A geochemical study on origins of shallow groundwater in a densely-populated urban area, Shinagawa City, Japan

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A geochemical study on shallow groundwater of the densely-populated Kitashinagawa and Minamishinagawa districts in Shinagawa City, central Tokyo was carried out in February and July 2019. In Kitashinagawa district, despite quite a small area of about 60 m (N-S) by 100 m (E-W), its shallow groundwater in February 2019 represents a wide range of chemistry; 38.6-67.6 mS/m electric conductivity, 17.4-30.2 mg/L Cl^-, 1.6-34.1 mg/L NO_3^-, and 112.2-290.1 mg/L HCO_3^-. This is also the case for July 2019; 38.5-53.1 mS/m electric conductivity, 15.7-42.3 mg/L Cl^-, 0.0-34.8 mg/L NO_3^-, and 116.4-242.0 mg/L HCO_3^-. These remarkable differences in water chemistry among the wellsand elevated concentrations of Cl^- and NO_3^- may result from sewage leakage strongly correlated with failures on the sewerage infrastructure. It is considered sewage leakage acts as a point source of pollutants to shallow groundwater in Kitashinagawa district. In contrast, shallow groundwater in Minamishinagawa district is almost free from sewage leakage and has water quality similar to each other.

$\delta^{18}O$ and Cl^- of water were applied to quantify 1) rainfall infiltration (natural recharge), 2) water supply leakage, and 3) sewage leakage for groundwater recharge of the shallow aquifer. A ternary mixing model was used based on the Cl^- concentration and $\delta^{18}O$ of these three plausible origins of groundwater to estimate fractions of each component in shallow groundwater. As a result, a fraction of sewage leakage in groundwater in Kitashinagawa district proved to be 2-34% in February 2019 and 13-52% in July 2019, while for most of wells in Kitashinagawa and Minamishinagawa districts, rainfall infiltration contributed more than 50% of water to groundwater recharge in both periods of the year. Remarkable differences in contribution of these plausible origins of groundwater may result from the different state of the water and wastewater infrastructure in the vicinity of each well. The surface coverage in Shinagawa City is over 80% of the land surface, but contribution of rainfall infiltration (natural recharge) is unexpectedly high with a maximum value of 99% in Minamishinagawa district. This is presumed to be caused by rainwater leakage taking place underground through breakages of rainwater drainage pipes in addition to infiltration from the ground surface.

Keywords: Tokyo, shallow groundwater, isotope, origin of groundwater, sewage leakage, water supply leakage

