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Original Research Paper

Effects of Growth of Angiosperms on the Monuments – Investigation Based on Historical Monuments of Gwalior Fort

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ABSTRACT

The very old constructions of the city of Gwalior include historical buildings like Gwalior Fort which is facing the problem of higher plant growth. The objective of this paper is to study the diversity of higher plants on old buildings and their effect on them. Gwalior fort with its various buildings was selected for this study. The qualitative analysis of the monuments showed high diversity of various higher plants. In tropical countries like India the growth of higher plants on old constructions is a serious problem as they damage constructions physically as well as chemically.

INTRODUCTION

Gwalior fort stands on an isolated rock, overlooking the Gwalior town, and contains a number of historic buildings. It is one of the biggest forts in India. From historical records, it is established that it was built in the 8th century. It is said that the Mughal Emperor Babur (1483-1531) described it as, "The pearl in the necklace of the forts of Hind".

The historical buildings are part of the biosphere, and their biodeterioration is a well recognized problem in tropical regions where different environmental factors like high temperature, high relative humidity, rainfall and sunlight interact with the surface of the stone and make it susceptible for biological damage. Pollutants play a major role in this aspect as they provide the carbonic source on the abiotic surface of the stone. Cyanobacteria are the first to inhabit rough and porous stone surfaces. They are followed by bacteria, fungi, lichens and mosses. At the end, higher plants, i. e., the seed plants, settle down in the cracks of the stones. Although the Archaeological Survey of India conserves all the historical monuments and temples of ancient times, remains of historical links do not fall in this category. This paper deals with such types of constructions and offers a study of the diversity of higher plants on old buildings and their effect on them.

MATERIALS AND METHODS

Gwalior fort with its buildings was selected for the study. The places of the study were the Man Mandir Palace, the Gujari Mahal (now an Archeological Museum), the Jahangir Mahal, the Karan Palace and the Shahjahan Mahal.

Twigs of the plants with flowering and possibly with fruiting were collected, usually in sets of four. Herbaceous plants were collected with roots and radical or basal leaves as far as possible. The field notes of the collected specimens regarding habit, habitat, abundance, colour, smell of flowers and similar characteristics that cannot be deduced from the examination of dried specimen were entered into the field book *in situ*.

The specimens were pressed and dried in blotting papers. To prevent the development of fungi on the dried plants, a concentrated solution of Pursue was applied. The flowers of the preserved material were studied under the microscope. The dried specimens were mounted on thick herbarium sheets and labelled (Sharma & Dhakre 1995). The plants were identified with the help of relevant literature (Sharma & Dhakre 1995, Maheshwari 1963, Bor 1960). The dispersion of the population of species in a community varies according to soil conditions, seed dispersal mechanisms, grazing and other biotic factors called frequency. The relative frequency (R.F.) is determined by the use of the following formula:

$$\text{R.F. of the species} = \frac{\text{Number of occurrence of a species} \times 100}{\text{Number of occurrence of all species}}$$

The two systems were compared by means of Czechanovski's Similarity Index (Dash 1993). This index is used to compare the species diversities of two systems.

$$\text{Czechanovski's Similarity Index (S)} = \frac{100 \times 2\ c}{(a+b)}$$

Where,
a is the number of species in one site.
b is the number of species in another site.
c is the number of species common to both sites

RESULTS AND DISCUSSION

The qualitative analysis of the monuments (Table 1) showed higher plant diversity in various ignored parts of the fort. The status of plant diversity was the mirror image of the degree of biodeterioration.

It could be inferred that the isolated parts of the fort are deteriorating rapidly. The angiosperms found on these monuments belonged to the families Moraceae, Poaceae, Asteraceae, Scrophulariaceae Amaranthaceae, Solanaceae, Nyctaginaceae, Asclepiadaceae, Capparidaceae, Aizoaceae, Ulmaceae, Apocynaceae, Convolvulaceae and Euphorbiaceae.

From a total of 14 plant species obtained from this building, three belonged to trees, one was a shrub and the others were herbs. The most abundant plants were *Ficus religiosa, F. benghalensis, Capparis decidua, Eclipta alba, Boerhavia diffusa* and *Holoptelea integrifolia*. These plants were growing throughout the year (R.F. 9.09 %). Other plants, *Amaranthus gracilis, A. spinosus, Pennisetum typhoides, Trianthema portulacastrum, Commelina benghalensis, Sonchus brachyotus* and *Caesulia axillaris* germinated during the rainy season and were noticed both during the rainy season and in winter (R.F. 5.12 %).

The plants of the family Moraceae are characterized by the presence of latex and aerial roots. The members of this family, mainly *Ficus religiosa* (Peepal) and *F. benghalensis* (Bargad), often meet in crevices of the boundary wall of old buildings. If these plants remain untouched they become large trees by the slow seepage of rain water into the crevices, and the regular expansion of the roots and aerial roots destroy the buildings significantly. According to Maheshwari (1963), the plant *Kickxia ramoissima* is interesting for its special habitat. It commonly occurs in the crevices and fissures of ancient fort walls from where it hangs downward. On 23.07.1955 he collected a number of individuals from the fort of Nizamuddin and Humaun's tomb, Delhi. Similarly, *Lindenbergia indica* is common in the crevices and amongst stones of ancient monuments from where it grows upward forming a "U" with the wall.

Capparis decidua of Capparidaceae also appear on the ridge and in other drier parts, either growing alone on the ground or hanging from the crevices of ancient walls or in clumps with *Salvadora persica, S. oleoides, Acacia leucophloea* and *Prosopis spicigera*.

Boerhavia diffusa, Tridax procumbens and *Vernonia cinerea* normally grow on the waste places and crevices of stones and ancient walls. *Vernonia cinerea* is erect and up to one meter tall during the monsoon; after the monsoon it is a small plant with a more diffuse habit. *Caesulia axillaris* occurs in marshy places. A variety of higher plants growing over the monuments have been reported by several workers. Shah & Shah (1992-1993) worked on Indian monuments and reported *Canscora decurrens, C. diffusa, Fleurya interrupa, Kickxia incana, Leucas biflora, Lindenbergia indica, Nepeta hindostana, Trachyspermum stictocarpum, Trichodesma amplexicaule* and *Woodfordia fruticoae*. Gigantomassi et al. (1993) reported *Capparis flavicans, C. horrida* and *Ficus rumphii* on surfaces of sandstone at Myanmar.

Mishra et al. (1995) from the National Research Laboratory for Conservation, Lucknow, studied the growth of higher plants over monuments and historic buildings, types and mechanisms of damage and their control methods. They reported a list of 30 plants species on Indian monuments in tropical environment:

Woody dicotyledons: *Acacia arabica, Albizia lebbeck, Azadirachta indica, Delbergia sisso, Ficus benghalensis, F. religiosa, Holoptelea integrifolia, Zizyphus jujube*.

Herbaceous dicotyledons: *Argemone maxicana, Boerhavia diffusa, Calotropis procera, Cassia occidentalis, Coccinia indica, Convolvulus* sp., *Croton bonplandianum, Datura* sp., *Eclipta alba, Euphorbia hirta, Heliotropium indicum, Mimosa pudica, Oxalis* sp., *Physalis minima, Sida cordifolia, Solanum nigrum*.

Non-herbaceous monocotyledons: *Agropyron repens, Cynodon dactylon, Cyperus rotundus, Imperata cylindria* and *Saccharum munja*.

Mechanism of Biodeterioration

Higher plants deteriorate the stone physically as well as chemically. Radial growth or the thickening of the roots results in an increase in the pressure on the surrounding areas of the masonry and therefore widens the cracks in the stone. According to Gill & Bolt (1955), the axial pressure along the long axis of the root is more powerful than the radial pressure but the surface area of the root is much larger for radial pressure than for axial pressure, which results in a high wedging force.

Winkler (1975) demonstrated that the mean pressure of the root is approximately 15 atmospheres. The penetration of the root is possible in the soil with a pressure less than 19

Table 1: Diversity of plants on various buildings of Gwalior Fort.

Plant sp.	Habit	Family	Seasonal Occurrence			Relative Frequency (%)
			Summer	Rains	Winter	
Ficus religiosa	Tree	Moraceae	++	+++	+++	9.09
F. benghalensis	Tree	Moraceae	+	++	++	9.09
Amaranthus gracilis	Herb	Amaranthaceae	-	+	+	6.06
A. spinosus	Herb	Amaranthaceae	-	+	+	6.06
Pennisetum typhoides	Herb	Poaceae	-	++	++	6.06
Trianthema portulacastrum	Herb	Aizoaceae	-	++	++	6.06
Commelina benghalensis	Herb	Commelinceae	-	+	+	6.06
Eclipta alba	Herb	Asteraceae	+	++	++	9.09
Boerhavia diffusa	Herb	Nyctaginaceae	+	++	++	9.09
Sonchus brachyotus	Herb	Asteraceae	-	+	++	6.06
Capparis decidua	Shrub	Capparidaceae	+	+	+	9.09
Caesulia axillaris	Herb	Asteraceae	-	+++	+++	6.06
Holoptelea integrifolia	Tree	Ulmaceae	+	+	+	9.09
Seedling	Herb	-	-	-	-	3.03

(+ + +) abundant; (+ +) frequent; (+) occasional; (-) absent

atmosphere and is impossible with a pressure off 25-30 atmosphere. This is the reason why roots do not penetrate undamaged rocks but only settle in cracks in between the stones. The process by which the plant tissue expands in a tight place requires the taking up of water through osmosis and imbibitions, and an overall increase in size by cell division. Although it may take years (or even centuries), woody stems and roots increase in girth by secondary activity of the cambium located just beneath the bark.

Chemically, the root surface is acidic in nature. The H^+ ions attack on silicate or carbonate, the mineral constituent of the substrate (William & Coleman 1950, Keller & Frederickson 1952). The high acidity produces an etching effect on minerals containing metallic ions like barium, calcium, magnesium, caesium, potassium, sodium, lithium and also ammonia. The transfer of nutritive positive metal ions (cations) occurs through a network of colloidal particles by a contact-exchange mechanism with the H^+ ions of the rootlets. The most interesting feature of plant survival on stone is that the root exudates which include amino acids, sugars, organic acids, vitamins, nucleotides, fatty acids, sterols, growth factors, enzymes, nematode cyst or egg-hatching factors, nematode attractants, fungal mycelial growth stimulants, zoospore attractants, spore and sclerotium germination stimulants and inhibitors, bacterial stimulants and inhibitors, parasitic weed germination stimulators etc. support the growth of other organisms in one way, and also, on the other hand, react with the components of the stone to make the stone weak and fragile (Subba Rao 2004). If the young plants are not removed from the monuments, temples or old structures the results may be inconceivably serious. The woody trees cause severe damage, for example, to Cambodian temples of the 13th century, to an extent that the temples are at the mercy of trees (Mydans 2001).

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