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Stable isotopic ratio of atmospheric vapor in Hiratsuka, Japan

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The origin of water vapor in atmosphere could be variable, for example, the water vapor at a specific point is transported from a distance or the vapor is generated from surface water near the specific point. If there is equilibrium between precipitation and atmospheric vapor, the hydrogen and oxygen isotope ratios (δD and δ^{18}O) of atmospheric vapor are plotted theoretically in meteoric water line. Recently, δD and δ^{18}O of atmospheric vapor is used as a tracer for atmospheric water cycle, because the water vapor is much ubiquitous than precipitation (Tsunakawa and Yamanaka, 2005). However, Japan has various water resources. From this aspect, δD and δ^{18}O of atmospheric vapor could be disturbed by several factors such as seasonal variation and difference vapor source of supply (Hiyama et al, 2008). In this study, we investigated the seasonal isotopic variation of atmospheric vapor and precipitation. Then, we also examined surface water on ground and transpiration from leaves of plants, as the candidates of atmospheric vapor sources.

Precipitation and atmospheric vapor were collected on the roof of a No.17 building at Shonan campus, Tokai University from May 2013 to Dec. 2014. Precipitation samples were collected based on the method described by Negrel et al. (2011) and Yoshimura (2002). The duration of collection varied from hours to days. Precipitation samples were percolated through 0.2 μm filter, and kept into a 100 ml low-density polyethylene bottle. Atmospheric vapor samples were collected by the cryogenic trap cooled with ethanol-dry ice mixture (Tsunakawa and Yamanaka, 2005). The total number of precipitation and atmospheric vapor samples were 142 and 90, respectively. The atmospheric vapor may be supplied by surface water on ground and transpiration from leaves of plants, therefore surface water samples were collected on 4 points (pond or river) near a No.17 building from Apr. to Dec. 2014. Transpiration samples were collected at 6 points near a No.17 building from Aug. to Dec. 2014 by polyethylene bag which covers leaves and twig over 1-4 days. Surface water and transpiration samples were percolated through 0.2 μm filter, and kept into a low-density polyethylene bottle. The total number of surface water samples was 6 in each points and the total number of transpiration samples were 16. δD and δ^{18}O of samples were measured by a Cavity Ring-Down Spectrometer analyzer (model L2120-i from PICARRO). Some data of rain water, which were sampled several times in a day, were processed to be the weighted average value.

Precipitation showed wide variations in δD and δ^{18}O from -124.7 to +9.1 ‰ and -16.6 to -0.6 ‰, respectively. Atmospheric vapor also showed wide variations from -223.5 to -82.2 ‰ and -31.2 to -11.6 ‰, respectively. The δD-δ^{18}O relationship of precipitation and atmospheric vapor were regressed by δD=8.5δ^{18}O+17.4 (R^2=0.95) and δD=6.6δ^{18}O-2.6 (R^2=0.92), respectively. The d-excess values (d=δD-8δ^{18}O) of precipitation has a variation from -0.7 to 31.4 ‰. The d-excess of atmospheric vapor shows a definite seasonal trend within the range between 5.6 and 35.7 ‰. The isotopic compositions of atmospheric vapor almost agreed to the calculated value from precipitation assuming isotopic equilibrium with the exception in May 2014, where a significant difference between the observed and the calculated isotopic ratios. Such a composition seemed to be generated by the completely evaporated vapor originating in precipitation (= bulk vapor). In Jun. 2014, the d-excess of atmospheric vapor was deviated from the seasonal variation. Such a deviation can be caused by the addition of evaporated vapor from local surface water. The δD-δ^{18}O plots of all sample suggested that atmospheric vapor was mainly composed by three kinds of vapor, namely, the vapor equilibrated with precipitation, the bulk vapor and the vapor evaporated from the local surface water near the observation point.

Keywords: Precipitation, Atmospheric vapor, Stable isotope