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Applying a technique of sequential indicator simulation and multivariate integration to evaluate groundwater quality used in aquacultural fishponds

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Aquaculture is a common landscape in coastal western and southwestern regions, Taiwan. Aquaculture industries typically need the massive amount of water supply. However, surface water is limited in the regions. Thus, because of reducing operation costs and convenient acquisition characteristics of water resources, fishers abundantly extract groundwater to farm fish and shellfish, resulting in significant decreases in groundwater levels and the occurrence of the seawater intrusion over several decades. This work used a technique of sequential indicator simulation (SIS) and multivariate integration to delineate zones of excellent groundwater quality used in aquacultural fishponds in the Pingtung plain, Taiwan. According to an aquacultural water quality standard in Taiwan, three pollutants in groundwater - manganese, arsenic and ammonium-nitrogen - were considered. Sequential indicator simulation was first adopted to reproduce the spatial distributions of the three pollutants. Then, the probabilities of the pollutants exceeding the aquacultural water quality standard were explored. Finally, to obtain safe groundwater used for aquaculture, a maximum exceeding probability was selected among the three pollutants in groundwater to integrate the pollution effect. Through the multivariate integration, safe groundwater used for aquaculture can be determined straight. Furthermore, this study compared estimated results by the technique of SIS and multivariate integration with those by multivariate indicator kriging (MVIK). The analyzed results indicate that Mn in groundwater is the critical factor impacting on groundwater used for aquaculture and 20.2% of aquifers in this plain are suitable for pumping groundwater to cultivate fish. The recommended pumping zones for aquaculture use are mainly distributed in the northern, northeastern and partial eastern regions. Moreover, the recommended pumping zones in the shallow aquifers are wider than those in the deep aquifers for aquaculture use. Additionally, the recommended pumping areas estimated by the technique of SIS and multivariate integration are slightly larger than those by MVIK and more vary with different aquifers than those by MVIK do.

Keywords: Groundwater; Probability; Aquaculture; Sequential indicator simulation; Water quality standard