Dust Accumulation, Heavy Metal Content and Stomata Morphology of Some Medicinal Plants at Rock Quarrying Locations at Lokpaukwu, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author CEO designed the study and wrote the protocol. Author FIN performed the laboratory tests and statistical analysis and wrote the first draft of the manuscript. Author OOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study evaluated the effect of rock quarrying on dust accumulation, heavy metal content and stomata features of some medicinal plants at Lokpaukwu, Nigeria.

Place and Duration of Study: Sample collection was carried out at the quarry sites in Lokpaukwu, followed by laboratory analyses which were conducted in the Department of Pharmacognosy and Environmental Medicines and Centre for Energy Research and Development (CERD), University of Nigeria, Nsukka between January and March, 2019.

Methodology: Five (5) commonly used medicinal plants were selected and collected from the two pollution sites (A and B). Same species collected 20 km away from the sites served as control. Clearing method was employed in foliar micro-analysis while heavy metal accumulation in the samples was estimated by atomic absorption spectrometry (AAS).

Results: The study showed considerable variation in dust load among the plants from each study site. This led to some observed physiological anomalies—occlusion of stomata pores, plasmolysis,

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and shrunk epidermal cells. Quantitative stomata parameters were also affected as plants from polluted sites had narrower pores and more number of stomata than the control. Concentrations of heavy metals (Pb, Zn, Cd, As and Cu) in plants collected from dust polluted sites were also higher than those from the control location. For example, lead and cadmium concentration in most of the plants were in this order: site A > site B > site C.

**Conclusion:** These findings have further validated reports of earlier researchers on the deleterious effects of dust pollution as a result of quarrying activities on plant health. Strict compliance to precautionary and mitigation measures by both the inhabitants and quarry companies are recommended for safer environment and good health.

**Keywords:** Heavy metals; stomata; dust pollution; quarry; medicinal plants.

**1. INTRODUCTION**

Air pollution is one of the severe problems the world is facing today [1]. Quarry sourced air pollution is a serious problem in both developing and developed countries [2]. The increase in quarrying activities has resulted in further increase in concentration of gaseous and particulate pollutants [3,4,5] and has become a key threat to the survival of plants [6]. The extent of pollution by dust depends on the local microclimatic conditions, the concentration of dust particles in the ambient air, the plant species planted in the area, the size of dust particles and their chemistry [6].

The ability of each plant species to absorb and adsorb pollutants by their foliar surface varies greatly and depends on several biochemical, physiological and morphological characteristics [7,8]. Plants growing in and around the quarry sites play significant role in assimilation and accumulation of pollutants and act as efficient interceptors of airborne pollutants mainly through their foliar surfaces [9]. Plants growing in and around rock quarrying sites are in direct contact with air pollutants and have possible biomonitoring potentials [10]. Air pollution from rock quarrying is not only a nuisance in terms of deposition on surfaces and possible effects on health, in particular for those with respiratory problems but dust can also have physical effects on the surrounding plants, such as blocking and damaging their internal structures and abrasion of leaves and cuticles, as well as trigger biochemical alterations which may affect long-term survival [11].

Previous authors observed morphological alterations and possible biochemical changes as a result of pollution stress in plants collected from quarry sites. These changes included abrasion of leaves and cuticles, necrosis and stunted growth [6,10,11]. Physiochemical alterations in plants limit their capacity to perform environmental and ethnobotanical functions. The impact of quarrying activities has major effect on plants and the accumulation of metal laden dust on plants may be poisonous, leading to health problems in individuals who consume the plants [6,10,11]. Physiochemical profiling and air pollution tolerance of some plants in Lokpaukwu has been evaluated by Ogbonna et al. [12]. Their study however covered only *Psidium guajava*, *Dialium guineense* and *Pterocarpus soyauxii*. Little is known about the tolerance of other plants to air pollution in the study area. In addition, heavy metal and dust accumulation on plant leaves have not been assessed for plants in the study area to help understand the possibilities for ecotoxicity. In the light of this, the study seeks to assess dust accumulation, foliar structure and heavy metal content of selected medicinal trees in Lokpaukwu rock quarrying environment in order to understand the effects of quarrying activities on these plants.

**2. METHODOLOGY**

**2.1 Study Site**

Lokpaukwu is situated in Umunneochi Local Government of Abia State, between latitudes 05.5500ºN and 06.0300ºN and longitudes 07°21'05''E and 07°31'33''E (Fig. 1). The study locations fall within the southern tropical climatic belt. Mean annual rainfall is about 2250 mm concentrated in the rainy season that last from March to October [13]. The study locations are within the tropical rain forest region of Nigeria - southeastern part of the lower Benue Trough and it accommodates discontinuous exposure of eroded volcanic and hyperbyssal features [14]. Quarry Site A is located in Eluama community while Site B is at Aguokeakpu- Amaubiri community. Site A is older, larger and has a higher level of quarrying activity than Site B.
2.2 Collection of Leaf Samples

Fifty meters by fifty meters (50 m by 50 m) transects were used as sampling plots on each side of the perimeter of quarry sites A and B. Frequency of occurrence of plant species in each transect was used to determine the most dominant tree species of ethno-botanical importance in the study locations. Out of the sixteen dominant plant species identified, five species (Alchornea cordifolia, Baphia pubescens, Napoleonia imperialis, Nauclea latifolia and Vitex doniana) were randomly selected. Leaf samples were collected in triplicate from the lowest branch of each selected plants with similar characteristics, particularly in age, from the study locations. Control samples were collected 20 km from pollution locations (within the premises of Abia State University, Uturu). Physical measurement of plant breadth was used to estimate the age bracket of the sampled trees in the study locations and at the control location as described by Sean et al. [15]. Plant breadth was measured using a meter tape. Leaf samples were collected during the dry season, in January, 2019. The leaf samples were identified by a taxonomist.

2.3 Measurement of Dust Accumulation

Dust load on the leaves were measured following the methods of Alhesnawi [16]. In brief, the collected leaf samples were first weighed on an electronic scale and their initial weights \(w_i\) were recorded. Dust accumulated on the leaf surfaces was carefully brushed off and the samples were reweighed to obtain the final weight \(w_f\). The difference between \(w_f\) and \(w_i\) gave the amount of dust accumulation in mg. To calculate dust accumulation per unit area, the leaf areas of the samples were first measured as the product of the length and width of the leaves, and the following expressions were used:

\[
\text{Leaf area (cm}^2) = L \times W
\]

\[
\text{Dust accumulation (mg/cm}^2) = \frac{w_f - w_i}{A}
\]

Where: \(L = \text{leaf length; } W = \text{leaf width; } w_f = \text{final weight of leaf; } w_i = \text{initial weight of leaf; } A = \text{leaf area}\)

2.4 Preparation of Leaf Samples

The leaf samples were washed in running water for further studies. Samples for foliar analysis were taken fresh while ones for heavy metal analysis were oven dried and ground. The powdered material so obtained was sieved through a 2 mm mesh pore size and stored in appropriately-labeled bottles until they were taken for heavy metals analysis [17].

2.5 Foliar Analysis

Foliar epidermis of the adaxial (upper surface) and abaxial (lower surface) surfaces of the leaves were prepared by clearing method [12]. The leaf samples were cleared by soaking in petri dishes containing commercial bleach (3.5% sodium hypochloride) for eighteen hours. Then the epidermal strips of the leaf samples were scrapped gently with the aid of forceps and placed on clean microscopic slides, stained with safranin and covered with cover slips. The slides
were viewed under light a microscope (Motic B3, Motic Carlsbad, CA, USA) at x x 400 magnifications and photomicrographs were taken with a Moticam 2.0 image system with software (Motic Carlsbad, CA, USA) fitted to the microscope. The epidermal cell types, stomata types, sizes, density and indices were assessed and recorded according to Evert [18].

2.6 Assessment of Heavy Metal Content

Metal (lead, cadmium, zinc and arsenic) content of leaf samples was determined using Atomic Absorption Spectrophotometer (AAS Model 210/211 VGC Buck scientific as described by AOAC [17].

2.7 Statistical Analysis

Data collected from the study were subjected to One-way Analysis of Variance at (p<0.05) on using statistical package for social sciences (SPSS) version 20. Duncan’s multiple range test (DMRT) post hoc analysis was used in mean separation.

3. RESULTS AND DISCUSSION

3.1 Dust Accumulation on Leaves

Variations were observed in leaf parameters of the plants such as in leaf size area, leaf type, surface texture and petiole length. A. cordifolia and N. latifolia had the largest leaf area at Site A and Site B respectively of 173.07 ± 24.96 cm² and 127.48 ± 9.85 cm² respectively while B. pubescens had the smallest leaf area (33.57 ± 1.41 cm² and 30.87 ± 2.42 cm² respectively). The study showed considerable variation in the amount of dust on each plant from the different locations of study. Dust accumulation per unit area was highest in B. pubescens (9.51 ± 1.83 mg/cm² and 1.61 ± 0.66 mg/cm²) and lowest in N. imperialis (0.28 ± 0.13 mg/cm² and 0.68 ± 0.48 mg/cm²). These differences were significant at p ≤ 0.05 (Table 1).

The range of values obtained from this study are similar to those reported by Pandey and Pandey [19], Frusty et al. [20] and Chaturvedi et al. [21] on dust accumulation on different plants in different environments. Dust load on plant had been attributed to a wide range of factors, which include the distinctive nature of the leaf (orientation, hairiness, form and size, surface texture, occurrence, petioles length), air current and its speed [22,23].

Climatic conditions and anthropogenic actions effect on dust interception/accumulation capacity of different plants had also been reported [24,25]. However, it was observed from our results that B. pubescens which had smaller leaves recorded higher amount of dust per unit area. This could be a pointer to the fact that the dust load of a leaf could be as a result of the surface texture and hairiness. B. pubescens morphologically has relatively rough leaf surfaces and abundant of hairs (trichomes). In addition, the differences in the amount of dust across the location could as well be indicator of the degree of mining activities going on in the site. Generally, the results showed that more amount of dust was accumulated by the plants from Site A more than those from Site B. This suggests that quarrying activities taking place at Site A could be more than that of Site B. It could also suggest longer years of activities at the former site and probably more awareness in dust waste management at the latter.

3.2 Heavy Metal Accumulation by Plants

There was variation in heavy metal accumulation by plants across the different locations. Heavy metal accumulation was generally higher in plants collected from site A and B as compared to the control. For example, lead concentration was lowest (0.03 ± 0.01 mg/100 g) in the N. imperialis and V. doniana plants from the control location; while B. pubescens from site A had the highest concentration (0.26 ± 0.01 mg/100 g). Cadmium concentration ranged from 0.00 (not detected) in V. doniana at the control location to 3.75 mg/100 g in B. pubescens from site A. Cadmium concentration in A. cordifolia, B. pubescens and N. latifolia plants were in this order: site A > site B > site C. Significant differences were not found in cadmium concentration of N. imperialis and V. doniana at the study locations A and B. Other values can be seen in Table 2.

Concentrations of heavy metals (Pb, Zn, Cd, As and Cu) in plants collected from dust polluted sites were higher than those from the control location. The variations in plant metals accumulations have similarly been reported to be site dependent, with plants in polluted sites having higher heavy metals concentration than in unpolluted sites [26,27,28]. This is as a result of heavy metal contamination in leaves from local sources including quarrying operations [29,30]. Ogbanshi and Akubugwo [31] also reported presence of heavy metals in quarry dust, though
they are not usually in significant concentrations [32]. Morphological and epidermal studies on *Baphia pubescens* indicated that the plant had hairy leaves [33]. This characteristic feature suggests that the plant has a higher pollutant capture capability than other plants assessed and corroborates with the results of heavy metals accumulation obtained in this study [34]. Since the leaf of this plant is used for treatment of diarrhea, wounds and aches [35], there is a potential ecotoxicological threat from their regular consumption.

### 3.3 Stomata Parameters of Plants

In most cases, the epidermal cells were distorted and the stomata were plamolysed compared to samples collected from the control location (Plates 1 and 2). The stomata of plants collected from the pollution sites were also clogged by dust particles and their guard cells appeared thinner and elongated. There were significant differences in stomata density, stomata length, stomata width, stomata size and stomata pore area among the plants across the study locations. Stomata density was highest in *N. latifolia* from site A (164.71 ± 2.40 mm⁻²) and lowest in (51.50 ± 2.87 mm⁻²) in *N. imperialis* at the control location. Stomata length ranged from 18.29 μm in *A. cordifolia* to 30.60 μm in *N. imperialis* both at site A. Generally, plants from site A and site B had shorter stomata length compared to those collected from the control location. However, the stomatal length of *N. latifolia* and *V. doniana* at site A and B did not vary significantly from the control. Stomata width significantly reduced in plants collected from the quarry sites as compared to plants collected from the control location. The results also showed significant variations in the stomata size and stomata pore size (Table 3).

#### Table 1. Dust accumulation on plant leaves

| Sample        | Leaf area (cm²) | Dust load (mg/cm²) |
|---------------|-----------------|--------------------|
|               | Location A      | Location B         |
| *A. cordifolia*| 173.07 ± 24.96² | 103.66 ± 5.37²     |
| *B. pubescens* | 33.57 ± 1.41⁵   | 9.51 ± 1.83⁴      |
| *N. imperialis*| 111.52 ± 13.25⁵ | 109.26 ± 3.12³    |
| *N. laevis*   | 141.07 ± 5.94³  | 127.48 ± 9.85³    |
| *V. doniana*  | 162.65 ± 9.24³  | 96.10 ± 5.61³     |

Means with different letters as superscripts along a column are significantly different at higher at P ≤ .05 Values expressed as mean ± SEM of 5 replicate data

#### Table 2. Comparative heavy metal analysis of plants across the three study locations

| Sample        | Location | Lead (mg/100 g) | Cadmium (mg/100 g) | Zinc (mg/100 g) | Arsenic (mg/100 g) | Copper (mg/100 g) |
|---------------|----------|-----------------|--------------------|-----------------|-------------------|-----------------|
|               | Location A | Location B      | Location A         | Location B      |
| AC            | A        | 0.11 ± 0.01⁴    | 1.26 ± 0.02⁴      | 0.31 ± 0.04³    | 0.10 ± 0.00²     | 0.39 ± 0.01²    |
|               | B        | 0.09 ± 0.01³    | 1.06 ± 0.03³      | 0.24 ± 0.03²    | 0.10 ± 0.00²     | 0.33 ± 0.04¹    |
|               | Control  | 0.04 ± 0.01⁵    | 0.02 ± 0.01⁵      | 0.12 ± 0.03³    | 0.01 ± 0.00²     | 0.27 ± 0.03³    |
| BP            | A        | 0.26 ± 0.01⁴    | 3.75 ± 0.11⁴      | 1.46 ± 0.01³    | 0.27 ± 0.03³     | 0.77 ± 0.01³    |
|               | B        | 0.24 ± 0.01³    | 2.59 ± 0.06³      | 1.91 ± 0.01²    | 0.25 ± 0.02²     | 0.76 ± 0.10²    |
|               | Control  | 0.04 ± 0.01⁵    | 0.01 ± 0.00⁵      | 0.40 ± 0.00²    | 0.02 ± 0.01¹     | 0.65 ± 0.05³    |
| NI            | A        | 0.10 ± 0.00⁴    | 1.13 ± 0.02³      | 1.14 ± 0.01³    | 0.14 ± 0.01¹     | 0.47 ± 0.02⁴    |
|               | B        | 0.11 ± 0.00³    | 1.08 ± 0.03³      | 0.91 ± 0.01²    | 0.14 ± 0.02²     | 0.42 ± 0.02²    |
|               | Control  | 0.03 ± 0.01⁵    | 0.02 ± 0.01⁵      | 0.47 ± 0.15³    | 0.01 ± 0.00²     | 0.39 ± 0.02²    |
| NL            | A        | 0.11 ± 0.01⁴    | 1.50 ± 0.04³      | 1.35 ± 0.01³    | 0.20 ± 0.01¹     | 0.78 ± 0.05³    |
|               | B        | 0.08 ± 0.02³    | 0.90 ± 0.04³      | 1.07 ± 0.01²    | 0.22 ± 0.01¹     | 0.66 ± 0.01²    |
|               | Control  | 0.04 ± 0.01⁵    | 0.02 ± 0.01⁵      | 0.43 ± 0.05³    | 0.01 ± 0.00²     | 0.61 ± 0.11³    |
| VD            | A        | 0.12 ± 0.01³    | 1.17 ± 0.03³      | 0.27 ± 0.03³    | 0.06 ± 0.01⁶     | 0.18 ± 0.01³    |
|               | B        | 0.19 ± 0.01³    | 1.16 ± 0.01³      | 0.21 ± 0.02³    | 0.07 ± 0.02³     | 0.17 ± 0.00³    |
|               | Control  | 0.03 ± 0.01⁵    | -                  | 0.09 ± 0.01³    | 0.02 ± 0.01⁴     | 0.16 ± 0.00³    |

Means with different letters as superscripts along a column are significantly different at higher at P ≤ .05 Values expressed as mean ± SEM of 5 replicate data

*AC = Alchornea cordifolia; BP = Baphia pubescens; NI = Napoleona imperialis; NL = Newbouldia laevis; VD = Vitex doniana*
Adaxial surfaces of the leaves of *A. cordifolia* from locations A, B and Control respectively

Adaxial surfaces of the leaves of *B. pubescent* from locations A, B and Control respectively

Adaxial surfaces of the leaves of *N. imperialis* from locations A, B and Control respectively

Adaxial surfaces of the leaves of *N. latifolia* from locations A, B and Control respectively.

Adaxial surfaces of the leaves of *V. doniana* from locations A, B and Control respectively.

Plate 1. Photomicrographs of the leaf upper epidermises of the samples: evidence of stress on the epidermal cells of plants from polluted sites is shown. The epidermal cell walls are distorted with faint outlines (Mg. x400)
Plate 2. Photomicrographs of the leaf lower epidermises of the samples: Evidence of stress on the epidermal cells of plants from polluted sites. The epidermal cell walls are distorted with faint outlines (Mg. x400)
This conforms to Yunus and Ahmed [36] who found a conspicuous increase in frequency of stomata, percentage of abnormal stomata, larger stomatal openings and conspicuous circular striations in polluted population of *Ricinus communis* L. The physiological changes as evidenced in the plasmolysis of epidermal cells and reduction of stomata length and width of plants collected from the polluted sites have also been reported by Ogbonna et al. [37], Nwafor et al. [38] and Ogbonna et al. [12]. Vijaywargiya and Pandey [39] had also reported that dust deposition similarly resulted in stomata clogging which gave rise to the decreased rate of carbon dioxide exchange, carbon assimilation, transpiration, and therefore net photosynthesis. The well-defined, unoccluded and better arranged stomata in plants at the control location in comparison with the study locations is a clear indication of pollution induced stress in plants at the quarry sites. These plants are vulnerable to other physiological and biochemical disturbances.

### 4. CONCLUSION

This study evaluated the effect of dust pollution at two different quarry sites on heavy metals accumulation and stomata micromorphology of selected medicinal plants. Dust load was higher at the quarry sites when compared with control site. The amount of dust was not influenced by the size of the leaf, rather other factors like surface texture and hairiness could be responsible for the accumulation. Heavy metals were also found to occur in the samples, most probably, as a result of the quarrying activities and fuel combustion by machineries and automobiles within the industries. These also negatively affected the stomatal features of the plants, evidenced by plasmolysed cells, distorted epidermal cell walls and change in stomata sizes, pore sizes and other relevant indices. We recommend that inhabitants of the study locations should be educated on the health issues of consuming or ingesting plants growing at the emission points. This can be done by using a water tanker browser to spray water on road surface and stockpiles at least once a day especially during the dry season. Other systems like pipes could also be developed to suppress dust at the blasting and processing sites and also along the roads.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

1. Tripathi AK, Gautam M. Biochemical parameters of plants as indicators of air pollution. *IJECC*, 10(12): 540-549, 2020; Article no. IJECC.62679

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Table 3. Comparative stomatal parameters of plants across the three study locations

| Sample | Location | Stomata density (mm⁻²) | Stomata length (µm) | Stomata width (µm) | Stomata size (µm²) | Stomata pore size (µm²) |
|--------|----------|------------------------|--------------------|-------------------|-------------------|------------------------|
| AC A   |          | 139.71 ± 3.70<sup>a</sup> | 18.29 ± 0.82<sup>b</sup> | 11.60 ± 0.25<sup>b</sup> | 211.87 ± 8.48<sup>b</sup> | 44.93 ± 1.94<sup>b</sup> |
| B      |          | 150.00 ± 1.70<sup>b</sup> | 19.82 ± 0.39<sup>ab</sup> | 11.68 ± 0.31<sup>b</sup> | 231.14 ± 2.07<sup>b</sup> | 45.58 ± 2.42<sup>b</sup> |
| Control|          | 97.00 ± 3.87<sup>a</sup> | 21.50 ± 0.65<sup>a</sup> | 14.50 ± 0.65<sup>a</sup> | 308.25 ± 21.30<sup>a</sup> | 70.18 ± 6.91<sup>a</sup> |
| BP A   |          | 101.47 ± 2.82<sup>a</sup> | 19.86 ± 0.43<sup>a</sup> | 14.89 ± 0.99<sup>ab</sup> | 294.53 ± 14.28<sup>b</sup> | 74.87 ± 9.86<sup>b</sup> |
| B      |          | 110.29 ± 5.02<sup>a</sup> | 19.21 ± 0.81<sup>b</sup> | 15.50 ± 1.04<sup>b</sup> | 299.94 ± 31.42<sup>b</sup> | 81.20 ± 10.77<sup>b</sup> |
| Control|          | 63.50 ± 1.50<sup>b</sup> | 25.50 ± 0.50<sup>b</sup> | 21.25 ± 0.48<sup>b</sup> | 541.75 ± 19.18<sup>a</sup> | 152.41 ± 6.62<sup>a</sup> |
| NI A   |          | 64.71 ± 2.40<sup>a</sup> | 30.60 ± 0.96<sup>b</sup> | 16.62 ± 0.52<sup>b</sup> | 508.25 ± 20.55<sup>a</sup> | 92.30 ± 5.66<sup>b</sup> |
| B      |          | 60.29 ± 2.82<sup>a</sup> | 27.65 ± 0.36<sup>b</sup> | 16.94 ± 0.32<sup>b</sup> | 468.74 ± 14.77<sup>b</sup> | 95.77 ± 3.59<sup>b</sup> |
| Control|          | 51.50 ± 2.87<sup>b</sup> | 28.75 ± 0.48<sup>ab</sup> | 23.50 ± 0.29<sup>b</sup> | 674.25 ± 8.92<sup>a</sup> | 183.58 ± 4.43<sup>a</sup> |
| NL A   |          | 164.71 ± 2.40<sup>a</sup> | 26.11 ± 0.48<sup>a</sup> | 14.24 ± 0.59<sup>b</sup> | 371.06 ± 9.92<sup>b</sup> | 67.95 ± 5.56<sup>b</sup> |
| B      |          | 145.59 ± 2.82<sup>b</sup> | 27.63 ± 0.99<sup>b</sup> | 13.33 ± 0.76<sup>b</sup> | 370.18 ± 33.93<sup>b</sup> | 59.81 ± 6.94<sup>b</sup> |
| Control|          | 123.75 ± 2.25<sup>c</sup> | 27.75 ± 1.11<sup>c</sup> | 17.00 ± 0.41<sup>c</sup> | 470.25 ± 14.66<sup>a</sup> | 96.76 ± 3.72<sup>a</sup> |
| VD A   |          | 144.12 ± 3.80<sup>a</sup> | 21.82 ± 1.29<sup>a</sup> | 12.77 ± 0.71<sup>b</sup> | 280.34 ± 29.22<sup>b</sup> | 54.87 ± 6.39<sup>b</sup> |
| B      |          | 133.82 ± 2.82<sup>a</sup> | 21.94 ± 0.08<sup>a</sup> | 12.35 ± 0.40<sup>b</sup> | 270.96 ± 9.15<sup>a</sup> | 50.98 ± 3.23<sup>b</sup> |
| Control|          | 115.00 ± 3.87<sup>b</sup> | 22.50 ± 0.87<sup>b</sup> | 17.75 ± 1.32<sup>c</sup> | 407.00 ± 34.37<sup>c</sup> | 108.18 ± 14.67<sup>c</sup> |

Means with different letters as superscripts along a column are significantly different at higher at P ≤ .05. Values expressed as mean ± SEM of 5 replicate data.

AC = Alchornea cordifolia; BP = Baphia pubescens; NI = Napoleona imperialis; NL = Newbouldia laevis; VD = Vitex doniana.
pollution. J Environ Biol. 2007;28(1):127-132.
2. Liu YJ, Ding H. Variation in air pollution tolerance index of plants near a steel factory: implications for landscape plants species selection for industrial areas. WSEAS Transactions on Environment and Development. 2008;1(4):24-32.
3. Singh P, Sthapak J. Reduction in Protein contents in few plants as indicators of air pollution. Pollution Res. 1991;18:281–283.
4. Joshi PC, Swami A. Air pollution induced changes in the photosynthetic pigments of selected plant species. J Environ Biol. 2009;30:295-298.
5. Saha DC, Padhy PK. Effects of Stone Crushing Industry on Shorea robusta and Medhuca indica foliage in Lalpahari Forest. Atmospheric Pollution Research. 2011;2:463–476.
6. Iqbal MZ, Shafiq M. Periodic effect of cement dust pollution on the growth of some plants. Turk J Botany. 2001;25:19-24.
7. Seyyednejad SM, Majdian K, Koochak H, Niknejad M. Air pollution tolerance indices of some plants around industrial zone in south of Iran. Asian J Biol Sci, 2011; 4:300-305.
8. Fowler D, Cape JN, Unsworth MH, Mayer H, Crowther JM, Jarvis PG, Gardiner B, Shuttleworth WJ. Deposition of atmospheric pollutants on forest. Philosophical Transactions of the Royal Society of London. 1989;324:247-265.
9. Rai PK, Panda LS. Leaf dust deposition and its impact on biochemical aspect of some roadside plants of Aizawl, Mizoram. Int Res J Environ Sci. 2014;3(11):14-19.
10. Sharma AP, Rai PK, Tripathi BD. Magnetic biomonitoring of roadside tree leaves as a proxy of vehicular pollution. Series In: urban planning and environment: strategies and challenges (V. Lakshmi). Mc Millan Advanced Research. 2007;326-331.
11. Mahchea GS, Bamniya BR, Nair N, Saini D. Air pollution tolerance index of certain plant species: a study of Madri Industrial area, Udaipur (Rajasthan), India. Int J Innovative Res Sci, Eng Technol. 2013; 2(12):7927-7929.
12. Ogbonna CE, Ugbogu EA, Nwafor F. Physiochemical properties and anticipated performance of selected plant species in Lokpaukwu quarry site in Abia State, Nigeria. J Environ Pollution Human Health. 2019;7(1):7-14.
13. Uma KO, Onuoha KM. Groundwater resources of the Lower Benue Trough, Southern Nigeria. Friedr Vieweg Sohn. 1989;77-91.
14. Adighieje CI. Gravity study of lower Benue trough, Nigeria. Geological Magazine. 2009;118:59-57.
15. Liang S, Li L, Xing W, Ran YL. Heavy metal contents in Buxus megistophylla leaves in urban area of Zhengzhou. J Northwest Forestry University. 2011;3:012.
16. Pandit J, Sood A, Bhardwaj SK, Sharma KK. Seasonal variation of leaf dust accumulation and biochemical parameters of selected plant species alongside the national highway-7 in Sirmaur, India. Current World Environment. 2017;12(2):421-428.
17. AOAC (Association of Official Analytical Chemicals) Official method of analysis of the AOAC (W. Horwitz Editor Eighteen Edition). AOAC, Washington, D. C. 2005; 250.
18. Evert R. Esau’s Plant Anatomy. (Third Edition). John Wiley and Sons Inc; 2020.
19. Pandey J, Pandey U. Evaluation of air pollution phytotoxicity in a seasonally dry tropical urban environment. Environmental Monitoring and Assessment. 1994;33(3):195–213.
20. Prusty BAK, Mishra PC, Azeex PA. Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India. Ecotoxicol Environ Safety. 2005;60(2):228–235.
21. Chaturvedi RK, Prasad S, Rana S, Obaidullah SM, Pandey V, Singh H. Effect of dust load on the leaf attributes of the tree species growing along the roadside. Environmental Monitoring and Assessment. 2013;185:383–391.
22. Uzma Y, Tasveer ZB, Muhammad HRS, Seema M, Saeed AM. Dust interception capacity and alteration of various biometric and biochemical attributes in cultivated population of Ficus carica L. IOSR J Pharm Biol Sci. 2013;6(4):35-42.
23. Walia K, Aggarwal RK, Bhardwaj SK. Leaf dust accumulation and its relationship with biochemical parameters of different plant species growing along national highway-22, India. Int J Chem Stud. 2019;7(1):1386-1390.
24. Prajapati SK, Tripathi BD. Seasonal variation of leaf dust accumulation and pigment content in plant species exposed...
to urban particulates pollution. Journal of Environmental Quality. 2008;36:865-870.
25. Somashekar RK, Ravikumar R, Ramesh AM. Pollution Res. 1999;18:445-451.
26. Wannaz ED, Carreras HA, Peñatez CA, Pignata ML. Assessment of heavy metal accumulation in two species of Tillandsia in relation to atmospheric emission sources in Argentina. Science of the Total Environment. 2006;361(1-3):267-278.
27. Sawidis T, Breuste J, Mitrovic M, Pavlovic P, Tsagaridas K. Trees as bioindicator of heavy metal pollution in three European cities. Environ Pollution. 2011;159(12):3560-3570.
28. Zhang T, Bai Y, Hong X, Sun L, Liu Y. Particulate matter and heavy metal deposition on the leaves of Euonymus japonicas during the East Asian monsoon in Beijing, China. PLoS One. 2017;12(6):0179840.
29. Simon E, Braun M, Vidic A, Bogyo D, Fabian I, Tothmeresz B. Air pollution assessment based on elemental concentration of leaves tissue and foliage dust along an urbanization gradient in Vienna. Environ Pollution. 2006;159(5):1229-1233.
30. Baidourela A, Zhavimujik K. Patterns of dust retention by urban trees in oasis cities. Nature Environ Pollution Technol. 2015;14(1):53-57.
31. Ogbanshi ME, Akubugwo EI. Heavy metal concentration and toxicity studies on rabbits exposed to quarry dust. IOSR J Environ Sci Toxicol Food Technol. 2012;6(1):64-67.
32. Daspan RI, Obadiah EG, Lekmang LC, Dibal HU, Chup AS, Daku S, Wazoh H, Diyelmak VB, Azi B. Preliminary assessment of trace element composition of dust from two granite quarries from Jos Plateau and their possible health implications. J Environ Earth Sci. 2018;8(8):140-154.
33. Ajuru MG, Okoli BE. Morphological and epidermal studies on certain species of Napoleona imperialis in Nigeria. Int J Modern Bot. 2012;2:115-119.
34. Ogbonna CE, Enete IC, Ugbohu AE, Egbo AU. Air pollution tolerance index (APTI) of some plants in the Ishiagu lead-zinc mining area, South Eastern Nigeria. World J Phytochem Earth Sci. 2015;2(2):109-114.
35. Anowi CF, Onyekaba TU, Patrick OE, Ezea CC. Antiinflammatory, phytochemical and toxicological investigation of ethanol extract of the leaves of Baphia pubescens. Asian J Biochem Pharma Res. 2014;2(4):247-248.
36. Yunus M, Ahmed KJ. Use of epidermal traits of plants in pollution monitoring. National Seminar on Environmental Pollution: A Status Review. National Productivity Council, India. 1979;1–10.
37. Ogbonna CE, Nwafor FI, Ugbohu EA, Nwazue K. Assessment of foliar parameters and air pollution tolerance index of broad leaved trees in Uguwele quarry site, Uturu, Nigeria. Appl Ecol Environ Sci. 2018;6(2):48-56.
38. Nwafor FI, Nwosu MO, Nwafor AZ. Taxonomic and ecological significance of foliar epidermal characters in four taxa of Mussaenda L. (Rubiaceae) in Nigeria. Annual Res Rev Biol. 2019;32(5):1-12.
39. Vijaywargiya A, Pandey GP. Effect of cement dust on soybean, Glycine max (L) Merr. and maize, Zea mays Linn. inflorescence study. Geobioscience. 2003;30:209–212.

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