Journal on New Biological Reports
JNBR 5(1) 10 – 18 (2016)

ISSN 2319 – 1104 (Online)

Published by
www.researchtrend.net

Biodeterioration of wall and roof in historic building and monuments in Lucknow city Uttar Pradesh

Gaurav K. Mishra* and D.C. Saini

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow, India

***Corresponding author**: gmishrak@gmail.com

| **Received**: 12 February 2016 | **Accepted**: 24 March 2016 |

ABSTRACT

This study was carried out to identify of 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, a total 36 families of vascular flora ware 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 as the result growth of roots, cracks were created at the growing place. After the plant death, the root remains 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: Biodegradation, Wall plants, Colonization, Damage.

INTRODUCTION

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, residential buildings and monuments are also present in the city. A study of wall flora was carried out to understand the urban environment, floral diversity and their impact on historical buildings, University of Lucknow, King Goerge Medical College, High court, Immambada, 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 responsible for the deterioration. 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. The 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 & 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 present (Brandes, 1995, Brandes & Brandes, 1999, Krigas *et al.*, 1999, Brandes, 2002, Zerbe *et al.*, 2003, Altay *et al.*, 2010 and Kelcey & Müller, 2011). The data concerning the flora changes in the urban conditions in Bulgaria are scarce and fragmentary (Dimitrov, 2005, Cheshmedzhiev & Vassilev, 2009 and Dimitrov *et al.*, 2011) and there are only a few specific studies on the wall flora (Pavlova & Tonkov, 2005 and Nedelcheva & 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.

MATERIALS AND METHODS

Lucknow, the capital city of Uttar Pradesh state, is situated on 26º 52´ latitude and 80º 56´ longitude at 120 m above sea level in the Ganga Plain, northern India (Fig. 1). The Lucknow urban centre covers an area of about 250 km^2. Temperature varies from 45ºC maximum in summer to 5ºC in winter seasons. 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.). An extensive field survey was conducted from March 2014 to February 2015 to record the vascular flora. 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, every building's roof and walls of the historical buildings and monuments were surveyed (Table 1).

The identification of plant flora on the basis of published literature and keys, systemic planning is very essential to cover the entire area and region (Duthie, 1903-1922 and Hooker, 1875-1897).

RESULTS AND DISCUSSION

After the surveying, the obtained result shows that the vascular wall flora of the main study sites of Lucknow city along with their habit and seasonal appearance were presented. A 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. Out of the total Angiospermic flora recorded, the maximum number of species, that is 13 (12.87%) belongs to Poaceae family, 12 (11.88%) to Asteraceae family, 8 (7.92%) species to Amaranthaceae family, whereas 7 (6.93%) species were represented by Fabaceae. This study suggested that Asteraceae, Poaceae, Amaranthaceae and Fabaceae are the dominant families observed on walls and roofs. On the basis of habitat, 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 plant species was appear in the rainy season then winter, whole year and summer season. 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, F. religiosa, F. racemosa, F. hispida, F. 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.*

Damage: - Generally plants are boon for our life because they provide food, clean air, fuel, voluble wood and ruins may be charming but it is also one of the main reasons for their deterioration 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 and grow their randomly (Garty, 1992). 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 such as *Ficus benghalensis, F. religiosa, Azadirachta indica,*

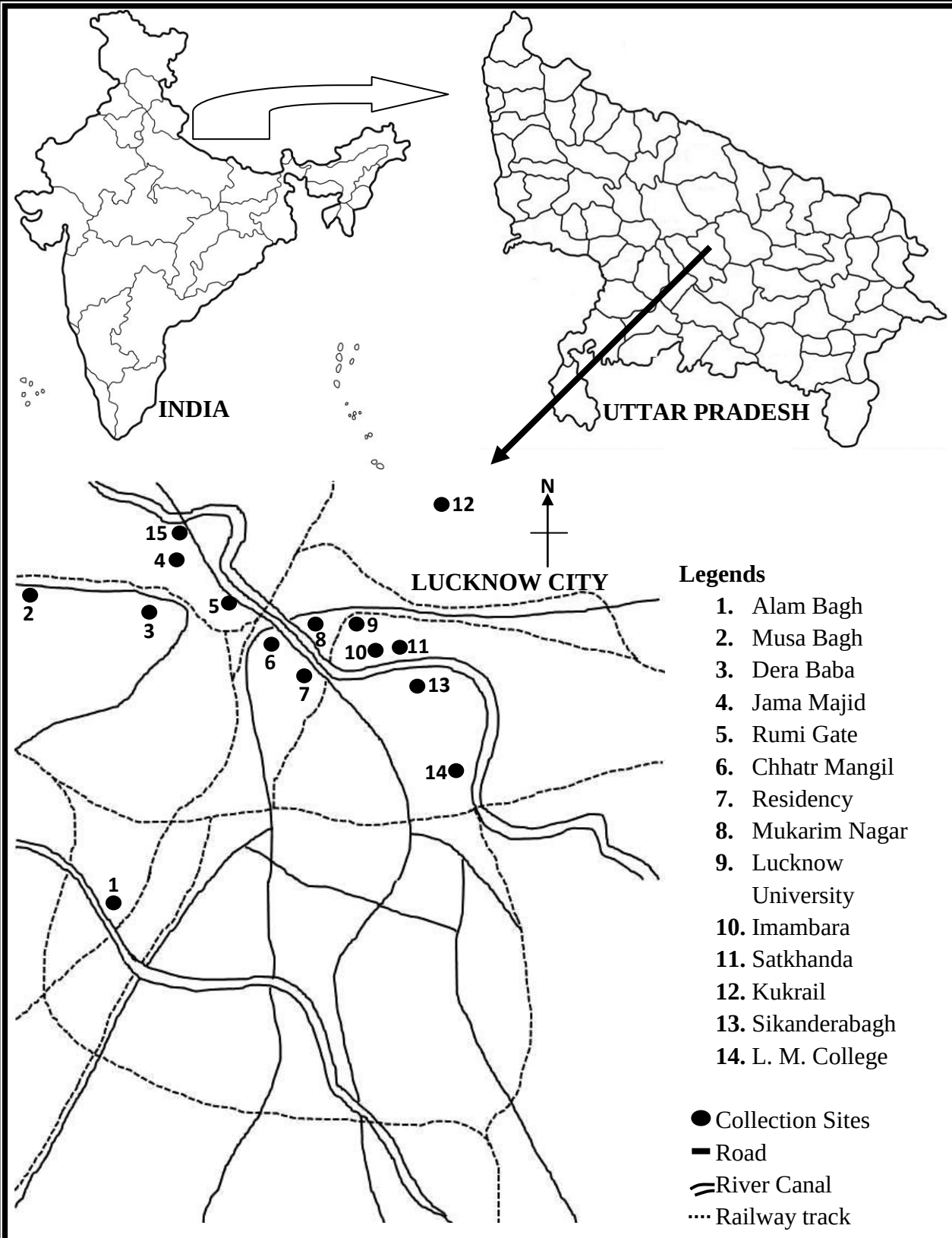

Fig. 1. Map showing collections sites in Lucknow city, Uttar Pradesh

Figure 2. A plant grows on different historical buildings of Lucknow city. **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 Talukdar 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.

Punica granatum trees. The roots may penetrate deep into the structure and grow to a large size, causing physical and chemical damage. The secretions of roots contain substances that attack building materials, and their mechanical force opens cracks, causes crumbling and loosens stones and large fragments of wall. The damage is not limited to that which the plant causes to the building, but also includes the consequences of falling stones. The damage varies according to whether the plant grows as a climbing plant from the soil or actually germinates and grows in the wall. In this case, the damage is due to the weight of the aerial part; in the second, there is additionally the destructive action of the roots. If it grows on a stuccoes wall, it may cause the plaster to fall away. Although their roots are weak at beginning of growth, they become stronger in time and causes widening of cracks. The roots and the aerial both part of the plants damage the structure of the walls. The branches and leaves hide of the building so that it cannot be appreciated, and cause static damage due to their weight, which may cause stones or large portions of wall to fall (Fig. 2).

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. 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.

Methods of control: - Methods of control vary according to the type of plant, the structure of the building, its state of conservation and its location. The study site of historical buildings made of classical materials should be checked to prevent the formation of substrate and the growth of pioneer plants. The speed of colonization depends on building structure and materials. The state of conservation of a building is very important in determining the appropriate method of control. For carcass, interrupted clearing of plants should be performed to prevent plant growth between the stones and crumbling of the remains. Large buildings of historical interest in towns should be checked for visual reasons, in the interests of their conservation and for the safety of inhabitants and visitors.

The surest method of control with long term advantages is total removal of the plants, including their roots. After this the cracks are filled so that other seeds do not germinate in them. This method works well for herbaceous plants but the roots of ligneous plants are difficult to remove, and pieces remaining may give rise to new growth. Other difficulties are encountered when the walls are impervious or very high. The surface may be damaged if tools such as saws, chisels and drills are used. Manual weeding is useful for preventing the establishment of herbaceous plants, but as we already mentioned, they are only the first colonizers. When the wall already hosts luxuriant vegetation in which the herbaceous plants have been replaced by ligneous ones, manual weeding is no longer effective, and more complex methods must be used. These may include killing the plant with chemicals, or if the position of the plant in the building permits, removing stones, extirpating the roots and rebuilding. Chemical herbicides are much faster and more efficient than manual weeding, but certain environmental (climate, chemical and physical properties of the building materials, analysis of the vegetation in the area where the chemical is to be applied) and toxicological (toxicity, volatility, biodegradability) aspects need to be established before they are used. Today herbicides with specific properties and different mechanisms of action are available. Their careful use can help greatly in the maintenance and protection of buildings and monuments (Caneva & De Marco, 1986 & Caneva *et al*., 1991). Contact and systemic herbicides belong to the latest generation and are especially indicated because of their reduced environmental impact. They may be applied sporadically or repeatedly, up to three times. The same product may be used or others may be alternated to exploit their different possibilities. The most commonly applied herbicidal methods are: **(I)** total elimination of all vegetation (bare ground) which has a long term effect; **(II)** temporary (short term) weeding; **(III)** selective weeding of herbaceous plants; **(IV)** brush control, consisting in removing shrubs and trees and leaving herbaceous vegetation. The last two methods are the most frequent in archaeological sites, whereas total and temporary weeding are used for historical buildings and monuments in towns. 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

Table 1. Distribution of plants in various localities of study area.

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.	*Amaranthus polygamosus* L.	Herb	Summer
4.	*Amaranthus spinosus* L.	Herb	Rainy & Summer
5.	*Amaranthus tenuifolius* Willd.	Herb	Summer
6.	*Amaranthus viridis* L.	Herb	Summer
7.	*Celosia argentea* L.	Herb	Winter
8.	*Digera arvensis* Forsk.	Herb	Rainy/ Summer
9.	*Alternanthera sessilis* R. Br.		
	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
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
	Cannabaceae		
29.	*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.	*Euphorbia thymifolia* L.	Herb	Rainy & Winter
42.	*Phyllanthus niruri* L.	Herb	Rainy & Winter
43.	*Euphobia pulcherrima* Willd. Ex Klotzsch	Sub shrub	Rainy & Winter
	Fabaceae		
44.	*Cassia tora* L.	Herb	Rainy
45.	*Lathyrus aphaca* L.	Herb	Winter
46.	*Melilotus alba* Desr.	Herb	Winter
47.	*Melilotus indica* All.	Herb	Winter
48.	*Lablab purpureus* L.	Shrub	Winter
49.	*Trifolium alexandrinum* L.	Herb	Winter
50.	*Dalbergia sissoo* Roxb.	Shrub	Whole year
	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
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
	Scrophulariaceae		
90.	*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.	*Dryopteris filix-mas* (L.) Schott	Herb	Winter
103	*Adiantum*	Herb	Winter

development provides valuable information for maintenance, sustainable development, and prediction of the urban environment.

ACKNOWLEDGEMENTS

We are thankful to the Director, Birbal Sahni Institute of Palaeobotany, Lucknow for providing necessary laboratory facilities to work

REFERENCES

Altay V, Özyigit I and Yarci C. 2010. Urban ecological characteristics and vascular wall flora on the Anatolian side of Istanbul, Turkey. Maejo Int J Sci Technol. 4(03): 483-495.

Brandes D. 1995. Flora of old town centers in Europe. In: Skupp H, Numata M, Huber A (Eds). Urban Ecology as the Basis of Urban Planning, SPB Academics Publishing, Amsterdam pp. 49-58.

Brandes D and Brandes E. 1999. The flora of Maltese walls, 25 S. Elektron.

Brandes D. 2002. Some remarks on the flora of walls and ruins in eastern Crete, Elektron.

Caneva G and De Marco G, 1986. Controllo della vegetazione nelle aree archeologiche e monumentali. Atti del Convegno Scienze e Beni Culturali. Lib. progetto Ed. Padova, Bressanone, pp. 553–569.

Caneva G, NugarI MP and Salvadori O. 1991. Biology in the Conservation of Works of Art. International Center for the Study of the Preservation and the Restoration of Cultural Property, Rome.

Cheshmedzhiev I and Vassilev R. 2009. Flora of Plovdiv. Bulgarian Biodiversity Foundation, Sofia.

Cleere H. 1984. Approaches to the Archaeological heritage: A Comparative Study of World Cultural Resource Management Systems. Cambridge University Press, Cambridge.

Cleere H. 1989. Archaeological heritage management in the Modern World. Unwin Hyman, London.

Darlington A. 1981. Ecology of Walls. Heinemann Educational Books Ltd., London.

Dimitrov D. 2005. Conservation important vascular plants and endemics from the flora of Sofia city. In: Proceeding of 8th symposium on flora of Southeastern Serbia and Neighbouring Regions, 20-24, June, Niš, 45-46.

Dimitrov D, Stoyneva M and Ivanov D. 2011. Sofia. In: Kelcey JG, Müller N (eds), Plants and Habitats of European Cities. Springer New York, Dordrecht Heidelberg, London, 453-475.

Duthie JF. 1903-1922. Flora of the Upper Gangetic Plain and of the Adjacent Siwalik and Sub-Himalayan Tracts. 3 Vols. Governments of India, Central Publication Branch, Calcutta, India.

Francis RA. 2011. Wall ecology: A frontier for urban biodiversity and ecological engineering. Prog. in. Phys Geography. 35(1): 43-63.

Garty J. 1992. The posture recovery of rock-inhabiting algae, microfungi and lichens. Canadian J Bot 70, 301–312.

Hooker JD. 1875-1897. The flora of British India. 7 Vols. L. Reeve & Co., London, U. K.

Krenn HW & Kristensen NP. 2004. Evolution of proboscis musculature in Lepidoptera. Eur. J. Entomol. 101: 565-575.

Krigas N, Lagiou E, Hanlidou E and Kokkini S. 1999. The vascular flora of the Byzantine Walls of Thessaloniki (N Greece). Willdenowia 29: 77-94.

Kelcey JG and Müller N. (eds) 2011. Plants and Habitats of European Cities. Springer, New York, Dordrecht, Heidelberg, London.

Nedelcheva A and Vasileva A. 2009. Vascular Plants from the Old Walls in Kystendil (Southwestern Bulgaria). Biotechnol Biotec Eq 23(2): 154-157.

Nedelcheva A. 2011. Observations on the wall flora of Kyustendil (Bulgaria*). Eurasia J. Biosc. 5: 80-90.*

Pavlova D and Tonkov S. 2005. The wall flora of the Nebet Tepe Architectural Reserve in the cityof Plovdiv (Bulgaria). Acta Botanica Croatica 64: 357-368.

Woodell S. 1979. The flora of walls and paving's. In: Laurie IC (ed), Nature in Cities: The Natural Environment in the Design and Development of Urban Green Space, John Wiley and Sons Ltd., New York, 135-157.

Zerbe S, Maurer U, Schmitz S and Sukopp H. 2003. Biodiversity in Berlin and its potential for nature conservation. Landscape and Urban Planning 62: 139-148.