Materials and methods
MATERIALS AND METHODS

Survey and collection

The research work initiated with the segregation of lichen texa collected earlier from the surrounding of Lucknow city, Mahmudabad in Sitapur district and Malihabad, which are preserved in the lichen herbarium of National Botanical Research Institute, Lucknow (LWG).

The recent survey and collection was initiated during a period of three years between Oct. 2002 to Feb. 2005. More than ten collection trips were undertaken and about 20 monuments of six district (Agra, Allahabad, Faizabad, Kanpur, Lucknow, Varanasi) were surveyed for collection of lichens (Table 2). More than 1000 lichen specimens were collected and identified which revealed the presence 14 species belonging to six genera and six families of lichens. The lichens were collected using a sheath knife, geological hammer and chisels. A hand lens (10x) is useful to differentiate the taxa in field. The foliose forms were scrapped out with the help of a scalp el after rendering them soft by wetting. Real difficulty arose in collection of crustose forms the firmly adhere to the substratum or even penetrate it and become endolithic. In general, they can be collected only along with the substratum on which they grow. It is not possible in case of monuments as they are protected structures. The lichen patches were, therefore, photographed and gently scraped after wetting. The scrapings constitute small fragments of lichens thallus. In spite of this technique, many crustose forms could not be collected. An exhaustive collection of lichens was performed from the near by unprotected structure. Sometimes due to reconstruction or renovation work can also provide good specimens from debris.
Table 2: Different localities of Uttar Pradesh, surveyed for collection of lichens from monuments and buildings

<table>
<thead>
<tr>
<th>Date of collection</th>
<th>Location</th>
<th>Monuments</th>
<th>No. of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.10.2002</td>
<td>Faizabad</td>
<td>'Gulab-Bari'</td>
<td>250 Nos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Maqbara'</td>
<td></td>
</tr>
<tr>
<td>20.08.2003 to 21.08.2003</td>
<td>Agra</td>
<td>'Turkish Bath' (near Buland Darwaza)</td>
<td>200 Nos.</td>
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<tr>
<td></td>
<td></td>
<td>'Kaanch Mahal' (near Sikandra, Akbar's Tomb)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>'Etemad-ud-daula-Tomb'</td>
<td></td>
</tr>
<tr>
<td>16.06.2004</td>
<td>Allahabad</td>
<td>'Khusro-Bagh'</td>
<td>300 Nos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Akbar's Fort'</td>
<td></td>
</tr>
<tr>
<td>17.06.2004</td>
<td>Varanasi</td>
<td>'Ram-Nagar Fort'</td>
<td>100 Nos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Banaras Hindu University'</td>
<td></td>
</tr>
<tr>
<td>21.06.2004 to 23.06.2004</td>
<td>Lucknow</td>
<td>'Residency', 'Bara Imambara',</td>
<td>200 Nos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Musa Bagh', 'Asafi Mosque',</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Sikander Bagh', 'Sadat Ali Khan Maqbara'</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Dilkusha'</td>
<td></td>
</tr>
<tr>
<td>15.02.2005 to 16.02.2005</td>
<td>Kanpur (Bithoor)</td>
<td>'Fort of Nana Saheb'</td>
<td>150 Nos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'Temples'</td>
<td></td>
</tr>
</tbody>
</table>

Collected specimens are placed in paper bags, together with details of locality, substrate, ecological notes, specimen's number, date of collection and name of collector. Fragile specimens needs to be wrapped in paper napkins or cotton. Lichens growing on lime or cement plaster or brick are fragile in nature and some adhesive (quirk fix or fevicol) is used around the patch as binding material. The preservation of lichens is easy as most of the lichens contains chemicals and it protects them from infection by pests.
Identification

Collected specimens were investigated morphologically, anatomically and chemically. The morphological characters were studied under a stereoscopic Letitz binocular microscope. Nikon E 400 Eclipse compound microscope as used for studying the anatomical characters. The colour test for identification of lichen species performed with the usual Reagents i.e. (5% Potassium hydroxide), (Aqueous solution of calcium hypochlorite) and PD (Paraphenylene diamine).

Laboratory work

All lichen specimens were dried by sunlight or oven dried, mounted on hard sheet and made into suitable herbarium specimens. All the specimens were carefully examined in respect of their morphology, anatomy and chemical colour reaction. Microcrystallography and thin layer chromatography (TLC) were also carried out.

Morphological features of the thalli and ascocarps were studied with the help of dissecting binocular or by 10 X hand lens. Anatomical features were studied by cutting thin dry section of thalli and ascocarps, obtained by razor blade that were mounted in 5% aqueous potassium hydroxide solution (K) or in distilled water and later stained by cotton blue. Sometime sections were also treated with 90% of alcohol before mounting in cotton blue. The nature of asci, spores and paraphyses were studied in squash preparation mounted either in Potassium hydroxide or in cotton blue. Ascus tholus of certain taxa were studied by staining ascus with iodine solution (I) and Lugol solution utilizing a compound microscope.

The main chemical reagents for colour test used in lichenology are K, C and PD. The K is the 15% aqueous solution of potassium hydroxide, gives positive reaction; yellow, yellow changing to red, red brownish or crimson. The K positive
reaction is denoted as K+ while no reaction with K as K-. The commercial bleaching powder (calcium hypochlorite) in water called C. The C positive reaction; red, rose, orange or green. The C positive reaction is denoted as C+ while no reaction with C as C-. KC is a drop of K followed after C. The positive reactions; red, rose or purple.

The PD solution can be prepared by combining 100 ml water, 10 gm sodium sulphite with 1 gm p-phenylene diamine and 40 drops of any liquid detergent. A positive reaction with p-phenylene diamine is specific for aldehyde (-CHO) radicals on both depsides and depsidones, gives yellow, yellow changing red to orange.

The C test is positive in acids that have a m-hydroxyl configuration (lecanoric, gyrophoric, oiliotic and hiassic acids). The KC+ red or orange reaction is produced by orchinol depsidones.

The microcrystallography was carried out usually in foliose and fruticose genera. Asahina's microchemical techniques, as enumerated by Hale (1974), were adopted. Small fragment of lichen thallus about 1-2 mm across was treated with acetone on a slide for extraction of lichen substances. The dry residue thus obtained was mounted in the following reagents and the slide heated on sprit lamp; till the bubbles appeared under the cover slip.

GE : Glycerine – Acetic acid, 1:3
GAW : Glycerine – Alcohol – water, 1: 1:1
GA-O-T : Glycerine – Alcohol-o- Toluidine, 2:2:1
G-A- An : Glycerine – Alcohol – Aniline, 2: 2:1

By this treatment of the reagents the residue on the slide gets recrystallized. The crystals of specific shape and patterns develop in the slide were identified with the help of standard photographs.
Thin layer chromatography (TLC) was also carried out. Concentrated micro extracts of lichen fragments were spotted by capillary tubes on precoated Merck silica gel aluminium plates or on glass plates (prepared by mixing 32 gms of silica gel with 80 ml of distilled water). The chromatograms were developed in solvent A (TDA Toluene : Dioxane : Acetic acid : 180: 60: 8, 248 ml), solvent B (HEF, Hexane: Ethyl Ether : Formic acid: 130: 100: 20, 250 ml) and occasionally in solvent C (TA. Toluene : Acetic acid : 200 : 30, 230 ml) up to a certain height, usually 13 cm on plate. The plates were taken out and dried in air and examined under UV light in a UV chromocab. UV + spots were marked then sprayed with an aqueous solution of 10% H₂SO₄ (Sulphuric acid) with the help of an atomizer and were heated for 5-15 minutes (5-7 minutes in case of plastic plates) in an oven at 100-110°C for developing the colours, which were noted and spots marked out. Relative Flow (Rf) values of lichen products were noted and calculated. Finally the lichen compound were identified with the help of tables given by Culberson and Kristinsson (1970), Culberson (1972) and Walker and James (1980).

All the taxa thus studied were identified by comparing the description available in the floras and latest monographic treatments of various genera (Awasthi, 1991a). The various taxonomical characters considered for identification of each taxon includes, the apothecial characters, lirellate and perithecia, together with types of rhizinae, presence or absence of isidia, soralia and spores type. Some specimens were also identified by matching with authentic lichen specimens of National Botanical Research Institute, Lucknow (LWG). All the specimens after making their confirmed identity have been deposited at Lichen herbarium of National Botanical Research Institute Lucknow (LWG).
In treatment of species, the current name is followed by the citation of relevant literature and the basionyms if any. The reference cited in the text have been abbreviated according to the usual convention. Each species is described in respect of its vegetative structures and ascocarps have also been given to facilitate identification.

**TAXONOMICAL CHARACTERS FOR SEGREGATION OF LICHEN GROUPS**

In the present study out of the fourteen lichen taxa, most of the species belongs to the pyrenocarpous group of lichens (*Arthopyrenia* and *Endocarpon*) followed by Lecanorioid group (*Lecanora, Peltula*). The taxonomical characters used for segregation of different species in above two lichen groups are as following.

**Pyrenocarpous**

The perithecia forming lichens mostly have less morphological variation in thallus structure, except the colour, presence and absence of pseudocyphellae and epi or endophloedal condition of thallus, the ascomatal characters play important role in segregation of pyrenocarpous taxa are as following:

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**Diagram**

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Position of Ascomata
    └── Superficial
        └── Immersed
            └── Completely covered

Ascomatal Condition
    ├── Solitary or fused
    └── Stromatoid or in verrucac
        └── Conical
```
Lecanoroid

The apothecial characters of lecanoroid taxa are used to segregate the different species under the group of lichens.

Apart from the above characters, the spore shape and size, septation and colour also plays important role in segregation of species. In squamulose lichens the size, shape, orientation and colour of squamules, the colour of underside of the thallus also play important role in segregation of species.
Study Area

AGRA

Agra lies on the west bank of the river Yamuna, 482 km above its confluence with Ganges at Allahabad and 223 km South-East from Delhi.

The district lies between 26°44' and 27°24' N latitude and 77°28' and 78°54' E longitude. To the west of the district lies Rajasthan, which with Madhya Pradesh also forms the southern boundary. On the north the district is bounded by the districts of Mathura and Etah and the east by those of Mainpuri and Etawah.

The district has, on the whole, a dry climate except during monsoon months. The summer is hot and the total annual rainfall is comparatively less than in the neighbouring districts to the east. The cold weather period is from December to February and the hot season covers the period from March to about the middle of June, followed by the rainy season which goes on till the end of September. October and November are the transitional months.

According to an ancient legend the name Agra is derived from Agravana, one of the twelve grooves of Braja Mandala where Krishna is said to have sported with his companions when a boy. A later tradition attributes the name to Agar, meaning salt-pan in Hindi, implying that the nature of the soil was brackish and indicating that at some period salt might have been produced in the parts.

The ancient history of the city is shrouded in obscurity. Agra became the capital of Sikander Lodi, the penultimate ruler of the Afghan dynasty, 1501. He died here in 1517 and Sikandra 8 km outside the city, the burial place of Akbar, is named after him. With the death of Sikander Lodi’s son Ibrahim Lodi at Panipat in 1526,
Agra become one of the principal cities of the Mughal Empire, which was founded by the Victorious Babar.

**Monuments**

(A) *Tomb of Etemad-ud-daula*

Standing within an enclosed quadrangle (about 180 yards square) with a terrace over looking the Yamuna, this is the exquisite mausoleum of Mirza Ghias-ud-din-Muhammed who came from Persia and whose daughter, Mehrunnisa (Nurjahan), married Jahangir. Ghias-ud-din, held a high position under Jahangir and received from him the title of Etemad-ud-daula. He died in 1622 and Nurjahan built beautiful tomb for him, which was completed in 1628.

It was not possible to collect the lichens from the main monument. The lichens were collected from a near by structure. The architectural pattern of the structure consist of a dome at the top. The construction material is of Lakhori bricks plastered with lime (Figs. 8, 10).

Both the vertical as well as horizontal walls provide a suitable niche for growth of a number of lichen taxa (Figs. 9, 11).

(B) *Turkish Bath*

Most of the old buildings have hammams (bath-rooms). The water was supplied from baolies (step wells) or wells sunk in the out-skirts of the city and traces of the earthen-ware pipes and other heating appliances used in those days are still visible. Outside the Buland Darwaza, against the south-western corner and adjoining the palace buildings to the east, there is a large hammams believed to have belonged
to Akbar's Turkish Queen with a severe and unadorned exterior, the interior of the component sight chambers is decorated with coloured geometrical patterns (Fig. 12).

It is a domed structure. The lichens were collected from the upper surface of the dome as well as from horizontal and vertical plane of the structure. The construction material is Lakhori bricks plastered with thick layer of lime. Beside using the whole bricks these were also milled and was used as one of the constituent of the cementing materials.

(C) Kaanch Mahal

A short distance to the east of the main entrance to the Akbar's tomb at Sikandra there stands, within a walled garden, a good specimen of early seventeenth century domestic architecture known as Kaanch-Mahal. On account of the encaustic tiling ornamenting its north façade, a remarkable feature being the half hexagonal bay windows in the upper rooms in the north-east and north-west angles, which are filled in with pierced stone screens. The whole building is profusely and elaborately decorated with carving.

The building was probably built by Jahangir for his wife and is sometimes called Jodha Bai's Mahal but by others it is associated with Birbal.

The construction material is red sand stone.

ALLAHABAD

According to the historian Badauni, when Akbar visited Prayag in 1575, he founded a new city and named it Al-lahabad ("City of God"), which in process of time became Allahabad and then Allahabad. It became a provincial capital in the Mughal Empire, and from 1599 to 1604. It was the headquarters of the rebellious
prince Salim (later the emperor Jahangir). From 1904 to 1949 the city was the capital of the United Provinces (now Uttar Pradesh). It was a center of the Indian independence movement.

The district lies between latitude 24°47' and 25°47' N and longitude 81°9' and 82°21' E, the length from east to west being 117 km, and breadth from north to south about 101 km. The northern boundary is formed by districts of Pratapgarh and Jaunpur, the former being separated from it by Ganga for a distance of about 35 km. On the east lies the district of Varanasi, on the south east that of Mirzapur, on the south the state of Madhya Pradesh. On the south west the district of Banda and the west that of Fatehpur. The surrounding area lies entirely on the Ganges plain.

Monuments

(A) Khusro Bagh

It was once the pleasure ground of Jahangir, son of Akbar. Khusro was the elder brother of the future Emperor Shahjahan. He died in 1615 and the tomb was completed seven years later, a large, handsome, domed structure in the Mughal style. The actual burial chamber is underground, enriched with plaster work painted with birds and flowers and following Persian inscriptions. West of the tomb is another, and believed to be the tomb of Khusro’s sister, west again is an equiainht, four sided, two storey tomb that of his mother, a Rajput lady of high birth (Figs. 13-18).

(B) Fort

The fort itself built by Akbar in 1575, at the confluence of the two major rivers the Ganges and the Yamuna is a rare specimen and the precursor of the entire subsequent Mughal architecture (Figs. 19-21).
AGRA

Fig. 8: A structure nearby Etemad-ud-daula Tomb – a centuries old monument

Fig. 9: Lichen growth on vertical and horizontal wall of structure nearby Etemad-ud-daula Tomb
AGRA

Fig. 10: A structure nearby Etemad-ud-daula Tomb

Fig. 11: Lichen growth on dome and vertical wall of a structure nearby Etemad-ud-daula Tomb
AGRA

Fig. 12: Turkish Bath Dome near Buland Darwaza, in Agra
Lichen growth on horizontal and vertical face
ALLAHABAD

Fig. 13: Khusro – Tomb – covered with dense tree growth, a monument with raised platform

Fig. 14: Khusro – Tomb – tapering top dome with luxuriant lichen growth
Fig. 15: *Endocarpon, Phylliscum* species growing on lime plaster wall of Khusro - Bagh

Fig. 16: *Phylliscum indicum* – a common squamulose lichen on lime plaster wall of Khusro - Bagh
Fig. 17: Dark-brown-patches – *Phylliscum*, greenish patches of *Endocarpon* on lime plaster wall of Khusro - Bagh

Fig. 18: *Endocarpon* – greenish grey patch – a most common lichen on lime plaster wall of Khusro - Bagh
ALLAHABAD

Fig. 19: Akbar's Fort – on the bank of River Ganga
Monument without raised platform

Fig. 20: Akbar's Fort – on the bank of River Ganga
Platform covered with moist soil
ALLAHABAD

Fig. 21: Akbar’s Fort – on the bank of river Ganga

Fig. 22: Lichen growth on sand stone outer wall of Akbar’s Fort
Originally it was an irregular triangle surrounded by a high embattled wall of red sandstone with three gateways with high flanking towers facing the two rivers and the city, the main gateway being protected by a deep moat.

The fort encloses many other curiosities, like the Ashoka Pillar (believed to have been erected in 232 BC, edicts and inscriptions of various monarchs), Saraswati Koop (supposedly the mythical Saraswati river), and Rani Mahal (Palace of Jodha Bai).

The Fort is under army administration and requires permission for entry. As the fort is situated on the bank of river, has moist plinth area suitable for growth of lichens. The middle strata of the monument is quite dry and do not bear any lichen growth, however, the topmost area along the parapet bears good growth of lichens (Fig. 22). The construction material of the fort is red sandstone at middle and top strata while Lakhori bricks were used on the platform.

FAIZABAD

Once the capital of Oudh, is a decayed town situated on the bank (left) of river Ghagra, 125.5 km east of Lucknow. Adjoining it to the west in Ayodhya, which lies on the site of an ancient city of the same name.

It lies between latitude 26°9' and 26°50' N and longitude 81°40' and 83°8 E and in shape is a fairly regular parallelogram with a projection on the north east jutting into the district of Azamgarh.

River Ghagra forms its northern boundary for about 85 miles and separates it from the districts of Gonda, Basti and Gorakhpur. On the west lies Barabanki and on the east and south-east Azamgarh.
The area in which Faizabad is situated consists of a strip of fertile, alluvial plain along the south bank of the Ghagra river. Rice, sugarcane, wheat, and oil seeds are the principal crops.

Faizabad was founded in 1730 by Sadat Ali Khan, the first Nawab of Oudh, who made it his capital but spent little time there. The third Nawab, Shuja-ud-daula, resided there and built a fort over the river in 1764. The mausoleums for him and his wife are located in the city. Following his death in 1775 the capital of Oudh was moved to Lucknow, and in the 19th century Faizabad fell into decay.

Monuments

(A) Gulab-Bari

Shuja-ud-daula was the first of this dynasty to be buried in Oudh. The remains of his predecessors having been carried away to Delhi. He himself built the mausoleum and it also served as a temporary resting place for his father’s remains. It has always been maintained by the government of the time, but not always in good repair and some of its surroundings have been altered considerably. It is striking building of fine proportions, standing in a garden surrounded by a wall, along which passes the road to Ayodhya (Figs. 23, 24).

It is approached through two large outer gateways and third leading to the inner enclosure in which stands the great mausoleum, a structure of plastered brick, in the basement of which is the tomb of Nawab.

The Gulab-Bari or mausoleum of Shuja-ud-daula lies about 2.4 km away from mausoleum of Bahu-Begum. In form and outline is resembles that of Bahu-Begum tomb, but three simple tomb stones on the ground storey, that in the center being the
FAIZABAD

Fig. 23: Gulab-Bari-Mausoleum – Lichen growth on dome and roof

Fig. 24: Phylliscum – growing luxuriantly on vertical face of wall in Gulab-Bari-Mausoleum
Fig. 25: Mausoleum of Bahu-Begum – Dome and horizontal parapet with lichen growth

Fig. 26: Mausoleum of Bahu-Begum – Dome with lichen growth at base of dome
FAIZABAD

Fig. 27: Mausoleum of Bahu-Begum – Middle strata of monument, horizontal parapet with luxuriant growth of lichens

Fig. 28: Mausoleum of Bahu-Begum – Middle strata of monument with lichen growth
Fig. 29: *Lecanora* – a whitish grey coloured lichen – on vertical wall of Bahu-Begum Maqbara

Fig. 30: *Endocarpon* – a squamulose lichen luxuriantly growing on middle strata of Bahu-Begum Maqbara
Fig. 31: *Phylliscum indicum* – a common lichen on vertical and horizontal face of wall in Bahu-Begum Maqbara

Fig. 32: Luxuriant growth of *Phylliscum* on the base of platform at Bahu-Begum Maqbara
tomb of Nawab. His mother lies to the west, his father to the east. The mosque on the edge of the compound and the Imambara to the south are both similar date.

(B) The mausoleum of Bahu-Begum

The mausoleum of Bahu-Begum (c 1816) described as ‘the finest building of the kind in Oudh’, is in marble but without inscription. Bahu-Begum was alleged to have ill treatment at the hand of Asafud-daula and his British adviser in an attempt to disclose the where about of the state funds, an incident for which Warren Hastings was later indicated. Her tomb is a huge sepulcher over 42.5 m (140 ft).

The mausoleum has three strata. The platform with lower strata bears good growth of lichens near the base. The more moisture loving lichen taxa prefers to grow there. The middle strata with horizontal parapet and 2-3 feet vertical wall bears good growth of lichens. The topmost dome is mostly exposed to sunlight and wind has xeric condition not suitable for growth of many lichen taxa. However, at the base of the dome some lichen taxa grow abundantly (Figs. 25-32).

KANPUR

Nestled on the banks of the Ganga, Kanpur stands as one of north India’s major industrial centers with its own historical, religious and commercial importance. Upto the 1st half of the 18th century Kanpur continued to survive as an insignificant village. Its fate, however, took a new turn soon after. In May, 1765, Shuja-ud-daula the Nawab Wazir of Oudh, was defeated by the British near Jajmau. It was probably at this time that strategic importance of the site of Kanpur was realized by the British. European businessmen had by this time gradually started establishing themselves in Kanpur. In order to ensure protection to their lives and property the ‘Oudh local
forces' were shifted here in 1778. Kanpur passed into British hands under the treaty of 1801 with Nawab Sadat Ali Khan of Oudh. This forms a turning point in the history of Kanpur. Soon Kanpur became one of the most important military stations of British India. It was declared district on 24th March, 1803.

Kanpur was soon to become the epicenter of the outbreak of 1857, as some of the leading luminaries of the War of Independence hailed from here, namely-Nana Sahib, Tantiya Tope, Azim-ullah-Khan and Brigadier Jawala Prasad.

Kanpur district is a fertile stretch of alluvial plain between the Ganges and Yamuna rivers. It is natured by tributaries of the two river and by the Lower Ganges Canal. Crops include wheat, gram, jowar and barley. There are mango and mahua grooves and a dhak forest.

Monuments

(A) Bithoor

The quite a beautiful township of Bithoor is situated on the Kannauj Road, 27 km from Kanpur City. Situated on the banks of the Ganga. During 1753-75 under the rule of Nawab Shuja-ud-daula, the administration of Bithoor was entrusted to Almas Ali Khan, who erected a mosque near Lakshman Ghat on the right bank of Ganga. The historic town of Bithoor, once famous by the name of 'Bavan Ghaton ki Nagari' (city of 52 Ghats) today left with only 29 Ghats.

Bithoor was the capital of Pargana from 1811 to 1819. After the departure of the courts, the place was assigned as a residence to Baji Rao, the deposed Peshwa. The palace of Nana Sahib was reduced to rubble by the British in 1857 and the only traces remaining of it are some large well heads and broken palace walls.
KANPUR

Fig. 33: Bithoor – Nana Sahib Fort near Kanpur city

Fig. 34: Nana Sahib Fort – Ruins showing lichen growth on vertical wall
Fig. 35: Bithoor – Nana Sahib Fort – lichen growth on lime plaster carvings
KANPUR

Fig. 36: Bithoor – Nana Sahib Fort – Vertical wall with lime plaster having luxuriant growth of *Phylliscum*

Fig. 37: Bithoor – Nana Sahib Fort – horizontal brick (Lakhori) with luxuriant growth of *Endocarpon* and *Peltula*
Fig. 38: Bithoor – Nana Sahib Fort – *Phylliscum* on vertical wall near well

Fig. 39: Bithoor – Nana Sahib Fort – luxuriant growth of *Phylliscum* on lime plaster wall
KANPUR

Fig. 40: Bithoor – An old temple with tapering dome on the bank of river Ganga

Fig. 41: Bithoor – An old temple with luxuriant lichen growth on horizontal wall at base of dome
KANPUR

Fig. 42: Bithoor – An old building on the bank of river Ganga, with luxuriant growth of lichens on its vertical face

Fig. 43: Bithoor – Old building lime plaster with luxuriant lichen growth
The Nana Sahib Fort area in Bithoor has few ruins of the fort covered with dense trees. The moist shady places provide a suitable niche for growth of mostly the *Phylliscum, Endocarpon* squamulose form of lichens (Figs. 33-35).

The ruins has mostly the exposed Lakhori bricks, as the lime plaster was removed from most of the vertical face on the outer side of the monument. The lime plaster used for carvings sometimes bear good growth of lichens.

In exposed areas the Lakhori bricks placed horizontally on the parapet of the wall of a well, bears luxuriant growth of *Phylliscum, Endocarpon* and *Peltula* (Figs. 36, 37).

Along the bank of the river Ganga, the temples in ghat areas have tapering dome shaped top most strata. The temples exhibits luxuriant growth of lichens in and around dome and horizontal roof parapet. Some old building along the ghat also bear good growth of lichens both on horizontal and vertical parapets (Figs. 38-43).

LUCKNOW

The city of Lucknow lies mainly on the south bank of river Gomti in a latitude of 26°52' N and 80°56' E longitude. Lucknow is popularly known as the city of gardens and palaces constructed by Nawabi aristocracy has no authentic history prior the establishment of Mughal rule in India. the development of Lucknow dates from 1775 when it became the capital of Oudh.

Situated on the banks of the river Gomti, UP's capital and bustling show piece of modernity. Lucknow is said to date back to the Suryavanshi dynasty. Nothing much is known about the early history of the place, except that it was chosen as the seat of the Subedar of Oudh when Mughal emperor Akbar divided India into 12 provinces. Though Oudh was founded by person adventurer Sadat Ali Khan in 1732,
it was Nawab. Asaf-ud-daula (1774-98) who beautified the city by constructing some
breath-taking monuments. Lucknow reached the zenith of sophistication, splendours
and refinement when the Mughal empire crumbled and the center of the Indo-Mughal
culture shifted here from Delhi. The city became known for its poetry and courtly
diction and transformed into an oasis of learning, music and adab during the reign of
Nawab Wajid Ali Shah, the last Nawab of Oudh.

The surviving monuments of the city mark the evolution of an interesting style
in architecture. In the reign of Nawab Asaf-ud-daula the Mughal stylistic legacy was
re-interpreted in brick and stucco instead of in marble and stone. Soon the builders
began to experiment with European styles and attempts were made to fuse the
occidental with the oriental.

It is of great interest to look into the materials and the way they were used in
Lucknow. This will speak about the intelligence and the vision of the supervisors
controlling the work. The most common materials used were bricks and stuccos. It
was used in buildings to the houses of well to do persons, the Nawabi palaces and the
religious buildings. The bricks used were Lakhauri. The brick work was done very
carefully and precisely. The more skilful the brick layers, the less coarse was there for
the stuccadors, who could concentrate on delicate work instead of covering the vast
area with stucco to imitate the stone-work effect.

Beside using the whole bricks these were also milled and was used as one of
the constituent of the cementing materials. The other constituents depends, varied
depending on weather the mixture was to be used solely for join bricks together, for
coarse plastering over walls, for the floors and roofs of building (when it was known
as tarras) or fort the final coating over the walls. The chunam (which is often
translated as lime), which should rendered as stucco had the cementing properties. The properties of lime of course depended upon the materials to produce the lime.

Lucknow workman believed that the stucco in Jama Masjid was made from red lime, gum, a kind of fine pulse called "Urad Ki daal," jaggery, shells and a sticky paste called saras. The composition of chunam could vary considerable according to the pocket and the taste of the builder. The Nawabi chunam of Lucknow was especially commanded upon and few examples of marble like chunam remains, for instance is the Residency Banqueting Hall. However, chunam in other parts of India like Udaipur and Jaipur in Rajasthan, where marble is used, is consistently better preserved and is of highest quality.

Stucco could be used to produce effects in quite deep relief, even applied to a flat wall, as in pediment on the Hussainabad wall where the figures in Greeco-Roman style are moulded to produce a two dimensional effect without relying on a skeleton of brick or iron. Similarly, the false domes appear on the walls of Safdar Jang tomb in Delhi, the Bara Imambara, and the Residency complex, Begum Kothi in Lucknow and are very characteristic of the eighteenth century Nawabi architecture, are built in stucco, and not built over a brick core.

As there was scarcity of stone near Lucknow, the buildings where the stone were used are rare, and speak about the status of the owner. Only two buildings are recorded that were constructed entirely from stone the Sungi Dalan in the Macchi Bhawan complex and the Lal Baradari in the chatter manzil.

Besides the bricks and Nawabi Stuccos, pottery was extensively used, not only for flow of hot air from lower rooms to the vents in the flat roofs but also for decorative purpose.
Monuments

(A) Asafi Imambara

Asafi Imambara is locally known as Bara Imambara is the largest building complex in Oudh style, which represents the Indo-Syrasenin School of Architecture. Built by Nawab Asaf-ud-Daula (175-1797) and designed by Kifayatullah, a famous architect of that period, it was constructed for holding majlises and observing rituals. The Imambara and the Rumi Gate were constructed as famine measures in 1784. The entire structure is make with the help of Lakhauri bricks, lime palstered and decorated with fine plaster mouldings. The main hall of the Imambara with a vaulted roof is one of the largest halls of its kind in the world, without pillar or support measuring 49.7 m in length, 16.16 m in breadth and 14.95 m in height. The verandah parallel to it is 8.30 m and 8.08 wide. Above the hall, there is a unique labyrinth of intricate balconies and passages with 489 identical doorways which gives the visitors the feeling of being lost on the way. As such it is also known as Bhul-Bhulaiya. The parapet wall of the building is decorated with undersized openings, chhatris and minarets. The main hall of the Imambara contains the graves of the Nawab of Oudh Asaf-ud-Daula, his wife Shamshunnisa and architect Khifayatullah. The Asafi mosque is located on western side of the main Imambara, a Shahi Baoli (stepped well) on eastern side, the Nakkar Khana or Naubat Khan (drum house) on northern side and the famous gate-way called Rumi Darwaza on the western side. The horizontal parapet with thick plaster of lime bears good growth of lichen (Fig. 44, 45).
(B) Asafi Mosque

It is situated in the Bara Imambara complex, constructed during the reign of Nawab Asaf-ud-daula (1775-1795) with the help of Lakhauri bricks, plastered with lime and decorated with fine plaster mouldings. The rectangular prayer hall on the west has a magnificent façade of eleven arches, the central arch being higher flanked by four storyed tapering minaretes on either sides. The prayer hall is surrounded by three pear shaped domes, decorated with inverted lotus while the parapet wall has a number of miniature domes.

The parapet wall both in Asafi mosque and Asafi Imambara show luxuriant growth of lichens on the lime plaster (Fig. 46-47).

(C) Residency Complex

The Residency complex was set up at the right bank of river Gomti in 1775 by Nawab Asaf-ud-daula (1775-1795) for British Resident, after shifting the capital from Faizabad to Lucknow. The main Residency building of three storyed, having a Tah-Khana (under ground chamber). The main enterance of Residency was from the eastern side, under a large double columned portico. To the western side there was a wide, loft colonnaded verandah, and the whole area of Residency complex covers thirty three acres of land, comprises several buildings and gardens. The roofless buildings of Residency complex had suffered great damages during the historic seize of 1857 which are still surviving in ruinous condition (Figs. 48-51).

The building shows lichen growth both on Lakhauri bricks and lime plaster. The lime plaster bears mostly the Phyliscum and Peltula species while the
Lakhauri bricks are preferred by *Endocarpon*. The lime plaster mouldings on the grave also show luxuriant growth of lichens (Fig. 52).

**(D) Sadat Ali Khan Maqbara**

The maqbara is situated on a raised platform with topmost tapering dome. The middle strata of the monument shows lichen growth both on vertical and horizontal parapets (Figs. 53-54).

**(E) Sikander Bagh Building**

The Sikander Bagh building was built by Wajid Ali Shah (1847-56) in the memory of his favourite Begum Sikander Mahal. The two rectangular domes on either side of the gate, built in Pagoda style, are the most significant parts of the entrance of the building. The building has a high walled enclosure wall, made up to Lakhauri bricks, with lime plaster and decorated with plaster mouldings.

The dome together with horizontal parapet bear good growth of *Phylliscum* species forming black circular patch on walls (Figs. 55-56).

**(F) Dilkusha Palace**

This castle like edifice was built of Lakhauri bricks, plastered with lime decorated with plaster mouldings in a typical European style during the reign of Nawab Saadat Ali Khan (1797-1814). Nasirud-din Haider (1827-37) made additions to this palace. It was originally a hunting lodge for Nawabs and subsequently used as a summer resort too. The corners of the palace were adorned with towers, which had circular staircases in them.
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Fig. 44: Asafi Imambara (entrance) monument with long parapet suitable for lichen growth

Fig. 45: Asafi Imambara (Main Building) lichen growth on parapet and wide roof
Fig. 46: Asafi – mosque – A monument with raised platform, the roof and horizontal parapet shows lichen growth

Fig. 47: Asafi – mosque – Parapet showing lichen growth on vertical and horizontal face
Fig. 48: Residency – ruins with Lakhaori brick and lime plaster suitable for growth of different lichen taxa

Fig. 49: Residency – ruins with Lakhaori brick, exposed due to removal of lime plaster
Fig. 50: Residency – ruins – devoid of lime plaster

Fig. 51: Residency – ruins – lichen growth on lime plaster
Fig. 52: Residency – ruins – lichen growth on grave mouldings
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Fig. 53: Sadat Ali Khan – Maqbara – Monument on raised platform, the tapering dome shows lichen growth

Fig. 54: Sadat Ali Khan – Maqbara – The horizontal parapet and vertical walls with lichen growth
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Fig. 55: Sikandarbagh – Gate – Lichen growth on domes and horizontal parapet

Fig. 56: Sikandarbagh – Moist horizontal parapet and dome shows growth of lichen
VARANASI

Varanasi is situated at the junction of three National Highways – NH 2 from Calcutta to Delhi, NH 7 to Kanyakumari and NH 29 to Gorakhpur and is excellently connected to all parts of India.

Varanasi or Banaras (also known as Kashi) is one of the oldest living cities in the world. The all along the river Ganga bears dense old buildings. The city has a mixture of both old and recently constructed buildings and monuments. The Lakhauri bricks plastered with lime is the major construction material used while the recently constructed buildings have bricks and cement as the main construction material.

Monuments

(A) Banaras Hindu University

There are two universities in Varanasi, the Banaras Hindu University and the Varanasi Sanskrit Vishvavidyalaya. The former has developed out of the Central Hindu College and the later out of the Queen’s College.

Distinguished educationist and representatives of Hindu Community of almost from every province of India attended a select committee in December, 1905, to discuss the venture of establishing a Hindu University at Varanasi, the prime mover being Pandit Madan Mohan Malviya who dedicated his life to his cause. Annie Besant, the founder of the Central Hindu College, Banaras was also working for establishment of such university and Maharaj Rameshwar Singh of Darbhanga were also sponsoring a scheme for establishment of a Sanskrit University at Banaras. As a result of combined efforts of these persons, the trustees of the Central Hindu College made it over to BHU Society, and with this college as a nucleus the BHU was instituted under the Hindu University Act (Act XVI of 1815), which was passed by
the Govt. of India. For this purpose, the foundation stone being laid by Viceroy on Feb. 4, 1916, and University is commencing to function from October, 1917.

As most of the temples and buildings are not more than hundred years old, the construction material comprises of cement and bricks. The lime plaster as well as cement having similar alkaline nature bears the growth of similar lichen taxa. The horizontal parapet are the suitable habitat for lichen colonization (Figs. 57-60).

(B) Ram Nagar Fort

The place came into importance in 1750 when Raja Balvant Singh shifted his capital from Gangapur to it and built a fort on the bank of the river Ganga, which has been the chief residence of the Rajas of Banaras. He also laid out the town and built two broad central roads, the one running east from the fort being crossed at right angles by that coming from Varanasi. His son Chant Singh built the Rambagh tank and a temple, known as Sumner Mandir, in the Rambagh gardens, to the north-east of the town and three miles from older temple of Veda Vyasa. Summer Mandir is a hundred feet high and is cared to a height of about forty feet from the ground. The tank also has a temple at each corner and height of step lead down to the water on all four sides.

The architecture of the fort has a typical tapering topmost dome common in north Indian monuments. It is constructed with Lakhauri bricks plastered with lime. Sometimes the front vertical fort walls are devoid of lime plasters while the domes are mostly plastered. The exposed Lakhauri bricks due to their dry nature are mostly devoid of lichen growth. However, the walls with lime plaster both on vertical and horizontal face bear good growth of lichens (Figs. 61-70).
Fig. 57: BHU – An old building with scarce growth of lichen on horizontal parapet

Fig. 58: BHU – An old building with scarce growth of lichen on horizontal parapet
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Fig. 59: BHU – An old building with lichen growth on horizontal parapet and vertical face

Fig. 60: BHU – An old pillar with cement plastered dome having lichen growth
Fig. 61: Ramnagar Fort entrance – Lakhori bricks devoid of lichens, plaster at horizontal and vertical face bear lichens

Fig. 62: Ramnagar Fort entrance – showing lichen growth on lime plaster only
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Fig. 63: Ramnagar Fort Gate – area without lime plaster devoid of lichens

Fig. 64: Ramnagar Fort Gate – walls with lime plaster show luxuriant growth of lichen
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Fig. 65: Ramnagar Fort (inner view) – lichen growth on lime plaster

Fig. 66: Ramnagar Fort – lichen growth on vertical wall of lime plaster
Fig. 67: Ramnagar Fort – lichen growth on horizontal parapet

Fig. 68: Ramnagar Fort – luxuriant growth of lichens on moist shady vertical face
Fig. 69: Ramnagar Fort – area on the bank of river Ganga – more moist – having good growth of lichens

Fig. 70: Ramnagar Fort – area facing river Ganga showing luxuriant growth of lichen