



Human drinking water compared with river waters throughout the United States with respect to their stable hydrogen and oxygen isotopic composition

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The composition of stable isotopes of hydrogen ($\delta^2\text{H}$) and oxygen ($\delta^{18}\text{O}$) in animal tissues, such as hair, nail, teeth and bone, has been used to trace migrations and geographic origin of individuals. Variations of these isotopic ratios in tissue are known to show significant correlations with the isotopic composition of ingested water, as well as with diet and other oxygen sources. Drinking water in natural ecosystems is defined by what is locally available for animal consumption, primarily surface waters such as streams, ponds, lakes, seeps, springs, etc. Tap water provides the drinking water in many human ecosystems. It may derive from local sources but can also draw on more diverse sources, such as large rivers with watersheds larger than those of local creeks, deep ground waters or even imported supplies, which may be isotopically distinct from local ecosystem supplies. Because of the potentially complex hydrologic pathways of water sources available in either animal or human ecosystems, the stable isotopic composition of these supplies may differ significantly from that of the (weighted average) local precipitation which is sometimes used to represent local water supplies. For example, water samples taken from three different taps in Washington, D.C., USA, on August 15, 2007, had measured $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values of -41.7 per mill and -6.13 per mill, -41.7 per mill and -6.06 per mill, and -42.2 per mill and -6.22 per mill, respectively. A water sample taken on the same day from the Potomac River, which is the source of the D.C. water supply, had $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values of -41.7 per mill and -6.06 per mill, respectively, consistent with that of the urban tap water. However, precipitation samples collected locally in Reston, Virginia, USA, had $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values of -16.1 per mill and -3.13 per mill, respectively, for the week ending on August 15, 2007; -17.5 per mill and -3.40 per mill, respectively, for the month preceding August 15, 2007; and -13.6 per mill and -3.39 per mill, respectively, for the average values for the month of August over three years. The isotopic composition of local precipitation was significantly more positive than that for the concurrently available tap water and the river water from which it was drawn. Thus, in order to allow valid geographic inferences for forensic purposes, it is necessary to have available the measured isotopic composition of drinking waters or of their appropriate sources. We have now collected tap water samples concurrently at 345 sites throughout the United States and measured $\delta^2\text{H}$ and $\delta^{18}\text{O}$ during both summer (2007) and winter (2008) seasons. Since large rivers are frequently the source of urban water supplies, we compare this information with data published for rivers and streams throughout the United States (Coplen and Kendall, 2000). These data and analyses should inform the use of stable isotopes of water for forensic determinations.