



A61 Investigating the Predictive Relationships Between Oxygen and Hydrogen Isotopes in Bottled Water and Human Hair in Mexican Populations

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Learning Overview: The goals of this presentation are to: (1) explore the relationship between oxygen ($\delta^{18}\text{O}$) and hydrogen ($\delta^2\text{H}$) in bottled water samples and human hair samples of known Mexican origin; and (2) demonstrate the distribution of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in bottled water samples across the major immigrant-sending states in Mexico to better understand the challenges of using hair as a tool for forensic geolocation in a Mexican context.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by presenting data on the relationship between Mexican bottled water and human hair and the utility of this relationship to act as a predictor of region of origin.

Recently, Juarez et al. reported the application of semi-mechanistic models with adjustable parameters to relate $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in tap water to $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in human hair from Mexico.¹ This study demonstrated that for this modern Mexican sample, positive correlations between isotopes in hair and water were not significant: $r=0.61$ ($p=0.05$) and $r=0.60$ ($p=0.06$) for ^{18}O and ^2H , respectively. This clearly demonstrated that data from this Mexican population do not exhibit the strong relationships between isotope values of ^{18}O and ^2H in tap water and hair characteristic of other populations studied to date. A first order conclusion from this study is that in Mexico, tap water does not equal drinking water. In order to better understand the distribution and variation in ^{18}O and ^2H in probable drinking water samples, bottled water samples representing all brand varieties available per sample location (representing 18 total brands) were collected for 16 states in Mexico ($N=90$ samples). In order to explore the relationship between bottled water and hair samples, this study used a subset of paired samples representing 8 states with $N=62$ hair samples and $N=70$ bottled water samples.

The results are reported here using delta notation and the Vienna Standard Mean Ocean Water (VSMOW) scale. General statistics were analyzed using SPSS version 25.0. Bottled water values spanned a range from +0.5‰ to -11.5‰ and +1.3‰ to -80.2‰ for $\delta^{18}\text{O}$ and $\delta^2\text{H}$, respectively. The lowest sample values came from Tepic Nayarit, but similarly low values were also found in Michoacán, Mexico City, Morelos, Oaxaca, and Campeche. The highest sample values were found in samples from Campeche and Tabasco. Isotope levels in bottled water samples differed in their standard deviation by collection location, ranging from 7.3‰ to 0.03‰ for $\delta^{18}\text{O}$ and 48.6‰ to 0.3‰ for $\delta^2\text{H}$. Samples from Nayarit showed the highest level of deviation. Isotope values in hair ranged from +9.5‰ to +16.1‰ and -90.8‰ to -53.7‰ for $\delta^{18}\text{O}$ and $\delta^2\text{H}$, respectively. The most depleted $\delta^{18}\text{O}$ and $\delta^2\text{H}$ hair values came from individuals in the state of Morelos.

Linear regression for the paired hair and bottled water samples were significant for H isotopes but not for O isotopes ($\delta^2\text{H} = -18.09 + 0.828 * \delta^2\text{H}_w$, $R^2=0.7$, $R=0.84$, $p=0.01$; $R^2=0.43$, $R=0.2$, $p=0.6$). Correlation coefficients for statistically significant relationships were lower than those previously published for tap water/hair or precipitation/hair relationships from other regions.

The variation in bottled water samples by state suggests that multiple sources for bottled water exist for purchase in each locality. While bottled water has comparatively better fits to hair data by state than previously published tap water data, the inconsistent results between this study and those on other regions suggests shifting water usage. Mexico has the highest consumption of bottled water per capita in the world. This study clearly demonstrates that in order to use water isotopes in Mexican hair to determine region of origin, these cultural contexts must be taken into consideration, and a better understanding of bottled water variation and usage is needed.

Reference(s):

1. Juarez, Chelsey A., Ramey, Robin., Flaherty, David T., Akpa, Belinda S. 2019. Oxygen and Hydrogen Isotopes in Human Hair and Tap Water: Modeling Relationships in Modern Mexican Population. *Human Biology*. 90(3) 1-15.

Bottled Water, Hair, Mexico