In Situ Investigation of the Biodeteriorative Microorganisms Lived on Stone Surfaces of the Sumela Monastery (Trabzon, Turkey)

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Abstract

The biodeteriorative microorganisms were identified using Microbial Identification System (MIS) and SEM-EDS combined system energy dispersive spectrometric investigations. The results showed that wide variety micro/macro-organisms dwell on stones of the Sumela Monastery. Total 24 species and 10 genuses were determined on the deteriorated stone surfaces by microbial identification studies. The settled way of these organisms on stone surface were illustrated by SEM images. EDS analyses show that the major elements constituting the stones of the Sumela Monastery are silicon, aluminum, calcium, potassium, titanium, magnesium, zinc, sulfur, iron, sodium and niobium. Some of these elements could provide energy resources for the microorganisms by dissolving stone-surfaces of the Monastery. However, the biodeteriorative effect of micro/macro-organisms is more significant on stones of the Sumela Monastery, we see that the man is the most destructive agents on the historical building among all of the deteriorative factors. The results showed that the stone surfaces of the Monastery are silicon, aluminum, calcium, potassium, magnesium, zinc, sulfur, iron, sodium and niobium. Some of these elements could provide energy resources for the microorganisms by dissolving stone-surfaces of the Monastery. However, the biodeteriorative effect of micro/macro-organisms is more significant on stones of the Sumela Monastery, we see that the man is the most destructive agents on the historical building among all of the deteriorative factors.

Keywords: Sumela monastery; Biodeterioration; Stone monuments

Introduction

The use of stone, clay and wood in monuments as construction materials is one of the principal stages in the evolution of civilization. The types of these construction materials found on the site of towns indicated development of the arts and give information about the level of civilization. As soon as a stone piece is used in stone monuments, it comes into contact with a variety of physical, chemical and biological agents which alter it. The problem of understanding the deterioration of stone is compounded by the large range of types with different mineralogical and physical characteristics and their varying weathering responses under different climatic and environmental conditions [1,2].

Many agents such as physical, chemical and biological contribute to the deterioration of stone monuments, buildings, and other objects of cultural value. Degradation of stone materials under permanently open air conditions is mainly controlled by interacting chemical and mechanical processes leading to the destruction of the microstructure by the degradation processes and the propagation of micro-cracks. Degradation processes is considerably affected by the accumulation of damage resulting from time variant external loading in conjunction with environmentally induced mechanisms such as moisture and heat transport, freeze-thaw actions, chemically expansive reactions, shrinkage and chemical dissolution or by the corrosion of the reinforcement. Physical, chemical and biological agents act together, ranging from synergistic to antagonistic, in the deterioration of stone. A considerable number of investigations have begun to examine the essential role of biological agents play in the deterioration of stone [1-3,5]. The stone is susceptible to colonization by several microorganisms such as bacteria, fungi, algae, cyanobacteria and more complex organisms such as lichens and mosses responsible for a series of mechanical and chemical processes that cause the biodeterioration of the stone. The relative effects of each of these organisms vary according to the topoclimatic environmental conditions, the stone type, its state of preservation and its position on the monument [6-8]. On the other hand, pore size, distribution and specific surface area together with the capillarity of a stone control the mechanical degradation caused by water, salts, and bacteria. Understanding the complex interactions between these microorganisms and their mineral substrate is a topic of current interest, since it may shed light on the bio-weathering of stone monuments [4,5].

Stone monuments and the other building materials exposed to open air deteriorate due to natural causes named as weathering agents such as temperature, rain, snow, moisture, wind and sunlight. These agents will incite both physical and chemical weathering processes [4,5,9-12]. The first affect the stability of the rock matrix, while the second act through chemical corrosion of the stone-forming minerals, such as oxidation and hydration reactions as well as dissolution of carbonates and solubilization of some elements from silicate bearing minerals. In addition to physical and chemical factors, microorganisms play a contributing role in deterioration of stone monuments [4,13]. Microbial colonization of buildings causes aesthetic and physical damage to the structure through the formation of biofilms, which contain microorganisms and their metabolic products, such as extracellular polymeric materials (EPS), and both inorganic and organic acids [7,14,15].

Biodeterioration has usually been considered to be a degradation process following the initial deteriorating effects of inorganic agents. These agents were thought to condition stone surfaces for microbial contamination due to structural changes and the enrichment of inorganic and organic nutrient substrates. Microorganisms have recently been recognized as potentially significant players in the decay of buildings and artwork. A wide variety of microorganisms such as chemoheterotrophic bacteria, chemolithotrophic bacteria, phototrophic bacteria, algae, fungi

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and lichens dwell on historical buildings and artwork. Among these, the photosynthetic microorganisms are potentially the most aggressive due to their photoautotrophic nature. Once established on stone surfaces, they permit the growth of more complex microbial flora formed by heterotrophic microorganisms, and these often activate strongly deteriorating effect. Therefore, photosynthetic microorganisms participate in decay processes directly, causing aesthetic damages and subsequently structural damages, and also indirectly, by supporting the growth of other microorganisms [4,16].

The weathering characteristics of stones related to their bioreceptivity and its depend on chemical nature, physical structure and geological origin of stones such as volcanic, sedimentary and metamorphic rocks. At the same time, microbial colonization of stones depends on environmental factors, such as water availability, pH, climatic exposure, nutrient sources, and on petrologic parameters, such as mineral composition, type of cement as well as porosity and permeability of the rock material [4].

Historical monuments are one of the most important values of cultural heritage. In this context, the Sumela Monastery had been begun 4th century for devoted in honour of the Virgin Mary as a represent a special civilization. This marvelous stone monument was plundered sometimes by the robbers of historical-heritages belonging to various nations, and at the same time the monuments was exposed to the biodeteriorating agents. This research aimed to determining of the micro/macro-organisms lived on stone surfaces and its biodeteriorative effects on the marvelous stone monuments: the Sumela Monastery.

Materials and Methods

Site description

The Sumela (Meryemana, the Virgin Mary) monastery is in Altındere village of Macka district (40º 47´ N, 39º 36´ E, elevation 1100 m), 48 km from Trabzon in the East Black Sea Region of Turkey. This region was established as Sumela National Park by the Republic of Turkey Ministry of Environment and Forestry. Macka town is known a monastery site along the Black Sea Region, and it has four unique monasteries such as Sumela, Vezelon, St. Barbara and Kustul (St. George Peristere). The Sumela monastery was built in a huge cave placed in the middle of very steep rock such straight as a wall (Figure 1). The monastery looks like it has been taken down from the sky and pasted on the side of the hill. The most important site in monastery is located above a valley inside the Pontic mountains and is reached after a pleasant ride with beautiful views of nature. This place is known as "Meryemana" by the local people.

Building of the Sumela Monastery had been begun 4th century and its building stages continued at 13th and 19th century with additional units. The Monastery founded in honour of the Virgin Mary. It is said that ‘Sumela’ comes from the word ‘melas’, which means "dark" or "black". No one has been able to answer the question of how mankind was able to build such a huge monastery on the wall of a mountain with the technology of the 4th century. The access to the monastery is through a narrow gate at the top of stairs cut into the rock (Figure 2).

The monastery complex had 5 floors and a total of 72 rooms (Figure 3). The internal walls of the church were full of frescoes and mural paintings (Figure 4). It was built in cutting huge rocks at lonely mountains so that the clergies could worship away from man. The spring-water issuing from the nearest rock of the Monastery were consented as sacred. The Monastery repaired many times from first building date, and the finally reparation performed in 1860, but this unique historical buildings was plundered many times by the robbers of historical-heritages belonging to various nations. It has been restored by The Ministry of Culture and Tourism Republic of Turkey according

![Figure 1: The view of Sumela Monastery.](image-url)
Figure 2: The access to the monastery.

Figure 3: The monastery rooms in the cave.
to the original forms now. Although the famous monument isn’t registered on the World Heritage List until now, it forms marvelous architectural complexes (Figures 1-4).

The meteorological characteristics of the Sumela are given in Table 1 [17].

The Sumela Monastery was built two originated stones: volcanic such as volcanic lava, andesite and trachide, and sediment as travertine. Volcanic stone is the main construction materials of the main walls of the Monastery for their durability. Sediment rocks were used as internal architectural building materials of the room-door, window domes and fresco for easy cutting peculiarities. Bricks is also used some vaults and domes.

Sample collection

The Sumela Monastery are protected by staff of the Sumela National Park, therefore the amount of sampled material was restricted especially internal parts of the monuments i.e., frescoes and mural paintings. Samples were collected according to two criteria: exposure to light (indoor and outdoor sections), and type of stone material. The four and the two sampling points were selected on external and internal parts of the monuments respectively in April 2004. Because it may be the contamination stemming from soil and ground at lower stone surface, the samples were taken from lower and upper parts of the walls. The samples were taken from about the 1 and 4 meter-high of the internal and external wall of the Monastery by means of knife, spatula and mini-hammer, and they were put into the Petri dish (and in lidded-polyethylene bags sterilized by UV-radiation). All sampling studies were carried out in aseptic conditions. There weren't differences for open-air conditions between internal and external walls of the Monastery because of devastation of monastery roof. Therefore, the internal walls exposed to open-air conditions.

Two different types of specimen were taken from the stone surface in each sample-taking point of the monuments. The first one of them (disaggregated) was taken by means of the erasing of samples from the stone surface. These samples were used bacterial and fungal identification studies. All microbiological studies were carried out in sterile conditions. The second type non-crumbed (aggregated) stone samples were taken and used in not only the identification of algae and lichens but also microscopic investigation and elemental analyses in the JEOL 6400 SEM-EDS combined system energy dispersive spectrometer.

Identification of lichens and algae

The lichens were identified by microscopic observation of the diagnostical characters such as thallus and reproductive organs of the various characteristics of the corpus by followed general keys [18]. Determination of the algal species was performed through direct observation by optical microscopy; taxonomic identification was drawn from a number of monographs [19].

Identification of bacteria and fungi

For identification of the fungi, a small portion of each specimen mounted in a few drops of 20% potassium hydroxide was examined for the presence of characteristic fungal elements and diagnostic morphology. The samples were cultured on sabouraud dextrose agar
Meteorological Parameters | Months
--- | ---
Temperature (°C) | 4.5 | 4.9 | 6.8 | 11.5 | 14.5 | 17.8 | 20.1 | 20.2 | 17.5 | 13.3 | 9.6 | 5.7 | 12.2 | Average
Precipitation (mm) | 45 | 47 | 51 | 103 | 125 | 130 | 92 | 91 | 68 | 81 | 56 | 53 | 902.0*
Moisture (%) | 70 | 70 | 70 | 73 | 77 | 78 | 80 | 82 | 82 | 81 | 78 | 72 | 76 | *Total

Table 1: The average of some meteorological parameters of Sumela.

As seen in Table 2, a total of 34 micro/macro-organism taxa were identified and compared to a library of reference organisms in the database to identify our bacteria. SEM micrographic examinations

Specimens taken from the sampling sites were broken into small pieces under aseptic conditions. Then, conductivity of external surfaces of the stone samples was provided by sputtering with Au-Pd target using a sputter-coater and thus the samples were ready to be examined as natural form in JEOL 6400 SEM-EDS combined system energy dispersive spectrometer. After the samples coated in a nanometer degree were attached in the holder of SEM, they were placed into the vacuum chamber to photograph and elemental analysis (EDS). Secondary electron images and energy dispersive spectrums were obtained at 10/25/30 and 25 keV energy level respectively. SEM micrographs were taken between 50-7,000X magnifications.

Results and Discussion

Building of the Sumela Monastery had been begun 4th century for devoted in honour of the Virgin Mary. Some parts of this marvelous stone monument was plundered many times by the robbers of historical-heritages belonging to various nations (Figures 4 and 5), and at the same time the monuments was exposed to the biodeteriorating agents because of open-air conditions. The Sumela Monastery is strictly protecting by staff of the Sumela National Park now. In particular, this research aims the interactions between the microbial community and its biodeteriorative effects on stones of the Sumela Monastery.

Our observations indicated that the external walls of the Sumela Monastery showed clear indications of biodeterioration, including stone disaggregation and the presence of lichens and mosses which were abundantly colonized on the lower parts of the walls and free stones (Figure 6). Algal and fungal cells were very abundant in the internal fragments of the splitting rock (Figure 7). Many white spots due to lichens were observed on the stone surfaces. The stone surface is frequently deteriorated due to the action of algae and lichens. It is well known that acid secreted by algae and lichens accelerates the deterioration of stone surfaces [4,20].

When applied in situ, scanning electron microscopy (SEM) is an ideal method of observing biofilms and diagnosing their effects on stone monuments [2,21]. The SEM images showed us how the thalli were closely attached to the internal fragments of the splitting rock and substrates (Figure 7). Fungal hyphae and algal cells could be seen in the inner substrate areas. It seen in Figures 6 and 7 that the biodeterioration of the Sumela Monastery stones is the result of complex microbial interactions in the microbial consortia and not the consequence of the action of a particular group of microorganisms.

By means of the microbial identification studies, the following species and genus of microorganisms were determined the stone surfaces and pores of the Sumela Monastery in April 2004 (Table 2). As seen in Table 2, a total of 34 micro/macro-organism taxa were identified, of which 10 were identified to genus level, 24 to species level.

Examination of Table 2, and carried out in situ investigation, it is seen that the species of lichens such as Umbilicaria cinereorufescens (Figure 8), Candelariella vitellina, the genus of lichen such as Collema

containing peptone (10 g), glucose (20 g) and agar (15 g). The medium was supplemented with chloramphenicol and cycloheximide (50 and 500 mg/l). The cultures were incubated at 26°C and examined twice a week for a total duration of 4 weeks. After that, the isolates were passed through tubes into Petri dishes containing sabouraud dextrose agar and potato dextrose agar. The isolates were examined macroscopically, and microscopically following staining with lactophenol cotton blue. The identification of yeast was based on their macroscopic characteristics as a result of germination tests and biochemical tests. The identification of molds was based on their macroscopic characteristics (growth period, colony morphology, production of pigment on the back of the colony), microscopic arrangements (characteristics hypha formation, types of conidia, sizes and shapes of the sterigmata, hyphae and organs of reproduction) and biochemical tests [5].

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Determination of the bacterial isolates was performed through the gaschromatography method in the Microbial Identification System (MIS) that is based on bacterial fatty acid methyl ester profiling [5]. First, all samples were incubated in bbrain heart infusion brothQ to bacterial growth at room temperature (26 ± 2°C) for 8 h. After incubating each cultures, 1 ml suspension was transferred to 5% blood agar and “btrypticase soy broth agar (TSBA)” media and incubated at 37°C for 8 h. After incubating each cultures, 1 ml suspension was transferred to 5% blood agar and “btrypticase soy broth agar (TSBA)” media and incubated at 37°C for 8 h. After incubating each cultures, 1 ml suspension was transferred to 5% blood agar and “btrypticase soy broth agar (TSBA)” media and incubated at 37°C for 8 h. After incubating each cultures, 1 ml suspension was transferred to 5% blood agar and “btrypticase soy broth agar (TSBA)” media and incubated at 37°C for 8 h.

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Figure 5: The stolen parts of frescoes of the Sumela monastery. The stolen parts have been presented by various persons and museums.

Figure 6: The colonization of lichens and mosses on the lower parts of the Monastery walls.

Figure 7: The SEM image of microbial consortia located on the internal fragments of the splitting rock.

The species and groups of microorganisms

| Lichens                         | The 1st | The 2nd | The 3rd | The 4th | The 5th | The 6th |
|---------------------------------|---------|---------|---------|---------|---------|---------|
| Candelariella vitellina         | +       | -       | +       | -       | +       | -       |
| Leparia incana                  | +       | -       | +       | -       | -       | +       |
| Xanthoria elegans               | +       | -       | +       | -       | +       | -       |
| Umbilicaria cinereorufescens    | +       | -       | +       | -       | -       | +       |
| Verrucaria sp.                  | -       | +       | -       | +       | -       | +       |
| Lecidea sp.                     | -       | -       | +       | -       | +       | -       |
| Chrysotrichia sp.               | +       | +       | -       | +       | -       | +       |
| Dermatocarpon sp.               | +       | -       | +       | -       | -       | +       |
| Collema sp.                     | +       | -       | +       | -       | +       | -       |
| Physicio sp.                    | -       | +       | -       | +       | -       | +       |

The sample points*

| External wall | Internal wall |
|---------------|---------------|
| The 1st       | The 2nd       | The 3rd       | The 4th       | The 5th       | The 6th       |
| 1m            | 4m            | 1m            | 4m            | 1m            | 4m            |
| 1m            | 4m            | 1m            | 4m            | 1m            | 4m            |
| 1m            | 4m            | 1m            | 4m            | 1m            | 4m            |

Sp. (Figure 9), Physicio sp. and Lecidea sp., the genus of algae such as Pleurococcus sp., Chlorella sp., Chrococcus sp. and Nostoc sp., the species of fungi such as Fusarium dimerum, Acremonium strictum and Aspergillus terricola, the species of bacteria such as Bacillus subtilis, Bacillus coagulans, Bacillus thuringiensis sotto, Paenibacillus larvae-pulvificiens and Virgibacillus pantothenicus widely live on the lower parts of the monastery walls. These microorganisms develop depending on relatively intensive moisture and soil derived enrichment nutrients that contamination of soil particles, including organic and inorganic nutrients. They were sprinkled by abundant rainfall from the ground or were dragged by wind from the top of the steep rock.

The genus of lichens such as Verrucaria sp. and Chrysothrix sp., the species of fungi such as Alternaria alternata and Penicillium verrucosum var. cyclopium, the species of bacteria such as Bacillus agri, Bacillus cereus, Bacillus mycoides, Bacillus lentimorbus, Brevibacillus laterosporus and Paenibacillus apiarius widely live on the upper surface of the Monastery walls. The species of bacteria such as Streptoverticillium reticulum, Arconobacterium haemolyticum live on both bottom and...
Algae (including Cyanobacteria)

| Species                  | 1st | 2nd | 3rd | 4th |
|--------------------------|-----|-----|-----|-----|
| Pleurococcus sp.         | +   | -   | -   | -   |
| Chlorella sp.            | -   | -   | +   | -   |
| Chroococcus sp.          | +   | -   | -   | -   |
| Nostoc sp.               | -   | -   | +   | -   |

Fungi

| Species                  | 1st | 2nd | 3rd | 4th |
|--------------------------|-----|-----|-----|-----|
| Alternaria alternata     | -   | +   | -   | -   |
| Fusarium dimerum         | +   | -   | +   | -   |
| Acrocomium strictum      | +   | -   | -   | +   |
| Penicillium jenini       | -   | -   | +   | -   |
| Penicillium verrucosum var. cyclopium | - | - | + | - |
| Aspergillus terricola    | -   | -   | +   | -   |

Bacteria

| Species                  | 1st | 2nd | 3rd | 4th |
|--------------------------|-----|-----|-----|-----|
| Bacillus subtilis        | +   | +   | -   | -   |
| Bacillus agri            | -   | +   | -   | +   |
| Bacillus cereus          | -   | +   | -   | +   |
| Bacillus licheniformis   | -   | +   | +   | -   |
| Bacillus mycoides        | -   | -   | -   | -   |
| Bacillus coagulans       | +   | -   | -   | +   |
| Bacillus lentimorbus     | -   | -   | -   | -   |
| Bacillus thuringiensis soto | + | - | - | + |
| Brevibacter latesporus   | -   | +   | +   | -   |
| Streptovercillium reticulum | + | + | - | - |
| Arconobacterium haemolyticum | + | - | - | - |
| Paenibacillus larvae-pulvificiens | + | - | - | - |
| Paenibacillus apiarius   | -   | -   | -   | -   |
| Virgibacillus pantothenticus | + | - | - | - |

*The samples taken from the 1st, the 2nd, the 3rd and the 4th sampling point belonging to the three different external walls of the Monastery, and the 5th and the 6th sampling points belonging to the window domes of the internal walls and swelled-parts of the fresco of the Sumela monastery respectively. Only the stones of the 5th sampling points were sediment (travertine) and the others except for fresco were volcanic.

Table 2: The microbial flora determined on the stone surfaces of the Sumela Monastery.

| Stone type                  | The elemental analyses of the stone samples (weight %) |
|-----------------------------|------------------------------------------------------|
|                             | Si  | Al  | Ca  | K   | Mg  | Zn  | S   | Na  | Mn  | Nb  | Others* |
| Granitic 1 (External wall)  | 29.20 | 8.34 | 1.88 | 1.18 | 1.50 | 0.50 | -   | 0.48 | 7.76 | 2.76 | 46.40   |
| Granitic 2 (External wall)  | 22.95 | 8.57 | 5.20 | 2.96 | 1.43 | 1.51 | 2.76 | 0.46 | 1.70 | 52.46 |
| Sediment (Internal wall)    | 7.68  | 2.69 | 37.12 | 0.56 | 2.45 | 3.32 | 2.87 | -   | 7.35 | 35.96 |

*These elements are carbon, hydrogen, oxygen and little amounts of non-detectable elements.

Table 3: The elemental analyses of the stone samples taken from the 4-meters-high parts of the Sumela Monastery.

Figure 8: The colonization of *Umbilicaria cinereorufescens* on the monastery wall.

Figure 9: The colonization of *Collema sp.*
upper surfaces of the Monastery walls, and *Penicillium jensenii* lived on bottom surfaces of volcanic rock and upper surfaces of sediment rocks of the Monastery walls. The species of lichen such as *Xanthoria elegans* (Figure 10), *Lepraria incana* (Figure 11) and *Dermatocarpon sp.* and the species of bacteria as *Bacillus licheniformis* live on bottom and upper surfaces.

Stone surface is a poorer enrichment media than humus contained soil for the microorganisms [4,5,22]. The microorganisms lived on soil sprinkled stone surfaces, lived on bottom parts of the Monastery walls, is dependent to soil derived inorganic/organic nutrients more than the microorganisms lived on upper parts of Monastery walls. For this reason, the bottom stone-surface, which permits the growth of more complex and intensive macro/microbial flora, are exposed to more biodeteriorative effects than the upper surfaces of the Monastery because of existing soil derived nutrients besides weathering agents (Figure 6). In other words, the upper stone-surface living microorganisms have to reconcile only the stones (poorer enrichment media) to soil derived nutrients, and so the development of the microflora can be restricted the poorer conditions. However, bottom stone-surface living microbial communities that develop associated with chemical and physical weathering factors may be more affective agents from the upper stone surface in the Sumela Monastery.

The elemental analyses of the stones and the secondary electron images (SEI) of the stone-surfaces on the Monastery, examined by means of SEM-EDS combined system energy dispersive spectrometry, are shown in Table 3 and Figures 7 and 12 respectively. SEM image of complex microbial consortia on volcanic stone in the 1 meter-high of the external wall of 3rd sampling point was shown in Figure 7. A dense mycelial growth of *Penicillium* sp. covers the surface of the stones and presents a very colonizing situation of sub-aerial biofilm. Thin filaments of actinomycetes develop together with fungus in near location. The stone-surface were covered with full of fungal and bacterial consortia.

Chemoorganotrophic fungi are especially concentrated in stone crusts. They are able to penetrate into the rock material by hyphal growth and by biocorrosive activity, due to the excretion of organic acids or by oxidation of mineral-forming cations, preferably iron and manganese [4]. Fungal hyphae penetrating the inner stone pores and conidiospores belonging to *Penicillium* sp. on volcanic stone in the 4 meter-high of the external wall of 3rd sampling point was exhibited in Figure 12. SEM images indicate that the microorganisms invading these stone surfaces showed extensive euendolithic destructive activity (Figures 7 and 12).

The growth and metabolic activity of algae, cyanobacteria, and lichens, as well as mosses and higher plants, is regulated by natural parameters such as light and moisture. Simultaneously, stone decay is correlated with the type of stone material and exposure conditions for the monuments, including wind, sunlight and temperature, as well as rain, snow and moisture [4]. In order to access the biological contribution on stone decay, the stone type, the mineralogical composition and the appearance of the microorganisms on the stone surfaces were determined. The elemental analyses of the stone samples of the Sumela Monastery are shown in Table 3. Table 3 shows Si, Al, Ca, K, Mg, Zn and Nb present in all samples. These elements constitute the main components of the stones. Si, Al, Ca, K, Mg, Zn and Nb are in the range of about 7-29%, 2-8%, 1-37%, 1-3%, 1-2.5%, 0.5-3.5 and 1-7.5% respectively. In addition, significant quantities of Na,
and even herb and trees settled on the walls of Sumela Monastery. Among them, acid-producing bacteria can cause biodeterioration due to metabolic acids biosolubilizing the stone. Phototrophic microorganisms, algae and lichens, induce biogeophysical formation of patina and crusts. These deposits enhance physical stress and also cause biogenic coloration of the stone, with consequent aesthetic loss. While lichens and mosses can cause deterioration of the stone by chemical rather than mechanical effects [8]. There may be additive biodeteriorative effect of the other microorganisms like cyanobacteria and etc., but we didn't search its. Similar researches demonstrated that cyanobacteria is a component of stone deterioration [4-8,21,24,25].

Besides the evident influence of light in distribution of phototrophic microorganisms, biofilms showed preference for different type of materials [15]. The Sumela Monastery was built over two originated stones: volcanic such as volcanic lava, andesite and trachite, and sediment as travertine. Table 3 shows that, volcanic and sediment analyzed materials were relatively heterogeneous in chemical composition but showed some important similarity concerning concentration in silicone, aluminum, magnesium and the other (carbon+hydrogen+oxygen) elements in volcanic stones. While sediment material is also abundant in calcium, volcanic materials showed the highest concentration of silicone and aluminum. The highest concentration of other (carbon+hydrogen+oxygen) elements in volcanic stones may be indicated organic mass belonging to the high moss, algal and lichen cells. Under similar light conditions, phototrophic microorganisms tend to colonize mainly calcareous materials. This is probably due to the chemical availability of calcium from soluble carbonate that can be a source for cyanobacterial sheath formation [15]. On the contrary of this general rule, the analysed materials in the sumela monastery, phototrophic microorganisms presented the highest abundance of volcanic stone because volcanic materials used in external walls and they exposed to direct sunlight. The sediment materials were used as internal architectural building materials of the room-door, window domes and fresco for easy cutting peculiarities.

The sum up: Urbani [26] said in the paper that “…at a time when man begins to feel the ominous historical novelty of the destruction of his own environment, certain values, like ancient art, demonstrate how the potential of human activity can integrate rather than destroy the beauty of the world” [27]. Unfortunately, we are sorry to say that the marvelous architectural monuments, the Sumela Monastery, was plundered many times by the robbers of historical-heritages belonging to various nations because this historical buildings was not conserved righteously due to placed in the solitary valley away from men. Simultaneously it was exposed to the biodeteriorative effects of the mentioned micro/macro-organisms. However the biodeteriorative effect of microorganisms is more significant on stones of the Sumela Monastery, we see that the man, as a plundering points, is the most destructive agents (see Figures 4 and 5) on the historical building among all of the deteriorative factors.

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