因子克利金法應用於地下水質監測井網設計之研究

Optimal design of groundwater quality monitoring network using Factorial kriging

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摘　　要

克利金法與聯合克利金法已廣泛的應用於地下水觀測井網之設計，但前述方法較難以直接運用於兼顧多種水質變數的井網設計問題，並且無法考量具多種空間尺度的統計結構。而因子克利金法(Factorial Kriging Method)則結合了半變異元模式(Multivariate variogram modelling)、主成份分析(Principal component analysis)與聯合克利金法(Co-kriging method)，利用此法可找出不同空間尺度，影響不同地下水參數間的主要因素，進而針對影響地下水質之因素，以及設計出兼顧多項水質項目的地下水質監測井網。

本研究以因子克利金法搭配遺傳演算法建立一地下水質觀測井網之優選模式，並應用在屏東平原含水層二之地下水質井網分析。首先進行因子克利金分析，再以遺傳演算法優選出不同監測井數限制下的最佳地下水質觀測井網。結果顯示屏東平原含水層二之空間結構，分別為：(1)影響範圍 28.5 公里之高斯模式；(2)影響範圍 40 公里之指數模式。且經由優選模式之計算後，成功的優選出監測井數為 10 口、

20 口及 30 口之最佳地下水質監測井網。本研究所建立之佈井模式，目前主要運用於單一含水層之地下水質監測井網，未來可將此模式推廣至其它地區之地下水水質監測井網設計。

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Abstract

In resent studies, geostatistical methods, as Kriging and Co-Kriging, have been applied to design the groundwater monitoring networks. These methods can determine an optimal network based on the spatial variability of a selected variable. However, since a representative variable is difficult to define, the conventional geostatistical methods will be difficult to apply directly when the monitoring network is used to monitor multi-variables. Besides, conventional geostatistical methods consider only single geostatistical structure represented by a variogram, and this may not accurately represent the geostatistical structures for an area with multiple regionalization structures. A Factorial Kriging is an integrated methodology consists of Multivariate Variogram Modeling, Principal Component Analysis and Co-Kringing method. Therefore, it can consider multi-scales geostatistical structures and solve a multi-variables problem by using the factor variables as a representative variable.

This research develops an optimal design method to solve groundwater network design problems by combining the Factorial Kringing with Genatic Algorithm (GA). The proposed model is applied to design the groundwater monitoring network in Pingtung plain, Taiwan.

The design considers nine groundwater quality variables and two scales of geostatistical structure represented by two variograms. One of the variogram is Gaussian type with an effective range of 28.5 km and the other is Spherical type with an effective range of 40 km. The model successfully obtains different optimal network designs with respect to 10, 20 and 30 wells. The study demonstrates that the proposed model can optimally design a complicated groundwater monitoring network that considers multiple groundwater quality variables and multiple scales of geostatistical structures.