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Air Pollution Tolerance Indices of Vegetables around Abattoirs within Uyo Municipality, Niger Delta Region of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author EUD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GAE and UEU managed the analyses of the study. Authors EUD and GAE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Four common biochemical constituents of some vegetable leaves sourced from some abattoir waste – impacted soils and a Control within Uyo Metropolis in Niger Delta Region of Nigeria were assessed for their air pollution tolerance capacities using standard analytical protocols. Results indicated varied amounts of biochemical constituents in studied leaves with respect to the different abattoir soils with some constituents showing direct relationship with another. Biochemical constituents analyzed were higher in leaves from the Control soil than in the leaves from the studied abattoir soils except for relative water content. Tolerance levels of the leaves based on Thakar's and Padmavathi's categorizations revealed varied tolerance capacities of the tested leaves towards air pollution. Correlation analysis of the biochemical constituents of the studied leaves using Pearsons' correlation analysis showed variable relationships.

Keywords: Abattoir; abattoir waste-impacted soil; air pollution tolerance index; air pollution; biochemical constituents.

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1. INTRODUCTION

Abattoirs are places assigned for the processing of meat and meat products. Abattoir wastes are unwanted materials generated during the processing of meat from slaughtered animals [1]. These abattoir wastes contain various amounts of organic and inorganic substances including toxic metals, faeces, bacteria, cellulose fibre and paunch manure [2]. These wastes are disposed on the soil and water environments around the abattoirs owing to lack of operational regulations concerning wastes disposal and management methods in abattoirs within Nigeria. Consequently, pollutants in these wastes interact with the environment including air causing different kind of contamination and subsequent pollution depending on the over time. In Uyo, Akwa Ibom State, local farmers usually cultivate these farmlands with vegetables due to their high levels of nutrients needed for plant growth [3]. Depending on some environmental conditions including variations in the species of these vegetables, there exist varied levels of responses of their leaves towards the accumulation of biochemical constituents such as water content, total chlorophyll, ascorbic acid, cellulose, proline, and even hydrogen ions. Several authors have reported on the influences of environmental pollutants on levels of biochemical constituents of plants [4-6]. Variations in biochemical responses of plants usually leads to different capacities in withstanding air pollution occasioned by these environmental pollutants. Changes in any of these biochemical constituents of plants affect their tolerance ability towards air pollution. The use of pH, relative water content, total chlorophyll and ascorbic acid to compute air pollution tolerance indices of leaves have already been reported by Singh et al. [7]. The studied vegetables were chosen since they are common around these abattoirs and are widely consumed in the study area. Thus; their air pollution tolerance indices should be examined to ascertain their suitability for consumption as the air environment around abattoirs are highly contaminated [8].

This work seeks to assess the air pollution tolerance indexes of common vegetable leaves cultivated on abattoir-wastes impacted soils within Uyo Municipality. Thus, the capability of each of the studied vegetables to tolerate air pollutants shall be exposed. The results of this work shall also help in understanding the air pollution status of the studied locations.

2. MATERIALS AND METHODS

2.1 Study Areas

Vegetable leaves were collected at four Abattoirs within Uyo Municipality, Niger Delta Region of Nigeria. The sample locations and their coordinates are presented in Table 1.

2.2 Collection of Vegetable Sample Specimen

Fresh leaves of Telfaira *occidentalis* (Hook F.), *Talinum triangulare* (Jacq.), *Amaranthus hybridus* L., and *Ociumum gratissimum* L. were collected around the four mentioned abattoirs within Uyo municipality using stainless knife. Samples collection was done in the morning hours between 8:30 am – 9:30 am. Vegetable leaves were also collected from the Botanical Garden of the University of Uyo, Uyo, and used as the Controls. Both the studied leaves and Controls were well labelled, packed into a cooler and taken to the Department of Botany and Ecological Studies, University of Uyo for authentication and specimen referencing before transporting the samples to the laboratory. Voucher specimens have been stored in the Herbarium of the Department of Botany and Ecological Studies, University of Uyo, Uyo, Nigeria.

Table 1. Sample location and coordinates

S/N	Location	Coordinates
1	Itam abattoir (ITA)	Lat 50°02! N – 50°03! N and Longitude 70°53! E – 70°54! E
2	Calabar –Itu abattoir (CIA)	Lat 50°04! N – 50°05! N and Longitude 70°55! E – 70°56! E
3	Uyo village abattoir (UVA)	Lat 50°03! N – 50°04! N and Longitude 70°56! E – 70°58! E
4	Uyo-Ik ekpene rd abattoir (UIA)	Lat 50°06! N – 50°08! N and Longitude 70°48! E – 70°49! E
5	Control (Ctrl)	Lat 50°05! N – 50°06! N and Longitude 70°54! E – 70°55! E

Table 2. Details of the studied vegetables

Scientific name	English name	Ibibio name	Brief description
Telfairaoccidentalis	Fluted Pumpkin	Ikong Ubong	Perennial climbing plant producing vigorous herbaceous stems that can be 1.5 m or more long. They scramble over the ground clambering onto other plant where they support themselves by means of tendrils [9].
Talinumtriangulare	Water Leaf	Mmonmong Ikon	Herbaceous perennial plant that normally has its stem above ground. The seed sprouts as a tiny, aqua-colored plant before growing into a more conscious plant with larger leaves. The leaf is sticky when cut due to high pectin [10].
Amaranthus hybridus	African Spinach	Inyang afia	Large erect annual herb reaching up to 2 – 3m, frequently reddish tinted throughout. The stems are longitudinally grooved a ridged, and slightly hairy. The leaves are simple and alternate with a grooved petiole, ovate, smooth and undulate along margins [9 and 11].
Ociumum gratissimum	Clove basil	Ntong	Is an herbaceous shrub, 1-3 m tall with erect stem, round –quadrangular, much branched at the base. Leave opposite, petiole (2 – 4.5m), slender, pubescent, blade elliptical to ovate, base cuneate and apex acute pubescent [10].

2.3 Sample Specimen

The leaves of four (4) vegetables commonly consumed in Akwa Ibom State, Nigeria were used for this study. The vegetables are: *Telfaira occidentalis* (Hook F.)*, Talinum triangulare* (Jacq.)*, Amaranthus hybridus* L.*,* and*Ociumum gratissimum* L. The Ibibio and English names of the vegetables including their brief descriptions are presented in Table 2.

3. BIOCHEMICAL CONSTITUENTS ANALYSIS OF VEGETABLELEAVES

3.1 Determination of Relative Water Content

Relative water content (RWC) of vegetable leaves was determined using the method of Singh et al. [7] Nwaogwugwu et al. [12]. Fresh weight (FW) of the leaves were immersed in distilled water overnight, blotted dry and the weighed to obtain the turgid weight (TW). The leaves were dried overnight in an oven at 70°C and reweighed to obtain the dry weight (DW). Relative water content of each leave was calculated using equation (1) below

$$Relative water content (\%) = \frac{FW-DW}{TW-DW} \times 100 \quad (1)$$

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

3.2 Determination of pH of Leaf Extract

Five (5) grams of each fresh leaf was homogenized in 10 ml distilled water. They resulting mixture was filtered and the pH of the leaf extract was determined using a pH meter after calibration with buffer solution of pH 4 and 9.

3.3 Determination of Total Chlorophyll Content

Chlorophyll contents of the leaves was determined using the method of Mukherjee et al.[13] and Lichtenthaler [14]. About 1.0 g of each of the fresh leaf was blended with a little quantity of distilled water and extracted with 10 ml of 80% (v/v) acetone and left for 15 minutes. The liquid portion was decanted into another test tube and centrifuge for 3 minutes. The supernatant was collected and 1 ml of the solution was used to determine the amount of chlorophyll. The absorbance of the extract was measured at 663 nm and 645 nm with UV/visible spectrophotometer using cell with 1 cm path against 80% (v/v) acetone blank. The levels of chlorophyll A, B, and total chlorophyll (A+ B) in the leaves extracts was calculated using equations (2), (3), and (4), respectively.

$$Chlorophyll A \left(\frac{mg}{g}\right) = \left(\frac{Absorbance\ @\ 663\ nm - Absorbance\ @\ 645\ nm}{1000W}\right) \times V \quad (2)$$

$$Chlorophyll B \left(\frac{mg}{g}\right) = \left(\frac{Absorbance\ @\ 645\ nm - Absorbance\ @\ 663\ nm}{1000W}\right) \times V \quad (3)$$

Total chlorophyll in the leaves extracts= Chlorophyll A +Chlorophyll B (4)

Where W = Fresh weight of leaf sample taken in grams, and V = Volume of leaf extract.

3.4 Determination of Ascorbic Acid

Concentration of ascorbic acid in leaves was estimated using spectroscopic method. About 1 g of fresh leaf each was placed in a test tube, 4 ml oxalic acid-EDTA extracting solution was added. The resulting solution was then added to 2 ml ammonium molybdate followed by 3 ml distilled water. The resulting mixture was allowed to stand for 15 mins before measuring its absorbance at 760 nm with UV/visible spectrophotometer using cell with 1 cm path length. The concentration of ascorbic acid in the studied leaves was then extrapolated using calibration curve prepared using different concentration of pure ascorbic acid [15].

3.5 Computation of Air Pollution Tolerance Indexes (APTI) of Studied Leaves

Air pollution tolerance indices of studied vegetable leaves were computed using four biochemical constituents of the leaves (relative water content, pH, total chlorophyll content and ascorbic acid) as described in details by Singh et al.[7] using the equation (5) below.

$$APTI = [A(T+P)] + \frac{R}{10} \quad (5)$$

Where A = Ascorbic acid; T = Average total chlorophyll; P = Leaf extractable pH; R = % Relative water content and 10, a factor to obtain a reasonable value from the aggregate whole.

3.6 Interpretation of Tolerance Levels of Studied Leaves

Tolerance levels of the leaves from each abattoir and the Control were carried out using the APTI values. Two categorizations approach by Thakar and Mishra [16] and Padmavathi et al. [17] were used. In Thakars' approach, APTI of the studied leaves were compared with mean APTI of allthe vegetables alongside with its standard deviation [16], while for the Padmavathi's approach, APTI values of the leaves were compared to three absolute values [17]. Table 3 summarizes these classifications.

4. RESULTS AND DISCUSSION

4.1 Biochemical Constituents of Studied Vegetables

Results for the relative water content, pH, total chlorophyll and ascorbic acid contents of the four (4) studied vegetable leaves are presented in Table 4.

Based on the results in Table 4, the studied vegetable leaves showed marked variations in biochemical constituents compared to their Controls. There was a significant relationship between constituents, this is an indication of a negative impact of abattoir wastes on the environment.

Results of pH for all the studied vegetables ranged from 4.73 in *Ocimum gratissimum*at Calabar – Itu Abattoir to 5.84 in *Telfaira occidentalis* obtained from Uyo – Ikot Ekpene Road Abattoir. The pH reported for the studied vegetables is lower than 8.00 – 8.34 obtained by Sunday et al. [18], but higher than 4.28 – 5.21 reported by Tawo et al. [19]. The pH range of the control vegetables (6.84 – 7.01) was higher than the pH range obtained for the studied leaves. This is consistent with the findings by Zamble et al. [20] and Ogagaoghene [21] in similar studies. The study has also revealed that, the pH of the studied leaves was acidic whereas, the pH range of the Controls ranged from slightly acidic to a neutral pH. The observed variations in pH levels between the studied leaves and their controls could be attributed to the negative impacts of abattoir wastes on the studied environment. The pH of the leaves of the studied vegetables varied as follows: *Telfaira occidentalis* > *Talinum triangulare* > *Amaranthus hybridus* > *Ocimum gratissimum.* Thus; indicating the highest pH level in the leaves of *Telfaira occidentalis* and the lowest in *Ocimum gratissimum.*

Results of the relative water contents of the studied vegetable leaves and their controls are shown in Table 4. The general results indicated a range of 16.52% in leaves of *Amaranthus hybridus* from Itam Abattoir to 36.18% in *Talinum triangulare* from calabar-Itu Road Abattoir. The obtained range is higher than 12.45 -15.82% reported by Iheanacho and Udebuani [22] but lower than 67.63 – 86.70% obtained by Akande et al. [23]. It was also observed that, the relative water contents of the studied vegetable leaves were significantly higher than in leaves from the control site. This is in agreement with the results obtained by Dan et al. [3] in their research. This could be the influence of abattoir wastes on the studied soil through the soil – plant transfer process [24]. It has been reported that the undigested materials in the first stomach of animals (paunch) which is normally disposed of on the soil environment contain as high as 88% of moisture [2]. The relative water content of a plant is usually used for the determination of the water holding capacity of a plant which will indicate whether a plant is stress or not [25]. However, the variations in the water holding capacity of plants could also be as a result of some physiological processes such as turgor pressure, stomatal conductance, transpiration, and photosynthesis in the leaves [26]. On the

Table 3. Classifications of tolerance levels by leaves

	Categorizations	
Tolerance level	**Thakar and Mishra's**	**Padmavathi's**
Tolerant	Leaf APTI value > mean APTI + SD	Leaf APTI value > 17
Moderate tolerant	Leaf APTI value lies between mean APTI and mean APTI + SD	NA
Intermediate	Leaf APTI value lies between mean APTI and mean APTI – SD	Leaf APTI value lies between 12 and 16
Sensitive	Leaf APTI < mean APTI	Leaf APTI < 12

SD = Standard deviation, NA = Not applicable, APTI – Air pollution tolerance index

Table 4. Biochemical constituents of the studied vegetable leaves and their Controls

	Telfaira occidentalis				***Talinum triangulare***				***Amaranthus hybridus***				***Ocimum gratissimum***			
	pH	**RWC (%)**	**TCh (mg/g)**	**AA (mg/g)**	**pH**	**RWC (%)**	**TCh (mg/g)**	**AA (mg/g)**	**pH**	**RWC (%)**	**TCh (mg/g)**	**AA (mg/g)**	**pH**	**RWC (%)**	**TCh (mg/g)**	**AA (mg/g)**
ITA	5.43	24.43	3.21	6.05	5.62	30.62	2.83	4.02	5.52	16.52	1.98	4.47	5.38	28.46	1.09	4.90
CIA	4.86	33.40	1.84	3.63	4.93	36.18	1.63	3.43	4.81	22.58	1.28	4.26	4.73	30.05	1.87	5.22
UVA	5.12	29.41	2.37	4.44	5.24	28.41	3.26	4.16	5.29	27.63	3.64	5.18	5.41	34.63	2.06	5.68
UIA	5.84	18.64	4.08	6.83	5.76	19.28	4.29	7.64	5.40	18.67	4.07	7.03	5.26	20.18	3.25	8.16
Min	4.86	18.64	1.84	3.63	4.93	19.28	1.63	3.43	4.81	16.52	1.28	4.26	4.73	20.18	1.09	4.90
Max	5.84	33.40	4.08	6.05	5.76	36.18	4.29	7.64	5.52	27.63	4.07	7.03	5.41	34.63	3.25	8.16
Mean	5.31	26.47	2.85	5.24	5.39	28.62	3.00	4.82	5.26	21.35	2.74	5.24	5.19	28.33	2.07	5.99
SD	0.42	4.38	0.96	1.46	0.37	5.04	0.21	1.05	0.31	2.84	0.36	1.05	0.32	3.03	0.21	1.07
Ctrl	6.84	10.74	6.21	8.63	6.92	14.15	5.23	13.45	7.01	15.44	5.84	11.04	6.89	11.65	4.96	10.24

RWC – Relative water content, TCh – Total chlorophyll, AA – Ascorbic acid; ITA – Itam Abattoir; CIA- Calabar-Itu Abattoir, UVA – Uyo village Road Abattoir, UIA-Uyo Ikot Ekpene Road Abattoir; SD – Standard deviation; Ctrl – Control whole, water retention capacity of the studied vegetables followed the order: *Ocimum gratissimum* >*Telfaira occidentalis*>*Talinum triangulare* > *Amaranthus hybridus.* This indicates that among the studied vegetables, *Ocimum gratissimum* had the highest capacity to retain water while *Amarathus hybridus* had the lowest.

Table 4 indicates the results for the total chlorophyll accumulation by the leaves of studied vegetables and their controls. The results revealed a high degree of variability in the rate of chlorophyll accumulation among the studied vegetables. The general range for total chlorophyll in the leaves of the studied vegetables varied from 1.09 mg/g fresh weight (FW) in *Ocimum gratissimum* from Itam Abattoir to 4.29 mg/g FW in *Talinum triangulare* obtained from Uyo-Ikot Ekpene Road Abattoir. This range of total chlorophyll is consistent with 2.70 – 4.25 mg/g obtained by Falusi et al. [27] but lower than 7.00 – 12.25 mg/g reported by Adetuyi et al. [28]. The results indicated a higher range of total chlorophyll (4.96 – 6.21 mg/g) for the leaves from the Control plot. This is similar to the results in studied vegetables and Control by Falusi et al. [27] during their research. This could be attributed to the difference in soil contaminants between the studied soils and Control which might directly affect the rate of photosynthesis and some biochemical constituents of plants [29,30]. The variations of total chlorophyll contents in plant leaves from soils impacted by different pollutants has also been reported by Chauhan and Joshi [31] and Igbal et al. [32]. The total chlorophyll contents of the studied vegetables followed the order: *Talinum triangulare* >*Telfaira occidentalis*>*Amaranthus hybridus* > *Ocimum gratissimum.* Accordingly; for all the vegetable leaves from the studied locations, the highest total chlorophyll content was obtained in *Talinum triangulare* while the lowest was in *Ocimum gratissimum.*

The concentration of ascorbic acid in the leaves of the studied vegetables and their Controls are indicated in Table 4. The overall results revealed a range of 3.43 – 8.16 mg/g FW for ascorbic acid with the highest level in *Ocimum gratissimum* from Uyo – Ikot Ekpene Road Abattoir while the lowest was in *Telfaira occidentalis* collected from Calabar-Itu Abattoir. This range is higher than 0.09 – 0.15 mg/g reported by Agbaire and Esiefarienrhe [33], but lower than 19.32 – 86.51 mg/g obtained by Abdulrazak et al. [34] in their respective studies. The results obtained also revealed a higher range of ascorbic acid (8.63 – 13.45 mg/g) in the Controls than in the studied vegetables. The observed variations between these locations is in agreement with the findings by Tanee and Albert [35]. According to Singh et al. [7], the observation could be as a consequence of some factors such as waste compositions, ecological and environmental factors, and age differences of the leaves. It has also been reported that higher levels of ascorbic acid in plants favours the air pollution tolerance capacity in plants [7]. Reports have shown that acidic nature of pollutants usually lead to a shift in the pH of the cell sap to an acidic zone which eventually causes a decrease in the conversion of hexose sugar to ascorbic acid in plants [36]. Hence, the pH of the studied vegetables indicated a direct relationship with the ascorbic acid and total chlorophyll contents of the plants. The pH levels of the studied vegetables were higher than 3.5 and this results in the super radicals undergoing dismutation to hydrogen peroxide with ascorbic acid protecting the chlorophyll from possible damage that would have been induced by the peroxide. Thus, the observed direct relationship between ascorbic acid and total chlorophyll contents in leaves of the studied vegetable [37].

4.2 Air Pollution Tolerance Indexes of Studied Leaves

To assess the capacity of vegetable leaves from abattoir soils within Uyo Municipality, Niger Delta Region of Nigeria to withstand and battle against air pollution that may have been occasioned by the discharged of abattoir wastes on soils, air pollution tolerance index (APTI) of the leaves were computed and the results are presented in Table 5.

The results presented in Table 5 indicate significant variations in APTI values of studied leaves. Generally, the APTI for the studied leaves varied between 12.53 in *Amaranthus hybridus* from Calabar – Itu Road Abattoir and 40.46 in *Talinum triangulare* at Uyo-Ikot Ekpene Road Abattoir. This range is consistent with those reported by Legheri et al. [38] and Lohe et al. [39]. However, APTI values in the leaves from the Control plot ranged from 58.85 in *Ocimum gratissimum* to 78.68 in *Talinum triangulare.* Consequently, the APTI values in leaves from the Control plot were higher than those obtained in the leaves of the studied vegetables. This is in agreement with the results obtained by Lohe et al. [39]. The observed variations could be

Table 5. Tolerance levels of the studied leaves from the different abattoirs and control

			Telfaira occidentalis	*Talinum triangulare*	*Amaranthus hybridus*	*Ocimum gratissimum*
ITA		APTI	38.50	20.09	16.02	13.57
	Class of tolerance	TMA	Tolerant	Sensitive	Sensitive	Sensitive
		PA	Tolerant	Tolerant	Tolerant	Intermediate
CIA		APTI	14.88	14.14	12.53	17.49
	Class of tolerance	TMA	Sensitive	Sensitive	Sensitive	Sensitive
		PA	Intermediate	Intermediate	Intermediate	Tolerant
UVA		APTI	18.58	21.64	26.91	20.57
	Class of tolerance	TMA	Sensitive	Sensitive	Sensitive	Sensitive
		PA	Tolerant	Tolerant	Tolerant	Tolerant
UIA		APTI	35.57	40.46	35.88	33.80
	Class of tolerance	TMA	Tolerant	Tolerant	Tolerant	Tolerant
		PA	Tolerant	Tolerant	Tolerant	Tolerant
CTRL		APTI	61.50	78.68	73.02	58.85
	Class of tolerance	TMA	Tolerant	Tolerant	Tolerant	Tolerant
		PA	Tolerant	Tolerant	Tolerant	Tolerant

ITA = Itam Abattoir; CIA = Calabar-Itu Abattoir, UVA = Uyo village Road Abattoir, UIA = Uyo Ikot Ekpene Road Abattoir; CTRL = Control; APTI = Air pollution tolerance index; TMA = Thakars' & Mishra's Approach; PA = Padmavathi's Approa

attributed to the disparity in the biochemical constituents of the leaves from the studied abattoirs and the Control plot. This result has also indicated that *Talinum triangulare* had relatively high APTI values at both the studied abattoir soils and Control.

4.3 Categorization of Air Pollution Tolerances of Studied Leaves

To determine the tolerance capacities of studied vegetable leaves from abattoirs and Control soils, two approaches namely Thakar's and Padmavathi's were used as reported by Uka et al. [25]. Based on Thakar and Mishra's Approach, vegetable leaves from Itam, Calabar – Itu road, and Uyo – Village road abattoirs except *Telfaira occidentalis* from Itam abattoir recorded APTI values lower than the mean APTI (32.63). This is an indication that these vegetables were sensitive to air pollution caused by the waste products generated at these abattoirs. Nevertheless, vegetable leaves obtained from Uyo-Ikot Ekpene Road Abattoir and Control were tolerant to air pollution as their individual APTI value was higher than the mean APTI value of the studied leaves. Literature has shown that Thakar and Mishra's Approach is effective in identifying comparative tolerant species by comparing the tolerance grade between plants under same environment disregarding how tolerant the studied species is [40]. Padmavathi's approach as opposed to Thakar's uses only three absolute APTI value in the selection of true tolerant plant species. Based on this approach, all the studied vegetable leaves except *Ocimum gratissimum* from Itam Abattoir, and *Telfaira occidentalis*, *Talinum triangulare* and *Amaranthus hybridus* from Calabar – Itu Abattoir were tolerant to air pollution because their APTI values were greater than 17 [12]. The study has shown some variations in the tolerance potential of some of the studied vegetables as a consequence of difference in the classification methods as reported by Uka et al. [25]. Based on Padmavathi's Approach, all the studied vegetables except *Ocimum gratissimum* from Itam, and *Telfaira occidentalis*, *Talinum triangulare* and *Amaranthus hybridus* from Calabar – Itu abattoir could be exploited in mitigating air pollution. Whereas, vegetables showing intermediate tolerant could be used as biomarkers of air pollution [41]. All the studied vegetable leaves from the abattoirs except *Ocimum gratissimum* from Itam, and *Telfaira occidentalis*, *Talinum triangulare* and *Amaranthus hybridus* from Calabar – Itu abattoir can be regarded as tolerant vegetables based on Padmavathi's approach and can be exploited in mitigating pollution in the studied areas, while vegetable leaves showing intermediate tolerant can be used as biomarkers of air pollution [41]. Based on Thakar and Padmavathi's Approaches, vegetables from Itam, Calabar- Itu, and Uyo – village Road Abattoirs except *Telfaira occidentalis* from Itam should be used as air pollution indicators for air pollution monitoring. Hence, they are more likely to be adversely affected by air pollutants from wastes generated from these abattoirs since they are less resistance to air pollution [42].

4.4 Correlation Coefficient between Biochemical Constituents in the Studied Leaves

Results in Table 6 show the Pearson's correlation matrix of the biochemical constituents determined in the studied leaves.

Table 6. Pearson's correlation coefficients for the biochemical constituents in the studied leaves

Variables	pH	RWC	TCh	AA
Ph	1.000			
RWC	-0.868*	1.000		
TCh	0.987*	-0.842*	1.000	
AA	0.996*	-0.746**	0.997*	1.000

**Correlation is significant at the 0.05; **Correlation is significant at the 0.010 level (2 tailed); RWC – relative water content; TCh – total chlorophyll; AA –ascorbic acid*

The results in Table 6 indicate significant negative correlation for pH and relative water content with r value of -0.868 at $P < 0.05$. Whereas, pH correlated with total chlorophyll and ascorbic acid of the studied leaves positively and significantly with r values of 0.987 and 0.996, respectively at $P < 0.05$. Accordingly, the level of pH in the studied leaves might have been inversely proportional to those of relative water contents but directly proportional to the levels of total chlorophyll and ascorbic acid. Consequently, higher level of pH in the studied leaves may result in a corresponding decrease in the relative water contents but increase in both total chlorophyll and ascorbic acid. However, this could be altered by the environmental factors and other biochemical compositions of the plants. The results have also shown that relative water contents of the studied leaves correlated negatively and significantly with total chlorophyll and ascorbic acid with r values of -0.842 and -0.746 at $P < 0.05$ and 0.10, respectively. Thus, higher levels of relative water contents might result in a significant decrease in total chlorophyll and ascorbic acid and vice versa. Total chlorophyll contents of the studied leaves showed a strong positive relationship with ascorbic acid. Hence, an increase in total chlorophyll contents of the studied leaves could result in a corresponding increase in ascorbic acid and vice versa. The observed strong positive correlations of the biochemical constituents of the studied leaves could also be an indication of their common source [43,44].

5. CONCLUSION

Vegetable leaves from some abattoirs within Uyo Municipality accumulated varying amounts of biochemical constituents as a result of differences in the rate in which some physiological processes occur including varietal differences of the studied plants. The differences in amounts of biochemical constituents leads to differences in tolerance capacities levels of studied leaves towards air pollution. Air pollution tolerance indices of all the leaves from Uyo – Ikot Ekpene abattoirs and the Control indicated that the leaves were tolerant to air pollution, while leaves from other studied abattoirs were sensitive based on Thakar's approach. This means that the vegetable leaves might have been affected by air pollution from abattoir wastes deposition on the soils. In terms of Padmavathi's approach, the studied leaves from all the locations and the Control were tolerant to air pollution although, some indicated moderate tolerance levels. However, routine assessment of vegetable leaves and other plants in these locations to monitor the changes in biochemical constituents is encouraged. The outcome could be useful in identifying effective bio-indicators plants for estimating air pollution status of an area and the tolerance level of these plants in a contaminated/polluted environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bandaw T, Herago T. Review on Abattoir Waste Management. Global Veterinaria, 2017;19(2):517-524.
2. Ezeoha SL, Ugwuishiwu BO. Status of abattoir waste research in Nigeria. Nig., Journal of Tech. 2011;30(2):143–148.
3. Dan E, Fatunla K, Shaibu S. Influence of Abattoir wastes on soil microbial and physicochemical properties. Asian Journal of Chemical Science, 2018;5(1):1–17.
4. Klumpp G, Furlar CM. Responses of stress indicator and growth parameters of Tibouchina Pulchra Cogn exposed to air and soil pollution near the industrial complex of Lubatoa, Brazil. The Science of the Total Env. 2000;246:79–91.

5. Flowers MD, Fiscus E, Bassey K. Photosynthesis, Chlorophyll Flourescene and Yeild of Bnap Bean Genotypes differing in sensitivity to Ozone. Env., and Expt. Botany, 2007;61:190–198.
6. Hoque MA, Banu MN, Oluma E. Exogenous proline and glycinebetaine increase NaCl-induced ascorbate – gluthione cycle enzyme activities and proline improves salt tolerance more than glycinebetaine in tobacco bright yellow-2 suspension-cultural cell. Journal of Plant Physiology, 2007;164:1457–1468.
7. Singh SK, Rao DN, Agrawal M, Pande J. Air pollution tolerance index of plant. J. Env. Manag. 1991;32:45–55.
8. Salama KF, Berekaa, MM. Assessment of air quality in Dammam slaughter houses, Saudi Arabia. International Journal of Medical Science and Public Health. 2016; 5(2):287–291.
9. Kayode, R. (2011). Some medicinal values of *Telferia occidentalis*: A review. American Journal of Biochemistry and Molecular Biology. 2011;1(1):30–38.
10. Aletor MV, Adeogun OA. Nutrient and anti-nutrient component of some tropical leafy vegetable. Food Chem., 1995;53:375–389.
11. Williams IO, Parker RS, Swanson J. Vitamin A content of South Eastern Nigerian vegetable dishes, their consumption pattern and contribution to vitamin A requirement. Pak. J. Nutr. 2009; 8(7):1000-1004.
12. Nwaogwugwu CJ, Nosiri CI, Uhegbu FO, Atasie OC. Air pollution tolerance index of some medicinal plants around Oil – Producing Community of Asah, Abia State, Nigeria. Int'l Journal of Scientific and Eng. Research, 2017;8(6):747–755.
13. Mukherjee A, Lau CS, Walker CE, Rai AK, Prejean CI, Yates G, et al. Thylakoid localized bestrophin-like proteins are essential for the CO_2 concentrating mechanism of *Chlamydomonas reinhardtii*. Proceedings of the National Academy of Sciences. 2019;116:16915-16920.
14. Lichtenthaler HK. Chlorophylls and carotenoids pigments of photosynthesis membranes. Methods in Enzymology. 1987;148:350-382.
15. Bajaj K, Kaur H. Spectrophotometric determination of ascorbic acid in vegetable and fruits. Analyst. 2008;106:117–120.
16. Thakar B, Mishra P. Dust collection potential and air pollution tolerance index of tree vegetation around Vedante aluminium limited. Jhatsuguda The Bioscan, 2010;3:603-612.
17. Padmavathi P, Cherukuri J, Reddy MA. Impact of air pollution on crops in the vicinity of a power plant: a case study. Int'l J. Eng Res., Technol., 2013;12(2):3641 – 3651.
18. Sunday A, Ehiagbonare J, Nwangwu S. Nutritional Evaluation of some leafy vegetables in Southern Nigeria. Journal of Agric., and Food Science. 2017;21:41–48.
19. Tawo EN, Abara AE, Malu SP, Alobi NO. Evaluation of pH levels in some common carbohydrate food items consumed by communities in the Central Senatorial District of Cross River State, South-South of Nigeria. Pakistan Journal of Nutrition. 2009;8(9):1387-1390.
20. Zamble FB, Djedoux M, Yao SB. Evaluation of air pollution tolerance indices of four ornamental plants arranged along roadsides in Abidjan. International Journal of Environ., Monitoring and Analysis. 2015; 3(3):22–27.
21. Ogagaoghene A. pH level, Ascorbic acid, proline and soluble sugar is bio-indicator for pollution. Chem Search Journal. 2017; 8(2):43–50.
22. Iheanacho KM, Udebuani A. Nutritional composition of some leafy vegetables consumed in Imo State, Nigeria. J. Appl. Sci. Environ., Manage. 2009;13(3):35–43.
23. Akande SA, Inana ME, Ugama EE, Azeke AE, Oledibe CF, Adinu MN. Ascorbic acid retention of freshly harvested seven Nigerian green leafly vegetables after soaking in water. Ruhuna Journal of Science. 2018;9:32–43.
24. Merckk R, Smolder E, Vlassak K. The soil to plant transfer of nutrients: Combining plant and soil characteristics. Plant Nutrition – Physiology and Application. 1998;123:3–8.
25. Uka UN, Ebenezer JD, Jonathan N. Roadside air pollution in a tropical city: physiological and biochemical response from trees. Bulletin of the National Research Centre. 2019;43:90–99.
26. Liu YJ, Ding H. Variation inair pollution tolerance index of plants near a steel factory: Implications for landscape – plant species selection for industrial areas. WSEAS Transactions on Environ., and Development, 2008;4(1):24–32.
27. Falusi BM, Odedokun OA, Abubakar AA, Agoh A.Effect of dumpsite air pollution on

the ascorbic acid and chlorophyll contents of medicinal plants. Environmental Chemistry, Pollution and Waste Mgt. 2016; 2:1 –13.

28. Adetuyi FO, Lola A, Ogundahunsi GA, Ademulegun TI. Storage of blanched vegetable at Temperature -102°C. Nig. Food J. 2009;27:1- 4.
29. Prajapati S, Tripathi BD. Seasonal Variation of Leaf Dust Accumulation and Pigment Content in Plant Species Exposed to Urban Particulates Pollution. Journal of Environmental Quality, 2008;37(3):865–870.
30. Joshi SJ, Swami A. Physiological responses of some tree species under road side automobile pollution stress around city of Haridwar, India, The Environmentalists. 2009;27:365–374.
31. Chauhan A, Joshi PC. Effect of ambient air pollution on photosynthesis pigments on some selected trees in urbanarea. Ecology Environ., and Conversations. 2008;14:23–27.
32. Igbal MZ, Shafig M, Qamar Z, Athar M. Effect of automobile pollution on chlorophyll content of roadside urban trees. Global Journal of Environmental Science and Mgt. 2015;1:283–296.
33. Agbaire PO, Esiefarienrhe E. Air pollution tolerance indices of some plants around Otorogun Gas Plant in Delta State, Nigeria. J. Appl. Sci. Env. Manage., 2009;13(1):11-19.
34. Abdulzarak S, Oniwapele YA, Sulyman YI. Comparative determination of ascorbic acid in some selected fruits and vegetables commonly consumed in Northern Nigeria. Journal of Global Biosciences. 2015;4(3):1 – 5.
35. Tanee FB, Albert E. Air pollution tolerance indices of plant growing around Umuebulu Gas Flare Station in River State, Nigeria. Afr. J. Environ. Sci. & Tech. 2013;7(2):1–8.
36. Agrawal AI. Air pollution control studies and impact assessment of stack and fugitive emissions from Akaltara Cement Factory. Project Report, project sponsored by M/S Akaltara Cement Factory, NEERI, Nagpur, India; 1988.
37. Agrawal M, Singh SK, Singh J, Rao DN. Biomonitoring of air pollution around industrial sites. Journal of Environ., Biology, (Special Issue). 1991;211-222.
38. Legheri SK, Zaidi MA, Ahmed M, Nazim K. Air pollution tolerance index (APTI) of various plant species growing in Quetta city, Pakistan. FUUAST Journal of Biology. 2011;2: 81-86
39. Lohe RN, Tyagi B, Singh V, Kumar PT, Bhutiani A. Comparative study for air pollution tolerance index of some terrestrial plant species., Global J. Environ. Sci. Manage. 2015;1(4):315-324.
40. Zhang P, Liu Y, Yang Z, Zhu M, Li Y. Pollution resistance assessment of existing landscape plants on Beijing streets based on air pollution tolerance index method. Ecotoxicol Environ Saf. 2016;132:212–223.
41. Singh SK, Rao DN. Evaluation of the plants for their tolerance to air pollution proc-symp of air pollution control held at IIT, Delhi, 1983;218–224.
42. Bhattacharya T, Kriplani L, Chakraborty S. Seasonal variation in Air Pollution Index of various Plant Species of Baroda City. Universal Journal of Environmental Research and Technology. 2013;3:199–208.
43. Romic M, Romic A. Heavy metal distribution in agric soil in Urban areas. Env. Geol. 2002;43:795 – 805.
44. Yang Z, Liu W, Long Y, Bao X, Yang Q. Assessment of heavy metals contamination in Urban topsoils from Chanchun City, China. Journal of Geochemical Explor. 2011;108:27-38.

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