

## **Assessment of land use control of urban groundwater quality in Ulaanbaatar and other cities over the world using hydrochemical and sulfur isotope study**

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We performed the hydrochemical and environmental isotopic assessment for urban groundwater in Ulaanbaatar (UB), to assess the groundwater quality in relation to land use. Specifically, we identified the sources of dissolved carbon and sulfate by using S-O isotopes of sulfate and C-O isotopes of DIC. The hydrochemical and isotopic values were also compared with those from six megacities in Eurasian countries (i.e., Birmingham, Halle, Manila, Taipei, Shuicheng, and Seoul). Our results clearly show that groundwater from suburban areas of UB generally show a better quality with lesser degrees of mineralization (i.e., lower TDS) than those from an urban center. In particular, groundwater from the urban center contains relatively high levels of  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$ . Such hydrochemical characteristics have been observed in other Eurasian megacities, indicating that the three major inorganic components are useful indicators (markers) of anthropogenic contamination of urban groundwater. Environmental isotope data indicate that these components are derived mainly from household and industrial effluents. Groundwater samples from the urban center of UB has the  $\delta^{34}\text{S}_{\text{SO}_4}$  values ranging between 4.5‰ and 8.3‰, which suggests the origin of sulfate from domestic sewage effluents, particularly from pit latrines in ger area of old residential zone. This study implies that there is an urgent need of better management of sanitation and waste-disposal systems in Ulaanbaatar.