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Microbial alteration of limestone from monuments exposed to an urban area

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In France, more than 50% of historical buildings are out of limestone, so that the preservation of this material is a major challenge. Moreover, many monuments are located in city centers and close to parks or gardens. Their alteration is thus due to several parameters: environment (rainfall, temperature and relative humidity), chemical pollutants (gases and particulate matter) and biological agents (bacteria, algae). In addition, these factors can interact and modify the alteration processes and associated kinetics.

In order to investigate the different alteration processes of limestone, this study is focused on the famous Père Lachaise Cemetery located in Paris (France) as it contains many monuments from the XIXth c. that were not restored. Firstly, limestone samples from one monument were collected in order to determine the alteration patterns and to identify and quantify the microbial population. The bacteria distribution and the alteration patterns depend on the local environmental conditions determined by the geometry of the limestone on the monuments. In parallel, pristine limestone samples were exposed close to the monuments in order to identify the first microbial populations that colonize the stone and the mechanisms of biodeterioration. At the same time, rainwater was collected to study its contribution via its microbial and chemical composition. Secondly, laboratory experiments were carried out to expose limestone samples to different site representative micro-organisms to determine their contribution to the alteration. The comparison of their activities on pristine samples and on weathered samples in a polluted medium allowed determining the impact of the microorganisms on the biodeterioration of limestone under pollution and continental climatic region.