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Effect of land use and urbanization on groundwater recharge in metropolitan area: time series analysis of groundwater level data

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In order to classify the groundwater recharge characteristics in an urban area, a time series analysis of groundwater level data was performed. For this study, the daily groundwater level data from 35 monitoring wells were collected for 3 years (Fig. 1). The use of the cross-correlation function (CCF), one of the time series analysis, showed both the close relationship between rainfall and groundwater level change and the lag time (delay time) of groundwater level fluctuation after a rainfall event. Based on the result of CCF, monitored wells were classified into two major groups. Group I wells (n=10) showed a fast response of groundwater level change to rainfall event, with a delay time of maximum correlation between rainfall and groundwater level near 1 to 7 days. On the other hand, the delay time of 17-68 days was observed from Group II wells (n=25) (Fig. 1). The fast response in Group I wells is possibly caused by the change of hydraulic pressure of bedrock aquifer due to the rainfall recharge, rather than the direct response to rainfall recharge.

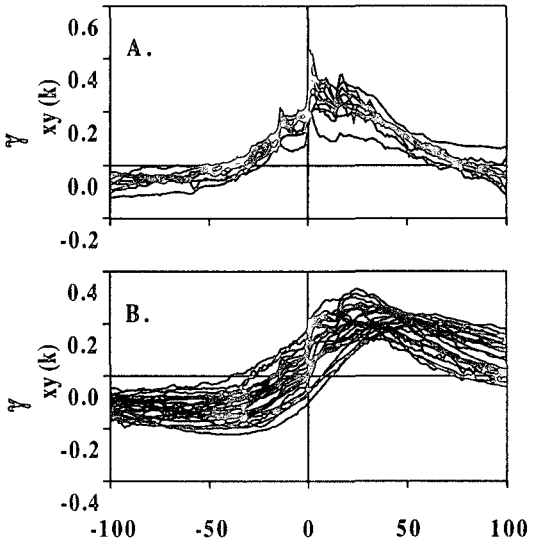

Fig. 1. The result of cross-correlation between rainfall and groundwater level

Group I wells are preferentially located at topographically higher land. Thus, the depth to groundwater level are deeper in Group I wells. The thickness of alluvium is also deeper in Group I wells. However, the land use pattern, especially the areal percentage of un-pavement area around each well, was not different between Group I and Group II wells.

The delay time showed a good correlation with topographic elevation, depth to groundwater, and thickness of alluvium (Fig. 2). However, the relationship between delay time and land use (un-pavement area) was not significant (Fig. 3). Therefore, natural conditions (esp., elevation, depth to groundwater, thickness of alluvium) are more important to control the groundwater recharge even in urban area, rather than the land use. Thus, we suggest that natural conditions, rather than surface conditions, should be considered more carefully when authorities designate the "Groundwater Preservation Area".

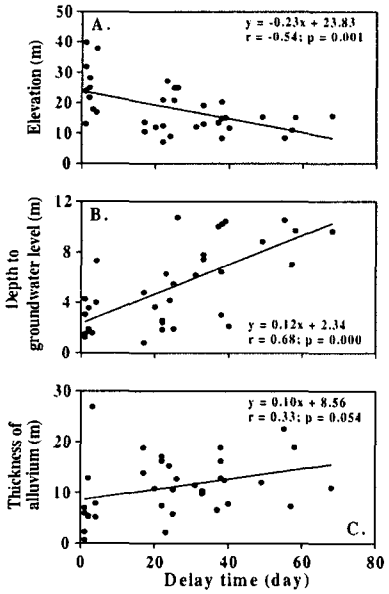

Fig. 2. The relationships between delay time and a) elevation, b) depth to groundwater level, and c) thickness of alluvium

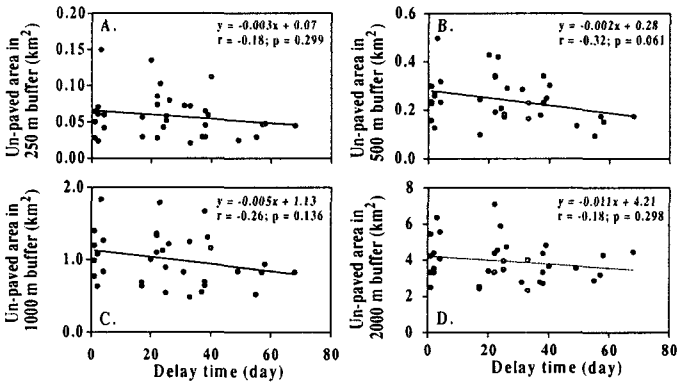

Fig. 3. The relationships between delay time and un-pavement area in buffers of the radius of a) 250, b) 500, c) 1000, and d) 2000 m.

Key words: Urban groundwater, Recharge characteristics, Time series analysis of groundwater level data, cross-correlation function