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AIR POLLUTION TOLERANCE INDICES (APTI) OF SOME SELECTED PLANTS GROWING CLOSE TO IRON AND STEEL INDUSTRY IN ILE- IFE, OSUN STATE NIGERIA

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Abstract
The air pollution tolerance indices (APTI) of five plants species randomly sampled from the vicinity of Iron and Steel factory in Ile-Ife Osun State, Nigeria were analyzed. A composite sample of five leaves for each of the plant was used for laboratory analysis. Four physiological and biochemical parameters: leaf relative water content (RWC), ascorbic acid content (AAC), total leaf chlorophyll (TLC) and pH of leaf extract were used to compute the Air pollution tolerance indices (APTI). Results showed order of tolerance as Banana (Musa species) (0.425%) > Sandpaper leaf (Ficus asperifolia) (1.230%) > Elephant grass (Pennisetum purpureum) (3.113%) > Cocoyam (Xanthosom species) (5.828%) > Cassava (Manihot esculenta) (22.019%); indicating that banana was the most tolerant plant while Cassava (M. esculenta)was the least tolerance (most sensitive) plant species to air pollution stress in the study area. Therefore, plants with high and low APTI can serve as tolerant and sensitive species for air pollution biomonitoring, respectively.

Key Words: *APTI, sensitivity, biomonitor, physiological parameters, biochemical parameters*

Introduction

As of today, air pollution is one of the major challenges facing the world. This is due to the continual change in concentration levels of some gaseous and trace metals in the environment resulting from man's activities such as road transportation, vehicular traffic and industries (Tanee and Albert, 2013). Plants are an integral basis of all ecosystem and air pollution can directly affect plant via leaves (which are usually the most abundant and most obvious primary receptors of large number of air pollutants) or indirectly via soil acidification. Most plant experienced physiological changes before exhibiting visible damage to leaves when exposed to air pollutants (Liu and Ding, 2008). Tiwari*et al.* (2006) observed that pollutants can cause leaf injury, stomata damage, premature senescence, decrease photosynthetic activities, disturb membrane permeability and reduce growth and yield in sensitive plant species.

Plants have been used over the years as biomonitors of pollution. This is because they provide an enormous leaf area for impingement, absorption and

accumulation of air pollutants to reduce the pollution level in the air environment with various extents for different species (Liu and Ding, 2008). Joshi and Swami (2009), agreed with this use of plants as biomonitors since it has been established that they are the initial acceptors of air pollutants due to having scavenging property for many air pollutants. Plants show varying degree of sensitivity and tolerance to air pollution stress. Air pollution tolerance index (APTI) is an inherent quality of plants to encounter air pollution stress which is presently of prime concern in industrial and non-industrial areas (Rai *et al.,* 2013). To arrive at APTI of plants, the chlorophyll content (Flowers *et al*., 2007); ascorbic acid content (Hoque *et a*l., 2007); leaf pH (Klumpp *et al*., 2000) and relative water content (Rao, 2006) are used. The combination of these parameters have been used in the formulation of APTI (Krishnaveni and Lavanya, 2014; Tanee and Albert, 2013; Rai *et al.,* 2013; Jyothi and Jaya, 2010; Agbaire and Esiefarienrhe, 2006).

The present study attempts to determine the air pollution tolerance indices (APTI) of some plants growing around iron and steel factory Ile –Ife, in Osun State, Nigeria. It will also determine plants that can be grown in air polluted environments based on their tolerance and sensitivity to air pollution. The knowledge obtained from this study will assist horticulturists, landscapers and environmental scientists in the selection of air pollution tolerant plants that can be planted in air pollution prone areas.

Materials and Methods

Description of Study Site

The area of study is Iron and steel company along Ilesha-Ibadan express road, Ile-Ife Osun State, Nigeria. Ife is an ancient town in Yoruba history and is regarded as the cradle of civilization. According to Yoruba tradition, Ife is the ancestral and spiritual home for all Yoruba. It is believed that the creation of the world started from Ife. Hence, it is popularly referred to as "Land of the Source". Geographically, Ile-Ife lies on longitude 4^0 69'E and latitude 70^0 50'N. The climate is tropical. Like every other Southwest area, the rainy season starts from April to October while the dry season is from October to March.

Sample Collection

The procedure adopted by Tanee and Albert (2013) was used for both the collection and analysis of samples. Plant sampling was done from in July, 2015. Fresh fully matured leaves of plants from the immediate vicinity of the factory were randomly collected designated as experimental site (ES). The plants selected for the study were those available at the experimental site. Sampling was done in the early hours of the day (before 10 a.m). A nearby site along Ondo-Ore express road, Ile-Ife with similar ecological conditions was chosen as the control site (CS). Replicates of fully mature leaf samples of the various plants were collected, put in polyethene bags and marked with marker. These were immediately taken to Biochemistry laboratory, FUTA for analysis. Composite sample of five leaves for each species were used for the analysis.

Analysis of Samples

The following physiological and biochemical parameters were analyzed: leaf relative water content (RWC), ascorbic acid content (AAC), total leaf chlorophyll (TC) and pH of leaf extract. These were used to compute the Air Pollution Tolerance Index (APTI) values for both the experimental site (ES) and control site (CS).

Determination of Relative Leaf Water (RWC) Content

The relative leaf water content (RWC) was calculated using the formula of by Singh (1997):

$$RWC = \frac{\text{Fresh Weight (FW)} - \text{Dry Weight (DW)} \times 100}{\text{Turgid Weight (TW)} - \text{Dry Weight (DW)}}$$

The fresh plants were immediately taken to the laboratory for the determination of the leaf fresh weight in order to minimize water loss. Leaf samples were weighed on a weighing balance (model KD-CN 100828072) to obtain the fresh weight (FW). The leaves were then immersed in water for 24 hours (overnight), blotted dry with Whitman filter paper and weighed to obtain the turgid weight (TW). The leaves were finally dried in an oven for 48 hours at 65°C and reweighed on the weighing balance to obtain the dry weight (DW).

Determination of Total Leaf Chlorophyll (TLC) Content

Total leaf chlorophyll content (TLC) was determined using the method described by Arnon, (1949). 2g of each leaf sample was weighed and soaked in 10 ml of 80% acetone, each leaf was then grinded in a clean mortar into fine pulp and then transferred quantitatively into boiling tube, the boiling tube containing the content was then transferred into a water bath at 70^0C for few minutes, this step was repeated until the residue became colourless. The volume was made up to 100ml with 80% acetone. The absorbance of the solution was taken at 645nm against the solvent (80% acetone) blank using the formula below using a spectrophotometer;

Total chlorophyll (mg/g) = 20.2 (A_{645}) + 8.02 (A_{663}) x $\frac{V}{1000 \times W}$

Where;

A = absorbance of specific wavelength

V = final volume of chlorophyll extract in 80% acetone

W = fresh weight of plant extracted

Determination of Leaf Extract pH

The leaf extract pH was obtained by homogenizing 0.2g of the fresh leaves in 10ml of distilled water. This was filtered and the pH of leaf extract determined using a pH meter (model: HANNA R102895) after allowing it to stabilize for 15 minutes and calibrated with buffer solution of pH 4 and 7.

Determination of Ascorbic acid Content (AAC)

The AAC was measured using the indophenol acetic acid method. 2 g of fresh leaf sample was crushed and made up to 100 ml using distilled water. It was centrifuged at 2,000rpm for 5 min. 10ml of 4% oxalic acid was added and then titrated with 2,6-dichlorphenol-indophenol as described by Sadasivam and Manickam (1996).

Air Pollution Tolerance Index (APTI) Determination

This was done following the method adopted by Tanee and Albert (2013). The formula of APTI is given as:

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

Where,

A = ascorbic acid content (mg/g); T = total chlorophyll content (mg/g): P = pH of leaf extract and; R= relative leaf water content (%).

Results

The results of the study are presented in tables 1 to 5.

Table 1: Relative leaf water content of plants

Plant species	Site	Dry weight(g)	Fresh weight(g)	Turgid weight(g)	RWC (%)
Elephant grass	ES	1.36	5.00	6.13	76.31
(*Pennisetum purpureum*)	CS	1.35	5.00	6.29	73.89
Cocoyam	ES	0.59	5.00	6.60	73.38
(*Xanthosom* species)	CS	0.91	5.00	6.83	69.09
Cassava	ES	1.52	5.00	6.60	68.50
(*Manihot esculenta*)	CS	1.27	5.00	7.96	55.75
Banana	ES	0.70	5.00	5.80	84.54
(*Musa* species)	CS	0.68	5.00	5.79	84.31
Sand paper leaf	ES	1.10	5.00	8.59	52.07
(*Ficus asperifolia*)	CS	1.14	5.00	8.67	51.26

Table 1 show that plant samples from the experimental site had higher RWCs than those from the control site. The relative water content (%) of a leaf is the water present in it relative to its full turgidity. The RWC of a leaf is associated with protoplasmic permeability in the cells. The relative leaf water content of all the plants in the experimental site (ES) was higher than those in the control site (CS) (Table 4.1). Banana plantin the experimental site had the highest RWC (84.54%). This is an indication that plants at polluted site retain more water than those at unpolluted site. A possible explanation to this might be that the plant at the polluted site absorbed more water as an adaptive feature which helps in maintaining its physiological balance against pollution stress. It might also be an indication that plants with high relative water content suggested that the pollutant absorbed by the plant are hydrophilic hence enabled the plant to retain more water content in polluted conditions may be tolerant to pollution stress.

Table 2: Leaf pH content

Plant species	Site	pH
Elephant grass	ES	6.0
(*Pennisetum purpureum*)	CS	6.2
Cocoyam	ES	6.9
(*Xanthosom* species)	CS	7.2
Cassava	ES	5.8
(*Manihot esculenta*)	CS	6.0
Banana	ES	6.2
(*Musa* species)	CS	6.6
Sandpaper leaf	ES	7.2
(*Ficus asperifolia*)	CS	7.4

Result of leaf pH shows a reduction in the leaf pH of plant species from the experimental site with respect to their control site (Table 2). This is in conformity with Tanee and Albert (2013) who observed a higher pH level in most of the in the control site. According to Tiwari and Tiwari (2006), leaf extract pH plays a significant role in regulating SO_2 sensitivity of plants and the presence of acidic pollutants in plants have led to lowering of leaf pH. This decrease is said to be greater in sensitive plants. Similar result was also observed in the ascorbic acid content (AAC) in which all the selected plants showed a lower AAC in the experimental site when compared to the control site (Table 3).

Table 3: Ascorbic acid content (AAC)

Plant species	Site	AAC (mg/g)	%AAC
Elephant grass	ES	3.15	0.032
(*Pennisetum purpureum*)	CS	4.73	0.047
Cocoyam	ES	7.25	0.073
(*Xanthosom* species)	CS	9.55	0.096
Cassava	ES	6.04	0.060
(*Manihot esculenta*)	CS	11.01	0.110
Banana	ES	5.34	0.053
(*Musa* species)	CS	6.85	0.069
Sandpaper leaf	ES	8.11	0.081
(*Ficus asperifolia*)	CS	10.04	0.100

From the table 3, it is observed that plants from the experimental site had lowered ascorbic acid content when compared to those of the control site. According to Rai*et al.* (2013), ascorbic acid is an antioxidant that is found in large amounts in all growing plant parts and it influences resistance to adverse environmental conditions including air pollution. Reduction in ascorbic acid content indicates adverse effect of air pollution on the plant.

Table 4: Total chlorophyll content

Plant species	Site	Total chlorophyll (mg/g)
Elephant grass	ES	0.406
(*Pennisetum purpureum*)	CS	0.429
Cocoyam	ES	0.226
(*Xanthosom* species)	CS	0.477
Cassava	ES	0.454
(*Manihot esculenta*)	CS	0.340
Banana	ES	0.355
(*Musa* species)	CS	0.328
Sandpaper leaf	ES	0.346
(*Ficus asperifolia*)	CS	0.388

Chlorophyll content is used to determine the photosynthetic activity of plant. This is very important because photosynthesis provides the food used by plants. It therefore follows that anything affecting the chlorophyll content of a plant will affect its overall wellbeing. Chlorophyll content of plants varies from species to species; age of leaf and also with the pollution level as well as with other biotic and abiotic conditions (Katiyar and Dubey, 2001). Result from this study shows that 60% of the plants selected for the study showed higher total chlorophyll TLC (%) in the control site than in the experimental site (Table 4). The reduction in total chlorophyll in the experimental site might be as a result of the effect on the degradation of chlorophyll synthesis. According to Joshi and Swami (2007), air pollution leads to gradual disappearance of chlorophyll which results in leaf chlorosis thereby resulting in a decrease in photosynthetic capacity. A widely used indicator of air pollution is the degradation of photosynthetic pigment (Ninave, 2001). Plants having high chlorophyll content under field condition are generally tolerant to air pollution (Tiwari and Twari 2006).

Table 5: Air Pollution Tolerance Index (APTI)

Plant species	Site	APTI	% increase in APTI
Elephant grass	ES	7.651	3.113
(*Pennisetum purpureum*)	CS	7.420	
Cocoyam	ES	7.390	5.828
(*Xanthosom* species)	CS	6.983	
Cassava	ES	6.888	22.019
(*Manihot esculenta*)	CS	5.645	
Banana	ES	8.502	0.425
(*Musa* species)	CS	8.466	
Sandpaper leaf	ES	5.268	1.230
(*Ficus asperifolia*)	CS	5.204	

APTI has been used to indicate tolerance and sensitivity to air pollution by plants (Tanee and Albert, 2010, Agbaire, 2009 and Tiwari, 2006). Plants with low APTI values are said to be tolerant to air pollution while those with

high APTI values are said to be sensitive to air pollution. APTI result from this study show that plants growing in polluted (experimental) site had higher APTI values than those in the less polluted (control) site. The percentage increase trend was in the order: Banana (*Musa* species) (0.425%), Sandpaper leaf (*Ficusasperifolia*) (1.230%), Elephant grass (*Pennisetumpurpureum*) (3.113%), Cocoyam (*Xanthosom*species) (5.828%) and Cassava (*Manihotesculenta*) (22.019%); indicating that bananawas the most tolerant plant while Cassava (*Manihotesculenta*)was the least tolerant (most sensitive) plant in the area studied. The plant with low and high APTI percentage values can serve as tolerant and sensitive plant, respectively. The results of this study suggest that plants have the potential to serve as excellent quantitative and qualitative indices of pollution; since biomonitoring of plant is an important tool to evaluate the impacts of air pollution on plants.

Conclusion and Recommendation

Air Pollution Tolerance Index (APTI) determinations are of importance because with increased industrialization, there is increasing danger of disappearance of vegetation cover due to air pollution. Therefore, only plant with low air pollution tolerance should be planted in areas prone to air pollution.

From the research conducted it was observed that banana had the least APTI and is therefore recommended that more of it should be planted in areas prone to air pollution.

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