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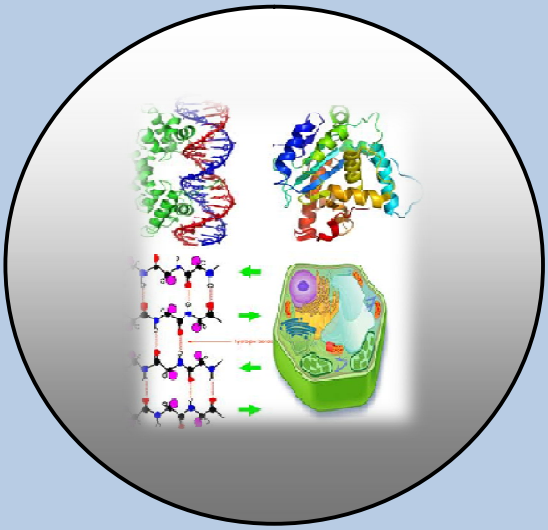

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RESEARCH PAPER

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Identification of Vascular Floristic Composition Growing on Buildings: A Slow Poison for Building Life

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ABSTRACT

This study was carried out to identify vascular plant flora growing on buildings, and their impact. For this study, some buildings of Lucknow city were selected as a study area. In vascular flora, two species of Pteridophyte were observed while rest of the Angiosperm, total 36 families of vascular flora was observed. Most dominant species were identified from the Amranthaceae, Asteraceae, Moraceae, Poaceae and Fabaceae families. This study reveals that plant growing on building primarily inserted their roots in roof and walls resultant; cracks were created at the growing place. After the plant death, the root remains in crack act as substrate for microbial activity. These microbes also harm to building materials i.e. reducing the binding capacity of cement. After decaying, the spaces emptied by roots act as habitat for insects that also harmful for buildings materials. This study suggested that naturally growing vascular plants on buildings are the slow poison for building life.
Key words: Wall plants, Lichens, Colonization, Exposure, Substrate and Damage.

INTRODUCTION

Vascular plants

The Lucknow city is the capital of Uttar Pradesh consisting of many historical buildings of national and international importance. In spite many hospitals, universities, colleges, and residential buildings are also present. A study of wall flora was carried out to understand the urban environment, floral diversity and their impact on buildings. University of Lucknow, King George Medical College, High court, Imambada, Residency, Dilkusha Garden, Sikandarabagh etc is the main buildings taken under study sites.

The main problems associated with the conservation of historic and non-historic building is the growing of the vascular plants on their walls and roofs. The continuous maintenance of the buildings creates conditions for the development of optimal wall flora which has an ornamental character and does not negatively affect their structure and appearance. But when the buildings are not properly cared the plants are grows on their wall and roofs creating cracks and destroying roof materials. The roofs are particularly vulnerable because of their horizontal placement, causing the deposition of sediments in the cracks and unevenness of the surface. This habitat is suitable for catching the fruits and seeds from the surrounding wild and ornamental vegetation. Other factors favoring colonization of plants on walls are the age of wall, the presence of lime mortar, exposure to rain and such aspect as south and verticality. Isolated walls and roofs generally believe to be more affected from the plants invasion. This also applies to the emergence of more significant cracks and niches in the vertical part of the walls. These parts of the walls need particular attention and care. The study of wall flora provides a better understanding of the urban environment (Woodell 1979; Darlington 1981 and Francis 2011). At the same time the investigation of those artificial habitats are of special importance in the maintenance and preservation of archeological monuments (Cleere 1984, 1989). Such observations have been conducted in many cities and historical sites in Europe, both in the past and today (Brandes 1995; Brandes and Brandes 1999, Krigas *et al*. 1999, Brandes 2002, 2004, 2008, Zerbe *et al*. 2003, Altay *et al*. 2010, Kelcey and Müller 2011). The data concerning the flora changes inthe urban conditions in Bulgaria are scarce and fragmentary (Dimitrov 2005; Cheshmedzhiev and Vassilev 2009 and Dimitrov *et al*. 2011) and there are only a few specific studies on the wall flora (Pavlova and Tonkov 2005; Nedelcheva and Vasileva 2009). The main purpose of the present paper is a comparative investigation of the wall flora on sites undergoing reconstruction, restoration, and maintenance activities during this period of study. The results will help to establish the regularities and trends concerning the origin and the dynamics of the wall flora at the studied sites (Lucknow city, Uttar Pradesh, India) as well as making recommendations about maintaining old walls and their neighboring area.

Study Area

Lucknow, the capital city of Uttar Pradesh state, is situated on 26º 52′ latitude and 80º 56′ longitude at 120 metre above sea level in the Ganga Plain, northern India. (Figure 2). The Lucknow urban centre covers an area of about 250 km^2. As per census 2001, the urban population of Lucknow is 2342239 out of which 11.7 per cent accounts for children population (below age of 6 yr). Temperature varies from 45ºC maximum in summer to 5ºC in winter seasons. Mean average relative humidity is 60 per cent and rainfall 100 cm per annum. Figure 1A shows the monthly data on rainfall, maximum and minimum temperature obtained from Indian Meteorological Department. Average weather conditions lead to recognize six well-marked traditional seasons i.e., spring (March-April), summer (May-June), monsoon (July–August), sharada (Sept.-Oct.), hemanta (Nov.-Dec.) and winter (Jan.-Feb.).

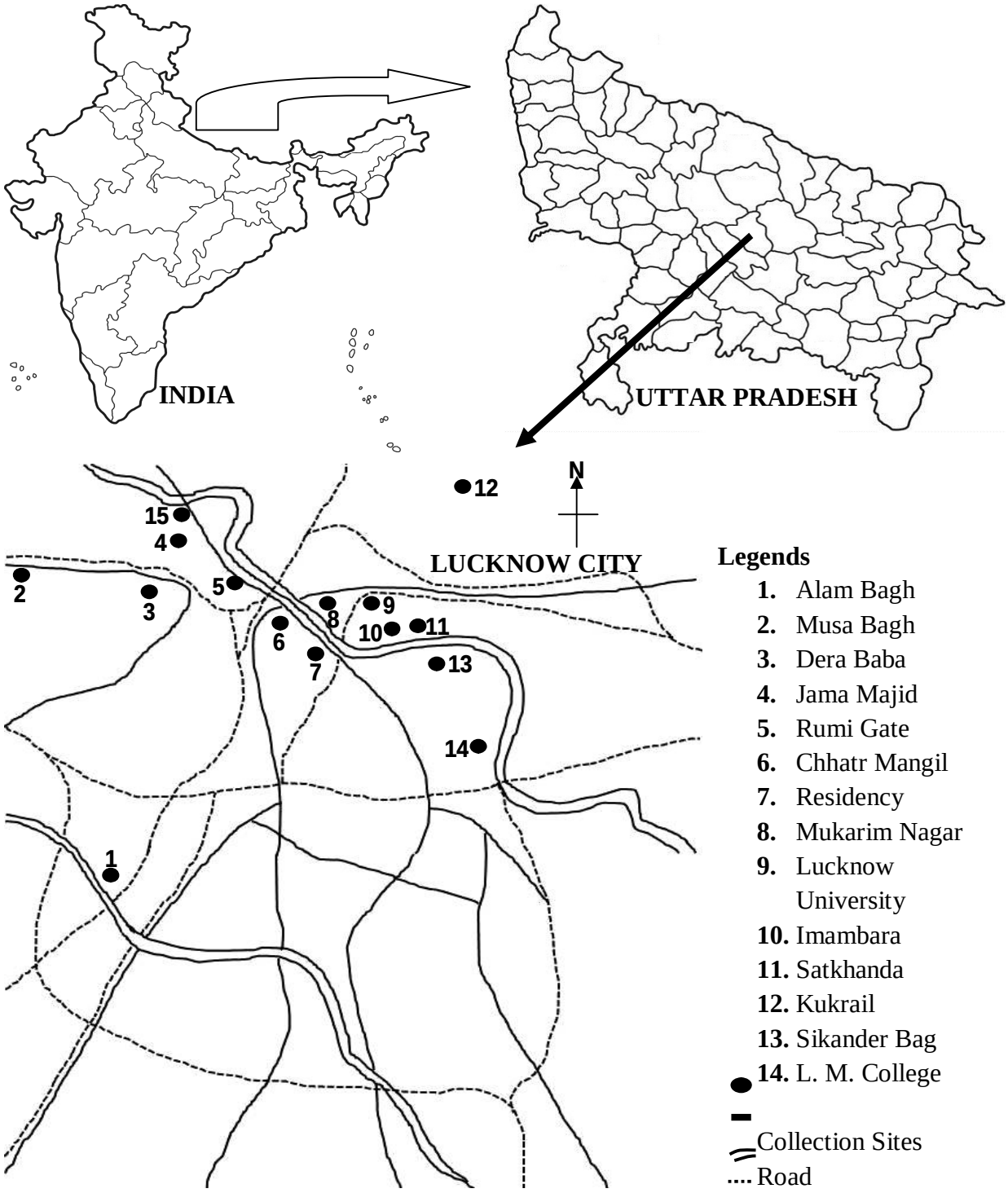


Fig. 1. Map showing collections sites in Lucknow city,Uttar Pradesh

Lucknow has uniform sub-tropical climate. Bar and line diagram shows an increasing trend of total and urban population and urban area of Lucknow (Figure 1B). The soil is of alluvial type formed by the deposition of sediments of river Gomti, which is fertile with sandy loam texture.

MATERIAL AND METHODS

For identification of flora, systemic planning is very essential to cover the entire area or region. For this study, layout of the main study sites like University of Lucknow, King Goerge Medical College, High court, Immambada, Residency, Dilkusha Garden, Sikandarabag etc areas were prepared and after that the surveying were started by observing one site by other. The layout map of the Lucknow city and important study sites was presented in figure 2. The study of all the sites was covered within 30 days.

Field observation

An extensive field survey was conducted from Jan 2013 to Dec 2013 to record the vascular flora, growing on buildings. Total number of six surveys was made for the field observations in a year. Every visit was made alternate months. During the process of observation, building's roof and walls of the given study sites were surveyed. The identification of plant species was done using taxonomic catalogue literatures (R). Photographs of plant growing on the buildings, cracks, decaying roots, insect living in the cracks were also taken. The result showed that the vascular wall flora of the main study sites of Lucknow city along with their habit and seasonal appearance were presented in the Table 1.The total number of 103 vascular plant species were observed, of which only two species was represented to pteridophyte while the remaining 101 plant species represents to Angiosperms.

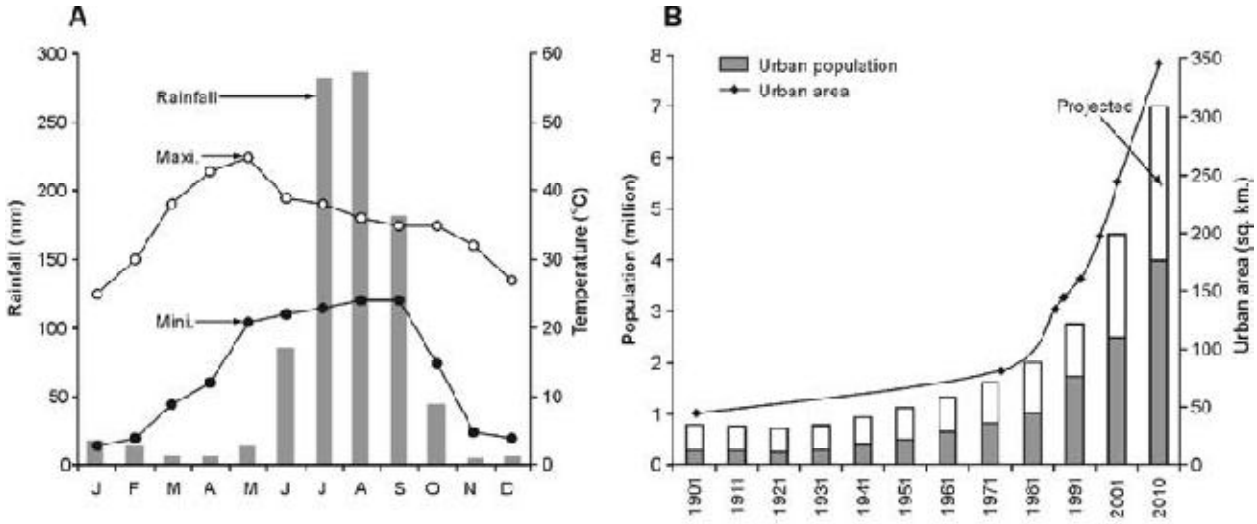


Figure 2. Some basic information about Lucknow urban centre: (A) Monthly rainfall, maximum and minimum temperature variation, (B) exponential growth of total population and urban area in the last 100 yr to house its urban population.

Figure A. *Ficus religiosa* growing on the roof of residential building, Mukarim Nagar B. Regional archeological monument (Badshah Bagh Gate), F. religiosa growing on wall. C. & D. The tree grows on the wall of historical building of Calvin Talukedar College and boundary of University campus. E. Department of Botany, University of Lucknow. F. Herbaceous grasses growing on the roof of water distillation unit of ICAR block.

RESULTS AND DISCUSSION

The Angiosperms were represented by 101 Genera belonging to 35 families, of which 32 were represented by dicotyledonous families while only 3 were represented by monocotyledonous families. Out of the total Angiospermic flora recorded, the maximum number of species, 13 (12.87%) belongs to *Poaceae*, 12 (11.88%) to *Asteraceae*, 8 (7.92%) species to *Amaranthaceae*, whereas 7 (6.93%) species were represented by *Fabaceae* (Figure 3).

Table 1. Number of plants species with their family, habit and seasonal appearance.

S. No.	Family/ Plant species	Habit	Seasonal appearance
	Angiosperms		
	Aizoaceae		
1.	*Trianthema portulacastrum* L.	Herb	Rainy
	Amaranthaceae		
2.	*Achyranthes aspera* L.	Herb	Whole year
3.	*Alternanthera sessilis* R. Br.		
4.	*Celosia argentea* L.	Herb	Winter
5.	*Digera arvensis* Forsk.	Herb	Rainy/ Summer
6.	*Amaranthus polygamosus* L.	Herb	Summer
7.	*Amaranthus spinosus* L.	Herb	Rainy & Summer
8.	*Amaranthus tenuifolius* Willd.	Herb	Summer
9.	*Amaranthus viridis* L.	Herb	Summer
	Apiaceae		
10.	*Centella asiatica* (L.) Urban	Herb	Winter
	Asclepiadaceae		
11.	*Calotropis gigantea* (L.) R. Br.	Shrub	Whole year
12.	*Calotropis procera* (Ait.) R. Br.	Shrub	Whole year
	Asteraceae		
13.	*Ageratum conyzoides* L.	Herb	Summer
14.	*Blumea aromatica* DC.	Herb	Rainy
15.	*Blumea eriantha* DC.	Herb	Summer
16.	*Blumea indica* Linn.	Herb	Summer
17.	*Eclipta alba* Hassk	Herb	Rainy
18.	*Ectipta prostrate L.*	Herb	Whole year
19.	*Parthenium hysterophorus* L.	Herb	Rainy
20.	*Sonchus arvensis* L.	Herb	Winter
21.	*Sonchus oleraceus* L.	Herb	Winter

Table Continuted……..

22.	*Tridax procumbens* L.	Herb	Summer
23.	*Vernonia cinerea* (L.) Less.	Herb	Winter
24.	*Xanthium strumarium* L.	Herb	Rainy
	Boraginaceae		
25.	*Heliotropium indicum* L.	Herb	Winter
26.	*Heliotropium strigosum* Willd.	Herb	Winter
	Cappardaceae		
27.	*Cleome viscosa* L.	Herb	Rainy
	Chenopodiaceae		
28.	*Chenopodium album* L.	Herb	Winter
29.	**Cannabaceae** *Cannabis sativa* L	Shrub	Whole year
	Commelinaceae		
30.	*Aneilema nudiflorum* R. Br.	Herb	Rainy
31.	*Commelina benghalensis* L.	Herb	Rainy
32.	*Cyanotis axillaris* Schult.	Herb	Rainy
	Convolvulaceae		
33.	*Evolvulus nummularius* L.	Herb	Rainy
	Cucurbitaceae		
34.	*Coccinia grandis* (L.) Voigt.	Herb	Winter
	Cyperaceae		
35.	*Cyperus compressus* L.	Herb	Rainy
36.	*Cyperus difformis* L.	Herb	Rainy
37.	*Kyllinga triceps* Rottb.	Herb	Rainy
	Combretaceae		
38.	*Quisqualis indica* L.	Shrub	Whole year
	Euphorbiaceae		
39.	*Acalypha indica* L.	Herb	Rainy
40.	*Euphorbia hirta* L.	Herb	Rainy & Winter
41.	*Euphobia pulcherrima* Willd. Ex Klotzsch	Sub shrub	Rainy & Winter
42.	*Euphorbia thymifolia* L.	Herb	Rainy & Winter
43.	*Phyllanthus niruri* L.	Herb	Rainy & Winter
	Fabaceae		
44.	*Cassia tora* L.	Herb	Rainy
45.	*Dalbergia sissoo* Roxb.	Shrub	Whole year
46	*Lablab purpureus* (L.)	Shrub	Winter

Table Continued……

47.	*Lathyrus aphaca* L.	Herb	Winter
48.	*Melilotus alba* Desr.	Herb	Winter
49.	*Melilotus indica* All.	Herb	Winter
50.	*Trifolium alexandrinum*	Herb	Winter
	Lamiaceae		
51.	*Hyptis suaveolens* (L.) Poir.	Herb	Winter
52.	*Ocimum canum* Sims.	Herb	Winter
53.	*Salvia plebeian* R. Br.	Herb	Winter
	Lythraceae		
54.	*Punica granatum* L.	Tree	Whole year
	Malvaceae		
55.	*Abutilon indicum* (L.) Sweet	Shrub	Rainy
56.	*Corchorus acutangulus* Lamk.	Herb	Rainy
57.	*Malvastrum tricuspidatum* L.	Undershrub	Rainy
58.	*Sida acuta* Burm. f.	Undershrub	Rainy
59.	*Urena lobata* L.	Undershrub	Rainy
	Meliaceae		
60.	*Azadirachta indica* A. Juss.	Tree	Whole year
	Moraceae		
61.	*Ficus benghalensis* L.	Tree	Whole year
62.	*Ficus glomerata* Roxb.	Tree	Whole year
63.	*Ficus hispida* L. f.	Tree	Whole year
64.	*Ficus racemosa* L.	Tree	Whole year
65.	*Ficus religiosa* L.	Tree	Whole year
	Menispermaceae		
66.	*Tinospora cordifolia* (Thunb.) Miers.	Shrub	Whole year
	Nyctaginaceae		
67.	*Boerhavia diffusa* L.	Herb	Rainy & Winter
	Oxalidaceae		
68.	*Biophytum sensitivum* DC.	Herb	Winter
69.	*Oxalis corniculata* L.	Herb	Rainy & Winter
	Papavaraceae		
70.	*Argemone mexicana* L.	Herb	Winter
	Polygonaceae		
71.	*Rumex nigricans* Hook	Herb	Rainy
	Poaceae		
72.	*Brachiaria ramosa* (L.) Stapf	Herb	Rainy

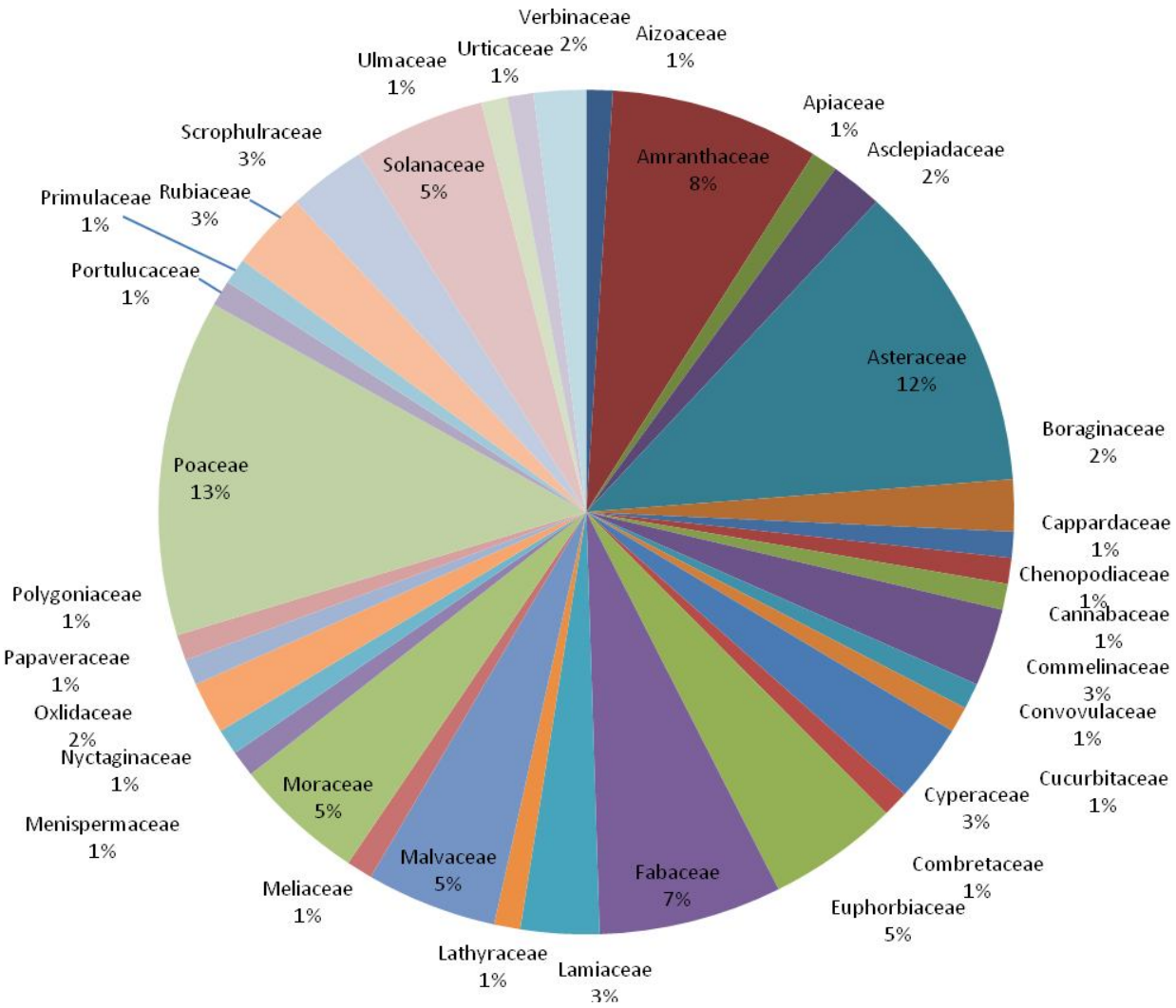
Table Continued….

73.	*Chloris virgata* Swartz	Herb	Rainy
74.	*Cynodon dactylon* (L.) Pers.	Herb	Whole year
75.	*Dactyloctenium aegyptium* Beauv.	Herb	Rainy
76.	*Digitaria marginata* Beauv.	Herb	Rainy
77.	*Echinochloa colonum* (L.) Link	Herb	Rainy
78.	*Eleusine indica* (L.) Gaertn.	Herb	Summer
79.	*Eragrostis tenella* (L.) P. Beauv.	Herb	Rainy
80.	*Eragrostis iscose* Trin.	Herb	Rainy
81.	*Eulaliopsis binata* (Retz.) C. E. Hubbard	Herb	Winter
82.	*Panicum psilopodium* Trin.	Herb	Rainy
83.	*Setaria glauca* (L.) Beauv.	Herb	Winter
84.	*Sporobolus diander* Beauv.	Herb	Rainy
	Portulacaceae		
85.	*Portulaca quadrifida* L.	Herb	Winter
	Primulaceae		
86.	*Anagallis arvensis* L.	Herb	Winter
	Rubiaceae		
87.	*Borreria articularis* L.	Herb	Winter
88.	*Oldenlandia corymbosa* L.	Herb	Winter
89.	*Oldenlandia diffusa* Roxb.	Herb	Winter
90.	**Scrophulariaceae** *Lindenbergia indica* (L.) Kuntz	Herb	Rainy
91.	*Lindernia crustacea* (L.) F. Muell	Herb	Rainy
92.	*Scoparia dulcis* L.	Herb	Summer
	Solanaceae		
93.	*Datura metel* Sims.	Undershrub	Rainy
94.	*Nicotiana plumbaginifolia* Viv.	Herb	Winter
95.	*Physalis minima* L.	Herb	Rainy
96.	*Solanum nigrum* L.	Herb	Winter
97.	*Solanum xanthocarpum* Schrad. & Wendl.	Herb	Rainy
	Ulmaceae		
98.	*Holoptelea integrifolia* (Roxb.) Planch	Tree	Whole year
	Urticaceae		
99.	*Urtica dioica* Roxb.	Herb	Rainy
	Verbenaceae		
100.	*Lantana camara* L.	Shrub	Whole year
101.	*Lippia nodiflora* Rich	Herb	Whole year
	PTERIDOPHYTE		
	Dryopteridaceae		
102.	*Adiantum*	Herb	
103.	*Dryopteris filix-mas* (L.) Schott	Herb	Winter

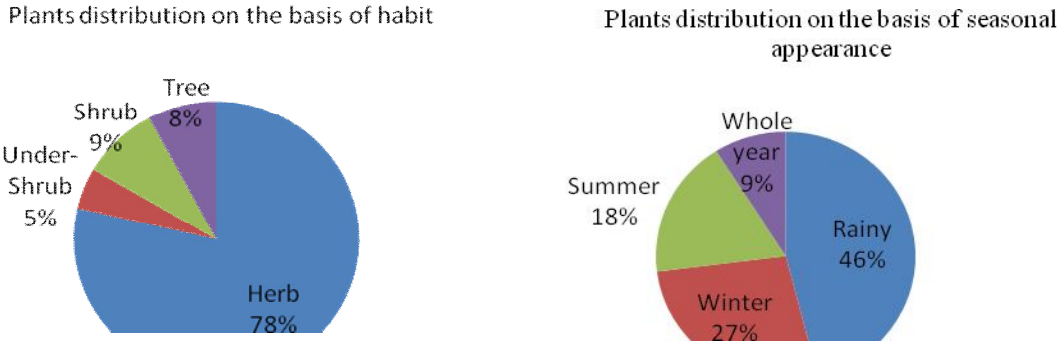
Asteraceae, Poaceae, Amaranthaceae and *Fabaceae* are the dominant families observed on walls and roofs. On the basis of habit, herb were represented by 81 (78.64%) of the total plant species while tree, shrubs and under shrub were represented by 8(7.76%), 9(8.73%) and 5(4.85%) respectively, while on seasonal basis, most of the plants species were appear in the rainy season then winter, whole year and summer season (Figure 3). These include about 46% rainy, 27% winter, 18% whole year and 9% plant species was appear in the summer season. Several of the tree species occurs the on the buildings such as *Ficus benghalensis, Ficus religiosa, Ficus racemosa, Ficus hispida, Ficus glomerata, Holoptelea integrifolia, Azadirachta indica, Punica granatum.* These tree species have been observed to grow throughout the year and believe to be most dangerous for walls, roofs and boundary's texture and matrix. This study also reveals that 31(30%) flora on the buildings of Lucknow city were represented by alien (exotic) plants species. That includes: *Ageratum conyzoides, Alternanthera sessilis, Amaranthus spinosus, Anagallis arvensis, Argemone Mexicana, Cassia tora, Chenopodium album, Corchorus acutangulus, Cynodon dactylon, Datura metel, Eclipta alba, Ectipta prostrate, Eragrostis tenella, Eragrostis iscose, Heliotropium indicum, Heliotropium strigosum, Euphorbia hirta, Euphorbia thymifolia, Lantana camara, Melilotus alba, Melilotus indica, Nicotiana plumbaginifolia, Physalis minima, Parthenium hysterophorus, Oxalis corniculata, Portulaca quadrifida, Sporobolus diander, Sonchus arvensis, Sonchus oleraceus, Punica granatum, Urena lobata.*

Therefore, the herbs dominate the wall flora of the buildings of Lucknow city. Plants of herbaceous habits are the chief representatives of wall flora. Generally plants are boon for our life because they provide food, clean air, fuel, voluble wood etc. But act as slow poison for buildings when grown on its roof and walls. Plants growing on the building reach on them through wind, animals mostly by birds and by stolon fragments (Duchoslav, 2002) and grow their randomly. Once plants grow on the surface of the buildings, because of well developed vascular system and secondary growth, the roots of plants deeply inserted in the wall and roof as a result cracks are created. Deep rooted plants can be destructive. Although their roots are weak at beginning of growth, they become stronger in time and causes widening of cracks.

During rainy season these cracks imbibe water and moistened the building inside. Although wall plants are often appealing, the local municipalities' occasionally clean up the walls to prevent damage by the plants. But partial removal of the pavement to the front of the building is a temporary and insufficient measure. Because the root is living inside the wall and new bud at cut point emerges and if the Arial part is completely destroyed then root act as substrate for microbial activity. Along with microbes, microbial product also injurious for the texture and cementation of the building material. After decaying of the roots space remain occupied by many insect like ants, termite, etc. These insect further increases the volume of the cracks that lead to disturbance in the matrix of the wall or roof. Plants of herbaceous habits are the chief representatives of wall and roof flora. But most damaging plants species are belong to tree habit. It was observed that the adventitious root of the herbaceous plants grows on the moist cemented plaster of the walls and roof maintain plaster moistened for long time.



Graph showing distribution of plants families observed on buildings



Graph showing distribution of plants on the basis of habit and seasonal appearance

This moistened environment of walls, support the growth of many other algal and fungal floras that also helps in the degradation of the wall plaster. Grasses of Poaceae family were found to most dominant on the boundary of roof and roof (figure 3). The continuous maintenance of the buildings creates conditions for the development of optimal wall flora which has an ornamental character and does not negatively affect their structure and appearance.

The roofs are particularly vulnerable because of their horizontal placement, causing the deposition of sediments in the cracks and unevenness of the surface. This habitat is suitable for catching the fruits and seeds from the surrounding wild and ornamental vegetation. This also applies to the emergence of more significant cracks and niches in the vertical part of the walls (Nedelcheva 2011). These parts of the walls need particular attention and care. After the restoration or reconstruction, complete maintenance of the buildings and the surrounding area is necessary. Ruderal species in the opposite part of the building are a potential source of diaspores. Investigation of the wall flora in the urban environments in terms of flora structure, dynamics, and patterns of development provides valuable information for maintenance, sustainable development, and prediction of the urban environment.

CONCLUSION

It can be concluded from the study that vascular flora grows on the brick cement walls and roofs of the buildings of the undertaken study sites is dominated by Angiosperms. Herbaceous plants loosen the binding affinity of the cement by injecting their adventitious roots in plaster while tree plants like *Ficus benghalensis* and *Ficus religiosa* by their strong root and trunk loosen the arrangement of bricks and roof material.

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