STUDIES ON THE CONVEYANCE AND DISTRIBUTION OF GEOTHERMAL HOT WATER (PART 24). RESULTS OF EFFECTIVE GEOTHERMAL WATER SUPPLY SYSTEM AT SHUZENJI HOT SPRINGS, SHIZUOKA PREFECTURE

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Shuzenji spa is situated on the northern part of Izu Peninsula. About 73 thermal springs (drilled wells) with a total discharge rate about 1000 l/min. are scattered along the Katsura River, a tributary of the Kano River. Formerly, all springs were of naturally issuing type, and the first shallow wells dug in the end of the 19th century. Pumping-up of the water (by suction pump) started at 1930, and deeper wells have been bored after 1950. Total number of wells and total discharge rate of the water had increased with the increase of demands for the water due to the development of spa, and then, marked drawdown of thermal water level had occured. The lowering of the water temperature and decrease of the content of major constituents (Cl^- and SO_4^{2-}) had been observed. It was clear that these changes had been caused by the exhaustion of thermal water resources, and not only the conservation of the resources but also the measures for the exhaustion had become a matter of great concern.

Recently, an effective thermal water supply system appeared on the stage as the measures for the exhaustion of thermal water resources. This system, which is characterized by the control of the pumping-up of thermal water and its efficient supply and distribution to a wide area through circulating pipe line net-system, was constructed in 1981, and since then, total discharge rate has been controlled under about 1000 l/min. It is worthy of special mention that the rise of pumping water level and water temperature have been observed after 1981.

This report presents the status of the restoration of thermal water resources and economical effects by this system including the analyses of the relationship between the consumption rates of the water and number of the guests in the spa.

(1) The restoration of thermal water level and temperature.
The rise of thermal water level has been observed after 1981. From the analysis of the data on 10 wells, the level is represented by the following equation.

$$Y\ (m) = 11.72 + 15.8\ \ln X\ (months) \qquad (1)$$

where, Y is average thermal water level in meter above sea level, and X is lapse of time in month. The correlation coefficient of this equation is 0.87 at the level of significance of 99%.
The fact that the average thermal water level on Sep. in 1987 showed 74.12 ± 1.85 m (above sea level) suggests that the water level restored to the state before overlifting of thermal water.
Average temperature (measured on the used wells in this system) on Aug. in 1979 and on Sep. in 1987 (before and after the start of this system) were 64 and 65.3°C, respectively. It is found from these results that the installation of this system is very useful for the stop of the deterioration of spring resources.

(2) Total Electric Power (T.E.P.) required for the withdrawal of thermal water.
T.E.P. in 1955 and in 1981 were 315 kW and 150 kW respectively. It is clear that electric power required for the pumping-up of thermal water is economized by the installation of this system.

(3) Some considerations on the consumption rates of thermal water for bathing
From the analyses of the data on the consumption rates, atmospheric temperature, total number of guests, the following equation is obtained.

$$Y = 27816 - 289.8\ X_1 + 0.071\ X_2 \qquad (2)$$

where, Y is the consumption rates of thermal water (m^3)/months, X_1, atmospheric temperature (°C), and X_2, the total number of guests/month.
The correlation coefficient of this equation is 0.885. The temperature of the water supplying to facilities is usually maintained at 61.2°C.

From the above equation, the total consumption rates correspond to the increase of demands of thermal water in near future can be estimated.