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Seasonal influence on suitability of masquerade tree as a bioindicator of vehicular pollution along University of Ilorin Road

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Abstract: This study focused on the seasonal impacts on the suitability of masquerade (*P. longifolia*) as a bioindicator of vehicular pollutants. Some leaves of the tree were plucked along the roadside and from a control site with no vehicular emissions. Biochemical parameters, including pH, ascorbic acid content, relative water content, total chlorophyll, and Air Pollution Tolerance Index (APTI), were determined in both dry and wet seasons using standard methods. Potentially toxic elements commonly associated with automobile pollutants (Pb, Zn, Cr, Mn, Fe, and Cu) were analyzed using atomic absorption spectroscopy (AAS), after acid digestion. The concentrations of potentially toxic elements were slightly higher in leaves from roadside masquerade tree than in those from the control site, except for Cr and Cu at some sampling points during the wet season. The biochemical properties in the roadside samples indicated the presence of pollutants compared to the control site in both seasons. APTI of the roadside samples showed higher sensitivity (mean value = 10.30) in the dry season, indicating a gradual loss in tolerance to pollution; however, a slight increase (mean value = 11.23) in tolerance was observed in the wet season. The masquerade tree demonstrated its sensitivity to vehicular pollution in both seasons. It is more sensitive in the dry season but tends to tolerate pollutants in the wet season by increasing APTI through improved defence mechanisms.

Keywords: bioindicator; vehicular pollution; masquerade tree; potentially toxic elements.

INTRODUCTION

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High levels of vehicular pollution are a common problem in urban areas, which can harm public health and air quality.[1] This is a consequence of using low--quality fuel, old and poorly maintained cars on the road,[2] and some other processes as friction between tyres and the road surface.[3,4] Air pollution through vehicular activities generates a lot of pollutants such as oxides of carbon (CO and CO_2), nitrogen (NO_x), sulphur (SO_x), polyaromatic hydrocarbons (PAHs) and potentially toxic elements.[5] This menace of air pollution needs immediate and long-term monitoring and mitigation as it has both direct and indirect effects on human health and the environment.

One potential approach to monitoring and mitigating this pollution is the use of bioindicators, or living organisms, that can serve as sensitive indicators of environmental conditions or sinks for pollutants. Two major sinks of pollutants are plants and soil.[5,6] Air pollution is among the many environmental challenges that plants, a lovely gift from nature, can help mitigate.[7] Most air pollutants are deposited on the plants' leaves and are removed through stomata on their surfaces.[8,9]

Several trees and plants have reportedly been used as bioindicators in many urban cities worldwide to monitor levels of air pollution caused by vehicular emissions and other activities, such as industrial discharges. Different plant species exhibit varying levels of sensitivity and tolerance to different forms of air pollution.[6] Bello *et al.*[10] reported the utilization of Mexican sunflower (*Tithonia diversifolia*) for monitoring air pollution around the iron smelting industry, and the study concluded that there was an impact of the industry on the plant. For vehicular emission, *Polyalthia longifolia* (masquerade tree), *Caesalpinia pulcherrima* (peacock flower or barbados pride tree), *Delonix regia* (flamboyant tree), *Tamarindus indica* (tamarind tree), *Terminalia catappa* (tropical almond tree), *Mangifera indica* (mango tree), *Ficus platyphylla* (broad-leaved fig tree), *Ficus benghalensis L* (banyan tree), *Azadirachta indica A.Juss* (neem tree), *Ficus religiosa L* (bodhi tree), *Ficus benjamina L* (as weeping fig tree) and *Bougainvillea glabra* (paper flower tree) that were exposed to roadside automobile pollution, stress was reported.[2,5,9] The Air Pollution Tolerance Index (APTI) is typically used to assess how sensitive and tolerant certain plants are to air pollution.[6,11] A measure of pH, ascorbic acid content (AAC), relative water content (RWC), and total chlorophyll in the leaves of a particular tree is used to determine how plants respond to pollution.[9] Plants that are sensitive to pollutants are used as indicators, while those that are tolerant consume the pollutant and reduce the level of pollution in the environment. [11,12]

Masquerade trees (*P. longifolia*), among others, have been widely studied as bioindicators of vehicular emissions. No wonder it is planted along the main road leading into the University of Ilorin's campus in Nigeria. This tall, evergreen tree native to tropical Asia is also known as the Indian mast tree.[13] Various positions have been taken on its application as a bioindicator. Kirthika & Vishnuprasad[14] reported that it has an intermediate tolerance to vehicular pollution based on its APTI value. Its potential as a bioindicator of vehicular pollutants was also related to its ability to accumulate potentially toxic elements.[15] Similarly, Umar *et al.*[16] stated that *P. longifolia* has the highest dust-carrying capacity among the studied plant species, indicating its potential as a bioindicator of vehicular pollution. Also, Azam *et al.*[17] reported that it is less sensitive to vehicular pollution than the other trees used in their study, based on APTI values.

According to the existing research, the masquerade tree is a viable bioindicator for tracking air pollution and vehicle emissions in urban environments. However, there is little or no information on the effect of seasons on its efficiency in response to pollution. Therefore, this present study investigated the effect of seasonal conditions on its ability to serve as a bioindicator of vehicular pollutants.

EXPERIMENTAL

Description of study area

The University of Ilorin (Better by Far), also known as Unilorin, is a federal government-owned University located in Ilorin, Kwara State, Nigeria. The institution has a large landmass of approximately 15,000 hectares and is situated in the southern part of the city. The University, with approximately 3,040 staff and 34,999 students, experiences a high number of vehicles plying the road from the gate to the campus, especially the University's main car park. The dry and wet seasons are the two main seasons in the region. The dry season covers November and April of the following year. The wet season lasts between April and October.

Sample collection

Leaf samples of masquerade tree (*P. longifolia*) known as the masquerade tree were collected in January (dry season) and May (wet season), 2023. These sites were the University roadsides from the Fountain roundabout towards the gate and walkways (control site). Four samples were collected from the roadside at the following coordinates: 8.47650°N 4.67212°E (RS1), 8.47617°N 4.67182°E (RS2), 8.47556°N 4.67165°E (RS3) and 8.47499°N 4.67100°E (RS4). The control sample was taken at 8.48105°N, 4.67400°E. The samples were collected in a sealed, air-tight bags.

Determination of potentially toxic elements (PTEs) concentration

A 20 mL of an aqua regia solution (15 mL 37% HCl and 5 mL 65% HNO_3) was added to 1 g of the finely ground leaf samples in the digestion beaker. This solution was then heated using a hot plate until it became transparent. The heating process then continued for an additional 20 minutes, after which deionized water (50 mL) was added. The mixture was filtered into a 100 mL standard flask using a funnel and Whatman filter paper. The content was brought up to the 100 mL mark and stored in a sample bottle for PTEs analysis.[18] Concentrations of selected PTEs (Pb, Zn, Cr, Mn, Fe, and Cu) were analyzed in the samples using a BUCK Scientific ACCUSYS 230 atomic absorption spectrophotometer.

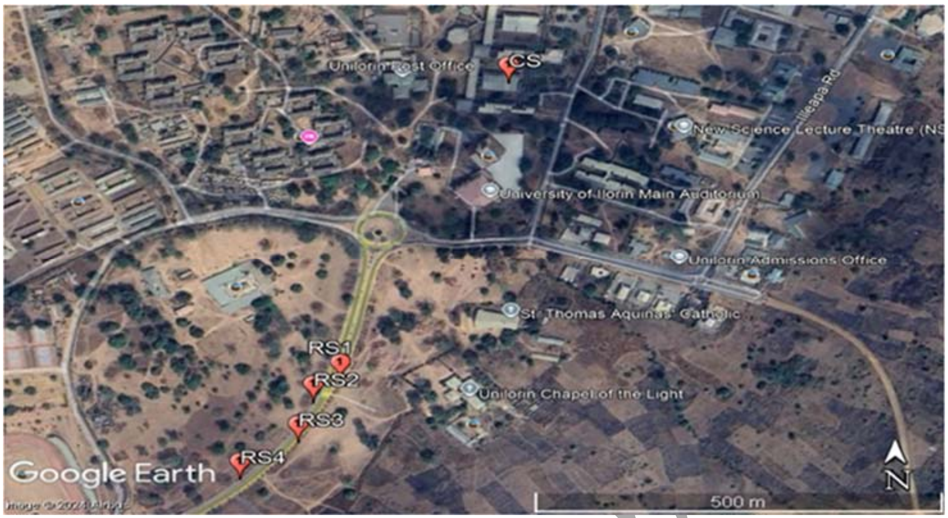

Fig. 1. Sampling site along the University of Ilorin main road Source: Google Earth

pH measurement

The pH of the leaves was determined using a slightly modified method reported by Pandey *et al.*[19] Here, five grams (5 g) of the leaves were crushed and homogenized with a pestle and mortar. It was mixed thoroughly for five minutes with 10 mL of distilled water. Then, the mixture was separated by centrifugation, and the supernatant obtained was subjected to pH estimation using a digital tabletop pH meter (Watson pH-2602).

Relative water content (RWC)

One gram (1 g) of fresh masquerade tree leaves was accurately weighed and immersed in water for 12 h. The fully hydrated weights of the leaves were measured after they were saturated with water. The leaves were further dried in an oven (Gallenkamp OV-160) at 105°C overnight, and their dry weight was subsequently measured. Then the RWC (%) was calculated using equation 1:

$$RWC(\%) = \frac{F - D}{T - D} \times 100 \tag{1}$$

where F is the weight (g) of the fresh leaves; T is the hydrated weight (g), and D is the dry weight (g) at 105°C. [11,20]

Ascorbic acid content (AAC)

The AAC in each sample was quantified and expressed as milligrams per 100 grams using a slightly modified method of Vahid.[21] Ten grams (10 g) of the leaves were blended with a 4% oxalic acid ($C_2H_2O_4$) solution, and the volume was made up to 100 mL using the same 4% oxalic acid solution. The solution was then filtered as an extract using a 110 mm grade 1 Whatman filter paper. A 5 mL aliquot of the sample extract was titrated with a standardized solution of 2,6-dichlorophenol indophenol (dye). The AAC was then calculated using equation 2:

$$AC(mg100g^{-1}) = \frac{\text{Dye\_factor} \times V_2 \times 100}{V_1 - W} \times 100 \tag{2}$$

where W is the weight (g) of a sample taken for extraction with oxalic acid; V_1 is the volume (mL) of sample extract taken for titration and V_2 is the volume (mL) of dye required (titer value). The dye factor was calculated from the standardization of the dye solution.

Total chlorophyll (TCh)

Fifty milligrams (50 mg) of the fresh leaves were crushed and added to a vial containing 7 mL of dimethyl sulfoxide (DMSO), and then incubated at 65 °C for 30 min. The mixture was centrifuged, separated into 10 mL standard and then made up to 10 mL with DMSO. The sample was analyzed using a spectrophotometer (VWR UV-6300PC) at wavelengths of 645 nm and 663 nm, with a blank as a reference. Then the TCh was calculated using equation 3:

$$Tch(mg \cdot g^{-1}) = \frac{20.34 \times A_{648} + 7.49 \times A_{665}}{W \times 1000} \times V \quad (3)$$

where V is the initial volume of extract; W is the weight of the sample taken; A_{648} and A_{665} are the optical density (OD) values measured at 648 nm and 665 nm, respectively. 20.34 and 7.49 are the absorption coefficients. [22]

Air pollution tolerance index (APTI)

The air pollution tolerance index (APTI) of the tree was calculated using the expression given in equation 4:

$$APTI = \frac{\left[AAC(TCh + \mathrm{pH}) + RWC\right]}{10} \quad (4)$$

where AAC is the ascorbic acid content (mg g^{-1}); TCh is the total chlorophyll (mg g^{-1}); pH is the pH of leaves, and RWC is the relative water content (%).[23]

Statistical analysis

For each sampling point and season, the mean values of each biochemical property, along with their standard deviations, are presented. Using Microsoft Excel 2016 Tool Packs for Data analysis, the relationship between biochemical properties and the Air Pollution Tolerance Index (APTI) was analyzed using correlation analysis.

RESULTS AND DISCUSSION

Concentration of potentially toxic elements (PTEs)

The concentration of PTEs in the leaves of the masquerade tree from the four (4) sampling points (RS1-RS4) and that of the control site (CS) with seasons are presented in Tables Ia and Ib for dry and wet seasons, respectively. The plot of their mean values relative to the control site is presented in Figs. 2a and 2b for dry and wet seasons, respectively.

It is observed that all selected PTEs, which are usually associated with vehicular emissions, are present in roadside samples. Their presence in the control sample is lower, except for chromium (Cr), which showed a slightly higher concentration in the CS than in the three RS (RS1, RS2, and RS3), and copper (Cu), which had a higher concentration in the CS than in all the RS samples during the wet season. This exception may be due to the high mobility of the metal ions during the wet season. Similarly, stormwater containing PTEs from various sources can be readily deposited and may affect the control sample.[24,25] Interestingly, a major PTE (Pb) attributed to vehicular emissions was not detected in the CS during the wet season. Additionally, the leaves of the plant from RS1 to RS4 recorded significantly higher values of potentially toxic elements than those of the CS in the dry season. The observation is justified by the plant's proximity to the road and the long accumulation of dust containing these potentially toxic elements on its leaves, which prevents rainwater from washing it away.

The mean concentrations of the potentially toxic elements from the roadside sampling points (RS1-RS4) are more than the control site (CS) copper (Cu) in the wet season (Figs. 2a and 2b). The presence of potentially toxic elements in such amounts (higher than those at the control site) is likely due to contamination of the ambient environment by vehicular emissions. The presence of PTEs in uncontaminated environmental media (air, soil, and water) is not unlikely, but vehicular emissions are a significant source in urban environments. These metallic elements originate from various car parts and operations, including fuel combustion, tyre friction, brake wear, and road surface abrasion.[3,4]

TABLE Ia. Concentration of potentially toxic elements (mg L^{-1}) in the masquerade leaves during dry season

Sites	Concentration of potentially toxic elements (mg L^{-1})					
	Pb	Zn	Cr	Mn	Fe	Cu
RS1	0.086	0.278	0.054	0.469	1.533	0.116
RS2	0.036	0.371	0.052	0.505	1.615	0.121
RS3	0.055	0.341	0.052	0.512	1.445	0.105
RS4	0.099	0.210	0.048	0.287	1.747	0.107
Mean±SD	0.069±0.02	0.30±0.06	0.052±0.002	0.443±0.09	1.585±0.11	0.112±0.01
CS	0.023	0.108	0.047	0.163	0.866	0.062

TABLE Ib. Concentration of potentially toxic elements (mg L^{-1}) in the masquerade leaves during wet season; ND means Not Detected

Sites	Concentration of potentially toxic elements (mg L^{-1})					
	Pb	Zn	Cr	Mn	Fe	Cu
RS1	0.047	0.623	0.032	0.558	2.511	0.051
RS2	0.087	0.520	0.038	0.492	2.578	0.089
RS3	0.048	1.221	0.040	0.409	1.604	0.058
RS4	0.046	1.832	0.084	0.297	1.836	0.012
Mean±SD	0.057±0.02	1.049±0.53	0.0489±0.02	0.439±0.10	2.132±0.42	0.053±0.03
CS	ND	0.301	0.044	0.272	0.384	0.109

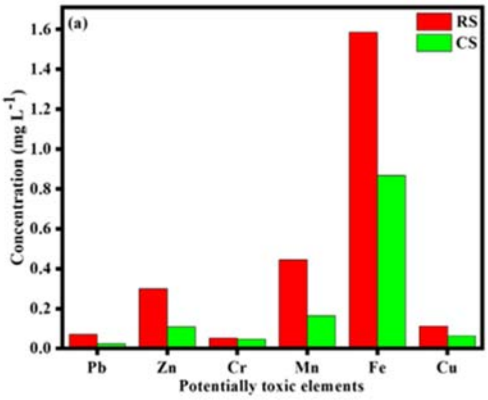

Fig. 2a. Mean concentration of potentially toxic elements in roadside (RS) samples compared with the control site (CS) sample in the dry season

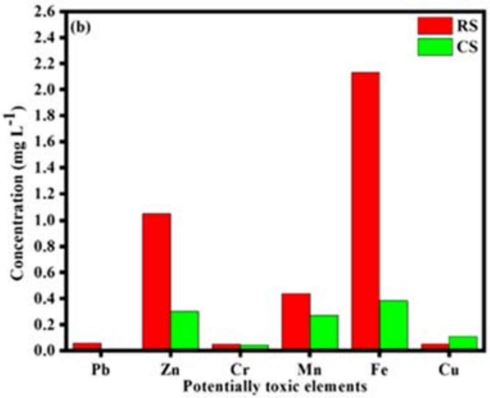

Fig. 2b. Mean Concentration of potentially toxic elements in roadside (RS) samples compared with the control site (CS) sample in the wet season

Biochemical properties and air pollution tolerance index (APTI)

This section presents the results on biochemical properties and the computed Air Pollution Tolerance Index (APTI). These biochemical parameters include ascorbic acid content, pH, relative water content, and total chlorophyll content of the tree's leaves. The results for each roadside sample point (RS1-RS4) are compared with those of the control site (CS).

pH

The pH value of the leaves of the masquerade tree from the four roadside sampling points (RS1-RS4) along the road with the University of Ilorin, and that of the control site (CS) are presented in Table II.

TABLE II. pH of the leaves from the masquerade tree at the roadside (RS) and control site (CS) samples

Season	pH					
	RS1	RS2	RS3	RS4	Mean±SD	CS

Dry	6.47	6.44	6.45	6.49	6.46±0.02	6.53
Wet	7.05	6.75	6.78	6.97	6.89±0.13	7.14

It is observed that all the samples, including the control, are slightly acidic in the dry season. Although the control site (CS) is less acidic (pH 6.53) compared to the individual roadside samples and their mean value (pH 6.46). The tree recorded higher pH levels during the wet season than in the dry season, with the highest value of 7.14 at the control site and the lowest value of 6.75 at RS2, which can be approximated to 7.0. An acidic pH indicates that NO_x and SO_x are present in the air, and their presence can be attributed to vehicular emissions from the burning of fossil fuels.[26,27] Plant health and soil composition are greatly impacted by acid rain, which is brought on by SO_x and NO_x emissions in the atmosphere.[28] It lowers the pH of rainwater below 5.6 and consequently affects the photosynthetic processes, influencing plant development, productivity, and yield.[28,29] It induces oxidative stress by generating reactive nitrogen species (RNS) when it reacts with reactive oxygen species (ROS), and damages lipids, proteins, and nucleic acids.[30] Plants with a pH of around 7.0 are tolerant.[27] In this study, the pH level of the masquerade tree's leaves from a less polluted control site (CS) is 7.14, indicating that the tree is naturally (without pollution) air pollution-tolerant plant.

Relative water content (RWC)

The results of the RWC are presented in Table III. The highest relative water content was observed in the control sample, at 97.88% and 98.21% in the dry and wet seasons, respectively.

TABLE III. Relative water content of the leaves from the masquerade tree at the roadside (RS) and control site (CS) samples

Season	Relative water content (%)					
	RS1	RS2	RS3	RS4	Mean±SD	CS
Dry	94.39	94.89	96.13	91.24	94.16±1.80	97.88
Wet	96.26	96.48	97.84	94.31	96.22±1.26	98.21

However, all selected locations showed a significant RWC value. The relative water content (RWC) of a leaf represents the water it retains compared to its fully turgid state and serves as a crucial indicator of plant response to pollution. Although the wet season affects the plant, the RWC of the roadside sample is still lower than that of the control site in the dry season. The result indicates roadside pollution, as plant RWC is reduced in contaminated environments. In stressful situations, such as exposure to air pollution, when transpiration rates are often high, a plant's high water content aids in maintaining its physiological equilibrium. [31] Plants with high relative water content under polluted conditions may be tolerant to pollutants.

Ascorbic acid content (AAC)

The AAC of tree leaves is a major biochemical property that is strongly affected by vehicular pollution, along with other factors such as chlorophyll content. The results of the ascorbic acid content in the leaves of the masquerade tree, in this study, are presented in Table IV.

TABLE IV. Ascorbic acid content of the leaves from the masquerade tree at the roadside (RS) and control site (CS) samples

Season	Ascorbic acid content (mg g^{-1})					
	RS1	RS2	RS3	RS4	Mean±SD	CS
Dry	1.056	1.036	1.023	1.234	1.087±0.08	0.99
Wet	1.538	1.386	1.564	1.736	1.556±1.02	1.367

The results of the study revealed that the masquerade tree recorded its lowest ascorbic acid content at the control site compared to the individual roadside sampling points (RS1-RS4) and their mean values in both the dry and wet seasons. The higher AAC observed at the roadside sampling point is likely due to their biochemical response to stress caused by pollution.[32,33] The tree maintains higher ascorbic acid levels under polluted conditions, indicating its tolerance to air pollutants. However, the AAC was higher at all sampling points, including the control site, during the wet season compared to the dry season.

Total chlorophyll content (TCh)

The highest total chlorophyll content was observed at one of the roadside sampling sites (RS1), at 2.839 mg g^{-1} and 3.448 mg g^{-1} for the dry and wet seasons, respectively (Table V). However, the mean values in both seasons are lower than those at the control site. The lower total chlorophyll value in the roadside samples (mean value) compared with the control site indicates the impact of automobile pollutants on the plant.

Iqbal *et al.*[32] reported that elevated levels of automobile pollution reduce chlorophyll content in plants growing near roadways. However, chlorophyll content in plants varies based on species, leaf age, pollution levels, and various biotic and abiotic factors.[35] Vehicular pollutants like SO_2, NO_x, and O_3 react with the leaf's chloroplast and consequently decrease the chlorophyll content.[36]

TABLE V. Chlorophyll content of the leaves from the masquerade tree at the roadside (RS) and control site (CS) samples

Season	Total Chlorophyll content (mg g^{-1})					
	RS1	RS2	RS3	RS4	Mean±SD	CS
Dry	2.839	1.387	1.024	1.643	1.723±0.68	2.396
Wet	3.448	1.749	2.153	2.538	2.472±0.62	3.232

Air pollution tolerance index (APTI)

The results of the Air Pollution Tolerance Index (APTI) of the masquerade tree from the roadside (RS) and control site (CS) are presented in Table VI. The APTI mean value of the roadside sampling points compared with the control site for both seasons is presented in Fig. 3. The results obtained from all the roadside sampling points (RS1-RS4) and control site (CS) compared with the APTI categories (Table VII) reported by Lakshmi *et al.*[12] suggested that the plant is sensitive to air pollutants. It is observed that the masquerade tree is sensitive to air pollution levels along the University's roadside.

TABLE VI. The APTI of the masquerade tree from the roadside sampling points (RS) and the control site (CS)

Sampling Points	APTI	
	Dry Season	Wet Season
RS1	10.42	11.24
RS2	10.29	10.83
RS3	10.38	11.18
RS4	10.13	11.08
CS	10.67	11.24

TABLE VII. APTI category

Category	APTI value range
Tolerant species	30–100
Intermediate-tolerant species	17–20
Sensitive species	1–16
Very sensitive species	< 1

The seasonal effect showed that its sensitivity is marginally higher during the dry season compared to the wet season. A plant's ability to mitigate air pollution is indicated by its Air Pollution Tolerance Index (APTI), where higher index values signify greater tolerance.[37] It is an index for determining how plants react biochemically and physiologically to environmental conditions. Pollution-sensitive plants aid in detecting pollution, whereas tolerant plants serve as sinks in polluted areas to help reduce pollution.[11,12]

The correlations between biochemical properties and APTI for the dry and wet seasons are presented in Tables VIIIa and VIIIb, respectively. A significant positive correlation ($r = 0.8450$) was observed between the plant's relative water content (RWC) and the Air Pollution Tolerance Index (APTI) during the dry season. During the wet season, the relationship is weak, although positive ($r = 0.1322$). A positive correlation between APTI and RWC was reported by Punit & Rai[36]. Other factors, such as leaf thickness and soil moisture, also affect the relative water content, even in the presence of pollutants. The total chlorophyll of the leaves also showed a weak but positive correlation ($r = 0.3132$) in the dry season, but a strong positive correlation (r = 0.7776) in the wet season. The amount of chlorophyll in plants' leaves varies depending on the species, age, season, drought stress, and pollution level.[8,38] Other parameters, pH (r = –0.5556) and ascorbic acid content (AAC) (r = –0.88722), indicated a negative relationship with APTI in the dry season. This result implies that the lower pH and AAC observed in the tree leaves correlated with higher sensitivity (lower APTI). The result is likely due to higher levels of vehicular pollutant dust during the season. Reports have shown that APTI values generally decrease (with higher sensitivity) in polluted areas with lower pH and AAC compared to control sites.[7,39] However, moderate positive correlations were found between the pH and APTI (r = 0.6316) and between AAC and APTI (r = 0.5224) in the wet season. Consequently, the increase in pH and AAC with increasing APTI value tends to reduce sensitivity and improve tolerance, suggesting a defence mechanism against air pollutants.

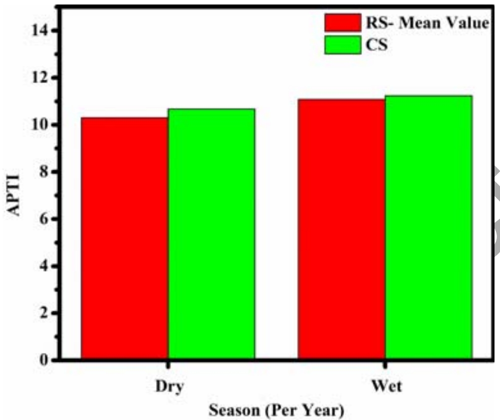

Fig 3. APTI of the roadside (RS) sampling points compared with the control site (CS) with season

TABLE VIIIa. Correlation between biochemical properties and APTI during dry season

	pH	RWC (%)	AAC (mg g^{-1})	TCh (mg g^{-1})	APTI
pH	1				
RWC (%)	–0.86411	1			
AAC (mg g^{-1})	0.876296	–0.97247	1		
TCh (mg g^{-1})	0.429714	–0.23069	0.06662	1	
APTI	–0.5556	0.845035	–0.88722	0.313231	1

TABLE VIIIb. Correlation between biochemical properties and APTI during wet season

	pH	RWC (%)	AAC (mg g^{-1})	TCh (mg g^{-1})	APTI
pH	1				
RWC (%)	–0.56025	1			
AAC (mg g^{-1})	0.549513	–0.60149	1		
TCh (mg g^{-1})	0.938304	–0.24072	0.367135	1	
APTI	0.631617	0.132173	0.522431	0.776754	1

CONCLUSION

This study focused on the seasonal impact on the suitability of the masquerade (*P. longifolia*) as a bioindicator of vehicular pollutants along the University of Ilorin Road. The results of potentially toxic elements and biochemical properties at the roadside sampling points (RS1-RS4) compared with the control site (CS) indicated the presence of air pollution during both dry and wet seasons. The seasonal effect on the plant is not significant since the pH is much closer to 7 in both seasons. The roadside masquerade trees can be considered pollution-tolerant due to their high ascorbic acid content, especially during the wet season. The relative water content was high in both seasons, but higher at the control site and in the wet season than at the roadsides and in the dry season. The plant's leaves showed the highest total chlorophyll content during the wet season. The APTI values in both seasons suggest that the plant is sensitive to air pollutants. Consequently, the overall conclusion is that the masquerade tree is sensitive to vehicular pollutants in both seasons, making it a suitable bioindicator. However, there was a reduction in sensitivity, resulting in improved tolerance during the wet season.

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@BUB@K@R @REMU[3] ¦ @BHD@G N.MUG@MMED[1]

[1]Ddb'qsl dmsneBgdl hrsqx, Umhudqrhsx neHknqhm, O M B.1414, Hknqhm, Mhfdqh', [2]Ddb'qsl dmsneM'stq'k Sbhdmbdr 'mc M'sgdl'shbr, BnkkdfdneÀqsr 'mc Sbhdmbdr, Vhkh'l U.S.Stal 'm Umhudqrhsx, O.N.Bnw 346/, G'qpdq Bhsx, M'qxk'mc Bntmsx, Khadqh' ¦ [3]M'shnm'kNhkSohkkDdsdbshnm 'mc Rdronmrd@fdmbx, O M B.134, @ati', Mhfdqh'

¹ú½ ÅµÙí¦½ ¦ý½Ã½ Ð ®½ õ¦, ¦Åñ¦µ¦ú½" Ð ÅÐ®ÇÁÅþÇé Ùµ¦õ½½ Á½ ñÇéÇíÁÇÅµ íðúÐµ½ Onkx'ksgh' knmfhenkh' þ½Ç Õ¦Ç¦Áí¦þ½µÇð½®½é½›Ð" ½ú½®íÙŠ½, ñÇðÐþÃÇý Çí Å½ÇÕð½»½½.ø¦ÅµÇú¦ ÅÙ ñð¦þÙñ, ÐÁ¦ íÙî Å½ÇÕð½»½Á¦õÐ ¦®ÃÇî ÐÁÐ ¦ÁµÐÁ®¦úÁ¦ý Å½ÇÕð½»½Á¦ý Ðý ¦Å¦ ½ý½, þ½Ç ¦ Å½ þÇÁµðÇÃÁÐ ÃÇþ½õ¦Ð ÕÐ® ñð¦ÅÙÅµú½ Å½ÇÕð½»½½. ÖÇþÇý ÅÙÚ ÁÐ ¦ þ¦Ú ÁÐ ÅÐ®ÇÁÐ ½Á½Ã¦®¦ð½Á¦ ÅÙ Õ¦ÇŠÐý¦Åþ¦ ñ½ð½ýÐµð¦, Ùþ, ÙÑÙÙ»¦ oG úðÐíÁÇÅµ Ã¦Åµ½, Å½íðî½ ½ÅþÇðÕ¦ÁÅþÐ þ¦ÅÐÃ¦ÁÐ, ðÐÃ½µ¦úÁ¦ Å½íðî½úÇíÐ, ÙþÙñÁ¦ ŠÃÇðÇÈ¦Ã ¦ ¦ÁíÐþÅ µÇÃÐð½Áõ¦Ð Á½®½é½›Ð" Ð ú½®íÙŠ½ (@OSH), ñð¦ýÐÁÇý Åµ½Áí½ðíÁ¦Š ½Á½Ã¦µ¦Ñþ¦Š ýÐµÇí½.ł ÇÁõÐÁµð½õ¦Ð ñÇµÐÁõ¦½ÃÁÇ µÇþÅ¦ÑÁ¦Š ÐÃÐýÐÁ½µ½ ñÇúÐ®½Á¦Š Å½ ½ÙµÇý ÇÕ¦ÃÅþ¦ý ®½é½›¦ú½Ñ¦ý½ (Oa, Zm, Bq, Mm, EdhBt) ÇíðÐ›ÐÁÐ ÅÙ ýÐµÇíÇý ½µÇý ÅþÐ ½ñÅÇðñõ¦ÇÁÐ ÅñÐþµðÇÅþÇñ¦Ð (@@S), Á½þÇÁ þ¦ÅÐÃÐ í¦éÐÅµ¦Ð Ù®Çð½þ½. øÇÕ¦ÐÁ¦ ðÐ®ÙÃµ½µ¦ Ùþ½®ÙÙ Á½ µÇ í½ ÅÙ þÇÁõÐÁµð½õ¦Ð ñÇµÐÁõ¦½ÃÁÇ µÇþÅ¦ÑÁ¦Š ÐÃÐýÐÁ½µ½ Ù úÐ»¦Á¦ ÅÃÙÑ½Ðú½ Õ¦ÃÐ ú¦ÚÐ Ù Ã¦ÅµÇú¦ý½ ñð¦þÙñ, ÐÁ¦ý íÙî Å½ÇÕð½»½Á¦õÐÙ ñÇðÐ›Ð" Ù Å½ þÇÁµðÇÃÁÇý ÃÇþ½õ¦Çý, ¦®Ù®ÐúBq¦ Bt Á½ ñÇÐí¦Á¦ý ýÐÅµ¦ý½ Ù®ÇðþÇú½"½, µÇþÇý þ¦ÚÁÐ ÅÐ®ÇÁÐ. °½®Ã¦þÐ Ù Õ¦ÇŠÐý¦Åþ¦ý ñ½ð½ýÐµð¦ý½ ¦®ýÐ›Ù Ù®Çð½þ½ Å½ Å½ÇÕð½»½Á¦õÐ ¦ þÇÁµðÇÃÁÐ ÃÇþ½õ¦Ð ñÇµúð›ÙÙ Ùµ¦õ½ Å½ÇÕð½»½ÁÇé ®½é½›Ð" ½ Ù ÇÕÐ ¦Åñ¦µ¦ú½ÁÐ ÅÐ®ÇÁÐ. ª ðÐíÁÇÅµ¦ @OSH Ùþ½®½ÃÐ ÅÙ Á½ úÐ»Ù ÇÅÐµ, ¦úÇÅµÕ¦, þÐ µÇþÇý ÅÙÚ ÁÐ ÅÐ®ÇÁÐ (ÅðÐí"½úðÐíÁÇÅµ = 1/,3/), Ú µÇ ÅÙéÐð¦Ú Ð Åý½" ÐÁÙ

µÇÃÐð½Áõ¦ˇÙ Á½ ®½é½›Ð”Ð, íÇþ ˇÐ µÇþÇý þ¦ÚÁÐ ÅÐ®ÇÁÐ ®½ÕÐÃÐî ÐÁÇ ÕÃ½éÇ ñÇúÐ»½”Ð µÇÃÐð½Áõ¦ˇÐ (ÅðÐí”½ úðÐíÁÇÅµ = 11,23). °Ð®ÙÃµ½µ¦ ñÇµúð›ÙˇÙ í½ Onkx`ksgh` knmfhenkh` ñÇþ½®ÙˇÐ ¦®ð½î ÐÁÙ ÇÅÐµ, ¦úÇÅµ Á½ Å½ÇÕð½»½ˇÁÇ ®½é½›Ð”Ð µÇþÇý ÇÕÐ ÅÐ®ÇÁÐ, þÇˇ½ ˇÐ ú¦Ú ½Ù ÅÙÚ ÁÇý ñÐð¦Çíx, íÇþ ˇÐ ÅñÇÅÇÕÁÇÚ µ µÇÃÐð½Áõ¦ˇÐ ñÇúÐ»½Á½ Ù þ¦Ú ÁÇˇ ÅÐ®ÇÁ¦, úÐðÇú½µÁÇ ÙÅÃÐí ½þµ¦ú¦ð½” ½ÐÈ ¦þ½ÅÁ¦ˇ¦Š È ¦®¦ÇÃÇÚ þ¦Š ÇíÕð½ý ÕÐÁ¦Š ýÐŠ½Á¦®½ý½.

(–ð¦ý,ÐÁÇ 2.ˇ½ÁÙ½ð½,ðÐú¦í¦ð½ÁÇ 28.ý½ðµ½ 2/24,ñð¦Šú½»ÐÁÇ 4.ˇ½ÁÙ½ð½ 2/26)

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