A.M.N.M.Adikaram[(1)], H.A.Dharmagunawardhane[(2)]

Diurnal temperature variations in thermal water springs: A case study at Mahaoya thermal spring cluster, Sri Lanka.

(1) Department of Physical Sciences, Faculty of Applied Sciences,
South Eastern University of Sri Lanka, Sammanthurai, Sri Lanka. +94718318140

(2) Department of Geology, University of Peradeniya, Sri Lanka.

Abstract: Daily temperature variations in the seven outlets of Mahaoya thermal spring cluster was monitored over a period of one month. Temperature of water was compared with rainfall events and the discharge of each outlet. The results revealed that the temperature variations are sensitive to the rainfall and, in individual outlets to the rate of discharge.

Keywords: Daily temperature, precipitation, thermal springs, discharge

Introduction

Geothermal waters acquire heat either from subsurface hot bodies or through deep percolation under the geothermal gradient of the earth. They emerge at the surface as naturally discharging hot water springs through the weak structural discontinuities. Further, the temperature of the geothermal waters decreases when in contact with ambient environments or by mixing with ground water at shallow depths.

There are ten low-enthalpy (34-62^{0}C) thermal springs situated at different places along the eastern boundary of Highland complex and Vijayan rock complexes of the country. Mahaoya thermal springs cluster in the eastern lowlands has temperature around 34-60^0C (Senevirathna and Balendran, 1968). There are seven overflowing outlets, presently developed as small wells for recreational purposes (Fig.1).

Several studies have being done on this spring site considering the geochemistry of thermal waters (Chandrajith et al., 2012) and the origin of the springs (Dissanayaka and Jayasena, 1988). However there is no study found considering the temperature variations of thermal waters in Sri Lanka.

Therefore, the purpose of the study was to evaluate the temperature variations of the outlets over a period of one month by taking the rainfall data into the account. Some workers have identified the rainfall variations is a factor to control some element concentrations and hence the temperatures of thermal waters (Popit, et al. 2005)

Methodology

A series of daily temperature measurements were done in the period of January, 2008. The temperature of each outlet was measured using a mercury laboratory thermometer by immersing the thermometer bulb in to the water. Initially the atmospheric temperature was measured by keeping the thermometer in the environmental conditions until the temperature is constant within about 10 minutes. The thermometer reading was readjusted to the environmental temperature before taking readings from each outlet. The steady discharge of each outlet was also recorded using a graduated container.

Results and Discussion

The daily ambient temperatures show high fluctuations during the first half of the month and nearly constant values during the second half (Fig.2). Similar behavior can be seen in the temperatures of the lowest discharging two outlets (Well No. 5 and 6). The higher temperature outlets (Well 1, Well 2, Well 3, Well 4 and Well 7) show nearly constant temperatures with low fluctuations of ambient temperature in the month January, 2008.

Heim (Cited in Conrad, 1956) reported that yielding thermal springs show higher ratios (5-10) of Maximum to minimum temperature where as smaller ratios (2) in low yielding ones. Maximum to minimum ratios of Mahaoya thermal springs are in the range of 1.0 (Table 1).

Table 1: Statistical analysis on temperatures of thermal springs for January, 2008

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7
Discharge (L/Sec)	0.28	0.09	0.12	0.22	<0.03	<0.01	0.11
Average temp.	57	55	56	58	38	44	57
Max. temp.	57	56	57	58	42	48	58
Min. temp.	56	54	56	57	34	41	56
Standard deviation	0.3	0.5	0.5	0.5	1.9	1.9	0.5
Max:Min	1.0	1.0	1.0	1.0	1.2	1.2	1.0

Weekly temperature variation at North California hot springs is about 4.9 ^{0}C (Hobba et al (1979). These fluctuations are reported to be due to mixing with cool river water. Conrad (1956) also suggested the low temperatures of thermal waters at Badgastein, Austrian Alps in different periods of the year is due to mixing of infiltrated cool surface water. Figure 2 shows the temperature variations of the Mahaoya springs in relation to rain fall during the studied period. Ambient temperature as well as the temperature of the low yielding outlets appears to be significantly influence by the rainfall. The higher yielding outlets however, appear to be unaffected by the rainfall associated temperature fluctuations. This probably indicates that the low discharges (Table 2) as well as the low temperatures of those are a result of barricading the flow paths of thermal water in the weathered overburden and mixing with infiltrated cool rain water. Higher discharging and high temperature outlets represent fast flow through overburden (preferential flow paths probably acting as conduits) hampering the mixing with shallow groundwater in the overburden.

Table 2 Calculated discharges of the Mahaoya spring cluster

Well name	Temperature of the particular day (°C)	Discharge (l/s)
Well 1	55	0.28
Well 2	53	0.09
Well 3	54	0.12
Well 4	55	0.22
Well 5	37	<0.03
Well 6	42	<0.01
Well 7	54	0.11

Figure 1: Well locations at Mahaoya thermal spring cluster

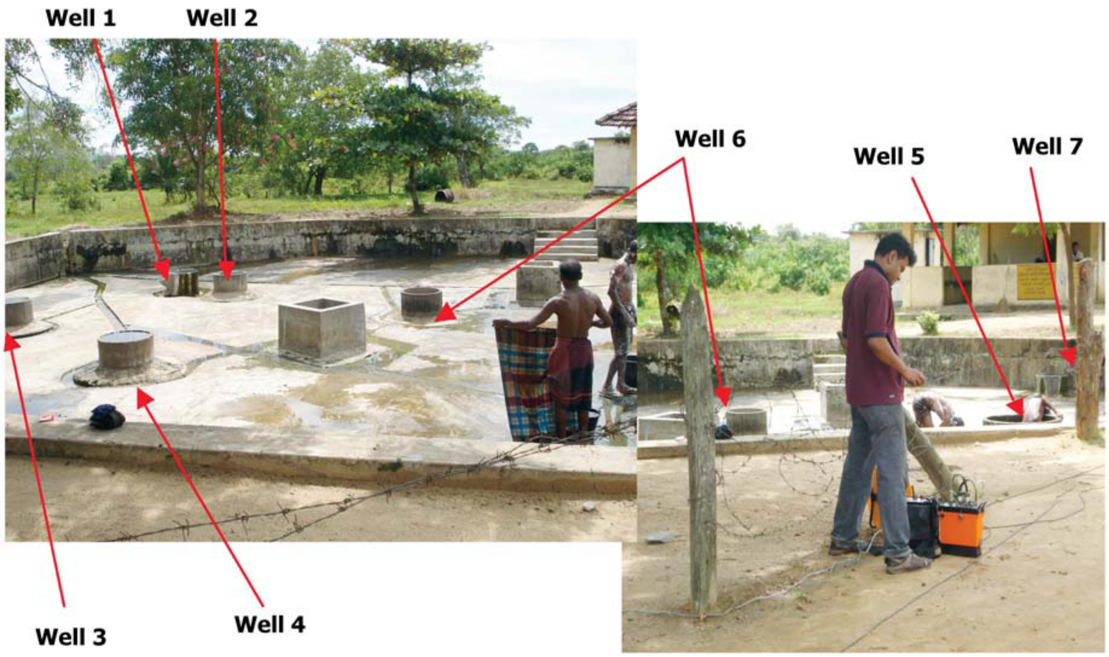
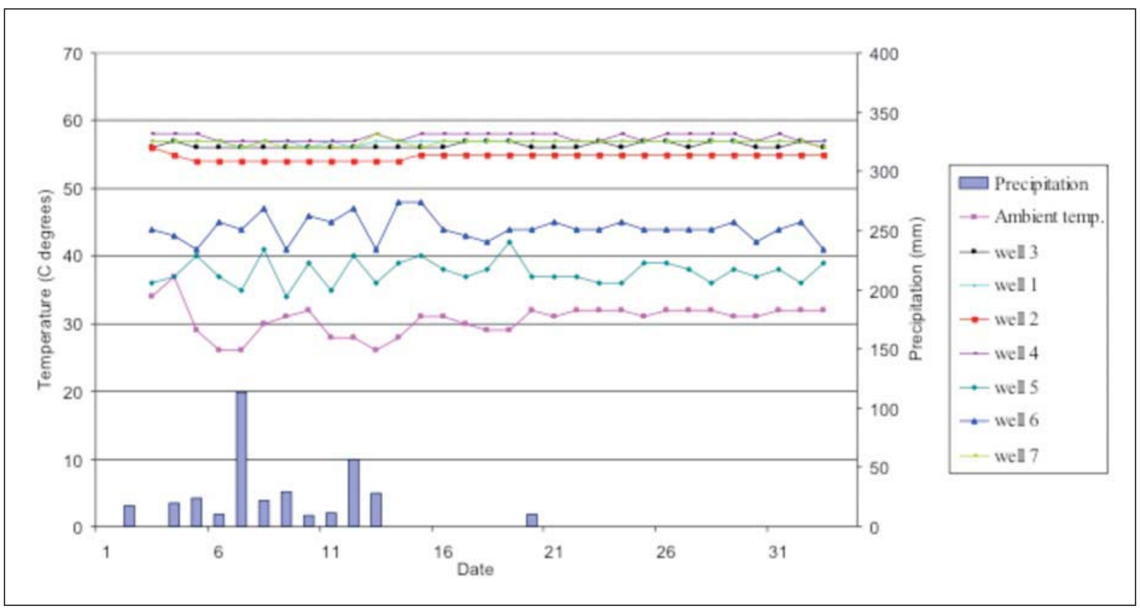


Figure 2: Daily temperature of Mahaoya thermal spring cluster in January, 2008



Conclusion

The study reveals that the slow yielding outlets of the Mahaoya thermal spring cluster is in good hydraulic connection with the shallow groundwater and the high yielding outlets have more effective preferential paths extending to depths.

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