Bogdan Filip Zerek[1,2]

The Microbiological Control of the library collections.

[1] National Library of Poland, Institute for Conservation of Library Collections,
[2] Academy of Fine Arts, Faculty for Conservation and Restoration of Works of Arts

Visegrad Fund

The assumptions 1.:

- **the microorganisms are one of the most dangerous factor for the library (archival, museum) collections**
- **the microbiological control of the indoor air is crucial for the preservation (conservation related) of the library collections; sedimentation**
- **without source of infection and under safe conditions (T, RH <60%) the indoor air quality depends on quality of the outdoor air**
- **every room that is used for storage, access, conservation of the library objects should be sampled at least once per year**
- **the sampling of the outdoor air is performed every working day**
- **the general rules and patterns of air sampling at the NL of Poland were presented at the 2012 IAQ conference (poster is available in the "portable" size – 3,7MB – mail: bfilipzerek@yahoo.com)**

The assumptions 2.:

- **the Department-Laboratory for Conservation of Library Collections performs also microbiological sampling of objects, microbiological surveys, evaluations and disinfection**

- **the identification of GENERA of hyphaceous fungi is usually simple**

- **the correct and key supported identification of the isolated fungi as far as species (including slide preparations and measurements of the characteristic morphological elements: conidia, sterigmata, conidiophores, vesicles etc.) with available human, time and funds resources – IS NOT POSSIBLE**

- **in 2013 (including 3 months break caused by windows replacement) approx. 4000 colonies were isolated from the indoor air only**

- **the most applicable criteria for comparing the indoor and outdoor air quality are the guidelines of** Umweltbundesamt (both 2002 & 2005 versions)

The assumptions 3. ("technical"):

- **the air is sampled on Petri dishes with Malt Extract Agar (MEA) medium (supplier: BIOCORP Polska) with MAS-100 Eco sampler by MERCK**

- **to simplify the future calculations:**
  20 litres is sampled from the outdoor air (and)
  50 litres from the indoor air

- **the identification is performed directly on the dish without re-inoculation**

- **the colonies upon open dish are observed in the transmitted light**
- **under lens of 10x (and the regular ocular, usually 10x)**

- **the statistical corrections for the number of colonies are applied to the total number of the colonies on the dish;**

the total number colonies of one genus usually does not exceed the threshold for corrections (21)

The National Library's holdings in registered items:

- **3 142 175 Monographs**
- **1 036 951 Serials**
- **2 608 488 Ephemera**
- **36 021 Manuscripts**
- **162 230 Early printed books**
- **138 021 Printed music**
- **373 377 Fine prints and drawings**
- **137 415 Maps and atlases**
- **248 400 Sound and audiovisual records**
- **237 129 Electronic documents**
- **274 794 Microfilms**

National Library building and storage rooms

Two buildings – main building and Krasiński Palace

Main building – about 80 rooms for storage, access and conservation of library objects

Krasiński Palace – 20 storage rooms and a reading rooms
Main building rooms – from uncontrolled conditions to full air condition

Krasiński Palace – uncontrolled conditions, relocation of objects to the main building in progress

Microbiological control of the air – methods.

1990 – 2006 – sedimentation sampling,
1993 – 2006 – no background sampling
Since 2007 background – outside air – 2 points x 3 dishes
Since 2008 – impact sampling – Mas 100 *Eco*
Since 2012 – background sampling every working day
Since 2012 – seven-month cycle
2013 – change: Sabouraud → MEA (Malt Extract Agar)

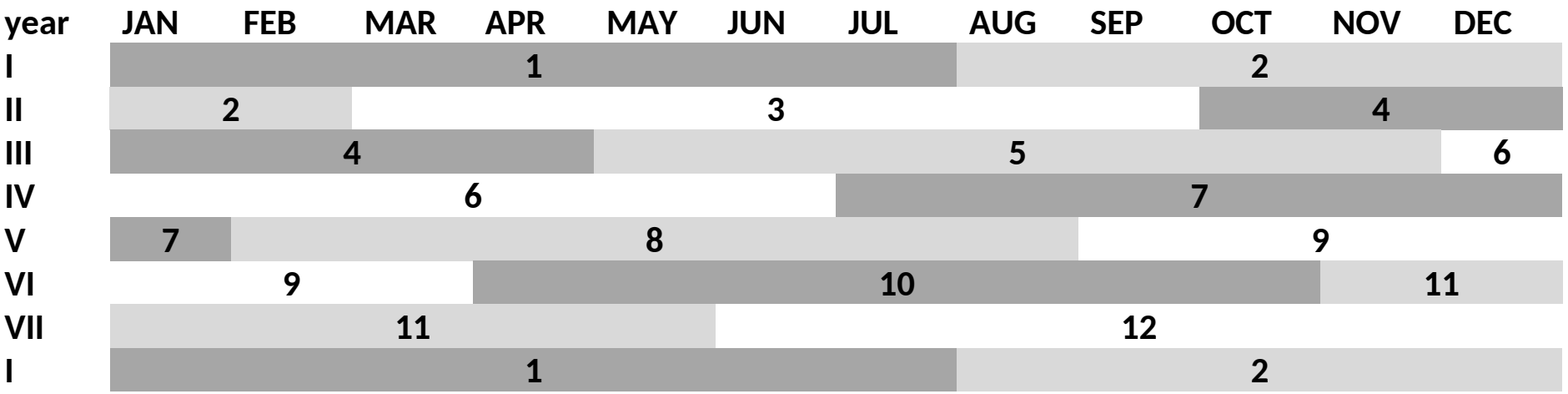
Microscopic identification as far as genus, directly on a dish

Microbiological control of the air - 7 months pattern – about 90 rooms

Floors of C building and samples rooms of Departments - number of samples

month	week I	week II	week III	week IV
I	Same floor in C building	Early Prints – 56	changeable floor in C building	Early Prints – 49 samples
II	Same floor in C building	Manuscripts - 20 Spec. Col. Access - 12	changeable floor in C building	Iconographic - 36 Cartographic - 36
III	Same floor in C building	Music Collection - 22	changeable floor in C building	Audio-visual Col. - 32
IV	Same floor in C building	Social Life Documents - 36	changeable floor in C building	Bibliographic Information - 40
V	Same floor in C building	The Archive – 15 Microfilms - 24	changeable floor in C building	S.-Inf., Conservation - 30
VI	Same floor in C building	Acquisition Dpt. - 45	changeable floor in C building	Mass Conservation - 34
VII	Same floor in C building	Exchangeable Collections Div. - 60	changeable floor in C building	Reading Rooms - 43

Microbiological control of the air - 7 months pattern



Introducing 7-month-long cycle we avoid sampling same rooms in same time of the year (contrary to fixed 6-month-long cycle or 12-month-long cycle)

Microbiological control of the air – results (cfu/m^3) – numbers

2008 – 3. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	153,3	356,6	186,7	146,6	525	833,3	2658,4	1345	1425	1567	3608	2333
in	2,7	6,6	6	44,3	22,3	34	61,4	30	inf.	12	34,2	5,3
in/out	0,2	0,2	0,03	0,3	0,04	0,04	0,02	0,02	inf.	0,01	0,01	<0,01
2009 – 7. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	217	26,7	163,3	233,3	416,7	1383,3	2280,3	2600	2816,7	1175	325	166,7
in	3,3	1,3	4	2,6	11,3	8,7	8	10	10	5,3	2	1,8
in/out	0,01	0,05	0,02	0,01	0,03	0,01	<0,01	<0,01	<0,01	<0,01	0,01	0,01
2010 – 5. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	66,7	7,8	70	303,5	2108,5	1680	1683,5	5483	2825	4346	433,5	175
in	3,5	24	10	6,7	117	188,7	57	207	575	50	43	36
in/out	0,05	3,1	0,14	0,02	0,05	0,1	0,03	0,04	0,2	0,01	0,1	0,2
2011 – 4. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	175	425	241,5	325	1241,5	1550	4825	733,5	900	1391,7	800	358,3
in	4	2	10	20,6	40	46	48,3	37,3	8,7	8	126,7	55,3
in/out	0,02	<0,01	0,04	0,01	0,03	0,03	0,01	0,05	0,01	0,01	0,16	0,15
2012 – 2. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	2045	167	200	266	1958	5425	1933	1608	2015	2341	-	-
in	47	10	28	8	35	150	124	37,3	8,7	20	-	-
in/out	0,02	0,06	0,14	0,03	0,02	0,03	0,06	0,02	<0,01	0,01	-	-

Microbiological control of the air – results (cfu/m^3) – numbers

2013 – 7. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	66,5	83,25	Inf.	658,3	1175	2391,5	658,25	Cons. works	675	2575	701,25	214,5
in	26,6	1,3	Inf.	10,0	57,3	74,0	50,0		56,6	32,7	36,7	13,3
in/out	0,4	0,01	-	0,01	0,04	0,03	0,07	-	0,08	0,01	0,05	0,06
2014 – P2 f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	74,25	305	486,75	357,25	330	1080,8	742,5	1856	3687	1254	1682,5	519,75
in	33,3	5,0	15,3	5,3	12,0	83,3	19,5	152,7	67,6	42,0	26,0	16,0
in/out	0,4	0,02	0,03	0,01	0,04	0,08	0,02	0,08	0,02	0,03	0,02	0,03
2015 – 8. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	639,1	240,7	514,6	365,5	1170,3	531,2	1311,4	846,6	1012,6	1054,1	356,9	639,1
in	26,0	7,3	15,3	134,6	10,0	10,0	14,0	8,0	12,0	5,5	21,3	0,0
in/out	0,04	0,03	0,03	0,037	<0,01	0,02	0,01	<0,01	0,01	<0,01	0,06	<0,01
2016 – 8. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	605,9	332	141,1	489,7	639,1	854,9	1867,5	2481,7	2597,9	1261,1	215,8	116,2
in	12,7	2,7	4,0	2,0	100,0	24,0	6,6	14,0	9,3	7,0	0,0	3,3
in/out	0,02	<0,01	0,03	<0,01	0,15	0,03	<0,01	<0,01	<0,01	<0,01	<0,01	0,02
2017 – 7. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	49,8	24,9	182,6	58,1	1386,1	2573	1917,3	1510,6	1925,6	838,3	307,1	473,1
in	0,7	5,3	28,0	5,0	10,0	14,7	13,3	22,7	19,3	12,0	6,0	2,0
in/out	0,01	0,02	0,15	0,08	<0,01	<0,01	<0,01	0,01	0,01	0,01	0,02	<0,01
2018 – 6. f	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
out	199,2	49,8	8,3	373,5	1917,3	2714,1	1070,7	805,1	904,7	871,5	298,8	83,3
in	2,7	3,3	2,0	6,0	6,7	62,7	13,3	28,7	8,0	13,3	8,0	9,3
in/out	0,01	0,06	0,24	0,02	<0,01	0,02	0,01	0,03	<0,01	0,01	0,03	0,1

Microbiological control of the air – results – isolated genera - 2011

	Rooms of the National Library: 984 samples (dishes)				**Background (atmospheric air): 1470 samples (dishes)**			
nr	microorganism	colonies	col./dish	cfu / m^3	cfu / m^3	cfu / m^3	col./dish	microorganism
1.	*Cladosporium* sp.	2533	2,6	51,5	565,8	11,5	16635	*Cladosporium* sp.
2.	NN*	824	0,8	16,7	124,0	2,5	3645	NN*
3.	*Penicillium* sp.	297	0,3	6,0	29,4	0,5	865	*Penicillium* sp.
4.	*Aspergillus* sp.	90	0,1	1,8	5,3	0,1	155	*Botrytis* sp.
5.	*Botrytis* sp.	27	0,03	0,5	3,3	0,06	95	*Aspergillus* sp.
6.	*Alternaria* sp.	12	0,01	0,2	0,2	< 0,01	5	*Rhizopus* sp.
7.	*Scopulariopsis* sp.	10	0,01	0,2	0,1	< 0,01	4	*Trichoderma* sp.
8.	*Acremonium* sp.	3	< 0,01	< 0,1	0,1	< 0,01	4	*Mucor* sp.
9.	*Trichoderma* sp.	2	< 0,01	< 0,1	0,1	< 0,01	4	*Chrysonilia* sp.
10.	*Rhizopus* sp.	1	< 0,01	< 0,1	< 0,1	< 0,01	2	*Alternaria* sp.
11.	ordo *Mucorales*	1	< 0,01	< 0,1				
	filamentous fungi	3800	3,9	77,2	728,5	14,6	21415	Grzyby strzępkowe:
	bacteria/yeast-like	209	0,2	4,2	216,0	4,3	6355	Bakterie/drożdzopodobne:
	total	4009	4,1	81,5	944,5	18,9	27725	Razem:
	microorganism	kolonii	kol./sz.	jtk / m^3	jtk / m^3	kol./sz.	kolonii	mikroorganizm

NN – unidentified – filamentous fungus without morphological features enabling identification

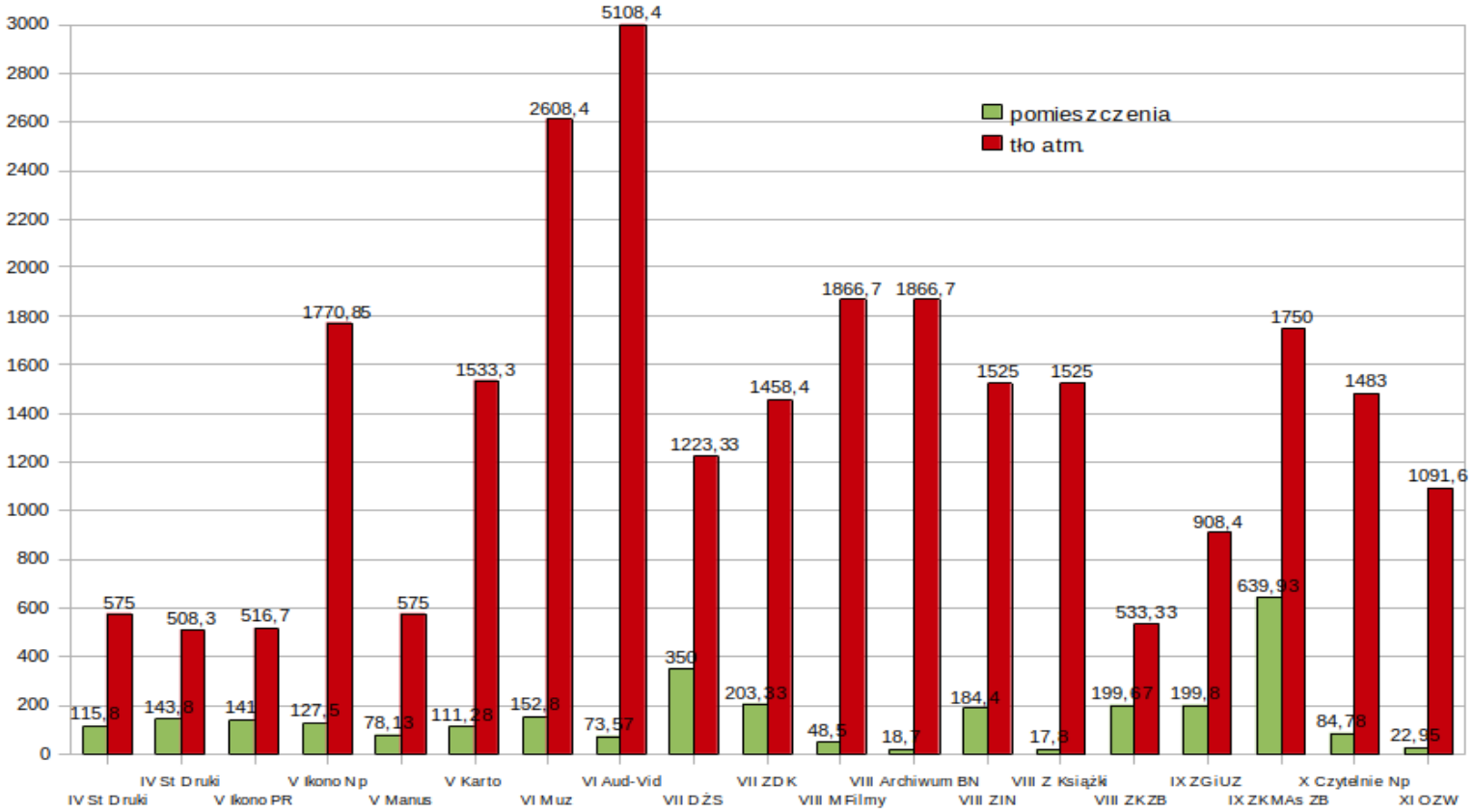
The taxa of the indoor and outdoor air isolated in 2011 – summary :

- for the **air samples from rooms of the National Library** - *Cladosporium* sp., *Penicillium* sp., NN,. *Aspergillus* sp., *Botrytis* sp., *Alternaria* sp., order *Mucorales*, *Trichoderma* sp., nonfilamentous organisms – are 97,6 % of the isolated colonies

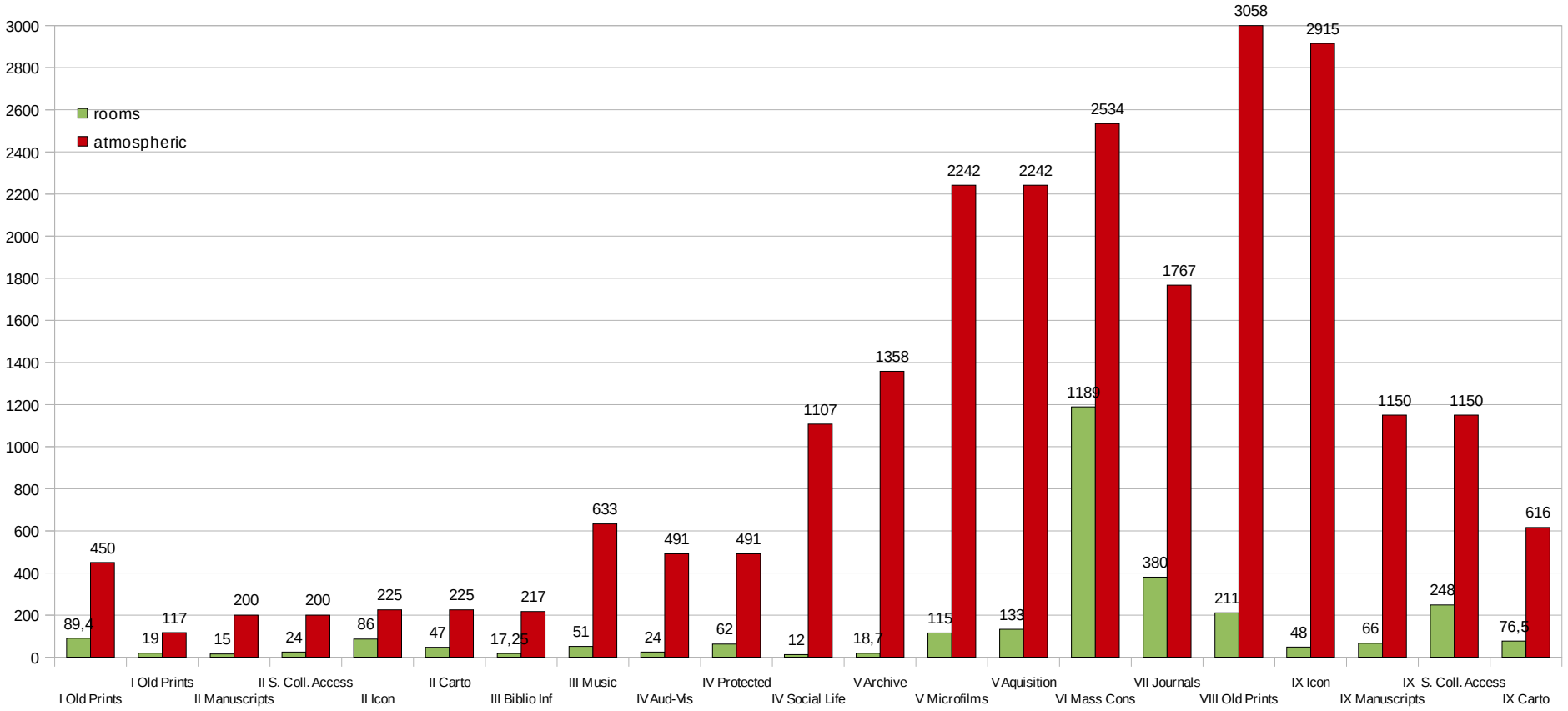
- for the **contact samples from the objects** - *Aspergillus* sp., *Penicillium* sp., *Cladosporium* sp., NN., nonfilamentous organisms - are 99% of the isolated colonies

- for the **background (atmospheric) air** - *Cladosporium* sp., NN., *Hormodendrum* sp., (treated lately as synonym for *Cladosporium* sp.), *Penicillium* sp., *Aspergillus* sp., *Rhizopus* sp., *Alternaria* sp., *Botrytis* sp., NN., nonfilamentous organisms – are 99,5% of the isolated colonies

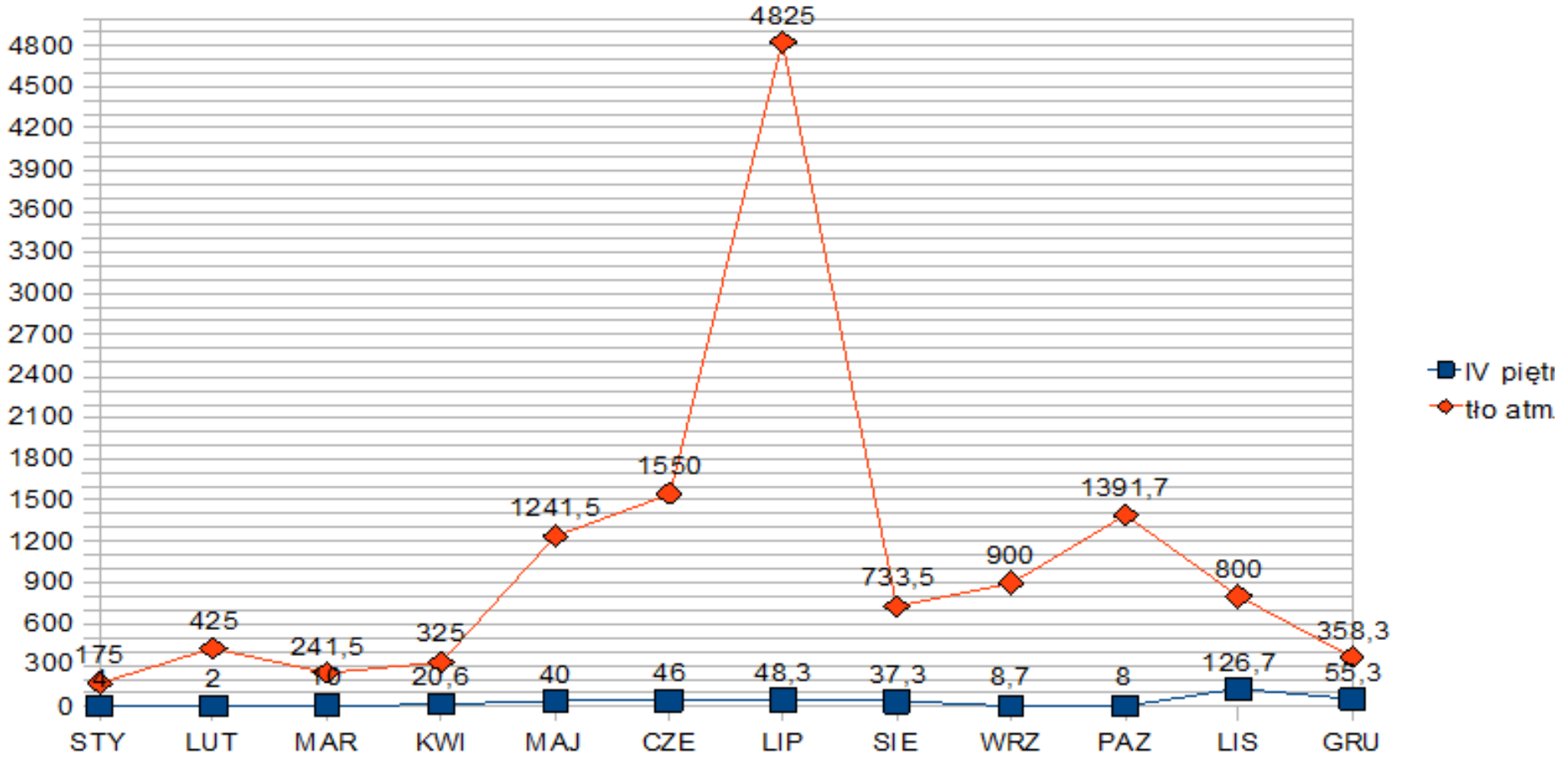
Microbiological control of the air – results (cfu/m^3) – indoor/outdoor (2011)



Microbiological control of the air – results (cfu/m^3) – indoor/outdoor (2012)



Microbiological control of the air – results (cfu/m^3) – indoor/outdoor



Indoor air quality evaluation:

- **a combination of above presented graphs and tables can be done for any room or set of rooms**
- **evaluation can be done for any group of microorganisms**
- **the key is the background data (atmospheric air) as well as the previous data for the sampled room(s)**
- **the general rules for evaluation were adapted from the Umweltbundesamt guidelines 2003 and 2005**
- **they lead to the following conclusions:**

Conclusions based on Umweltbundesamt guidelines 2003 and 2005:

1. **For the parameter (of culturable microorganisms):**
   Cladosporium and other genera which may reach high concentrations in the outdoor environment (sterile mycelia, yeasts, Alternaria, Botrytis).
   the safe values for the indoor air are (*Indoor source unlikely Background level*) :

   Concentration (cfu/m^3) of one genus in the indoor air is lower than 0,8 to 1,2 times the concentration in the outdoor air

   (Italics - quoted from Baschien, C., Moriske, H-J., Becker, K., Kolossa-Gehring, M., Szewzyk, R. (2012))

2. **For all other culturable microorganisms:**
   Concentration (cfu/m^3) of one genus in the indoor air is lower than the concentration in the outdoor air (my general conclusions covering the remaining four parameters of culturable microorganisms).

When the two above mentioned conditions are met, the indoor source of infection is unlikely !

[1] [edition] Heinz-Jörn M., Szewzyk R. (2002). *Leitfaden des Umweltbundesamtes zur Vorbeugung, Untersuchung, Bewertung und Sanierung von Schimmelpilzwachstum in Innenräumen*. Umweltbundesamt, Berlin.

[2] [edition] Heinz-Jörn M., Szewzyk R. (2005), *Leitfaden zur Ursachen-suche und Sanierung bei Schimmelpilzwachstum in Innenräumen („Schimmelpilzsanierungs-Leitfaden")*. Umweltbundesamt, Berlin.

online materials: https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4218.pdf
https://www.umweltbundesamt.de/sites/default/files/medien/421/publikationen/uba_schimmelleitfaden_final_bf.pdf

[3] Zyska B.. (2005), *Mikologia środowiska budynków mieszkalnych i gmachów użyteczności publicznej oraz pomieszczeń wybranych gałęzi przemysłu ze szczególnym uwzględnieniem taksonomii grzybów*, Biuletyn Informacyjny Konserwatorów Dzieł Sztuki, vol. 16 No2-4, p. 61-63

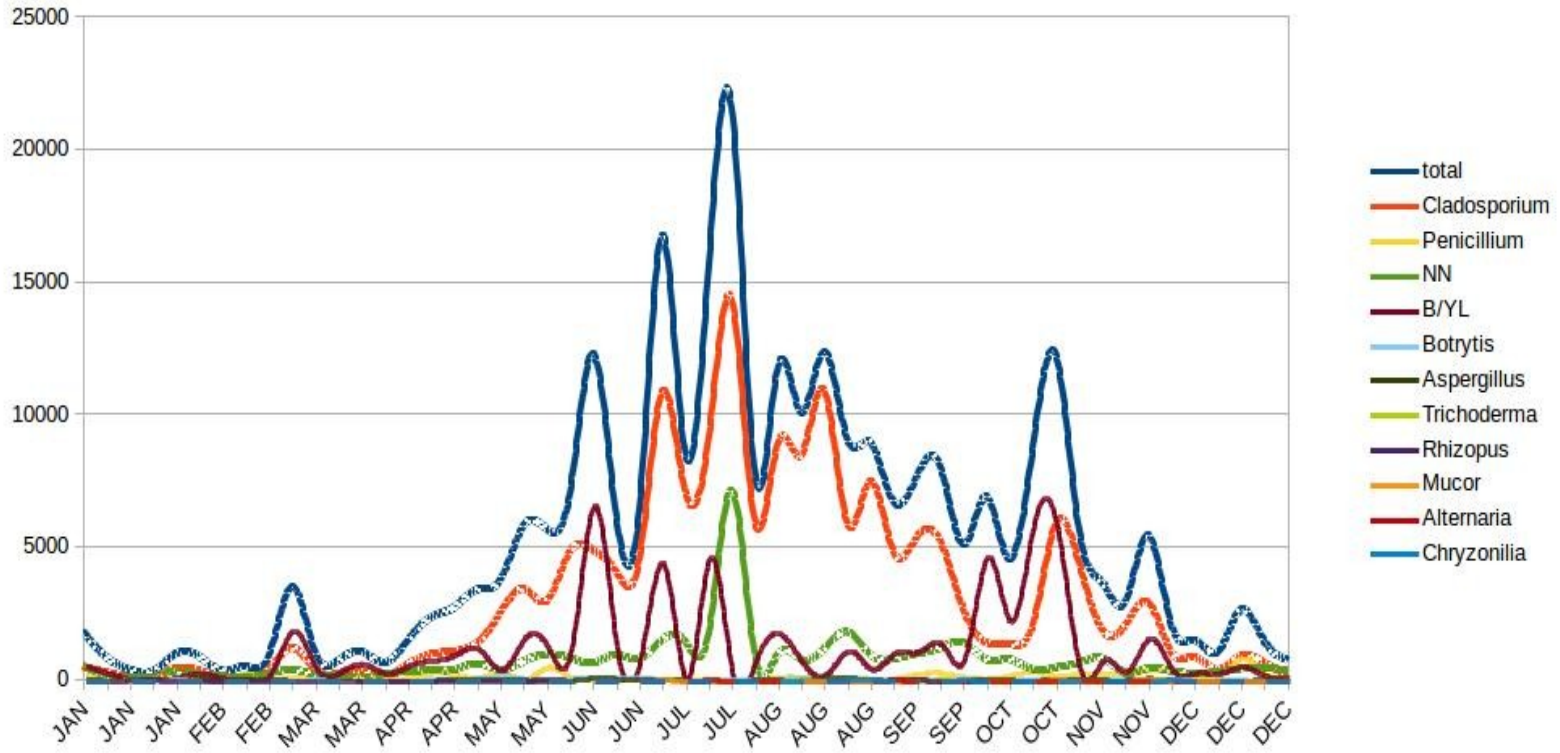
See also:

Heinz-Jörn Moriske, Regine Szewzyk, Maryline Leonidas, *Mould guide for the prevention, investigation, evaluation and remediation of indoor mould growth.*
In No. 32, WHO Collaborating Centre for Air Quality Management and Air Pollution Control, Berlin

and:

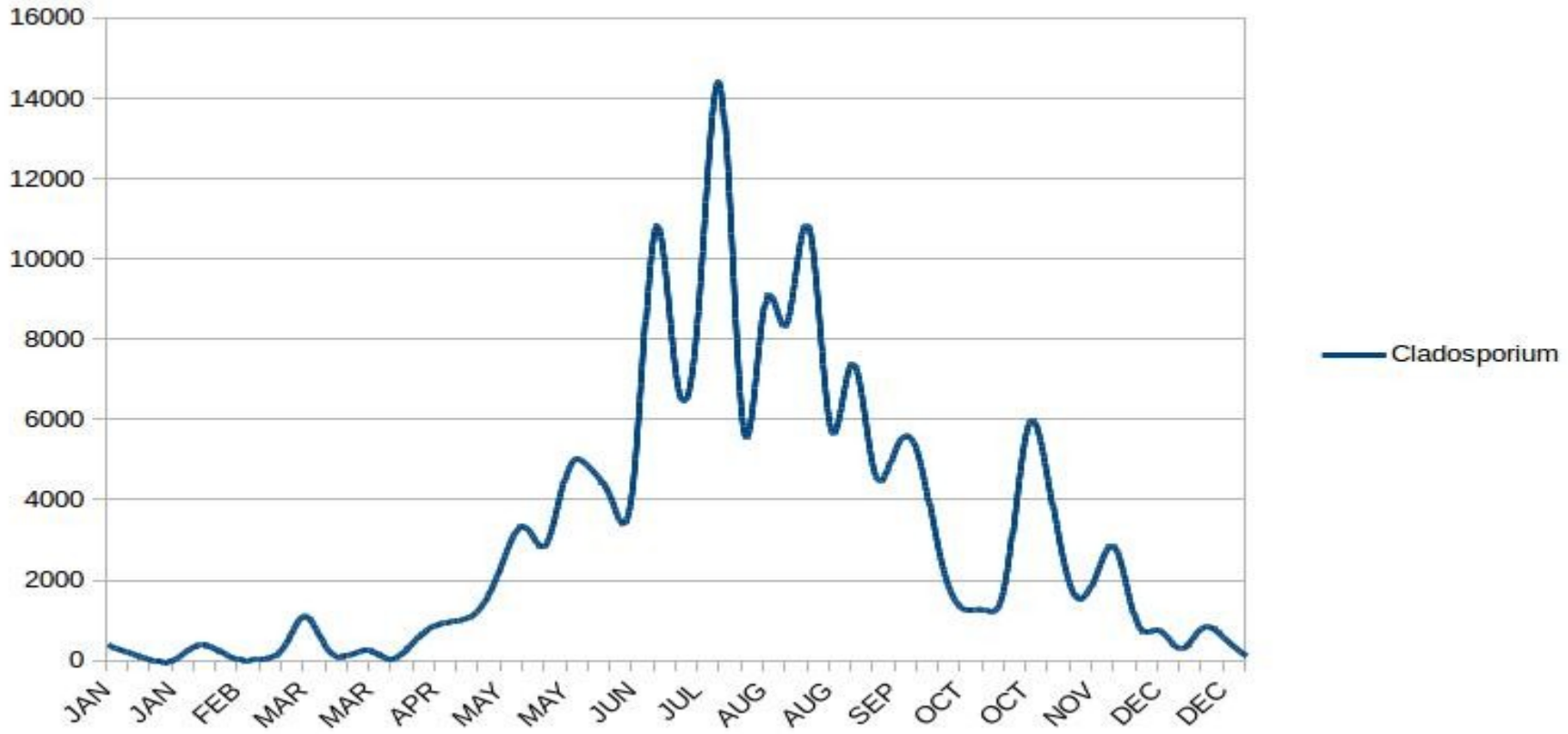
Baschien, C., Moriske, H-J., Becker, K., Kolossa-Gehring, M., Szewzyk, R. (2012): *Recommendations for detection and remediation of mold growth in indoor environments in Germany*. In: Johanning, E, Morey, P. R., Auger, P.: Bioaerosols - 6th International Scientific Conference on Bioaerosols, Fungi, Bacteria, Mycotoxins in Indoor and Outdoor Environments and Human Health.Fungal Research Group Foundation, Inc., Albany, New York. p. 328-335.

Microbiological control of the air genera of background air (2013)

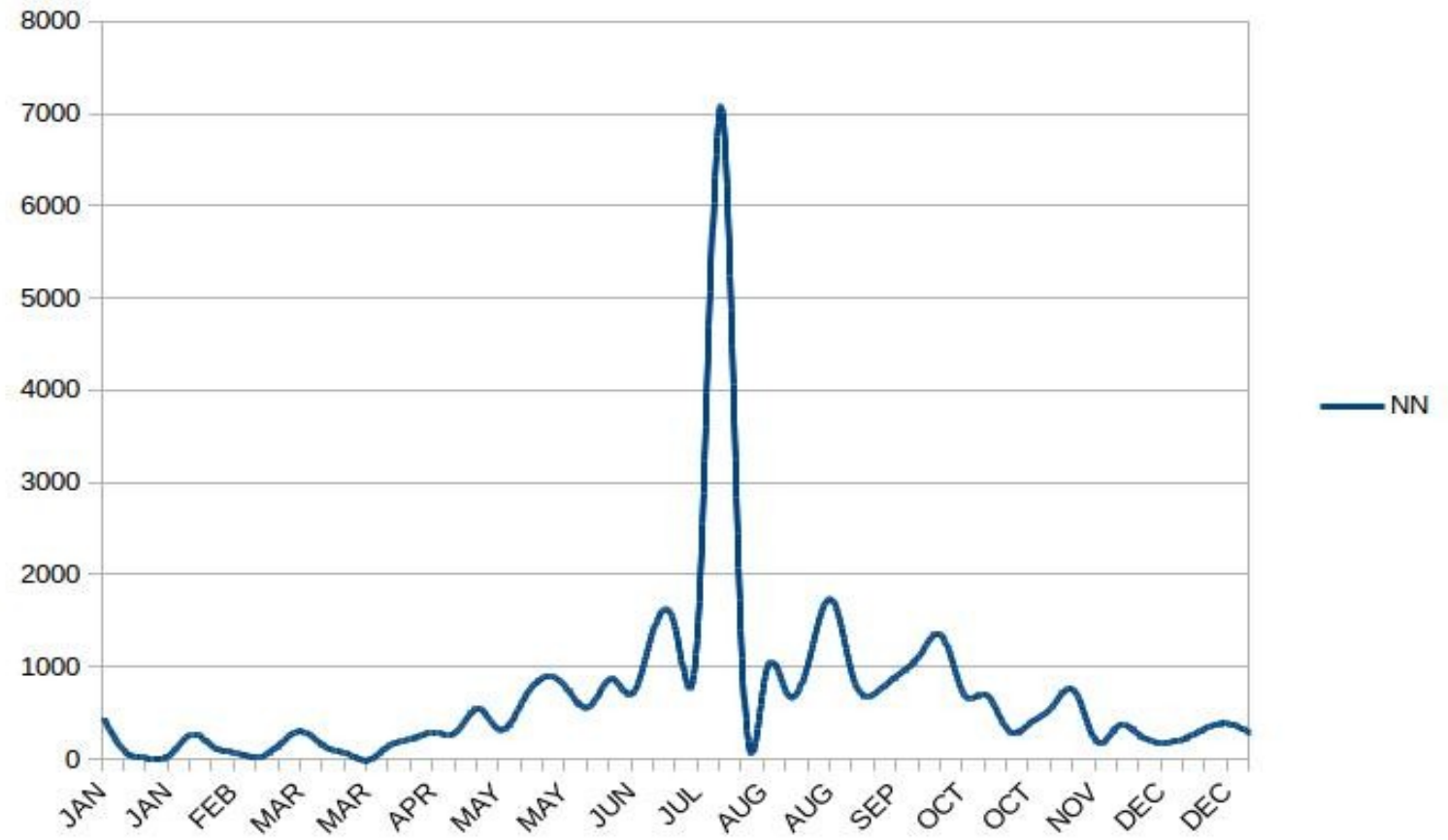


(cfu/m^3) – values of different microorganisms in atmospheric (background air) in one year

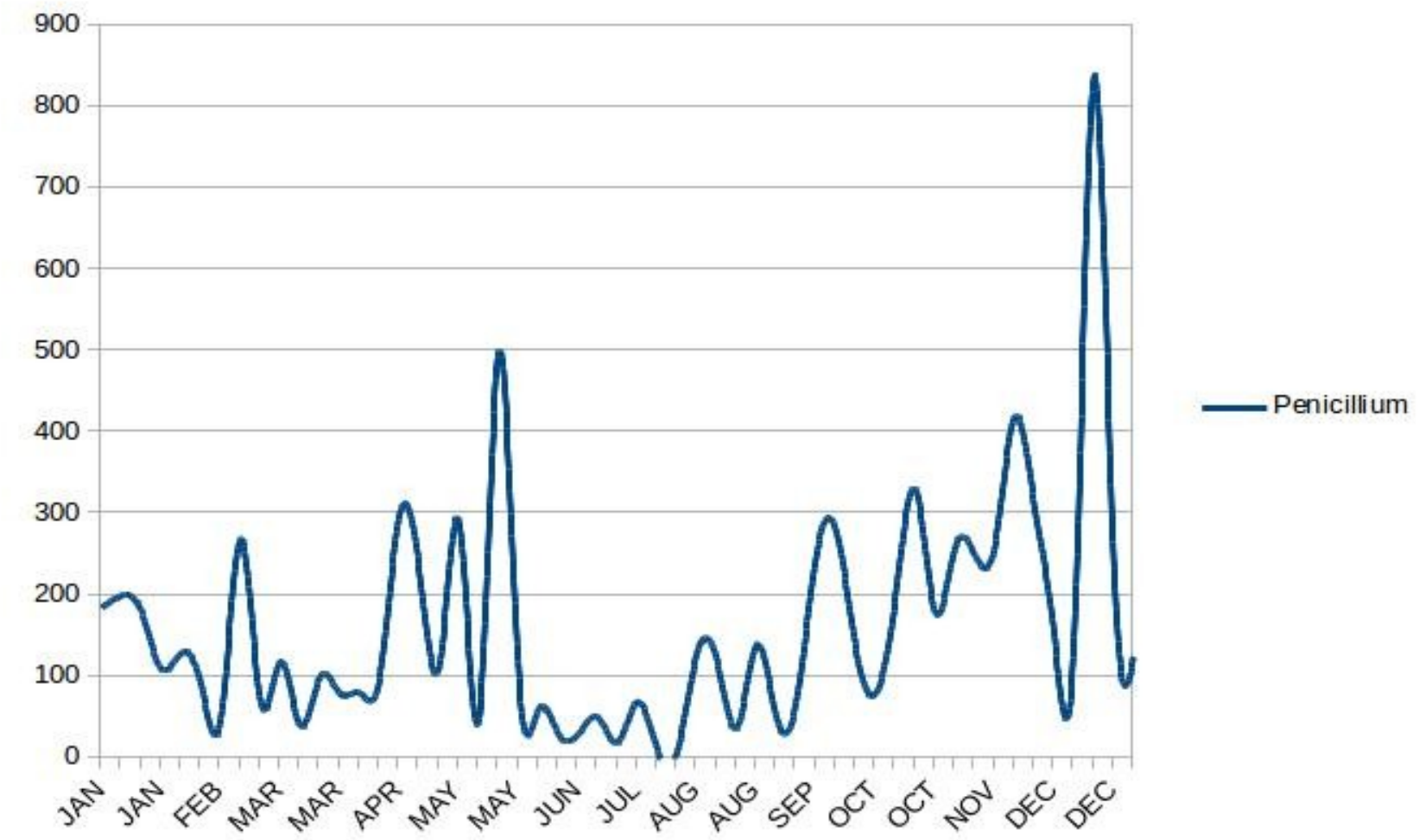
Cladosporium sp. in outdoor air in 2013; average values in cfu/m^3:



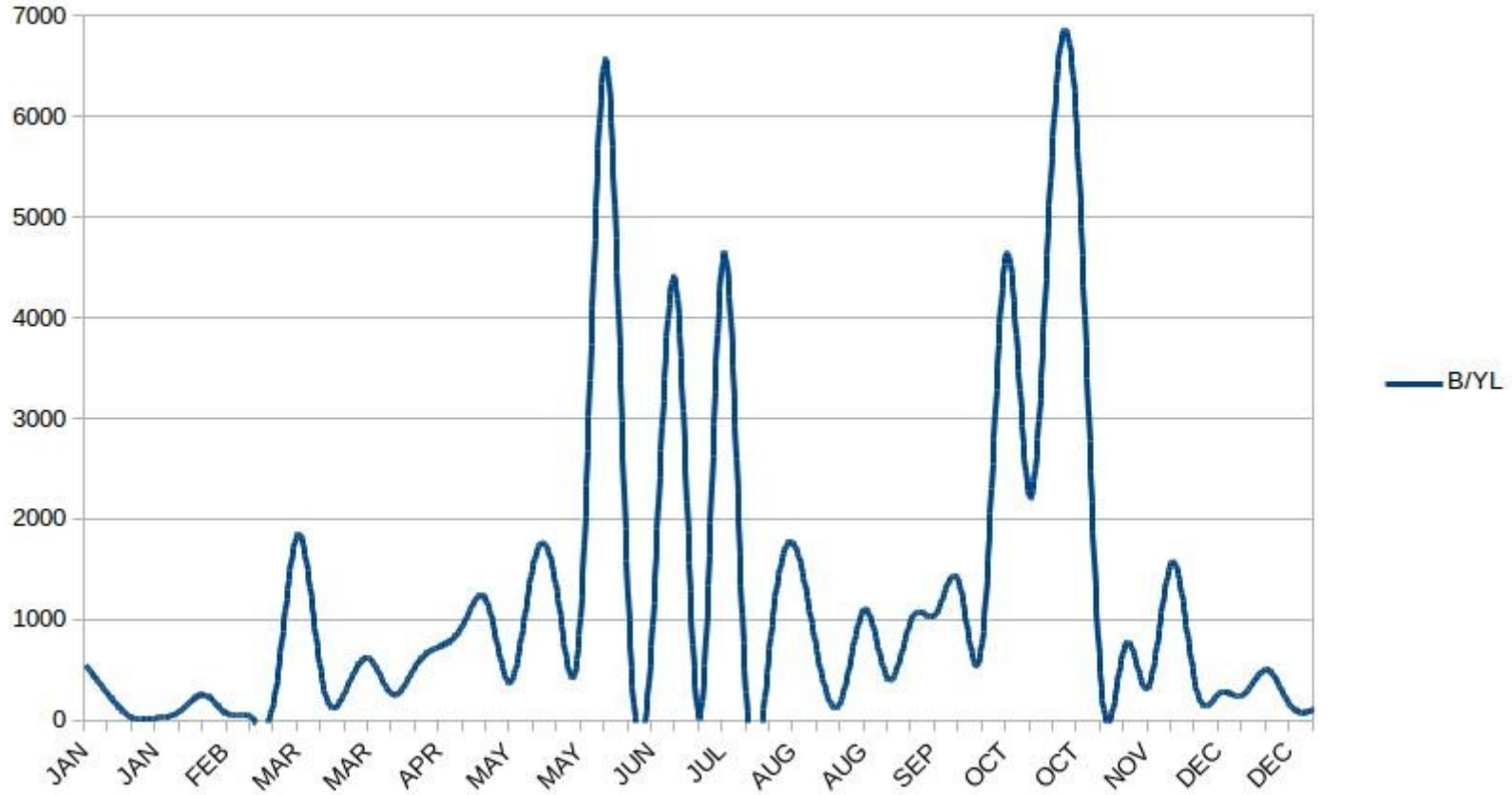
NN ("unknown" - unidentified) in outdoor air in 2013; average values in cfu/m^3 :



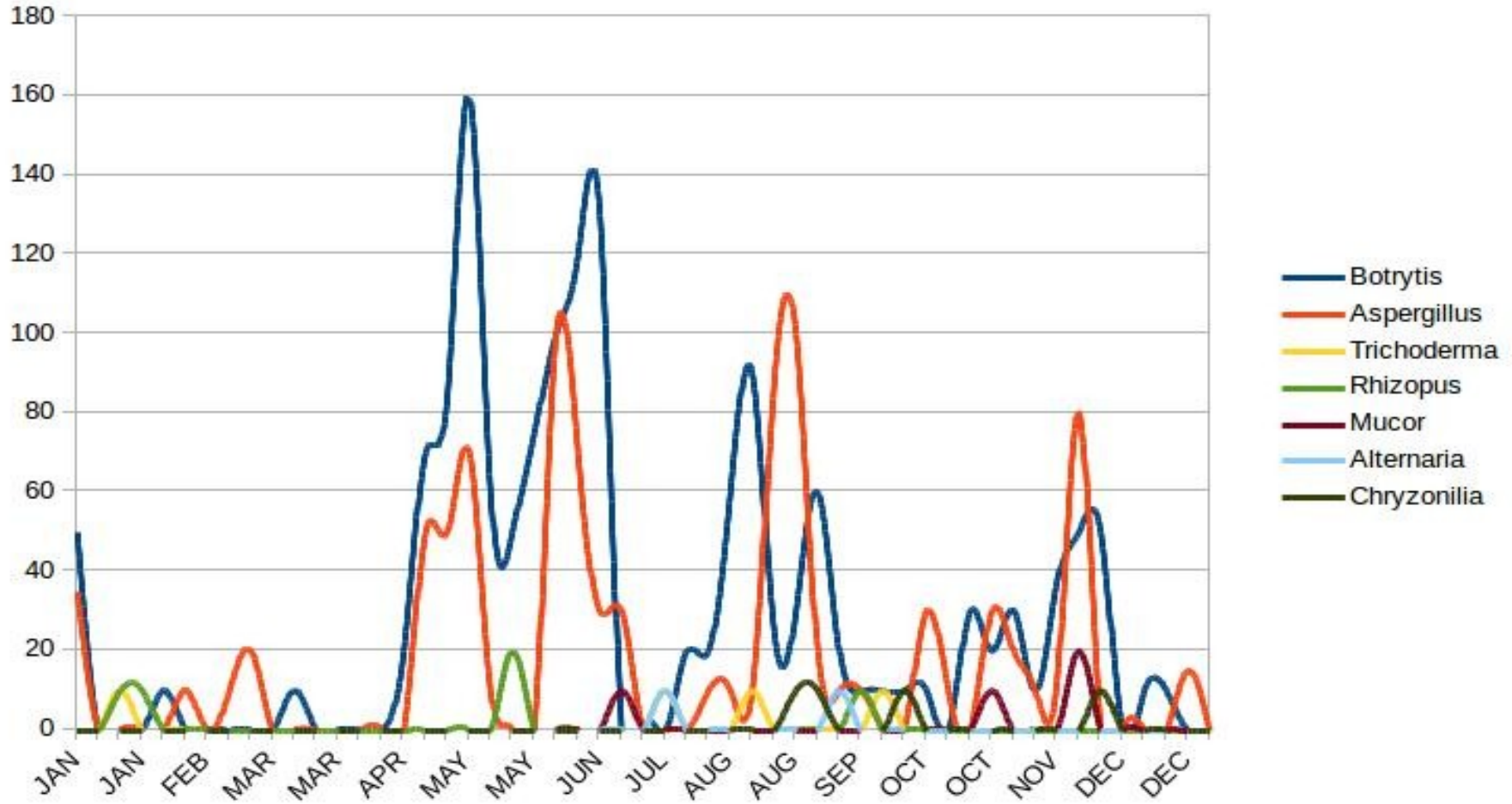
Penicillium sp. in outdoor air in 2013; average values in cfu/m^3 :



Bacteria & Yeast-like in outdoor air in 2013; average values in cfu/m^3 :



Other *taxa* of moulds in outdoor air in 2013; average values in cfu/m^3:



Microbiological control of the objects – assumptions.

- **The microbiological sampling of objects in the laboratory of the National Library of Poland has been executed for over 25 years.**
- **The presence of CFU's (colony forming units) of fungi (moulds) is the greatest concern.**
- **Microbiological sampling is essential for the conservator's decision on further treatment.**
- **This includes the choice of a potential disinfection method, taking into account the safety of objects and personnel.**

Microbiological control of the objects – methods

- **dry and sterile 5x5cm impress filter paper,**
- **'dry swab' (opposite to 'wet swab' - used in industrial sampling),**
- **commercial ATP test - Kikkoman® PD-20.**

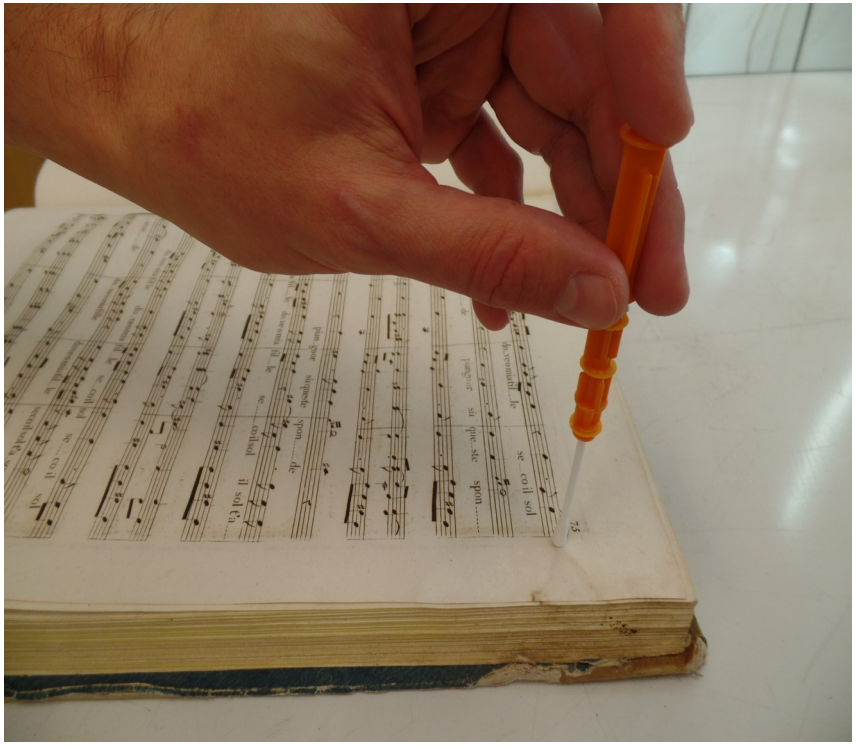
Microbiological control of the objects – ATP method modification:

- **Sampling by touching directly from above with the dry swab**
- **the swab was placed into a sterile test tube with a ~50µl of the sterile re-distilled water and secured with a cap**
- **the incubation time at the room temperature was 2 and 6 hours**
- **the original test-tube with Luminescent reagent was secured with a cap and stored in the fridge, removed to warm up 20' before measuring the RLU's – as in producer's manual**
- **measuring the RLU's – as in producer's manual**

- **Bogdan Filip Zerek, Jakub Piechal,** ***Use of luminometric assays (ATM/AMP) in microbial examination of the National Library of Poland's collections*** **https://notes.bn.org.pl/upload/pdf/28439_02_Notes_21%20Zerek_Luminometria_49%E2%80%9378.pdf**

Impress sampling:

Swab (point) sampling for ATP/AMP test:



Evaluation of new disinfection methods

Investigation of the effectiveness of the BIO-MASTER Korean etheric oils fumigation system installed in the Vilnius University Library.

The research was performed using the following test papers:

- Whatman paper,
- Whatman paper covered with 2% gelatine,
- Xerox printer paper with a density of 80 g/m^2.

Evaluation of new disinfection methods

The samples were infected with mould monocultures diluted 1/10, 1/100 and 1/1000, using:

- *Penicillium funiculosum*,
- *Penicil lium ochraceum*,
- *Aspergillus niger*,
- *Aspergillus versicolor*,
- *Botryotrichum piluliferum*

in a way that makes it possible to determine the quantity of units on samples.

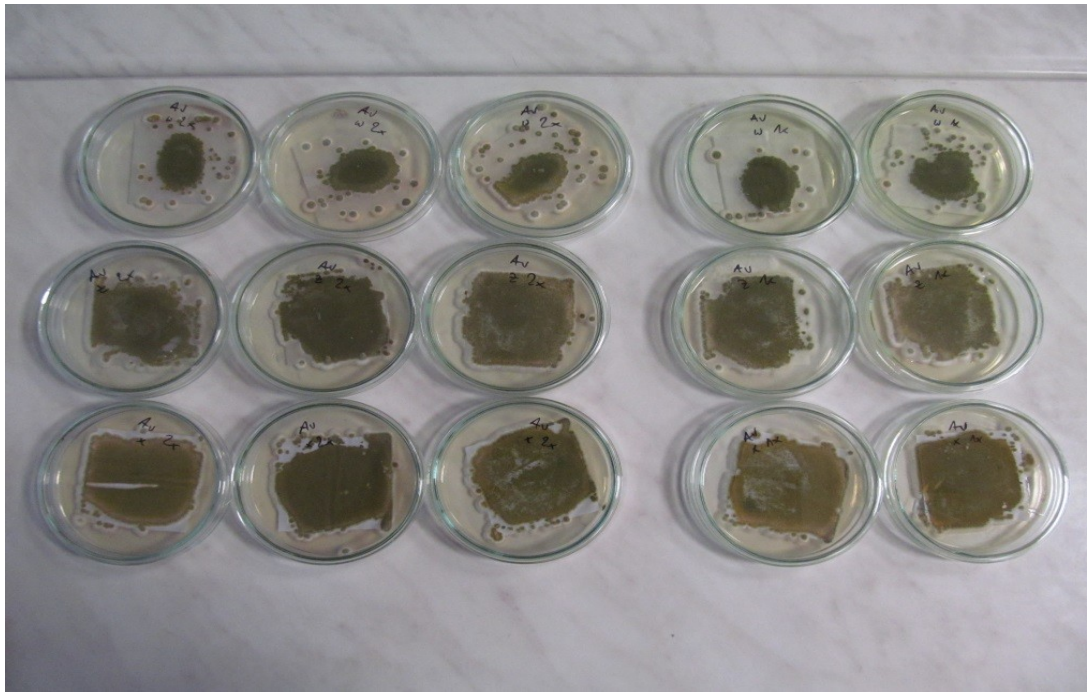
Evaluation of new disinfection methods

After disinfection the samples were:

- transferred onto MEA medium,
- incubated for 14 days (at room temperature),
- subsequently assessed for the growth of the colonies (counted) and compared with control samples (infected likewise but not disinfected).

In the conditions used in the experiment the system proved completely ineffective.

Evaluation of new disinfection methods – *Apergillus versicolor* series



From above: Whatman, Whatman + gelatine, Xerox
3 left columns – double "disinfection", 2 right columns – single "disinfection"

Microbiological control of collections

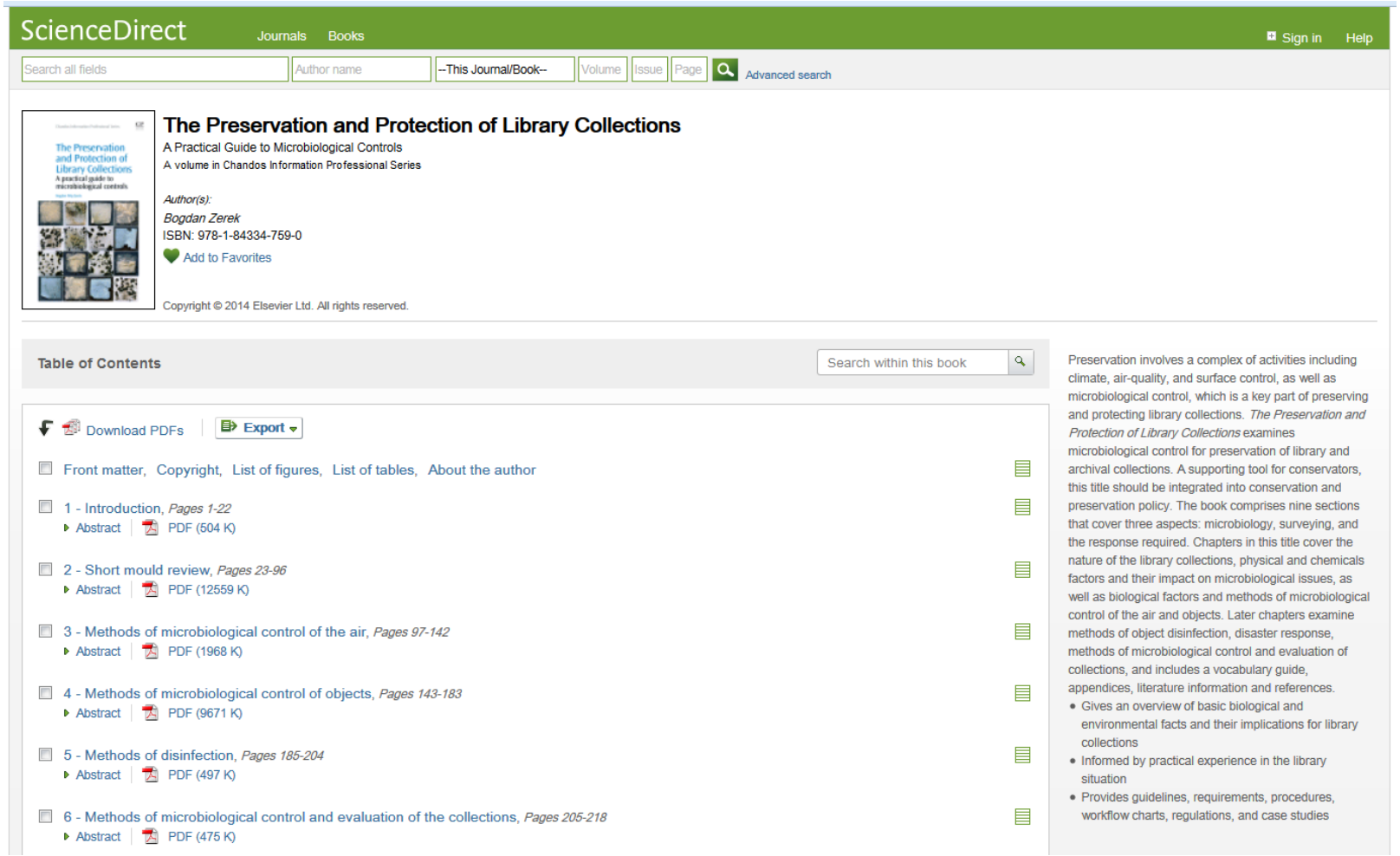
- surveys based on visual evaluation of random objects
- 384 objects are suggested - randomization as in Stanford method

3 symptoms:

- visible mould
- visible effect of microbial activity
- visible effect of water activity

Sampling of suspected objects → statistics → general conclusions, e.g.:

If 1/3 of the collections is "suspected" and should be sampled, the whole collection is suspected



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The Preservation and Protection of Library Collections

A Practical Guide to Microbiological Controls

A volume in Chandos Information Professional Series

Author(s):
Bogdan Zerek
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Preservation involves a complex of activities including climate, air-quality, and surface control, as well as microbiological control, which is a key part of preserving and protecting library collections. *The Preservation and Protection of Library Collections* examines microbiological control for preservation of library and archival collections. A supporting tool for conservators, this title should be integrated into conservation and preservation policy. The book comprises nine sections that cover three aspects: microbiology, surveying, and the response required. Chapters in this title cover the nature of the library collections, physical and chemicals factors and their impact on microbiological issues, as well as biological factors and methods of microbiological control of the air and objects. Later chapters examine methods of object disinfection, disaster response, methods of microbiological control and evaluation of collections, and includes a vocabulary guide, appendices, literature information and references.

- Gives an overview of basic biological and environmental facts and their implications for library collections
- Informed by practical experience in the library situation
- Provides guidelines, requirements, procedures, workflow charts, regulations, and case studies

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Thank You!

bogdan.zerek@cybis.asp.waw.pl

bfilipzerek@yahoo.com