

Evaluation of Hazardous Status of Avenue Trees in University of Port Harcourt

F. S. Eguakun, T. C. Nkwor

Abstract—Trees in the university environment are uniquely positioned; however, they can also present a millstone to the infrastructure and humans they coexist with. The numerous benefits of trees can be negated due to poor tree health and anthropogenic activities and as such can become hazardous. The study aims at evaluating the hazardous status of avenue trees in University of Port Harcourt. Data were collected from all the avenue trees within the selected major roads in the University. Tree growth variables were measured and health condition of the avenue trees were assessed as an indicator of some structural defects. The hazard status of the avenue trees was determined. Several tree species were used as avenue trees in the University however, *Azadirachta indica* (81%) was found to be most abundant. The result shows that only 0.3% avenue tree species was found to pose severe hazard in Abuja part of the University. Most avenue trees (55.2%) were rated as medium hazard status. Due to the danger and risk associated with hazardous trees, the study recommends that good and effective management strategies be implemented so as to prevent future damages from trees with small or medium hazard status.

Keywords—Avenue tree, hazard status, inventory, urban.

I. INTRODUCTION

THE University environment is an example of a typical urban environment in which the presence of trees is essential to the comfort living of the people. Trees growing and managed along street right-of-way are called avenue trees. Although avenue trees account for a relatively small fraction of the entire urban forest, they are usually prominent because of their impact on the urban lives. According to [15], these trees are termed the unsung heroes of the environment. Although positioning of trees in University environment is done uniquely, they can also present a millstone to the infrastructure and humans they coexist with.

The benefits of trees in the campus environment cannot be over emphasized. Unfortunately all of these benefits can be limited or negated completely by poor tree health due to neglect, ignorance, and direct human impacts. Trees present some level of risk to nearby people, structures, and utilities. Typically, this risk is very small compared to the environmental, social, and economic benefits offered by the tree in question [8]. According to [16], a hazardous tree is a tree that has a physical deficiency that may result to the tree or

a portion of the tree falling on someone or something else of value, causing property damage, personal injury or fatality in the event of a failure.

Trees can become hazardous over time and become a significant risk to personal safety and property. Hazardous trees are used in the context of evaluating trees for their failure potential, and their immediate risk. Evaluation of hazardous trees or tree risk involves the process of inspecting and assessing trees for their potential of fall thereby posing threat, injury to lives and properties. Carrying out urban forests inventory could provide a basis for effective monitoring and management of the urban trees. Reference [12] stated that evaluation of our street trees to determine what is out there will ensure timely tracking of urban tree's health condition. Without the basic resource information obtained from tree inventory, development of a good management plan that will steer decision making will be impaired. Knowledge of the hazardous status of trees may also lead to improved application of silvicultural maintenance practices such as pruning that will increase the useful life span of the trees. This will in turn reduce the needless expenses associated with tree maintenance as a result of the effect of hazard including removal of trees.

II. MATERIALS AND METHODS

A. Study Area

This study was carried out at the three campuses; Abuja campus, Delta campus and Choba Campus, of the University of Port Harcourt, Obio-Akpor Local Government Area of Rivers state, Nigeria. The University of Port Harcourt is located on latitude 4° 53' 14"N through 4° 54' 42"N and longitude 6° 54' 00" E through 6° 55' 50" E. The three campuses are separated by road networks however; Abuja and Delta campuses are closer to each other than the Choba campus which is just after the East-West Road. The three campuses and their landmarks are shown in Fig. 1.

B. Sampling Technique

Reconnaissance survey was carried out in order to identify the major roads within the University. Purposive sampling technique was used to select three major roads for the study based on the presence of avenue trees. Within the roads complete enumeration of the avenue trees was done.

C. Data Collection

Data were collected from all the avenue trees within the selected roads in the study area. Data collection was a combination of data from tree health and hazard status of all

F. S. Eguakun is with the Department of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt, Nigeria (corresponding author, phone: +2348038624661; e-mail: funmilayo.popoola@uniportharcourt.edu.ng).

T.C. Nkwor is with the Department of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt, Nigeria (e-mail: author@lamar.colostate.edu).

trees.

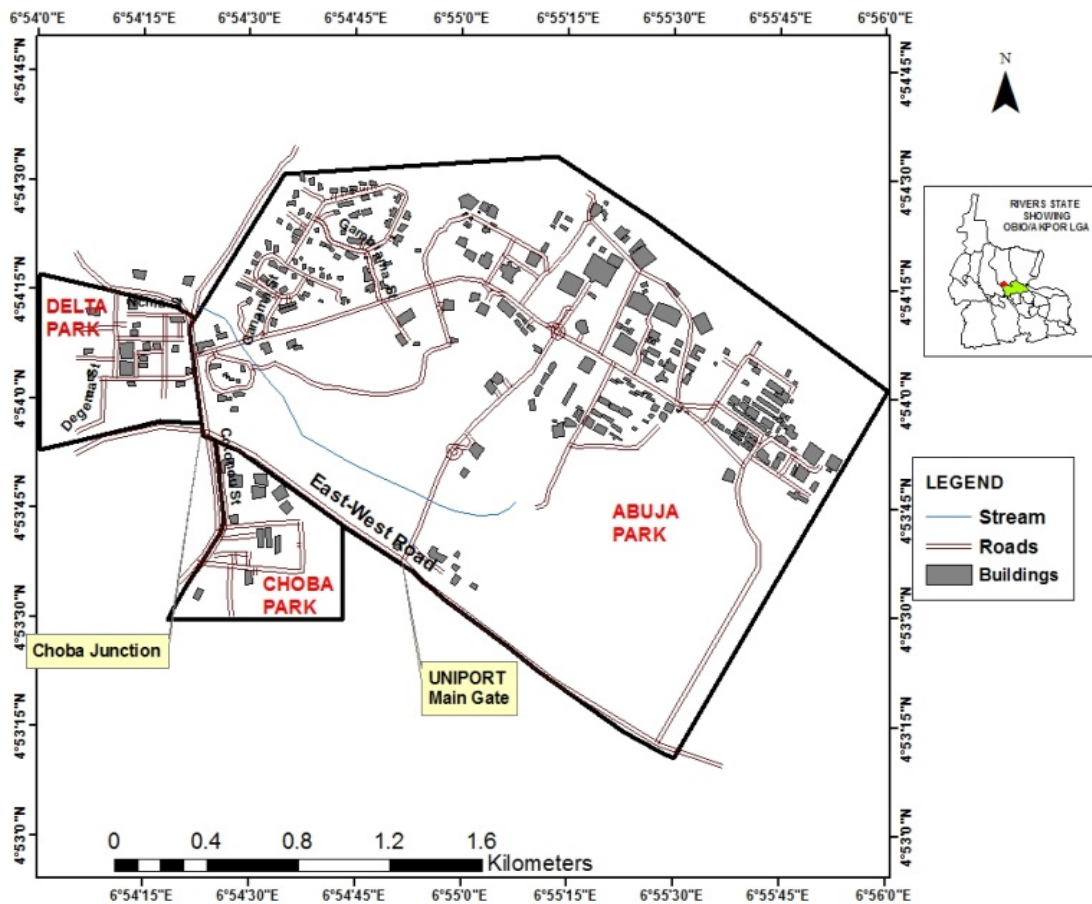


Fig. 1 Map of University of Port Harcourt

D. Health Condition

Health condition of avenue trees was assessed since it can be an indicator of some structural defect. The following variables were observed:

1. Foliage density
2. Vigor
3. Wound wood development
4. Defect

E. Hazard Status

Data on the hazard status of the avenue trees were taken. A tree can be considered hazardous if it possesses some type of structural defect associated with a target, such as buildings, vehicles, pavements, or areas where people and property are present. The hazard status of avenue trees was determined following the method developed by [10]. The method is as follows:

$$\text{Hazard Rating} = \text{Failure Potential} + \text{Size of Part} + \text{Target Rating}$$

where Failure Potential = the likely possibility that the structural defect(s) will result in failure (Scale 1–4: low, medium, high and severe). Size of Part = the size of the part

most likely to fail is rated. The potential damage is directly proportional to the part that fails (Scale 1–3: branch, trunk and whole tree). Target Rating = rating of the use and occupancy of the area that would be struck by the defective parts (Scale 1–4: occasional use, intermittent use, frequent, constant). Hazard Rating will be assigned according to the total rating given, with 3 to 5 points as the minimum value and 12 points being the maximum (Table I). This rating indicates the level of hazard and the extent of potential danger of the tree to potential targets. Using this rating system, the hazard status observed were very high, high, moderate and low respectively.

TABLE I
HAZARD RATING

Hazard Status	Hazard Rating
12	Very High
9–11	High
6–8	Moderate
3–5	Low

F. Statistical Analysis

The data collected from tree measurement were processed into suitable form for statistical analysis. Descriptive and inferential statistic was used in the study. Microsoft Excel and

SPSS version 16.0 was used for the statistical analysis.

III. RESULTS

A. Inventory of Avenue Trees

The avenue tree species in the three parks of the University of Port Harcourt are presented in Table II and Fig. 2. From the result, the tree species with the highest occurrence are; *Azadirachta indica* 209 (81.0%) in Abuja park, *Terminalia mantaly* 31 (55.4%) in Delta park, and *Lucina leucocephala* 4 (28.6%) in Choba park respectively. However, *Azadirachta indica* is the most abundant roadside tree species which has the highest population among the avenue tree species in University of Port Harcourt, which is found only in Abuja Park.

B. Hazard Status

The hazard rating of the roadside trees in the three parks of the University of Port Harcourt is presented in Table III. From the study, only one avenue tree species was found to pose severe hazard in the three parks of the University of Port Harcourt. Most (181) avenue tree species had a medium hazard rating. However, 57 roadside tree species are high in hazard rating and 88 roadside tree species are low in hazard rating, in the three parks of the University of Port Harcourt (Table III). Fig. 3 presents the geo location of these trees with

their hazard rating in the campuses.

TABLE II
AVENUE TREE SPECIES USED IN THE THREE PARKS OF THE UNIVERSITY OF PORT HARCOURT

Location	Species	Family	Frequency
Abuja	<i>Azadirachta indica</i>	Meliaceae	209 (81.0)
	<i>Terminalia mantaly</i>	Combretaceae	38 (14.7)
	<i>Anacardium occidentale</i>	Anacardiaceae	4 (1.6)
	<i>Delonix regia</i>	Papilionaceae	3 (1.2)
	<i>Mangifera indica</i>	Anacardiaceae	2 (0.8)
	<i>Persea Americana</i>	Lauraceae	1 (0.4)
	<i>Hura crepitans</i>	Euphorbiaceae	1 (0.4)
Delta	<i>Terminalia mantaly</i>	Combretaceae	31 (55.4)
	<i>Casuarinas equisetifolia</i>	Casuarinaceae	13 (23.2)
	<i>Cassia fistula</i>	Caesalpinaceae	5 (8.9)
	<i>Albizia lebbbeck</i>	Mimosaceae	3 (5.4)
	<i>Eucalyptus camaldulensis</i>	Myrtaceae	2 (3.6)
	<i>Anacardium occidentale</i>	Anacardiaceae	1 (1.8)
	<i>Terminalia catapa</i>	Combretaceae	1 (1.8)
Choba	<i>Lucina leucocephala</i>		4 (28.6)
	<i>Eucalyptus camaldulensis</i>	Myrtaceae	3 (21.4)
	<i>Adenanthera pavonina</i>	Fabaceae	2 (14.13)
	<i>Gmelina arborea</i>	Verbanaceae	2 (14.3)
	<i>Delonix regia</i>	Papilionaceae	1 (7.1)
	<i>Terminalia catapa</i>	Combretaceae	1 (7.1)

*The figures in parentheses are frequencies.

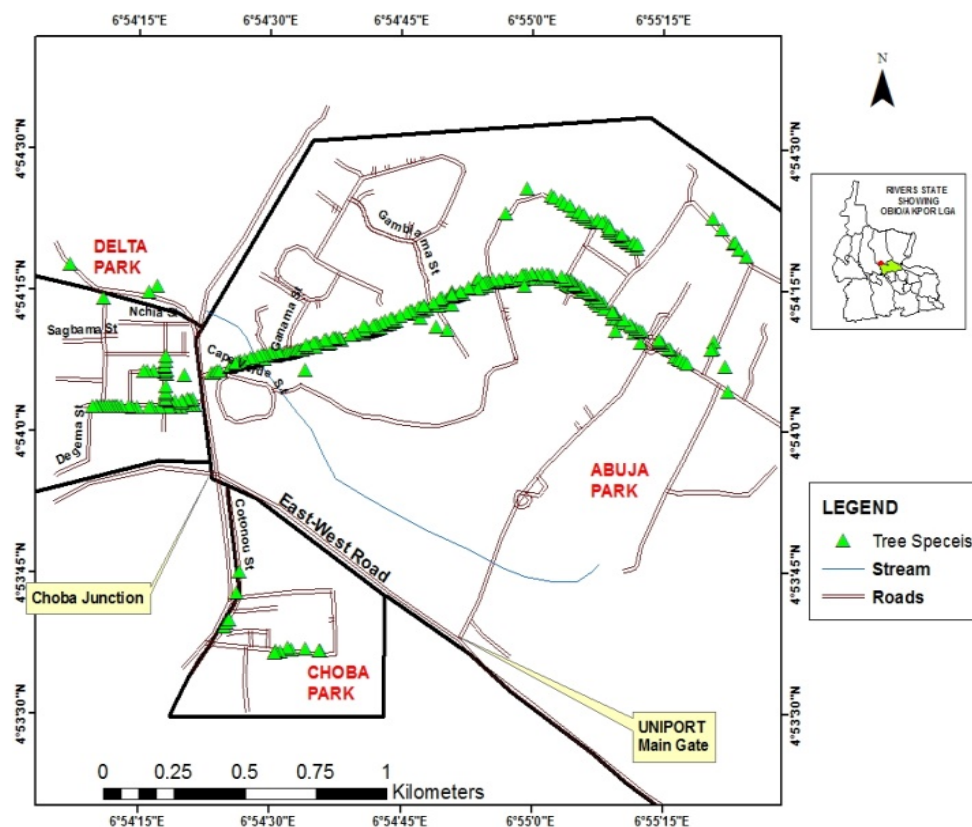


Fig. 2 Map of avenue trees in University of Port Harcourt

TABLE III
HAZARD STATUS OF THE AVENUE TREES IN UNIVERSITY OF PORT HARCOURT

Location	Low	Medium	High	Severe
Abuja	58(22.4)	163(62.9)	37(14.3)	1(0.4)
Delta	29(52.7)	12(21.8)	14(25.5)	
Choba	1(7.1)	6(42.9)	6(42.9)	
Total	88(82.2)	181(5.6)	57(17.7)	1(0.3)

C. Hazard Status of Avenue Trees Species in Abuja Campus

The avenue trees species present in Abuja campus of the University of Port Harcourt, and their hazard rating status are presented in Table IV. Among the avenue trees species in Abuja campus, one *Azadirachta indica* was noted to have severe hazard rating and its location is clearly shown in the map in Fig. 3. And also, *Azadirachta indica* was found to have the highest number in high, medium and low hazard status, which is the most abundant avenue trees species in Abuja campus of the University of Port Harcourt.

TABLE IV
HAZARD RATING OF AVENUE TREES IN ABUJA CAMPUS

Species	Low	Medium	High	Severe
<i>Azadirachta indica</i>	15(7.21)	158(75.6)	35(16.7)	1(0.5)
<i>Terminalia mantaly</i>	38(100)	-	-	-
<i>Anacardium occidentale</i>	-	3(75)	1(25)	-
<i>Delonix regia</i>	3(100)	-	-	-
<i>Mangifera indica</i>	-	1(50)	1(50)	-
<i>Persea Americana</i>	-	1(100)	-	-
<i>Hura crepitans</i>	1(100)	-	-	-
TOTAL	57(22.1)	163(63.2)	37(14.3)	1(0.4)

TABLE V
HAZARD RATING OF AVENUE TREES IN DELTA CAMPUS

Species	Low	Medium	High	Severe
<i>Terminalia mantaly</i>	29(96.7)	1(3.3)	-	-
<i>Casuarina equisetifolia</i>	-	2(13.3)	13(86.7)	-
<i>Terminalia catapa</i>	1(100)	-	-	-
<i>Eucalyptus camaldulensis</i>	-	2(100)	-	--
<i>Cassia fistula</i>	-	5(100)	-	-
<i>Albizia lebbbeck</i>	-	2(66.7)	1(33.3)	-
Total	30(53.6)	12(21.4)	14(25)	-

TABLE VI
HAZARD RATING OF AVENUE TREES IN CHOBA CAMPUS

Species	Low	Medium	High	Severe
<i>Delonix regia</i>	-	1(100)	-	-
<i>Terminalia mantaly</i>	1(50)	1(50)	-	-
<i>Terminalia catapa</i>	-	-	1(100)	-
<i>Eucalyptus camaldulensis</i>	-	1(33.3)	2(66.7)	-
<i>Gmelina arborea</i>	-	1(100)	-	-
<i>Lucina leucocephala</i>	-	1(25)	3(75)	-
<i>Adenanthra pavonina</i>	-	1(50)	1(50)	-
Total	1(7.1)	6(42.9)	7(50)	-

D. Hazard Status of Avenue Trees Species in Delta Campus

The avenue trees species present in Delta campus of the University of Port Harcourt, and their hazard rating status are presented in Table V. Among the avenue trees species in Delta campus, *Casuarina equisetifolia* was found to have the highest number of high status of hazardous tree. However *Terminalia*

catapa is the most abundant avenue trees species in Delta campus with low hazard rating.

E. Hazard Status of Avenue Trees Species in Choba Campus

The avenue trees species present in Choba campus of the University of Port Harcourt, and their hazard rating status are presented in Table VI. Among the avenue trees, *Terminalia catapa* was rated as high hazard status in Choba campus.

IV. DISCUSSION

Avenue trees are trees planted along road side in an urban environment. They are considered as part of in situ conservation methods necessary in protecting and conserving tree species of the society which in turns presents greater benefits [2]. The results of this study confirmed that urban forest (avenue trees) is a store house of many tree species in different families. Avenue tree populations have their own unique structure, tending to be less diverse, containing more large-stature species and exhibiting higher levels of spatial continuity than other components of the urban forest [7]. The inventory of the avenue tree species in the major roads in the three parks (Abuja, Delta and Choba) of the University of Port Harcourt shows the presence of the following tree species; *Azadirachta indica*, *Terminalia mantaly*, *Anacardium occidentale*, *Delonix regia*, *Mangifera indica*, *Persea Americana*, *Hura crepitans*, *Casuarina equisetifolia*, *Cassia fistula*, *Albizia lebbbeck*, *Eucalyptus amaldulensis*, *Terminalia catapa*, *Lucina leucocephala*, *Adenanthra pavonina*, *Gmelina arborea*, used as roadside trees. According to [9], avenue tree species are selected with care because of longevity of the tree species, impacts on human/environment, long time required for planting and maturity. Though [3] reported that conventionally, urban forest areas have been regarded as locations of low biodiversity that are dominated by nonnative species; evidence from this study as well as those from published information reveals that urban and suburban areas can contain relatively high levels of biodiversity [4]. The University environment is rich with diverse avenue tree species because of the benefits of trees in the environment. Reference [17] stated that these avenue tree species have been found useful in bioremediation of urban environmental pollution i.e., abatement of environmental pollution and improvement of the environment.

Considering shape and size of the leaves and crowns, height of trees, tree character (deciduous or evergreen), color and time of flowering, availability of healthy materials and climatic adaptability, *Albizia lebbbeck*, *Azadirachta indica*, *Cassia fistula*, *Eucalyptus* spp., *Mangifera indica* and *Delonix regia* were mostly used as avenue trees in Chandigarh, India [9]. The results from this study showed that *Azadirachta indica* and *Terminalia mantaly* are the most dominant species in the University, which is in agreement with the earlier study of [6]. Researchers have reported *Azadirachta indica* and *Terminalia mantaly* as dominant trees species in their study thus indicating the importance of these tree species as good avenue tree. The existence for these avenue trees on campuses might be because of their inherent characteristics such as fire

resistance, sources of timber, wood antimicrobial and medicinal values [11], [13], [14].

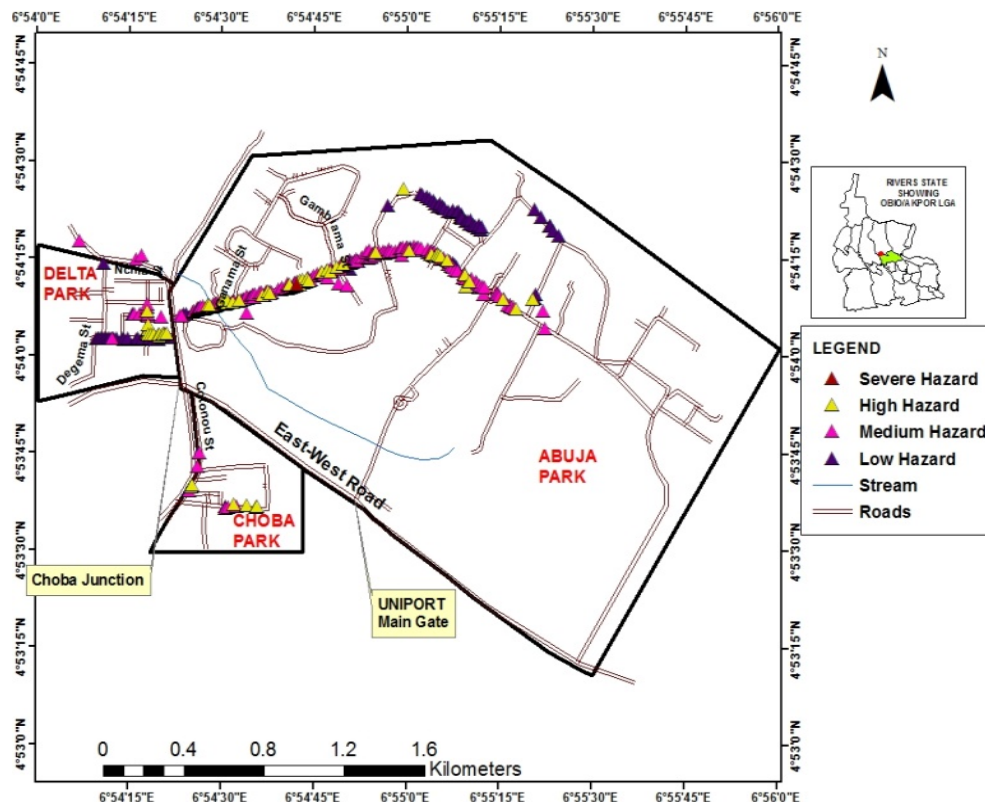


Fig. 3 Map of hazardous status of avenue trees in University of Port Harcourt

Most surveyed avenue trees in the University were considered as medium in hazard status. Dead branch/twigs, termite infestation were among the structural defects observed. The avenue trees were located adjacent to high target areas, such as along busy roads, and adjacent to buildings, which increases their risk rating. Reference [5] stated that the unsustainable removal of the stem barks of *A. indica* and *M. indica* around the DBH had resulted to the death of many stands of these trees, thereby increasing the hazard status of these avenue tree species. The study carried out by [1] reported severe incidence and infestation of termites and fungus on *Azadirachta indica* trees in Abuja Park of the University of Port Harcourt which has resulted in the decline of the species.

V.CONCLUSION

Despite the unquantifiable benefits and impacts of avenue trees to the environment, they tend to cause hazard to lives, properties and its surrounding, when they have unattended severe tree defects. These tree defects include attack by termites and pests, fungi, leaning tree as a result of wind throw, cracking of the roots and stem barks, decay/rotting of the roots and stem, climber infestations, die-back of individual branches, deadwood, exposed roots, necrotic foliage, multiple attachment, severe debarking of stems, wounds, etc. The

hazard status of 327 avenue trees found in major roads of the three parks of University of Port Harcourt were determined by rating the trees' failure potentials (the most likely possibility that the structural defect(s) resulted in failure), the size of the tree part most likely to fail (the potential damage is directly proportional to the size of the tree part likely to fail e.g.; branch, trunk and whole tree), and the target rating i.e. the use and occupancy of the area that would be struck by the defective parts which are; occasional use, intermittent use, frequent, constant.

The tree hazard status assessment process has provided some very useful and informative tools for evaluating and planning of avenue trees. The models developed provide better understanding of the hazard situation. This study concludes that most of the avenue trees at the University of Port Harcourt are safe in which 55.2% (181 trees) of total trees inventoried are classified as medium hazard rating. Based on the high accuracy assessment achieved by the models, it is perceived as a potentially suitable tool for accurate hazard-rating evaluation of avenue trees.

REFERENCES

- [1] Adedeji, G.A. and Emerhi, E.A. 2015. Occupancy of *Azadirachta indica* A. Juss. By fungus and termites in Port Harcourt: Implication for integrated protection strategies. IOSR Journal of Environmental Science,

- Toxicology and Food Technology. ISSN: 2319-2402,p-ISSN:2319-2399. 9, 2:68-72.www.iosrjournals.org.
- [2] Agbelade A.D., Onyekwelu, J.C. and Oyun M.B. 2016, Tree Species Richness, Diversity and Vegetation Index for Federal Capital Territory, Abuja, Nigeria. Hindawi International Journal Of Forestry Research. 2017, 1-13. <https://doi.org/10.1155/2017/4549756>.
 - [3] Alvey, A.A. 2006. Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening* 5:195–201.
 - [4] Cornelis, J. and Hermly, M., 2004. Biodiversity relationships in urban and suburban parks in Flanders. *Landscape and Urban Planning* 69, 385–401.
 - [5] Eludoyin O.S., Oladele A.T. and Iyanda O.M. 2015. Mapping and assessment of ethno-medicinal trees in built up areas- University of Port Harcourt, Nigeria.
 - [6] Fuwape, J.A. and Onyekwelu, J.C., (2011). Urban Forest Development in West Africa: Benefits and Challenges. *Journal of Biodiversity and Ecological Sciences*, 1(1): 77–94.
 - [7] Jim, C.Y. and Liu, H.T., 2001. Species diversity of three major urban forest types in Guangzhou City, China, *Forest Ecology and Management*. 146, 99-114.
 - [8] Koeser, A.K., Hasing, G., Mclean, D. and Northrop, R. 2016 Tree Risk Assessment Methods: A Comparision of Three Common Evaluation Forms. ENH 1226, UF/IFAS Extension. 1-8. <http://edis.ifas.ufl.edu>.
 - [9] Kohli R.K, H.P. Singh, and Daizy R. Batish 1998. An inventory of multipurpose avenue trees of urban Chandigarh, India: Boise, Idaho, USA. Pp; 169-704.
 - [10] Matheny, N.P., and J.R. Clark. 1994. A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas. International Society of Arboriculture, Champaign, IL.
 - [11] Marijoan, B.(2011).Westfield State University Campus Tree Survey Fall, 2011 AICP http://www.westfield.ma.edu/uploads/geography-region_planning/stewardship_of_WSU_tree_resources.
 - [12] McPherson, E. G. 2006.Urban Forestry in North America. *Renewable Resources Journal*, 24(3) : 8-12.
 - [13] Olorunmaiye, K.S., Fatoba, P.O. and Imeh Nathaniel, A.(2004).Effects of Seed Coat Removal on Seed Germination and Seedling Development in *Azadirachta indica* Sm NISEB Journal 4 (1): 5-9. Published by the Nigerian Society for Experimental Biology.
 - [14] Olorunmaiye, K.S., Olorunmaiye, P.M. and Fatoba, P.O.(2010). The effects of planting orientation attributes on the seed germination and seedling development of *Daniellia oliveri* (Rolfe) Hutch and Dalz. *Biological and Environmental Sciences Journal for the Tropics (BEST)*. 7 (2) 146-150. Published by the Department of Biological Sciences .Faculty of Science, Bayero University, Kano, Nigeria.
 - [15] Oyeade, B.A., Popo-ola, F.S. and Itam E.S. 2013. Perception of Urban Dwellers about the Benefits and Management of Urban Trees in Uyo Metropolis, Akwa Ibom State, Nigeria. *ARP Journal of Science and Technology*. 3(7): 769-773.
 - [16] Pokorny, J. 2003. Urban Tree Risk Management: A Community Guide to Program Design and Implementation. USDA-FS NA-TP03-03.
 - [17] Ramesh K.S., Arumugam T., Anandakumar C.R., Balakrishnan S. and Rajavel D.S. 2013. Use of plant species in controlling environmental pollution- A review. *Bulletin of Environment, Pharmacology and Life Science* volume 2 {2}:52-63.