Irradiation Conservation of Cultural Heritage

Introduction

Natural polymers, including cellulose, lignin, or collagen, are biodegradable. This is a great chance for the world in the time-perspective. In their lack, the world was supposed to be already collapsed for a long time under a huge amount of wastes.

Biodegradation is due to the insects and microorganisms like bacteria or fungi. For them natural polymers are nutrients. Water, oxygen, polluting gases from the atmosphere, acids (from soil in the case of buried objects or those produced into the paper during its aging), temperature, and light are other aggressive agents inducing structural modification. The mentioned physical and chemical factors may independently act and/or synergistically interfere in biodegradation.

While one could say the past is lost by biodegradation, there is also a pragmatic point of view associating to biodegradability a great concern of humankind. An important part of the cultural heritage inventory is preserved in objects made of the same biodegradable materials, including wood, leather, textile, and paper. To lose them means to lose a part of humankind's identity.

Different fighting methods against biodeterioration have been established and used.

Based on its biocide effect, gamma irradiation could be used for disinfestations and conservation purposes. Important advantages can be mentioned in favor of irradiation treatment:

- the treatment associates no risk for the operator; it is performed only in the irradiation room, which is a confined and protected area;
- the treatment associates no risk for restorer, curator, visitor, or environment; no toxic or radioactive residues remain in the treated item;
- excellent efficiency is extended on the whole inner volume based on excellent penetration of gamma radiation; alternatively, any gas treatment efficiency (anoxic or

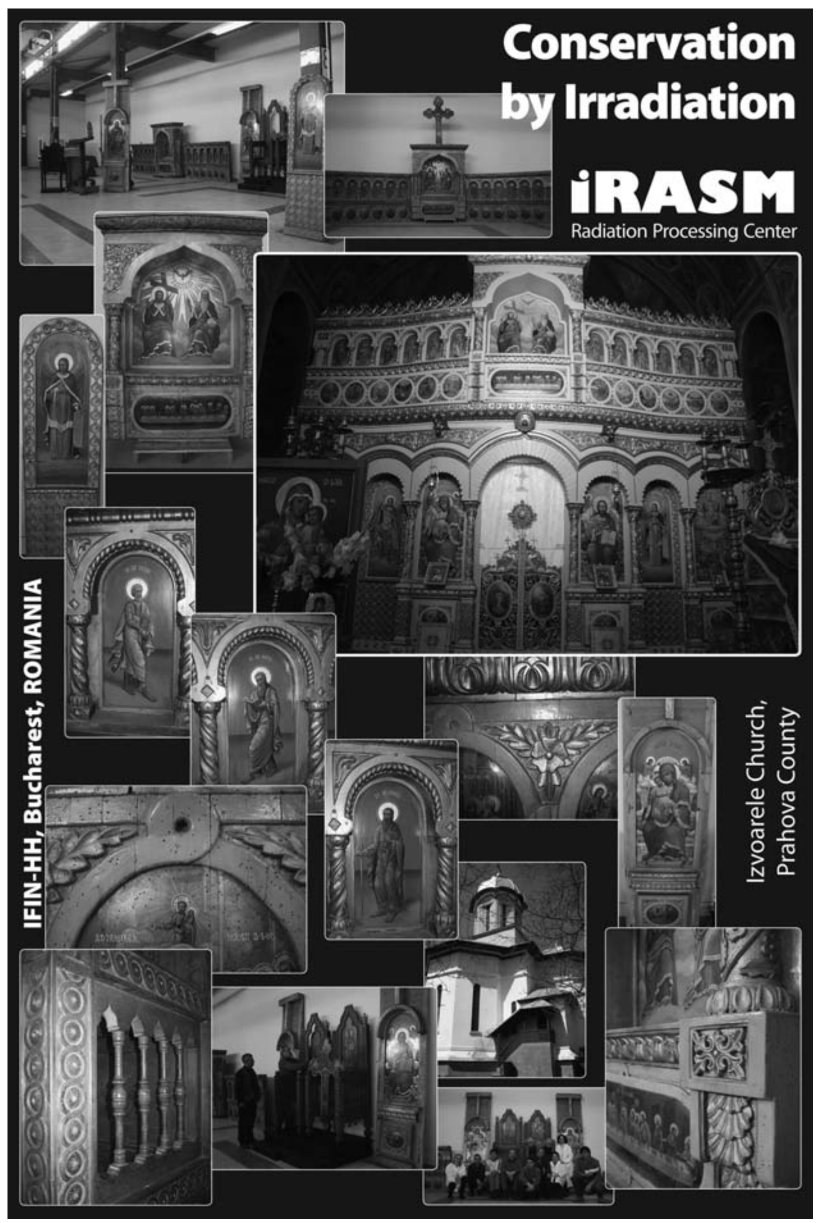

Figure 1. *Izvoarele Church.*

poisonous gases) is limited by diffusion;
- efficiency is correlated with absorbed dose, which is a parameter easy to measure and control;
- excellent reliability based on the fact that the irradiation field is always the same;
- large amounts of objects can be treated simultaneously;
- treatment in industrial facilities is performed in a short time;
- attractive cost.

In the same time, interaction of gamma rays with any substance may change its chemical and physical properties. The effects are cumulative. The change is proportional with the irradiation dose. Repeated treatments have to be considered with great care. Depending on specific items to be treated, also on its importance for cultural heritage, one may use well-established safety doses or may perform supplementary tests.

The irradiation conservation is applied especially when one of the following circumstances is present:

- emergency intervention (e.g., Alan Mason Chesney Medical Archive—USA [1]);
- intervention on objects with complex structure (e.g., Ramses II mummy—treated in France [2]);
- intervention on large objects/assemblies (e.g., Romanian Film Archive [3], iconostases—Romania);
- classical methods cannot be applied (e.g., a gas chamber is not available);
- cost/benefit rate supposed or has to be low (e.g., icons from parish churches—Romania).

To better understand in what circumstances such a technology may be used a brief review on the meaning of cultural heritage is necessary.

"Cultural heritage" is a broad concept including abstract ideas, mentalities, beliefs and habits, also objects illustrating all live aspects of a community: buildings, worship and cultic items, tools, furniture, clothes, artistic and scientific achievements.

For ancient times, preserving cultural heritage means to preserve objects. They are the only remains to discover and reconstruct ancient cultures. All of them are considered for conservation and study at any cost. The conservation act is decided by high-ranked specialists.

For historical times, cultural heritage preservation seems to be an easier task. There are plenty of elements to reconstruct a cultural moment: written documents and other abundant and varied material remains. Sometimes persistence of mental products may be found. Some cultural products are still in use, like churches for instance. Having to choose, guardians of cultural heritage notice not all remains are relevant or precious. There are too many that one could even think to preserve them all. The decision for conservation is often taken at the level of small communities, taking into account not only the object relevance but also cost/benefit ratio.

Radiation treatment in industrial facilities is probably the only realistic alternative that can be chosen in case of emergency like the one described in what follows.

Radiation Treatment Applied at the Whole Wooden Inventory from a Parish Church Under a Massive Attack of *Anobius punctatum*

The church from Izvoarele village was constructed in 1935. Internal decoration—wooden pieces, furniture, and painted panels—was performed by people native to or living in the village. Some of them used to have engagements with the royal house. Especially for this reason the church was important for local community.

The inventory consisted of 6 × 8 × 0.8 m *iconostasis* (great painted wooden wall separating the altar and narthex in Christian Orthodox churches), balcony, holly chairs, and other cultic pieces. Most pieces were linden made. Although the decoration is beautiful, the church is not considered among the special heritage objectives under care and surveillance of the Ministry of Culture.

Facing an active attack and an advanced biodegradation stage, the priest and local council decided for a conservation/restoration intervention. After unhappy and costly tests using conventional methods, the priest took into consideration irradiation disinfection. The *iconostasis* was dissembled and transported together with the rest of the inventory to IRASM irradiation facility. The largest piece was 3.2 m long.

Brief Description of the Irradiation Facility

IRASM facility is a category IV gamma irradiator. When not in use the source is sheltered in a water pool 6 meters deep. During irradiation the source is lifted up in the air. During normal utilization the goods to be treated are placed in aluminium tote-boxes moving in the irradiation field. The tote-box movement is supported by a conveyer. The tote-box volume is rather small and has unchangeable dimensions (50 × 50 × 90 cm).

Due to geometrical restrictions, the irradiation procedure applied for medical devices is not applicable for the treatment of church items. The wooden pieces were placed against the inner wall of the irradiation chamber to not interfere with conveyer pass.

Dosimetry

The evident enemy was the insect *Anobius punctatum*. An experienced biologist detected old fungi infestation since the wood was into the forest (!). A dose between 0.7–1.3 kGy is accepted to be enough for killing larvae and to prevent the emergence of adult insects [4]. Fungi are killed by a total dose of 10–12 kGy [5]. Mechanical properties of wood are affected at doses over 10 kGy [6].

Irradiation doses were chosen following historical experience and taking into account the aforementioned information. No supplementary tests on possible modifications of treated materials have been performed.

Except in very small items one can expect a variation in dose received by different parts of the treated object. The pieces were placed in the irradiation chamber in positions with known 3-D dose mapping. The ratio between maximum dose and minimum dose was less than 2.

Ethanol–chlor benzene dosimetry system (ECB) was used. The dosimeter is a sealed ampoule. The solution conductivity is measured by oscillometry. ECB ampoules do not lose information during reading. Irradiation may be stopped for accumulated dose checking. If it is not sufficient, irradiation is restarted. IRASM ECB dosimetry system is traceable to High Dose Reference Laboratory RISO–Denmark.

Up to 10 dosimeters were attached to the items to follow the accumulated minimum and maximum doses. Doses between 4.4–7.6 kGy were applied.

Treatment Moment

Insects have 4 living stages: egg–larva–pupa–fly. *Anobius punctatum* is dangerous for wood in its larval stage. In this stage it is also radiation sensitive. Most insects have a flying season. After this moment the insect lays eggs. Being a resistance stage, eggs are more radiation resistant than larvae and pupae. In Romania *Anobius punctatum* flying season is in the month of May. The treatment was performed in December.

Conclusions

An emergency treatment was applied for disinfestations of the entire wooden inventory of a parish church (see Figure 1). Approximately 10 m^3 of wood items of various shapes have been treated. The treatment lasted 4 days. There was no subjective evidence of color modifications on paintings.

After radiation disinfestations the pieces were reassembled, insect holes filled following a proper procedure, and paintings restored.

The treatment was efficient. After 4 years no sign of re-infestation appeared.

Although irradiation treatment is an excellent method of conservation in well-defined situations, it is rarely used. This has happened mostly because subliminal connections are made with nuclear bombs and radioactive contamination. Considered an exotic method irradiation conservation is not well understood by the objects' owners, which usually are decision people in choosing the intervention treatment. A real understanding should be based on a complex approach and an interdisciplinary decision team.

A rational reason must be also mentioned. It is connected to the side-effects evaluation. The relevance of scientific studies on this subject is limited by the difficulty of establishing the characteristics of a reference sample in case of materials of natural origin. However, this aspect is now taken into consideration by the scientific community, at least for the wood, in the frame of COST Action IE0601—Wood Science for Conservation of Cultural Heritage. Extended from 2007 to 2011, the project agglutinates in an interdisciplinary team of scientists and conservators of various experience and background, including radiation scientists from IRASM department.

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