



ORNAMENTAL PLANTS FOR ENVIRONMENTAL MANAGEMENT AT ROADSIDES IN KATHMANDU VALLEY, NEPAL

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Abstract

Plant species growing along roadsides in Kathmandu gives the development which is necessities of the good environment. This study determines plantation, coverage, leaves condition of important ornamental species at different sites of Kathmandu. Many Plant species are growing and applicable for bio-indicator and maintaining greenery. *Bougainvillea glabra*, *Callistemon citrinus*, *Duranta erecta*, *Euphorbia pulcherrima*, *Jasminum mesnyi*, *Lagerstroemia indica*, *Malvaviscus penduliflorus*, *Nerium oleander* and *Rose indica* are documented. The heavily polluted sites shows dominance of *C. citrinus* 73.33 ± 2.08 and *N. oleander* has 73.7 ± 1.6 . The coverage of *C. citrinus*, *D. erecta*, *J. mesnyi*, *L. indica* and *N. oleander* has been observed as excellent along the roadside. However *B. glabra*, *E. pulcherrima*, *M. penduliflorus* and *R. indica* are seen at some places. These trees have the capacity to absorb carbon dioxide and reduce pollution levels. The study sites are heavily, moderately and less polluted sites. Plants in the period of study (2017 to 2022) from the observation and comparison are in further development. Elements analysis of soil and leaves are from ICP-OES (Inductively coupled plasma-optical emission spectrometry) were done. Subsequently, following elements Aluminium, Barilium, Cadmium, Cobalt, Chromium, Copper, Iron, Manganese, Nickel, Lead, Vanidium and Zinc were determined. The dust deposition on plants, chlorophyll content and anatomy of *N. oleander* was with less deposition of dust and chlorophyll values is increased (0.001547 ± 0.000788 and 2.397 ± 0.299). The stomata and stomatal index of *C. citrinus* are calculated (33.607 ± 4.509 and 15.699 ± 0.898). Evergreen and broad leaf trees have advantageous in environment. The summer in Kathmandu is gorgeous with *L. indica* flowers while flowers of *C. citrinus* and *N. oleander* observed in all seasons of the year. The success programs are recommended from the authority that is evaluated and continued for long term benefit.

Keywords: Air quality, environments, floral diversity, plants, pollution, roadsides

Introduction

The urban area of capital city consists of designed planted roadsides in Kathmandu. Different selected ornamental plants are conserved. They are trees, shrubs and grasses as well. The ornamental plants with leaves, flowers are giving good scenic environment at different sites. Vehicles, population, education, economic, business, political, national importance are in many places (Nepal Government, 2017). The management of environment, controlling of unwanted in the cities are for the civilization and a long term programs. Urban roadsides plants management is in importance to make a city more attractive, peaceful and environmental protections.

Biodiversity makes the Earth habitable, and is necessary for our existence. Biodiversity provides various other important goods and services such as cultural, recreational, and spiritual nourishment that play an important role in maintaining environments, urbanization as well as social life. Chaudhary, R. P. et. al. (2020). Biodiversity includes fundamental things to our health like fresh water, clean air and food products, as well as the many other products such as

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timber, fiber, medicinal plants, etc. Ambient air quality is relates at different sites in the capital of Nepal. This promotes the plantation and it brings floral diversity.



Figure 1. The road site vegetation, Koteshwor
Green vegetation, the roadside ornamental plants in city area; Kathmandu



Figure 2. Ornamental plants, Kathmandu
Ornamental plants, the roadside ornamental plants in city area; Kathmandu

Objectives

General objective

Study of plants for the environmental management through plantation program at roadsides in Kathmandu valley

Specific objectives

The study determine the flora with environment conservation, coverage of vegetation for beauty environment in the roadsides

1. Study the plantation and coverage of important ornamental plant species at different sites of Kathmandu.
2. Determine the leaves dust condition by air pollution and its chlorophyll analysis
3. Determine the leaves and soil elements in study areas.
4. Analyze green vegetation, morphology and anatomical structural values of plants leaves.

Significance of the Study

The conservation of environments and make appropriate for human society has different useful aspects. It is an important task for the country. Conservation of biodiversity plays active role for present and coming days. Study arranges plans and conserves results for academic programs which have economic, ecological, social and spiritual progress. This is the real benefits of large exploration and established greenery roadside designed in the development.

Statement of the problems

The study is necessary to analyze the resources. Development is giving further movement. Along this, arise unnecessary harmful and makes difficulties. These cases should identify and need to bring good plans. This is the ways for highly appreciation in the field of work and achievements. The environmental factors and biodiversity plays an important role in maintaining and sustaining the supply of good air and services (MEA, 2005). So, it is also important to preserve every species of plants and animals as each one has some advance role to play in our nature and make assessments of biodiversity.

Hypothesis

- Plant species growing along roadsides in Kathmandu vary in their sensitivity to roadside pollution and environment.
- Plant species growing along roadsides in Kathmandu are giving the advantageous beautiful scenario.

Materials and Methods

The study plants are *Bougainvillea glabra* Choisy, *Callistemon citrinus* (Curtis) Skeels, *Duranta erecta* L, *Euphorbia pulcherrima* Willd, *Jasminum mesnyi* Hance, *Lagerstroemia indica* L., *Nerium oleander* L., *Malvaviscus penduliflorus* (*M. arboreus*) and *Rose indica*.

Many plant species are growing and applicable for bio-indicator and maintaining greenery.

The trees are *Callistemon citrinus*, *Lagerstroemia indica* and shrubs are *Bougainvillea glabra*, *Duranta erecta*, *Euphorbia pulcherrima*, *Jasminum mesnyi*, *Nerium oleander*, *Malvaviscus penduliflorus* (*M. arboreus*), *Rose indica*.

Methods

- i) Survey and selection of the study area
- ii) Ambient air quality monitoring in different sites.

Based on different reports in field study, sites were categorized into 3 different types. These are,

A: Heavily polluted sites: Urban area

Koteshwor-Airport area, Tudikhel-Ratna Park area, Kalanki area.

B: Moderately polluted sites: Bhudhanilkantha area

C: Less polluted sites: Sub urban area, Tribhuvan University, Kirtipur Campus area is taken as for the comparative study.

- iii) The methods for this piece of work are applied specially by field visit. All plants are available in all selected sites but the distribution pattern and coverage are not similar. The botanical description and their natural phenomenon are also different.

The field study is carried through the years. As the observation, comparison, plants, among the streets, in the period of 5 years and now the work and environment is in further development. Some samples experimental works are analyzed in Central Department of Botany, Tribhuvan University and some were in School of Environmental Science in Jawaharlal Nehru University, Delhi. The work is related with respect to plant and environment.

- 1 The coverage of different plants. Field documentation of plants, comparative study and statistical analysis were followed.

- 2 Formula in different work analysis are,

$$\text{i) Total Chl} = \frac{A \times 652 \times 1000 \times V}{34.5} \quad 1000 \times W \quad (\text{Arnon, D. J. 1949})$$

$$\text{ii) } W = \frac{(W_1 - W_2)}{A}$$

$$\text{iii) } W (\text{Dust \%}) = \frac{W_1 - W_2}{W_1} \times 100$$

(Prajapati, S. K. and Tripathi, B. D. 2008)

- iv) ICP-OES methods were used to determine the different elements, Anju, 2016

$$\text{v) Stomatal Index} = \frac{\text{No. of stomata present per unit area of leaf}}{\text{No. of stomata} + \text{no. of epidermal cells within a unit area of leaf}} \times 100$$

Results and Discussions

Biodiversity conservation, its scope in research and in environment is presented. The coverage of *C. citrinus*, *D. erecta*, *J. mesnyi*, *L. indica* and *N. oleander* are very good. The coverage of *B. glabra*, *E. pulcherrima* *M. penduliflorus* and *R. indica* are also in different places. *L. indica* is flowering in summer. *C. citrinus* and *N. oleander* is flowering in different seasons. The plants are well in heavily and less polluted sites equally. The plants are recommended. The plants are good with beauty environment in the roadside. Some of experimental results are also good as the elements analysis of the soil and plants leaves.

- 1) Plantation, coverage of important ornamental plant species at different sites of Kathmandu which results green roadsides environmental management.

The concept of environment, civilization and decoration built the ideas for the green streets in the Kathmandu. The research is in Kathmandu city. The general environmental condition of the city can be considered as environmental, social, economic and the green floral conservation in the country.

- i) This study determine; floral conservation, coverage, beauty environment in the roadsides. In general, plantation and greenery is the primary work in study area (Kathmandu).

Table 1. Description and documentations

S.N.	Study Sites	Places	Road Plants Trees	Coverage of Plants	Road Plants Shrubs	Coverage of Plants
1	Less Polluted	Kirtipur	Good plantation, normal coverage	68±3	Good plantation, normal coverage	64±3.60
2	Moderately Polluted	Bhudhanilkantha	Good plantation, normal coverage	61.33±3.05	Good plantation, less coverage	59.66±4.50
3	Heavily Polluted	Kathmandu	Good plantation, good coverage	71.33±3.51	Good plantation, good coverage	72±3

The above table explains the plants and its coverage in the different sites. The heavily polluted sites shows comparatively maximum plantation (trees 71.33±3.51 and shrubs 72±3).

- ii) Selected plants in study areas (Kathmandu).

Bougainvillea glabra, *Callistemon citrinus*, *Duranta erecta*, *Euphorbia pulcherrima*, *Jasminum mesnyi*, *Lagerstroemia indica*, *Malva viscus penduliflorus*, *Nerium oleander* and *Rose indica* are documented. These trees and shrubs have the capacity to absorb carbon dioxide and reduce pollution levels.

Table 2. Description and documentations

S.N.	Study Sites	Places	Study Plants Trees	Coverage of Plants	Study Plants Shrubs	Coverage of Plants
1	Less Polluted	Kirtipur	Good plantation, normal coverage	66.33±1.52	Good plantation normal coverage	62.33±2.52
2	Moderately Polluted	Bhudhanilkantha	Good plantation,normal coverage	64.66±.51	Many plants less coverage	56.33±2.30
3	Heavily Polluted	Kathmandu	Good plantation good coverage	69.66±1.52	Good plantation good coverage	70.332±.08

The above table explains the study plants and its coverage in the different sites. The heavily polluted sites shows comparatively maximum plantation (trees 69.66±1.52 and shrubs 70.332±.08) in Kathmandu.

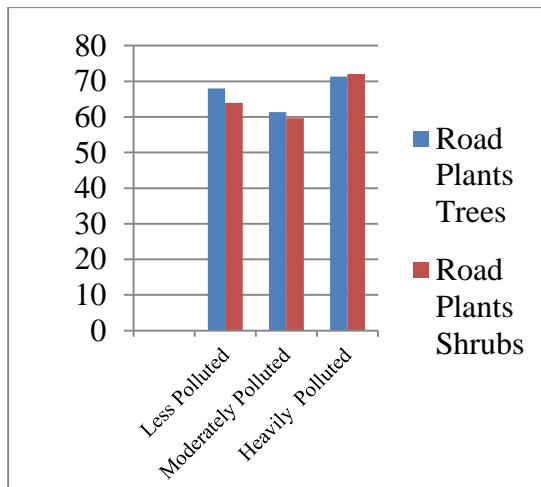


Figure 3. Plants in different sites

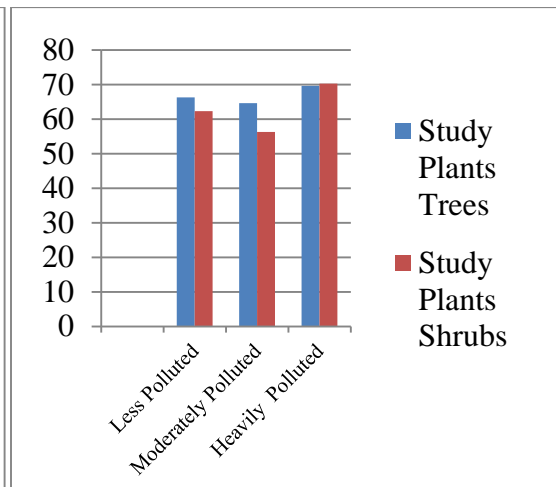


Figure 4. Plants in different sites

Table 1 and Table 2 are represented in Bar Diagrams Figure 3 and Figure 4.

The coverage of plants in different sites is good (Table 1 and Table 2; Bar Diagrams Figure 3 and 4). Field observation describes evergreen plants, many flowers and capacity to survive in the different environment with ornamental purpose.



Figure 5. Study sites, Koteswor



Figure 6. *Jasmine mesnyi*



Figure 7. *Rose indica*

Green street plant coverage makes important results. This gives the ornamental plants for environment management in the roadsides of Kathmandu.

Table 3. Study plants documentations

S. N.	Plants	Heavily Polluted	Moderately Polluted	Less Polluted
1	<i>B. glabra</i>	52±2	45±1	41.7±1.7
2	<i>C. citrinus</i>	73.33±2.08	52.7±2.08	72±2
3	<i>D. erecta</i>	73.33±1.6	51.33±1.52	64.7±1.52
4	<i>E. pulcherrima</i>	44±1	51±1.52	55±1
5	<i>J. mesnyi</i>	54±1	61.7±1.52	75±1
6	<i>L. indica</i>	61±1	54.7±1.52	74.3±0.6
7	<i>M. enduliflorus</i>	55±1	44.7±1.52	51±1
8	<i>N. oleander</i>	73.7±1.6	55±1	51±1
9	<i>R. indica</i>	54±1	51.7±1.52	54.7±0.6

The above table explains the nine study plants and its coverage in the different sites. The heavily polluted sites shows comparatively maximum plantation of species. Tree *C. citrinus* shows 73.33±2.08 and shrubs *N. oleander* has 73.7±1.6.

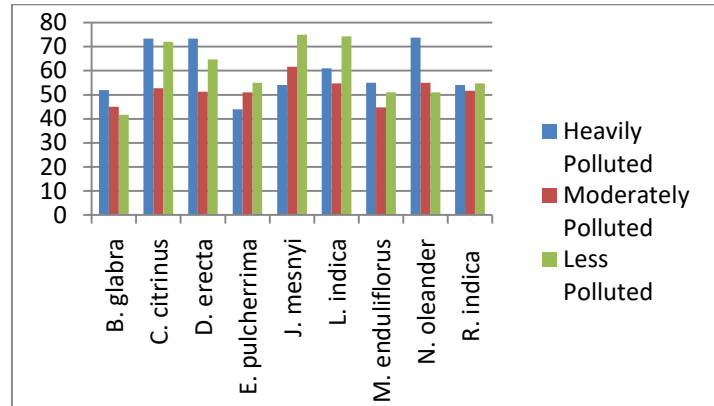


Figure 8. The bar diagrams representation of the coverage of plants

- iii) Determine the leaves condition by air pollution on study plants.
 Impacts of dust are on normal leaves rather than in glossy leaves. Dust deposition is on leaves as like in different places. The *Duranta species* looks a little clean leaves in the roadsides. Leaves kind and its coverage in the ornamental, environmental management are high in different sites.

The dust deposition on plants in different sites and in seasons

Table 4. Field study, the two plants results are presented.

S.N.	Study Sites	Places	<i>Callistemon citrinus,</i>	<i>Nerium oleander</i>
1	Less Polluted	Kirtipur	Green, leaves and plants are being in good results	Green, leaves and plants are being in good results
2	Moderately Polluted	Bhudhanilkantha	The minimum environmental effects in the dust deposition was obtained	The minimum environmental effects in the dust deposition was obtained
3	Heavily Polluted	Kathmandu	The area is wide. Vehicles, dust were in the environment gives some effects	The area is wide. Vehicles, dust were in the environment gives some effects

Different plants are representative in the fields, Such as trees, shrubs and herbs. Field observation makes beauty, evergreen. The dust in polluted sites, plant with capacity to the environment with ornamental purpose.



Figure 9. *C. citrinus*



Figure 10. *M. penduliflorus*



Figure 11. *Nerium indica*



Figure 12. *N. oleander*



Figure 13. *C. citrinus*

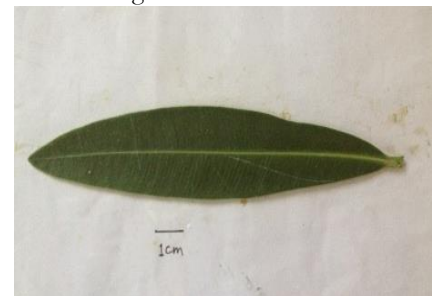


Figure 14. *N. oleander*

The experimental works and the results were presented in the tables. Leaves are for physiological activities of the plant body. The important part, biochemical process and survival, development depends on it. The leaves surface, anatomical structure, purpose and study keep very good in different research for plants and environment. The different pigments and chlorophyll are available in plants

The dust deposition and total Chlorophyll content of *Callistemon* and *Nerium* plants leaves.

Table 5. Study of *Callistemon citrinus*

Study Sites	Places Name	Dust Deposition	Total Chlorophyll
Study sites	Kathmandu	0.004155±0.003513	1.48±0.02309

Table 6. Study of *Nerium oleander*

Study Sites	Places Name	Dust Deposition	Total Chlorophyll
Study sites	Kathmandu	0.001547±0.000788	2.397±0.299

The study of dust deposition and chlorophyll content in these two plants are given in the tables.

Nerium oleander was with less deposition of dust and chlorophyll values is increased (0.001547±0.000788 and 2.397±0.299).

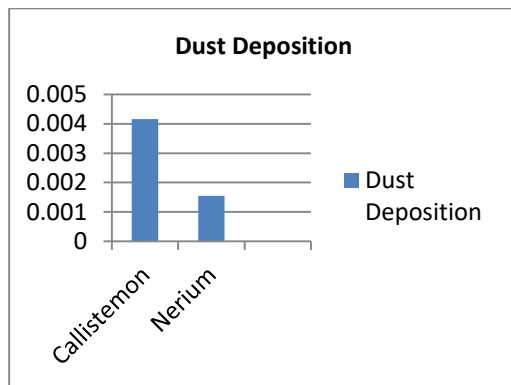


Figure 15. Dust deposition of 2 plants

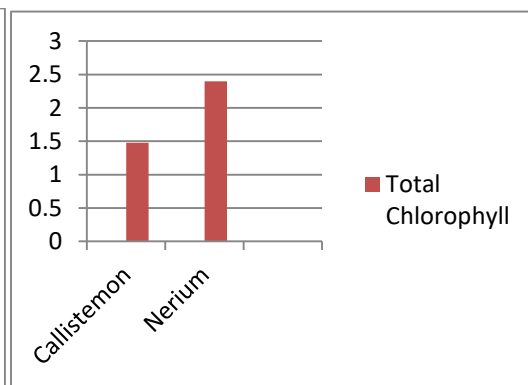


Figure 16. Chlorophyll content of 2 plants

The dust deposited on the surface and chlorophyll results are related with different activities in the leaves and in environment (Table 5 and 6; Fig 15 and 16). It affects in selection of the plants and comparative advantageous in the development programs.

Flagella et. al. (1995) explains chlorophyll concentration to provide rapid and accurate techniques of detecting and quantifying plant tolerance to stress. This implies that trees with higher foliar chlorophyll content could have the ability to withstand adverse weather conditions as would increase their adaptive capacity. Suitable ornamental plants in some areas can be planted to reduce problem as chlorophyll degradation in air polluted conditions. As in international airport sites *L. indica* will be the good work for the development in roadsides. Because it has very nice flowers as suitable in Asian countries.

Morphology and anatomy give some results in floral diversity. Field observation is pleasant, evergreen, capacity to survive in the environment with tolerance resistant and ornamental purpose are collectively for the plants and environments.

Table 7. The description of the morphological structure of plants.

Study Sites	Places	<i>C. citrinus</i>	<i>N. oleander</i>
Less, moderately and heavily Polluted	Kirtipur, Bhudhanilkantha and Kathmandu	Green, long leaves and red flowers are good. Leaves are thick and numerous in plants.	Green, long, broad leaves and pink flowers are good. Leaves are thick, quality, flowers are excellent.

The heavily polluted sites, area is also good and is showing the affirmative influences in the plants and in environments. The coverage of *C. citrinus*, *D. erecta*, *J. mesnyi*, *L. indica* and *N. oleander* has been observed as excellent along the roadside. However *B. glabra*, *E. pulcherrima*, *M. penduliflorus* and *R. indica* are seen at some places.

Some experimental results of Elements analysis of soil and leaves are also good. Comparatively in different seasons in general different elements are important. Some are benefitted and some are not good in the environment in their higher percentage.

Sample: Soil

Season: Winter 017

Table 8. Elements (Metal ions) in the soil collected from different study sites.

Sites	Al	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Aver	44996.68	1.6±0.026	8.1	81.027	25.47	21033.28±105	343.	30.303±4.29	41.61±	58.6	117.23
age	3	457513	13	±43.9	±12.12	91.46343	61	0108779	5.98	7±	±6.92
of 3	±14998.		±3.	3084	93253		±24			25.1	
sites	92671		97				2.38			8	

Al, Fe, Mn, Zn and Cr values are more. Other 6 elements values are also in environment. Co and Cd values are normal. Aluminium value is high (44996.683 ±14998.92671). Iron value is also good.

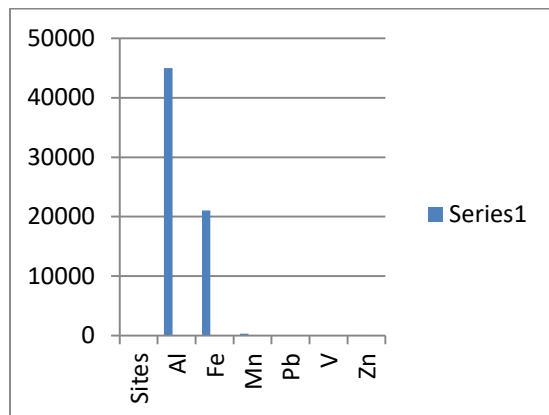


Figure 17. Soil elements values

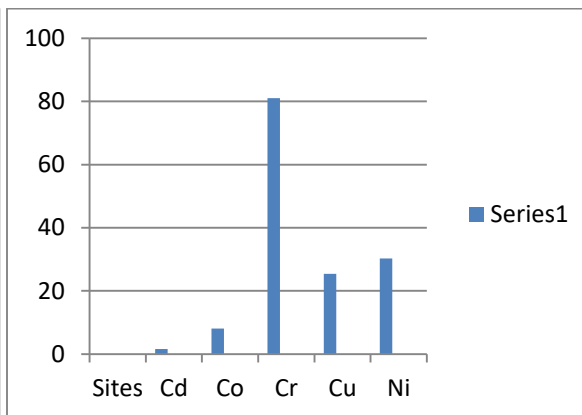


Figure 18. Soil, elements values

Plant: *Callistemon* Season: Winter 017

Table 9. Elements (Metal ions) in the leaves collected from different study sites.

Sites	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Average	6.46±0	0.097±0.	0.0143±0	1.163±0	5.87±1.	139.55±1	26.64±9.	2.163±0.	5.43±2	0.933	19.
of 3	.2967	0445	.0140	.3667	7548	9.938	6034	5300	.9154	±0.0	7±
sites										208	4.9
											450

Fe, Mn, Zn, Ba and Cu values are normal. Other 6 elements values are also in environment. Cd and Co values are normal.

Fe>Mn>Zn>Ba>Cu>Pb>Ni>Cr>V>Cd>Co

The lowest values showed to Cobalt (Co) in *Callistemon* is 0.0143mg/kg at polluted site and in winter/summer season. The values of Cadmium (Cd) and Cobalt (Co) elements are low in all study plants, in different season and at different sites.

Plant: *Nerium* Season: Winter 017

Table 10. Elements (Metal ions) in the leaves collected from different study sites

Sites	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Average	3.99	0.4763	0.03266	2.231±	10.2	325.93±	74.85±45.	4.7333±	1.84	1.35±	26.4
of 3	±1.28	33±0.5	7±0.022	0.65			46	5829	±0.65	0.23	4±8.
sites		3			±2.420792	121.7286			0		82

In comparison with seasons Fe, Mn, Zn and Cu value is more in different study sites.

The elements are in these series, Fe>Mn>Zn>Cu>Ni>Ba>Cr>Pb>V>Cd>Co

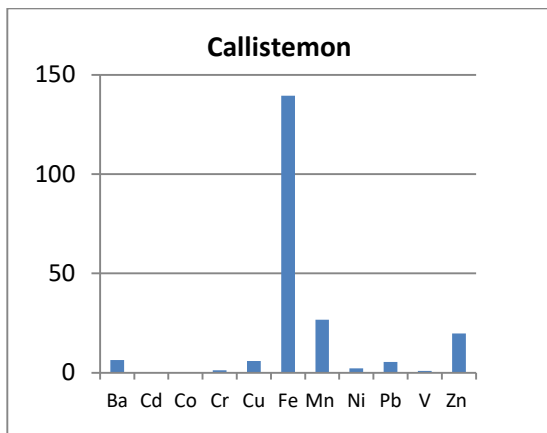


Figure 19. *Callistemon*, elements values

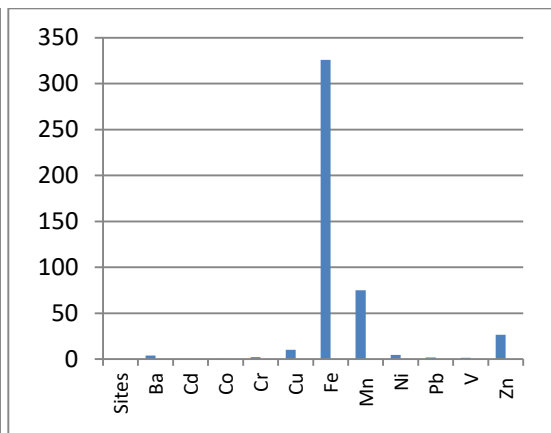


Figure 20. *Nerium*, elements values

The *Callistemon* and *Nerium* leaves were used in the elements analysis. Different values of 11 elements are present. Iron and manganese are in maximum values (*C. citrinus* 39.55 ± 19.938 and 26.64 ± 9.6034) and (*N. oleander* 10.2 ± 325.93 and 121.7286).

The study of heavy metal (HMs) contamination of environment is of great interest due to health and environmental impacts. The leaves of common trees i.e. *Azadirachta indica*, *Butea monosperma*, *Eucalyptus*, *Ficus religiosa*, *Mangifera indica* and *Tectonia grandis* were selected for assessment of the HMs contamination as bioindicator. The concentration of HMs (i.e. As, Fe, Cr, Mn, Cu, Zn, Cd, Pb and Hg) in the tree leaves was observed, ranging from 2.8 - 43, 728 - 5182, 8.6 - 49, 48 - 1196, 43 - 406, 79 - 360, 1.12 - 1.65, 1.6 - 16.4 and 0.13 - 0.76 mg/kg, respectively. The concentration, enrichment and sources of the HMs in the leaves are described. *Azadirachta indica* leaves, accumulating higher concentration of the HMs, showed a higher efficiency as bioindicator for the urban pollution, Khageshwar, S. P. et.al., 2015. The different values promote the research results and sites environments.

Need to be aware and make proper choices concerning which Plants are best suited for the surrounding urban environment. We need evergreen and broad leaf trees, these trees have the capacity to absorb carbon dioxide and reduce noise levels. The country has diverse environmental resources; biodiversity, water, forest, land, climate and weather. Landslide, soil erosion, deforestation, forest fires have caused the land to deteriorate, water sources to decrease away, rivers to flood, biodiversity to deplete and people to migrate into urban areas and elsewhere, Poudel, K. 2010. Many Plant species are growing and applicable for bio-indicator, remove unwanted environmental problems and maintaining greenery.

2) **Morphological structure, *Callistemon citrinus* and *Nerium oleander*.** Structural analysis of leaves: and anatomical structure (micromorphology; epidermal cells, stomatal index / frequency, stomatal size).

1. Plant: *Callistemon* Season: Winter 017 / 018

Within the two seasons, winter and spring seasons have taken and different anatomical structures of plant leaves were studied, Figures 21-23.

Table 11. Different anatomical structures of plant leaves were studied.

Sites	No. of Stomata	Clogged Stomata	Stomatal Pore Size Length (L)	Stomatal Pore Size Breadth (B)	Subsidiary Cells	Epidermal Cells	Stomatal Index
Kathmandu	33.607 ± 4.509	2.633 ± 1.055	5.11 ± 1.067	4.093 ± 0.502	6.503 ± 0.335	181.687 ± 14.535	15.699 ± 0.898

The number of stomata and stomatal index are calculated (33.607 ± 4.509 and 15.699 ± 0.898). Structural analysis of leaves of selected plants, morphological structure is being analyzed.

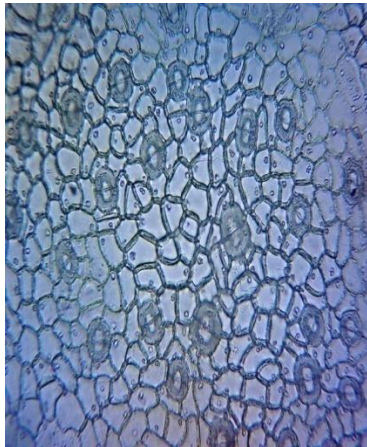


Figure 21. *Callistemon citrinus*

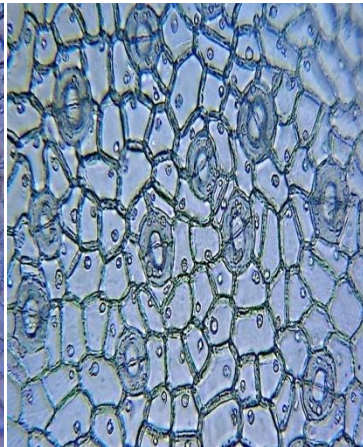


Figure 22. Enlarge cells



Figure 23. Plant diversity richness



Figure 24. *Nerium oleander*.

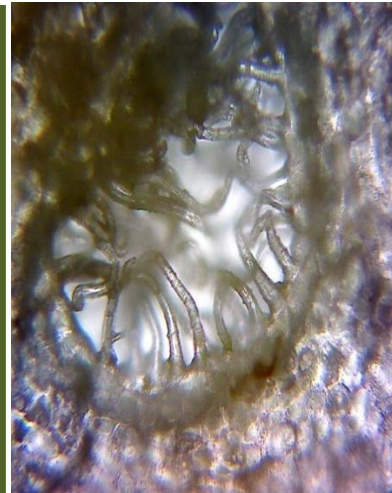


Figure 25. Sunken stomata



Figure 26. Floral diversity in a good planning, Kathmandu.

Study of anatomical, cells and its different measurements values for the plants.

Sarma et. al. (2017), leaf thickness was found to increase in all the roadside plants; however, maximum leaf thickness was observed in *C. sojera* than other plant species. It is also evident that plant under the environmental stress, produces thicker leaves as an adaptive response (Gostin, 2009) and to cope with the stress of vehicular dust; roadside plants may produce thicker leaves.).

Light capturing capacity of leaf via lowering photosynthetic rates, clogged stomata and increased foliage temperature are the cause behind dust deposition reported earlier. Stomatal index has been proven to be an indicator of

environmental stress (Gostin 2009). (Reduction of the stomata index of the roadside plant may be due to shading effect of dust layers, which may block the stomata and reduce the photosynthesis rate of roadside plants, Khan et al. 2015).

Conclusions

The ornamental plants of Kathmandu are giving green vegetation streets. In general, greenery is the achievements in study area; Kathmandu. Along with this, the work is useful in the other industrial cities of the country. Planting trees is not enough to beautify the roads and clean the air. It needs to be aware and make proper choices concerning which trees are best suited for the surrounding urban environment. Evergreen and broad leaf trees have the capacity to absorb carbon dioxide and reduce noise pollution levels. Research results and findings in biodiversity, environments, pollutant effects, tolerance index of plants, structure, plants beauty and adaptation in the roadsides of urban area are appropriate in different highly organizes government programs. Analysis of plants and soil in elements has different adaptive values in environment.

The government programs, managements are excellent. Ornamental environment of the plant species with proper management in the main city is encouraged. In different places either in sides of the road or in the central; plantation and greenery program is suitable. The civic important in the national and international exploration are useful. The work, implementation, popularity of the programs with is successful. The responsibilities of roadside plants are of Department of Metropolitan Traffic Police Office and Department of Road, Municipality (Metropolitan Office), Government of Nepal are with united efforts.

Recommendations

- 1) Study programs are very useful. The distribution pattern, floral diversity and coverage of selected species have good places.
- 2) It is very important to be in the coming days with still beauty as possible. In this context, the scientific results and the program are nice. The perfect results and appreciation are available in different sites of the Kathmandu valley.
- 3) The purpose for ambient air quality, bioindicators, monitoring and evaluation in different sites resulted environmental management is increased.
- 4) The successful results for documentation, presentation, uplift and influences are existed.

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Conflict of Interest

The author declares no conflict of interest.

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