

The Characteristics of Thermal Water in High Geothermal Potential Area of Ilan, Taiwan

Shih-Ting Chou¹, Ching-Huei Kuo¹, Chia-Mei Liu¹, Ke-Han Song², Jun-Yi Lin¹

¹Department of Geology, 55, Hwa-Kang Road, Yang-Ming-Shan, Taipei, Taiwan 11114, R. O. C.

E-mail: cindy1212amy@gmail.com

E-mail: ckuo@faculty.pccu.edu.tw

E-mail: ljm12@ulive.pccu.edu.tw

E-mail: joanne2400@gmail.com

²Faculty of Science and Graduate School of Engineering and Science, 1 banchi, Sembaru, Nakagami Gun Nishihara Cho, Okinawa Ken, 903-0129, Japan

E-mail: k198601@eve.u-ryukyu.ac.jp

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ABSTRACT

This is the first study to monitor thermal water in high geothermal potential area of Ilan of Taiwan. The geothermal power plant of Chingshui Geothermal Field existed between 1980 and 1993, and it had a serious problem of calcite scaling. This study expects provide information for solving problem of calcite scaling. This study collects thermal water, surface water, which are located between Tuchung area and Chingshui Geothermal Filed, from July 2018 to August 2019. We collect 6 surface waters and 4 thermal waters in the Tuchung area, and 3 surface waters and 3 thermal waters in the Chingshui Geothermal Field.

In the Tuchung area, the solid solution of surface waters, thermal waters are less than 500 ppm and from 1,000 ppm to 3,500 ppm, respectively. In the Chingshui Geothermal Feild, the solid solution of surface waters, thermal waters are less than 500 ppm and from 2,500 ppm to 3,500 ppm, respectively. The thermal waters of Tuchung-Chingshui Geothermal Field belong to Na-HCO₃. In the Tuchung area and Chingshui geothermal filed, the rock belongs to argillite, slate, and meta-sandstone, and consists of quartz, calcite, muscovite, and clay minerals. Finally, we will simulate the process of water-rock interaction by the Geothermist's Workbench software.

1. INTRODUCTION

According to the result of previous study, the highest geothermal potential area of metamorphic rock is located in Ilan of Taiwan (Chang et al., 2013; Liu, 2015). Therefore, there was a 3-MWe geothermal energy power plant was installed in Chingshui Geothermal Field of Ilan at 1981 that geothermal power plant was shut down at 1993 (Lin, 2013). On the whole there are three reasons that caused the geothermal power plant was shut down in Chingshui Geothermal Field: 1) selecting wrong power generation, 2) didn't inject the waste thermal water, 3) calcite scaling in the geothermal power plant system (Chen and Liu, 2013). Moreover, the results of previous studies pointed out that the topics of groundwater recharge of Ilan area must be more studies, and that must focus on the monitoring of time and different elevation sampling (Peng, 1995; Huang, 2016).

The purpose of the research presented in this article is to understand characteristics groundwater recharge in high geothermal potential area of Ilan. Finally, this study expects that provide the information what kind of the environment cause calcite scaling in Ilan area.

2. SAMPLING SITES

This study collects 40 water samples from borehole of Ilan Plain and its southern foothill, and Tuchang-Chingshui Geothermal Field (Figure 1). In addition, we collects different water including river water, thermal water in the Tuchang-Chingshui Geothermal Field from July 2018 to August 2019.

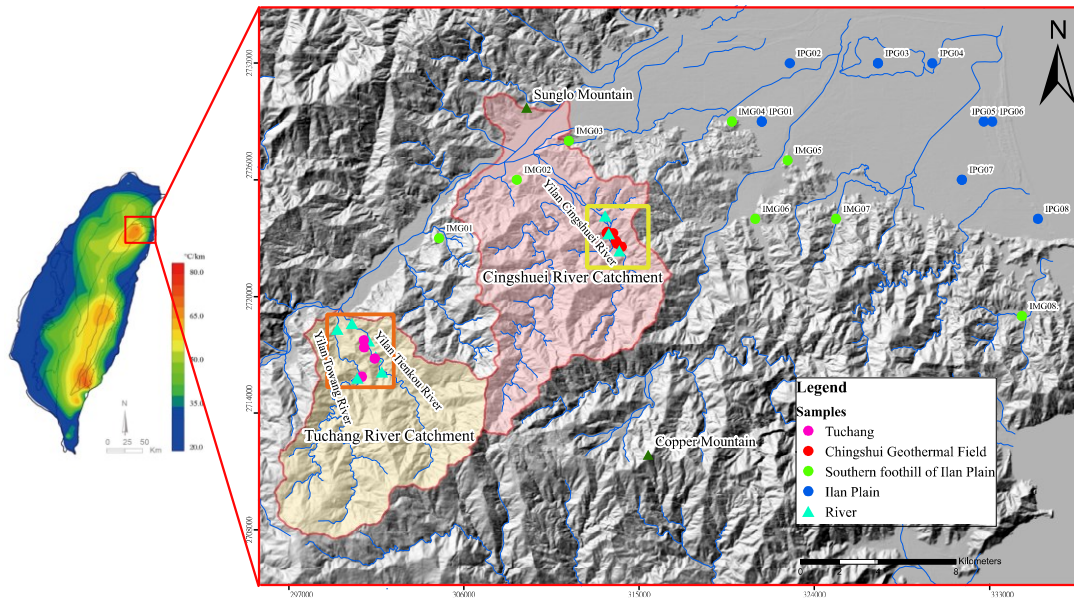


Figure 1: The sample locations in this study.

3. RESULTS AND DISCUSSION

3.1 The characteristics of water in Ilan Plain and its southern foothill

The samples are collected in Ilan Plain and its southern foothill from 35-179 m and 80-100 m of depth, respectively, and pH values are between 6 and 8.5. The values of total dissolved solids of water samples are two group, one is less than 600 ppm, and the other one is more than 800 ppm (Figure 2a).

Based on the Piper diagram, the samples can be classified to two groups, one belongs to Na-Ca-HCO₃ Type-Ilan Plain, and the other one is Ca-HCO₃ Type-southern foothill of Ilan Plain (Figure 2b).

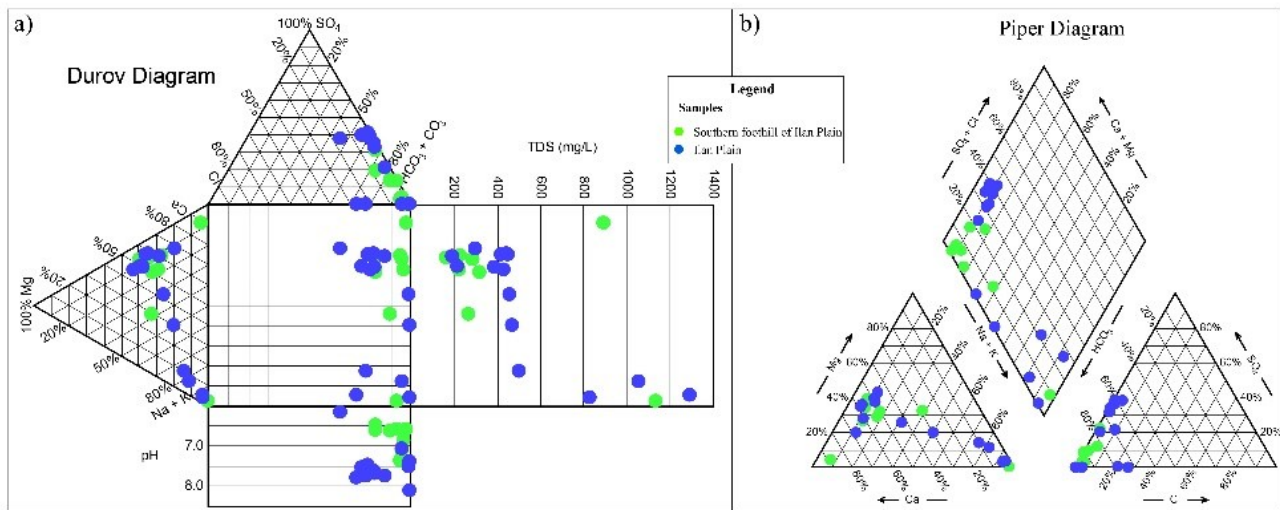


Figure 2: (a) The pH value and total dissolved solids of water samples in Ilan Plain and its southern foothill. (b) The Piper diagram shows water types in Ilan Plain and its southern foothill.

3.2 The characteristics of different waters in Chingshui River Catchment

For the river samples of Chingshui River catchment, the pH values are from 6.5 to 9.8, the total dissolved solids are less than 500 ppm (Figure 3a). Based on concentrations of the major elements, these samples are Ca-HCO₃ Type (Figure 3b).

For the thermal water of natural and artesian, the pH values are from 7.5 to 9.5, the total dissolved solids of most samples are about 2,500-3,500 ppm (Figure 3a). Based on concentrations of the major elements, these samples are Na-HCO₃ Type (Figure 3b). One sample-2019051CH02- displays the anomaly phenomena that the value of total dissolved solids is less than 500 ppm.

We compared the pH value, total dissolved solids (TDS), oxidation-reduction potential (ORP) and conductivity (COND), anions and cations with precipitation. The results of pH value, sodium and chloride of natural thermal water have variation with precipitation in the Chingshui River catchment. (Figure 4,5,6).

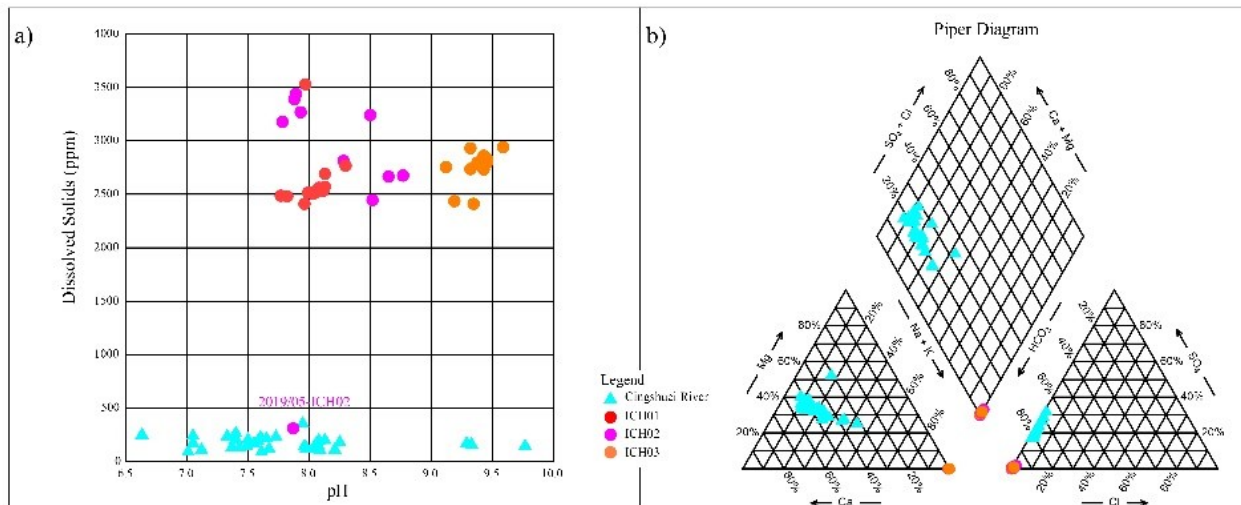


Figure 3: (a) The pH value v.s. total dissolved solids in different waters of Chingshui River catchment. (b) The Piper diagram shows water types in different waters of Chingshui River catchment.

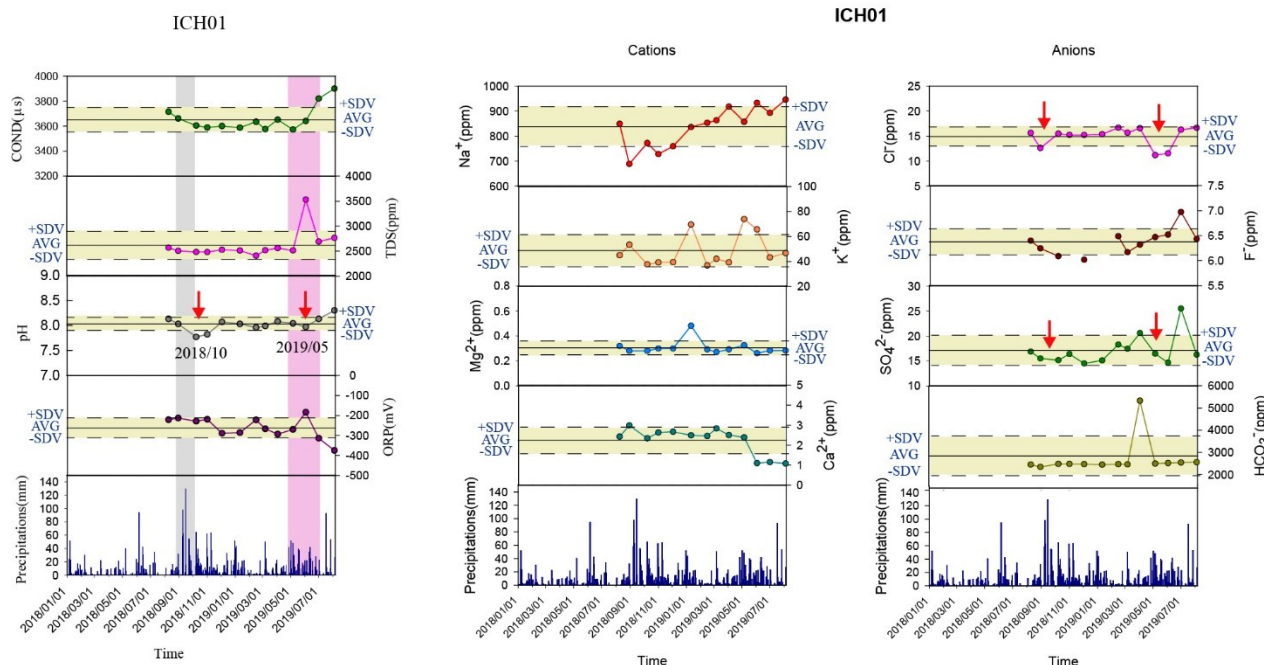


Figure 4: In the Chingshui River Catchment-ICH01, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

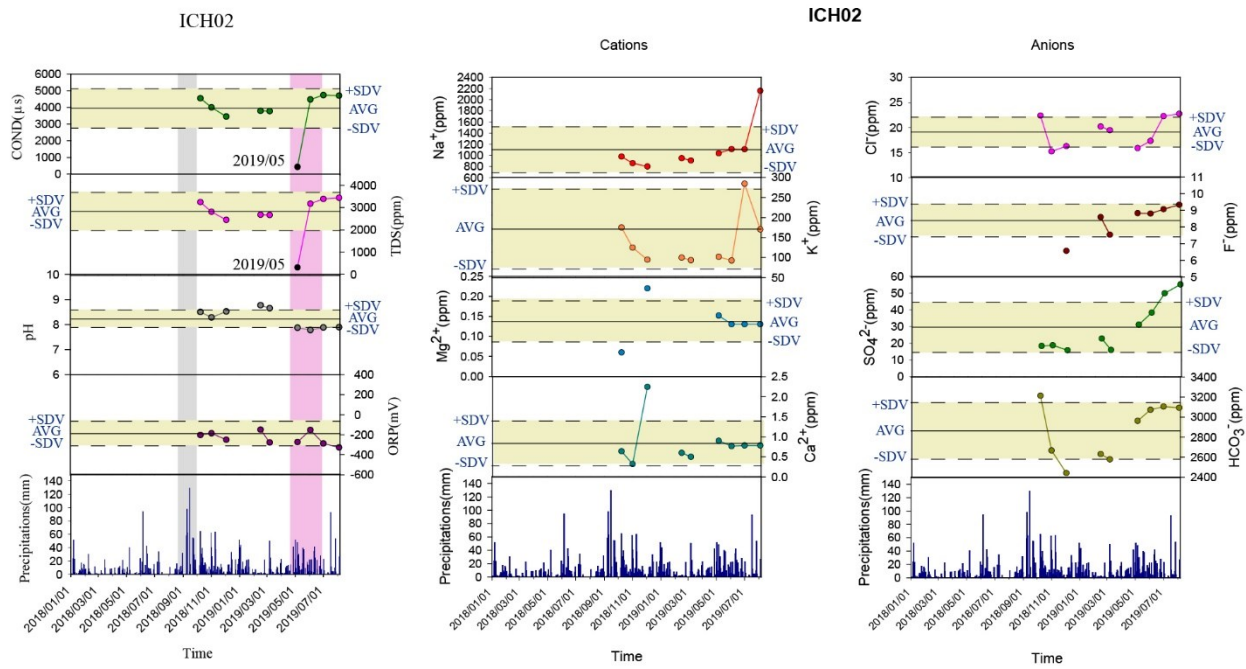


Figure 5: In the Chingshui River Catchment-ICH02, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

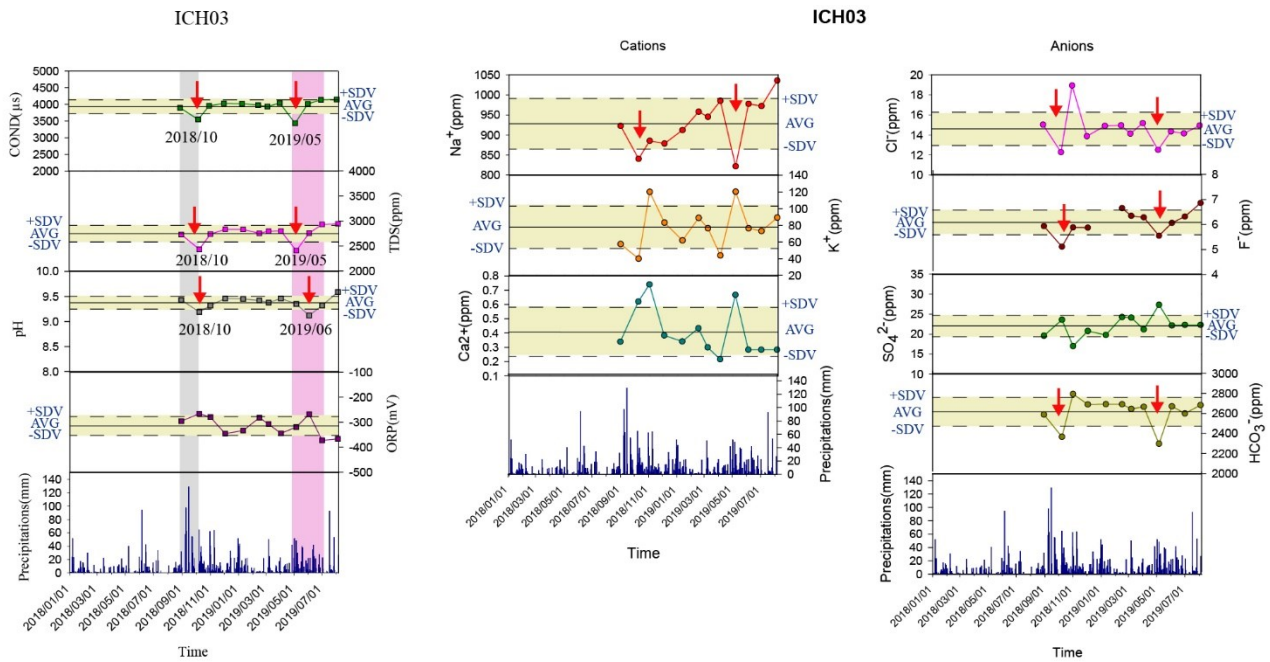


Figure 6: In the Chingshui River Catchment-ICH03, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

3.3 The characteristics of different waters in Tuchang River Catchment

For the river samples of Tuchang River catchment, the pH values are from 6 to 9, the total dissolved solids are less than 500 ppm (Figure 7a). Based on concentrations of the major elements, these samples are Ca-HCO₃ Type (Figure 7b).

For the thermal water of natural and artesian, the pH values and the total dissolved solids of samples are grouped two from 6.5 to 8.0 and from 7.5 to 8.5, and near 1,000 ppm, between about 2,500-3,500 ppm (Figure 7a). Based on concentrations of the major elements, ITH01, ITH04 and ITH05 samples belong to Na-HCO₃ Type and ITH03 samples are Na-Ca-HCO₃ Type (Figure 7b).

We compared the pH value, total dissolved solids (TDS), oxidation-reduction potential (ORP) and conductivity (COND), anions and cations with precipitation. The results of pH value, sodium and chloride of natural thermal water have variation with precipitation in the Tuchang River catchment. (Figure 8,9,10,11).

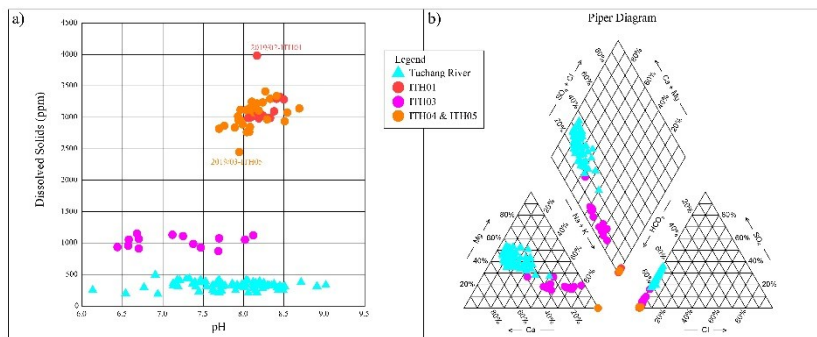


Figure 7: (a) The pH value v.s. total dissolved solids in different waters of Tuchang River catchment. (b) The Piper diagram shows water types in different waters of Tuchang River catchment.

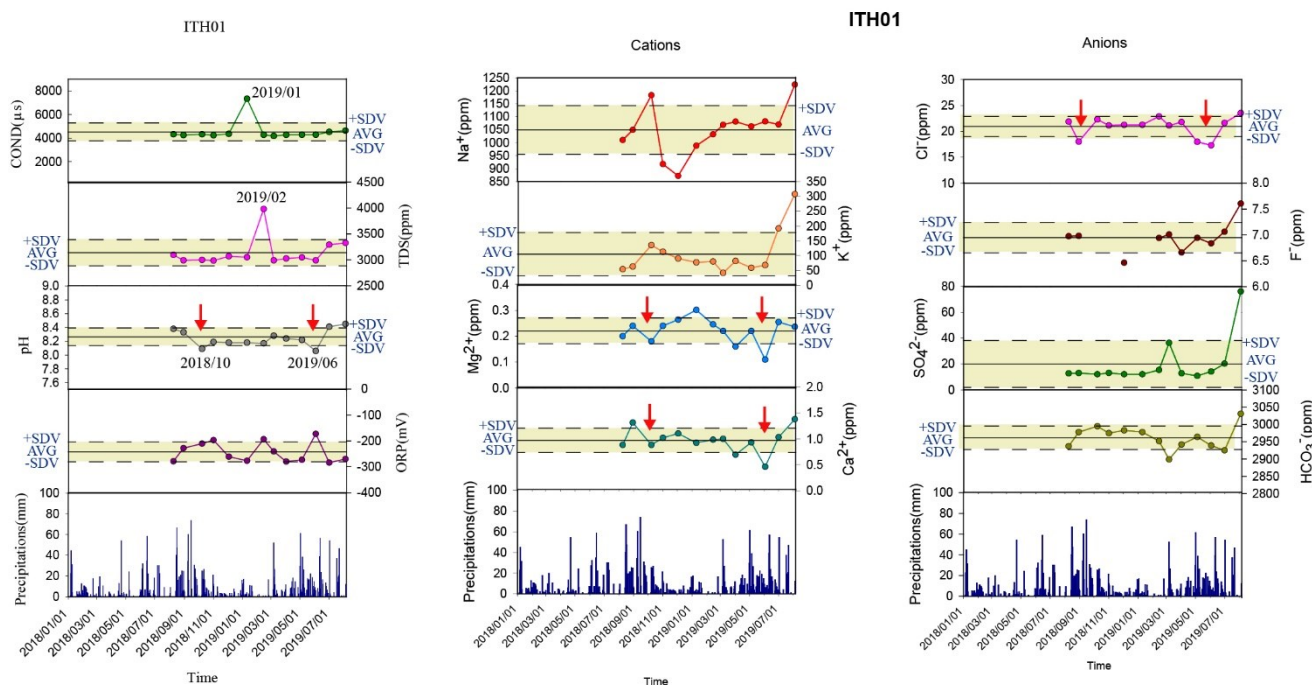


Figure 8: In the Tuchang River Catchment-ITH01, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

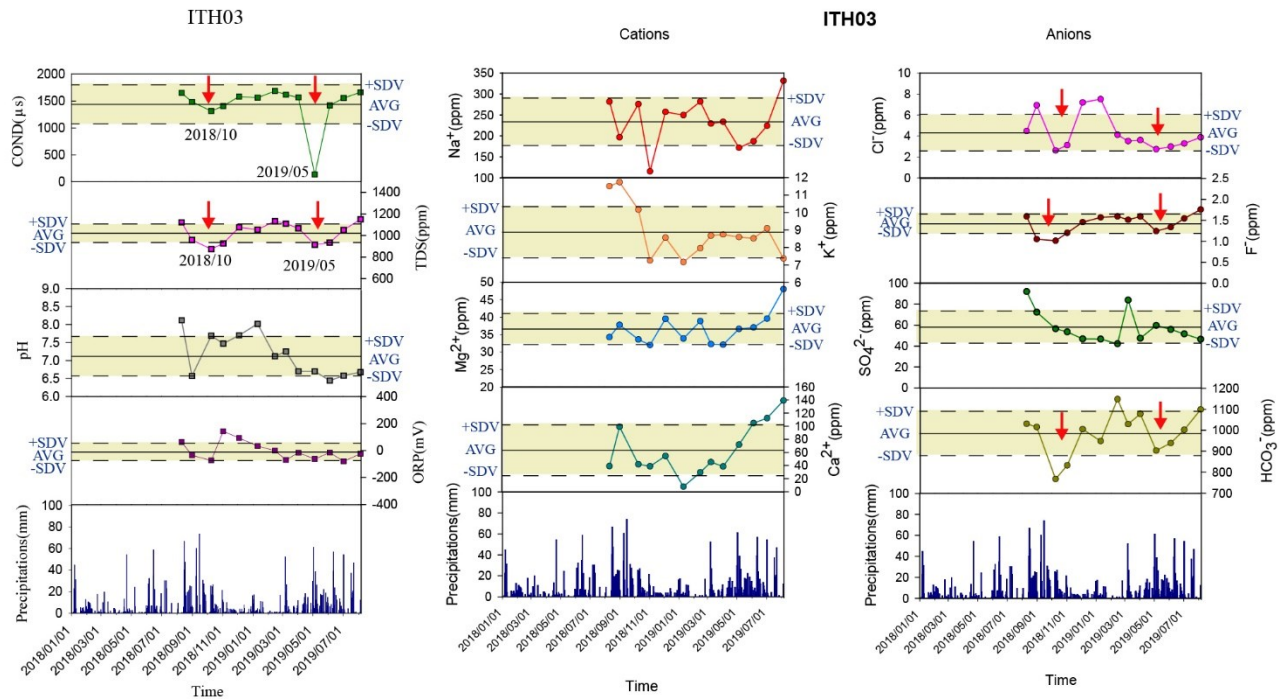


Figure 9: In the Tuchang River Catchment-ITH03, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

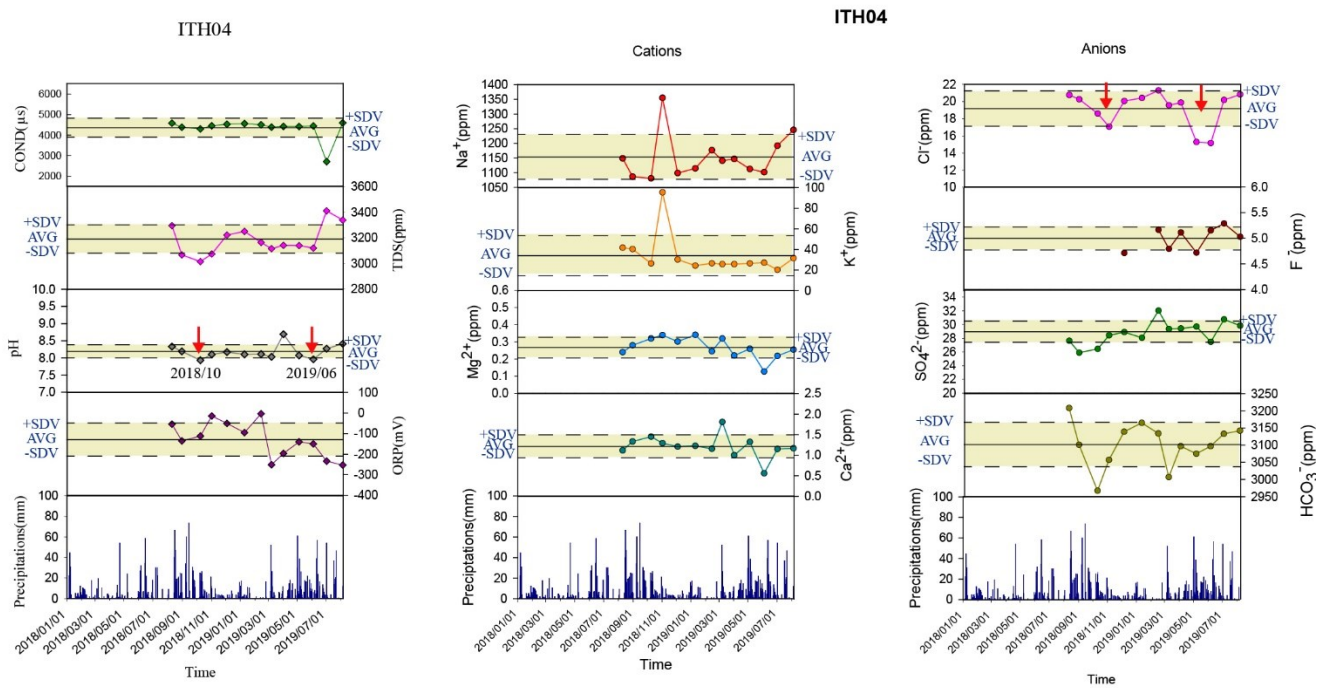


Figure 10: In the Tuchang River Catchment-ITH04, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

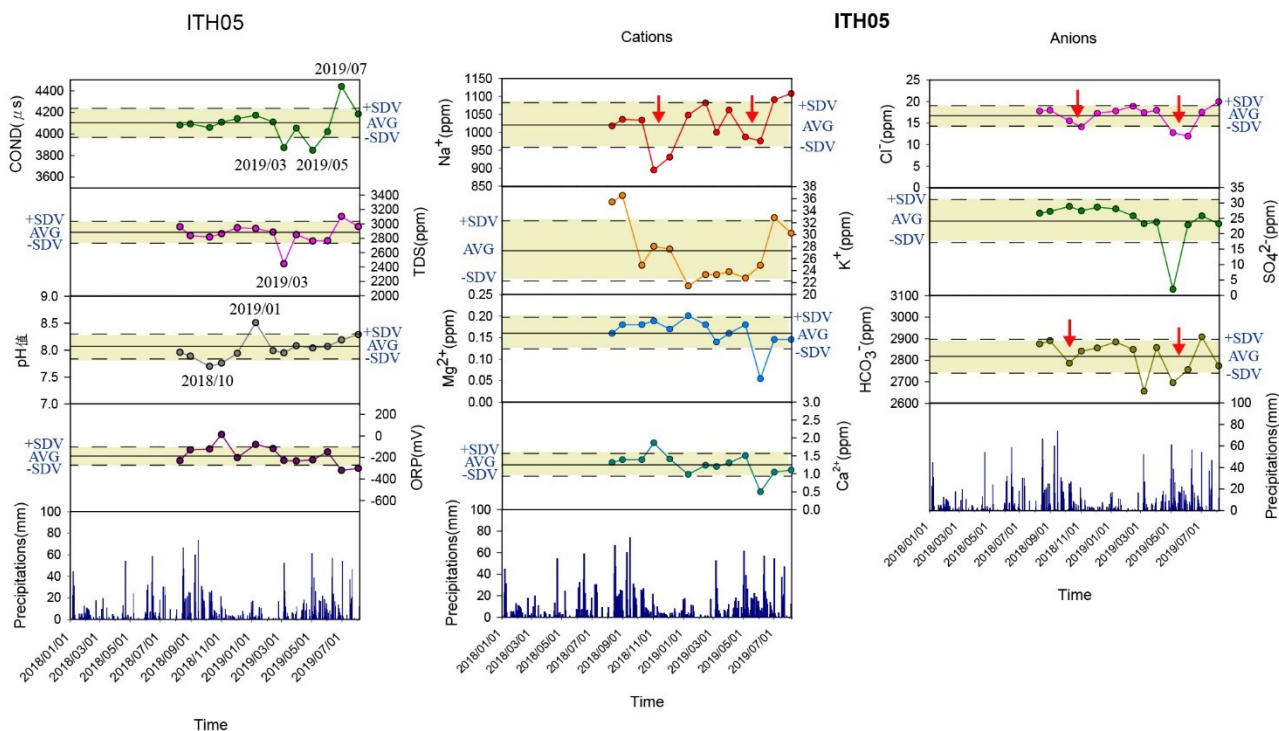


Figure 11: In the Tuchang River Catchment-ITH05, the pH value, ORP, TDS, COND, and cations and anions of the thermal water compare with precipitation.

4. CONCLUSIONS

Three of these findings are worth summarizing:

- (1) In Ilan Plain and its southern foothill, the water belong to Na-Ca-HCO₃ and Ca-HCO₃ Types, respectively.
- (2) In the Chingshui River Catchment, the thermal water of natural and artesian are Na-HCO₃ Type. In the Tuchang River Catchment, the thermal water of natural and artesian belong to Na-HCO₃ and Na-Ca-HCO₃ Types, respectively.
- (3) It is shown that the results of pH value, sodium and, chloride of natural thermal water which have variation with precipitation, and this study points out that natural thermal water can be diluted by precipitation, immediately. However, the thermal water of artesian doesn't present the significant phenomena.

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