken the air sample for analysis, and the results of the meterological parameters wind, solar radiation and maximum temperature showed both negative and positive correlation values in the studied site as a result of the botanical gardens characteristics which have a lot of plants species that help in the regulation of meterological parameters which as well bring about the reduction in the pollution level of the gardens according to the USEPA ambient air quality standard, and that shows another influence of botanical garden structure, planning and design on air quality.

Many variables studied such as plant location, occurrence of lichens, pollution levels, wind, seasons and temperature all modify the air pollution mitigation effect of the botanical garden structure. The diversity of trees species, vegetation density, plant height and plant leaf characteristics (qualitative and quantitative) all these are also believed to have contributed to the reduction in the pollution levels of the various botanical gardens studied, and that shows a strong indication of influence of botanical garden structure (BGS) on atmospheric air quality (AAQ). In the experiment reported in this study, the outcome of the correlated loadings plot of the air pollutants and meterological parameters during, the dry and rainy seasons at selected locations outside universities botanical gardens. The highest value gotten during the dry season was as a result of dry weather conditions of either positive or negative correlation value of wind, solar radiation and maximum temperature which occurred in each of the studied site. The rainy season correlated value was also high but not as high as that of the dry season; the reason was also based on the impact of the weather conditions resulted at that time of taking the air sample for analysis. The high value could also be due to the traffic blocking and joint of both the outgoing and incoming vehicles, also it could be as a result of the smokes coming out of the vehicles during the checking operations by the security officers. Similar results have been reported by (AbdulRaheem *et al*., 2008) for ozone, sulphur dioxide and nitrogen oxides in two Nigerian cities. The wind effect which may transfer pollutants away from point of high concentrations to another area and since the gate is an exit from the University, the surroundings may generate some pollution form either traffic or charcoal and firewood that can easily be transferred by the weather parameters such as wind. But because of the minimum presence of trees species the effect though high but not to the level of making it difficult to live and according to the USEPA ambient air quality standard, the rating falls to the category of 'Moderate' which shows that the surroundings are still very save to live in and this also supports the influence of botanical gardens structure on atmospheric air quality.

The significant difference $p \leq 0.05$ existed among the botanical garden structure, pollutants and air quality index from the correlation analysis. Therefore, support the environmental benefit of botanical garden structure findings in terms of pollution monitoring and reduction. Air pollution parameters are known to have many adverse effects, including those on human health, building facades and other exposed materials, vegetation, agricultural crops, animals, aquatic and terrestrial ecosystems, and the climate of the earth as a whole, Climate change mitigation especially through temperature reduction is also part of the benefit of Botanical Garden Structure and this is confirmed with the results of the meterological parameters analysis obtained. Effect of air pollution on receptors, animate and inanimate, depends on atmospheric conditions, hence significant results of meterological parameters. However, working with taxonomic characters of trees species in the various gardens studied concluded that scientific assessment is *sine qua non* to the determination of damage to the environment and the measurement of adequate, equitable restoration and compensation for environmental damage, hence positive influence of Botanical Garden Structure, Planning and Design on Ecosystem Services and Atmospheric Air quality.

5.5 Prototype Design of Botanical Garden Structure and Leaf Morphology Plan

Botanical garden structure prototype designed by computer-aided design ranged from layout plan, building 9825mm by 19870mm, planting and leaf morphology plans for tree species families of Apocynaceae, Moraceae, Araucariaceae and Mimosaceae as sensitive species and Anacardaceae, Meliaceae, Annonaceae and Mytaceae as tolerant species just to metion a few of them.The tactic to computer-generated building layout plan is motivated by a approach for building layout design commonly faced in real-life architectural practice.The significance of the results of the proposed prototype botanical garden structure is that the planning and design which are based on idealized (prototype) and does not take into account the numerous of site and client-specific factors that are measured by the architects. The layout design is la-di-da by the local climate, the views from the site and environmental concern. The client's personality, human security, requirements of the organization, accessibility and social values also play a vital role as well. This was in agreement with the observation of Alexander *et al.* (1977); Susanka (2001); Jacobson *et al*. (2005) that various guidelines have been suggested for the building layout design and a few are near-universal in practice. However, Hillier and Hanson (1989) had earlier reported that a central role in building layout is played by the role of individual spaces within the building and the well-designed relationships between spaces.

The site layout plan is a land planning for bigger scale advancement involving subdivision into several or many parcels, including analyses of soil and landscape, feasibility studies for economic, social, political, research, technical, conservation and ecological constraints. It involves working with plant architects and taxonomists on plant materials, architects on the building patterns/green buildings, engineers on the building structure/green engineering, horticulturists on the planting plans, landscape architects on the landscape design plans, graphic and industrial designers on garden furniture, signs, and lighting, planners on the overall land usage, environmental impact assessment and general circulation of the ecosystem services, economists on entreprenurship/economic feasibility, and sociologists on social feasibility.

The input to tool is a concise list of high-level requirements, such as the number of offices, conference rooms, multipurpose hall, herbarium, toilets, and approximate square footage. However, introduction of shape grammers to computer graphics and developed a system for interactive manipulation of architectural layouts and techiques were developed for creating building exteriors from photographs and sketches (Muller *et al*., 2007; Harada *et al.,* 1995; Chen *et al*., 2008). In this study these requirements are stretched into a full architectural design, comprising a list of offices, their adjacencies, and their desired sizes. The floor plan was used to construct the elevation, sections and roof plan model of the building, while the remaining square footage of land was developed to green house, recreational arena with proper organization of ornamental plants to bring out the aesthetic values of the prototype botanical garden design. Set of leaf morphology plans using shape grammers methodology are also generated from photographs in order to realize the architectural model for good marketing strategy as part of science entreprenurship, which make it different from the normal tradition of direct pasteing of the photographs. The over all implication of this is that most of the gardens visited need to be upgraded to modern garden, which can serve both the educational, research, conservational value and also the science entreprenurship aspect of a prototype botanical gardens structure well design would generate revenue with minimum pollution level.

Socio-cultural benefit, visual and aesthetic value, well-being value and recreational function of botanical garden structure were confirmed in this experiment and design. Similar results have been reported by Shukla and Chandel (2008); Ihenyen *et al*. (2009); Harada *et al.* (1995); Muller *et al*. (2007); Whiting *et al.* (2009), Lefebvre *et al.* (2010).The details of Botanical garden collection are normally held in sophisticated computer databases specifically designed for a purpose. However, AbdulRahaman *et al.* (2010) had earlier reported the computerized system for identification of some savannah trees species in Nigeria. The results of the present study also support his innovation. This greatly facilitates the production of information called 'Plant Information Science' that is of Information and communication Technology (ICT) compliance and the production of plant lists could be made available online, which can also be made available to scientists around the world without necessarily being to the place before getting the information required. It was noted from the study that the origin of botanical gardens for conservation, education and training with the plants properly named and classified set the general direction for research and design of the garden thereafter and this persists to the present day. The principal areas covered vary greatly from one garden to another, depending on the nature of the research, design, collection and the resources and facilities available for the study.

It has already been shown that botanical garden collections and the fruit of their research are important *ex situ* and *in situ* conservation resources (Ingram *et al*., 2008). Moreover, the architectural skills, horticultural skills, and scientific knowledge of those involved in the planning and design of botanical garden would be very useful in the reintroduction of plants to people of the world in an aesthetic and visual model, matrix plot forms where they have become rare or extinct, and also form a useful matrix plot patterns in building industry, also provision of recreational facilities with minimum pollution level to the natural habitats for tourism, human health and general wellbeing (air quality) that set a good environmental footprint of the 21st century. Human cultures co-evolve with their environment and the conservation of biological diversity can be important for cultural identity (Raj and Lal, 2013). The natural environment provides for many of the inspirational, psychological, aesthetic, spiritual, architectural and replenishment educational needs of people now and in future (Alamu and Agbeja, 2011; Ogunkunle and Oladele, 2004; Nodza *et al*., 2014). The aesthetic values of our natural ecosystems and landscapes contribute to the emotional and spiritual well-being of highly urbanized population. However, in the present study the design documentation cannot be overemphasized, yet it is not alwalys as complete as it could and should be. Most botanical gardens have green houses, building (herbarium, multipurpose hall, offices), and generator house. All these need to be well planned and designed by the team of Architects, Horticulturists and Plant scientists in order to have a botanical garden that is free of pollution. Similar pattern of this was followed in this work as presented in the prototype new garden design which is of design with minimum pollution level. This also supports the Influence of Botanical Garden Structure, Planning, and Design on Ecosystem Services and Atmospheric Air Quality as cleanliness is next to godliness. The cultural value of biological diversity conservation for present and future generations is an important reason for conserving it today. The conservation of biological diversity also has ethical values, which also confirmed the therapeutic power of plants and garden environment.

5.6 Ambiguous Beneficial Effect of Botanical Garden Structure

It has been observed that increase in green density from trees or other plants may increase air pollution which could be detrimental to health, particularly in polluted areas, also some trees emit biogenic volatile organic compounds (BVOC) which can increase levels of ground-level ozone when mixed with NO_2 in the presence of sunlight for example, deciduous trees emit great amounts of compound ‘isoprene’ and ‘monoterpenes’ during a hot day; coniferous trees emit the volatile organic compound ‘pinene’ day and light (Amorim *et al*., 2013; Roy *et al*., 2012; Escobedo and Nowak, 2009). Implication for this observation was found in this study with a significant moderate taxonomic characters effect on the trees (deciduous and conifers) and vegetational zones (forest, montane and savannah). However, other workers have reported that trees with moderate or low emission showed an unambiguously beneficial effect (Pugh *et al*., 2012). The results of this study also support the finding of another researcher, that the capability for forest to remove ground-level ozone is greater than the potential ozone production resulting from BVOC chemical interaction (Alonso *et al*., 2011; Nowak, 2000) hence the influence of botanical garden structure, planning and design on ecosystem services and atmospheric air quality despite the negative impacts that sometimes associated with green space density.

5.7 Conclusion

The foregoing discussion on the Influence of Botanical Garden Structure, Planning, and Design on Ecosystem Services and Atmospheric Air Quality in both the tropical rain forest, sudano-guinea savannah and motane vegetational zones of Nigeria studied under different locations, inside and outside universities botanical gardens during the dry and rainy seasons with the values of frequency analysis and multivariate analysis of both trees species and associated lichens and air quality parameters could be used as indicators to evaluate the economic, environmental and socio-cultural benefit of botanical garden structure.

Thus, certain taxonomic and morphological characters like qualitative characters, quantitative characters, including their frequency analysis of trees and associated lichens, shade and shelter characteristics, meteorological data collection and analysis, air samples collection and analysis, aesthetic characteristics, biodiversity index, air quality index, air pollution tolerance index, taxonomic analysis and modern garden design concept methods which represent most frequent cases found during the mapping measures of various universities botanical gardens were considered and found that botanical gardens are relevant and responsible for significant air – borne pollutants removal. The study concluded that, trees species families of Apocynaceae, Anacardiaceae, Meliaceae, Moraceae, Mimosaceae, Myrtaceae and Araucariaceae out of 25 families were good candidates for ecosystem services such as: lichens occurrence, shading, pollutant removal and atmospheric air quality improvement by botanical garden structure.

Plant Architecture and Amentity Horticulture serve as foundation on which the study was based, an original feature of Plant Architectural studies that they were initiated in tropical regions and were at first, concerned with the analysis of the aerial vegetative structure of tropical trees, from the definition, architectural concepts have provided great tools for studying plant form or even tropical forest structure, while Amenity Horticulture, involves in garden design, plant form and function combination to provide the vital nutrition and aesthetically pleasing environments for plant health, human health and wellbeing, climate change mitigation, conservation and biodiversity knowledge communication to the world.

Science entreprenurship also form part of the outcome of the study, in the sense that we cannot continue to separate science from business. Science is not just an academic exercise, it is also an avenue for creation of wealth, through science, and we can make use of natural resource such as botanical gardens to create wealth. Entreprenurship is an vital element for economic growth as it manifests its fundamental importance in different way: by identifying, evaluating and manipulating business opportunities; creating new ideas or renewing existing ones by making them more dynamic, example is find in most of the botanical gardens visited and also by driving the economy forward through research, technology, invention, proficiency, job creation and by generally improve the wellbeing of the society. Therefore, science entreprenurship management can be measured as being different to traditional ways of managing organizations. There is need for education of the individual; in other words, entrepreneurial action is regarded as a human feature, such as the readiness to face vagueness as a person coming from science background, accepting risks, the need for achievement in planning and design of a pollution free botanical gardens, which differentiates 'plant architects' with plant taxonomy and horticulture knowlegde from the rest of society. The motivational ideas accentuates economic, environmental factors that motivate and enable entrepreneurial activity, such as the dimension of markets for the creative ideas in production of computer-based planting plans and leaf morphology plans, the dynamic of technological changes for the structural upgrading of existing botanical garden Structure to a modern proposed well planned and designed botanical garden structure with minimum pollution level. The other area is the supporting environment of the institutions, culture and social and societal values.

Thus the accomplishment of science entreprenurship depends on the combined effort of interested individuals, the Plant Biology Department, University Management and National

Universities Commission. Nigeria need more Scientist Entreprenurs competence to solving problems, design and analytical thinking to overcome it economic, environmental and socio-cultural challenges than Scientist laboratory job seekers. This was strongly supported by one of the Bill Gates speech: Bill Gates said at a discussion with Lin-Manuel Miranda that he thinks future entrepreneurs should go into science. Specifically, Gates thinks people should mien at areas of the world where noteworthy Invention is going to be needed in the near future to help humankind deal with coming challenges. He said, if your talents could take you toward science or programming, advances in biology or energy breakthroughs, those kinds of profound areas are going to be the biggest source of change, he went further by saying the challenges that he considers most important include global diseases and the need to develop a new energy system for the planet which this study also supported.

Finally, regular conservation of ecosystem otherwise known as sustainability very essential, ecosystem relationships resembles a web of connections from one living to many other living and non-living things. Vegetation is integral to the upkeep of water and humidity levels and essential for the preservation of oxgen and carbondioxide balance of the atmosphere. The works also portray the vegetational zones of tropical rainforest, sudano-guinea savannah and montane vegetation regions with universities botanical gardens studied as a good determination of aesthetic and functional ecosystem services value to the society. On the whole, the data revealed a good level of air quality index inside the universities botanical gardens and also a moderate level of air quality index outside the universities botanical gardens during dry and rainy season which is also in line with the recommended permissible limit (USEPA, 2014).

The study went further to highlight the various roles of botanical gardens as an crucial need for even more aggressive plans to reduce air pollution from Power Plants, Industrial

Manufacturing, Vehicle exhaust and burning of charcoal and wood. In Nigeria, major contributor to poor atmospheric air quality is the practice of burning wood for charcoal as a source of biomass for cooking and heating and also the vehicle exhaust in our urban areas. Millions of families, among the people in Nigeria that are living in urban centres, are regularly exposed to air pollution. Therefore, bioremediation strategies of creating a well design building plan surrounded with beautiful flowers, indeginous and exotic trees would go a long way to reduce some diseases resulted from air pollution, such as brain fatigue, cortisol, heart disease and cancer.

5.8 Recommendation

Botanical garden structure, planning and design shows a significant influence on ecosystem services and atmospheric air quality; therefore, it is recommended for the provision of ecosystem services to the people of the society at large. Also, in my own opinion there should be a research and training organization called Nigerian Institute of Plant Architecture and Amenity Horticulture (NIPAAH) in Nigeria that will develop Plant Architectural and Taxonomic guidelines that are based on the best scientific evidence currently available concerning the Botanical Garden structure, as a Green Infrastructure to the plant form and function combining to provide the essential nutrition and aesthetically pleasing environment so important for plant health, human health and general wellbeing of the society.

Government at all levels Federal, State and Local should, as a matter of strategic plan, pay a special consideration to the environmental safety and protection. The relevant agencies of government including National Environmental Standards and Regulations Enforcement Agency (NESREA) should be mandated to participate in regular monitoring of the pollution level of the environment. While upgrading of the existing Botanical Gardens to world class standard and creation of new ones in each of the state capitals in Nigeria by the government would be of the following benefit: national identity, conservation of plants species for healthy biodiversity, decrease of pollution levels, climate change mitigation, tourism and recreational value that can serve as means of internally generated revenue.

Planning, design, building and maintenance of botanical garden require dynamic thinking and creativity. To achieve the many potential value of the garden, in my own opinion require the knowlegede of Plant Architecture, Building Architecture, Horticulture and Plant Taxonomy. Therefore, the Government, Industry, University, National Universities Commission (NUC) and the Department of Plant Biology should work together in formulating a robust and capacity building Policy for Planning, Design, Establishment, Development and Maintenance of Botanical Garden as an essential element of Science Entrepreurship Studies.

Also, student of Plant Architecture and Taxonomy should be well grounded in the domestic, constitutional and international defense of right to development, contemporary legal and policy retorts to issues such as climate change, global warming, preservation of both forest and savannah regions, hazardous waste management and biodiversity awareness to the world. This would be of positive relationship effect in the rightful restructuring of Parks and Gardens as a research and technical unit in University with mandate in the campus environmental management.

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APPENDICES

Appendix 1: Existing University of Lagos Biological Garden Structure.

Appendix 2: Existing University of Ibadan Botanical Garden Structure.

Appendix 3: Existing Federal University of Technology Botanical Garden Structure, Akure.

Appendix 4: Existing University of Ilorin Botanical Garden Structure.

Appendix 5: Existing Bayero University Botanical Garden Structure, Kano.

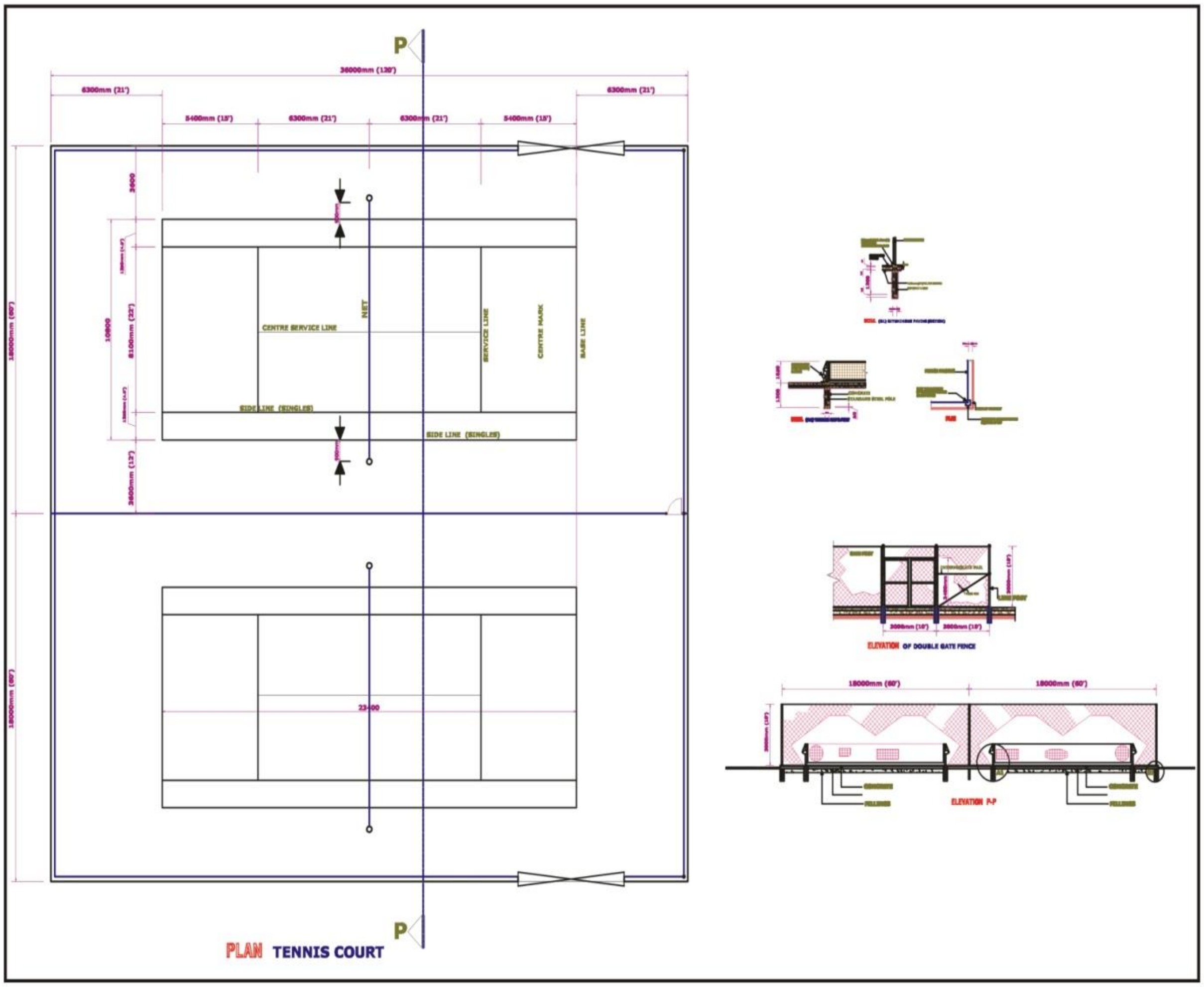
Appendix 6: Existing University of Jos Botanical Garden Structure.

Appendix 7: Perspective of the Parking Lots and Fountain of the Prototype Botanical Garden.

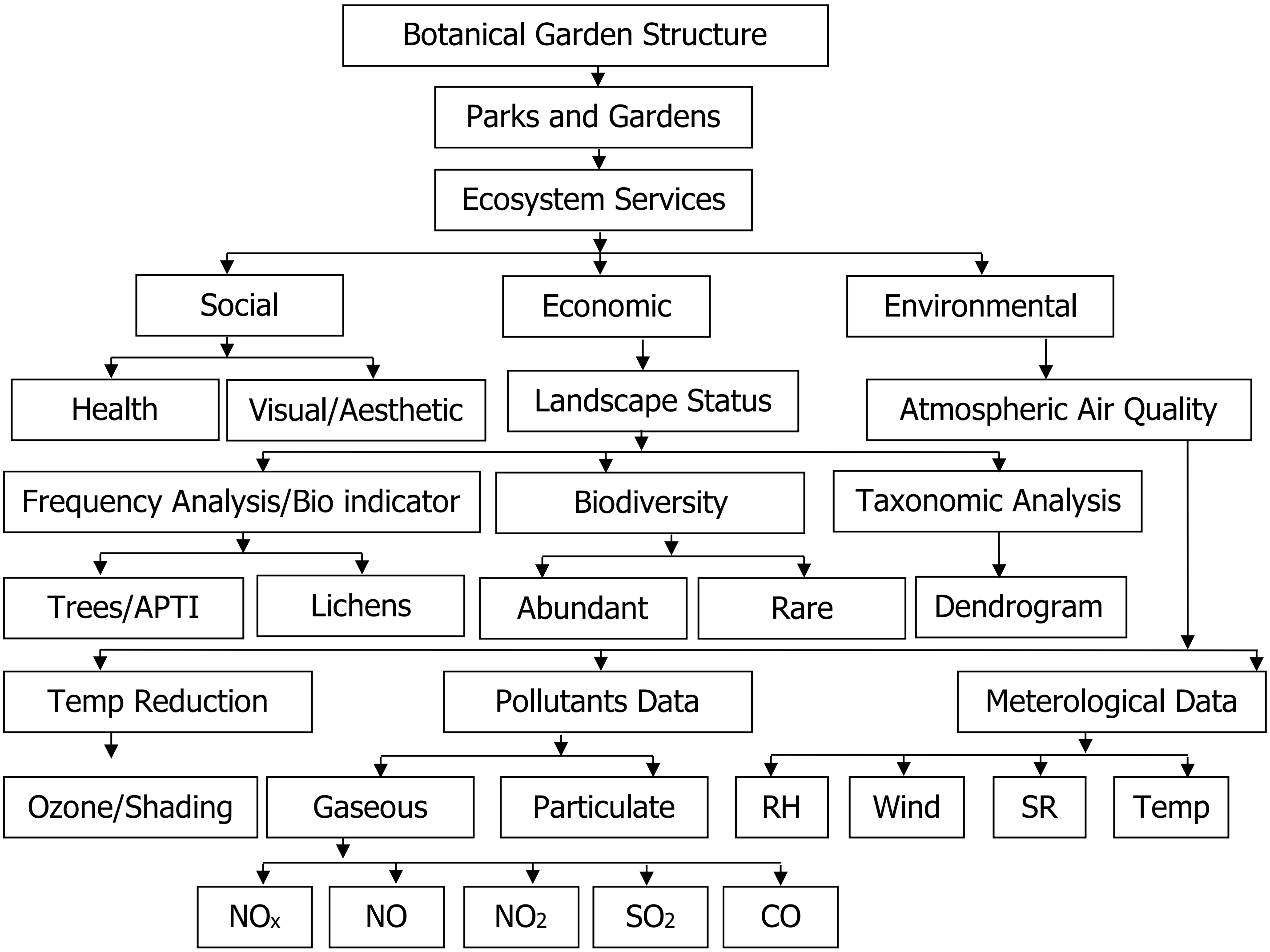
Appendix 8: Perspective of the Parking Lots of Prototype Botanical Garden Structure.

Appendix 9: Perspective showing the Green House, Parking Lots and the Tennis Court.

Appendix 10: Perspective of the Recreational Area of the Prototype Botanical Garden



Appendix 11: Prototype Botanical Garden Section and Elevation of Tennis Court Plan.



Appendix 12: Summary of the Influence of Botanical Garden Structure, Planning and Design on Ecosystem Services and Atmospheric Air Quality