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MICROBIAL ASSESSMENT OF THE CONSERVATION STATUS OF SELECTED LIBRARY COLLECTIONS FROM JASNA GÓRA LIBRARY IN CZĘSTOCHOWA

Agnieszka BANGROWSKA (BAKALARZ)

Institute of Library and Scientific Information of Silesia University in Katowice,
Laboratory for the Protection and Maintenance of Library Collections,
1, Sejm Śląski Sq., Katowice, 40-032, Poland, tel. (032) 200-93-14,
e-mail: bakalarzadr@poczta.onet.pl

The Jasna Góra library has 10,252 items of the most valuable literature, including 2,534 volumes coming from the Polish publishers and printers, incunabula and the earliest publications on the Christian ethics. Most common, however, are publications of the 17th and the 18th centuries. Among the books of the 16th – early 17th century there are scientific papers on medicine, mathematics and astronomy, published primarily in Basel and, later, in Amsterdam and Leiden. The book collection dating back to the 18th century consists of the publications coming from the Jesuits' printing houses (especially from Poznan, Kalisz and Vilnius), as well as the Pijars' printing house in Warsaw. To assess the level of microbiological threat to the books from the Jasna Góra library, 101 volumes, including 63 old prints and 38 incunabula, have been randomly selected. Samples have been taken from all of these books and tested for the presence of molds. Four microbiological samples have been taken from each of the volumes mentioned: from the spine and the front cover of the binding, the inset or the title page, and a page from the middle of the book. After a period of incubation, a quantitative and a qualitative analysis of the species of fungi have been conducted. For the saving of books it is necessary to apply proper methods and means of destroying microorganisms in library funds, and provide appropriate storage conditions on a regular basis, which is actually being done at Jasna Góra library.

Keywords: preservation of library funds, preservation of old prints, microbiological research of paper, Jasna Góra library.

Monastic libraries the library of Jasna Góra included collect the most valuable historical collections, which operate through the ages thanks to appropriate conditions of storage. The whole historic Jasna Góra Library collection contains 10252 positions, however 17th and 18th century books are dominant. The number of works from Polish printing houses and publishing houses reaches 2534 among which some are impossible to determine the place and date of printing because of a defective title card. The 18th century collection consists of prints from the Jesuit printing houses, especially from Poznań, Kalisz and Vilnius and the Piarists House from Warsaw. The collection of the 16th and 17th century includes works of scientific medicine, mathematics and astronomy issued primarily in Basel, and later also in Amsterdam and Leiden. A collection of Jasna Góra also has biblical prints, including incunabula and the earliest release of Christian ethics.

General characteristics of the micro-organisms existing in the library collection

Bacteria invade libraries' collections usually after flooding at a relative humidity of 95–100 %, Actinomycetes require relative humidity of 65–80 %, fungi need a relative humidity of 65–85 %, hence both these groups play a major role in the destruction of library collections. Nonetheless, apart from humidity, it is temperature and paper pH (that is an indicator of the concentration of hydrogen ions in the environment) are very important for the development of microbes. Bacteria and Actinomycetes grow in a neutral or slightly alkaline (6,8–8 pH), fungi and in an environment of weak acid (pH from 4 to 6)[1]. Most actively, a large number of forms of microorganisms grows in the temperatures range from 10 to 37°C. Bacteria and fungi break down lignin, hemicellulose, cellulose aromatic compounds, aliphatic hydrocarbons. The building material for the microbes are glues of animal origin (skin, bone structure, parchment, fishy) and plant (starch adhesive), then the skin, paper, cardboard and canvas. Traces of micro-organisms are proved by different kinds of hyperpigmentation, taints, water stains or dirt. The biggest threat are filamentous fungi spores, their sizes are that of a few microns and their light weight makes it very easy to spread in the air, accumulate in dust.

After falling to the base they begin to germinate under the influence of humidity. To the survival structures of fungi one may include sclerotia, chlamydospories which are very drought- and environmental-resistant. During germinating spores produce mycelium, which is built with thread-like cells called hyphae. The mycelium when growing, creates colonies with a diameter of several millimeters to several centimeters. It feeds on the skin nutrients, paper and adhesives production processes. Fungi and other microorganisms cannot obtain food in the form of macromolecular compounds (they need to dissolve by using enzymes) which include fats (leather), protein (collagen-building component Base skin, parchment), poly-sugars (cellulose, starch-vegetable glue component). Growing fungus colony begins to produce spores, which by dispersing around the colony, may germinate and create next colonies, damaging the book even further. In these places there are difficult to remove colored spots on the paper. Most often we find the spores and thus staining in white, cream, green, gray, black. This type of colors are specified as mechanical. Discoloration may also be of chemical origin[2]. Fungi produce a very wide range of colors, which can be excreted outside cells causing the occurrence of different colored stains. Strong yellowing of paper is associated with the distribution of cellulose. The paper in the place in which the mycelium develops, becomes brittle, thin, porous, and finally as a result of depolymerization of cellulose molecule it disintegrates and losses arise[3]. Microbes first attack these places in books which is easily accessible by moisture and the nutrition is present: back of the book, the inner side of the cover, endpapers, the edges of the book. Ridge books and endpapers are saturated with glue – either plant or animal. These natural adhesives are an excellent medium for micro-organisms. The distribution of the glue on the back of the book leads to relaxation of the book's sides and after the destruction of twines and sewing, to spillage of papers. Backs of the books are also places through which water and fungus spores easily penetrate. With a strong humidity micro-organisms grow into the backs reaching the depths that the level of oxygen allows them. In its absence, a slowing down of paper degradation

[1] Strzelczyk A., Karbowska J. The role of microoganisms in the decay of parchment // *Acta Microbiologica*. – 1994. – Nr 43. – S. 165.

[2] Strzelczyk A., Karbowska J. Microbial decay of historical parchment // *Postępy mikrobiologii*. – 1993. – Z. 32. – S. 19.

[3] Strzelczyk A. Chora książka – destrukcyjne czynniki biologiczne // *Notes Konserwatorski*. – 1998. – Nr 1. – S. 36.

may be observed, stains are formed and the drying book is becomes distorted. Cardboard or canvas binding are attacked by microbes cellulolytic. Leather and parchment paper contain collagen which is decomposed by anaerobic bacteria. In addition to collagen in both materials we may observe proteins, fats, carbohydrates, mineral salts. These substances are an excellent source of nutrition for thermophilic Actinomycetes[4].

Characteristics of research material

The subject of my studies was limited to selected excerpts from historical collection of books from the Jasna Góra Library in which I examined the paper – both the printed parts and the margins. Basic chemical tests include, first and foremost, the measurement of the acidity of the paper and also in justified cases, also the end paper of the binding. Paper from the volumes the Jasna Góra Library can be considered model material for determining the dynamics of the natural process of aging. An important factor of the credibility of any physicochemical measurement is lack of knowledge of the random variable, associated with prospective moving of the collection and librarian catastrophes. In case of this library in its rich history such situations did not take place. All incunabulas pH values were measured. Four measurement points were located on the first pages of four first inserts, on the printed surfaces between the print's lines. In the study of the younger books the period from 1501 to 1700, in order to avoid a random choice of such vast test, historical information were used. In the 15th and 16th century the highest quality paper was manufactured by the mills located in Valley of the Pad river and Basel in the upperstream of the Rhine river. Paper from Basel, Switzerland, was the best in Europe throughout the second half of 16th century. To test the acidity of the printed paper from years 1501–1550 Venetian printing house and from the years 1551–1600 from Basel printing house. Paper from the period between 1601–1650 was represented by printing houses in Antwerp. In the opinion of the historians of the printing industry, the impresors of the city presented a stable and reliable level of publication. Such an opinion was associated with the quality of the paper. The last examined period was that of 1651–1700. As representatives of this time prints from the printing house of Cologne were selected. In the 16th century for the production of paper natural materials were used. It was only in the mid-17th that the filling substances of mineral origin were introduced together with alum stabilizing the gluing process. These essential technological changes were introduced by German papermakers hence the interest in Cologne prints from this period.

Print's period	Number of Objects	Average Value	The Median Value	Interval	Variance	Standard Deviation
1470–1500	161	6.26	6.25	0.98	0.039	0.197
1501–1550	42	6.22	6.16	0.81	0.045	0.212
1551–1600	64	6.32	6.37	0.99	0.052	0.228
1601–1650	71	6.16	6.16	0.70	0.027	0.164
1651–1700	64	6.08	6.08	0.65	0.038	0.194

Table 1. Statistic analysis of tested paper's pH

[4] Nyuksha Yu. P. *Biodeterioration of paper and books.* – St.-Petersburg, 1994. – P. 171–192.

Variance and standard deviation are a measure of the dispersion of results. In the calculations the standard deviation will range from 0,164 to 0,228 pH. It suggested that pH value in the are ordered in a cohesive section of numbers incident cases (*Table 1*). In spite of this, before I move to the microbiological research, I decided to visualize the examined set eliminating from further tests objects showing clear symptoms of past fungal diseases. In this way, from a total of 402 objects 101 books were examined. 38 of them were incunabula. It seems that such a number of volumes is fully representative and statistically believable to perform research aiming at eliminating such objects from the set on which the aging process was influenced by factors not only chemical but also physicochemical ones.

Microbial assessment

Evaluation of the microbial hazards of Jasna Góra library was limited to 101 randomly selected volumes including 63 old prints and 38 incunabula. The books published after 1800 were not examined. After analyzing them, traces of microorganisms were observed and proved by various kinds of stains, discolorations, soiling, damp patches, deformations or cavities. From all 101 objectes samples were tested for the presence of filamentous fungi.

Each volume was described by four microbiological samples, taken from the back and the front of the binding, front endpapers or the title card and a middle card from a pad of a book. The examination of the pad of a book or a title card was conveyed by imprinting a moist, sterile paper disc with a 6 cm diameter in places with visible micro-organisms' activities.

From the book's back a sample was taken by moving a sterile wad from inside of the book's back where, below the headband, adhesive binding is found. The paper disc and a sample wad were transferred onto a Petri dish with a 12 cm^3 diameter containing the medium of 10 cm^3, that was prepared according to the recipe of Czapek-Doxa. The evaporating dishes were incubated at temp. 30°C, which is considered an optimal temperature for the development of fungal pathogens, that develop on a historic library material. In order to assess the microbiological risks it was assumed, that optimal time interval after which the mycelium covers the entire dish is 21 days. It was also assumed that if within seven days of incubation a mycelium with a 3 cm^3 diameter should appear a highest level of hazard will emerge suggesting a presence of live mycelium in the examined material. The growth of mycelium to a diameter of 6 cm^3, after 14 days of incubation, was qualified as an average hazard which means that preventive measures such as disinfectants treatments should be undertaken. Incomplete and uneven covering of the dish by small-sized colonies (a few millimeters) after 21 days of incubation will prove the presence of inactive spore forms (*Table 2*).

Place of extracting the sample	The numbers of evaporating dishes that had colonies developed on them	The percentage of infected dishes in the entire test
Endpaper or title card	59	28,3
Binding	57	27,3
Front cover lining	51	24,4
Book's pad	42	20,1

Table 2. The number of infected evaporating dishes.

Having regarded to the construction of the book, it was found that microbial infection is not evenly located. The greatest threat is created by a lining connecting the pad of books with the inner surface of the lining and the outer surface of the binding. Microbial infection located on endpaper is transferred onto title cards and further pages of book's pad deep enough to have a free access to light and air. Binding, especially covering material was infected in 33 cases and the paper of the book's pad 24 case (*Table 3*). Generally, a good evaluation of the collection's condition was caused by the fact that out of 101 infected volumes there was only 10 in which a fungal growth zone reached 3 cm diameter after seven days of incubation, and in the other 15 objects it reached such diameter after fourteen days. In the endpapers such an elevated level of infection was observed in 17 cases; in the back of the books in 8 cases, and in the lining also in 8 cases. The number of objects with advanced forms of fungi diseases that does not exceed 25 % proves that the mycelium development in the storage conditions was limited.

Time interval	The back of the book			Lining			Endpaper			Printing paper		
	•••	••	•	•••	••	•	•••	••	•	•••	••	•
1498–1500	4	6	28	2	2	34	7	9	22	4	6	28
1501–1550	2	3	7	1	2	9	3	3	6	2	3	7
1551–1600	2	5	6	1	2	10	2	3	8	1	2	10
1601–1650	3	8	7	2	1	15	3	1	14	1	2	15
1651–1700	3	5	12	2	2	16	2	5	13	2	2	16
Sum	14	27	60	8	9	84	17	21	63	10	15	76

••• the fungal surface with a diameter of 3 cm^3 after 7 days of incubation.
•• the fungal surface with a diameter of 6 cm^3 after 14 days of incubation.
• the fungal surface did not reach 12 cm^3 diameter after 21 days of incubation.

Table 3. Qualitative and quantitative microbiological assessment of the tested set.

Microbiological risk assessment has been completed with a qualitative analysis of the micro-organisms. The isolated fungi are signed to the species (*Table 4*).

Material / Kind of fungus	Paper	Leather	Parchment	Animals and plant glues
Penicillium chrysogenum	×	×	×	
Penicillium funiculosum	×	×		
Aspergillus niger	×	×		
Aspergillus flavus	×	×	×	×
Aspergilus versicolor	×	×	×	×
Aspergillus fumigatus	×	×		
Botritis cinerea	×	×		×
Cladosporium herbarum	×	×		×
Mucorracemosus	×	×		×
Fusarium solani	×	×		
Trichoderma viride	×	×	×	
Scopulariopsis brevicaulis	×	×	×	
Chaetomium globosum	×			
Geotrichum candidum	×			
Trichothecium roseum	×			
Rhizopus stolonifer	×	×		

Table 4. Isolated fungi from a historic library collection's sample.

Among the species marked on all kinds of materials there were two species of Aspergillus flavus and Aspergilus versicolor. Six species appeared on three materials, the others appeared on two or one material. All fungi dwelling on the library material are typical pathogens that in favorable conditions of relative humidity and ambient temperature can pose a threat to the harvest. Aspergillus is one of the most toxins-producing fungi. The symptoms of its presence are characterized by blackstains on paper cards that is difficult to remove. On the other hand, Botritis in low level of concentration is treated as harmless in the air, a librarian space included. Penicillium, being filamentous fungus is a natural material with antibiotic-like qualities.

Conclusions

On 20,5 % of 101 studied objects alive and active spores and spore of fungi were observed. This shows that the development of the mycelium in the conditions of storage of the collection was limited. This result implies the need of preventive disinfectants treatments. The Jasna Góra collection is stored in wooden cases. One may assume therefore that the form of storing books limits access to the air, light, and first of all, dust (which is the main medium for fungal spores) creates a specific microclimate, constraining hazards or stimulating diseases' development on of stable and safe for the collection level. After the research and analysis of the results, all of the objects have been fumigated in the vacuum chamber which is installed in the Silesian Library. The applied Fumigants were ethylene oxide with strong properties of fungi- and insecticides.

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МІКРОБІОЛОГІЧНА ОЦІНКА СТАНУ ЗБЕРІГАННЯ ГРУПИ КНИГ ІЗ ЯСНОҐУРСЬКОЇ БІБЛІОТЕКИ В ЧЕНСТОХОВІЙ

Аґнєшка БАНҐРОВСЬКА (БАКАЛЯЖ)

Сілезький університет, Інститут бібліотекознавства та наукової інформації,
Лабораторія захисту і збереження бібліотечних колекцій,
пл. Сілезького сейму, 1, м. Катовіце, 40-032, Польща, тел.: (032) 200-93-14,
ел. пошта: bakalarzadr@poczta.onet.pl

У Ясноґурській бібліотеці зберігається 10252 позицій найціннішої літератури, у т. ч. 2534 томів, які походять із польських видавництв і друкарень, інкунабули та найраніші видання з християнської етики. Переважають, однак, видання XVII і XVIII ст. Серед книг XVI – початку XVII ст. присутні наукові праці з медицини, математики та астрономії, видані передовсім у Базелі, а згодом також у Амстердамі та Лейдені. Збірка видань XVIII ст. складається із книг, які походять із друкарень єзуїтів (особливо з Познані, Каліша та Вільна), а також із друкарні піярів з Варшави. Для оцінки рівня мікробіологічної загрози для книг із Ясноґурської бібліотеки довільно відібрано 101 том, зокрема, 63 стародруки і 38 інкунабул. Із всіх цих книг взято проби, які досліджувалися на присутність пліснявих грибів. Із кожного з описаних томів взято чотири мікробіологічні проби: із хребта та передньої обкладинки оправи книги, передньої вклейки або титульної сторінки і середньої сторінки із книжкового блоку. Після періоду інкубації проведено кількісний і якісний аналіз видів грибів. Для порятунку книг необхідно застосувати відповідні методи і засоби знищення мікроорганізмів у бібліотечних фондах, а також забезпечити на постійній основі належні умови зберігання, що у Ясноґурській бібліотеці й відбувається.

Ключові слова: збереження бібліотечних фондів, зберігання стародруків, мікробіологічні дослідження паперу, Ясноґурська бібліотека.

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