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A Comparative study of Air Quality of an Urban and a Sub-urban Cities in Delta State Nigeria

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Abstract

Twenty plant species were screened for their sensitively/tolerance level to air pollution in an urban as well as a semi-urban environment. The aim of this study is to establish any definite pattern between air quality in urban and semi urban. In order to do this the air pollution tolerance index (APTI) was used to evaluate the plants in these environments. This is an indirect monitoring of the environment. It was found that plant from the urban environment had consistently higher APTI than those from a similar ecological environment in a semi-urban setting. A definite gradient was then established between the urban and semi urban environment.

Keywords: APTI, sensitivity, tolerance, urban and semi-urban.

Introduction

Air pollution is a major problem plaguing most nations of the world today. Pollution of the environment could be attributed largely to industrial and infrastructural development as these also means increased vehicular activities. Air pollution is the contamination of the atmosphere. This contamination is generally said to be largely due to increased human activities. The air is very important to life on earth and so its quality is of equally great importance. Life on earth is said to highly dependent on air and its quality[1]. When the quality of air is compromised in any form, that air, is said to have been polluted. Air pollution is therefore the emission of substances into the atmosphere in quantities that would alter the natural composition of air to the extent of causing harm, or discomfort of living things and /or damage to the environmental[2]. Air pollution arises as a fall-out from industrialization and urbanization[2-9]. Plants are known to play a major role in removing pollutant from the environment as part of their normal functioning[2,10,11]. Plants therefore increase the quality of air as a way of a natural air cycle. Plants generally respond differently to pollutants; while some could withstand plants others cannot. They therefore obey Darwin's survival of the fittest rule. Those that can withstand pollution are termed tolerant species, while those that cannot withstand known as a sensitive species. Tolerant species act as pollution sink while sensitive ones are known as pollution indicators. Some air pollutant are NO_*, SO_*, heavy metals and particulate matters[12]. Plants are constantly exposed to these pollutants since they are naturally stationary; therefore in order to cope with the presence of pollutant, they resort to adaptive strategies. The adaptive strategies include changes in physiological and biochemical processes[12,13]. It is therefore expedient to use plants biochemical parameters as an index of pollution. Several workers had in fact used plant as indication of air pollution[3,4,8,11,12,14,15]. Air pollution can directly affect plants via the leaves or indirectly via soil acidification[2]. Plants are therefore effective in monitoring and managing air pollution. Parameters that could be used in monitoring air quality includes; Ascorbic acids content relative water content, chlorophyll content and leaf extract pH[16-19]. Singh and Rao[20] developed the Air Pollution Tolerance Index (APTI), which is based on the above four parameters to assess tolerance/resistance of plants against air pollution. The formular is as shown below;

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

This study therefore compared the air quality of an urban (Asaba) community with that of a semi-urban one (Anwai) so as to establish a relationship. These sites have similar geographical conditions but are exposed the different degree of air pollution.

Material and Methods

Samplings site, Asaba is the capital of Delta State, Nigeria. It is a very busy State capital because it is a link between the western, eastern and northern regions of the country. It therefore records very high land traffic of vehicles. Anwai on the other hand is rural setting where one of the State University Campus is sited. It could be referred to as a benign environment.

Sampling: Plants were randomly selected from the sites. Plant selection was however based on availability on both sites. Three replicates of fully matured leaves were taken from the fifth from the top of the plants. They were well labeled in polyethylene bags and taken to the laboratory for analysis. Samples not immediately used were preserved in a refrigerator.

Relative Water Content (RWC): The method described by Singh[21] was used. Fresh weights of leaves were obtained and designated Fw. The leaves were then immersed in water for 24 hours, blotted dry and weighed to get the turgid weight (Tw). The leaves were then dried in an oven at 70^0 C until a constant weight was obtained. This was designated Dw. The relative water content was then calculated using the formular

$$\text{RWC} = \frac{\text{Fw} - \text{Dw}}{\text{Tw} - \text{Dw}} \times 100$$

Determination of Leaf Extract pH: The method as described by Agbaire *et al.*[8], was adopted. 1 g of fresh leaves was homogenized in 10 ml deionized water. This was then filtered and the pH measured after calibration of the pH meter with buffer solution of pH 4 and 9.

Determination of Ascorbic Acid: This was done according Bajaj and Kaur[22]. 1 g of the fresh leaves was put in a test tube 4 ml oxalic acid – NaEDTA extracting solution was added. To this, 1 ml of orthophosphoric was added and then 1 ml 5% tetraoxosulphate (vi) acid. 2 ml of ammonium molybdate was added and then 3ml of water. The solution was then allowed to stand for 15 minutes. The absorbance was then taken at 760 nm with a spectrophotometer. The concentration of ascorbic acid in the sample was then extrapolated from the standard ascorbic acid curve.

Determination of total chlorophyll: The method of Singh *et al.*[23] was employed. 200 mg of leaves was ground with a small quantity of acid washed sand in 80% acetone. It was then filtered and the absorbance measured at 645 nm and 633 nm.
Total chlorophyll (mg/g) =

$$20.2 \times A_{64j} + 8.02 \times A_{663} \times \frac{V}{1000} \times W$$

A_{645} = Absorbance at 645 nm, A_{663} = Absorbance at 663 nm, V = Total volume of extract, W = Weight of leaf material in gramm.

Calculation of APTI: This was done using the formular and prescribed by Singh and Roa[20] as shown below;

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

A = Ascorbic acid concentration mg/g, T = Total Chlorophyll (mg/g – f. w), P = pH of leaf extract, R = Relative Water Content, The result obtained from this calculation was divided by 10 to have a manageable figure

Results and Discussion

The effect of air pollutant on some biochemical parameters of twenty plants is shown in table-1. The Changes in plant anatomy, physiology and biochemistry is an indication of a polluted environment. Plant response to air pollution varies from species to species and from the type of pollutant to another. Plants can therefore be used to monitor air pollution.

Singh and Rao[20] developed the air pollution tolerance index base on four biochemical parameters. These parameters are the plant extract pH relative water content, the ascorbic acid content and the total chlorophyll. All these parameters affect productivity of the plant in one way or the other.

Ascorbic acid is known to be important in cell wall synthesis, photosynthetic carbon fixation and cell division[24]. It is also a natural toxicant known to be able to prevent the damaging effect of air pollutant in plant tissues[23]. The high amount of ascorbic acid therefore favors pollutant tolerance in plants[17,25,26]. It is a very important indicator of pollution that it is given a top priority and so used as a multiplication factor in the APTI Formular. Plants with high ascorbic acid content are generally resistant/tolerant to air pollution while those with low ascorbic acid content are sensitive/non tolerant species.

pH is an indicator of pollution since it affects the conversion of a hexose sugar of ascorbic acid. High pH increases the efficiency of conversion of a hexose sugar to ascorbic acid[27]. Low pH has been reported to show a good correlation with sensitivity to air pollution[28]. pH is also indicative of the type of pollutant. Acid pollutants would give a lower (more acidic) pH values. This information would be very useful in case of mitigation measures.

Chlorophyll content in plants is indicative of their photosynthetic activity. It signifies the growth and development of biomass[29]. Total Chlorophyll is also related to the ascorbic acid productively and ascorbic acid is concentrated mainly in the chloroplast. It should be noted that the leaf extract pH affects the photosynthetic efficiency of the plant, thus in the Formular the pH is added to total chlorophyll and them multiplied with the ascorbic acid content. It has been reported that total chlorophyll reduces under stress condition[30].

Water in the plant is necessary for the physiological activities in the plant. A high water content within the plant helps to maintain its physiological balance under stress condition. This parameter can also be used as an indicator of pollutant. Although all these four parameters can indicate air quality of an environment, results from individual parameter is not as reliable as those of the combination of all four as APTI.

From the table-1 above, the APTI of plants ranged, from 6.80 to 11.45 for urban, and from 5.75 - 8.58 for semi urban. The range of percentage increase in APTI is from 3.44 to 74.78. The result showed higher APTI values for the urban as compared with the semi urban. The higher APTI values in the urban area could be attributed to higher anthropogenic activities. The results also showed a definite and clear gradient in the air quality of the urban and semi-urban environment.

Table-1
Air Pollution Tolerance Index (APTI) of various plant species from the sampling sites

S/No	Species	Site	RW	TC	AA	pH	APTI	% increase
1.	*Magnifera indica*	SU	64.20	15.60	0.96	5.9	8.48	
		U	72.40	15.70	0.99	5.4	9.33	10.02
2.	*Carica papaya*	SU	54.50	15.41	0.90	5.7	7.54	
		U	64.40	15.65	1.00	6.6	8.67	14.99
3.	*Delonix regia*	SU	52.50	16.22	0.92	6.1	7.30	
		U	79.40	15.65	0.99	6.1	10.09	38.22
4.	*Musa Spp*	SU	60.50	15.69	0.95	5.2	8.03	
		U	73.90	15.65	1.00	5.7	9.53	18.78
5.	*Psidium guajava*	SU	40.50	15.80	0.94	5.2	6.02	
		U	49.50	16.02	1.00	2.5	6.80	12.96
6.	*Anacadium occidental*	SU	43.40	16.31	1.00	2.7	6.24	
		U	58.80	16.02	0.98	4.3	7.77	24.52
7.	*Tectona grandis*	SU	55.40	15.00	0.98	5.5	7.55	
		U	57.40	16.05	0.95	5.7	7.81	3.44
8.	*Tipu tipuana*	SU	60.00	15.66	0.95	3.7	7.84	
		U	69.80	15.77	1.00	3.9	8.95	14.16
9.	*Citrus sinensis*	SU	58.10	15.51	0.95	6.3	7.88	
		U	67.30	15.71	0.99	5.8	8.86	12.44
10	*Terminalia catappa*	SU	58.30	14.40	0.96	4.8	7.67	
		U	82.20	15.99	0.99	4.9	10.28	34.03
11.	*Bamboo bamusa*	SU	35.90	15.96	0.99	4.9	5.75	
		U	47.50	16.08	0.93	6.0	6.80	18.26
12.	*Thevetia peruviana*	SU	50.70	15.80	1.00	5.7	7.22	
		U	85.10	16.28	0.99	5.6	10.68	47.92
13.	*Plumeria alba*	SU	56.00	15.56	0.99	5.6	7.69	
		U	94.20	16.04	0.94	5.6	11.45	48.89
14.	*Gmelina arborea*	SU	48.00	14.41	0.99	5.9	6.81	
		U	52.40	16.22	0.98	6.0	7.42	8.95
15.	*Chromoloena odoratum*	SU	46.70	15.69	0.95	5.9	5.75	
		U	77.50	16.95	1.00	6.1	10.05	74.78
16.	*Casuriana equistefobia*	SU	45.50	16.89	1.00	5.3	6.76	
		U	57.40	16.12	1.00	5.1	7.86	16.27
17.	*Elaeis guineensis*	SU	51.00	16.02	0.95	5.5	4.14	
		U	66.40	15.98	0.99	5.6	8.78	22.97
18.	*Polyathia longifolia*	SU	63.50	15.81	1.00	5.8	8.51	
		U	75.30	15.85	0.94	5.7	9.56	12.33
19	*Persea americana*	SU	49.50	16.24	0.96	6.0	7.08	
		U	61.70	15.86	1.00	5.9	8.35	17.94
20	*Azadirachta indica*	SU	65.50	15.69	0.94	6.0	8.58	
		U	70.10	15.89	0.98	5.9	9.14	6.53

RW= Relative Water Content, TC = Total Chlorophyll, AA = Ascorbic Acid, pH = pH of Leaf Extract, SU = Semi-urban, U = Urban, APTI = Air Pollution Tolerance Index

Conclusion

It is important to note that parameters gave a more reliable result than using the individual parameter. The results of such studies are very handy for future planning, especially when it pertains to air quality. APTI determinations are important, simple tool, and less expensive tool for monitoring air quality.

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