

# BIOLOGICAL DETERIORATION OF WOODEN STRUCTURES OF THE BIALYSTOK OPEN-AIR MUSEUM

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**Abstract:** The preliminary survey of the biodeterioration in the Bialystok open-air museum (Poland) shows that wooden buildings are in good condition and 92% of historical and architectural constructions were estimated to the second category of technical state. Buildings were examined to identify kinds of biological agents. The main biodeteriorations of wooden constructions were made by insects, lichens, algae films and colonies of microfungi. The comparison of the biodeterioration impact was made for the Bialystok open air museum and the skansen "Pyrogovo" (Ukraine). The probability of germination on the wooden structures of some species of fungi has been calculated taking into account the temperature conditions of the north-eastern region of Poland.

*Key words:* open-air museum, wooden buildings, biological deterioration, mycological damage.

## 1. Introduction

The open-air museum is a category of museums in which the collection of buildings and artefacts are exhibited out-of-doors. The first open-air museum in the world and is located on the island Djurgården in Stockholm, Sweden, called "skansen". It was founded in 1891 by Artur Hazelius to show the way of life in the different parts of Sweden before the industrial era. Later the name "skansen" has also been used as a noun to refer to other open-air museums and collections of historic structures. European open-air museums are variously known as skansen, museums of buildings and, sometimes, folk museums (Bashkatov and Terpylovsky, 2011; Rentzhog, 2007).

Until today, the open-air museum has been one of the most common ways to preserve the cultural heritage of the people. Skansen is a research institution that collects, studies and documents in detail the monuments of material and spiritual culture. In addition, many of these museums are cultural and educational centers, where museum activities cover only part of their overall development program (Danyliuk, 2006).

The objectives of this work is to assess the impact of biodeterioration on wooden buildings in the Bialystok Open-Air Museum, in order to promote the preservation of architectural and historical values in its original and holistic form from the destruction.

## 2. The Bialystok Open-Air Museum

### 2.1. Description

Bialystok Open-Air Museum is the Branch of Podlaskie Museum in Bialystok, where situated the historic wooden architecture of Podlasie countryside. In the skansen, there are residential (cottages, manor houses, blackcaps, forester's houses), farm buildings (barns, granaries, stables, livestock buildings, etc.), included the small architecture (crosses, shrines, wells, dings) and three windmills. The Bialystok Open-Air Museum is developing constantly by moving new buildings from the area of Podlaskie district. Bialystok Open-Air Museum was founded in 1982 as the Department of the District Museum in Bialystok. The projects of wooden construction protection in the region of Bialystok by creation a museum like the heritage park was established in the sixties. For the heritage park museum a "village" form was chosen as the most fully reflecting the natural cultural landscape of villages in north-eastern Poland.

In 1984 the first building was moved into the museum-it was the forge from the Grodek. An intensive construction works were continued until 1991, when the funds for the further development of the museum were limited. A forest farm and nobleman's hamlet was reconstructed there. It also managed to move the manor with a granary to the future sector presenting manor building. A windmill, a water mill and a smithy was also moved to the heritage park. To the beginning

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of the nineties almost thirty buildings were successful moved into the museum.

In November 1994 a fire broke out, nine buildings completely burned down, the tenth were survived, but intended only for non-exhibition use. The heritage park area was limited to approximately thirty hectares. This appreciable reduction of the museum area allowed to fence and secures many buildings of emergency installations. Since the end of the nineties, the architectural buildings started moving to the heritage park again (Gawęł, 2012).

## 2.2. Biological damage of wooden structures

The museum wooden structures in the process of storage expose to a number of adverse internal and external factors. The internal factors include technological properties and features of the wood; conditions and mode of storage belong to the external factors. The main environmental factors, that promote and exacerbate the development of mycological damages, primarily include increased humidity and temperature range 20-22°C and above, the lack of the ventilation and natural light, as well as increased air pollution (Koval and Mytkivska, 2011).

Falling to the surface of structures, fungi produce enzymes in its process of life that in the interaction with components of construction wooden materials turn them into more available organic compounds (water and carbon dioxide). Usually the end result of the mycodamage process is the destruction of organic matter, i.e. change the anatomical structure of the material and the loss of proper physical and mechanical properties (Varchenko, 2014; Knyazeva, 2005).

The reason for the appearance of the mycological factor is the combination of the natural process of aging wood with the operational process of construction and dangerous environmental factors. Mycological damage is much more relating to the storage conditions of architecture construction than to the nature of the wooden material. Thus, the state of museum wooden structures depends on the level of preventive measures, which requires regular mycological examination to prevent the development of mycological destructor.

## 3. Materials and methods

During the inspection of buildings we followed an algorithm of the monitoring of historical monuments, which was developed during the research in the museum "Pyrogovo". The algorithm consists of the following items: observation, analysis, assessment and comparison of results. In this study the first stage of the algorithm – "observation" has been performed (Perebynos, 2015). The primary inspection of buildings has been carried out to identify the biological damage in general.

The stage consisted of visual inspection of buildings and description of the studied architecture construction. The following elements of buildings have been examined carefully because they belong to highly probable areas

of the destruction by biological agents: joints of logs, girders and boards, knots and cracks of wooden parts of structures, places without natural light and ventilation, attics, places near the surface of the soil, under the roof, etc. Characteristic features of mechanical (cracks, crumbling, peeling), entomological (holes of beetles, web) and other biological (fungi colony and marks, algae films, discoloration of wood) damages has been marked during the examination.

Twelve buildings of the forestry and manorial sectors of the Białystok Open-Air Museum have been involved. There were taken to research: a forester's house from Lipniak, a barn from Karczmisko, a granary from Karczmisko, a stable from Karczmisko, a blackcap from Krusznik near Wigry, a barn from Wdowin, a livestock building from Krusznik, a cottage from Jacowlany, a granary from Lewki, a cottage from Stara Grzybowski, a barn from Nowy Ostrów near Krynki and a manor from Bobra Wielka.

## 4. Results and Discussion

On external structures of the blackcap from Krusznik near Wigry (the 20<sup>th</sup> century) and the barn from Nowy Ostrów near Krynki (the 19<sup>th</sup> century) were observed such biological damages as result of entomological activity, black spotted colony of fungi and lichenthallus. The cottage from Stara Grzybowski (the 19<sup>th</sup> century), the manor from Bobra Wielka (the 19<sup>th</sup> century) and the granary from Lewki (between the 19<sup>th</sup> and 20<sup>th</sup> centuries) had slight entomological damages and black spotted colony of fungi. Slight entomological damages and algae films were also found on external structures of the forester's house from Lipniak (20s of the 20<sup>th</sup> century). Following buildings had only slight entomological damages: the cottage from Jacowlany (second half of the 19<sup>th</sup> century), the barn from Karczmisko (the beginning of the 20s of the 20<sup>th</sup> century), the barn from Wdowin (20s of the 20<sup>th</sup> century), the granary from Karczmisko (about 1920) and the stable from Karczmisko (1925). And only the livestock building from Krusznik (the 20<sup>th</sup> century) was found without visible biological damages. Thus, the main biological damages were identified as: entomological, mycological, damaging algae and lichen (Fig.1).

A comparison of biological damages between some structures of the Białystok Open-Air Museum in Poland and the National Museum of Folk Architecture and Life of Ukraine "Pyrogovo" presented in the Table 1. The research of the biodeterioration of wooden structures in the "Pyrogovo" was started in February and lasted until May 2015. As a result of the initial examination of wooden buildings of historical and ethnographic exhibits were created the previous database for biodeterioration monitoring and supervision of the technical condition in compliance with environmental safety (Kryvomaz and Perebynos, 2015).

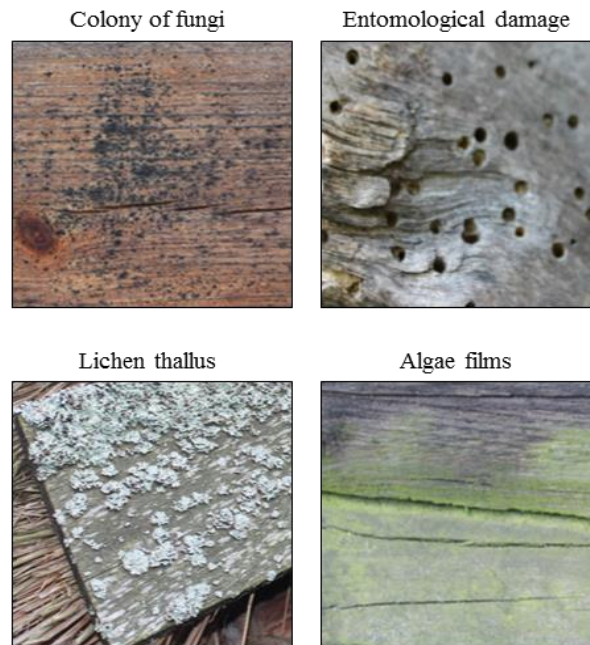


Fig. 1. Types of the biological damage of wooden structures of the Bialystok Open-Air Museum.

Tab.1. Comparison of biological damages between some structures of the Bialystok Open-Air Museum in Poland and the National Museum of Folk Architecture and Life of Ukraine "Pyrogovo".

Podlaskie region (Bialystok Open-Air Museum)						Polesie region (Open-Air Museum "Pyrogovo")					
Name of the building	Identified biodamages				Category of the technical state	Name of the building	Identified biodamages				Category of the technical state
	Entomological	Fungi	Algae films	Lichen thallus			Entomological	Fungi	Algae films	Lichen thallus	
Forester's house from Lipniak	+	-	+	-	2	Circumferential courtyard from Volyn region	+	+	-	+	4
Barn from Karczmisko	+	-	-	-	2	Barn from Chernihiv region	+	-	-	-	2
Granary from Karczmisko	+	-	-	-	2	Smithy from Volyn region	+	+	-	-	3
Stable from Karczmisko	+	-	-	-	2	Barn from Chernihiv region	+	+	-	-	2
Blackcap from Krusznik near Wigry	+	+	-	+	2	Cottage from Rivne region	+	+	+	-	3
Barn from Wdowin	+	-	-	-	2	Peeling mill from Chernihiv region	+	+	+	-	3
Livestock building from Krusznik	-	-	-	-	1	Barn from Chernihiv region	+	+	-	-	2
Cottage from Jacowlany	+	-	-	-	2	Cottage from Zhytomyr region	-	+	-	+	3
Granary from Lewki	+	+	-	-	2	Peeling mill from Chernihiv region	+	+	+	-	3
Cottage from Stara Grzybowszczyzna	+	+	-	-	2	Cottage from Chernihiv region	-	+	-	-	2
Barn from Nowy Ostrów near Krynki	+	+	-	+	2	Peeling mill from Chernihiv region	+	+	+	-	3
Manor from Bobra Wielka near Nowy Dwór	+	+	-	-	2	Cottage from Rivne region	+	+	-	-	2

The comparison showed a significant difference between technical states of buildings despite the fact that for this were used buildings with the appropriate technological purpose (residential, household or public buildings) and were approximately of the same age. In our opinion this is due to a small, but apparently significant difference, in the climate and the mode of operation of historical and architectural structures. The climate in Białystok is drier than in Kiev, which can affect the formation of biological damages (mycological, algological, etc.).

The damage of wooden structural elements of buildings such a biological agent as lichen was recorded in two buildings as in the Białystok museum and in the "Pyrogovo". Algae films were recorded on one building in the Białystok skansen and on four in the Open-Air Museum "Pyrogovo" (Fig. 2). It should be noted that such biological destructors as green algae, lichens and mosses have a feature to appear only on the outer parts of structures. The reason is that these organisms are capable to the photosynthesis, so the light is vital in their life as well as other outdoor environmental factors. Fungi and beetles are universal biodestructors that damage wooden structures both outside and inside the building.

Mycological damages were described in six buildings of the Białystok skansen as spotted colonies and in eleven buildings in the museum "Pyrogovo" as stains, wood discoloration and spotted colonies as well. Entomological damage was observed most among biodeteriorations of wooden constructions: eleven buildings in the Białystok Open-Air Museum and ten buildings in the "Pyrogovo" (Fig. 2).

The category of technical state is set by the classification features of wooden structures of buildings depending on the presence of certain defects and damages. The first category includes buildings without any defects and damages. Under the second category are subject buildings where notable distortions and other uneven deformation of wall structures; exists local and superficial lesions of wood rot (less than 5% of the surface or 10% of the sectional area of structures), there is little moisture and others. The third category includes a significant range of defects: lesion of wood by rot for 5-10% of the surface; moistening above the standard and design values; fouling

moss at the level of the basement; presence of signs of wood-beetles and others. The fourth category includes buildings with diagnostic signs of wood-destroying fungi; significant lesions of the wood by rot (more than 10% of the surface) and beetles, most of the wood has high moisture content and others (DSTU B V.1.2-№: 201X, 2012).

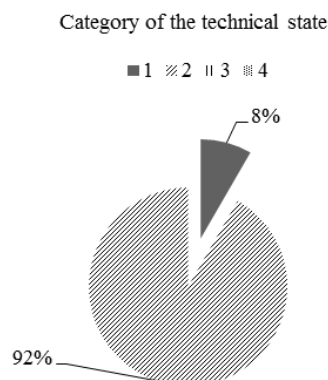


Fig. 3. Category of the technical state of buildings of the Białystok Open-Air Museum

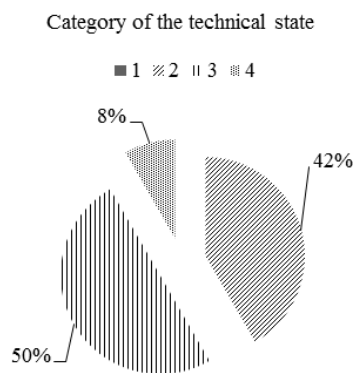


Fig. 4. Category of the technical state of buildings of the Open-Air Museum "Pyrogovo"

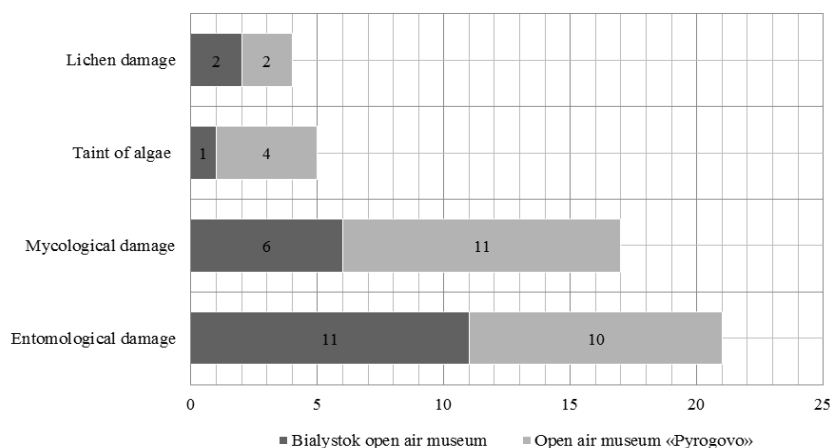


Fig. 2. Biological damages of buildings of the Białystok Open-Air Museum and the Open-Air Museum "Pyrogovo"

Taking the above into consideration, 92% of examined buildings were evaluated as the second category of the technical state, 8% refer to the first, and third and fourth category were absent in the Bialystok skansen (Fig. 3). In the comparison with the skansen "Pyrogovo": 42% of the presented buildings belong to the second category, 50% – the third, and 8% – the fourth (Fig. 4). It is important to note, that buildings in "Pyrogovo" were removed from their original places from whole Ukraine to the museum territory. This acts and changing of their native environment made the significant effect on the state of wooden constructions.

## 5. Conclusion

1. The preliminary survey of biodeterioration in the Bialystok Open-Air Museum showed that wooden buildings are in good condition and 92% of historical and architectural constructions were estimated to the second category of the technical state.
2. The inessential biological damages of studied wooden constructions were caused by entomological, mycological, algological and lichenological agents.
3. Entomological damage prevails among the biodeterioration of the wooden elements of historical and architectural structures both in the Bialystok Open-Air Museum and the Open-Air Museum "Pyrogovo".
4. The comparison of both skansens showed that the condition difference of wooden constructions depends on the initial state of buildings, the process of operation and the environmental factors.
5. The probability grade of fungi germination could predict the reaction of fungi to certain climatic data to improve the conditions of historical and architectural structures.

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