OPEN ACCESS

Haya: The Saudi Journal of Life Sciences

Abbreviated Key Title: Haya Saudi J Life Sci
ISSN 2415-623X (Print) | ISSN 2415-6221 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Simpson's Diversity index of Macroflora at Khajuraho Group of Monuments

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DOI: 10.36348/sjls.2023.v08i07.001 | **Received:** 16.12.2021 | **Accepted:** 21.01.2022 | **Published:** 21.08.2023

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Abstract

Indian culture has versatile cultural beliefs, most of them symbolize by their fascinating cultural monuments those tells us so many backgrounds history of before time. Each temple is unique in their pattern of architect. So it is very importance to take attention on to preserve them from deterioration not only for present but also long term preservation of future aspects. Many of reasons are behind it but effect of climate is one of the main causes because it plays a crucial role in the fulfillment of the basic needs for the growth of micro and macro organisms for their survival on the monumental surface. The macro organisms lead the growth of plants species on the monumental surface enhance the rate of deterioration and damage. This paper is mainly concerned on the diversity of the macroflora present at Khajuraho group of monuments.

Keywords: Cultural beliefs, Deterioration, Khajuraho, Macroflora, Monuments.

INTRODUCTION

India is a nation with incredibly diverse culture. In India Monuments are established under the religic belief for specific deity. There are several fascinating cultural monuments constructed by many known and unknown individuals in different parts of India which silently provide us with idea of relevant cultural, social and religious beliefs of that time. Khajuraho group of temples are situated in Madhya Pradesh, a state of central part of India, district name is Chhatarpur, and approximately 620 kilometers (385 miles) far from New Delhi. Khajuraho is in the middle part between local hills and rivers of this region. The early Hindu tradition is well symbolized by these temples complex. The historical temple and ancient heritage are shows differences in their structural material and architectonic passion. The temples of Khajuraho occupies in range of Vindhya Mountain in central part of India.

Atmosphere is the demonstration of every environmental occasion, for example, precipitation, temperature, wind, pneumatic stress and moistness and so on. Atmosphere related damages on the historical artifacts came about because of temperature contrasts between summer-winter and day-night, water flow the monumental surface because of capillarity, rough impacts of raining, salt decompositions and a few synthetic materials engaged with water, particles conveyed with airflow and contamination. The decays happened on the stone temple because of atmosphere changes have examined and the crumbling impacts on development materials have been stated.

The growth of higher plants on temple surface leads a severe damage which is irreparable. The growth of Ficus *religiosa* is very common on monumental surface because the seed of this plant is spread by the means of bird's excreta and it has the outstanding quality to germinate anywhere even on the rock surface. Roots of this plant can expands into the depth of stone substrata may cause aesthetical damage. Besides of this plant there many other plants species mainly belonging from grasses and weed also take part in the process of deterioration.

Investigation of Upreti *et al*., (2009); Dakal and Carmeotra (2012); Ortega-Calvo *et al*., (1991) state that not always does the bio-deterioration take place separately rather, it is usually accompanied by physical, chemical or physiochemical erosion. Biological deterioration can be described as any unexpected transformation in the properties of a substances generated by the activities of microorganisms.

The study of various scientists as Dakal and Cameotra (2012); Ortego-Calvo *et al*., (1995); Grossi *et al*., (2006) acknowledged process of deterioration is a serious issue of tropical climate that provides an ease to deteriorating organisms to thrive and produce their lethal emphasis to the fullest on monumental and buildings stone under massive rainfall, tight humid conditions and high temperature (Upreti *et al*., 2009; Negi *et al*., 2019).

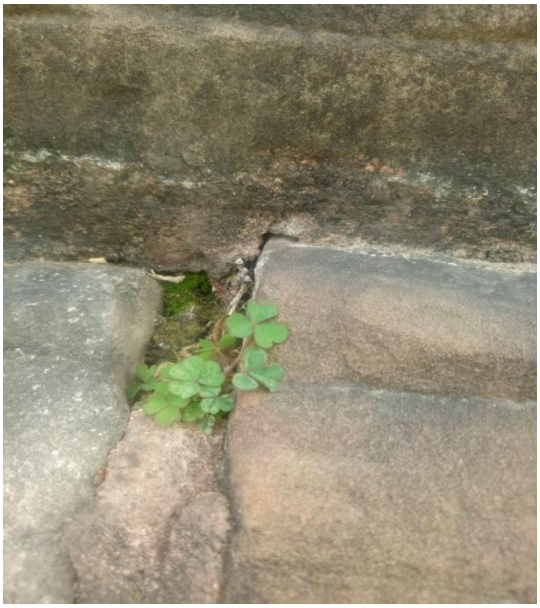
The growth and radial thickenings of the higher plant species leads the biophysical and biochemical damage of monuments (Winkler, 1975; 2013; Singh et al. 2018). When higher plant species grow on monumental surface, their well developed root system can penetrate deep into the cracks and drifts of monuments cause direct detachment of large particle of stone from the monuments (Caneva and Altieri 1988; Caneva and Galotta 1994; Riederer 1981; Siswowiyanto 1981). The development of micro and macro flora is very harmful to the stone temple in tropical climates where climatic conditions like heavy rainfall and fluctuation in the temperature greatly increase the growth of micro vegetation and macro vegetation (Tiano & Caneva 1987; Fusey & Hyvert 1966).

MATERIALS AND METHODS

The macro biological study was done by quadrate method (Brown, 1954) of the collection at every site. A standard size of quadrate 1x1 m2ft taken and total 100 quadrates sampled at sites randomly. Collected macrofloral species from the monumental area identified with the help of their taxonomic character (morphology, inflorescence etc.) followed by Bentham and Hooker's (1862-83) system of classification. The diversity pattern of vegetation at monuments has been studied by the Simpson's Diversity index in different seasons.

Temple Site A

Temple Site B



(A) Oxalis *trifolia* grown on temple site

(B) Bothriocloa *pertusa* grown on temple site

Simpson's Diversity Index

A population dominated with one or two individual is measured as less varied than one which has many types of individuals have a similar abundance. Simpson's Diversity Index (Simpson, 1949) is an evaluation of diversity which represents by the account of numerous individuals occurs, in addition to the relative abundance of every individual. An increase in species richness and evenness, diversity is also increases. To calculate Simpson's Index in Khajuraho group of monuments, selected 10 locations are sampled by use of quadrates placed with random manner. The numbers of individuals within every quadrate, with the number of individuals of each class have noted.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

n = the total number of organisms of a particular species

N = the total number of organisms of all species

By this index, 0 indicate infinite diversity while 1 shows no diversity. That can understand as the diversity increase, the value of D is decrease and diversity decrease, the value D increase. This is neither perceptive nor logical that's why the problem is shorted out by the subtraction of D with 1.

RESULT & DISCUSSION

This study provides a detailed account of botanical diversity which exists naturally at this site of study. Available species of macro flora at these sites is quite different from another site. The diversity pattern of vegetation around the monuments has been studied

by the Simpson's Diversity index in different seasons. Simpson's index explains a population or community dominated by one or two individuals is denoted as less diverse in compare to where more than one individual of similar abundance.

Table 1.1: Simpson Diversity Index of Khajuraho monuments in Rainy Season

S. No.	Name of the species	Name of the location/ sites with their D values mentioned adjacent to it																			
		A	D value	B	D value	C	D value	D	D value	E	D value	F	D value	G	D value	H	D value	I	D value	J	D value
1	*Amaranthus viridis*	4	0.001	0	0	0	0	0	0	0	0	6	0.0091	0	0	4	0.0005	3	0.0006	3	0.0009
2	*Alicicarpus monolifer*	0	0	0	0	0	0	0	0	6	0.0059	0	0	0	0	9	0.0031	6	0.0029	0	0
3	*Agiratum* species	0	0	0	0	4	0.0019	0	0	3	0.0012	0	0	0	0	8	0.0024	4	0.0011	0	0
4	*Auria scandence*	7	0.0034	6	0.003918	6	0.0046	3	0.0021	0	0	7	0.0127	8	0.0023	8	0.0024	0	0	8	0.0082
5	*Boerhaavia diffusa*	4	0.001	6	0.003918	0	0	0	0	4	0.0023	0	0	0	0	5	0.0008	5	0.0019	4	0.0018
6	*Bothriochloa pertusa*	15	0.0172	12	0.017241	15	0.0324	9	0.0252	15	0.0411	7	0.0127	8	0.0023	8	0.0024	0	0	8	0.0082
7	*Cassia tora*	8	0.0046	0	0	0	0	0	0	8	0.011	0	0	0	0	9	0.0031	7	0.004	0	0
8	*Cynodon dactylon*	18	0.0251	20	0.049634	18	0.0472	12	0.0461	20	0.0743	14	0.0551	30	0.0355	14	0.0077	14	0.0173	20	0.0558
9	*Cyperus rotundus*	0	0	0	0	0	0	0	0	0	0	0	0	15	0.0086	6	0.0013	0	0	9	0.0106
10	*Euphorbia hirta*	7	0.0034	9	0.009404	6	0.0046	6	0.0105	0	0	3	0.0018	8	0.0023	8	0.0024	7	0.004	8	0.0082
11	*Ficus benghalensis*	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	*Ficus religiosa*	4	0.001	0	0	5	0.0031	2	0.0007	0	0	1	0	6	0.0012	5	0.0008	5	0.0019	4	0.0018
13	*Indigofera asteragalina*	8	0.0046	5	0.002612	0	0	0	0	4	0.0023	0	0	12	0.0054	12	0.0056	12	0.0126	8	0.0082
14	*Malvestrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.0005	0	0	0	0
15	*Oxalis trifolia*	10	0.0074	0	0	10	0.0139	8	0.0196	0	0	0	0	15	0.0086	11	0.0047	14	0.0173	0	0
16	*Phyllanthus niruri*	5	0.0016	7	0.005486	0	0	0	0	7	0.0082	5	0.0061	10	0.0037	0	0	7	0.004	0	0
17	*Sonchus sps.*	0	0	0	0	0	0	2	0.0007	0	0	0	0	6	0.0012	3	0.0003	4	0.0011	2	0.0003
18	*Sida acuta*	5	0.0016	3	0.000784	0	0	0	0	3	0.0012	0	0	0	0	5	0.0008	0	0	0	0
19	*Sida cardifolia*	0	0	0	0	0	0	0	0	0	0	0	0	7	0.0017	6	0.0013	0	0	0	0
20	*Sporobolus indicus*	10	0.0074	15	0.027429	8	0.0086	12	0.0461	0	0	8	0.0169	15	0.0086	13	0.0066	0	0	0	0
21	*Tridex procumbens*	5	0.0016	5	0.002612	6	0.0046	0	0	0	0	7	0.0127	10	0.0037	12	0.0056	10	0.0086	6	0.0044
21	*Parthenium hysterophorus*	0	0	0	0	3	0.0009	0	0	2	0.0004	0	0	7	0.0017	4	0.0005	5	0.0019	3	0.0009

Table 1.2: Simpson Diversity Index of Khajuraho monuments in Winter Season

S.No.	Name of site	Name of the location/ sites with their D values mentioned adjacent to it																			
		A	D-Value	B	D-Value	C	D-Value	D	D-Value	E	D-Value	F	D-value	G	D-Value	H	D-Value	I	D-Value	J	D-Value
1	*Amaranthus*	0	0	0	0	6	0.00297	0	0	5	0.0036	0	0	0	0	3	0.000251	3	0.0005	0	0
2	*Agiratum* species	4	0.0017	0	0	0	0	0	0	6	0.00541	0	0	5	0.0006	4	0.000503	0	0	0	0
3	*Auria scandence*	6	0.0042	0	0	8	0.00555	0	0	0	0	5	0.0116	8	0.0016	6	0.001257	8	0.0042	0	0
4	*Boerhaavia*	5	0.0028	0	0	2	0.0002	0	0	0	0	0	0	6	0.0008	0	0	0	0	0	0
5	*Bothriochloa*	17	0.0381	12	0.0414	14	0.01802	6	0.0202	10	0.01622	2	0.0012	14	0.0051	17	0.011395	18	0.0229	14	0.0164
6	*Cassia tora*	0	0	0	0	5	0.00198	0	0	5	0.0036	0	0	12	0.0037	8	0.002346	0	0	0	0
7	*Cynodon dactylon*	20	0.0532	15	0.0658	20	0.03762	8	0.0378	15	0.03784	11	0.0639	25	0.0169	22	0.019355	23	0.0379	19	0.0307
8	*Cyperus rotundus*	0	0	0	0	0	0	0	0	0	0	0	0	9	0.002	9	0.003016	0	0	0	0
9	*Euphorbia hirta*	0	0	7	0.0132	7	0.00416	4	0.0081	8	0.01009	5	0.0116	10	0.0025	10	0.00377	11	0.0082	11	0.0099
10	*Ficus*	0	0	0	0	0	0	0	0	0	0	0	0	3	0.0002	0	0	0	0	0	0
11	*Ficus religiosa*	4	0.0017	0	0	0	0	3	0.004	0	0	2	0.0012	6	0.0008	5	0.000838	4	0.0009	3	0.0005
12	*Indigofera*	10	0.0126	4	0.0038	9	0.00713	7	0.0283	5	0.0036	0	0	9	0.002	12	0.00553	14	0.0136	13	0.014
13	*Malvestrum*	0	0	0	0	0	0	0	0	0	0	2	0.0012	0	0	2	8.38E-04	0	0	2	0.0002
14	*Oxalis trifolia*	0	0	0	0	12	0.01307	0	0	8	0.01009	0	0	15	0.0059	0	0	0	0	0	0
16	*Phyllanthus niruri*	0	0	5	0.0063	7	0.00416	0	0	0	0	6	0.0174	12	0.0037	14	0.007625	10	0.0067	13	0.014
17	*Sida acuta*	0	0	0	0	0	0	0	0	0	0	4	0.007	7	0.0012	6	0.001257	0	0	0	0
18	*Sida cardifolia*	0	0	0	0	3	0.00059	0	0	0	0	0	0	9	0.002	0	0	0	0	0	0
19	*Sonchus sps.*	0	0	0	0	1	0	0	0	0	0	0	0	9	0.002	0	0	0	0	0	0
20	*Sporobolus*	10	0.0126	10	0.0282	0	0	8	0.0378	13	0.02811	0	0	13	0.0044	18	0.012819	16	0.018	19	0.0307
21	*Tridex*	5	0.0028	4	0.0038	7	0.00416	0	0	0	0	5	0.0116	9	0.002	12	0.00553	3	0.0005	8	0.005

Simpson's diversity index provides knowledge about the richness and evenness of a particular species in a selected area. According to the Simpson (1949), diversity of a particular species is not depends on only the richness while there is also need to study the evenness of species. On the basis of Simpson' index of diversity most of the species calculated as highest diversity value 1 (Table 1.1 to 1.3) and few have been estimated with lowest diversity at the Khajuraho temple sites.

Value of Simpson's index is not resembles with frequency, density and abundance. It means that even low value of density of a particular species at a location can reflect with higher diversity index. Like *Ficus religiosa* accounted with lowest FDA value but their presence at mostly sites calculated with highest diversity.

Table 1.3: Simpson Diversity Index of Khajuraho monuments in Summer Season

S.No	Name of species	Name of the location/ sites with their D values mentioned adjacent to it																			
		A	D-value	B	D-value	C	D-value	D	D-value	E	D-value	F	D-value	G	D-value	H	D-value	I	D-value	J	D-value
1	*Agiratum species*	0	0	0	0	4	0.0014	0	0	0	0	2	0.00037	4	0.000177	5	0.0004	3	0.0005	0	0
2	*Alicicarpus monolifer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.0003	0	0	0	0
3	*Amaranthus viridis*	3	0.00066	0	0	0	0	0	0	0	0	0	0	4	0.000177	4	0.0003	2	0.0003	0	0
4	*Auria scandence*	5	0.0011	0	0	6	0.0021	0	0	6	0.001	5	0.000926	0	0	6	0.0004	0	0	0	0
5	*Boerhaavia diffusa*	2	0.00044	0	0	0	0	0	0	0	0	2	0.00037	3	0.000132	0	0	0	0	6	0.002
6	*Bothriochloa pertusa*	9	0.00198	10	0.0034	10	0.0035	8	0.0086	12	0.0021	15	0.002777	17	0.000751	18	0.0013	12	0.0019	14	0.0047
7	*Cassia tora*	0	0	0	0	0	0	0	0	0	0	0	0	8	0.000353	7	0.0005	0	0	0	0
8	*Cynodon dactylon*	12	0.00263	12	0.004	14	0.0049	0	0	15	0.0026	20	0.003702	20	0.000883	15	0.0011	19	0.003	0	0
9	*Euphorbia hirta*	0	0	8	0.0027	5	0.0017	5	0.0054	6	0.001	6	0.001111	12	0.00053	6	0.0004	6	0.0009	6	0.002
10	*Ficus benghalensis*	0	0	0	0	0	0	0	0	0	0	0	0	2	8.83E-05	0	0	0	0	2	0.0007
11	*Ficus religiosa*	4	0.00088	2	0.0007	1	0.0003	0	0	0	0	0	0	6	0.000265	2	0.0001	3	0.0005	0	0
12	*Indigofera asteragalina*	8	0.00176	3	0.001	6	0.0021	6	0.0065	9	0.0015	8	0.001481	10	0.000442	11	0.0008	9	0.0014	7	0.0024
13	*Malvestrum coromandelianum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.0002	0	0	2	0.0007
14	*Oxalis trifolia*	0	0	9	0.003	0	0	0	0	0	0	0	0	15	0.000662	0	0	0	0	0	0
15	*Parthenium*	4	0.00088	0	0	1	0.0003	0	0	0	0	0	0	8	0.000353	4	0.0003	3	0.0005	3	0.001
16	*Phyllanthus niruri*	8	0.00176	0	0	0	0	0	0	8	0.0014	4	0.00074	9	0.000397	10	0.0007	10	0.0016	6	0.002
17	*Sida acuta*	0	0	4	0.0013	4	0.0014	0	0	0	0	6	0.001111	9	0.000397	0	0	4	0.0006	0	0
18	*Sonchus*	0	0	0	0	0	0	0	0	2	0.0003	0	0	4	0.000177	3	0.0002	2	0.0003	2	0.0007
19	*Sporobolus indicus*	9	0.00198	0	0	0	0	8	0.0086	13	0.0022	0	0	12	0.00053	12	0.0009	0	0	0	0
20	*Tridex procumbens*	4	0.00088	7	0.0024	3	0.001	4	0.0043	6	0.001	6	0.001111	8	0.000353	8	0.0006	7	0.0011	7	0.0024

REFERENCES

- Bentham, G., & Hooker, J. D. (1876). Genera plantarum. Reeve And Co.; London.
- Brown, D. (1954). Methods of surviving and measuring vegetation. Commonwealth bureau of pastures and field crops pp. xv+223.
- Caneva, G., & Altieri, A. (1988). Biochemical mechanisms of stone weathering induced by plant growth. VIth International Congress on Deterioration and Conservation of Stone, Torun, 12-14 sep 1988, proceeding. Nicholas Copernicus University press department, 32-44.
- Caneva, G., & Galotta, G. (1994). Floristic and structural changes of plant communities ofthe Domus Aurea (Rome) related to a different weed control. In proceedings of the 3rd International Symposium, "The Conservation of monuments in the Mediterranean Basin", Venezia, 317-322.
- Dakal, T. C., & Cameotra, S. S. (2012). Microbially induced deterioration of architectural heritages: routes and mechanisms involved. *Environmental Sciences Europe*, *24*(1), 36.
- Fusey, P., & Hyvert, G. (1966). Biological deterioration of stone monuments in Cambodia. *Soc Chem Ind Monograph*, *23*, 125-129.
- Grossi, C. M., Brimblecombe, P., Esbert, R. M., & Alonso, F. J. (2006): Color changes in architectural limestones from pollution and cleaning. *Color Res Appl*, *32*(4), 320-331.
- Negi, A., & Sarethy, I. P. (2019). Microbial Biodeterioration of Cultural Heritage: Events, Colonization, and Analyses. *Microb Ecol*, *78*(4), 1014-1029. doi:10.1007/s00248-019-01366-y.
- Ortega-calvo, J. J., Hernandez-Marine, M., Naturales, R., & Saiz-Jiminez, C. (1991). Biodeterioration of building materials by cyanobacteria and algae. *Int Biod*, 28(1-4):165-185.
- Ortega-Calvo, J. J., Arino X., Hernandez-Marine, M., & Saiz-Jiminez, C. (1995). Factors affecting the weathering and colonization of monuments by phototropic microorganisms. *Sci Tot Environ*, *167* (1-3), 329-341.
- Simpson, E. H. (1949). Measurement of diversity. *Nature*, 163, 688.
- Singh, R., Tiwari, J., & Ahirwar, N. K. (2018). The distribution and diversity of fungi and macroflora on the temple groups of khajuraho (MP). *International Journal of Research in Applied, Natural and Social Sciences*, 6(6), 51-57.
- Syswowiyanto, S. (1981). How to control the organic growth on Borobudur stones after the restoration. In The Conservation of Stone –II, Preprints of the contributions to the international symposium, 27-30 October 1981. Part B: treatment, Bologna, 759-768.
- Tiano, P. (1987). Procedures for the elimination of vagetal biodeteriogens from stone monuments. In ICOM Committee for conservation. 8th Triennial Meeting, Sydney, 3, 1201-1205.
- Upreti, D. K., Bajpai, R., & Nayaka, S. (2009). Indian monuments needs lichen study. New horizons, 7:64-69.
- Winkler, E. M. (1975). Stone: Properties, Durability in Man's Environment. Springer-Verlag Berlin Heidelberg, 154 -163.
- Winkler, E. M. (2013). Stone: properties, durability in man's environment. Springer Science & Business Media. 2nd edition, 4, 230.