

ICARST 2017

1st International Conference on Applications
of Radiation Science and Technology

Irradiation Method in the Protection of Cultural Heritage Objects Endangered by Massive Biodegradation

Branka Katušin-Ražem, Branka Mihaljević
Ruđer Bošković Institute, Zagreb, Croatia

Mario Braun
Croatian Conservation Institute, Zagreb, Croatia

IAEA headquarters, 24–28 April, 2017, Vienna, Austria

Biodeterioration: permanent problem of safekeeping of cultural heritage objects

Biodeterioration is a widely present natural process which is causing undesirable changes in cultural heritage (CH) objects: alteration of appearance, loss of strength, partial degradation, which eventually leads to complete disintegration.

Safeguarding cultural heritage requires all necessary actions including:

- preventative measures
- all actions aimed at suppression, eradication and control of biodegradation agents

Nevertheless, severe infestations occur in store rooms of museums, collections and sacral spaces¹⁻³, which is an acute problem worldwide

1. International Centre for the Study of the Preservation and Restoration of Cultural Property, ICCROM (<http://www.re-org.info/en>) - "an estimated 60% of the world's collections in storage are inaccessible and deteriorating rapidly."
2. D. Allsopp, K. Seal, C. Gaylarde, 2004. *Introduction to Biodeterioration*, Second ed., Cambridge University Press, Cambridge, UK.
3. P. Tiano, 2001. *Biodegradation of Cultural Heritage: Decay Mechanisms and Control Methods*. CNR Centro di studio sulle "Cause Deterioramento e Metodi Conservazione Opere d'Arte". Via G. Capponi 9, 50121 Firenze, Italy. /http://www.arcchip.cz/w09/w09_tiano.pdf.



Biodeterioration: permanent problem of safekeeping of CH in museums and church premises

The situation in Croatia is similar to conditions elsewhere in the world: serious deterioration in store rooms is caused by insects and moulds.



Museum store room



Sacral collection, CrCI archive

The pronounced problems of biodeterioration of CH objects in case of natural and man-made catastrophes

Intense biodegradation of CH objects is provoked by abrupt changes of stable state and optimum keeping conditions caused by:

- natural catastrophes (floods, earthquakes, etc.)
- man-inflicted activities and conflicts (wars, riots,



War in Croatia: St. Mary, Gora, Petrinja (1992).



The flood at the Morgan Library, CO State University USA (1997)

The consequent repositioning of a large number of objects in the course of a necessary rescue operation brings infested and uninfested materials in mutual contact, which leads to an abrupt development of pests and endangers whole collections.



Methods suitable for rescuing large quantities of CH objects endangered by biodeterioration

The suppression of massive biocontamination of CH objects requires fast processing of large quantities of materials. The suitable methods are:

- treatment with poisonous gases
- treatment with ionising radiation

The use of ethylene oxide is severely restricted nowadays.

Irradiation proved an effective physical, noncontact method of preservation, applicable to massive treatment of cultural heritage objects.

- Simple and safe to apply
- Non-contact action
- Acceptable cost
- Rapid, duration measured in hours
- Leaves no residues
- Does not induce radioactivity



B. Katušin-Ražem, R. Jagić, M. Braun, *Irradiation as a method of salvation of cultural heritage objects under massive jeopardy* (in Croatian) // Proceedings of the Ninth Symposium of the Croatian Society of Radiation Protection / Knežević, Ž.; Majer, M.; Krajcar Bronić, I. (Eds.), Zagreb: HDZZ, 2013. 77-83.

Radiation desinsection, a suitable treatment of entire infested museum collections

Irradiation method is most often applied for desinsection of wooden CH objects (about 90 % of all our treatments)

Radiation desinsection in mass treatment of entire museum collections during regular and urgent clean-up and renewal actions, represents an example of especially successful application of irradiation method

France:

(2004) Gadagne Museum¹

The entire collection of the Historical Museum of Lyon (about 200 m³ mostly wooden objects), was treated for desinsection by irradiation at the ARC-NucléArt in Grenoble in the process of rearrangement, cleaning up of the museum and repositioning of the objects.



1. Conservation-restauration du patrimoine. Objets en bois sec. In: Art-Nucleart Rapport de Activite 2004. p 46. Atelier Régional de Conservation NUCLÉART, CEA Grenoble, France

Radiation disinfection in rescuing of CH collections heavily endangered by moulds

Professional literature presents some especially successful cases of radiation decontamination of heavily infested large collections:

Romania:

(2001) film archive, tens of boxes of film rolls (300 rolls), heavily infested by moulds, were successfully treated with 25 kGy.¹



Poland:

(2001) 60.000 pieces of prisoners' shoes, exhibits from the Majdanek Nazi Camp Museum, were irradiated with 19 kGy²

1. A. Mitran, C. Ponta, A. Danis, 2002. *Traitement antimicrobien des films cinématographiques au moyen du rayonnement gamma*. In: La Conservation à l'ère du Numérique. In: Proceedings of the 4th International Days of Research of the Association for Scientific Research on Graphic Arts (ARSAG), Paris, 27–30 May 2002. Association pour la recherche scientifique sur les arts graphiques (ARSAG), Paris, France. pp. 235

2. J. Perkowski, T. Gozdicki, 2002. *Disinfection of prisoners' shoes from the National Museum in Majdanek*. Conservator–Restorers' Bulletin 13 (3–4), 219–223.



Radiation disinfection in rescuing of CH collections endangered by moulds (cont.)

The Netherlands:

(2006) A famous collection of books in international law and archives of the Peace Palace Library, The Hague, had to be moved to a new place. Prior to transportation, archival and library materials had to be cleaned, dusted and subjected to urgent mould and insects eradication. Radiation disinfestation with 10 kGy was applied, followed by vacuum cleaning.



Clean treated materials are kept in new storage under controlled conditions.

J. Havermans, *Gamma Disinfection of Ligno Cellulose Historical Collections*,
New Approaches to Book and Paper Conservation-Restoration, P. Engel, J. Schirò, R. Larsen, E. Moussakova & I. Kecskeméti,
ed. Wien/Horn: Verlag Berger 2011, XXIV, pp. 559– 574.

Radiation disinfection in rescuing of CH collections endangered by moulds (cont.)

USA:

(1982) abandoned collection of the Alan Mason Chesney Medical Archives, Johns Hopkins Medical Institutions, Boston, MA

295 packages of heavily infested archival and paper materials were irradiated with 4.5 kGy. Monitoring of treated artefacts over 8 years revealed no apparent changes:

“the project has to be considered a success”¹

(1997) water-damaged book collection,

The Morgan Library, Fort Collins, CO

Library collection at the Colorado State University suffered the largest water-related library disaster in the USA. After a rapid outbreak of mould infection, 425 000 soaked books were freeze dried and successfully treated with 15 to 25 kGy²



1. *Gamma radiation*, Abbey Newsletter, Volume 8, Number 2, Apr 1984

<http://cool.conservation-us.org/byorg/abbey/an/an08/an08-2/an08-201.html>

2. R. Silverman. *The Day the University Change*

<http://cool.conservation-us.org/byauth/silverman/day/index.html>



Croatia: Irradiation facility at the Ruđer Bošković Institute (RBI), Zagreb

Panoramic batch-type, dry storage ^{60}Co irradiator (erected 1967)

Pilot plant level (50 kCi): 1983

presently (2017): ~ 80 kCi (~ 2900 TBq)

Irradiation chamber:

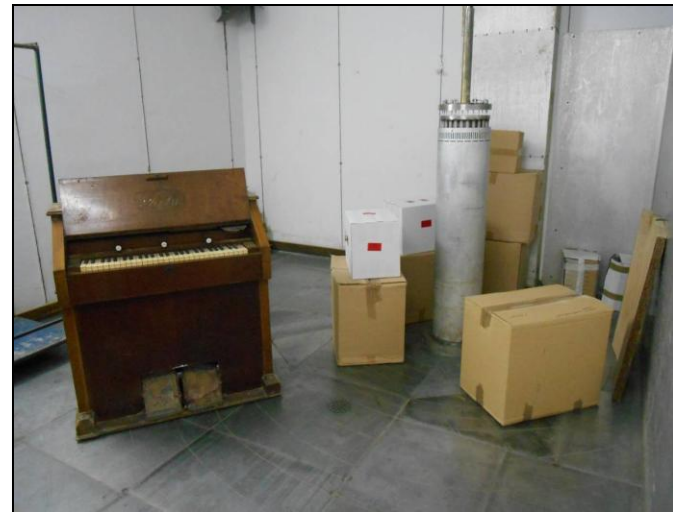
- rectangular room: $4.9\text{ m} \times 3.9\text{ m} \times 3.5\text{ m}$ high
- capacity $4 - 6\text{ m}^3$ of material ($\sim 800\text{ m}^3/\text{year}$)

Applications:

- multipurpose services: desinsection, disinfection and sterilization of medical, pharmaceutical, cosmetic and food materials¹
- 30 years application to CH objects protection, about $20\text{ m}^3/\text{year}$, mainly wooden objects

Recommended doses:

insect eradication	0,5 - 2 kGy
fungi control	5 - 18 kGy
decontamination	10 - 25 kGy

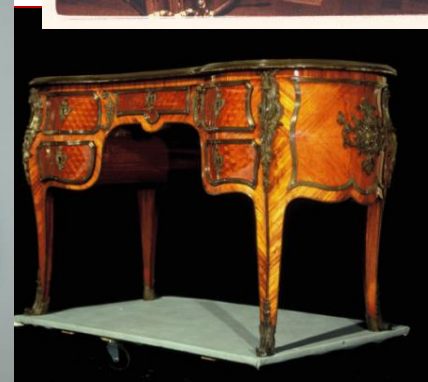
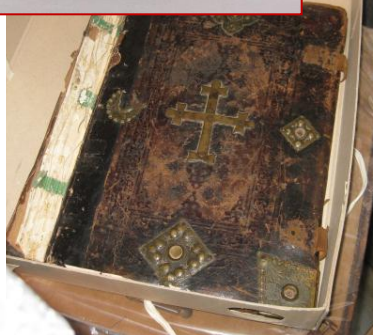
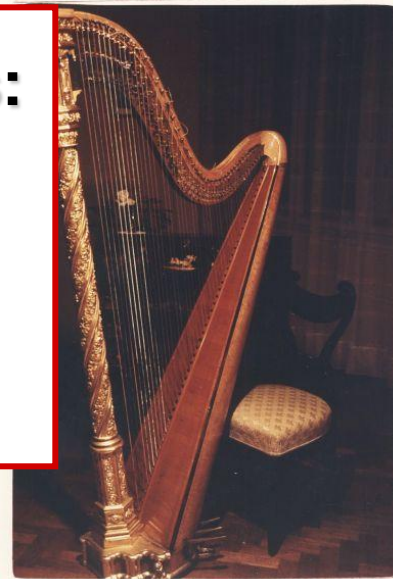


Radiation treatment of cultural heritage objects in the RBI facility

In colaboration with Croatian Conservation Institute and all interested parties

Treated by irradiation over 25 years:

More than 8,000 wooden sculptures, parts of altars, furniture pieces, tools, musical instruments, other wooden, paper, leather, textile, straw items, etc.



B. Katušin-Ražem, D. Ražem, M. Braun, *Irradiation treatment for the protection and conservation of cultural heritage artefacts in Croatia*, Radiat. Phys. Chem., 78(2009)729-731.

Radiation treatment of cultural heritage objects in the RBI: Cooperation within the IAEA system

Regional Technical Cooperation Projects:

RER 1006 (2006-2008): *Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region;*

RER 8015 (2009-2011): *Using Nuclear Techniques for the Characterisation and Preservation of Cultural Heritage Artefacts in the Europe Region;*

RER 0034 (2011-2013): *Enhancing the Characterization, Preservation and Protection of Cultural Heritage Artefacts;*

RER 0039 (2014-2015): *Extending and Diversifying the Application of Nuclear Technology in Cultural Heritage*

The significant outcomes of the IAEA RER projects so far:

At the IAEA Task Force Meeting in Grenoble, France, 2009, the participating invited experts from Romania, Poland, The Netherlands, France and Croatia, recognizing pitfalls in the field, kicked off the idea that a book on CH irradiation should be published by the IAEA.

The book “Uses of Ionising Radiation for Conservation of Tangible Cultural Heritage,” (IAEA Radiation Technology Series No. 6) is due to be published soon.

IAEA Coordinated Research Project (2016-2019): Disinfection and Consolidation of Archived Materials and Cultural Heritage Artefacts by Radiation Processing Technique.



Selected case of massive radiation desinsection

I: Contemporary art objects

Museum of Contemporary Art, Zagreb (MSU), received in 2007 the entire inventory of Atelier Kožarić (~ 6000 items: sculptures, reliefs, assemblages, objects, paintings, prints, drawings, etc) for future permanent exhibition, management and maintenance.

Before moving into new Museum building a large number of objects were treated with 2 kGy for preventative and curative purposes.

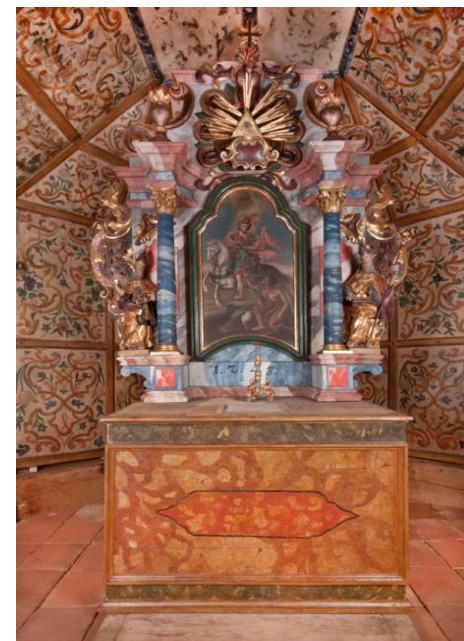


I.R. Janković, *Project "Atelier Kožarić". Conservation of objects by irradiation desinsection.* (Poster No. 11)
Seminar: [Irradiation Methods in the Protection of Cultural Heritage](#), Mimara Museum, Zagreb, 4 - 5 Oct 2011. Croatian Conservation Institute - Ruđer Bošković Institute, Zagreb (2011).

Selected case of massive radiation desinsection

II: Wooden chapel of St. Martin, Stari Brod

The wooden chapel of St. Martin is a rare example of a traditional folk Baroque architecture with a completely preserved painted interior. Prior to conservation it was in the poor state due to roof leakage and high humidity.



The altar was removed from the chapel in 1994 for the exhibition, restored and put in CrCI depot until completion of the restoration of the chapel itself.

The works on the chapel started in 2001. One of the first steps was radiation desinsection of all 88 wooden painted panels with 2 kGy at the RCDL, RBI before proceeding to subsequent lengthy conservation restoration procedures.

By 2015 the renovation was completed and the chapel returned to its function.

Radiation treatment in rescuing large quantity of CH objects during the war in Croatia

The war against Croatia 1991-1995, which followed the breakdown of Yugoslavia put many cultural objects on the Croatian soil to severe peril.

In anticipation of war, in 1991 the Institute for the Protection of Cultural Monuments of the Croatian Ministry of Education, Culture and Sports initiated a massive action of withdrawing CH objects from immediate war zone. The collections of museums and galleries, churches, libraries and archives were moved into previously determined, very often improvised, storage spaces¹.

On the territory of northern Croatia there were 15 pre-selected secret depots outside the areas affected by war operations.

In joint actions of conservators and restorers, church authorities and other involved groups and individuals, with wholehearted cooperation and support by the (then) Croatian National Guard, later to become Croatian Army, about 5,000 objects, mostly polychromic sculptures, altar parts and other wooden objects, comprising about 3,000 complete altars, were evacuated to safer places.

 ¹ Ž. Laszlo, *Protection and restoration of movable cultural monuments in war*. (in Croatian). Informatica Museologica, No.1 - 4 (1992) 58-61.

Radiation treatment in rescuing large quantity of CH objects during the war in Croatia (cont.)

Cooperation of Croatian conservation Institute (CrCI) and RBI:
Especially successful case of protection of heritage objects in Croatia

Inadequate safeguarding and keeping, repositioning, inadequate temporary shelters and other adversities of war caused severe deterioration of CH objects susceptible to biodegradation.

To mitigate the problem of massive biodeterioration it was decided to irradiate endangered CH objects by ^{60}Co gamma rays at the RBI as an interventive and/or preventative treatment¹.

Supervised by the CrCI, more than one third of CH objects evacuated from northern Croatia, mostly polychromic sculptures, parts of altars and other wooden pieces, comprising about several hundred complete altars, were transported to the RBI for desinsection or, if necessary, disinfection.

Irradiation treatment enabled their safe storage jointly with many other such objects prior to their conservation and restoration, without the risk of cross-contamination. Significant number of objects were stored in the newly prepared CrCI spacious depot in the Batthany castle, Ludbreg.



Selected case of rescuing CH objects in war I: St. Ladislaus, Pokupsko (1736 - 1739)

The church was heavily damaged by an incendiary bomb in 1991, affecting mostly wooden inventory. It was grouped in 13 assemblies: 5 altars, a pulpit and 7 assorted artefacts and distributed to various improvised shelters.



Each group of was treated by irradiation with 2 kGy at the RBI facility before being brought into the restoration workshops at the CrCI in 1995.

The conservation restoration works extended until 2014.

A. PEDIŠIĆ, *Wartime evacuation and an overview of protective treatments on the movable furnishings from parish church of St. Ladislaus in Pokupsko*, (in Croatian), Portal, 5 (2014.), 193-210, 193.

Selected case of rescuing CH objects in war II: Polychromic sculptures, St. Mary, Gora, Petrinja

Polychromic sculptures remained buried in the crypt of the church destroyed at the beginning of the war. After 6 years, in 1997, seven of them were found in poor state, soaked and covered with dirt and mud.



Sculptures were processed by cleaning, drying, irradiation with 20kGy for decontamination, and with 5 kGy after recontamination appeared. After conservation & stabilisation the sculptures were stored at the CrCI depot.

M. Braun, N. Krstulović, L. Lalić: *Overview of the current state of wooden polychromed sculptures from Gora* (poster No. 2), Seminar: [Irradiation Methods in the Protection of Cultural Heritage](#), Zagreb, 4 - 6 Oct 2011. Croatian Conservation Institute - Ruđer Bošković Institute (2011).



Conclusions

For more than 25 years Croatia has been following leading trends in conservation and has been able to contribute to successful application of radiation treatment for the prevention of CH biodegradation in Europe.

The international community recognized the use of irradiation desinsection and disinfection for the preservation CH objects against massive biodeterioration during the war in Croatia (1991 - 1995) as an example of successful application¹.

As a result of more decades of worldwide experience and on the basis of collected knowledge it is safe to say:

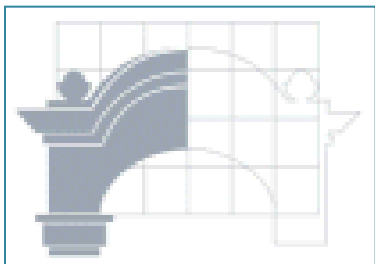
- ❖ Desinsection by irradiation has proved a suitable method in situations demanding a large number of objects to be treated in a short period of time, such as arise during renovation of buildings or repositioning of entire numerous collections attacked by insects.
- ❖ In addition to that, disinfestation by irradiation has proved to be the method of choice in cases of massive jeopardy by fungi and moulds arising in consequence of elevated humidity caused by catastrophes .

¹News in Conservation, August 2007; <http://www.iiconservation.org/publications/nic/nic.php>



ICARST 2017

Thank you!



EU Prize for Cultural Heritage / Europa Nostra Awards 2017 for St. Martin's Chapel in Stari Brod and art historian Ferdinand Meder