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Air Pollution Tolerance Indices (APTI) of Some Edible Plants Exposed to Industrial Effluents at Nnewi in Anambra State, Nigeria.

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Abstract: *Air pollution tolerance indices (APTI) were analysed in 2 plants (Telfairia occidentalis and Ocimium gratissimum) growing on farm sites surrounding three industries: Lead-acid battery factory (experimental site 1), Petroleum products factory (experimental site 2) and PVC Pipes and Cement packaging factory (experimental site 3) with a non industrial site selected as control site all in Nnewi, Nigeria. Leaf relative water content, Ascorbic acid, Total chlorophyll and Leaf extract pH were analysed and used to calculate the APTI values. The two plants growing in experimental (polluted) sites had significantly higher ($p< 0.05$) APTI than those in the control site with their APTI values ranging from (8.05 to 11.20) in experimental sites and (7.83 to10.00) in control site. Both plants were found to be sensitive to air pollution with Ocimium gratissimum being the more sensitive specie with a higher percentage APTI increase (33.07±13.80%) in the experimental sites. Consumption of both plants from polluted sites may be deleterious to health with T. occidentalis being more harmful because it accumulates more pollutants. Higher APTI values with a corresponding reduced Total chlorophyll composition ($p<0.05$) recorded for both plants in experimental site 1suggests that effluents from Lead-acid battery factory have more hazardous effect on edible plants*

Keywords; *APTI; chlorophyll; tolerance; sensitive; pH*

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I. Introduction

In developing countries, industrialization has immensely contributed to the elevated levels of air pollution in the urban and suburban environments [1]. Over the past few decades, Nnewi city in Anambra State; a part of Eastern Nigeria's industrial axis has witnessed an explosion of industries [2]. These industries are distributed across the city, close to residential areas and surrounding farm lands in an unorganized manner, a development that have exposed the city and environ to air pollution.

Air pollution affects plants' physiology and biochemical indices because plants are able to sufficiently accumulate particulate and gaseous pollutants in the environment which they grow in through their leaves [3]. Previous studies have reported that most plants experience physiological changes before exhibiting visible damage to leaves when exposed to air pollutants [4], [5]. It has long been established that plants can be used as biomonitors of air pollution because they are the initial acceptors of air pollutants due to their possession of scavenging property for many air pollutants [6]. Plants sensitivity and tolerance to air pollutants varies with change in leaf extract pH, relative water content, ascorbic acid content and total chlorophyll content [7]. Ascorbic acid is a known antioxidant molecule which is capable of detoxifying air pollutants. It is also able to control cell expansion and cell division [8]. Chlorophyll is essential for the vital process of photosynthesis in green plants. Changes in leaf chlorophyll can serve as relative indicators of environmental quality [5]. The pH plays an important role in mediating physiological responses tostress [9]. The relative water content of a plant is one approach to figure out whether a plant is stressed. The high water content inside of a plant body will keep up its physiological equalization under stress. These separate parameters gave conflicting results for same species [10], [11]. However, the air pollution tolerance index (APTI) based on all these four parameters have been used for identifying tolerance levels of plants species [10], [11]. Air pollution tolerance index expresses the capacity of a plant to battle against air contamination when exposed to airborne pollutants [11] and has been used to rank plant species in their order of tolerance to air pollution as follows: (< 1: Very sensitive; 1 – 16: Sensitive; 17 –29: Intermediate and 30 -100: Tolerant) [12], [13]. The identification and categorization of plants into sensitive and tolerant groups is based on the fact that sensitive plants serve as markers and can be utilized to demonstrate levels of air pollution while tolerant ones can be brought about as sinks for the bio accumulation of pollutants hence alleviating air contamination in urban and industrial spaces [11]. According to[14], plants with lower percentage increase in APTI values are more tolerant. The aim of this study is therefore to determine the APTI values of two plants species within industrial areas. The study will also identify the plant specie which is more sensitive to the prevailing atmospheric conditions and the industry whose effluents have more debilitating effect on edible plants.

II. Material And Methods

2.1 Study Area

This study was carried out on farm sites located around three different industries in Nnewi area of Anambra state, South East Nigeria. The town lies within the tropical rain forest region of Nigeria. It is situated at longitude $6^0$1'N and latitude $6^0$55'E. Nnewi spans over 1076.9 square miles (2789km^2) of rain forest alluvial land. Nnewi has a population of about three hundred and ninety one thousand, two hundred and twenty seven and an annual growth rate of 2.77% [2]. Nnewi is home to many major indigenous manufacturing industries with about 20 medium-to-large-scale industries established across a variety of sectors in the city

2.2Sampling:

Three different industries were selected through non random sampling method. The industries include lead acid-battery factory, petroleum products factory and PVC pipes, plastic products and Cement packaging factory. Farm lands within 1km distance of these industries were randomly selected and designated as Experimental Sites (ES) 1, 2 and 3 respectively. A fourth site situated in a non industrialized area situated within 25km distance from the industries with similar ecological conditions was selected as the control site (CS). Four replicates of fully matured Leaf samples of two edible plants, *Telfairia occidentalis* (Fluted pumpkin leaf) and *Ocimium gratissimum* (Scent leaves) grown on the selected farm lands were randomly collected and immediately taken to the laboratory for analysis. A composite sample of each plant species was obtained before analysis. The plants selected for the study were those available in all the experimental and control sites. The leaf analysis was done immediately upon getting to the laboratory.

2.3Analysis of samples

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

2.3.1 Relative leaf water content (RWC):

With the method described by [11], leaf relative water content was determined and calculated with the formular. RWC= [(FW-DW) / (TW-DW)] x 100.

FW = Fresh weight
DW = Dry weight
TW = Turgid weight

Fresh weight (FW) is obtained by weighing the leaves. The leaf samples are then immersed in water over night blotted dry and then weighed to get the turgid weight (TW). The leaves are dried overnight in a hot air oven at 700^{0}c and reweighed to obtain the dry weight (DW).

2.3.2 Total chlorophyll content (TCh)

This was carried out according to the method described by [15]. 3g of fresh leaves were blended and then extracted with 10ml of 80% acetone and left for 15 minutes for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged at 2,500rpm for 3 minutes. The supernatant was then collected and the absorbance of chlorophyll a and b taken at 645nm and 663nm using a spectrophotometer. Calculations were done using the formula below.

Total chlorophyll (mg/kg) = 17.76 (A645) + 7.34(A663) x V/1000 x W
Where
A= absorbance of specific wave length
V= final volume of chlorophyll extraction in 80% acetone
W= fresh weight of tissue extracted.

2.3.4 Leaf extractspH

For pH estimation, the method described by [14] was used. 5g of the fresh leaves was homogenized in 10 ml deionized water. The extract was filtered and the pH was determined after calibrating pH meter with buffer solution of pH 4 and pH 9.

2.3.5 Ascorbic acid (AA) CONTENT ANALYSIS

Ascorbic acid content was measured by Titrimetric method described by [16] using 2, 6, Dichlorophenol indo phenol dye. 500mg of leaf sample was extracted with 4% oxalic acid and then titrated against the dye until pink colour develops. Similarly a blank is also developed.

2.4Air Pollution Tolerance Index (APTI) Determination

This was done following the method of [11]. The formular of APTI is given as
APTI= [A (T+P) + R] / 10.
Where: A=Ascorbic acid content (mg/kg)
T=Total chlorophyll (mg/kg)
P=pH of the leaf extract
R=Relative water content

III. Result

Table 1 shows the Biochemical Parameters and APTI values of *T.occidentalis* and *O.gratissimum* for control site and the three different experimental (polluted) sites. The result shows that both plants are sensitive plants with their APTI values ranging from 7.83 to 11.20. Also, the APTI values of the respective plants were significantly higher ($p<0.05$) in experimental site 1 (10.80±0.00), (11.20±0.00); experimental site 2 (10.60±0.00), (11.10±0.00) and experimental site 3 (10.30±0.00), (8.96±0.00) when compared with the control site (10.00± 0.01), (7.83±0.05) indicating that the plants from the experimental sites are exposed to Air pollutants.

Table 1: Air Pollution Tolerance Index (APTI) values of *T. occidentalis* and *O.gratissimum* for control site and respective experimental sites (mean ± SD)

SPECIES	GROUPS	pH	RWC (%)	TCh (mg/g)	AA (mg/g)	APTI	APTI increase (%)
T.occidentalis	**CS**	6.07±0.11	92.25±0.50	5.54±0.01	0.68±0.01	10.00±0.00	0.00±0.00
	ES 1	5.92±0.00^{a}	104.00±0.01^{a}	1.85±0.00^{a}	0.52±0.00 ^{a}	10.80±0.00^{a}	8.00±0.00^{a}
	ES 2	5.89±0.00 ^{a,b}	101.00±0.00^{a,b}	2.94±0.00^{a,b}	0.55±0.00 ^{a,b}	10.60±0.00 ^{a,b}	6.00±0.00 ^{a,b}
	ES 3	6.01±0.02 ^{a,b,c}	97.00±0.00 ^{a,b,c}	4.92±0.00 ^{a,b,c}	0.63±0.00^{a,b,c}	10.30±0.00	3.00±0.00 ^{a,b,c}
	P- VALUE	0.001*	0.000*	0.000*	0.000*	0.000*	0.002*
O.gratissimum	**CS**	5.42±0.01	75.75±0.96	4.41±0.01	0.26±0.05	7.83±0.05	0.00±0.00
	ES 1	4.59±0.00^{a}	109.00±0.00^{a}	2.71±0.00^{a}	0.41±0.00 ^{a}	11.20±0.00^{a}	43.00±0.00^{a}
	ES 2	5.20±0.00 ^{a,b}	107.00±0.00^{a,b}	3.00±0.00^{a,b}	0.32±0.00 ^{a,b}	11.10±0.00 ^{a,b}	41.80±0.00 ^{a,b}
	ES 3	5.32±0.00 $^{a\ b,c}$	86.00±0.00 $^{a\ b,c}$	3.86±0.00 ^{a,b,c}	0.39±0.00$^{a\ b,c}$	8.96±0.00 $^{a\ b,c}$	14.4±0.00 $^{a\ b,c}$
	P- VALUE	0.000*	0.000*	0.000*	0.047*	0.000*	0.000*

* Mean difference significant at P ≤0.05, a – Significantly different from control site, b - Significantly different from Site 1, c- Significantly different from Site 2

Table 2 shows the Comparison of Air Pollution Tolerance Index (APTI) values of *T.occidentalis* and *O. gratissimum*for the mean experimental (polluted) sites and the control sites respectively. Thepercentage APTI increase of*T.occidentalis* (5.67±2.15%)was significantly lower ($p<0.05$) than that of*O.gratissimum* (33.07±13.80%). Indicating that *Telfairia occidentalis* is more tolerant to Air pollution

Table2: Comparison of Air Pollution Tolerance Index (APTI) values of *T.occidentalis* and *O.gratissimum* for Control and Mean experimental sites (Mean±SD)

	Mean of the Experimental Sites			Control Sites		
Parameter	T.occidentalis	O.gratissimum	P-value	T.occidentalis	O.gratissimum	P-value
pH	5.94±0.05	5.04±0.33	.000*	6.72±0.01	5.42±0.00	.000*
RWC(%)	100.67±2.99	100.67±10.87	1.000	92.01±0.01	75.75±0.01	.000*
TCh(mg/kg)	3.24±1.33	3.19±0.51	.911	5.53±0.01	4.41±0.01	.000*
AA (mg/kg)	0.57±0.05	0.37±0.04	.000*	0.68±0.01	0.25±0.01	.000*
APTI	10.57±0.21	10.42±1.08	.653	10.01±0.01	7.83±0.01	.000*
APTI increase (%)	5.67±2.15	33.07±13.80	.000*	0.00±0.00	0.00±0.00	NA

* Mean difference significant at P ≤0.05 NA- Not Applicable

IV. Discussion

The results demonstrates that plants in experimental sites retained more water than those at the control site with the relative water content (RWC) of both plants in all the experiment (polluted) sitesbeing significantly higher than those in the control site. This is comparable with what is obtained in a similar studywhich reported that there is significantly higher level of relative water content in the plants in the polluted site than the unpolluted siteprobably because the plants at the polluted site absorb more water as an adaptive feature which helps in maintaining its physiological balance under stress condition of air pollution when transpiration rates are high [14]. It might also be an indication that the pollutants absorbed by the plant are hydrophilic hence enabling the plant to retain more water[4].

A reduction in the pH of the leaf extract was observed in the plant species from the experimental sites with respect to the control site. This is indicative of acidic contaminants [16]. However, the pH values of *O. gratissimum* were lower than those for *T.occidentalis*. Plants with lower pH are more susceptible while those with higher pH are more tolerant and accumulate pollutants more [4], [11].

The ascorbic acid (AAC) content of *Telfairia occidentalis* was found to be lower in the experimental sites when compared to the control site. Lower ascorbic acid contents are therefore associated with lower pH of the leaf. Ascorbic acid is a strong reductant which plays a role in cell wall synthesis, defense and cell division and its reducing power is directly dependent on its concentration [7]. However it's reducing activity is pH dependent, being more at higher pH levels. A shift in cell sap pH towards the acid region might diminish the conversion of hexose sugar to ascorbic acid [17].

The result shows that for the two plants selected for this study, there was a higher total leaf chlorophyll (TCh) in the control site than in the experimental sites. One of the most common impacts of air pollution is the gradual loss of chlorophyll with an attendant leaf chlorosis which may be associated with a resultant decline in photosynthetic capacity [8]. The reduction in total chlorophyll might be as a result of the effect on the degradation of chlorophyll to phaeophytin caused by the replacement of magnesium ions from the chlorophyll molecule with heavy metals [18]. Degradation of photosynthetic pigment has been widely used as an indicator of air pollution [10]. The TCh in the two plants varies with different sites. This could be as a result of difference in the pollution status with experimental site1 showing least TCh contents for both plants indicating that the site could be more polluted than the other sites. Certain air pollutants have been reported to reduce chlorophyll content [6], [10], [11], [16].

The entire APTI results obtained from this study reveals that both plants are sensitive plants with their APTI values ranging from 7.83 to 11.20 and the two plants responded differently to air pollution, hence the variation in the indices. It was observed that plants growing in the experimental (polluted) sites have significantly higher APTI values than those in the control site with experimental site 1presenting with the highest APTI values for both plants. This is in agreement with other studieswho reported an increase in APTI values in polluted sites when compared to the control sites[19], [20]. This may be due to exposure of these plants to particulate matter emitted from industrial activities in the vicinity were these plants are grown. *Telfairia occidentalis* was found to be more tolerant than Ocimium gratissimum which is more sensitive since it had a significantly lower percentageAPTI increase in the experimental sites. This is in line with what is obtained in a similar study where*O. gratissimum* was reported as the most sensitive plant among ten Nigerian plants studied[4].

V. Conclusion

Findings from the present study suggest that plants growing in industrial sites have significantly higher APTI values than those in the control site, indicating that they are under pollution stress. The APTI values for both plants reveals that *Ocimium gratissimum* is more sensitive to pollution than Telfairia occidentalis which is more tolerant implying that consumption of T. occidentalis from polluted sites may be more deleterious to health than consuming *O. gratissimum* because they accumulate pollutants more. Higher APTI values with a corresponding reduced Total chlorophyll composition recorded for both plants within experimental site 1in comparison to the other experimental sites is an indication that effluents from industries that manufacture Lead-acid battery may have more hazardous effect on edible plants.

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