Evaluation of Biotic Damage to Structures as a Risk Factor for Environmental Pollution During a Comprehensive Survey of the Cultural Heritage Site of Regional Significance "The Building of the Izvestia Newspaper"

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Abstract. This article presents the results of mycological studies and determination of the composition of water-soluble salts found during a field survey of the facades and interiors of the cultural heritage site of regional significance "The building of the Izvestia newspaper", 1927, arch. Barkhin G.B. with the participation of Barkhin M.G. The reasons for the destruction of finishing materials are determined. The factors whose influence affects the chemical destruction of materials resulting from the action of acidic products on them have been identified. A base has been formed for determining the actual state of building and finishing materials of a structure under the conditions of the existing operating mode.

Keywords: Biotic damage · Structures · Risk factor · Environmental pollution · Comprehensive inspection of the facility

1 Introduction

The development in nature of alien living organisms that carry a danger means biological pollution. Pathogenic microorganisms, which appeared as a result of human activities, cause biological pollution, contribute to the emergence of dangerous diseases. A particular threat comes from the forms in which new types of pathogens develop. This causes outbreaks of epidemics, the spread of infections and viruses. Microorganisms are a form of life that is invisible to the naked eye. It can be detected on any surface with a microscope. The simplest fungi, bacteria, viruses, yeast, multiply in a warm environment. Substances that affect the environment as a result of biotic pollution have toxic properties, carcinogenicity, cause mutations, and accumulate in the external environment and the human body.

In recent decades, there has been an intensity and danger of biological pollution and destruction of buildings and structures. It is exacerbated by human economic activity - neglect of environmental standards in the construction of buildings and their illiterate

A. Beskopylny et al. (Eds.): INTERAGROMASH 2022, LNNS 575, pp. 150–160, 2023.
https://doi.org/10.1007/978-3-031-21219-2_15

and careless operation. Microorganisms and macroorganisms are the main cause of biodamage.

In addition to the negative impacts on the environment in general and on capital construction projects, biodestruction also has a detrimental effect on people: their health level decreases, their ability to work deteriorates, and their immune system weakens. Mycological examinations are carried out in order to prevent possible problems with the collapse of buildings and structures and with the health of people operating them.

Specialists of the NRU MGSU carried out mycological studies during a full-scale examination of the facades and interiors of the cultural heritage site of regional significance "The building of the Izvestia newspaper", 1927, arch. Barkhin G.B. with the participation of Barkhin M.G., at the address: Moscow, Pushkinskaya sq., 5. In 2016–16, large-scale restoration work was carried out at the facility. However, during that period, insufficient attention was paid to engineering measures to remove moisture from the walls of the monument.

Based on the results of the analysis of the available technical documentation for the facility, the following was established:

- In fact, works were performed, such as: reinforcement of monolithic reinforced concrete floors, installation of interfloor stairs, replacement of roofing, etc., affecting the structural characteristics of the object.
- At the survey site, work was carried out on the reconstruction of engineering systems that affected the design characteristics of the reliability of building structures (for example, due to the cutting of floors, walls, installation of holes, etc.).
- Separate restoration works were carried out either of poor quality or not in full: the decoration of the walls of the premises with wooden panels was not completed; actually made wall panels do not meet the requirements of security obligations, which say the need to use mahogany. Existing wall panels are made of painted chipboard sheets.

During the visual inspection of the object, places with leaks, destruction of the surface of finishing materials with salts and biodamages were found.

These studies were carried out in order to determine the actual state of building and finishing materials of the structure under the conditions of the existing operating mode.

The selection and laboratory analysis of material samples was carried out on the basis of the results of a field survey, in order to qualitatively assess the main technological characteristics, types and degrees of destructive lesions of the latter, as well as to make basic methodological decisions on restoration.

The sample #1 was selected in the basement. On the wall in the place of destruction of finishing materials as a result of the release of salts and biological damage. (Fig. 1) Under the microscope, the surface of the selected sample. Efflorescence and biodamage in the form of mold. (Fig. 2).

The next sample was selected in the interior of the basement. Visible damage on the surface of finishing materials. Salt outflows, metal corrosion, biodamage in the form of black mold (Fig. 3). Under the microscope, the surface of the selected sample (Fig. 4).

Fig. 1. The place of sampling in the basement.

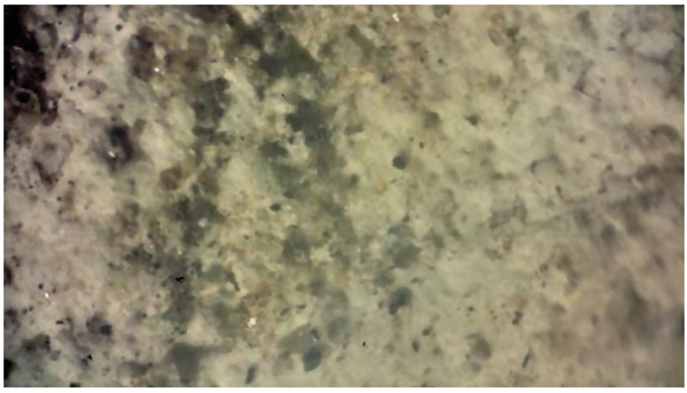

Fig. 2. The salt on the surface of the selected sample from basement under a microscope.

The third sample was taken on the surface of the facade at the level of the 1st floor. Visible destruction of the plaster: delamination, salt outcrops, fouling with biodegradations in the form of algae and mold (Fig. 5). Under the microscope, the surface of the selected sample (Fig. 6).

The sixth sample was taken on the wall of the 6th floor. Delaminations of wall finishing materials are observed in places of leakage. Salt outlets (Fig. 7). Under the microscope, the surface of the selected sample (Fig. 8).

2 Research Methodology

We selected 4 samples for mycological studies in different locations. Samples were taken with visible biodamages on the surface of finishing materials. Purpose: mycological study of building elements for contamination with biodestructor fungi (biological

Fig. 3. Place of sampling in the interior of the basement.

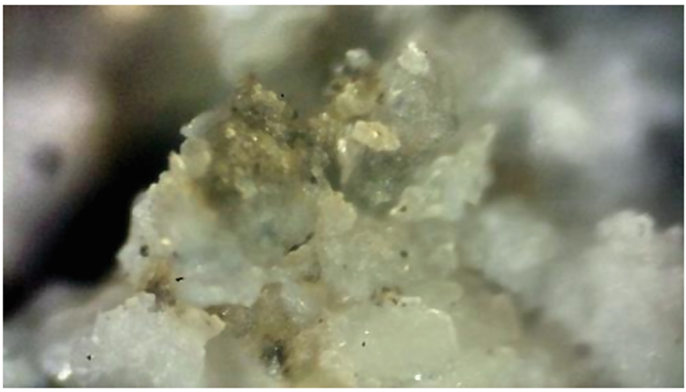

Fig. 4. Salt on the surface of the selected sample from the interior of the basement.

lesions), identification of possible causes of damage, issuance of recommendations for normalizing the state of the object.

We were guided in the process of work by the methodological recommendations described in SP 28.13330.2017 "Protection of building structures against corrosion", Strategic Missile Forces 20-01-2006 St. Petersburg (TSN-20-303-2006 St. Petersburg) "Protection of building structures, buildings and structures from aggressive chemical and biological influences of the environment", and generally accepted mycological methods (Methods of experimental mycology, 1982). The selection of fragments of materials was carried out in places of their spontaneous destruction, or by surface mycological methods that do not affect the integrity of the structure. Samples were taken in sterile containers.

To determine the degree of fungal growth on the selected samples, the samples were placed on the surface of sterile wort-agar in Petri dishes and incubated at a temperature

Fig. 5. Place of sampling on the surface of the facade at the level of the 1st floor.

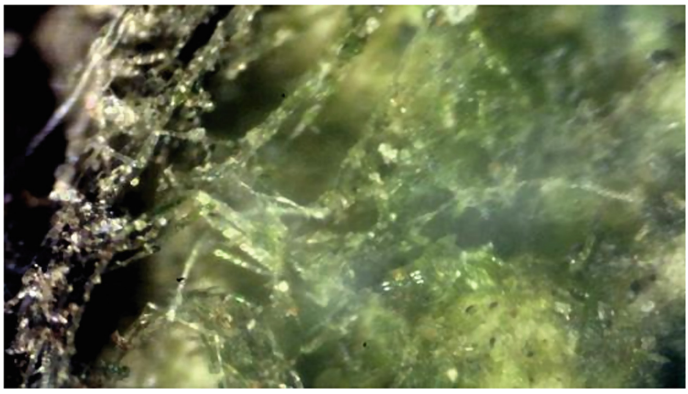

Fig. 6. The surface of the selected sample from the surface of the façade.

of 27–28 °C and a relative humidity of 90% for a week [1] (Fig. 9). On samples where fungal growth was noted, the grown cultures were examined at 630x magnification under a microscope [2]. For this purpose, mycological preparations were prepared to study the nature of sporulation of the studied fungal cultures [3].

In addition, cultures of moldy fungi were grown on a liquid nutrient medium containing mineral components (KH_2PO_4, $MgSO_4$, $NaNO_3$, KCl, $FeSO_4$, $7H_2O$) and sucrose. The isolated cultures were maintained on Czapek-Dox medium [4].

The identification of moldy fungi species was carried out using standard domestic and foreign determinants [5]. Determination of the number of viable fungal spores per 1 cm^2 was carried out by direct sowing and subsequent counting of germinated spores.

The research results are presented in Table 1.

Fig. 7. Place of sampling for laboratory research on the wall of the 6th floor.

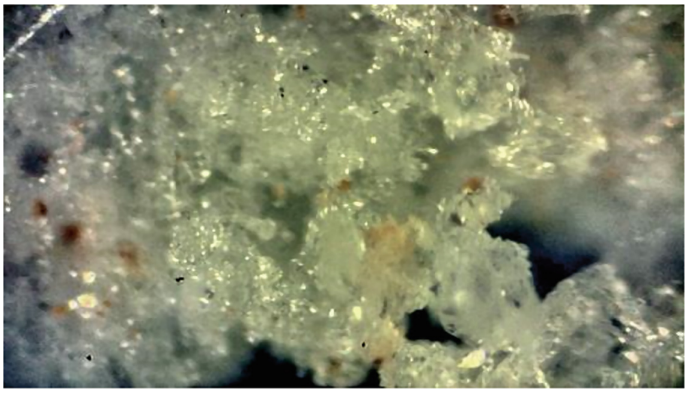

Fig. 8. Salt on the surface of the selected sample from the wall of the 6th floor.

3 Main Part

As a result of microbiological examination, it was established:

- Infestation of examined samples by microscopic (mould) fungi was detected.
- Microscopic (mould) fungi found in the sample can, under favorable conditions, quickly spread over the surface of materials and cause damage not only to the appearance of the surface, but also to the structural destruction of the material.

The following types of moldy fungi have been identified:

1. Aspergillus niger; Cladosporium spp.; Cladosporium herbarum; Alternaria alternata; Torula herbarum. Mucor spp. Aspergillus flavus; Fusarium spp., Acremonium. Spp.

Table 1. Results of mycological studies.

Sample number	Sampling location	Identified bio-destructors	Number of colony-forming units
1. Petri dish 1	1 sample - taken in the basement. On the wall in the place of destruction of finishing materials as a result of the release of salts and biological damage. Photo 1. 2	Aspergillus flavus; Alternaria alternata; Torula herbarum; Cladosporium herbarum; Mucor spp.	467 КОЕ/г
2. Petri dish 2	Sample 2 - taken in the basement at the bottom of the wall. Visible biodamages in the form of black mold on the surface of finishing materials. Photo 3, 4	Aspergillus flavus; Alternaria alternata; Cladosporium spp.; Torula herbarum;	800 КОЕ/г
3. Petri dish 3	Sample 3 - selected in the interior of the basement. Visible destruction on the surface of finishing materials. Salt outflows, metal corrosion, biodamage in the form of black mold. Photo 5, 6	Cladosporium spp.; Mucor spp. Aspergillus niger; Fusarium spp.,	880 КОЕ/г
4. Petri dish 4	4 sample - taken on the surface of the facade at the level of the 1st floor. Visible destruction of the plaster: delamination, salt outflows, fouling with bio-damage in the form of algae and mold Photo 7, 8	Acremonium spp Cladosporium spp.; Mucor spp. Torula herbarum; Green algae Chlorella	670 КОЕ/г

2. In accordance with SP 1.3.2322-08, the mold fungi found belong to groups III and IV of potential pathogenicity.
3. An increase in humidity and destruction of the roof is a risk factor for the development of microscopic fungi and damage to materials by biodestructor fungi.
4. Chemical treatment of affected building materials is possible. For chemical treatment, the use of the antiseptic preparation “Polysept” (5%) is recommended.

The dominant species in crops are micromycetes Aspergillus niger; Penicillium spp. Cladosporium spp, Mucor spp.; Torula herbarum. They belong to organisms called

Photo 1. Photo 2.

Petri dish 1. (Photo 1.) Chemoorganotrophic microorganisms found in the sample: Aspergillus flavus;
Alternaria alternata; Torula herbarum; Cladosporium herbarum; Mucor spp.
Petri dish 2. (Photo 2.) Chemoorganotrophic microorganisms found in the sample: Aspergillus flavus; Alternaria alternata; Cladosporium spp.; Torula herbarum;

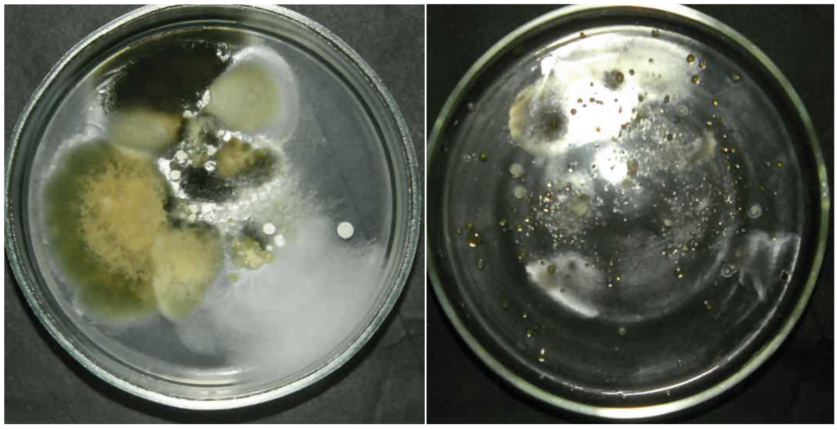

Photo 3. Photo 4.

Petri dish 3. (Photo 3.) Chemoorganotrophic microorganisms found in the sample: Cladosporium spp.; Mucor spp.. Aspergillus niger; Fusarium spp.,
Petri dish 4. (Photo 4.) Chemoorganotrophic microorganisms found in the sample: Acremonium. spp. Cladosporium spp.; Mucor spp.. Torula herbarum;

Fig. 9. Macrophotographs in «Petri dishes».

"mold fungi" or micromycetes-biodestructors. They are able to use various building materials as a source of nutrition, process them and include them in the metabolism of their organisms [6]. This leads to the destruction of building materials. In addition, many of these organisms release organic acids during their vital activity, which also leads to

the destruction of materials [7]. Their presence indicates unsatisfactory conditions for the maintenance of structures (high humidity, the presence of leaks). In the unfavorable direction of the parameters of the temperature and humidity regime, the activity of biolesions will increase, therefore, it is necessary not only to carry out biocidal treatment, but also to establish the optimal TBP.

Cladosporium spp. The main condition for the survival of the mold fungus Cladosporium is high humidity. The usual habitat for him is the soil. With insufficient production of polyphenol, the microorganism can also parasitize the fruits or leaves of plants [8].

Cladosporium herbarum. This mold fungus is one of the most popular species, the habitat of which can be not only the street, but also the house. Under certain conditions, the fungus Cladosporium herbarum lives on an ordinary sheet of paper. Constant air humidity and heat leads to the formation of foci of development. It is dangerous because it can cause cladosporiosis in humans, a disease that has unpleasant symptoms [9].

Torula herbarum. The genus Torula is defined as a filamentous fungus, or more commonly, a dark-pigmented fungus that grows slowly and reproduces asexually by bead-like conidia. T. herbarum grows at 24–28 °C (75–82 °F). Growth is absent below −5 °C and above 37 °C. T. herbarum is a secondary colonizer, meaning it usually only establishes growth on surfaces already colonized by other fungi; it occurs in both aquatic and terrestrial ecosystems subject to very humid or even humid conditions.

Alternaria alternata, pathogenic, present on organic substrates of the environment, mainly in moist soil. Mold grows especially well in rooms without an air ventilation system [10].

Mucor spp. - a genus of lower mold fungi of the class Zygomycetes, which includes about 60 species. They are widely distributed in the upper soil layer, and also develop on food and organic residues. Some species cause diseases (mucormycosis) in animals and humans. The mycelium is not divided by partitions and is represented by one giant multinucleated branched cell.

Mold is unpretentious, therefore it can appear and grow anywhere. The main condition for the appearance is nutrients, moist and warm air. In case of unfavorable conditions, the spore is covered with a protective capsule, metabolic processes slow down and the organism can exist in this form until the conditions for the resumption of life appear. According to the type of nutrition, mucor belongs to heterotrophs, that is, it is not able to synthesize organic substances from inorganic ones. For proper nutrition, the body needs a high coefficient of humidity, heat, the presence of oxygen and ready-made organic substances. Also, this species can be attributed to saprotrophic organisms, since they are characterized by the extraction of organic substances from dead material..Mucor is the causative agent of mucormycosis. This is a disease that affects several systems of the human body at once and has a toxic effect on it.

The fungus Aspergillus belongs to the genus of higher mold aerobic fungi. Today there are about 200 species of these mushrooms. They are widespread on all continents, in all countries of the world. Fungi of the genus Aspergillus cause severe diseases (mycoses) in humans, but at the same time, many of them are of very significant practical importance and are successfully used in industry due to their ability to produce a number of substances and enzymes. For energy synthesis processes, they need access to free molecular oxygen. Fungi of the genus Aspergillus are saprophytes. They use exclusively

organic substances for their livelihoods. They thrive in damp environments and indoors [11].

According to the currently adopted standards of the World Health Organization, the number of fungal spores in the air of residential premises should not exceed the permissible level of 500 CFU/m^3, and the standard indicator of the content of fungal spores in industrial premises should not exceed 800 units/m^3.

Acremonium spp. is a genus of fungi in the Hypocreaceae family. Also, this genus of mushrooms is known under the name "Cephalosporium". The genus Acremonium contains about 100 species, most of which are saprophytic, being isolated from dead plant material and soil.

Many species are recognized as opportunistic pathogens causing mycetoma, onychomycosis, and hyalologhomycosis. Human infections with fungi of this genus are rare, but clinical manifestations of Acremonium hyalohyphomycosis may include arthritis, osteomyelitis, peritonitis, endocarditis, pneumonia, cerebritis, and subcutaneous infection [12].

Fusarium spp. - a species of imperfect mushrooms belonging to the genus Fusarium (Fusarium) of the Nectriaceae family (Nectriaceae).

Good growth of these fungi occurs in humid conditions and the spread of their conidia by wind and precipitation [13].

Fusarium spp. - is a complex of strictly anamorphic morphologically similar phylogenetic species. Fungi of the genus Fusarium have a wide variety of enzymes, which allows them to use various organic compounds as a substrate. Most representatives of fungi of the genus Fusarium are phytopathogens, but Fusarium spp. Are known to parasitize insects.

Chlorella is a genus of unicellular green algae, assigned to the Chlorophyta division. Chloroplasts of chlorella contain chlorophyll a and chlorophyll b. For the process of photosynthesis, chlorella requires only water, carbon dioxide, light, and a small amount of minerals for reproduction. Reproduction is vegetative, asexual and sexual.

4 Conclusions

According to the results of the chemical analyzes of water-soluble salts, it can be concluded that the predominant salts in these samples are water-soluble sulfates and a small amount of bicarbonates. Chloride salts are presented in small quantities.

Analysis of the results of the study indicates that the wall finishing materials are subject to type II (carbonate) and type III (sulfate) corrosion, according to the accepted classification. Chemical destruction of materials occurs as a result of the action on them of acidic products formed in a capillary-porous structure saturated with excess moisture under the influence of the following factors:

1. the influence of the technogenic environment - an increased content of sulfur compounds in the atmosphere, which form aggressive sulfuric acid with water;
2. leaching under the action of the so-called aggressive carbon dioxide, which is formed in the pore space of the masonry supersaturated with moisture, and dissociating, with a shift in equilibrium towards the formation of the HCO3 ion, which is aggressive towards calcium and magnesium hydroxides.

3. products of metabolism (life activity) of biological destroyers, which are a number of organic acids that enter into chemical interaction with the binder of masonry and plaster mortars, contributing to their destruction and destruction.

Corrosion products, represented mainly by water-soluble salts, increasing in volume, contribute to a cyclic change in pressure on the thin walls of pores and cracks, and fatigue failure of masonry and finishing materials.

Analyzing the obtained results of water-soluble salts present on the surface of building materials, we can say that they were formed as a result of prolonged waterlogging of the wall surface. The reason for the appearance of salts is the migration of water-soluble salts. These are places of leaks, water suction - the destruction of masonry mortar, bricks from excess moisture. It is required to carry out measures to drain water from the walls of the building and dry the masonry, as well as to carry out measures to waterproof the basement of the walls. The roof and drainage system needs to be repaired.

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