GROUND WATER IN KYOTO CITY

BY

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Kyoto Basin is said to have been a lake in a geological epoch. Borings do not attain down to the bottom base rock even at 200 m depth. The catchment area surrounding the basin is 110 km^2. The Katura River, which flows into this western area, receives rain water from the Tamba Plateau of 870 km^2 catchment area. This river feeds the ground water along its running course, which is proved with unconfined ground water contours shown as in Fig. 1. The Kamo River running down in the eastern area, also feeds the unconfined ground water, at least, in the neibouring area. In the central area of the basin, the unconfined ground water comes from the north mountain, and flows down southwards. Rain fall on the town, flows down from the roofs, paved roads, and the ditches to rivulets, and does not percolate into the ground. But there are many little home gardens, great school gardens and temple gardens, these are not paved and the area sum is not negligible compared to whole town area. Thus rainfall on the town may partly percolate into the ground.

Kyoto Meteorological Observatory Measures 1579 mm as yearly rainfall. Boring logs show the strata near the two rivers are of large size sand, but in the center of the basin, the strata contain much smaller sizes sands and clay,.

The ground water levels in Kyoto Basin were measured by means of the water level in wells, five times as follow,

1st 1944-45, K. Yoshida,
2nd Aug. 1956, K. Seno and K. Kikkawa.
3rd Jan. 1958, K. Seno and K. Yuhara.
4th Jul. 1959, H. Kawabata.
5th Mar-Jun. 1961, Hankyu Electric Railway Co.
6th Aug. 1962, K. Seno and H. Kawabata.

Figs 1 and 2 show 2nd and 6th observation. Some remarkable facts are descrived below.

1) Remarkable depression of ground water level in the west southern area

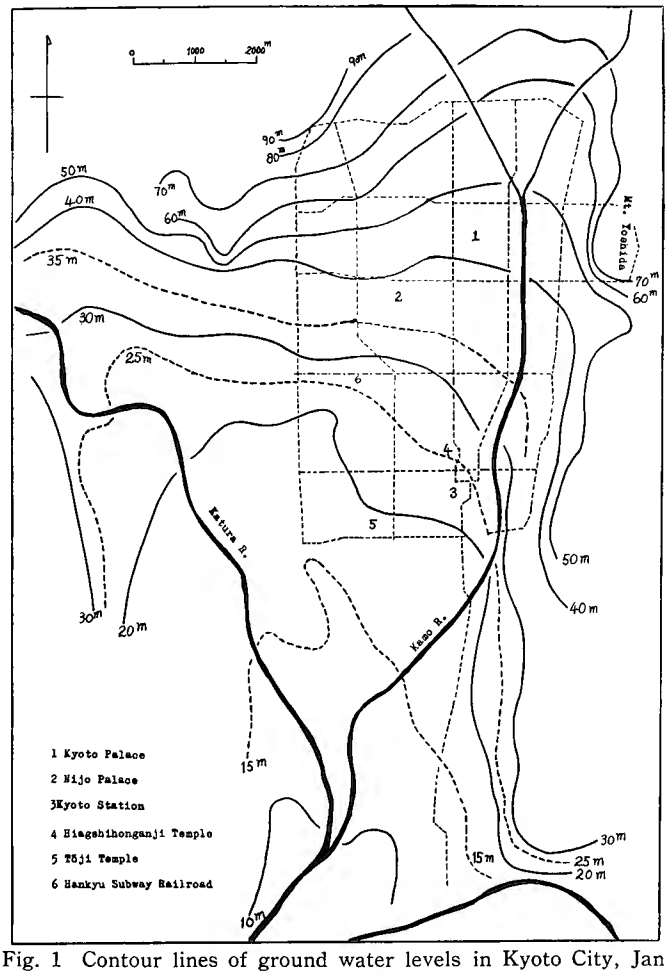

Fig. 1 Contour lines of ground water levels in Kyoto City, Jan. 1958. (Numbers attached to Curves are heights in m T.P.)

in 1956 compared with that in 1944–45. This is the effect of industrial use of the ground water in this area.

2) There is no remarkable diferrence of the water levels in 1958 compared with that in 1956, as time interval is not so long.

3) In the eastern part, the water of the Takano River percolates into the ground, and appears again into the down river course. For, Cl ion is dilute of the ground water near the east side of the river as same as in the river water. On the ground water levels 25–30 m along the river, Fe-contents of the ground water just west side of the river is larger than that of east side. Moreover, the water level bored in the Kamo River major bed is lower than that of the river water. These suggest that the ground water passes under the river bed, with no

relation to the river water. The industrial wastes are thrown into the river, and deposit on the bottom, which prevents the communication of two waters. The boundary where the communication is cut off, is now cleared. The Hankyū Electric Railway Co. began the subway construction, and the ground water levels lowered. The Ground water contour appeared parallel to the Kamo River, shown in Fig. 2. This suggests the percolation of the river water.

4) On the western area. The Katura River meanders, and the water percolates into and out the ground shown in Fig. 1. The ground water near the south side of the river is warm in summer and cold in winter. This variation diminishes in course of percolating southwards. Both sides of the river are permeable, some works situate on the sides, use the ground water, plentifully supplied from the river water.

5) They say the ground water levels lowers gradually year by year, and this is due to over pumping by minor factories scattered in the city. Recently the use of the ground water for air cooling in summer accerates water level lowering. The ground water levels in neighbourhood of Shijō-street measured in 1962, show the level lowering of 2–3 m, compared to that in 1956.

6) The establishment of the Hankyū subway must have disturbed the ground water before 30 years ago, but the ground water level across the subway naturally decreases down towards the south, leaving no disturbance in 1956. The seeping water into the subway tonnel is so little as amount of 0.5 ton/min., which is contrast with the initial discharge of 6 ton/min. 30 years ago.

The elongation contruction of subway to the Kamo River, needs to draw down the ground water, pumping up began from April, 1962. The present state of the ground water at Aug. 1962 is shown in Fig. 2. In the north side of Shijō Street, the draw down of the ground water is limitted, but in the southern area from Shijō Street, the draw down is wide and serious. These facts are due to the check of flow

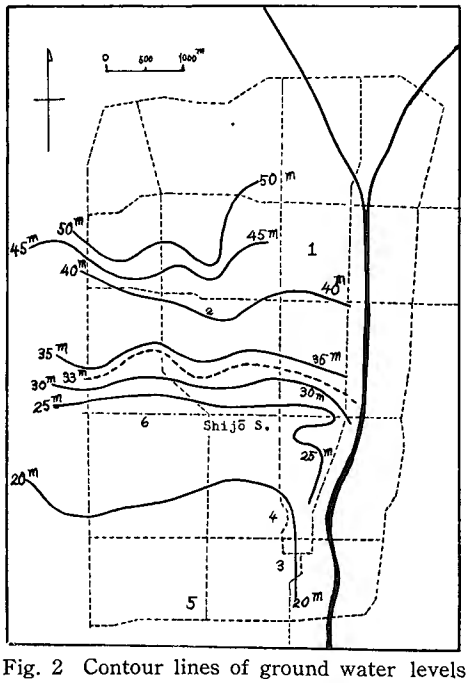

Fig. 2 Contour lines of ground water levels in Kyoto City, Aug. 1962.

down of the unconfined water from the north to the south. The water supply to the south side is from deep ground water and rain fall on the dotted area.

7) After the water levels decreased, there appeared some ground water mounds. The ones near Shijō Street is the effect of artificial recharge, the others are on Nishihonganji Temple, Tōji Temple etc, where are not paved and large ponds.

8) The deep ground water, which is confined water, may be supplied from the north high land as well as unconfined water. Generally, the pressure heads of the confined water are higher than those of the unconfined water at one point, but the relation is inverse in the Kyoto Basin, which suggests as follow. If the deep water originates from the remote high land, coefficient of transmissibility of deep water is so small, that water supply does not compensate pumping. Free O_2 gas in the water is not distributed regularly along the pressure head decrease. This fact shows that the water is supllied from the upper water, even if partly the water is supplied from the north. In spite of this phenomen, the daily variation of the pressure head show its maximum at about 8 o'clock, and minimum at about 20 o'clock. This phenomenon is said to be distant pumping effect in the confined water. Especially, Japanese workers leave their posts during the first 3 days of January (Shōgatu) after their custums. The water variation appears as usual in these days. The over time workers are found at the Kyoto Station and at breweries in Fushimi district, 3 km distant from the observation well. The distant pumping effect must be through the confined water. Thus, the deep water in Kyoto Basin have two contradictory characters.

9) Fushimi district is the southern area of Kyoto City, where are many famous breweries. the ground water is said to be very good for brewery, this is unconfined water shown in Fig. 1. the unconfined water flows down from the east mountain. The chemical elements in the waters do not always come from the water origin, but they are supplied everywhere they flow, presumed from their geographical distribution. Thus the unconfined water is sufficient for brewery.

The deep confined water is supplied from nothern area, of which pressure head is decreasing every year, this must be an effect of the over pumping in the northern area.

10) The shallow unconfined ground water is so pure as surface water that it is fitted to dying, but it is depleting by overpumping. Some deep boring succeed to acquire good water to dying or brewery, but in many cases the deep waters have much Fe ion, and it is difficult to get a large quantity of water for less permeability of the formation. Kyoto City searched ground water for industrial use along the Katura River. Pumping test got poor quantity on the right side,

large quantity on the left side, but of much Fe- or Mn-ion. The river water itself contains often some Fe- or Mn-ion. This is due to the river water which originates from the Tamba Plateau, where are many Mangan mines.