The Microorganism Investigation and Information Visualization Display in Qingliangshan Grottoes, Yan 'an

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Abstract. There are many grottoes of the Song and Jin Dynasties in northern Shaanxi, the Qingliangshan grottoes of Yan'an is typical representatives. Due to the influence of environmental and geographical factors, the microbial of the Qingliangshan grottoes have caused the surface weathering, pollution or discoloring of cultural relics, as well as the potential dangers, which have caused some damage to the grottoes. This paper based on the investigation of harmful microbial samples on the surface of the grottoes of Qingliangshan in northern Shaanxi Province. Using microscopy and molecular biology to analyze microbial communities, Understand the influence and harm of microorganisms on grottoes, then to display and publicize with graphical information, to make readers understand the influence of microbial disasters on the grottoes and further attract people's attention. It is form a consensus on protecting the material and cultural heritage of grottoes and promote the inheritance of traditional Chinese culture.

1. Introduction

The Chinese Buddhist Grottoes art is an important immovable cultural relic, which has special historical value and artistic value.[1] Because the environment of the grottoes is generally outdoors, it will produce the bacteria, algae, and other microorganisms on the grottoes. These microorganisms will cause some white spots, green rust and other damage phenomena on the surface of the stone carvings. It will not only destroy the artistic value of the grottoes but also may cause devastating damage to the grottoes' relic. As time goes by, the microorganisms will cause structural instability of the rocks and aggravation of biological disasters in grotto relics. This paper collected the organisms on the cliff face of the Qingliangshan grottoes, analyzed the types of organisms, pests and diseases in the grottoes, and found some common rules in cultural relic diseases. After the text information is transformed into the graphic, it is displayed in typesetting with charts, characters, colors and so on to popularize the microorganism status and biological hazards of the Qingliangshan grottoes and to promote the attention of the society and relevant organizations. Achieve the purpose of protecting the material cultural heritage.

2. The geographical environment of Qingliangshan grottoes and current situation

The stone cultural relics of our country are various and large in quantity, which has extremely high artistic value and tourist value.[1] But many stone cultural relics are suffering from serious erosion of weathering diseases at present.

The Grottoes of the Qingliangshan were excavated in Yan'an, north of Shaanxi Province. It is the first excavated in the Northern Wei Dynasty and further excavated in the Sui, Tang, Song and Ming dynasties, etc. At present, Grottoes of the Qingliangshan are displayed in large quantities and on a grand scale. They are an important representative of grottoes in Yan'an area and a valuable historical and cultural heritage of mankind. The grotto is located at 36°36'0.13" in north latitude and 109°29' 2.45" in east longitude, dug in the Qingliangshan more than 100 meters above sea level, facing the Yan River. The seasons of there is distinct and the temperature difference is large. The highest temperature in a day is about 34.7℃ in July. However the lowest temperature in January can reach about -16.6℃. The annual sunshine duration can reach 1800~2000h. The strata in Yan'an area are part of the Jurassic Yan'an Formation in the Triassic period. The geology is argillaceous sandstone with

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calcium carbonate and covered with a thick yellow soil layer.

The environment is an important factor for the growth of microorganisms. The microorganisms are different environmental conditions, and the vegetation is lusher at Qingliangshan in Yan'an which will provide a certain existing environment for the microorganisms.[2] At the same time, since the grottoes exposure to the outdoor environment for a long time, the grottoes experience natural phenomena, for example the wind-blown, precipitation and dust etc, which all promote the reproduction of microorganisms. Due to the presence of numerous of microorganisms the Qingliangshan grottoes have weathered and fallen off and the moss, which has brought certain damage to the grottoes and reduced their aesthetic value of the grottoes.

3. Experimental Process

The microorganisms on the surface of the grottoes are different because of the geographical environment and temperature in different areas. The Qingliangshan is sandstone structure, the climate is four distinct seasons. The Most of Qingliangshan grottoes are cliff carvings and in the open area .[3] So such an environment is also more suitable for the long-term existence of microorganisms. This experiment mainly studied the microbial species and the harm of different microorganisms in the environment of Qingliangshan grottoes, and display to people, inspire people to do some basic work to prevent microbial damage to the grottoes.

3.1 Collect samples

First, collect the algae and the mucor growing around the stone surface of *Maitreya Cave* in Qingliangshan Grottoes. Put them in tubes, then stored and numbered. Then it is observed under an optical microscope as usual. and the same time to observe the shape of the object and record it.

It is necessary to make glass slides before observation. Due to the algae on the rock surface being mostly densely growing,[4] the collected objects should be soaked in distilled water for a while before making glass slides to better separate the objects into single cells.

3.2 Extraction of DNA

The suspension of microbial DNA was centrifuged for 5 minutes using a high-speed centrifuge of 10000. The clear liquid above was removed and only the precipitated part was retained. The DNA was dissolved in 50μL dilute solution. The DNA was extracted using the QIAGEN kit.

3.3 Biological detection and analysis

Take some DNA samples. Using PCR polymerase chain reaction. According to the instructions. The reaction system and conditions were as follows: Tap enzyme (5u/μL), 0.5μL, DNA template, 0.2μL, upstream primer1μL, downstream prime1 μ L, sterilized deionized water, 17.3mL.[5] Then, based on The ILLUMINA HISEQ sequencing platform, the sequencing and clustering were carried out by the method of double terminal sequencing (Paired-End), and the abundance analysis was performed. (Figure1)

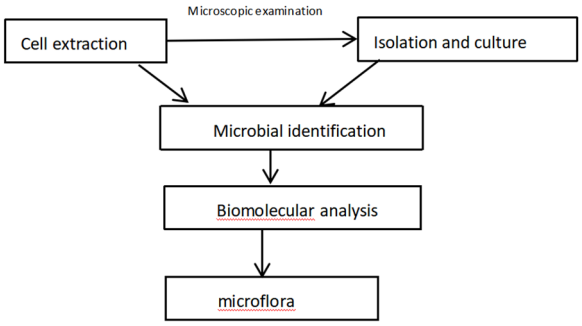

Figure 1. Microorganism detection process of stone relics

4. Biological analysis and discussion of Qingliangshan Grottoes

4.1 Observe the appearance of microorganisms

The microorganisms were placed under a microscope to observed the morphology of the samples. It was found that the microorganisms in the Qingliangshan grottoes mainly included Bacteria, Cyanobacteria and visible Mosses, which were mainly photosynthetic bacteria. The bacterial filaments are generally wrapped around soil or sandstone, the diameter is about 5 microns, the algae cells are about 8-15 microns. (Figure 2)

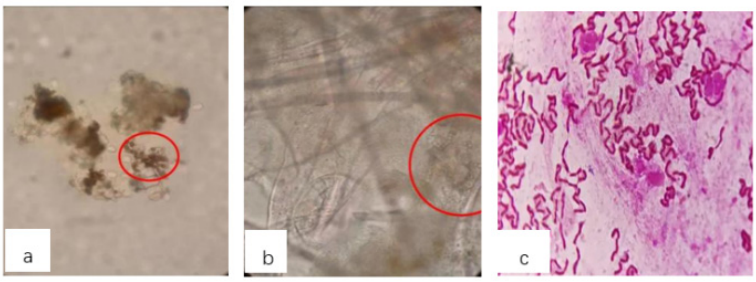

Figure 2 Picture of bacteria a--40times b--40times c--50times

4.2 Biological molecular analysis

Use the CUTADAPT software to filter out the invalid sequence columns in the results of DNA sequencing. After dividing the samples according to bar code,then to OTU (Operational Taxonomic Units) clustering and species classification, to obtain the corresponding species information and proportion. At the genus level, the abundance of each sample was selected from high to low to ranking.

According to the results of inspection to analysis, the bacteria is one of the main microorganisms in Qingliangshan carvings. There are mainly heterotrophic bacteria and mold in grottoes. The heterotrophic bacteria is main *pseudomonas*, the proportion of the *pseudomonas* is relatively large, accounting for 35% and the *halomonas* is 16.8%. The *pseudomonas* is a Gram-negative bacillus free bacterium, straight or slightly curved rod shape, the size of the cell is 0.5-1×1.5-4μm.[6] General flesh eye can't be observed, but its adaptability is strong. At present, 29 species have been confirmed, and the common representative species are *pseudomonas aeruginosa*, *Halomonas*, *Pseudomonas fluorescens*, *pseudomonas putida* etc. As the environmental conditions are suitable, they will grow rapidly and form visible plaques or biofilms. (Figure 3)

In the Qingliangshan grottoes, there are some algae, including the *quiver algae*, *candida* and *chlorella* etc. The algae belong to six families and seven genera in three phyla, such as *cyanobacteria*, green algae and diatoms, the ratio is about 22%. It is long and cylindrical bodies with pigment cell, especially the flutter algae have the strongest reproduction ability. What's more, the flutter algae are widely distributed. The proportion of algae is 25%. Since the algae do not have the great requirements on the environment, it is not affected by seasonal climate and temperature, which contribute to the growth of algae, which can be seen all year round.

The Moss usually is growing in the cracks of the rock in the grottoes, which are usually visible and irregular in shape. The leaf cells are round or diamond-shaped, containing multiple pigment bodies. It is About 28% of the grottoes' microbes, and the moss can live all year round. (Figure 4)

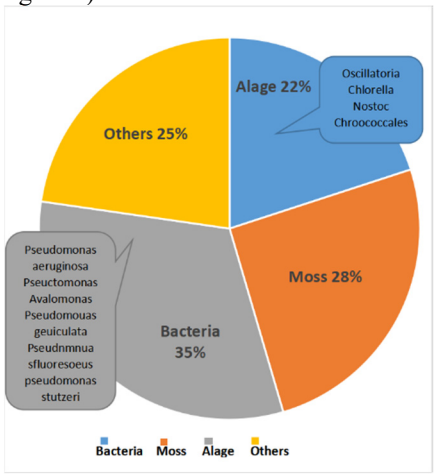

Figure 3 Microbial proportion map

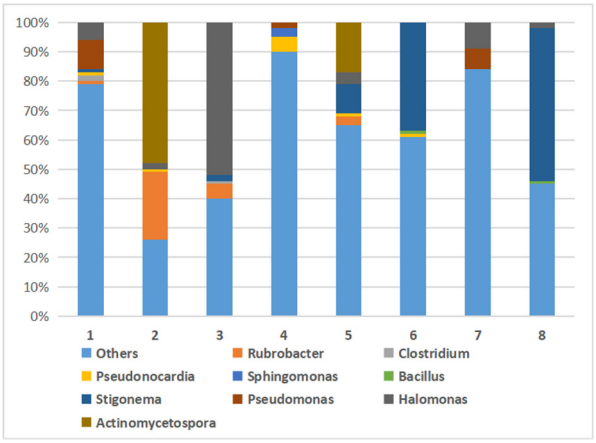

Figure 4 Biological community

5. Discussion results and visual display

5.1 Discussion results

According to the investigation of microorganisms in the grottoes of Qingliangshan, there are a large number of cyanobacteria, fungi and moss in the 11th grottoes of Qingliangshan. *Pseudomonas* and *halomonas* are the most abundant and frequent bacteria, accounting for more than 50% of the bacteria. In addition, *halomonas* and *actinomycetes* have greater adaptability in the temperature, salinity and nutrition, it is good for survival and reproduction.

The bacteria's mycelium covers the surface of grottoes, which look like the root system of plants. It causes particles or minerals in the air to gather on the surface of cultural relics, forms biofilms and clogs the pores of rock structures. This phenomenon will lead to the pollution of cultural relics.[7] The bacteria will secrete extracellular pigments or organic acids in the process of growth and reproduction. These secretions can also stain artifacts and encroach on rock surfaces because the secretions react chemically with the rocks then form many melanin, chlorophyll, photosynthetic pigments, etc. This causing the stone surface discoloration or corrosion. There are also bacteria, such as the *pseudomonas* with combined nitrogen fixation. The free nitrogen in the air in the form of NH3 fixed down and then forms nitric acid and nitrite, which will led to the formation of mottling on the surface of the stone layer.

Algae can accelerate the dissolution rate of grotto rocks. When the algae grow, the CO2 produced by respiration dissolves in the water of the surrounding environment will produce carbonic acid, which has the damaging effect of corrosion and dissolution on the grotto relics.[8] At the same time, algae live on rocks, which will form uneven rocks and produce small dissolution forms. Damage to the fine stone carvings on the surface of the stone carvings. [9]

As the moss grows, it will secrete organic acids like citric acid and oxalic acid, which will cause the mineral

particles on the rock surface to fall off or change color.[10] What's more, the moss can produce carbon sources and other nutrients through photosynthesis to supply microorganisms to meet the growth of microorganisms. At the same time, the moss can also provide a certain growth environment for bacteria, fungi, algae, lichens and other invisible microorganisms, which encourages the growth of harmful microorganisms and has a certain impact on the grottoes' environment.

To sum up, the different microorganisms bring different damages at the grottoes. The phenomenon of destruction includes green rust, cracks, change of color and so on, which not only change the appearance of stone carvings and reduce their aesthetic value but also cause damage to the rock structure of stone cultural relics and accelerate the damage process of stone carvings. This is not conducive to the protection of cultural heritage.

5.2 Visual display

In order to adapt to the public popularization of science in the current era, this paper investigates the microorganisms in the grottoes of Qingliangshan. Based on the design principle of information visualization to carry out the popularization exhibition of the microorganisms in the Qingliangshan grottoes.

According to the geographical location, microbial species and proportion of Qingliangshan grottoes, the legend is displayed while the certain colors, shapes and legends are used. Therefore, readers can intuitively see the environment of microbial growth, which helps people to understand the composition and evolution of microbial flora better, improve information transmission, reduce wrong understanding and improve cognitive efficiency. At the same time, readers can understand the impact of different microbes on the grottoes, arouse people's attention and protect the scientific and humanistic value brought by the grottoes' art in the longer term.

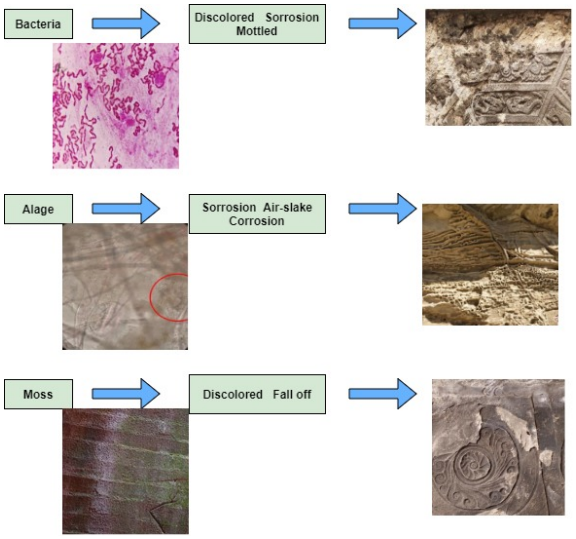

Figure 5 Visual presentation part

Through the investigation of the microbial species on the rock surface of Qingliangshan grottoes and the visual display of information, it is hoped that readers can understand the current situation of microorganisms in Qingliangshan grottoes and the harmful microorganisms in the grottoes through the graphical information, try to attract the attention of the public and relevant organizations through the investigation, and explore the physical and chemical methods that can effectively use and restrain the growth of harmful microorganisms. Slow down the surface damage of the grottoes' relics and strengthen the protection of the grottoes.[11] At the same time, the common social consciousness of protecting the grottoes is further formed, and the material cultural heritage of our country is effectively protected, while also meeting the growing spiritual culture of people.

Secondly, based on the characteristics of microorganisms in the grottoes of Qingliangshan and the microorganisms' damage to cultural relics, it is considered that the relics of Qingliangshan grottoes face a high risk of microbial erosion. In order to provide a scientific basis for the tourism opening and preventive protection of the heritage site, it is necessary to carry out monitoring of microorganisms in the environment of the grottoes.

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