



Applying spatial analysis techniques to assess the suitability of multipurpose uses of spring water in the Jiaosi Hot Spring Region, Taiwan

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The Jiaosi Hot Spring Region is located in northeastern Taiwan and is rich in geothermal springs. The geothermal development of the Jiaosi Hot Spring Region dates back to the 18th century and currently, the spring water is processed for various uses, including irrigation, aquaculture, swimming, bathing, foot spas, and recreational tourism. Because of the proximity of the Jiaosi Hot Spring Region to the metropolitan area of Taipei City, the hot spring resources in this region attract millions of tourists annually. Recently, the Taiwan government is paying more attention to surveying the spring water temperatures in the Jiaosi Hot Spring Region because of the severe spring water overexploitation, causing a significant decline in spring water temperatures. Furthermore, the temperature of spring water is a reliable indicator for exploring the occurrence and evolution of springs and strongly affects hydrochemical reactions, components, and magnitudes. The multipurpose uses of spring water can be dictated by the temperature of the water. Therefore, accurately estimating the temperature distribution of the spring water is critical in the Jiaosi Hot Spring Region to facilitate the sustainable development and management of the multipurpose uses of the hot spring resources.

To evaluate the suitability of spring water for these various uses, this study spatially characterized the spring water temperatures of the Jiaosi Hot Spring Region by using ordinary kriging (OK), sequential Gaussian simulation (SGS), and geographical information system (GIS). First, variogram analyses were used to determine the spatial variability of spring water temperatures. Next, OK and SGS were adopted to model the spatial distributions and uncertainty of the spring water temperatures. Finally, the land use (i.e. agriculture, dwelling, public land, and recreation) was determined and combined with the estimated distributions of the spring water temperatures using GIS. A suitable development strategy for the multipurpose uses of spring water is proposed according to the integration of the land use and spring water temperatures. The study results indicate that OK, SGS, and GIS are capable of characterizing spring water temperatures and the suitability of multipurpose uses of spring water. SGS realizations are more robust than OK estimates for characterizing spring water temperatures. Furthermore, current land use is almost ideal in the Jiaosi Hot Spring Region according to the estimated spatial pattern of spring water temperatures.

Keywords: Hot spring; Temperature; Land use; Ordinary kriging; Sequential Gaussian simulation; Geographical information system