PREVENTIVE CONSERVATION – SIGNIFICANT ROLE IN PRESERVATION OF ARCHIVES AND LIBRARIES

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Despite the fact that the deleterious effect of light/radiation on paper support of archives and library materials has been proven in many studies and that there exist recommendations as standards for acceptable levels of radiation, in reality this task has been very often underestimated. Measurements of light conditions in some Slovak archives and libraries showed that real values highly exceed recommended values given by archival legislation.

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***Jozef Hanus… et al: Preventivna konzervacija – pomembna vloga pri varovanju arhivskega in knjižničnega gradiva**. Tehnični in vsebinski problemi klasičnega in elektronskega arhiviranja. Zbornik referatov z dopolnilnega izobraževanja, Maribor 6/2007, str. 156-167.*

Izvirnik v angleščini, izvleček v angleščini in slovenščini, povzetek v slovenščini.

Kljub temu, da so številne študije dokazale škodljiv učinek svetlobe/sevanja na papir, iz katerega je arhivsko in knjižnično gradivo, in da obstajajo priporočila in standardi za še sprejemljive ravni sevanja, je v resnici ta učinek zelo podcenjen. Meritve svetlobnih pogojev v nekaterih slovaških arhivih in knjižnicah so pokazale, da realne vrednosti visoko presegajo z arhivsko zakonodajo priporočene vrednosti.

INTRODUCTION

Archives and libraries collections and holdings represent a unique part of the cultural heritage of human society. Preservation and management of those precious resources and accessibility to them by public are principal responsibilities of all public archives and libraries. Most of archival documents are made from organic raw materials, largely plant fibres and animal skin. This makes them (especially paper) prone to decay and vulnerable by the environmental conditions in which they are kept. Ageing is an irreversible process that deteriorates mechanical, physical, chemical and optical properties of paper. Paper becomes brittle and yellow due to the influence of internal and external degradation factors. The most important internal factors are given by the nature of materials which the documents are made of or they are established during manufacture of these materials, e. g. in the case of

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paper they include type and quality of fibres, sizing materials, coatings, the presence of acidic compounds, metallic compounds and other components of sheets. The external factors are related to deleterious influence of the storage conditions - such as temperature and humidity, light, air pollutants, microbial attack, atmospheric oxidation, etc.[1]

Light is one of degradation factors which deleterious effect is very often underestimated. Especially paper containing high portion of groundwood, produced since the 2nd half of the 19th century is sensitive to its influence and is expected to have a short life-time. Nowadays there is a good deal of information about the influence of light on the ageing of groundwood papers[2, 3, 4, 5]. Light induced oxidation degradation reactions are typical reactions of lignin, which characteristically manifest as the yellowing of paper, producing a large amount of low molecular degradation products, a significant increase of acidity and intensely reduced strength during 30 days of daylight ageing, even with significantly reduced portion of UV radiation[6].

Therefore protection against the influence of light/radiation should be included in preventive conservation as a significant role in preservation of archives and libraries.[7]

RADIATION/OPTICAL RADIATION/VISIBLE RADIATION (LIGHT) - DEFINITIONS OF SOME BASIC TERMS

Natural phenomenon, which is called light, influences in a great scale practically the whole life of human civilisation. It is stated that nearly 90% of information obtained by people by perception from the surroundings is mediated by light.

Every object emits radiation into the environment, which is in its substance electromagnetic waving. It is emitted and absorbed as particles and diffused as waves. It is recognised according to its wave length λ (nm - nanometer = 10^{-9} m) in the form of heat, visible light, X-rays, etc. It can also be characterised by its frequency ν (s^{-1}). The relation between λ and ν is expressed by the equation

$$\lambda \, . \, \nu = c$$

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[1] *Hanus, J.: Štúdium starnutia papiera z hľadiska ochrany archívnych dokumentov. Kandidátska dizertačná práca. (Study of paper ageing from the point of preservation of archives. PhD thesis). Chemical-Technological Faculty, STU Bratislava, 1987.*

[2] *Heitner, C, Scaiano, J. C.: Photochemistry of lignocellulosic materials. ACS Symposium Series 531, Washington, D.C., Am. Chem. Soc. 1993.*

[3] *Havermans, J. B. G. A., Dufour, J.: Photo oxidation of paper documents. A Literature Review. Restaurator 18 (1997) 103-114.*

[4] *Bukovský, V.: Yellowing of newspaper after deacidification with methyl magnesium carbonate. Restaurator 18 (1997) 25-38.*

[5] *Bukovský, V.: The natural ageing of paper after exposure to daylight. Restaurator 21 (2000) 229-237.*

[6] *Bukovský, V.: Influence of light on ageing of newsprint paper. Restaurator 21 (2000) 55-76.*

[7] *Ďurovič, M. et all: Vliv světla a ultrafialového záření na archivní dokumenty. Závěrečná zpráva grantového úkolu. SÚA Praha 2001.*

where *c* is the speed of light in vacuum ($2{,}998.10^8$ $m.s^{-1}$)[8]. The shorter the wave length is the greater the energy of radiation is. Radiation can be divided continuously according to its wave length to a set which is called spectrum.

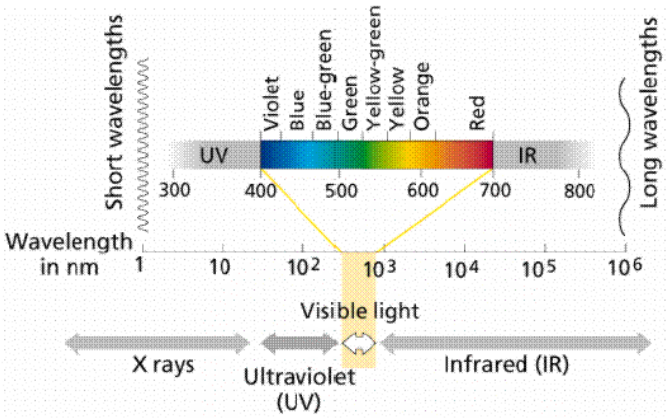

Figure 1. Schematic illustration of spectrum

Optical radiation is a part of radiation within the range of wave length from 1 nm (nm = nanometer = 10^{-9} m) to 1 mm.

Visible radiation (light) is a part of radiation, which is able to irritate an eye retina and to raise an optical perception. It represents only a very small part of the whole spectrum. The human eye is able to accept only light rays within the range of wave lengths 400 - 700. However this light seems to be white it can be decomposed to the basic spectral parts of the following wave lengths: violet 380-450 nm, blue 450-500 nm, green 500-570 nm, yellow 570-590 nm, orange 590-610 nm, red 610-780 nm.

Radiation with longer wave length (800 nm - 1 mm) is called **infrared** and is perceived as heat.

Ultraviolet radiation is invisible for the human eye, its energy charge is considerably higher than of visible radiation and covers the range of 380 nm - 1 nm. Its most important parts are UV-A (315 - 400 nm), UV-B (280 - 315 nm) and UV-C (100 - 280 nm). The most significant source of UV radiation is the Sun.

From the physical point of view the ultraviolet and infrared radiation show similar properties as visible radiation, however the human eye is not able to perceive it. Light is thus the electromagnetic radiation, which is able to generate visual perception of the human eye. The bounds of spectral range of visible radiation depend on the spectral sensitivity of the human eye of an observer; its lover part is considered within 380–400 nm and the upper within the range of 760–780 nm.

[8] *Kellő, V., Tkáč, A.: Fyzikálna chémia. Nakladateľstvo Alfa, Bratislava 1969.*

Table 1. Ranges of optical radiation within electromagnetic spectrum[9]

Radiation	Specification	Wave length λ (nm)	frequency N (Hz)
Ultraviolet	UV-C	100–280	(30–17) x 10^{14}
	UV-B	280–315	(17–9.5) x 10^{14}
	UV-A	315–380	(9.5–7.89) x 10^{14}
Visible	violet	380–430	(7.89–6.98) x 10^{14}
	blue	430–490	(6.98–6.12) x 10^{14}
	green	490–570	(6.12–5.26) x 10^{14}
	yellow	570–600	(5.26–5.00) x 10^{14}
	orange	600–630	(5.00–4.76) x 10^{14}
	red	630–780	(4.76–3.84) x 10^{14}
Infrared	IR-A	780–1 400	(3.84–2.14) x 10^{14}
	IR-B	1 400–3 000	(2.14–1.00) x 10^{14}
	IR-C	3 000–10 000	(1.00–0.30) x 10^{14}

When the radiation meets an object (depending on the material which the object is made of) it is divided into three parts. One part is reflected by the surface of the object, another part penetrates through it and the third part is absorbed by the object. The absorbed energy can cause or accelerate chemical reactions (photolysis, oxidation, hydrolysis) resulting in degradation and decay of organic materials. All natural fibres lose their strength if they are exposed to light. The rate of degradation depends on the intensity of light, time of exposition, temperature and humidity of the atmosphere.

RECOMMENDED VALUES FOR ILLUMINATION

New Slovak archival legislation also deals with protection of archival documents from light[10]. In storage areas the illumination is restricted to the time necessary for retrieval and returning archival documents. If daylight or other illumination sources emit portion of ultraviolet radiation higher than 75 μW/lm, ultraviolet filters removing radiation of shorter wave length than 400 nm and decreasing the portion of ultraviolet radiation to the acceptable above mentioned value must be used. The same values are recommended also by ISO 11799[11] and the British Standard 5454:2000[12]. In archives premises and exhibition areas light sources of the following intensity illumination should be used:[8]

[9] *Publication IEC: Lighting handbook. Eng. Society I11, N.Y., 1981.*

[10] *Vyhláška č. 628 Ministerstva vnútra Slovenskej republiky z 29. októbra 2002, ktorou sa vykonávajú niektoré ustanovenia zákona o archívech a registratúrach a o doplnení niektorých zákonov.*

[11] *ISO 11799: Information and Documentation – Document storage requirements for archive and library materials.*

[12] *BS 5454:2000 Recommendations for the storage and exhibition of archival documents.*

a) up to 300 lux in search room,

b) up to 200 lux in storage areas,

c) up to 50 lux in exhibition areas.

Special requirements and specifications are set up for exhibition of archives[13, 14, 15].

The portion of ultraviolet radiation in archives libraries, museums and galleries is thus minimized under the value of 75 μW/lm and total UV radiation should not exceed the value of 20 mW/m^2.[10, 16]

Recommended values of intensity of illumination for different types of materials are presented in the following table.

Table 2. Recommended maximal values of illumination intensity for different types of exhibits[17, 18, 19]

Exhibits		**Recommended values of illumination intensity (lx)**
The least sensitive	Stone, metal, glass, ceramics, jewels, enamel, minerals	No limits
Moderately sensitive	Oil and tempera paintings, horn, bones, ivory, colourless leather, furniture, ebonite, b&w photographs	150 - 200
Highly sensitive	Water colours, textile, tapestry, drawings, prints, stamps, manuscripts, illuminations, wall papers, colour photographs and slides, natural and botanic exhibits, some minerals	50

[13] *International symposium "Exhibiting Archival and Library Materials and Work of Art on Paper: Standards in Preservation". Ljubljana, Slovenia, June 5-6, 2003. ISBN 961-6137-76-X. National and University Library Ljubljana, Proceedings 2004, p. 195 - 204.*

[14] *Hanus, J.: Exhibition of Archival Documents and Legislation (A Survey of International Legislative Provisions). International symposium "Exhibiting Archival and Library Materials and Work of Art on Paper: Standards in Preservation". Ljubljana, Slovenia, June 5-6, 2003. ISBN 961-6137-76-X. National and University Library Ljubljana, Proceedings 2004, p. 195 - 204.*

[15] *Norme NF Z 40-010 Prescriptions de conservation des documents graphiques et photographiques dans le cadre d´une exposition. AFNOR Juin 2002.*

[16] *764 Environmental Monitor. User Manual, Preservation Equipment Ltd.*

[17] *Cuttle, Ch.: Lighting works of art for exhibition and conservation. Lighting Research and Technology, 20 (No. 2), 43-53 (1988).*

[18] *Cuttle, Ch.: Damage of Museum Objects Due to Light Exposure. International Journal of Lighting Research and Technology, 28 (No. 1), 1-9 (1996).*

[19] *Michalski, S.: Towards Specific Lighting Guidelines. In: Proceedings ICOM-CC, 9. Triennial Meeting, Dresden, 1990, p. 583-588.*

EXPERIMENTAL

Measurements of light conditions in selected areas of some archives and libraries were performed with the help of environmental monitor 764 ELSEC, Preservation Equipment Ltd., UK. [14] The equipment allows determination of portion of ultraviolet radiation expressed in [μW/lumen], total amount of ultraviolet radiation in [mW/m^2] and amount of visible light in [lux]. It can also measure temperature in °C or °F and relative humidity of air. An optional computer interface allows connection to any computer. MS Windows software is provided to display and store UV, visible light, temperature and relative humidity results. A real time graph of the readings can be printed or shown on the computer screen. Technical specification of 764 ELSEC environmental monitor:

Detection of radiation: a pair of silicone photo-diodes connected to the microprocessor

Range of visible wave length (VIS): 400 – 700 nm

Range of measurement of illumination intensity (VIS): 0,1 – 200000 lux

Range of ultraviolet wave length (UV): 300 – 400 nm

Range of total amount of ultraviolet radiation (UV): 2 – 50000 mW/m^2

Range of portion of ultraviolet radiation (UV): 0 – 10000 μW/lumen

Light conditions in several Slovak archives and libraries were measured and evaluated within the framework of the State programme of research and development "Preservation, stabilisation and conservation of traditional information carriers in the Slovak Republic – KNIHA SK"[20, 21, 22]. The conditions in the search room of the Slovak National Archives in Bratislava and one study room at the Slovak National Library in Martin are presented in this work as two examples.

RESULTS AND DISCUSSION

LIGHT CONDITIONS IN THE SLOVAK NATIONAL ARCHIVES

ORIENTATION OF THE BUILDING

Search room as well as a part of archivists' offices are situated along the southeast side of the building (Figure 2).

[20] *Katuščák S.: Chemical Technology of Wood, Pulp and Paper in Culture, Education and Industry. In: Baudin G., Fellegi J., Gellerstedt G., Katuscak S., Pikulik I., and Paris J. (Editors): WPP – Chemical Technology of Wood, Pulp and Paper. 490 pages. ISBN 80-227.1942-0. STU Bratislava 2003.*

[21] *V. Bukovský, D. Katuščák, J. Hanus, Program ochrany papierových nosičov informácií v SR, Buničina a papier – technológie, vlastnosti, životné prostredie. Zborník z medzinárodnej konferencie. Bratislava (2001) p. 179-182.*

[22] *Hanus, J., Katuščák, S., Katuščák, D., Bukovský, V., Rychlý, J.: Integrated effort for paper cultural heritage preservation in the Slovak Republic. International Conference Durability of paper and writings, Papylum, InkCor, MIP, 16. – 20. 11. 2004 Ljubljana. Proceedings of the conference, p. 86-87.*

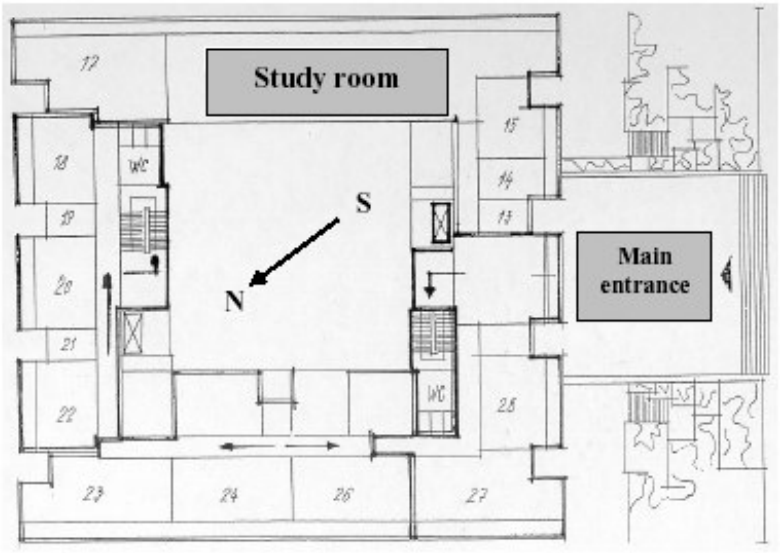

Figure 2. Orientation of the SNA building

MEASURED SPOTS IN THE SEARCH ROOM OF THE SNA

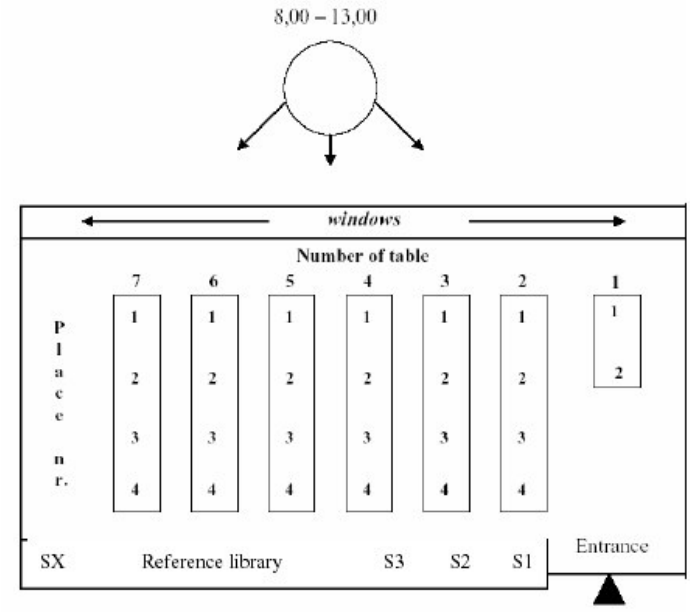

Figure 3. Scheme of measured spots in the search room of the SNA

The above scheme shows placement of tables and places in the search room of the Slovak National Archives and measured spots on tables as well as on the shelves of the reference library where books are stored (however only covers and edges of books are permanently exposed to the light).

LIGHT CONDITIONS IN THE SNA SEARCH ROOM

Date of measurement: September 30, 2005; Time of measurement: 10.00 – 12.00; presented values – average of 3 measurements.

Conditions of measurement: cloudy with sporadic intensive sunshine (frequent and intensive changes during measurement), curtains, no lights in search room switched on.

Table 3. Light conditions on measured spots in the search room of the SNA

Place	VIS (lux)	Total UV (mW/m^2)	UV portion (μW/lumen)	Place	VIS (lux)	Total UV (mW/m^2)	UV portion (μW/lumen)
outside the window	37505	11520	311				
inside between window and curtain	21629	2672	347				
table 1, nr. 1	3161	805	241	**table 4, nr. 4**	779	119	145
table 1, nr. 2	1375	293	202	**table 5, nr. 1**	1529	282	291
table 2, nr. 1	11849	2344	320	**table 5, nr. 2**	664	148	258
table 2, nr. 2	1882	458	246	**table 5, nr. 3**	369	94	258
table 2, nr. 3	1014	262	278	**table 5, nr. 4**	263	65	248
table 2, nr. 4	870	157	186	**table 6, nr. 1**	1232	455	328
table 3, nr. 1	2201	548	276	**table 6, nr. 2**	629	193	312
table 3, nr. 2	1350	339	265	**table 6, nr. 3**	666	167	243
table 3, nr. 3	1091	243	214	**table 6, nr. 4**	751	128	189
table 3, nr. 4	603	135	231	**table 7, nr. 1**	2186	542	256
table 4, nr. 1	1821	549	292	**table 7, nr. 2**	628	228	365
table 4, nr. 2	947	246	246	**table 7, nr. 3**	840	119	208
table 4, nr. 3	662	169	231	**table 7, nr. 4**	486	119	208
Shelves 1	1041	232	224	**Shelves 3**	1333	243	223
Shelves 2	1249	253	221	**Shelves 4**	1259	313	251
recommended limits	**300 - 500**	**20**	**75**		**300-500**	**20**	**75**

Recorded and presented results clearly indicate that all recommended values for safety light and illumination conditions are highly exceeded in the search room of the SNA. The average value of total ultraviolet radiation reached 342 mW/m^2. Recommended value is 20 mW/m^2; that means that this value is exceeded more than 16 times in real conditions in the search room.

Real portion of UV radiation reached average value of 249 μW/lumen. The quoted standards[8, 9, 10] recommend the cutting of UV radiation from any light sources in order that no value should exceed 75 μW/lumen. Real values of UV portion in the search room of the SNA exceeded recommended value 3 times.

That was the reason for deciding to apply protective foils on all windows of the search room as the basic step in protection of documents against light/radiation.

Date of measurement: October 28, 2005; Time of measurement: 12.30 – 13.30; presented values – average of 3 measurements.

Conditions of measurement: sunny weather, blue sky without clouds, curtains, no lights in search room switched on, all windows covered by protective foil.

Average values for places 1 – 4 from all tables and shelves in the search room under the conditions without protective window foil and after application of the foil are presented in ***Figure 4***.

From the recorded data it can be clearly seen that protective foil significantly changed conditions in the search room. Values of illumination of visible light were decreased from several thousands lux to the range of 250–500 lux, the total values of UV radiation from 200–800 mW/m^2 to the average value of 20 mW/m^2 (range 9–33) and portion of UV radiation from 200–300 µW/lumen to the average value of 37 µW/lumen (range 33-47)(recommended 75 µW/lumen).

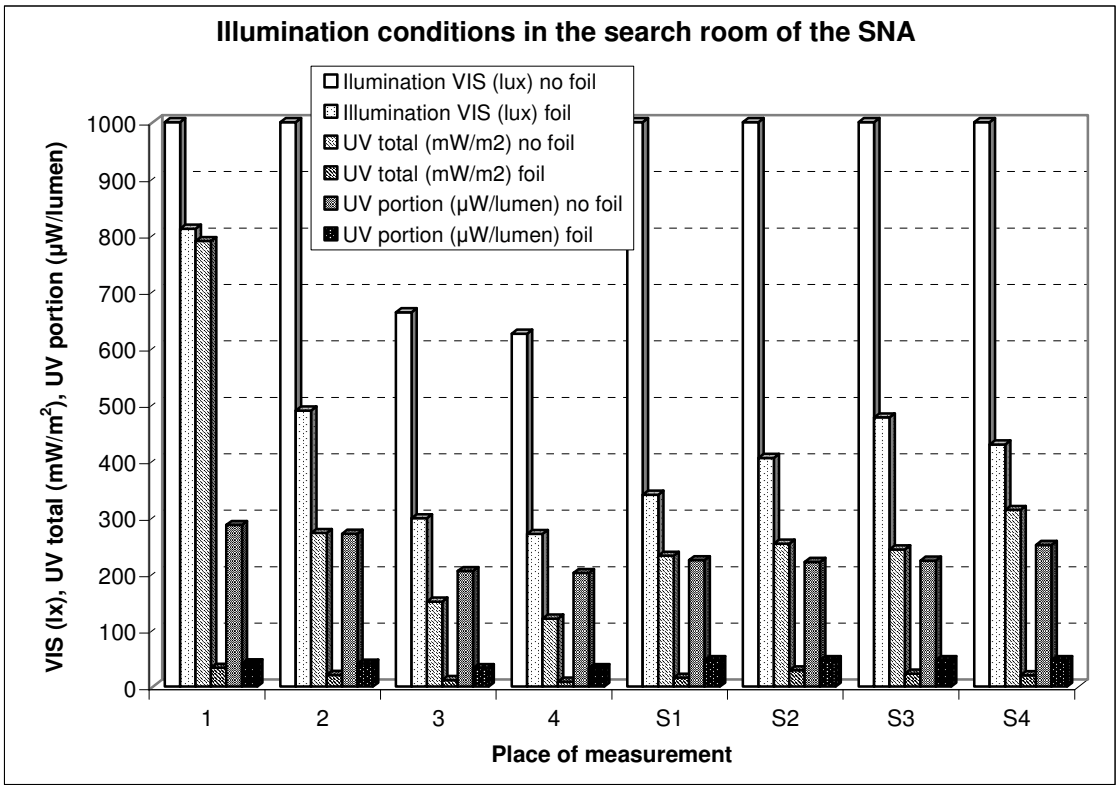

Figure 4. Light conditions in the search room of the SNA without and with protective window foil

LIGHT CONDITIONS IN STUDY ROOM AT THE SLOVAK NATIONAL LIBRARY MARTIN (SNL)

Date of measurement: October 24, 2005; Time of measurement: 15.00 – 16.00; presented values – average of 3 measurements.

Conditions of measurement: sunny weather, blue sky without clouds, no lights in search room switched on.

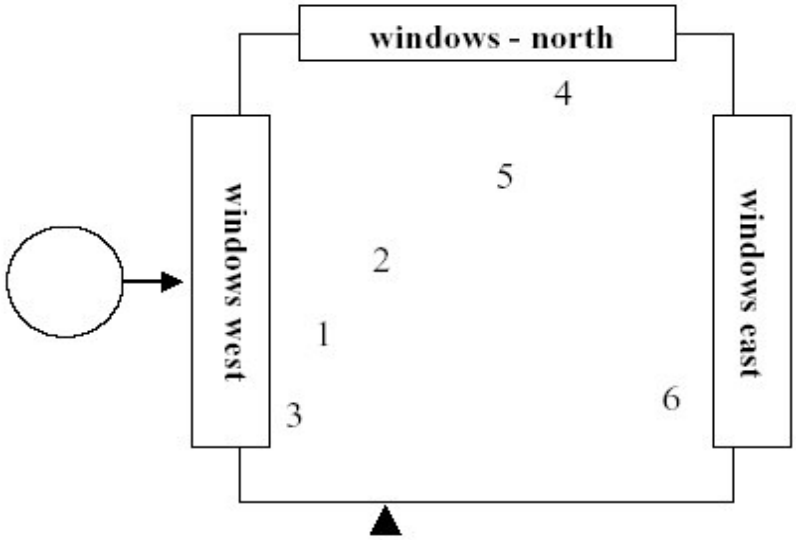

Figure 5. Scheme of measured spots in the study room of the SNL

Table 4. Light conditions on measured spots in the study room of the SNL

Place	VIS (lux)	Total UV (mW/m^2)	UV portion (µW/lumen)	Notice
western side				
(1) table at the window	2469	328	801	direct sunshine
(2) table 4 m from the window	211	319	69	in shadow
(3) table at the window	278	118	33	direct sunshine closed jalousie
northern side				
(4) table at the window	663	636	414	indirect sunshine
(5) shelves 8 m from the window	753	734	568	
eastern side				
(6) table 2 m from the window	343	993	344	in shadow

Situation was similar as in the search room of the Slovak National Archives before installation of protective window foils. Recorded and presented results clearly indicate that all recommended values for safety light and illumination conditions are highly exceeded also in the study room of the SNL. On the basis of this and some other works in this field, the situation will be solved in very near future also at this institution.

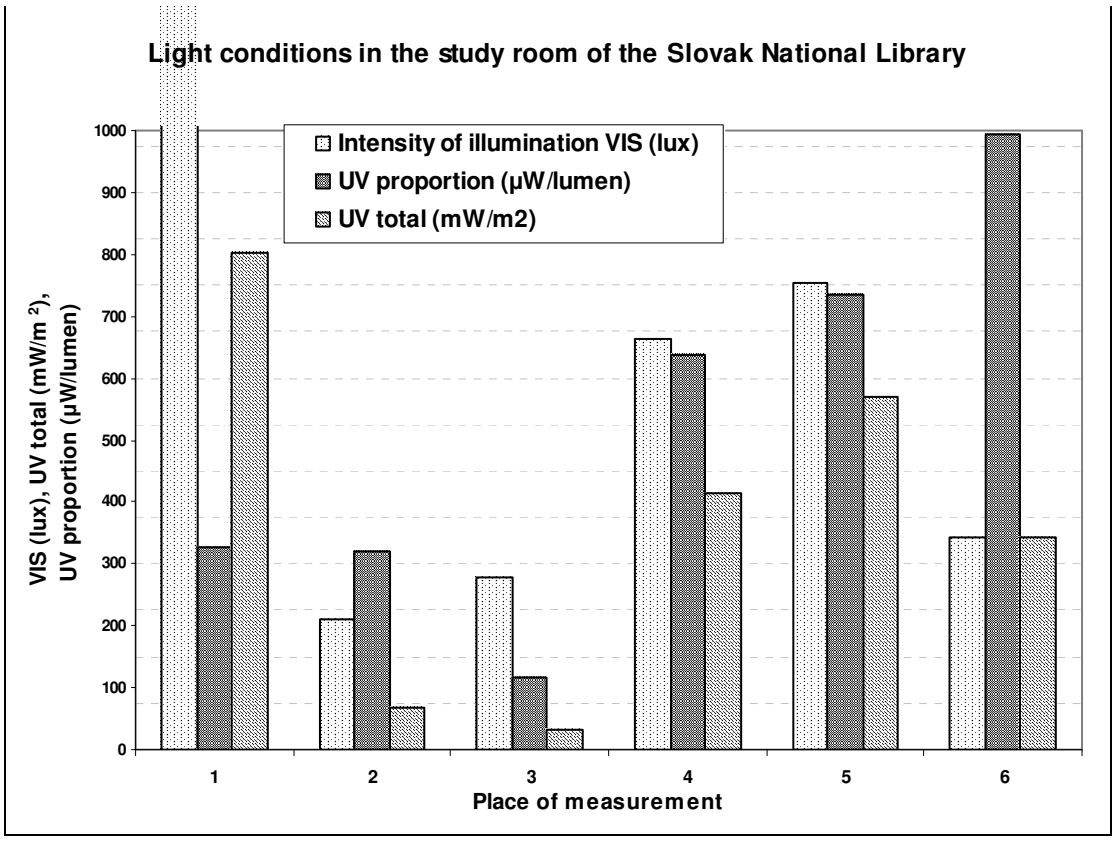

Figure 6. Light conditions in the study room of the SNL

CONCLUSION

Despite the fact that the deleterious effect of light/radiation on paper support of archives and library materials has been proven in many studies and that there exist recommendations as standards for acceptable levels of radiation in reality this task has been very often underestimated. Measurements of light conditions at study rooms of two Slovak national institutions showed that real values highly exceed recommended values given by archival legislation.

Within the program KNIHA.SK also a long-term effect of radiation on archives and library materials is being followed. After installation of protective window foils the values of total ultraviolet radiation in the search room of the Slovak National Archives decreased from average 342 mW/m^2 to 20 mW/m^2. At the same time the average value of UV portion dropped from average 248 µW/lumen to 37 µW/lumen, which is about a half of recommended value given by Slovak legislation in this field.

Acknowledgement

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POVZETEK

PREVENTIVNA KONZERVACIJA – POMEMBNA VLOGA PRI VAROVANJU ARHIVSKEGA IN KNJIŽNIČNEGA GRADIVA

Kljub temu, da so številne študije dokazale škodljiv učinek svetlobe/sevanja na papir, iz katerega je arhivsko in knjižnično gradivo, in da obstajajo priporočila in standardi za še sprejemljive ravni sevanja, je v resnici ta učinek zelo podcenjen. Meritve svetlobnih pogojev v nekaterih slovaških arhivih in knjižnicah so pokazale, da realne vrednosti visoko presegajo z arhivsko zakonodajo priporočene vrednosti. Po namestitvi zaščitne folije na okna so se vrednosti ultravijolične svetlobe v sobi za raziskovanje Slovaškega narodnega arhiva znižale s povprečja 342 mW/m^2 na 20 mW/m^2. Istočasno se je delež povprečne vrednosti UV spustil s povprečja 248 µW/lumen na 37 µW/lumen, kar predstavlja polovico dovoljene vrednosti, ki jo priporoča slovaška zakonodaja na tem področju.