

Application of low energy X-rays for conservation and restoration of Nguyen dynasty woodblocks in Vietnam

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The woodblock of the Nguyen dynasty of Vietnam is one of the World Documentary Heritage recognized by UNESCO. Fungi and termites play a considerable role in the deterioration of these woodblocks. Both chemical and physical methods have been developed for treatment and restoration, and their results are not as expected. Based on the merit of low-energy X-rays, such as their low shielding requirements, cost-effectiveness, easy transport to storage places like museums and libraries, as well as the demand for reducing the negative effect of fungi and understanding the inner deterioration of woodblocks from the restorer; low-energy X-rays seem appropriate for conserving treasured wooden cultural heritage objects. In this study, the effects of low-energy X-rays irradiation were investigated for disinfection of fungi-contaminated woodblock and inspection of the internal damage level of woodblock by termites.

Decontamination of woodblocks by X-ray irradiation was studied at 160 kV, 18.6 mA (3 kW). Fungi were isolated from these woodblocks, and *Cladosporium* sp. was identified as the most radiation-resistant strain in the woodblock. The dose rates of the 1-mm-aluminum filter that was used to cut the low energy part of the X-rays and non-filtered X-rays at the woodblock's surface were 1.14 and 4.64 kGy/h, respectively. At the woodblock middle (8.5 mm from the surface), the doses of the filtered and non-filtered X-rays decreased to 76% and 20% of the surface doses, respectively. The concentration of the fungi in the middle decreased by more than 4 log fractions at 6.2 kGy, and the fungi were eliminated with a surface dose 8.3 kGy. Furthermore, the contaminated fungi in the woodblock were disinfected by both-side irradiation with filtered X-rays delivering a dose of 10 kGy at a dose uniformity of 1.04. The low-energy X-rays showed their effectiveness in disinfecting fungi, and a cut-off filter (1-mm-aluminum) could be recommended to avoid high surface doses of the X-rays. X-Ray Radiography can provide morphological and physical information on the inner structure of woodblock. X-ray Computed Tomography (CT) was used for the whole 3D inspection of a woodblock. The results 3D obtained were very satisfactory, but it took a long time and was expensive. Whereas X-ray images from the surface can detect the hole and tunnels within the woodblocks caused by termites. Therefore, in this study, the simple method, Radiographic testing for the woodblock in the two directions with an X-ray generator (MG165: COMMET group) at 50kV and 4mA, was carried out to detect the deterioration inside the woodblocks by termites. Based on this data, adequate conservation and restoration procedures will be proposed.

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