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Development of Urgent Conservative Treatment by using Seawater for Flood-Damaged Paper Cultural Heritage

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Summary

Concentrative heavy rains and the consequent floods have been increasing these days because of abnormal weather phenomena caused by the global warming. Main problems of flood-damaged papers are subsequent fungi growth and cohesion between book pages. To avoid these problems, the freeze-drying method is currently adopted as a standard for paper cultural properties. However, this method requires expensive apparatus and long freezing terms. Therefore, we proposed a new simple method of the salt water immersion.

We focused on salt water effects on preventing fungal growth. Salts in the standard artificial seawater and microcrystalline cellulose were added to a liquid culture (Wood) medium and the amount of growth of *Trichoderma reesei*, a cellulose-metabolizing fungus was measured. At 3.2% or higher salt concentrations, it did not grow at all. This critical concentration is similar to those of general seawater, suggesting that it can be applied for fungi growth prevention. Individual salts contained in seawater such as NaCl, KCl, $MgCl_2$, and $CaCl_2$ exhibited solely similar tendencies. In addition to *T. reesei*, *Aspergillus terreus* and salt-tolerant *Aureobasidium pullulans*, both of which are fungi that grow typically on paper, were inoculated into a Wood medium with artificial seawater salts and a sheet of copy paper as a substrate. The growth was inhibited more greatly with increased salt concentrations for all the fungi. At 3.5% or higher salt concentrations, the growth was almost completely inhibited, except that *A. pullulans* grew with thin mycelia and small sporangium that were observed by scanning electron microscopy again as a salt effect.

Adverse effects of residual salts in paper on the tensile strength were evaluated. A hydrophilic laboratory handsheet immersed in artificial seawater of 3.0% and dried contained 14% and 7% (when wiped) salts based on the original dry sheet mass. The tensile strength of the salt-containing sheets was lower by about 18% and 10%, respectively than that for the handsheet immersed in distilled water. This strength reduction level as low as 10% is not much serious in handling.

The salt water method was found to be promising for effective conservation of flood-damaged papers. The rescue activity for cultural properties damaged by the Great East Japan Earthquake was organized by the Agency for Cultural Affairs of Japan. We presented the effectiveness of this method as one option of first-aid treatments in the first meeting of the activity. After the meeting, we created an operation manual because this method is potential to be applied practically to paper and documents damaged by the earthquake and tsunami.