

## Study of Heavy and Trace Elements in Regional Groundwater Around MahaOya Thermal Springs

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### Introduction

Clusters of thermal springs are observed at ten localities along the Highland and Vijayanlitho-tectonic boundary of Sri Lanka (Dissanayake and Jayasena, 1988). MahaOya is one such cluster of thermal springs. The thermal springs are situated about 3 km north of MahaOya town on A5 road. The selected study area falls near the boundary between the Eastern province and Uva province and bounded by  $7^{\circ} 18'$  and  $7^{\circ} 35'N$  and  $81^{\circ} 14'$  and  $81^{\circ} 25'E$ . The area is characterized by rolling topography dominated by some flat terrains around 50m above mean sea level. The area is underlain by the Vijayan Complex (Chandrajith et al., 2013; Dissanayake and Jayasena, 1988). Granitic gneisses, granites and dolerite are the common rock types found (Cooray, 1994, 1984).

In terms of climate, MahaOya is located in the dry zone of Sri Lanka. The average temperature of the area is in between  $33.3^{\circ}C$  and  $34.7^{\circ}C$ . The highest temperature is recorded in the month of August. The average annual rainfall is about 1500mm gaining from the Northeastern monsoon during the period of October to February. The area falls within the drainage basin of MahaOya, which flows, from Southwest to Northeastern direction. MahaOya thermal spring clusters are situated within a distance of 1-1/2 km from the river. MahaOya thermal springs consist with seven thermal springs having mean flow rate of 3 L per minute. Springs never run dry in dry period. The thermal springs show a surface temperature range of  $37 - 55 C$ .

Thermal water sometimes mix with regional or local groundwater and surface water. Such mixing can be identified with their geochemical characterization (Gibson and Hinman, 2013; Petrini et al., 2013; Vitale *et al.*, 2008). Thus, the study intended to analyze the regional and intermediate groundwater around the springs and thermal water in order to examine any relationship between different water categories. The database can be developed into a model which could predict possible occurrences of thermal springs.

### Methodology

Eighty four locations including dug wells, tube wells and thermal springs were sampled in the study area. Those included seven thermal springs, seventy three dug wells and four tube wells. It is important to note that one dug well (L8) is located very close to the thermal springs and all other wells were selected within the extent of 2 km from the MahaOya thermal springs.

The electrical conductivity was measured in situ with Orion 3 Star EC meter. The collected water samples were analyzed for 21 parameters including major cations, anions, heavy metals and trace elements. Cations, heavy metals and trace elements concentration with the Varian SpectrAA AAS facility available at the Uva Wellassa University. Fluka<sup>®</sup> standard solutions were used for the calibration of the instrument. Anions including  $SO_4$ ,  $Cl^{2-}$  and  $HCO_3$  were measured using standard methods. (APHA, 2005). The major cations and anions were plotted in the Piper plot in order to distinguish the water types with their chemistry. Visual MINTEQ software was used to identify the possible speciation, saturation indices and geochemical

composition of water. Principal Component Analysis was performed by using Minitab software in order to generate a correlation between different water types in terms of their chemical composition.

**Results and discussion**

In terms of electrical conductivity, it varied from 837 $\mu$ S/cm to 1065 $\mu$ S/cm, while it ranged from 45.5 $\mu$ S/cm to 1310 $\mu$ S/cm in dug wells and it ranged from 342 $\mu$ S/cm to 1229 $\mu$ S/cm tube wells. The Piper plot shows that there is a clear difference in the chemistry of major cations and anions among the three water types (Figure 1). Thermal water are more Na and K type, while tube wells and dug wells do not show a trend. However, Mg is not a dominant element in Maha Oya water. Sulphate is the main anions found tube wells while dug wells and thermal water have similar concentrations of sulphate and chloride. It is an indication of thermal water has an influence of intermediate groundwater around the thermal spring.

Furthermore, there is a high correlation between Sr and Rb in both thermal springs and dug well samples (r-values are 0.897 and 0.657), as well as Zn and Rb (r values are 0.708, 0.328) and in between Rb and Mn (r values are 0.308, 0.97) also. This indicates that there is a good geochemical relationship between normal groundwater and thermal water. Usually, natural groundwater is not consists of higher concentrations of Al, Li and Be. However, most of these samples contain those elements. It may due to water interaction with anomaly, which is contained particular elements.

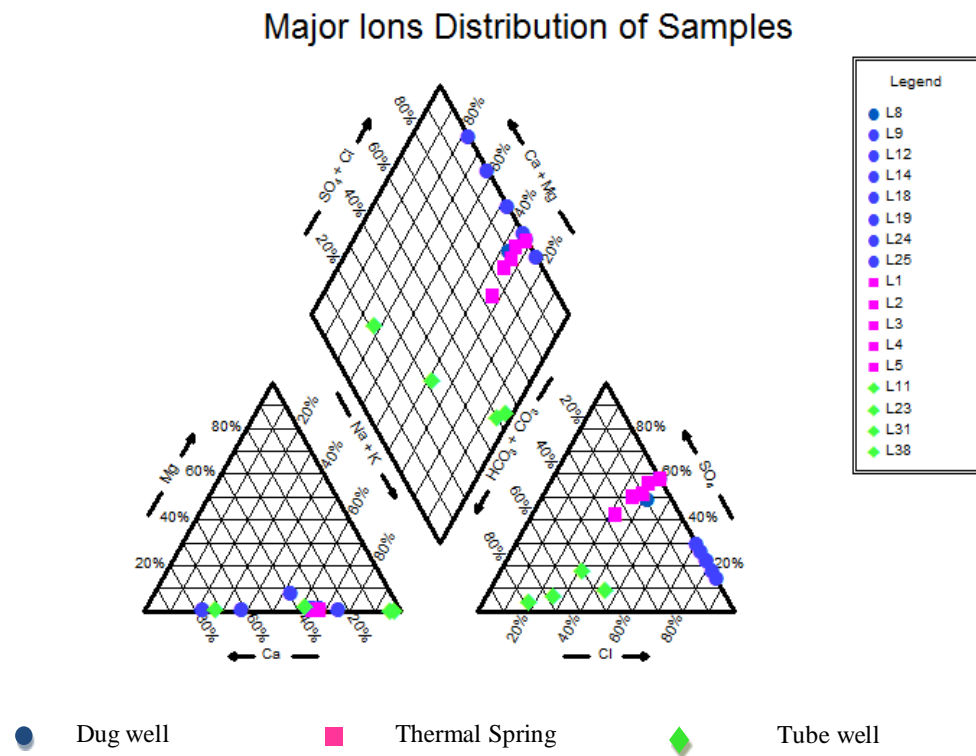


Figure 1. Major ion distribution of samples.

## Conclusions

This study reveals that the major ions concentration of dug wells and thermal water are similar. Thus, it could be assumed thermal water enrich the intermediate groundwater. The tube well very close to thermal springs shows Remarkable similarities in their pH, EC and in major ion contents. This indicates common recharge sources and circulation patterns. Additionally, the positive correlation between Sr and Rb and Zn and Rb show the relationship between thermal water and intermediate groundwater. Thus, the study shows that the validity of the concept. Increased sampling around the thermal springs would deliver a better outcome.

## References

- APHA, 2005. Standard methods for the examination of water and wastewater, 21st/ Cent.ed. American Public Health Association, the American Water Works Association, and the Water Environment Federation, New York.
- Chandrajith, R., Barth, J.C., Subasinghe, N., Merten, D., Dissanayake, C.B., 2013. Geochemical and isotope characterization of geothermal spring waters in Sri Lanka: Evidence for steeper than expected geothermal gradients. *J. Hydrol.*, 476, 360–369.
- Cooray, P.G., 1984. An introduction to the geology of Sri Lanka (Ceylon), 2<sup>nd</sup> ed. National Museums of Sri Lanka Publication, Colombo.
- Cooray, P.G., 1994. The precambrian of Sri Lanka: a historical review. *Precambrian Res.* 66, 3–18.
- Dissanayake, C.B., Jayasena, H.A.H., 1988. Origin of geothermal systems of Sri Lanka *Geothermics*, 17, 657–669.
- Gibson, M.L., Hinman, N.W., 2013. Mixing of hydrothermal water and groundwater near hot springs, Yellowstone National Park (USA): hydrology and geochemistry. *Hydrogeol. J.*, 21, 919–933.
- Petrini, R., Italiano, F., Ponton, M., Slejko, F.F., Aviani, U., Zini, L., 2013. Geochemistry and isotope geochemistry of the Monfalcone thermal waters (northern Italy): inference on the deep geothermal reservoir. *Hydrogeol. J.*, 21, 1275–1287.
- Vitale, M.V., Gardner, P., Hinman, N.W., 2008. Surface water–groundwater interaction and chemistry in a mineral-armored hydrothermal outflow channel, Yellowstone National Park, USA. *Hydrogeol. J.*, 16, 1381–1393.