ChemSearch Journal 8(1): 34 – 40, June, 2017
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 05/11/2016 Accepted: 15/01/2017
http://dx.doi.org/10.4314/csj.v8i1.5

Study of Air Pollution Using the Leaves of Some Plant Species from Two Cities in Delta State, Nigeria

[1]Akpoghelie, J. O., [1]Irerhievwie, G. O., [2]Emudiobagware, B. U., [2]Ayiwe, C. and [2]Eyenubo, B. O.
[1]Department of Industrial and Safety, Petroleum Training Institute Effurun, Delta State. Nigeria.
[2]Department of Chemistry, Delta State University, P. M. B. 1, Abraka, Nigeria.
Email: comradeogaga@yahoo.co.uk

ABSTRACT

The comparative study of air quality in two cities in the Niger Delta Region of Delta State, Nigeria was investigated. Eleven duplicates of fully matured leaves samples of *Vernonia amygdalina, Magnifera indica, Citrius sinesis, Psidium guajava, Colocasia esculanta L., Anacadium occidentale, Carica papaya L., Elais guinensis, Bambosa Bambosa, Delonix regia* and *Musa paradisiacal L.* cultivated in Agbarho metropolis in Ughelli North local government area and Osubi metropolis in Okpe local government area both of Delta State were randomly collected and analyzed for their ascorbic acid content, water retention capacity, chlorophyll and pH. Data from this study reveals higher relative water and chlorophyll content in experimental site as compared to the control site. This study further reveals that about 82% of plant species collected from the experimental sites showed higher ascorbic acid and pH content. While the air pollution tolerance index values were higher in experimental site as compared to those from the control site, the percentage increase in APTI values in the leaves of the plant species ranges from 5.42 to 26.49. The plant species under investigation shows increasing tolerance to air pollution in the order of *Vernonia amygdalina* (5.42) > *Magnifera indica* (6.54) > *Citrius sinesis* (6.69) > *Psidium guajava* (7.13) > *Colocasia esculanta L.* (7.61) > *Anacadium occidentale* (7.93) > *Carica papaya L.* (11.46) > *Elais guinensis* (16.20) > *Bambosa bambosa* (22.00) > *Delonix regia* (26.01) > *Musa paradisiacal L.* (26.49). Though, this study reveals conflicting results for the individual biochemical parameters to the tolerance of air pollution in both experimental and control sites, combining the various biochemical parameters for computing the APTI values gives more reliable results. Hence, a relationship is not only observed in the accumulation of chemical substance used in determining the extent of damage done by pollution in the leaves of all the plant species under investigation, but a gradient also exist for the individual parameters in the experimental sites as compared to those from the control sites and it is thus reflected in the APTI values recorded from both sites.

Keywords: Air, APTI, Ascorbic Acid, Biochemical, Delta State, Pollution Water retention capacity

INTRODUCTION

Air, elementarily could be defined as the mixture of gases that composes of the atmosphere surrounding earth. It consists of approximately 78% Nitrogen, 21% Oxygen, 0.9% Argon, 0.03% Carbon dioxide, and the remaining 0.07 percent is a mixture of hydrogen, water, ozone, neon, helium, krypton, xenon, and other trace components. Any activities that may alter or lead to the change in concentration of this gaseous mixture in the atmosphere is term pollution. It occurs when substances that are not considered to be a natural constituent of the environment are released into the atmosphere, thus leading to the fluctuation in the atmospheric component (Akpoghelie, *et. al.*, 2016). According to *Irerhievwie, et. al., (2014*), air pollution is defined as any unusual increase or decrease in the concentration of the normal component of the atmosphere. Agbaire and Esiefarienrhe (2009) describe the source of air pollution as mainly anthropogenic, Rai, *et. al.*, (2013) reported the enormous impact air pollution on human health and vegetation. Literature reveals that worldwide epidemiological study on the hazard of air pollution shows that gaseous pollutants and particulate matter has enough potential to cause severe health effect like respiratory, cardiovascular diseases and cardio pulmonary mortality. Pollutants also have direct effect on plant species with the greatest effects on that part of a plant that serves primarily as the plant's food-making organ in a process called photosynthesis, thus resulting to reduced productivity. Liu and Ding (2008) observed the physiological change in the leaves of plant before physical changes appears when exposed to air pollution. These leaf injuries leads to stomata damage, thus leading to reduced photosynthetic activity and reduce growth and yield in sensitive plant species. Since air pollution have adverse effects on both man and plants, it became necessary to investigate the air quality of living things as well as the environment. Thus, the adverse effects of air pollutants on plant could be studied by calculating the index known as air pollution tolerance index (*Irerhievwie, et. al., 2014)*. APTI is based on four biochemical parameters such as ascorbic acid, leaf extract pH, retention water capacity and leaf pigment (chlorophyll). Literature reveals that the combination of the individual biochemical parameters gives a more reliable result in determining the APTI for plant species as compared to individual parameters. Mahecha, *et. al.,* (2013) describes APTI as a tool use for the determination and consideration of the quality and extent of the tolerance as well as the sensitivity of plant species. They further states that it can be used effectively by planners and green belt developers in managing urban pollution. APTI is an accessible method of monitoring air pollutants as well as recommending pollution abatement measures. It is thus a standard quality of plants to measure air pollution stress which is presently of major concern particularly in urban and sub - urban areas, more also, in developing countries. Hence, the APTI of the leaves of plant species cultivated along Agbarho metropolis in Delta State in the Niger Delta region of Nigeria, observed as an experimental site by the researcher is measured and compared with the APTI of the leaves of plant species from composite sites deemed as less polluted or control site. Literature also reveals that plants act as sink to pollutants and thus reduces their concentration in the atmosphere by regulating the amount of pollutant present in the atmosphere. This study owes its significance to the facts that most cities in Delta State, Nigeria is ill planned and is thus characterized with numerous sharp spot popularly called pot holes, thus leading to vehicular traffic; poor drainage system leading to flood during heavy down pour, thus resulting to traffic and the combustion of bones, rubber wheel cover, bush burning among other. Hence, the aims and objectives of this study is to determine the concentration of four biochemical parameter of plant species collected within two semi - urban cities in Delta State, use the individual biochemical parameters to compute the APTI for each plant species obtained from both experimental and control site; attempt to established a gradient for the fluctuation of the results of the individual biochemical parameters obtained for the leaf of plant species for all experimental and control sites and also to attempt to establish if pollution gradient exist between all the experimental and control sites.

MATERIALS AND METHODS

Sampling

Eleven duplicates of fully matured leaves samples of some plants species cultivated in Agbarho metropolis in Ughelli North local government area and Osubi metropolis in Okpe local government area of Delta State were randomly collected. The former is designated as an experimental site while the latter is designated as a control sites. The plants selected for the study were those available at the experimental site. Identification of the plant species were done at the Department of plant science, Delta State University, Abraka. Replicates of fully mature leaf samples of the various plants collected were put in polyethene bags and marked with masking tape and well labeled. These were immediately taken to the laboratory for analysis.

Analysis of Samples

Various biochemical parameters such as pH, relative water content, total chlorophyll, and ascorbic acid were chemically determined from the leaf extracts as discussed below.

Total Chlorophyll Content

5g of the fresh leaves was weighed and blended. This was extracted with 10ml of 80% acetone and this was left for 15 minute for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged at 2,500rm for 3 minutes. The supernatant was collected and the absorbance was taken at 645nm and 663nm using a spectrophotometer. Total Chlorophyll was calculated using the formula described by Agbaire and Esiefarienrhe (2009) is shown below

$$Tch = 20.2D_{645} - 8.02D_{663}\ X\ \frac{V}{1000W}$$

WhereD_{645} = Absorbance of leaf extract at 645nm; D_{663} = Absorbance of leaf extract at 663nm
V = Volume of leaf extract in cm^3; **W** = Weight of leaf extract in g

Leaf Extract pH

5g of the fresh leaves was ground to paste and then extracted using 10ml of deionize water. This was filtered and the pH of the leaf extract determined after calibrating the pH meter with buffer solution of pH 4 and 9.

Estimation of Relative water Content

The relative water content was determined according to the method described by *Irerhievwie, et. al., (2014) and Akpoghelie (2016).* Fresh weight (FW) was obtained by weighing the fresh leaves after the excess water on it was removed with the help of blotting paper. After hydration, the samples were taken out of water and were well dried of any surface moisture quickly and lightly with filter/tissue paper and immediately weighed to obtain fully turgid weight (TW). Samples were then oven dried at 80^0C for 24h and weighed (after being cooled down in a desiccators) to determine dry weight (DW). All weighing is done to the nearest mg.

$$RWC = \frac{FW - DW}{TW - DW} X \frac{100}{1}$$

FW: Fresh Weight; DW: Dry Weight; TW: Turbid Weight

Ascorbic Acid (AA) Content Analysis

Ascorbic acid content (expressed in mg/g) was measured using the spectrophotometric method. 1g of the fresh foliage was put in a test - tube, 4ml oxalic acid - EDTA extracting solution was added; and then 1ml of orthophosphoric acid, 1ml 5% tetraoxosulphate (vi) acid was added to this mixture. 2ml of ammonium molybdate was added and then 3ml of water. The solution was then allowed to stand for 15 minutes. After which the absorbance at 760nm was measured with a spectrophotometer. The concentration of ascorbic acid in the samples was then extrapolated from a standard ascorbic acid curve.

Air Pollution Tolerance Index (APTI)

APTI was calculated as described by Krishna and Lavanya (2014), using the following relationship below

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

Where, A = Ascorbic acid; T = total chlorophyll, P = pH of the leaf extract;
R = Relative water content of leaf (%).

Percentage Increase in Air Pollution Tolerance Index (%APTI)

The Percentage Increase in Air Pollution Tolerance Index was calculated according to the method described by Akpoghelie (2016).

$$\%APTI = \frac{ES - CS}{CS} X \frac{100}{1}$$

ES= Experimental site CS= Control site; APTI= Air pollution tolerance index

RESULTS AND DISCUSSIONS

The results of the biochemical parameters, APTI and the percentage increase in APTI of plant species collected from two cities in Delta State, Nigeria showing the study experimental and control sites is shown in Table 1.

Table 1: Mean Concentration of Biochemical Parameters of Plant Species in mg/g Collected From Both Experimental and Control Sites, Delta State, Nigeria

S/N	Common Name	Botanical Name	Site	RWC	AA	TCh	pH	APTI	%APTI
1	Mango	*Magnifera indica*	ES	61.10	0.843	1.230	5.50	6.68	6.54
			CS	56.75	0.792	1.680	5.80	6.27	
2	Bamboo	*Bambosa bambosa*	ES	79.40	0.931	1.110	5.30	8.54	22.00
			CS	64.41	0.847	1.230	5.40	7.00	
3	Oil Palm	*Elais guinensis*	ES	77.45	0.827	0.935	5.60	8.29	16.20
			CS	66.70	0.794	1.010	5.50	7.11	
4	Cashew	*Anacadium occidentale*	ES	78.20	1.015	1.680	4.20	8.44	7.93
			CS	71.90	0.923	2.000	4.80	7.82	
5	Guava	*Psidium guajava*	ES	72.90	0.816	1.530	4.90	7.81	7.13
			CS	65.90	0.991	1.750	5.30	7.29	
6	Orange	*Citrius sinesis*	ES	73.30	0.915	1.060	5.90	7.97	6.69
			CS	66.60	0.929	1.310	6.20	7.47	
7	Bitter Leaf	*Vernonia amygdalina*	ES	69.20	0.930	1.340	5.80	7.58	5.42
			CS	65.80	0.898	1.504	5.30	7.19	
8	Plantain Leaf	*Musa paradisiacal L.*	ES	92.00	0.940	1.001	5.30	9.79	26.49
			CS	71.40	0.910	1.214	5.40	7.74	
9	Paw paw	*Carica papaya L.*	ES	75.00	0.897	0.923	5.30	8.06	11.46
			CS	67.10	0.832	1.009	5.30	7.23	
10	Cocoyam	*Colocasia esculanta L.*	ES	70.80	0.910	0.887	5.30	7.64	7.61
			CS	65.50	0.868	0.998	5.40	7.10	
11	Flamboyant	*Delonix regia*	ES	36.99	0.529	0.526	6.50	4.07	26.01
			CS	29.17	0.428	0.616	6.80	3.23	

ES – Experimental site; **CS** – Control Site

DISCUSSIONS

The result of the effects of air pollution on biochemical parameters on the leaves of plant species analyzed is shown in table 1. Plants are an integral basis for all ecosystems. The growth and productivity of these plants are known to be infected or damaged by air borne pollutant and is identified as the organisms with most potential to receive impacts from ambient air pollution. Data from this study reveals higher relative water content in polluted site term as experimental site as compared to the control (less polluted) site as represented in Figure 1. The results reveal significant difference between the ability of the plant leaves to retain water in experimental site as compared to those from the control sites. Water is a crucial prerequisite for plant life. Relative water content of a leaf is the water present in it relative to full turbidity. The relative water content in a plant body helps in maintaining it physiological balance under stress conditions of air pollution when transpiration rates are high. Akpoghelie (2016) reported that plant species, when exposed to air pollution experiences the reduction of the rate of transpiration and the damage to the leaf engine that pulls water up from the roots. There is a correlation between the water retention capacity and the ascorbic acid content recorded in the leaves of plant species collected from both sites. In other to annul the environmental stress for the leaf of plant species under investigation, the plant species attempt to absorb more water to accommodate the high ascorbic acid content for experimental site as shown in Figure 2. The high level of water retention capacity of the leaf of plant species as witness in this study may be responsible for the normal functioning of the biological processes in plant at the polluted site. The relative water content (RWC) indicates changes in the leaf matrix hydration condition and thus generates higher acidity condition when RWC is low. Higher relative water content is advantageous for drought resistance in plants Dedio (1975).

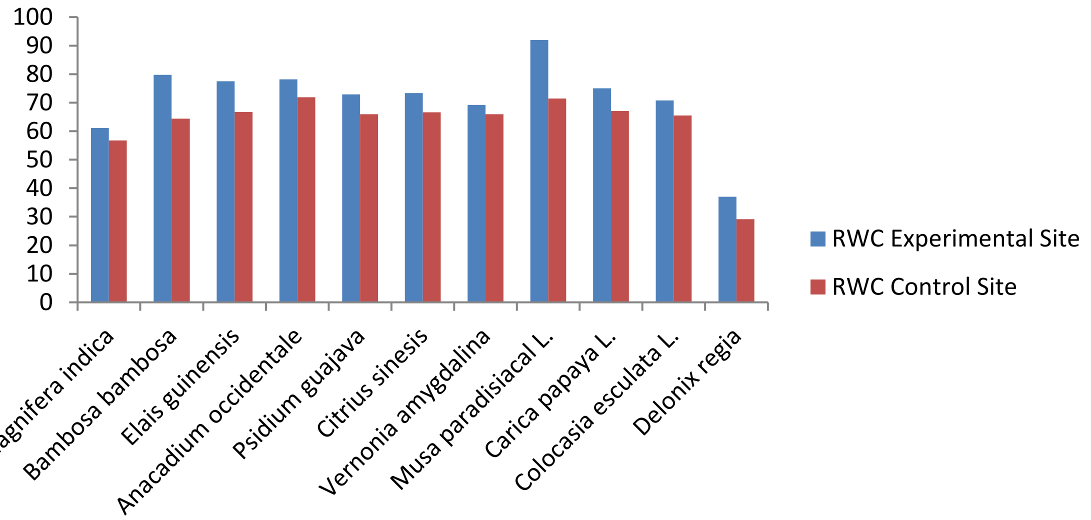

Figure 1: Chart showing the water retention capacity of the leaf of plant species collected in experimental and control site.

Ascorbic acid is a byproduct of metabolism that could be considered as a substance that inhibits the destructive effects of oxidation existing in significant concentration in plant species. In other words, ascorbic acid at the present time play important role in plant physiology, mainly due to its possession of substance that inhibit the destructive effects of oxidation and reducing properties, and also its diverse roles in plant growth and development and the regulation of a broad spectrum of plant cellular mechanisms against environmental stress. In this study, the ascorbic acid content in the leaves of plants species ranges from 0.816 to 1.015 mg/g in the experimental site as compared to 0.792 to 0.991 mg/g for the control site. Data’s from Figure 2 reveals that the ascorbic acid concentration for the leaves of the plant species under investigation shows higher concentration in experimental sites as compared to the control site, except for *Psidium guajava* and *Citrius sinesis* showing higher concentration in control or less polluted site as compared to the experimental sites. The increased concentration of ascorbic acid in the experimental site may be due to the fact that when the plant species where exposed to environmental stress, more ascorbic acid is not only produced to annul the stress as shown in figure 2 below, but could evidently be that it is needed for the growth of the plant (University of Exeter, 2007).

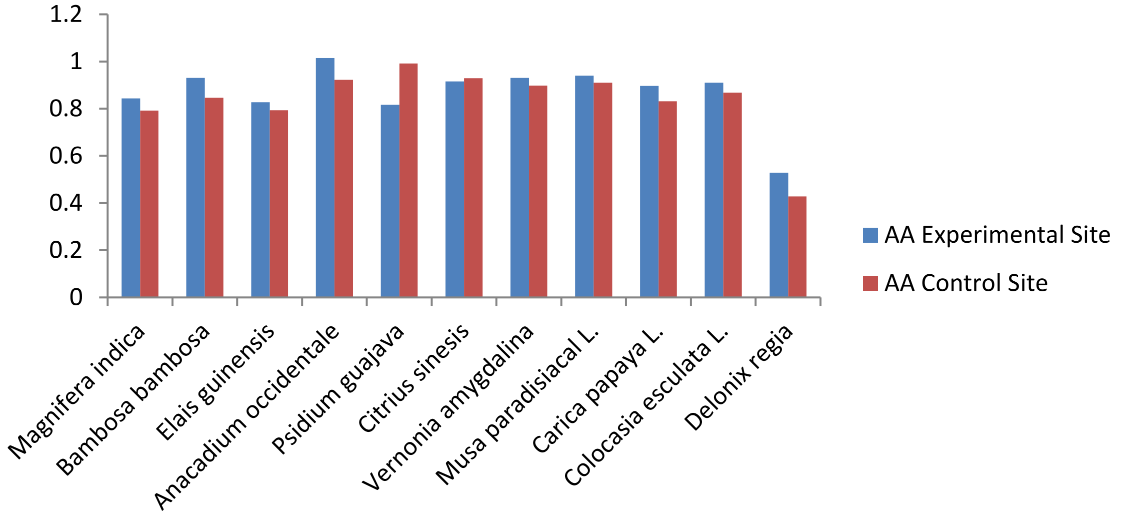

Figure 2: The ascorbic acid content of the leaf of plant species collected in experimental and control sites

Table 1 and Figure 3 reveals that the reducing power of ascorbic acid is pH dependent, being higher at lower pH level. A gradient could also be seen established between the relative water content and ascorbic acid. It could be that when plants are exposed to pollution stress, ascorbic acid accumulates forcing the leaves of plant to retain more water, thereby reducing plant pH. The increase in the level of ascorbic acid reported in this study could be attributed to the fact that it does not just act as a defense mechanism of the respective plant species, but it could be a necessary ingredient for the plant growth (University of Exeter, 2007). Data represented in figure 3 reveal higher concentration of pH of the leaves of plant species in control sites as compared to the experimental sites except for *Elais guinensis* and *Vernonia amygdalina*. *Carica papaya* has pH of 5.30 for both control and experimental sites. Species wise, the pH difference is not much. The change in leaf extract pH might cause the stomata sensitivity due to air pollution. The plant with high sensitivity to acidic gases such as SO_2 and NO_X closes the stomata faster when they are subjected to the pollutant. Furthermore, data from this study also reveals that a relationship could also be established between leaf pigment (chlorophyll) and pH.

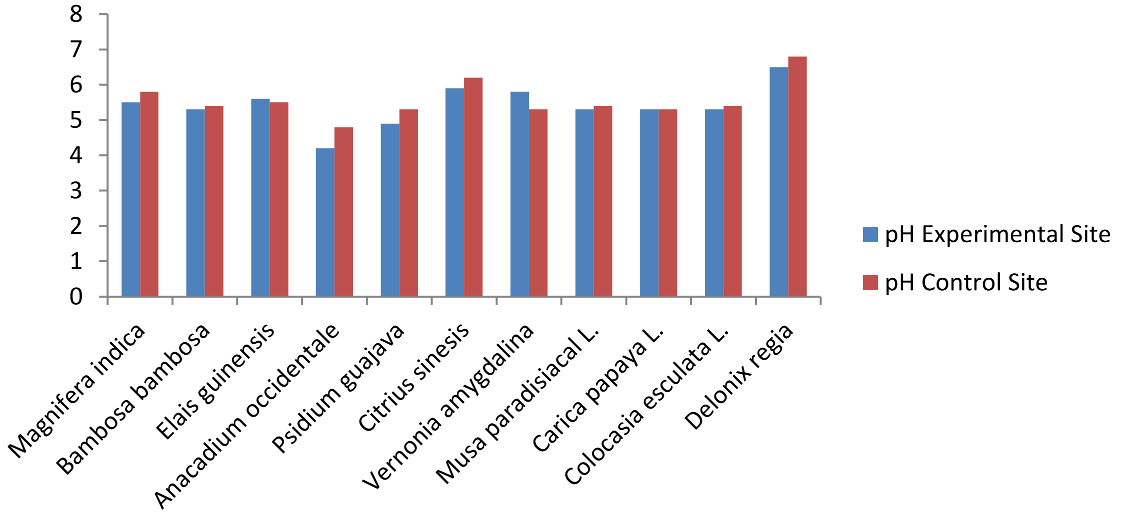

Figure 3: pH of the leaf of plant species collected from experimental and control sites

The leaves of the plant species under investigation as reveal in Figure 4 show higher concentration of chlorophyll in control site as compared to the experimental site (Table 1). Chlorophyll is the green pigment in the leaves of plant used for the manufacture of plant food, usually starch by the combination of enzymes, water and sunlight through a process that is called photosynthesis. It could be described as an indicator for photosynthesis. In other words, they contain molecules which make photosynthesis possible by passing its energized electron on to molecules which manufacture sugar. The reduction of chlorophyll content in the leaves of plant species could be that plants that are constantly exposed to environmental pollution absorb, accumulate and integrate pollutants into their system. This may lead to stomata closure, which reduces CO_2 availability in leaves and inhabit carbon fixation. SO_2, NO_X and CO_2 as well as suspended particulate matter, when absorbed by the leaves, may cause a reduction in the concentration of photosynthetic pigment such as chlorophyll and carotenoids, which directly affect plant productivity.

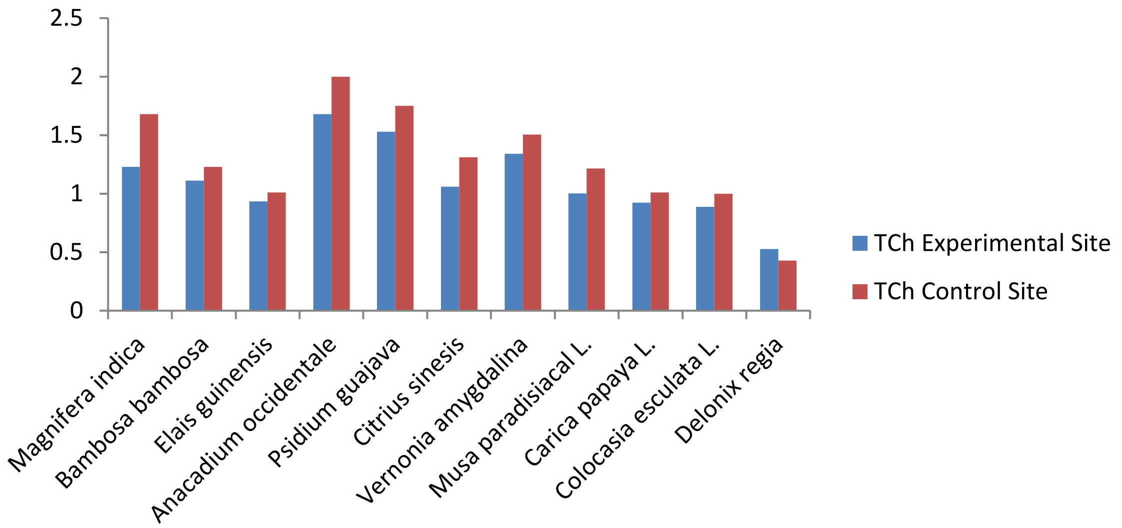

Figure 4: the total chlorophyll content of the leaf of plant species collected in both experimental and control sites

Data's from Table 1 and Figure 5 reveal a gradient between the concentrations of biochemical parameters of the leaves of plant species collected in the experimental sites as compared to the control sites. Data from this study further reveal that using individual biochemical parameters to study the extent and damage done by air pollution could give conflicting results. Thus, combining the individual biochemical results gives a more satisfying result as it is used to compute an index called APTI. Air pollution tolerant index (APTI) is a sign use to denote the maximum output of plant to tolerate pollution. It is thus described by Akpoghelie, (2016) as a basic standard or characteristics of plants to confront air pollution stress. Results from Table 1 reveal that the APTI values are higher in experimental site as compared to those from the control site. The percentage increase in APTI values ranges from 5.42 to 26.49. All the plant under investigation is sensitive species except *Musa paradisiacal L.* and *Bambosa bambosa* which are tolerant to air pollution. The plant species under investigation shows increasing tolerance to air pollution in the order of *Vernonia amygdalina* (5.42) > *Magnifera indica* (6.54) > *Citrius sinesis* (6.69) > Psidium *guajava* (7.13) > *Colocasia esculanta L.* (7.61) > *Anacadium occidentale* (7.93) > *Carica papaya L.* (11.46) > *Elais guinensis* (16.20) > *Bambosa bambosa* (22.00) > *Delonix regia* (26.01) > *Musa paradisiacal L.* (26.49). Hence, judging from existing literature, since the sensitivity and the ability of plant to survive in extreme condition such as air pollution varies, air pollution tolerance index is a tool used for the categorization of plant into sensitive and tolerant groups. This is a useful tool as the former can be used as indicators of pollutant and the later as sink for abatement of air pollution.

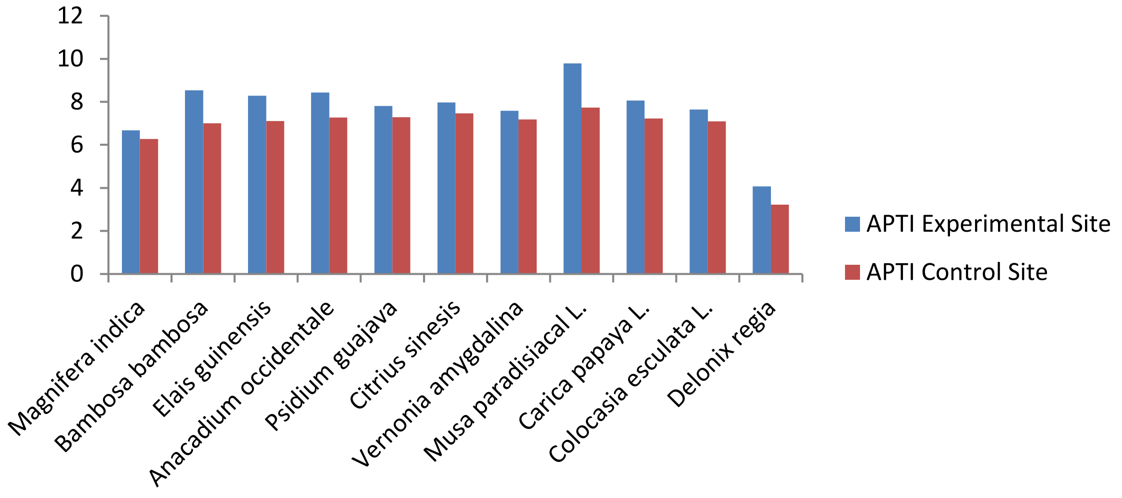

Figure 5: APTI value of the leaves of plant species collected from experimental and control sites

CONCLUSION

The leaves of eleven plant species from two cities in Delta State, in the Niger Delta Area of Nigeria were collected in duplicates and their biochemical parameters determined. Data's from this study show significant relationship across the individual biochemical parameters investigated. While this study reveals conflicting results for the individual biochemical parameters to the tolerance of air pollution in both experimental and control sites, combining the various biochemical parameters for computing the APTI values gives more reliable results. Hence, there is a gradient for the individual parameters in the experimental sites as compared to those from the control sites and it is thus reflected in the APTI values recorded from both sites. Study should be carried out to investigate and integrate the defense and growth mechanism of the ascorbic acid and Proline content in the leaves of plant species.

REFERENCES

Agbaire, P. O. and Esiefarienrhe E. (2009). "Air pollution tolerance index (APTI) of some plant around Otorogun gas plants in Delta State, Nigeria". *Journal of Applied Science and Environmental Management*. 13 (1), 11 – 14.

Akpoghelie, J. O. (2016). Effects of Air Pollution on Biochemical Properties of Plant Species. Lambert Academic Publishing. ISBN 978-3-659-83420-2. Pp45 - 50

Akpoghelie, J. O., Irerhievwie, G. O., Agbaire, P. O., and Orisaremi, A. (2016). An assessment of air quality in sub – urban cities in Isoko, Delta State Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS).* 7(4): 179 - 185

Dedio W. (1975). "Water retentions in wheat leaves as screening test for draught resistance". *Journal of Plant Science*. 55: 369 - 378

Irerhievwie, G. O; Akpoghelie, J. O., and Esiefarienrhe, E. (2014). Evaluation of Some Plant Species for Soluble Sugar and Air Pollution Tolerance Index in Oleh Metropolis, Isoko South L. G. A., Delta State, Nigeria. ***Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS).*** 5 (5) : 323 – 328

Krishna, Veni Marimuthu* And Lavanya K (2014). Air Pollution Tolerance Index of Plants Comparative STUDY. International Journal of Pharmacy and Pharmaceutical Sciences. 6 (5): 320 - 324

Liu, Y. J., and Ding, H., (2008). Variation in air pollution tolerance index of plants near a steel factory: implication for landscape –plant species, selection for industrial areas. Wseas Trans. Environ. Dev. 4:24-32.

Mahecha G. S., Bamniya B. R., Neelima N., and Dhavan S. (2013). Air Pollution Tolerance Index of Plant Species – A study of Madri Industrial Area, Udaipur (Raj.), India. *International Journal of Innovative Research in Science*. 2 (12) : 7927 - 7929

Rai, P. K., Panda, L. L. S., Chutia, B. M., and Singh, M. M. (2013). Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non industrial area (Aizawl) of India: An eco-management approach. African Journal of Environmental Science and Technology. 7 (10) : 944 – 948.

University of Exeter. (2007)."Vitamin C Is Essential For Plant Growth." ScienceDaily. ScienceDaily, 27 September 2007 <www.sciencedaily.com/releases/2007/09/070923205844.htm>. Retrieved 13th January, 2017.