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# Effects of Environmental Pollution (Auto-Exhaust) on the Micro-Morphology of Some Ornamental Plants from Sudan

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**Abstract:** Ten ornamental plants belonging to different families from five sites in Khartoum the capital city of Sudan with equivalent environmental pollution were selected to determine the effect of auto-exhaust pollution on their micro morphological traits. The parameters utilized were numbers of stomata/unit area, numbers of epidermal cells/unit area, length and width of stomata, stomata calculated area, L/B ratio of stomata and stomatal indices from upper and lower surface of the fixed leaf which were found distinctive for each locality.

**Key words:** Auto-exhaust, pollution, ornamental plants, Khartoum city, Sudan

## INTRODUCTION

It is well known that environmental conditions affect plant micro morphology (Halloy and Mark, 1996; Orshan, 1986; Meinder and Mansfield, 1968; Fahn, 1967). The impact of environmental pollution on plants is well documented (Solberg and Adams, 1956; Heggestad, 1968; Feder, 1970; Heck *et al*., 1973; Mukammal, 1976; Guderian, 1977). For most plants leaves usually perform basic functions such as capture of light energy and carbon molecules (Halloy and Mark, 1996).

These functions can best be fulfilled by flat, thin leaf surface full of chlorophyll (Cooper *et al*., 1993) Leaf micro morphology has often been interpreted as a sensitive indicator of environmental pollution. Although, there is paucity of information on the effect of environmental pollution on the epidermal features of the plant leaves (Bondada *et al*., 2006), the research in this field is probably recent or it is still unpublished. However, Singh *et al*. (1995), Sharma and Tyree (1973), Sharma and Butter (1975), Garg and Varshney (1980), Weyers and Travis (1981) reported a decrease in the size of stomatal opening and an increase in the frequency of epidermal cells and stomata in response to environmental pollution in some plant taxa. Interest in growing ornamentals is increasing as a profitable business.

They have many desirable qualities such as color, texture, shapes and planting patterns. The cut flowers and flowering plants in general are being used widely for family and outdoor gardens as well as for decoration purposes. Because many of these plants are grown along the roadsides and highways and the absence of strict disease control as well as exhaust pollution may affect these plants, most people do not look upon ornamentals as being of economic importance. Therefore, the present research was designed for the first time to evaluate the effect of auto-exhaust pollution which constitutes 50-60% of the air pollution in urban environment on morphological and leaf epidermal features of some ornamental plants from Khartoum, the capital city of Sudan.

## MATERIALS AND METHODS

The research was conducted in the Department of Microbiology and Molecular Biology, Faculty of Science and Technology, Al Neelain University, Sudan during 2007-2008. Maximum attention was given for the collection of ornamentals which were closer to the traffic pathway getting direct contact to auto-exhaust. Fresh collections were made from five sites in the industrial area of Khartoum city where the auto-exhaust air pollution is present. For comparison, collections were done also from a relatively clean area of Khartoum such as Al-Mogran garden which was considered as control on the same day at fixed time. A single leaf proved to be the fully developed youngest leaf per plant species was fixed using F.A.A (Formaldehyde 5%, Acetic acid 5% and Ethanol alcohol 90%).

The ornamental plants investigated were: *Argyreia nervosa* Bojer (Convolvulaceae), *Aristolochia elegans* Mast. (Aristolochiaceae), *Barleria calophylla* Lindau (Acanthaceae), *Bauhinia candida* Act. (Caesalpiniaceae), *Begonia elatlor* Hort. (Begoniaceae), *Caladium hortulanum* Birdsey (Araceae), *Canna indica* L. (Cannaceae), *Eulophia quartiniana* A. Rich (Orchidaceae), *Euphorbia trigona* Haw (Euphorbiaceae) and *Nerium oleander* L. (Apocynaceae). The fixed leaf (5th leaf) was taken and washed in distilled water carefully. The upper and lower pealings were carefully

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taken with extra care mounted in lactophenol-cotton blue and examined under compound microscope using 10x ocular and 40x objective. $CuSO_4$ treatment and nail polish impression methods were also performed (Dickison, 2000) where pealing removal was hardly possible and ten observations were made per parameter. For measuring the length and breadth of stomata ocular micrometer of 10 μm least count was used and for counting the number of stomata and epidermal cells a diaphragm eyepiece of unit area (3600 $\mu m^2$) was taken or sometimes a haemocytometer ( 1×1 mm grid) (Meinder and Mansfield, 1968) was also used. Stomatal index was determined by Salisbury (1927) equation:

$$S.I. = \frac{S \times 100}{S + E}$$

where, S.I. is Stomatal Index; S is Number of stomata/unit area and E isNumber of epidermal cells/unit area.

**Data analyses:** Data obtained were pooled and the means were used in analysis for significant differences using appropriate procedure (SAS Institute Inc., Cary, NC, USA).

## RESULTS AND DISCUSSION

The auto-exhaust-polluted ornamentals grown on the roadside at Khartoum city showed unthriftness with erea. severe retardation and obvious chloroses. These observations show how much the auto-exhaust pollution at the city affects plants at different percentages on each of the parameters of micro morphology (Table 1-4).

Table 1: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the upper surface of the leaf (Values are means±SD of 10 observations/parameter)

| Plant species (Botanical family) | Location | Number of stomata/unit area (3600 $\mu m^2$) | Number of epidermal cells/ unit area (3600 $\mu m^2$) | Stomatal index |
|---|---|---|---|---|
| *Argyreia nervosa* Bojer | Control | 1.22±0.310 | 3.27±0.76 | 19.20±3.11 |
| (Convolvulaceae) | Polluted | 2.00±0.440*** | 5.75±2.90 | 16.00±5.15 |
| *Aristolochia elegans* Mast. | Control | 1.20±0.40 | 5.87±0.48 | 20.86±4.67 |
| (Aristolochiaceae) | Polluted | 1.65±0.60*** | 6.81±0.99*** | 19.27±6.66 |
| *Barleria calophylla* Lindau | Control | 1.29±0.46 | 4.87±0.75 | 21.36±8.90 |
| (Acanthaceae) | Polluted | 1.29±0.46 | 6.56±3.89** | 26.47±5.90 |
| *Bauhinia candida* Act. | Control | 1.29±0.46 | 3.57±0.99 | 23.16±7.07 |
| (Caesalpiniaceae) | Polluted | 1.55±0.51* | 6.00±0.52*** | 34.81±8.60 |
| *Begonia elatlor* Hort. | Control | 1.15±0.320 | 8.67±1.09 | 14.86±4.27 |
| (Begoniaceae) | Polluted | 1.33±0.49*** | 8.67±1.11 | 16.57±4.30 |
| *Caladium hortulanum* Birdsey | Control | 1.35±0.46 | 3.87±0.69 | 24.86±8.47 |
| (Araceae) | Polluted | 1.55±0.79*** | 5.56±0.89*** | 31.87±7.60 |
| *Canna indica* L. | Control | 1.20±0.41 | 7.60±0.96 | 22.16±7.17 |
| (Cannaceae) | Polluted | 1.65±0.79*** | 9.20±2.09*** | 32.35±13.17 |
| *Eulophia quartiniana* A. Rich | Control | 1.40±01.15 | 3.57±0.89 | 18.56±3.97 |
| (Orchidaceae) | Polluted | 1.41±0.05 | 5.60±0.89*** | 21.80±7.04 |
| *Euphorbia trigona* Haw. | Control | 1.11±1.160 | 5.37±0.70 | 20.26±8.70 |
| (Euphorbiaceae) | Polluted | 1.32±0.060 | 6.16±2.99 | 05.17±4.14 |
| *Nerium oleander* L. | Control | 1.20±0.41 | 6.87±1.40 | 21.36±8.90 |
| (Apocynaceae) | Polluted | 2.11±0.84*** | 9.56±3.53** | 26.47±5.90 |

* = Significant at p<0.1% level, ** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Table 2: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the upper surface of the leaf (Values are means±SD of 10 observations/parameter)

| Plant species (Botanical family) | Location | Length of stomata (L) (μm) | Breadth of stomata (B) (μm) | L/B ratio | Calculated area of stomata ($\mu m^2$) |
|---|---|---|---|---|---|
| *Argyreia nervosa* Bojer | Control | 28.44±1.25 | 3.21±0.29 | 8.85±2.45 | 91.29±17.03 |
| (Convolvulaceae) | Polluted | 20.18±2.00*** | 2.14±0.44*** | 9.42±0.00 | 43.18±11.80 |
| *Aristolochia elegans* Mast. | Control | 42.36±2.30 | 3.65±0.46 | 11.60±1.30 | 154.61±16.13 |
| (Aristolochiaceae) | Polluted | 27.33±3.42*** | 2.99±0.39*** | 9.14±2.56 | 81.71±18.44 |
| *Barleria calophylla* Lindau | Control | 13.33±1.65 | 4.47±0.39 | 3.00±1.05 | 59.58±13.01 |
| (Acanthaceae) | Polluted | 10.66±0.74*** | 2.50±0.44*** | 5.20±1.45 | 21.85±2.500 |
| *Bauhinia candida* Act. | Control | 22.18±2.80 | 5.44±0.63 | 4.07±0.88 | 120.65±15.39 |
| (Caesalpiniaceae) | Polluted | 20.00±2.75 | 5.13±0.66*** | 3.89±0.74*** | 102.60±16.57 |
| *Begonia elatlor* Hort. | Control | 16.11±3.55 | 4.80±0.68 | 3.35±1.73 | 77.32±18.16 |
| (Begoniaceae) | Polluted | 15.95±3.50 | 2.98±0.37*** | 5.35±2.60** | 47.53±16.21 |
| *Caladium hortulanum* Birdsey | Control | 20.41±4.260 | 5.60±1.40 | 3.64±1.60 | 114.29±16.00 |
| (Araceae) | Polluted | 13.94±4.13*** | 6.00±2.00 | 2.30±1.45 | 83.64±20.00 |
| *Canna indica* L. | Control | 25.91±2.88 | 4.35±1.22 | 5.95±1.00 | 112.70±16.00 |
| (Cannaceae) | Polluted | 19.64±0.77*** | 3.38±0.87*** | 5.81±1.13 | 66.38±12.00 |
| *Eulophia quartiniana* A. Rich | Control | 14.77±0.74 | 4.50±0.98 | 3.19±0.75 | 66.46±11.50 |
| (Orchidaceae) | Polluted | 6.14±1.88*** | 3.00±1.23*** | 2.04±1.75 | 18.42±2.500 |
| *Euphorbia trigona* Haw. | Control | 14.18±1.75 | 5.15±1.34 | 2.75±1.40 | 73.02±19.22 |
| (Euphorbiaceae) | Polluted | 10.77±1.88 | 2.80±0.39*** | 3.84±1.04 | 30.15±6.930 |
| *Nerium oleander* L. | Control | 30.11±2.25 | 4.80±0.88 | 6.27±1.37 | 144.52±14.66 |
| (Apocynaceae) | Polluted | 26.24±2.22*** | 2.95±0.46*** | 8.89±2.81 | 77.40±16.37 |

** = Significant at p<0.05% level,*** = Significant at p<0.01% level

Table 3: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the lower surface of the leaf (Values are means±SD of 10 observations/parameter)

| | | Lower surface | | |
|---|---|---|---|---|
| Plant species (Botanical family) | Area | No. of stomata/unit area (3600 μm²) | No. of epidermal cells/unit area (3600 μm²) | Stomatal index |
| *Argyreia nervosa* Bojer | Control | 1.33±0.41 | 4.22±0.83 | 22.00±3.60 |
| (Convolvulaceae) | Polluted | 2.60±0.18*** | 7.14±3.00** | 25.09±6.360 |
| *Aristolochia elegans* Mast. | Control | 1.44±0.32 | 6.11±0.49 | 22.46±3.93 |
| (Aristolochiaceae) | Polluted | 1.88±0.63*** | 8.37±0.90** | 23.67±5.140 |
| *Barleria calophylla* Lindau | Control | 1.37±0.52 | 5.00±0.88 | 22.46±7.50 |
| (Acanthaceae) | Polluted | 1.40±0.43 | 7.00±2.99*** | 28.27±5.400 |
| *Bauhinia candida* Act. | Control | 1.43±0.41 | 4.11±0.80 | 24.26±6.08 |
| (Caesalpiniaceae) | Polluted | 2.11±0.24* | 7.55±0.51** | 36.81±9.300 |
| *Begonia elatlor* Hort. | Control | 1.90±0.22 | 9.90±1.90 | 18.22±3.66 |
| (Begoniaceae) | Polluted | 2.00±0.50*** | 10.80±1.50 | 20.11±4.110 |
| *Caladium hortulanum* Birdsey | Control | 1.60±0.72 | 4.00±0.81 | 26.11±3.42 |
| (Araceae) | Polluted | 2.50±01.01 | 6.00±0.86*** | 34.18±6.00 |
| *Canna indica* L. | Control | 1.50±0.31 | 8.00±0.95 | 24.41±6.00 |
| (Cannaceae) | Polluted | 1.95±0.87 | 9.11±1.99*** | 34.67±11.11 |
| *Eulophia quartiniana* A. Rich | Control | 1.77±1.25 | 4.32±0.81 | 19.00±4.11 |
| (Orchidaceae) | Polluted | 1.50±0.16 | 6.75±0.73*** | 27.11±6.450 |
| *Euphorbia trigona* Haw. | Control | 1.20±1.01 | 6.00±0.72 | 21.34±7.70 |
| (Euphorbiaceae) | Polluted | 1.50±0.07 | 8.18±3.22** | 27.12±3.760 |
| *Nerium oleander* L. | Control | 1.60±0.33 | 7.00±1.37 | 22.40±7.15 |
| (Apocynaceae) | Polluted | 2.80±0.44*** | 10.33±3.13** | 28.20±6.950 |

* = Significant at p<0.1% level, ** = Significant at p<0.05% level,*** = Significant at p<0.01% level

Table 4: Effect of autoexhaust pollution at Khartoum city on the micromorphology of some ornamentals in the lower surface of the leaf (Values are means±SD of 10 observations/parameter)

| Plant species (Botanical family) | Location | Length of stomata (L) (μm) | Breadth of stomata (B) (μm) | L/B ratio | Calculated area of stomata (μm²) |
|---|---|---|---|---|---|
| *Argyreia nervosa* Bojer | Control | 27.34±1.280 | 4.47±0.37 | 6.11±1.44 | 122.20±18.03 |
| (Convolvulaceae) | Polluted | 18.11±2.11 | 3.27±0.69* | 5.53±1.00 | 59.21±13.76 |
| *Aristolochia elegans* Mast. | Control | 40.82±2.500 | 4.63±0.60 | 8.81±1.20 | 188.99±18.00 |
| (Aristolochiaceae) | Polluted | 26.00±3.00*** | 3.00±0.41*** | 8.66±2.22 | 78.00±15.30 |
| *Barleria calophylla* Lindau | Control | 12.13±1.580 | 5.44±0.46 | 2.22±1.15 | 65.98±14.02 |
| (Acanthaceae) | Polluted | 9.30±0.34*** | 3.90±0.66*** | 2.38±1.65 | 36.27±3.500 |
| *Bauhinia candida* Act. | Control | 21.57±2.750 | 6.28±0.75 | 3.43±0.76 | 135.45±16.24 |
| (Caesalpiniaceae) | Polluted | 19.28±2.60 | 6.80±1.00 | 2.83±0.65 | 131.10±17.04 |
| *Begonia elatlor* Hort. | Control | 15.18±3.450 | 5.38±0.71 | 2.82±1.60 | 81.66±19.30 |
| (Begoniaceae) | Polluted | 14.00±3.41 | 3.47±0.48** | 4.03±2.11 | 48.58±16.48 |
| *Caladium hortulanum* Birdsey | Control | 19.36±3.460 | 4.11±1.32 | 4.71±1.85 | 79.56±12.01 |
| (Araceae) | Polluted | 14.90±3.99** | 5.22±1.88 | 2.85±1.56 | 77.77±16.28 |
| *Canna indica* L. | Control | 24.88±2.810 | 5.20±1.33 | 4.78±1.25 | 129.37±18.00 |
| (Cannaceae) | Polluted | 18.41±0.75*** | 4.17±0.75*** | 4.41±1.38 | 76.76±13.00 |
| *Eulophia quartiniana* A. Rich | Control | 13.23±0.650 | 5.12±0.72 | 2.58±0.88 | 67.73±10.50 |
| (Orchidaceae) | Polluted | 5.88±1.98*** | 2.30±1.46*** | 2.55±1.89 | 13.52±1.780 |
| *Euphorbia trigona* Haw. | Control | 13.00±1.600 | 6.28±1.50 | 2.07±0.90 | 81.64±19.90 |
| (Euphorbiaceae) | Polluted | 8.00±2.17 | 3.22±0.40*** | 2.48±0.75 | 25.76±4.640 |
| *Nerium oleander* L. | Control | 29.33±2.500 | 5.17±0.75 | 5.67±0.98 | 151.16±16.00 |
| (Apocynaceae) | Polluted | 25.18±2.54 | 3.38±0.46*** | 7.44±1.95 | 85.10±17.40 |

* = Significant at p<0.1% level, ** = Significant at p<0.05% level, *** = Significant at p<0.01% level

Length, breadth and calculated area of stomata exhibited different percentages of inhibition whereas number of stomata, epidermal cells and stomatal index showed stimulation. It is obvious that *Aristolochia elegans* Mast. (Aristolochiaceae) showed more number of parameters inhibited in maximum percentage and was considered a good indicator of auto-exhaust pollution and the most sensitive one while *Nerium oleander* L. (Apocynaceae) was the most resistant plant. Similar observations were made by Salgare and Lyer (1991), Salgare and Rawal (1990) and Darrall (1989). Since ornamental plants were found polluted severly area, it would therefore suggest that emphasis must be given for the control of auto-exhaust pollution in the area.

## CONCLUSION

Several differences were recorded and showed significant inhibition due to the auto-exhaust pollution. In polluted sites, leaves became smaller with reduced length and width and stomatal index per leaves area. These changes corresponded to rate of auto-exhaust density regardless of mean annual air temperature of each site. The results indicate that micro morphology in ornamental leaves is an emergent property, the magnitude of which is environmentally constrained.

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