

## CASE STUDY ON THE SYSTEM FOR DECOMPOSITION OF GARBAGE BY USING SMALL WOOD PIECES TREATED IN THE HOT SPRING WATER

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### ABSTRACT

*We invented a new system to decompose garbage completely during short period by bacteria in the small woodpieces treated with geothermal water and geothermal energy from the Matsukawa Geothermal Power Plant in Iwate Prefecture, which is the first geothermal power plant established in Japan.*

*We found that the small wood pieces can be used as fine places which cultivate bacteria as the decomposer of garbage, since the wood materials has many porous sites after treatment in geothermal water or hot spring water for several days. These porous sites work as places for propagation of bacteria. Generally, a conventional system for decomposing garbage uses small ceramic balls or saw dusts to cultivate bacteria and needs some special bacteria in it. However, this system does not need any bacteria. Therefore, this system is more simple and economical. This system can decompose 150 kg garbage for 12-24 hrs to generate gases (CO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>O etc.) and so there was nothing remained except some bones of meat.*

*This system would get an advantage over the others to solve garbage problems in a big city and to use unused lumber from thinning by financial reasons of using geothermal water and geothermal energy.*

### 1.0 INTRODUCTION

The best use of resources and geothermal energy has lately been paid considerable attention not only for solving environmental and energy problems but also for developing local areas in Japan. The geothermal water from the Matsukawa Geothermal Power Plant was heat-exchanged with river water, which directly contributes to the betterment of life in the local residents through facilities such as the heating system for schools and for plants. However, no attempt has been carried out to develop the new technique to produce fine goods by using the geothermal water and energy, which influences local industries directly. We have reported the case studies on developing local industry in Iwate by using the geothermal water and energy such as "Geothermal Dyeing" and "Geothermal Wood" (Sasaki et al., 1997).

In the present work, we tried to analyze some woods treated in the geothermal water or the hot spring water for clarifying their characteristics. As a result, we recognized that the treated woods became lightweight and have many porous sites (Sasaki et al., 1997). We also tried to find new peculiarities on the structures of the treated woods and ideas for industrial use. Then, we did experiments to find the differences of structures between two woods treated by using hot spring water and H<sub>2</sub>SO<sub>4</sub> solution. We considered micro-porous areas in the treated woods.

In this study, we report the decomposing garbage system to use the small wood pieces treated in the geothermal water by cultivating bacteria in these micro-porous areas.

## 2.0 EXPERIMENTAL

### 2.1 Treatment of wood

A conifer, SUGI (*Cryptomeria japonica* D.DON), and a broadleaf tree, NARA (*Quercus serrate Murray*), were used. SUGI has two types, heartwood and sapwood. Dimensions of the specimens were 2.0 cm (L) × 2.0 cm (R) × 1.0 cm (T). They were boiled in the artificial hot spring water (AHS-water) or H<sub>2</sub>SO<sub>4</sub> solution of pH 2.3 or 2.7 for several hours. AHS-water was filtrate of YUBANA solution. YUBANA was a precipitate of mineral matter in the hot spring water at Matsukawa, Iwate. Table 1 shows the chemical component of AHS-water and hot spring water.

### 2.2 X-ray diffractometry

X-ray diffractograms of the treated woods were obtained with 2.0 cm<sup>2</sup> square disks prepared. The X-ray diffractometer used was a JEOL JDX-8200. The equatorial diffraction pattern was measured with Cu-K  $\alpha$  radiation generated at 40kV and 30 mA. Length and width-of crystalline regions were estimated by the measurements of (040) reflection and (002) reflection according to Scherrer's method (Cullity, 1995).

### 2.3 Decomposing system

#### Materials

Wood pieces of SUGI (5-10 mm) were treated in the geothermal water at 90°C for 3 days in Matsukawa, Iwate. After being treated, these pieces were dried and kept for experiments.

#### Culture Bacteria

The wood pieces treated with geothermal water were kept under 60% humidity. In order to cultivate bacteria, peptone and glucose were used as nitrogenous and carbonic ingredients, respectively. The treated wood pieces of 4 kg and the nourishment of 800g (20%; as the weight of wood pieces) were put into the decomposing garbage equipment (for domestic use; SNS-KI SANYO Inc.) under 37°C and 65%RH. The acid-producing and anaerobic bacteria contents in the decomposing garbage equipment were determined by counting the number of bacteria on agar plate and the contents of nitrogenous ingredient was determined by Kjeldahl method.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Loss in weight, vacant space and moisture absorption of the treated woods

Figure 1 shows the loss in weight of SUGI (heartwood and sapwood) and NARA after treatment in AHS-water and H<sub>2</sub>SO<sub>4</sub> solution. The weight of the woods decreased with the elapse of the treating time. SUGI had almost constant weight after 100 hrs, but the weight of NARA decreased slowly after 200 hrs. The difference in the effect of AHS-water and H<sub>2</sub>SO<sub>4</sub> solution were not so appreciable but H<sub>2</sub>SO<sub>4</sub> solution showed a tendency to decrease the weight more compared to AHS-water.

Table 1. Analytical Data of hot spring water and artificial hot spring water.

(1)Cation	Hot spring water <sup>a</sup> (mg/l)	Artificial hot spring water <sup>b</sup> (mg/l)
H <sup>+</sup>	1.90	2.00
pH	2.70	2.70
Na <sup>+</sup>	13.7	1.65
K <sup>+</sup>	4.20	1.22
Mg <sup>2+</sup>	6.80	0.46
Ca <sup>2+</sup>	33.7	0.05
Fe <sup>2+</sup> , Fe <sup>3+</sup>	17.6	46.7
Mn <sup>2+</sup>	0.70	0.56
Al <sup>3+</sup>	9.00	14.2
(2) Anion		
F <sup>-</sup>	1.20	0.86
Cl <sup>-</sup>	0.70	0.20
HS <sup>-</sup>	0.00	0.54
SO <sub>4</sub> <sup>2-</sup>	366	861

Figure 2 shows that the vacant spaces in the wood increased slightly and the tendencies were almost the same as the weight loss. NARA indicated a S-curve because the inside structure of broadleaf tree was broken by the long time treatment in the solutions. As can be seen in Fig. 3, the absorption capacity for moisture of the SUGI treated in H<sub>2</sub>SO<sub>4</sub> solution decreased more quickly than ones treated in the AHS-water. It means that H<sub>2</sub>SO<sub>4</sub> solution works harder as hydrolysis agent. Unlike SUGI, the absorption capacity of moisture for NARA has no obvious difference with the treatment.

### 3.2 Changes of crystallite size of the treated woods

Figures 4 and 5 show the changes in the width and length of crystallite with the elapse of the treating time. The crystallite of the treated woods tended to increase in width with treating time, especially NARA was remarkably changed. Heartwood of SUGI changed in the width more than sapwood of SUGI by the treatment with the AHS-water. The length of crystallite was found to reduce with the elapse of the time. In the case of SUGI treated in the H<sub>2</sub>SO<sub>4</sub> solution, the length of crystallite was shorter than the ones treated in the AHS-water. However in the case of NARA treated in the AHS-water, the length of crystallite was shorter oppositely. These results indicate that AHS-water works softly as hydrolysis agent to break hydrogen bond of the crystallite structure in the direction of the width. On the length of crystallite, the H<sub>2</sub>SO<sub>4</sub> solution works to break folded places of crystallite structure faster than by the AHS-water. Considering the circumstances mentioned above, the treated woods in the AHS-water have a tendency to make a different form of crystallite structure compared with treated woods in H<sub>2</sub>SO<sub>4</sub> solution.

### 3.3 Bacteria in the system for decomposition of garbage

Figure 6 shows the number of acid-producing bacteria in the wood pieces treated with geothermal water, which was agitated in the decomposing garbage equipment. The number of acid-producing bacteria increased with the elapse of the treating time and kept a number of the order in 10<sup>9</sup> after 2 days worked. However, the same bacteria in untreated wood pieces were decreased. The acid-producing bacteria work to restrain an outbreak of anaerobic bacteria. Shown in Figure 7 is the number of anaerobic

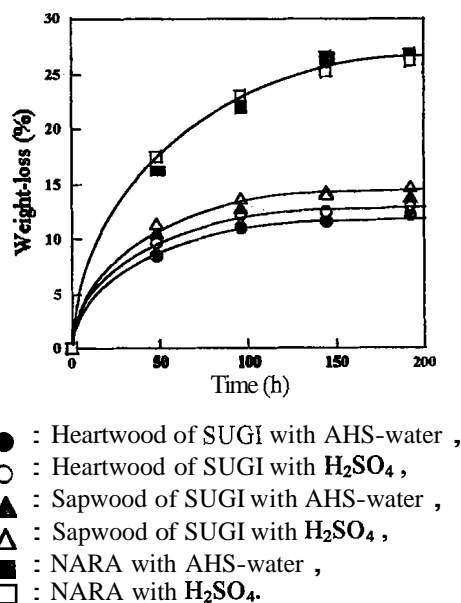


Figure 1. Weight-loss of the woods treated with AHS-water and H<sub>2</sub>SO<sub>4</sub> solution at pH 2.7.

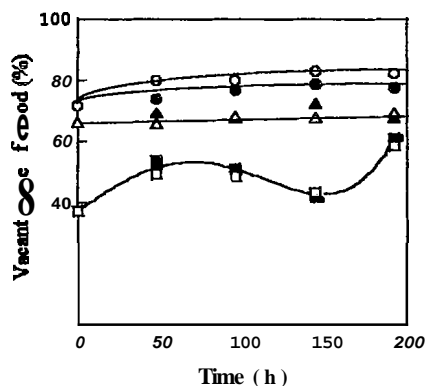


Figure 2. Relation between vacant space of wood and treating time at pH 2.7.

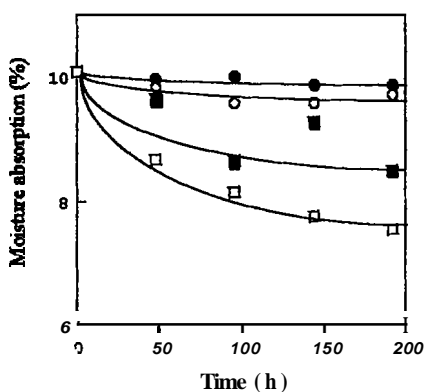


Figure 3. Relation between moisture absorption of sapwood of SUGI and treating time.

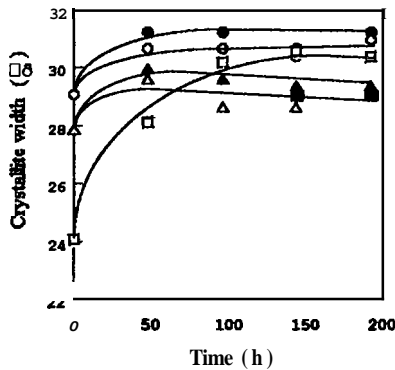


Figure 4. Changes of crystallite size after treating with AHS-water and H<sub>2</sub>SO<sub>4</sub>. (Signs are the same as Fig. 1).

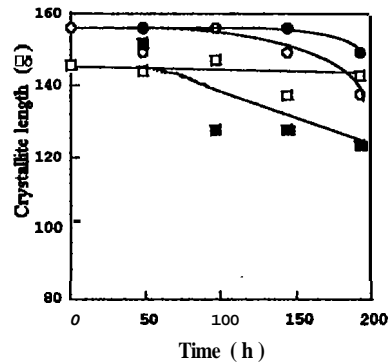
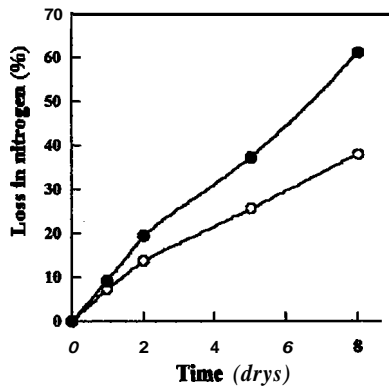


Figure 5. Changes of crystallite size after treating with AHS-water and H<sub>2</sub>SO<sub>4</sub>. (Signs are the same as Fig. 1).



○ : untreated wood pieces  
 ● : treated wood pieces in Hot spring water for 3 day:  
 Figure 6. Number of acid producing bacteria in decomposing box

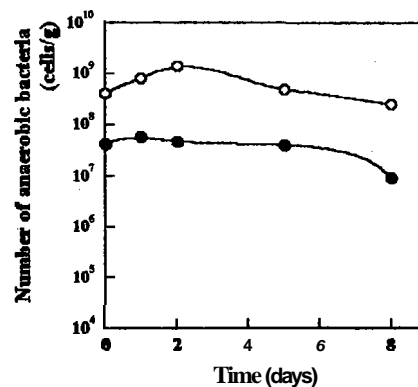


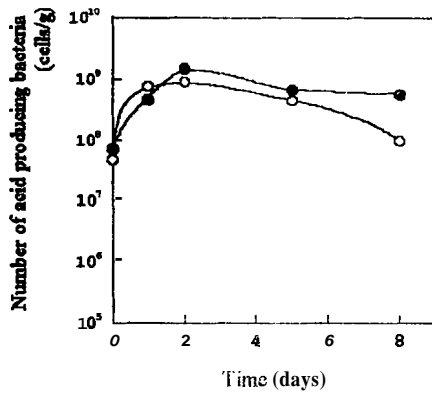
Figure 7. Number of anaerobic bacteria in the decomposing garbage equipment. (Signs are the same as Fig. 6).

bacteria that could rot food The wood pieces treated in the geothermal water had less anaerobic bacteria than untreated wood pieces. Figure 8 shows a loss in nitrogen of the wood pieces with the elapse of the treating time in the geothermal water. The rate of resolving organic substances of nourishment into nitrogen elements by using the wood pieces treated in the geothermal water was almost twice as fast as by using the untreated wood pieces.

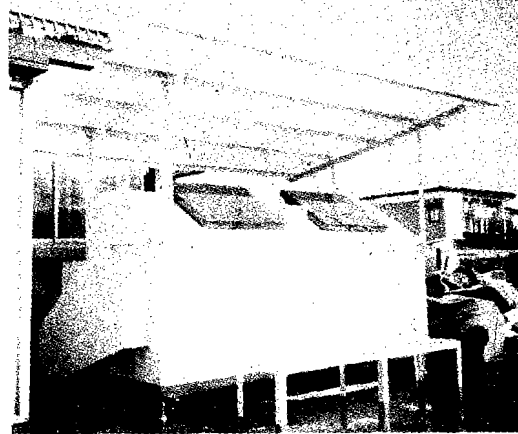
Consequently, the wood pieces treated in the geothermal water have the ability for culturing bacteria in the micro-porous state of crystallite which works effectively to decompose garbage.

### 34 Practical decomposing system

We produced the practical machines (3061×1473×1750 mm) for decomposing garbage completely by using the wood pieces treated in the geothermal water in Matsukawa, Iwate. This machines could decompose 100kg vegetables or meat for 12-24 hrs to generate gases like CO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>O etc and nothing remained except some bones of meat. And also, this machine has a function to deodorize these gases. This machine will go on sale this year.



**Figure 8.** Nitrogen-Loss data in the decomposing garbage equipment. (Signs are the same as Fig. 6)



**Figure 9.** The system for decomposition of garbage.

#### 40 CONCLUSION

We have developed a new system of the effectively decomposing garbage with the use of wood pieces treated in the geothermal water. The wood pieces were found to have ability to cultivate bacteria living in their micro porous states. And in order to be managed using the geothermal energy, natural bacteria and unused wood, the system considered the environment.

#### REFERENCE

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