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# A study on groundwater and pollutant recharge in urban area: use of hydrochemical data

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Urban groundwater has a unique hydrologic system because of the complex surface and subsurface infrastructures such as deep foundation of many high buildings, subway systems, and sewers and public water supply systems. It generally has been considered that increased surface impermeability reduces the amount of groundwater recharge. On the other hand, leaks from sewers and public water supply systems may generate the large amounts of recharges. All of these urban facilities also may change the groundwater quality by the recharge of a myriad of contaminants.

This study was performed to determine the factors controlling the recharge of deep groundwater in an urban area, based on the hydrogeochemical characteristics. The term 'contamination' in this study means any kind of inflow of shallow groundwater regardless of clean or contaminated. For this study, urban groundwater samples were collected from a total of 310 preexisting wells with the depth over 100 m. Random sampling method was used to select the wells for this study. Major cations together with Si, Al, Fe, Pb, Hg and Mn were analyzed by ICP-AES, and Cl, $NO_3$, $NH_4$, F, Br, $SO_4$ and $PO_4$ were analyzed by IC.

There are two groups of groundwater, based on hydrochemical characteristics. The first group is distributed broadly from Ca-$HCO_3$ type to Ca-Cl+$NO_3$ type; the other group is the Na+K-$HCO_3$ type. The latter group is considered to represent the baseline quality of deep groundwater in the study area. Using the major ions data for the Na+K-$HCO_3$ type water, we evaluated the extent of groundwater contamination, assuming that if subtract the baseline composition from acquired data for a specific water, the remaining concentrations may indicate the degree of contamination. The remainder of each solute for each sample was simply averaged. The results showed that both Ca and $HCO_3$ represent the typical solutes which are quite enriched in urban groundwater. In particular, the $_{P}CO_2$ values calculated using PHREEQC (version 2.8) showed a correlation with the concentrations of major inorganic components (Na, Mg, Ca, $NO_3$, $SO_4$, etc.). The $_{P}CO_2$ values for the first group waters widely ranged between about $10^{-3.0}$ atm to $10^{-1.0}$ atm and differed from those of the background water samples belonging to the Na+K-HCO3 type ($<10^{-3.5}$ atm). Considering that the $_{P}CO_2$ of soil water (near $10^{-1.5}$ atm), this indicates that inflow of shallow water is very significant in deep groundwaters in the study area. Furthermore, the $PCO_2$ values can be used as an effective parameter to estimate

the relative recharge of shallow water and thus the contamination susceptibility. The results of our present study suggest that down to considerable depth, urban groundwater in crystalline aquifer may be considerably affected by the recharge of shallow water (and pollutants) from an adjacent area. We also suggest that for such evaluation, careful examination of systematically collected hydrochemical data is requisite as an effective tool, in addition to hydrologic and hydrogeologic interpretation.

**Key words:** urban groundwater, hydrogeochemistry, recharge, anthropogenic pollution