Links between Purchase Location and Stable Isotope Ratios of Bottled Water, Soda, and Beer in the United States

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This study investigated the impact of purchase location on the stable isotope ratios of beverages by measuring the δ^2H and $\delta^{18}O$ values of bottled water, soda, beer, and tap water collected across the contiguous United States. Measured beverage δ^2H and $\delta^{18}O$ values generally fit the Global Meteoric Water Line (GMWL), suggesting region-of-origin information is recorded in beverage water. Tap water δ^2H and $\delta^{18}O$ values were strongly correlated with the stable isotope ratios of bottled water and soda purchased in the same location. Beer water δ^2H and $\delta^{18}O$ values were also correlated with tap water, although not as strongly. Variability in δ^2H and $\delta^{18}O$ values among beverages purchased at a single location ranged from 2 to 41‰ and from 0.3 to 5.2‰, respectively, but was generally moderate in most locations. It was concluded that the isotopic composition of local tap water is a reasonable proxy for consumers' fluid intake in most U.S. cities.

KEYWORDS: Hydrogen stable isotope; oxygen stable isotope; geographical origin; body water; tap water

INTRODUCTION

A semimechanistic model has been recently presented to describe the incorporation of hydrogen and oxygen atoms into human hair keratin by following inputs to the body water pool, from which the proteins used for keratin synthesis are derived (*1*). In its current form the model considers four body water pool inputs: (1) drinking water, (2) water contained within food, (3) food solids, and (4) diatomic oxygen. In previous model applications the stable isotope ratios of the drinking water input were assumed to be analogous to locally available environmental water (*2, 3*). The hydrogen (δ^2H) and oxygen ($\delta^{18}O$) isotope values of both precipitation and tap water vary in a predictable manner across landscapes, with higher values observed in low-latitude, low-elevation coastal regions and lower values in high-latitude, high-elevation inland regions (*4, 5*). These predictable variations form isotopic landscapes, or isoscapes (*6*). Because the δ^2H and $\delta^{18}O$ values of locally available environmental water are incorporated into a consumer's body water pool, and then into synthesized tissues such as hair, the model can be used to investigate the geolocation of humans, as demonstrated by recent studies at historic (*2*) and modern (*3*) time scales.

Modern humans often have the freedom to choose from a wide variety of commercially available beverages to slake thirst. Some beverages may not be produced near the consumer (e.g., national brands of beer, bottled water of specific origin), and the isotopic composition of these inputs would no longer be tied to the geographic location of the consumer. The δ^2H and $\delta^{18}O$ values of a fluid input composed of beverages distributed on a large, regional scale may not necessarily mirror those of local tap water.

The power of prediction using local tap water isotope ratios in models like that of Ehleringer et al. (*1*) would be confounded by the consumption of nonlocal beverages. On the other hand, some beverages (e.g., carbonated soft drinks, microbrew beer) likely use a more local distribution system. We expect the isotopic composition of a fluid input composed of beverages distributed on a small, local scale would generally mirror those of local tap water.

The potentially confounding presence of nonlocal beverages in the fluid intake of a human has been previously addressed both directly (*7*) and indirectly (*8*), but to date there has been no concerted effort to investigate the impact of location on the stable isotopic composition of different beverages. Modern Americans have access to an array of beverages including alcoholic beverages, bottled water, carbonated soft drinks, coffee, fruit juices and other fruit drinks, milk, tea, and vegetable juice (*9*). The availability of bottled waters and soft drinks in particular has dramatically increased in the past two decades (*9*), and both the variety and volume of beverages consumed in 2002 were noticeably increased over 1965 and 1977 beverage consumption patterns (*10*). The increasing contribution of beverages to energy intake in the U.S. population has recently prompted the creation of a Beverage Guidance Panel to counsel consumers on beverage choices (*11*). Nevertheless, the number one food item contributing to the daily energy intake of an American in 1999−2000 was soft drinks; beer was number 9 (*12*).

We present here a directed survey of three widely consumed beverages, bottled water, soft drinks (soda), and beer, to assess the links between purchase location and the isotopic composition of beverages. To investigate whether or not these beverages could have a confounding impact on the overall isotopic composition of a consumer's fluid intake, we collected tap water from the same

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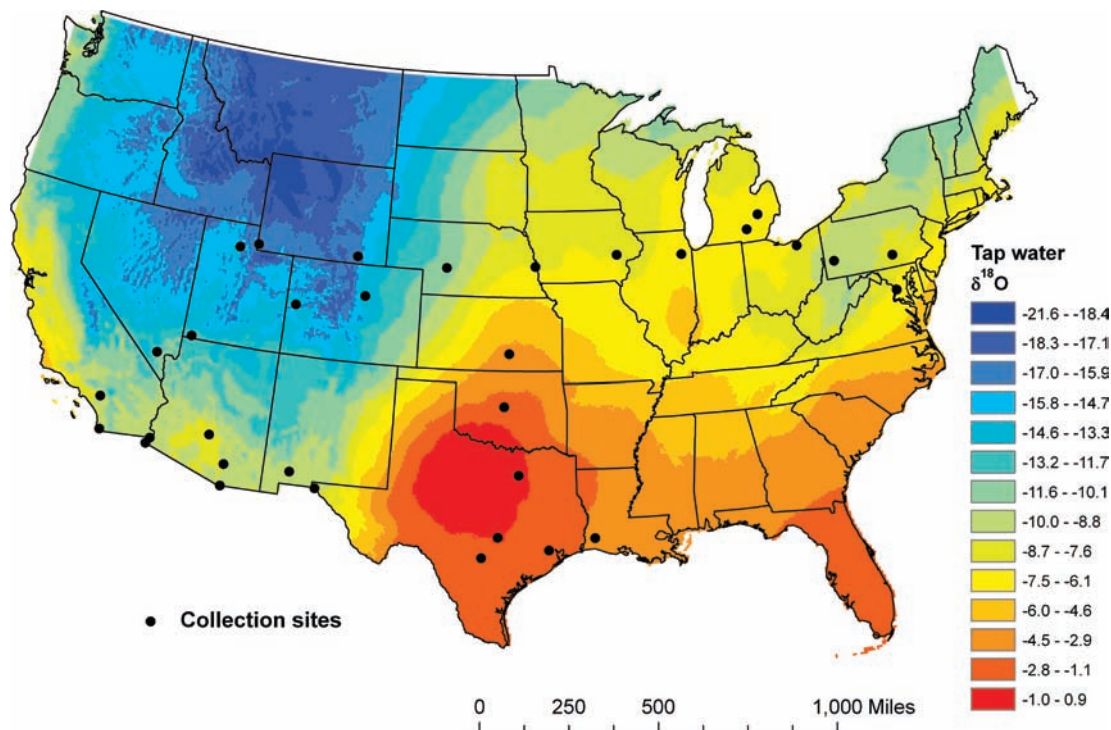
Figure 1. Locations of cities within the continental United States visited in this survey, shown on a predicted tap water oxygen isoscape (*4*).

cities in which beverages were purchased. We hypothesized that the δ^2H and $\delta^{18}O$ values of beverages distributed more locally would be correlated with those of local tap water, whereas the δ^2H and $\delta^{18}O$ values of beverages distributed on a more regional scale may not be correlated with the consumer's tap water. We further hypothesized that most beverages available to consumers are distributed locally due to transport costs, and therefore the impact of nonlocal beverages to a consumer's liquid input is relatively small.

MATERIALS AND METHODS

Sample Collection and Processing. In February 2008 a single container of bottled water (Dasani brand), soda (Coca-Cola Classic), and beer (Budweiser) was collected from each of 33 cities in the contiguous United States (**Figure 1**). Cities were chosen to span the maximum range of predicted tap water δ^2H and $\delta^{18}O$ values in the United States (see **Figure 1** and ref *4*). Samples were purchased from traditional grocery retailers as well as convenience stores and gas stations. Upon purchase, water bottles, soda bottles, and beer cans were labeled and stored as is until returned to the laboratory. In each city three samples of tap water were also collected as detailed previously (*13*).

In the laboratory soda bottles and beer cans were opened, and a 1 mL subsample of liquid was transferred onto clean glass wool as described in ref *14*. Liquid subsamples were immediately frozen, and water was cryogenically extracted using a vacuum distillation line (see ref *15* for a schematic of the line). A 0.5 mL aliquot of the extracted water sample was then transferred to a 1.8 mL crimp-top GC vial and sealed. A 0.5 mL aliquot of each purchased Dasani bottled water and each collected tap water was transferred to a GC vial without distillation. Sealed vials were stored in a cool, dark location prior to analysis.

Stable Isotope Analysis. Water samples were analyzed at the Stable Isotope Ratio Facility for Environmental Research (SIRFER; http://sirfer.net) at the University of Utah in Salt Lake City, UT. Stable isotope compositions were measured using a ThermoFinnigan-MAT Delta Plus XL isotope ratio mass spectrometer (Bremen, Germany) with a high-temperature conversion elemental analyzer (TC/EA) attached. Water was introduced to the TC/EA using a PAL autosampler (LEAP Technologies, Carrboro, NC) where samples were pyrolyzed at 1400 °C in the presence of carbon to produce H_2 and CO gases. Gases were separated using a 1 m,

0.25 in. (o.d.) molecular sieve 5 Å gas chromatography column (Costech Analytical, Valencia, CA). Water samples were analyzed alongside a set of three laboratory water reference materials that had been previously calibrated on the Vienna Standard Mean Ocean Water (VSMOW) scale. The analytical precisions, defined as 1σ, were ± 2 and ± 0.2‰ for H and O, respectively.

Stable isotope abundances are reported in δ-notation in parts per thousands (‰), where

$$\delta = (R_A/R_S - 1) \times 1000$$

and R_A and R_S are the molar ratios of the rare to abundant isotope (e.g., $^2H/^1H$) in the sample of interest and a standard, respectively. The international standard for both hydrogen and oxygen stable isotope analysis is VSMOW.

Statistical Analysis. Statistical analysis was performed using Prism version 5.0c for Mac OS X (Graphpad Software Inc., San Diego, CA). The relationship between the δ^2H and $\delta^{18}O$ values of each beverage data set was tested using linear regression. The slopes of the regression lines for the beverage and tap water data sets were compared using analysis of covariance (ANCOVA). The intercepts of the regression lines were compared using analysis of variance (ANOVA) with a Newman–Kuels multiple-comparison post hoc test to identify significant differences among the intercepts; the significance level was set to $\alpha = 0.05$. The relationships between the measured δ^2H values and $\delta^{18}O$ values of the beverage and tap water data sets were tested using the Pearson correlation coefficient.

RESULTS

Patterns Observed in the Beverage Data Set. There was sizable variation in the δ^2H and $\delta^{18}O$ values of the bottled water, soda, beer, and tap water data sets, presented in **Table 1**. The tap water data set had the largest variation in δ^2H and $\delta^{18}O$ values, with ranges of 121 and 16.0‰, respectively. Variation was modestly smaller for water extracted from beer samples, with ranges of 106 and 14.0‰ for H and O, respectively. The overall means ($\pm 1\sigma$) for all collected beverages were -61 ± 28‰ for δ^2H values and -7.9 ± 3.6‰ for $\delta^{18}O$ values.

The δ^2H and $\delta^{18}O$ values of Dasani bottled water, water extracted from Coca-Cola Classic, water extracted from Budweiser beer, and tap water all exhibited significant covariance (**Figure 2**).

Table 1. Measured δ^2H and $\delta^{18}O$ Values for Tap Water, Bottled Water, Soda, and Beer Collected across the United States[a]

city	state	tap water δ^2H, ‰	tap water $\delta^{18}O$, ‰	bottled water δ^2H, ‰	bottled water $\delta^{18}O$, ‰	soda δ^2H, ‰	soda $\delta^{18}O$, ‰	beer δ^2H, ‰	beer $\delta^{18}O$, ‰	beverage mean δ^2H, ‰	beverage mean $\delta^{18}O$, ‰	beverage 1σ δ^2H, ‰	beverage 1σ $\delta^{18}O$, ‰
Chandler	AZ	−70	−9.4	−66	−8.5	−70	−9.1	---	---	−69	−9.0	3	0.5
Nogales	AZ	−57	−7.9	−61	−7.1	−73	−9.2	−55	−6.9	−61	−7.8	8	1.0
San Luis	AZ	−107	−13.6	−80	−9.6	−64	−7.7	−115	−14.7	−92	−11.4	24	3.3
Tucson	AZ	−61	−8.0	−62	−7.6	−73	−9.4	−78	−9.4	−68	−8.6	8	0.9
Yuma	AZ	−95	−11.4	−77	−9.5	---	---	−54	−6.9	−75	−9.3	21	2.3
Chula Vista	CA	−32	−4.2	−57	−7.8	−128	−15.1	−75	−9.1	−73	−9.1	41	4.6
Riverside	CA	−60	−8.7	−59	−8.0	−73	−8.9	−75	−9.1	−67	−8.7	8	0.5
Denver	CO	−104	−13.2	−105	−13.2	−113	−14.3	−56	−6.9	−95	−11.9	26	3.4
Grand Junction	CO	−102	−13.5	−121	−15.8	−119	−15.2	−52	−6.4	−99	−12.7	32	4.3
Des Moines	IA	−75	−10.7	−63	−8.6	−71	−8.5	−52	−6.6	−65	−8.6	10	1.7
Joliet	IL	−46	−6.9	−43	−5.5	−48	−5.3	−53	−6.9	−48	−6.2	4	0.9
Wichita	KS	−23	−3.4	−44	−6.8	−26	−3.1	−51	−6.3	−36	−4.9	14	1.9
Lake Charles	LA	−21	−4.1	−39	−5.9	−26	−4.4	−10	−1.0	−24	−3.9	12	2.1
Fenton	MI	−66	−9.7	−53	−6.7	−60	−6.7	−46	−5.5	−56	−7.2	9	1.8
Jackson	MI	−60	−9.1	−54	−6.7	−54	−5.6	−39	−5.4	−52	−6.7	9	1.7
North Platte	NE	−82	−10.7	−103	−13.0	−53	−7.0	−45	−6.0	−71	−9.2	27	3.3
Omaha	NE	−65	−8.9	−63	−8.6	−56	−6.4	−53	−6.9	−59	−7.7	6	1.2
Las Cruces	NM	−90	−11.5	−112	−14.4	−67	−7.8	−73	−9.0	−86	−10.7	20	2.9
Las Vegas	NV	−99	−12.3	−57	−7.7	−71	−8.9	−71	−8.7	−74	−9.4	18	2.0
Strongsville	OH	−49	−6.3	−46	−7.3	−50	−6.6	−37	−5.4	−45	−6.4	6	0.8
Oklahoma City	OK	−7	−1.0	−13	−1.9	−9	−0.7	−52	−6.3	−20	−2.5	21	2.6
Harrisburg	PA	−49	−7.9	−47	−7.4	−55	−7.4	---	---	−50	−7.6	4	0.3
Pittsburgh	PA	−62	−9.5	−46	−7.4	−54	−6.0	---	---	−54	−7.6	8	1.7
Austin	TX	−12	−2.0	−9	−1.6	−19	−2.1	−9	−0.8	−12	−1.6	5	0.6
Dallas	TX	−7	−1.3	---	---	−10	−1.0	−9	−0.8	−9	−1.0	2	0.3
El Paso	TX	−83	−11.1	−106	−13.1	−73	−9.7	−13	−1.3	−69	−8.8	40	5.2
Houston	TX	−15	−2.7	−8	−1.3	−23	−3.0	−9	−1.0	−14	−2.0	7	1.0
San Antonio	TX	−20	−3.4	−10	−1.6	−28	−4.0	−8	−0.7	−17	−2.4	9	1.5
Kaysville	UT	−122	−16.0	−125	−16.5	−118	−15.3	−54	−6.6	−105	−13.6	34	4.7
St. George	UT	−88	−11.3	−124	−16.4	−121	−15.7	−52	−6.9	−96	−12.6	34	4.4
Alexandria	VA	−41	−6.4	−37	−6.0	−39	−5.9	−37	−5.2	−39	−5.9	2	0.5
Evanston	WY	−128	−17.0	−121	−15.8	−120	−14.9	−48	−6.2	−104	−13.5	38	5.0
Laramie	WY	−120	−15.6	−119	−15.4	−120	−15.6	−48	−6.1	−102	−13.2	36	4.7
mean												16	2.2

[a] Mean and standard deviation values for the four beverages grouped by purchase location are also calculated.

Best-fit lines for the data sets were described by the equations

$$\delta^2H = 8.0\delta^{18}O + 4.1‰ \quad (r^2 = 0.98,$$
$$p < 0.0001), \text{ for bottled water}$$

$$\delta^2H = 7.8\delta^{18}O - 1.8‰ \quad (r^2 = 0.98, p < 0.0001), \text{ for soda}$$

$$\delta^2H = 7.8\delta^{18}O - 1.1‰ \quad (r^2 = 0.99, p < 0.0001), \text{ for beer}$$

$$\delta^2H = 8.1\delta^{18}O + 6.2‰ \quad (r^2 = 0.98,$$
$$p < 0.0001), \text{ for tap water}$$

The slopes of the bottled water, soda, and beer regression lines ($m = 8.0$, 7.8, and 7.8, respectively) were not statistically different from each other or from the tap water line ($m = 8.1$). Additionally, the slopes of all the beverage and tap water regression lines were nearly identical to the slope of the Global Meteoric Water Line (GMWL), which describes the global relationship between water δ^2H and $\delta^{18}O$ values and has a slope of 8 (**Figure 2**; ref *16*). The *y*-intercept of the soda line was statistically different from the *y*-intercepts of the bottled water and tap water lines. Additionally, the *y*-intercept of the beer line was statistically different from both the bottled water and tap water lines. The *y*-intercepts of the soda and beer lines were not statistically different from one another;

the *y*-intercepts of the bottled water and tap water were also not different from each other.

Tap Water and Beverage Comparisons. The Pearson correlation coefficients (*r*) for the correlations between the δ^2H values and $\delta^{18}O$ values of tap water, bottled water, water extracted from soda, and water extracted from beer are shown in **Table 2**. Correlations were strongest between tap water stable isotope ratios and the δ^2H and $\delta^{18}O$ values of bottled water and water extracted from soda. We also observed strong correlations between bottled water and soda, which were expected because the Coca-Cola Co. owns the Dasani brand and both Coca-Cola Classic and Dasani water are likely bottled at the same production facility. Beer water δ^2H and $\delta^{18}O$ values were well correlated with tap and soda water δ^2H and $\delta^{18}O$ values but not bottled water. However, the correlations between beer and other beverages were in general not as strong as those between tap water, soda, and bottled water.

Isotopic Variation among Beverages Grouped by Location. Isotopic variability was calculated as the standard deviation among the δ^2H and $\delta^{18}O$ values of the four beverage samples grouped by purchase location and varied widely across the 33 cities visited in this survey (**Table 1**). Standard deviations ranged from 2 to 41‰ for δ^2H values and from 0.3 to 5.2‰ for $\delta^{18}O$ values. Average 1σ values across all surveyed locations were 16 and 2.2‰ for H and O, respectively. In general, the isotopic variation among beverages was highest in the southwestern United States, including cities in the states of Colorado, Utah,
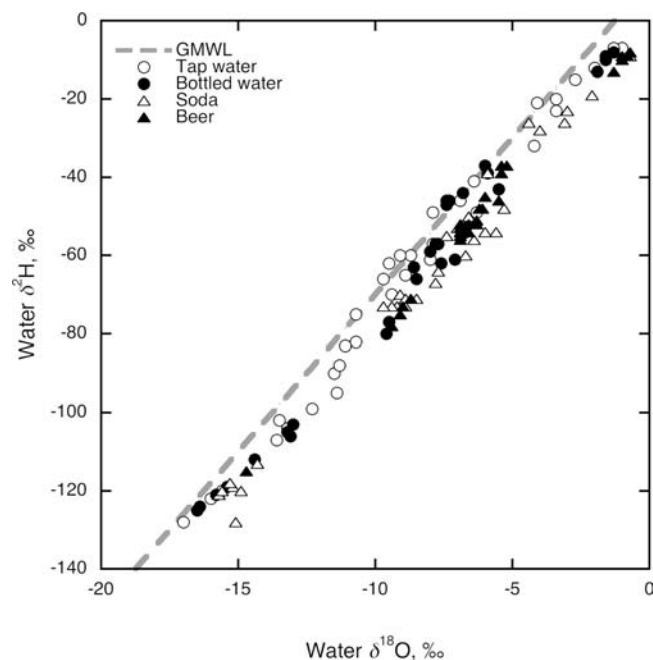
Figure 2. Measured hydrogen and oxygen stable isotope ratios of tap water, bottled water, water extracted from soda, and water extracted from beer. The Global Meteoric Water Line (GMWL), which describes the relationship between the δ^2H and δ^{18}O values of water around the globe (*17*), is presented for reference.

Table 2. Correlation Coefficients (*r*) between Measured δ^2H (Top) and δ^{18}O (Bottom) Values of Tap Water, Bottled Water, Water Extracted from Soda, and Water Extracted from Beer

	tap	bottled	soda	beer
Hydrogen				
tap water	1			
bottled water	0.89[a]	1		
soda	0.79[a]	0.82[a]	1	
beer	0.51[b]	0.36	0.47[c]	1
Oxygen				
tap water	1			
bottled water	0.87[a]	1		
soda	0.78[a]	0.84[a]	1	
beer	0.49[b]	0.35	0.42[c]	1

[a] $p < 0.0001$. [b] $p < 0.01$. [c] $p < 0.05$.

and Wyoming. Two other notably variable locations were Chula Vista, CA, and El Paso, TX. However, other Texas cities (i.e., Austin, Dallas, Houston, and San Antonio) had generally low isotopic variability among beverages. Variation was also low in cities in eastern and Midwestern states, including Illinois, Nebraska, Ohio, Pennsylvania, and Virginia.

DISCUSSION

Beverages May Contain Geographic Source Information. The δ^2H and δ^{18}O values of water extracted from three commonly consumed beverages collected in this survey, bottled water, soda, and beer, generally fit the GMWL. The bottled water line we observed agrees well with previous surveys of multiple bottled water brands collected globally, which also found that water δ^2H and δ^{18}O values clustered near the GMWL (*8*, *17*, *18*). To our knowledge, this is the first description of soda and beer water lines that also generally fit the GMWL.

We do note that the *y*-intercepts of the best-fit lines for the soda and beer data sets were lower than those of the bottled water and tap water lines observed in this survey and also lower than the *y*-intercept of the GMWL. Although there may be multiple explanations for the lower *y*-intercepts, we present two possibilities here. First, processes during the production of soda and beer could isotopically fractionate water between source and final beverage, which manifests as differences in *y*-intercept values. Second, the presence of secondary compounds in the extracted water collected via distillation may have affected the δ^2H and δ^{18}O values of soda and beer. For soda, these compounds were most likely flavorings; the water extracted from beer also contained ethanol. On the basis of information available on the beverage labels, these secondary compounds likely accounted for a small proportion of the extracted water sample volume (< 1% for flavorings and < 6% for ethanol). Future work could focus on these *y*-intercept differences, including production of soda and beer in a controlled laboratory setting to characterize the isotopic impact of synthesis processes or filtration of extracted water to remove secondary compounds.

Despite the slight variations in *y*-intercept values, the congruence between bottled, soda, and beer water lines and the GMWL implies the δ^2H and δ^{18}O values of water in these beverages may act as a recorder of source water used in production. If so, the collection and analysis of beverage water could potentially be useful in determining the location of the original source of the water. This has been previously suggested for bottled water (*8*, *17*, *18*), but was also recently suggested for commercially available dairy cow milk (*19*). Such location investigations will require some estimation of certainty for predictions, using a probability-based assignment approach like those that have very recently been applied to wildlife forensics questions (*20*). More work will be needed to understand both source water and beverage water baseline variability so that certainty estimates can be calculated in future applications of the probability-based assignment approach to questions of beverage sourcing (see ref *21*).

Water Source May Control Beverage Stable Isotope Ratios. The stable isotope ratios of water contained within a marketed beverage can be affected by at least three processes: (1) the original source of the water used to make the beverage; (2) transport and fractionation of the source water before the beverage was produced; and (3) seasonal variability that affects the source water prior to its transport. The State of California has a notoriously complex water distribution infrastructure, and the water supply system of many metropolitan areas is subject to all three processes. Consider the tap water, bottled water, soda, and beer we purchased in Chula Vista, CA, which were characterized by large interbeverage isotopic variability. Chula Vista is located near the Los Angeles Anheuser-Busch brewery. On the basis of the number of bottling plants (*22*), we also assume the city has a local source of Coca-Cola and Dasani. However, the δ^2H and δ^{18}O values of all three beverages purchased in Chula Vista varied between samples and each, in turn, was quite different from local tap water (**Table 1**).

The Water Education Foundation (www.water-ed.org/water-sources/) provides an interactive map to aid California residents in identifying the source(s) of their tap water. There are four sources for Chula Vista: the State Water Project (SWP), the Colorado River Aqueduct (CRA), groundwater, and local streams and reservoirs. A survey of water from similar water sources in Orange County, just north of Chula Vista, found the δ^2H and δ^{18}O values of the different sources were distinct (*23*). The stable isotope ratios of water from the CRA were typically lighter than values measured for other water sources. Aquifer and groundwater sources were notably variable. Water in the SWP began with relatively light δ^2H and δ^{18}O values, but residence time in reservoirs enriched stable

isotope ratios. Overall, the δ^2H and $\delta^{18}O$ values of water sources in Orange County ranged ~60 and ~8‰, respectively.

We assume the water supply of the city of Chula Vista can include water from as many as four different sources. We further assume the measured isotopic variability among the different water sources in Orange County (*23*) is analogous to variability among water sources in Chula Vista. Because of the unique isotopic composition of each source, the amount of water from any one source used to supply water for beverage production can have a profound impact on final beverage δ^2H and $\delta^{18}O$ values. If we also assume the relative contribution of each water source changes through time, we have a scenario for variability in Chula Vista water δ^2H and $\delta^{18}O$ values due to different water sources, the transport of water from its source, and the seasonal demand for water.

Tap Water Is a Reasonable Proxy for Most Purchased Beverages. As hypothesized, some beverage δ^2H and $\delta^{18}O$ values were strongly correlated with local tap water δ^2H and $\delta^{18}O$ values, suggesting those beverages are produced near the consumer and then distributed locally. The Dasani bottled water data (**Table 1**) from this survey corroborate a conclusion of the bottled water survey by Bowen et al.: namely, bottled water is generally analogous to local environmental water. Therefore, increased bottled water consumption is unlikely to affect the isotopic relationship between a consumer tissue, such as hair keratin, and local environmental water. We observed a similar relationship between paired soda and tap water. The high correlation coefficients between local tap water and soda water suggest that soda is generally produced locally to the consumer (*22*). From these data, we conclude that isotopically there is no difference in the water input for a consumer who drinks Dasani versus a consumer who drinks Coca-Cola, and those beverage inputs are generally no different from a consumer imbibing only tap water, in the continental United States.

We observed weaker correlations between tap water and beer water isotope ratios. We assume this is due to the inherent regionality in the production and subsequent distribution of a national brand of beer such as Budweiser. Anheuser-Busch Co., Inc. (which brews Budweiser beer; www.anheuser-busch.com), operates 12 breweries in the United States. Because of the limited number of production facilities, Anheuser-Busch must use regional distribution systems to market its beer, and the beer available to a consumer may have traveled several hundred miles from brewery to supermarket shelf. Each brewery could be considered the point source of a distribution region, and the distance a consumer is from a point source will affect the isotopic composition of the nonlocal beverage input.

As a practical application, consider a consumer living near the Houston Anheuser-Busch brewery, for example, in Austin, Dallas, or San Antonio, all within 250 miles of Houston. The δ^2H and $\delta^{18}O$ values of Houston tap water (-15 and -2.7‰, respectively; **Table 1**) are similar to the mean tap water δ^2H and $\delta^{18}O$ values (-13 and -2.0‰, respectively) for Austin, Dallas, and San Antonio. In turn, the mean beer water δ^2H and $\delta^{18}O$ values (-9 and -1.0‰, respectively) in the three cities are indistinguishable from those of beer purchased in Houston (-9 and -1.0‰, respectively; **Table 1**). On the other hand, consider a consumer in El Paso, TX, some 750 miles west of Houston. The Budweiser beer available to a consumer in El Paso may also have been produced in Houston, but the differences in the δ^2H and $\delta^{18}O$ values of water extracted from beer purchased in El Paso (-13 and -1.3‰, respectively; **Table 1**) and local El Paso tap water (-83 and -11.1‰, respectively; **Table 1**) are much larger because of El Paso's greater distance from the Houston brewery.

Beverage Isotope Ratios May Be Useful for Spatial Forensic Investigations. From this survey of commonly consumed U.S.

beverages we observed links between purchase location and the stable isotope ratios of beverages. In general, the δ^2H and $\delta^{18}O$ values of beverages that were likely produced and distributed on a local scale were strongly correlated with local tap water δ^2H and $\delta^{18}O$ values. The isotopic composition of beverage inputs can vary for consumers who live in regions where the water available for beverage production comes from distinct sources, travels long distances, or changes seasonally. We also found evidence that consumers who live far distant from the production center of a regionally distributed beverage may be incorporating δ^2H and $\delta^{18}O$ values that are quite different from local tap water stable isotope ratios.

However, despite the large isotopic variability (defined as 1σ in **Table 1**) among beverages in a few cities, the mean of the standard deviations across all surveyed cities was relatively low for both δ^2H and $\delta^{18}O$ values (16 and 2.2‰, respectively). Variability was even lower for δ^2H and $\delta^{18}O$ values when the stable isotope ratios of only tap water, bottled water, and soda were considered (10 and 1.4‰, respectively). A survey of tap water collected monthly in the contiguous United States observed the δ^2H and $\delta^{18}O$ values of extreme months fell within 12 and 1.8‰ of annual mean values (*4*), which implies the variability in the stable isotope ratios of beverages available to a modern American will affect body water δ^2H and $\delta^{18}O$ values no more than the natural temporal variability of the consumer's tap water source. Thus, we conclude that the use of local environmental water δ^2H and $\delta^{18}O$ values as a proxy for drinking water input is reasonable for most applications of the Ehleringer et al. (*1*) model at modern time scales.

Finally, we suggest the approach and work presented here serve as an example for creating databases of the stable isotope ratios of water and beverages. When combined with probability-based assignment approaches, collections of stable isotope measurements like these may eventually allow investigators to predict the original source of water used in beverage production from the stable isotope analysis of a beverage. The difference between the predicted stable isotope ratios of beverage source water and local tap water may represent a measure of transport, either (a) the distance the source water used to produce the beverage traveled to the production facility or (b) final beverage product transport. Regardless, the transport measure could quantitatively describe how beverages move across geographic isotopic gradients from production to consumption, an "iso-footprint" for liquid intake. We recognize much more work is needed to develop such an application; however, this survey demonstrates the potential power of beverage stable isotope analysis for authentication and tracing studies.

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