Using dual isotopes to evaluate sources and transformation of nitrate in the West Lake watershed, east China

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The West Lake is a world-famous tourist destination. The water is used for landscape uses, recreational activities and fishing in the West Lake watershed. Finally, the water in the West Lake watershed flows into the Hangzhou Bay. The chemical parameters and isotopic ratios of nitrate were analyzed. This information was then used to identify the sources of nitrate and their transformations in the watershed, and to calculate the nitrogen flux into West Lake and its' discharge to the Hangzhou Bay. The $\delta^{15}N$ and $\delta^{18}O$ isotopes values in dissolved NO3$^-$ samples were determined using the bacterial denitrifier method.

The results revealed that the geochemical facies of the water samples were dominated by $Ca^{2+} + Na^+ - HCO_3^- + SO_4^{2-}$ in the surface water and transfer water, $Ca^{2+} + Na^+ - HCO_3^-$ and $Ca^{2+} + Na^+ - SO_4^{2-}$ types in groundwater, which was likely the result of natural reactions and anthropogenic inputs. About 13% of the groundwater samples containing NO_3^- exceeded the WHO standard of 10 mg N L^{-1}. NO_3^- was the dominant form of total nitrogen, which was the major contaminant in surface water in the West Lake watershed. The $\delta^{15}N_{NO3}$ (–1.7–6.0‰) and $\delta^{18}O_{NO3}$ (–13.1–40.3‰) values indicated that NO_3^- sources included soil nitrogen, chemical fertilizer, precipitation, and manure in surface water, and revealed that the distribution of NO_3^- in groundwater is affected by land use. Soil nitrogen at the forest land, chemical fertilizers and manure at the tea garden, sanitary sewage at the old and small residential area in the forest land and at the urban area were the primary sources of NO_3^- in groundwater. It also supported the existence of a significant degree of nitrification in water of the West Lake watershed. Nevertheless, denitrification processes were also recognized in groundwater. Pollutants flux analysis showed that the annual net flux of TN, NO_3^-, and NH_4^+ into the West Lake was 2.0×10^4, 4.0×10^3, and 1.31×10^4 kg as N, respectively. water that is transferred from the Qiantang River to the West Lake must be treated to reduce the amount of N entering the lake.

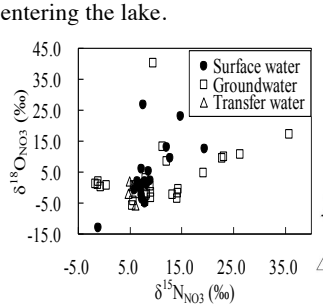

Fig. 1 $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ values **Fig. 2** Piper plots of water of NO_3^- in water samples from samples from the West Lake watershed