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ECOLOGICAL VARIABLES AND ECOSYSTEM SERVICES: COMPARATIVE EFFECTS OF AIR QUALITY ON UNIVERSITY OF IBADAN BOTANICAL GARDEN, NIGERIA

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ABSTRACT

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Pollution from smoke, dust and other aerial pollutants pose serious challenges to atmospheric air quality, plant, animal and human health. The study investigated the influence of selected botanical garden and associated ecological variables on ecosystem services and atmospheric air quality. The study determined the level of ambient air quality indices within and outside boundaries of the University of Ibadan Botanical Garden (UIBG) using standard methods and equipment during dry and rainy seasons. Data obtained values were used to determine air quality index with correlation analysis conducted. The study revealed that air quality index ranged from of 37.73 (dry season) to 34.87 (rainy season) within; and 92.85 (dry season) to 81.56 (rainy season) and outside the garden, respectively. Significant differences $p \leq 0.05$ existed among the pollutants and air quality index. Influence of air pollution on plants, animate and inanimate components of UIBG depends on atmospheric air conditions. The Botanical garden is recommended for proper maintenance for provision of ecosystem services and good air quality to the University community.

Keywords: Air quality index, Ecosystem services, Green space, Air pollutants, Botanical gardens

INTRODUCTION

Botanic Gardens Conservation International – BGCI (2010) defines a botanic garden as an institution holding standard collections of living plants for the purposes of scientific research, conservation, display and education. John Brookers (1969) in his book title "Rooms Outside" painted the picture of early men garden when man first attempt not to be nomads 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.

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. The concept of ecosystem service is vital to an understanding of Botanical Gardens 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).

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.

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, 2016). 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, 2016).

Figure 1: Standard LaMotte Air Sampling Kit and Complement Reagents

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. 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 Botanical Garden on ecosystem services and atmospheric air quality set the general direction for research thereafter. Against this backdrop, the study is therefore set to determine the level of ambient air quality indices inside and outside the university of Ibadan Botanical Garden.

MATERIALS AND METHODS

Description of Experiment Location

The experiments were conducted in University of Ibadan Botanical Garden of Nigeria. The climate of the area is designated as sub-humid with mean annual rainfall between 1200-1800 mm and two distinct seasons which are the dry season occurs between December and February and rainy season occurs between March and November. The concentrations of the pollutants were monitored within and 200 m away from the gardens during both dry and rainy season with time replications between 6:30 am – 6:30 pm for 12 months. 8samples were collected at site per week for the trace gases monitored on a short-term basis for the purpose of trend investigation.

Collection of Meteorological Data and Analysis

Four measurements of meteorological data were taken at three hours intervals between 6:30am and 6:30 pm within and 200 m outside the Botanical Garden. The following factors were measured and analyzed: Relative Humidity, Temperature, Wind speed and Solar radiation.

Determination of Pollutant levels within and outside the Botanical Garden

The pollutants levels within and outside the Botanical Gardens were determine using the method of AbdulRaheem *et al.,* (2009). 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. 1). The concentrations of pollutant gases (Carbon-monoxide , Oxides of nitrogen (NOx), Nitrogen oxide (NO), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Ozone (O_3) and Particulates (PM_{10})) were determined.

Air Quality Index (AQI) was calculated from the observed pollutants using this formula.

$$AQI = \frac{1}{4} X \frac{summation\ of\ observed\ pollutants}{standard\ ambient\ air\ quality} X100$$

(Rao *et al*., 2003)

The air quality index (AQI) results obtained were correlated with the use of standard air quality index value (Table 1). The ambient air pollutants were classified into categories ranging from good to hazardous, each with different colour code for easy identification. The regulatory framework 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 1). A vacuum 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 air 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 was 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.

Table 1: Air Quality Index Value categorisastion

Air Quality (AQI) Values when the AQI is on this range	Levels of Health Concern Air Quality Conditions are:	Colour 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

Statistical Analysis

The data obtained were subjected to modelling and correlational analysis using

Paleontological Statistical Software Application Packages 3.14 (Hammer and Harper, 2006). Mean values were used to perform air quality index.

RESULTS

Air Quality Index Inside - Outside the University of Ibadan Botanical Garden

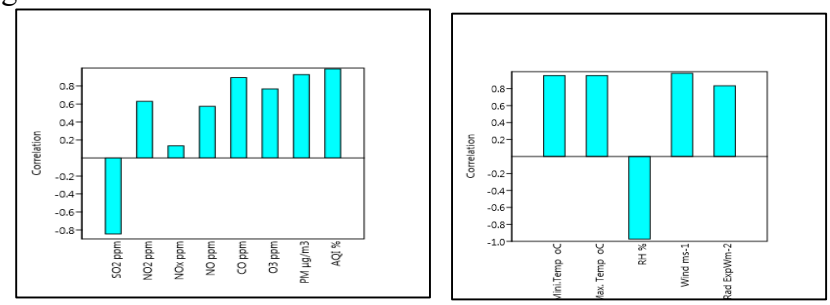
In terms of seasonal air quality index, the results of the AQI for dry season 37.73 (Table 2) which was below the permissible limit of USEPA ambient air quality standard i.e. levels of health concern (Table 1). The same trend was also recorded as 34.87 (Table 2) for the rainy season which was also below the permissible limit of USEPA ambient air quality. Outside the Botanical Garden, the results of the air quality index for dry season 92.85 (Table 2) which was not too high above the permissible limit of USEPA ambient air quality standard i.e. levels of health concern (Table 1). The same similar trend was also recorded as 81.56 (Table 2) for the rainy season which was also not high above the permissible limit of USEPA ambient air quality.

Table 2: Seasonal Air Quality Index Inside - Outside University of Ibadan Botanical Garden

Botanical Garden	Air Quality Index	Air Quality Condition
Inside Garden		
Dry Season	37.73	Good
Rainy Season	34.87	Good
Outside Garden		
Dry Season	92.85	Moderate
Rainy Season	81.56	Moderate

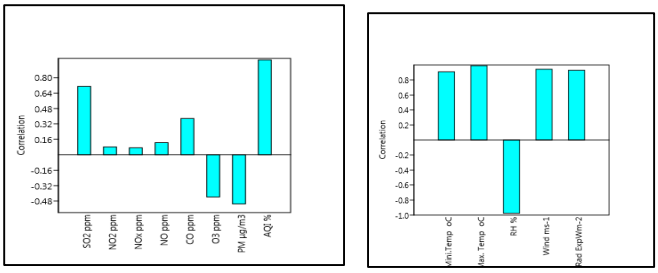
Modelling of Dry Season Data Inside and outsidede University of Ibadan Botanical Garden

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' (Figure 2). 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' (Figure 3).



Pollution Parameters Meteorological Parameters

Figure 2: Correlated Loadings Plot showing Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters inside University of Ibadan Botanical Garden

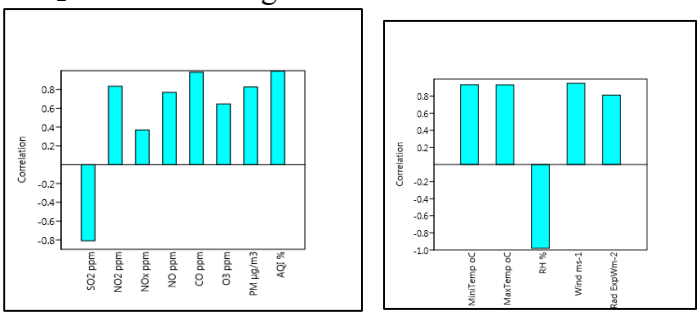


Pollution Parameters Meteorological Parameters

Figure 3: Correlated Loadings Plot Showing Correlation Values of Dry Season Pollution Parameters and Meteorological Parameters outside University of Ibadan Botanical Garden

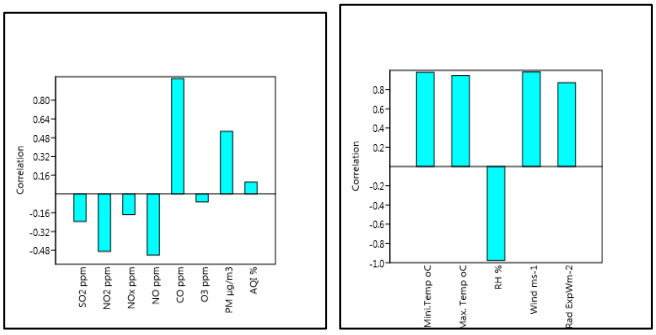
Modelling of Rainy Season Data Inside and outside the University of Ibadan Botanical Garden

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' (Figure 4). 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' (Figure 5).



Pollution Parameters Meteorological Parameters

Figure 4: Correlated Loadings Plot Showing Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters inside University of Ibadan Botanical Garden.



Pollution Parameters Meteorological Parameters

Figure 5: Correlated Loadings Plot Showing Correlation Values of Rainy Season Pollution Parameters and Meteorological Parameters outside University of Ibadan Botanical Garden.

DISCUSSION

Many variables such as plant location, pollution levels, wind, season, temperature, and precipitation can all modify the air-pollution mitigating effects of green space. 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). As mentioned above, there is debate over whether 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 (Roy *et al*., 2012).

The air quality was classified into good (0 – 50), moderate (51 – 100), unhealthy for sensitive groups (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 the Botanical Garden during the dry and rainy season determine the air quality circumstances listed above. The inside air quality index value during the dry season was (37.73%). While the inside air quality index value during the rainy season was (34.87%) for the University of Ibadan Botanical Garden. However, seasonal air quality index outside Botanical Gardens during dry and rainy season gave the following dry season (92.85%) and rainy season value (81.56%). Therefore, the overall air quality conditions of the gardens inside and outside resulted into 'good' and 'moderate' respectively according to the USEPA ratings which was in support of the findings of Baro *et al.,* (2014) that *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. Ozone deposition rates may be higher in spring than in summer, showing that drought stress may lower the sink activity for O_3 pollution (Zupancic, 2015).

The significant difference $p \leq 0.05$ existed within and outside the Botanical Garden, pollutants, and air quality index from the correlation analysis. The highest value gotten during the dry season was because of dry weather conditions of either positive or negative correlation value of wind, solar radiation and maximum temperature which occurred in 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 because of the smokes coming out of the vehicles during the checking operations by the security officers which was also in support of similar report by (AbdulRaheem *et al*., 2009) for ozone, Sulphur dioxide and Nitrogen Oxides in two Nigerian cities. But because of the 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 on atmospheric air quality.

CONCLUSION

The study revealed that the impact of air pollution on ecological receeptors (plants, animate and inanimate entities) in the University off Ibadan Botanical Garden depends on atmospheric air conditions. Thus careful manipulations of such as plant type

and their location; and other variables. lke wind, season, temperature, and precipitation can help mitigate air-pollution effects.

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