*International Research Journal of Environmental Sciences*_____ ISSN 2319–1414
Vol. **10(2),** 45-51, April **(2021)** *Int. Res. J. Environmental Sci.*

An assessment of dust accumulation and leaf morphology at roadside plants in Kathmandu Valley, Nepal

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Available online at: www.isca.in, www.isca.me
Received 2nd October 2020, revised 6th February 2021, accepted 7th March 2021

Abstract

Air pollution is one of the serious environmental issues. The vehicular emissions have a very harmful effect on the environment, human health and ecology. This research was planned to assess dust deposition on leaves of two selected plants are Callistemon citrinus and Lagerstroemia indica growing along the roadside of a city having high traffic density and construction. The work determines the variation in dust deposition on leaves and different structure of leaf with respect to species, seasons and study sites. The study was conducted in these seasons, i.e. spring, summer, autumn and winter, during 2017 / 2018. In C. citrinus, the deposition of dust on leaf was highest in heavily polluted sites in all seasons. The dust deposition and the morphology of leaf show the interrelationship in the growth and development. If dust accumulation was increased then the growth was decreased instead if dust deposition was decreased then leaf growth was increased. In L. indica, the deposition of dust on leaf was highest in heavily polluted sites. In different seasons, the dust deposition and the value of morphology of leaf showing the interrelationship in the growth and development differently. It was because of different environmental factors. In heavily polluted site, some dust deposition result and with this the growth of morphology of leaf was decreased. The result about the deposition of dust and in the morphology (length, breadth, area and specific length area) indicated that it was affected from the environment and deposition of dust on leaf.

Keywords: Dust, leaves, morphology, pollution, roadside, season.

Introduction

Dust pollution is a great problem in capital city Kathmandu of Nepal. Digging of roads, long delay in repairing roads, lying of utility pipes of the drinking water project, due to heavy and unmanaged traffics and unrest vehicles movements are the major causes of the pollution[1].

Plants can be effectively used for monitoring air pollutants as different plant species respond to different types of air pollutants. The leaf area is for the absorption and accumulation of air pollutants to reduce the pollution level in the air environment[2].

Due to industrialization and rapid expansion of city the environmental problems are increasing especially air pollution. Three years vehicles registration data were given the increasing number of vehicles in Bagmati Zone, 2013-2014 registered 67449, 2014-2015 registered 72633 and 2015-2016 registered 94721[3]. This gives that the pollution issues increases as vehicles increases in the cities.

Vehicular traffic is one of the major contributors to accumulate dust on plants grown alongside roads. Plants intercept tons of dust, absorb noise and serve as acoustic screens on busy highways[4]. Vegetation contributes in reducing dust concentration in environment by acting as a receptor for air pollutants.

Objectives: The present study was conducted on i. The dust deposition on leaf, leaf area and specific leaf area measurements, ii. The effect of environment on dust deposition and in different leaf structure with the study sites and seasons.

Materials and methods

These plants are common and thus selected for the study. The selected plant species and their characteristics,

***Callistemon citrinus* Skeels:** The leaves are long, narrow, pointed and leathery with a thick texture of the leaf surface (Figure-1, 5). In different study sites, these leaves could be seen with the heavy deposition of the dust from the roadside environments. Even though, the leaves surface covered by dust, plants is able to maintain its activities

Lagerstroemia indica L.: The leaves are small, wide and lightly the surface of the leaves is glossy and leathery (Figure-2 and 7)[5]. The leaves can be seen with a little more deposition of the roadside dust, smokes and pollutants.

The collection and washing of the leaves also indicated that the surface of the leaf is suitable for the attachment of the pollutants. In some sites and in a few plants, leaves are with pollutants and some pests, then leaves losing some beauty in the planting areas.

Figure-1: *Callistemon citrinus.*

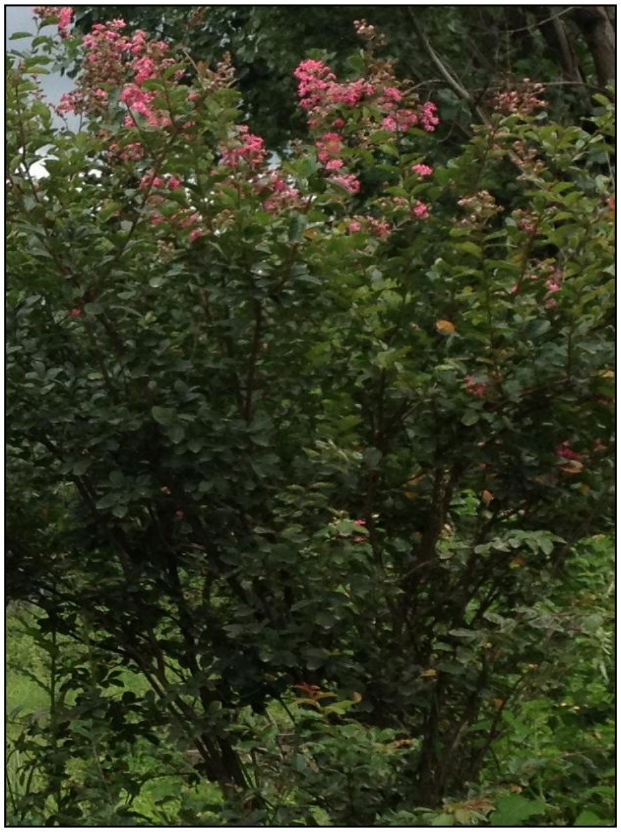

Figure-2: *Lagerstroemia indica.*

Figure-3a: *Callistemon citrinus* (Less Polluted Site).

Figure-3b: *Callistemon citrinus* (Polluted Site).

After this leaves were cut from the small branches very lightly and pack in the polythene bags. The samples were brought in laboratory and arrange systematically[7]. The fresh samples were weighed before washing and after washing (made shade dry) by using an electronic balance. These samples were photographs separately (for the purpose of *Image J* program) and the amount of dust was calculated using the formula as follows[4].

$$W = \frac{(W_1 - W_2)}{A} \quad (1)$$

Where: Dust Content (W) = Weight of Dust /Area of Leaf, W= weight of dust content (g/cm²) and A is total area of the leaf (cm²), W1= weight with dust (before leaf wash), W2 = weight without dust (after leaf wash).

Leaf area measurements and determination of specific leaf area (SLA) of leaves: Prepare the set for the leaf photographs in laboratory with a paper (draw a scale line) and the glass plate. Cut the leaves from petiole and take photographs pressing by glass plate. For the determination of area, measurement of leave is from *Image J Program* and makes calculation (Figure-4 and 5).

Figure-4: *Lagerstroemia indica* leaves samples in the experiment.

Figure-5: *Lagerstroemia indica* leaves samples in the experiment.

The leaf pressing from glass plate for the photographs and area measurements from *Image J Program.*

Figure-6: *Lagerstroemia indica*, leaves samples in the experiment.

Figure-7: At roadside (Less polluted site) flowering in summer.

Leaf Morphology: Around from 30 mature leaves, the measurement of leaf length (LL), leaf width (LW), leaf area (LA), dry weight of leaf (LDW) and specific leaf area (SLA) were completed. Length and width of leaves, and area measured in fresh leaves photographs. Then these leaves are oven dried (60ºC-70ºC, 24 hours) and mass of each leaf was weighed in electronic balance (0.001g). SLA was calculated as the ratio of leaf area and dry weight of leaves, i.e. SLA=Leaf Area / Dry Weight of Leaves.

Results and discussion

The status of selected plant leaves on dust deposition and morphology are given in Table-1-6.

Table-1: Plant: *Callistemon* Season: Spring.

Measurement	Heavily Polluted	Moderately Polluted	Less Polluted
Dust Content	0.013 ± 0.005	0.0034 ± 0.0003	0.0012 ± 0.0002
Length	5.8 ± 0.47	5.74 ± 0.45	6.21 ± 0.221
Breadth	0.52 ± 0.03	0.5 ± 0.034	0.62 ± 0.04
Area	2.95 ± 0.2	2.8 ± 0.14	3.84 ± 0.34
SLA	49.95 ± 1.14	54.67 ± 1.7	40.0 ± 3.14

Within the three seasons, the breadth and dust content values are comparatively high in this season. The experimental values, length, breadth and area of leaf measurements were high in the less polluted sites. SLA is high in moderately polluted site. Dust content is high in heavily polluted site.

Table-2: Plant: *Callistemon*, Season: Autumn.

Measurement	Heavily Polluted	Moderately Polluted	Less Polluted
Dust Content	0.007±0.001	0.003±6.97	0.002±0.0002
Length	6.13 ± 0.264	5.94±0.241	6.57 ± 0.2
Breadth	0.57 ± 0.03	0.56±0.0074	0.6 ± 0.03
Area	3.49 ± 0.17	3.33 ± 0.154	3.92 ± 0.29
SLA	34.97 ± 1.39	31.52 ± 1.32	33.03 ± 3.72

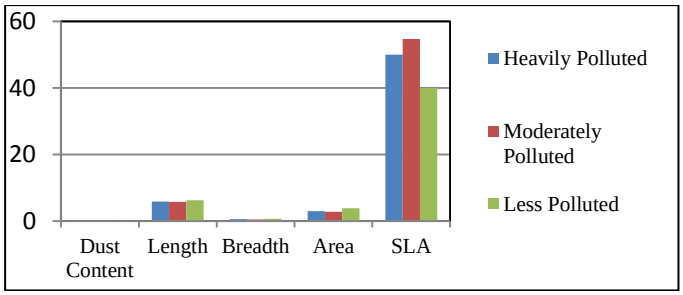

Figure-8: *Callistemon citrinus*: Season: Spring.

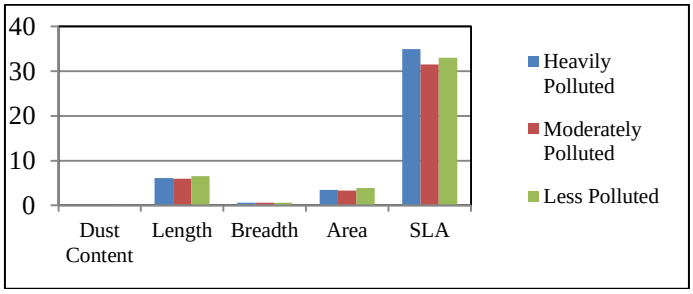

Figure-9: Season: Autumn.

The different values are given in the diagram representation (Figure-8,9). Within the three seasons, the length and area values are comparatively less in this Autumn season. The experimental values, length, breadth and area of leaf measurements were high in the less polluted sites. SLA and dust content is high in heavily polluted site.

Table-3: Plant: *Callistemon*, Season: Winter.

Plants	Heavily Polluted	Moderately Polluted	Less Polluted
Dust Content	0.0042 ± 0.0014	0.003 ± 0.0005	0.0006 ± 6.56
Length	5.77 ± 0.34	5.32 ± 0.3002	6.19±0.201
Breadth	0.51 ± 0.021	0.52 ± 0.019	0.55±0.024
Area	2.95 ± 0.17	2.75 ± 0.16	3.436±0.25
SLA	52.14 ± 1.72	56.901 ± 4.303	41.823 ± 3.06

The experimental values, length, breadth and area of leaf measurements were high in the less polluted sites. SLA is high in moderately polluted site. Dust content is high in heavily polluted site. Within the three seasons, the SLA value is comparatively high in this winter season.

The impact of seasons and study sites for the deposition of dust and pollutants on plant leaf was given as follows:

In *Callistemon citrinus* (Curtis) Skeel, the deposition of dust on leaf was highest in heavily polluted sites in all three seasons (Spring, Autumn and Winter). Among three seasons, the highest value was in the spring season. Likewise, length, breadth and area's values were highest in the less polluted sites. SLA values were high in the moderately polluted sites.

SLA which is supposed to be an indicator of plant morphology was found to decrease in roadside plant species in compare to control. Among the roadside plant species, *Cassia sofera* exhibited maximum reduction in SLA. Reduction in SLA specifies decrease physiological as well as the biochemical status of the plant. Strong negative correlation has been reported earlier in between dust accumulation and SLA[8,9].

In different seasons, the dust deposition and the value of morphology of leaf showing the interrelationship in the growth and development. If dust accumulation was increased then the growth was decreased instead if dust deposition was decreased then leaf growth was increased. Because of this, in heavily polluted site the growth of morphology of leaf was decreased[10].

Table-4: Plant: *Lagerstroemia indica*, Season: Spring.

Plants	Heavily Polluted	Moderately Polluted	Less Polluted
Length	4.6 ± 0.12	4.9 ± 0.12	4.5 ± 0.11
Breadth	2.6 ± 0.10	2.8 ± 0.06	2.6 ± 0.05
Area	8.6 ± 0.5	9.7 ± 0.4	7.8 ± 0.3
SLA	73.62 ± 2.92	85.81 ± 2.6	88.73±2.84
Dust Content	0.003 ± 0.001	0.002 ± 9.6	0.002±9.18

Figures-10,11, the different values are given in the diagram representation. The dust content is less comparatively with length and SLA.

Within the three seasons, the values of breadth, SLA and dust content are comparatively high in this season. The experimental values, length, breadth and area of leaf measurements were high in the moderately polluted sites. SLA is high in less polluted site. Dust content is high in heavily polluted site.

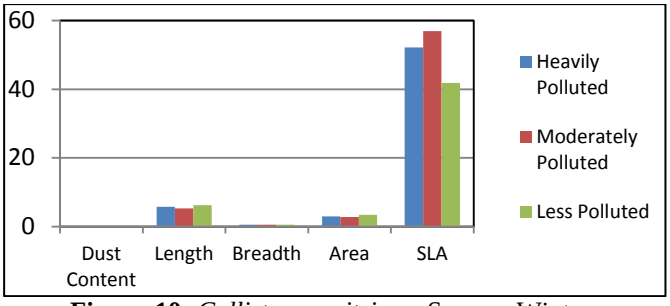

Figure-10: *Callistemon citrinus*, Season: Winter.

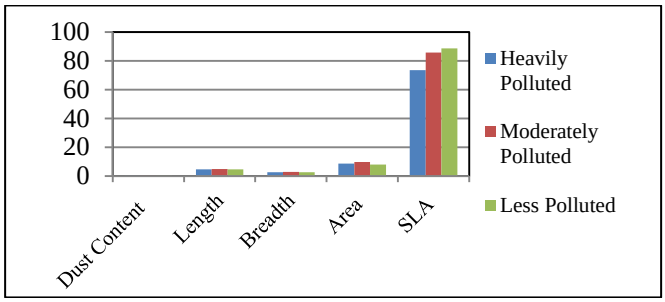

Figure-11: *Lagerstroemia indica*, Season: Spring.

Table-5: Plant: *Lagerstroemia indica*, Season: Summer.

Plants	Heavily Polluted	Moderately Polluted	Less Polluted
Dust Content	0.003 ± 0.001	0.002 ± 0.0001	0.001 ± 6.6
Length	4.8 ± 0.16	4.8 ± 0.1	4.53 ± 0.104
Breadth	1.97 ± 0.06	2.0 ± 0.05	2.0 ± 0.05
Area	9.51 ± 0.7	9.5 ± 0.30	9.03 ± 0.33
SLA	75.42 ± 13.91	68.3 ± 2.17	64.21 ± 1.94

Within the three seasons, the dust content value is comparatively high in this season. The experimental values, length, breadth and area of leaf measurements were high in the moderately polluted sites. SLA and Dust content is high in heavily polluted site.

Table-6: Plant: *Lagerstroemia indica*, Season: Autumn.

Plants	Heavily Polluted	Moderately Polluted	Less Polluted
Dust Content	0.002±0.0024	0.0024±0.0002	0.0012±9.03
Length	4.8 ± 0.16	5.06 ± 0.09	4.91±0.17
Breadth	1.93 ± 0.08	2.0 ± 0.05	2.13±0.06
Area	9.25 ± 0.7	9.93 ± 0.32	10.30±0.24
SLA	68.71 ± 10.5	79.2 ± 2.3	65.4±2.02

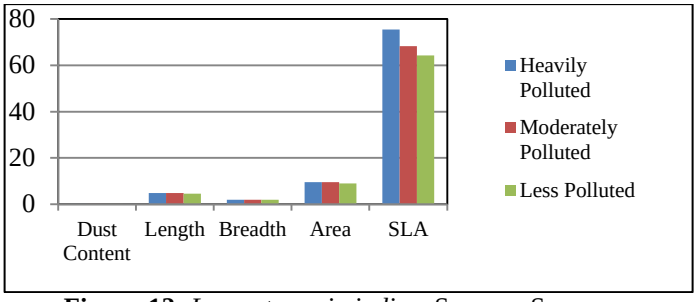

Figure-12: *Lagerstroemia indica*, Season: Summer.

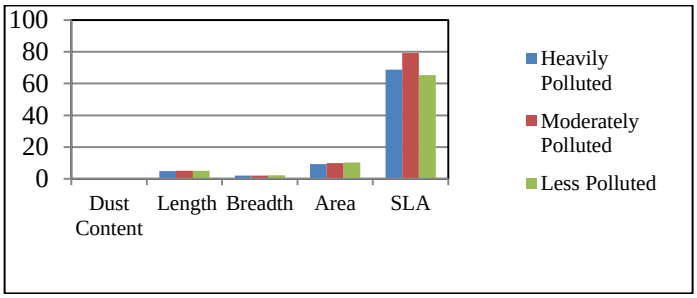

Figure-13: Season: Autumn.

Figure-12,13. The different values are given in the diagram representation.

The dust content is less comparatively with length, area and SLA.

The experimental values, length, breadth and area of leaf measurements were high in the less polluted sites. SLA is high in moderately polluted site. Dust content is high in heavily polluted site. Within the three seasons, the length value is comparatively more in this season. Within the three seasons, the SLA value is comparatively high in this Spring season at less polluted sites.

The impact of seasons and study sites for the deposition of dust and pollutants on plant leaf was given as follows:

The high dust accumulation in the winter season may be due to wet surfaces of leaves which help in capturing dust, with a gentle breeze and foggy condition preventing particulate dispersion. In the rainy season the least dust accumulation is reported because of washing of leaves and settling of particulates due to rain. Despite a high concentration of dust in summer, high wind speed may be the reason for the relatively lower dust accumulation in the summer than in winter[4].

In *Lagerstroemia indica*, the deposition of dust on leaf was highest in heavily polluted sites in two seasons (Spring and Summer). Likewise, length, breadth and area's values were highest in the moderately polluted sites and a little result in the part of heavily and less polluted sites as well. This was because of different factors in the roadside environment. SLA values were high in Spring at the less polluted sites. Continuous

exposure to dust in leaf surface leading to the formation of dense dust layers, which reduce light capturing capacity of plants[4,11] and finally affect plant photosynthetic activity[12] .

In different seasons, the dust deposition and the value of morphology of leaf showing the interrelationship in the growth and development. In *L. indica*, dust accumulation was increased and the growth was also increased. It was because of different environmental factors. Dust deposition decreased then leaf growth was increased in less polluted sites in Autumn season. In heavily polluted site, some dust deposition result and with this the growth of morphology of leaf was decreased.

Conclusion

These study plants were able to give the expected results. The experimental results were analyzed and can be concluded that a little difference in obtained results following the effect of seasons and study sites. It might be some environmental effect in the leaf also. This could be due to plants physiological and biochemical activities getting exposure of plants with air pollutants produced from various auto emission sources and from construction activities in the roadsides.

Leaves texture is also applicable for the dust and pollutant deposition[13]. If the leaf surface is plane and glossy than possibilities to deposit the dust on the leaf surface is decreased. Roadside growing plants are more affected by air pollutants because of heavy traffic load. In polluted area plants shows some changes in dust deposition and in morphology of leaves. The impact of seasons and study sites for the deposition of dust and pollutants on leaf was given the conditional impact in the plants. The increased movement in the area; increased dust and dust air made the plant affected externally and internally as well.

Trees act as an absorber for air pollutants and thus reduce their concentration in the air, 14. Dust interception capacity of plants depends on their surface geometry, phyllotaxy, and leaf external characteristics such as hairs, cuticle, height, and canopy of trees. Removal of pollutants by plants from air is by three means, namely absorption by the leaves, deposition of particulates and aerosols over leaf surfaces. The result about the deposition of dust and in the morphology (length, breadth, area and SLA) with the sites and seasons indicated it was affected from the deposition of dust on leaf in the cities environment.

Acknowledgements

I am grateful to the Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur and the University Grants Commission, Bhaktapur, Kathmandu; Nepal, was supported this research work under Faculty Research Grants. We are thankful to the Ecology Section, Central Department of Botany for accessibility of equipment and facilities to complete this Laboratory work and their kind encouragement.

My gratitude is for Prof. Dr. Ram Kumar Sharma; Central Campus, Institute of Engineering, Tribhuvan University, Pulchowk, Lalitpur for providing the research paper to me from which I was able to explore to submit the research paper in this Journal. I am thankful to the Prof. Dr. Dipak Sharma and ISCA family for very harmonious cooperation.

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