World Herigate Research

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Abstract

The present investigation was carried out to evaluate the status of biodeterioartion of world fame archaeological monuments of Taxila. Twenty-three stone built monuments of six world heritage sites of Taxila were evaluated for biological decay and deterioration. 54 sampling materials including different colored patinas, biofilms, stains and thick and hard crusts were analyzed for the presence of fungi on the monuments.

Twenty-two fungal species belonging to fifteen different genera were isolated from the sampling materials obtained from stone monuments of Taxila. The fungal species Alternaria alternata, Aspergillus fumigatus, Aspergillus flavus, Aspergillus niger, Cladosporium herbarum, Cladosporium cladosporioides, Fusarium oxysporum, Mucor hiemalis, Penicillium chrysogenum, Penicillium frequentans, Rhizopus oryzae, Trichoderma sp., Curvularia lunata and Dematium sp. Were prevalent fungi isolated from
the selected monuments of Taxila. The isolated fungal species showed a variation not only in their composition but also in their occurrence on different monuments of archaeological sites.

The transportation of fungal spores from air to the surface of monuments was also monitored by one-year aeromycological studies of archaeological sites of Taxila. The air around the monuments of Taxila was found contaminated as thirty fungal species belonging to nineteen genera were isolated from the air of these sites. The fungal species Alternaria alternata, Aspergillus niger, Cladosporium herbarum, Penicillium chrysogenum, Fusarium oxysporum, Aspergillus flavus, Aspergillus fumigatus, Mucor mucedo, Penicillium frequentans, Rhizopus oryzae, Alternaria solani, Helminthosporium solani, Cladosporium cladosporioides, Mucor hiemalis, Curvularia lunata and Fusarium culmorum were prevalent fungi in the air of archaeological sites of Taxila. Seasonal variations in the composition and occurrence of fungal species were also obvious in present study. Many fungal species was found restricted to a particular site. Some fungal species showed their seasonal occurrence throughout the year. The highest number of fungal colonies was isolated in Spring followed by Summer, Autumn and Winter. Dust samples were also taken from stone monuments of Taxila for microbiological analysis. It was observed that almost all fungal species that were isolated from the surface of monuments were also present in dust samples except Fusarium culmorum that was not present in any dust sample.

Comparative analysis of fungi showed that a large number of fungi isolated from air and dust of archaeological sites of Taxila were found active biological agents involved in decay and deterioration of stone monuments of Taxila. The growth of large number of fungi on the surface of monuments of Taxila caused many surface alterations by producing different colored patinas, biofilms, stains and crusts. Many physical decays like biopitting, fracturing, crumbling and disfigurement of monuments of Taxila are very obvious due to the growth and physico-chemical actions of fungi.

The XRD analysis of patinas, biofilms and crusts was done and it was found that these patinas and biofilms showed highest peaks of calcium, potassium, aluminum and lowest peaks of silicon, iron and magnesium. The mineral composition of patinas and biofilms revealed that most of the patinas and biofilms are calcite, gypsum and calcium oxalate. The calcite and calcium oxalate was the major components of patinas and biofilms. Some patinas also showed magnesium carbonate, magnesium oxalate and calcium sulfate with low peaks.

The isolated fungal strains were tested in vitro for their ability to lower the pH of broth medium. All isolated fungi lowered down the pH of broth medium with 3% and 5% glucose.

The fungal species Aspergillus niger, Penicillium frequentans, Trichoderma sp., Mucor hiemalis, Aspergillus flavus, Aspergillus fumigatus, Penicillium chrysogenum, =Fusarium oxysporum, Cladosporium herbarum, Rhizopus oryzae and Alternaria alternata decreased the pH to lower acidic values. The organic acids produced by these fungal strains were citric acid, fumaric acid, oxalic acid, gluconic acid, succinic acid and acetic acid. The highest amounts of acids were produced by Aspergillus niger followed by Aspergillus flavus, Fusarium oxysporum, Mucor hiemalis, Penicillium frequentans, Penicillium chrysogenum, Trichoderma and Rhizopus oryzae. The fungal species Alternaria alternata, Cladosporium herbarum, Curvularia lunata and Cladosporium cladosporioides produced lowest quantity of organic acids in broth medium.

Eight fungicides including Ridmil gold, Sancozeb, Benomyl, Tri-miltox, Captan, Acrobat, Daconil and Vitavix were tested for their fungicidal effects on thirteen fungal species that were isolated from stone monuments of Taxila. These fungicides were used with concentrations of 10, 20, 40 and 60 ppm. The fungicides Ridmil gold, Sancozeb and Acrobat were found to be the most effective by inhibiting Alternaria alternata, Aspergillus niger, Aspergillus flavus, Cladosporium herbarum, Fusarium oxysporum and Penicillium frequentans at a concentration of 40 and 60 ppm. The fungicides Daconil and Vitavix were found ineffective on all tested fungal strains with all concentrations.

The present investigation is the first scientific study of stone monuments of world heritage sites of Taxila regarding biodeterioration of these monuments. Many recommendations were suggested to the conservation Authorities of Archaeology Department to prevent the further decay of these monuments from biological decay.

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