Consumer Reports' Test Methodology for Heavy Metals and Per- and Polyfluoroalkyl Substances (PFAS) in Bottled Water

The objectives of this study were to determine the levels of total arsenic, inorganic arsenic, cadmium, lead, mercury, and PFAS in commercially available brands of bottled water, and to assess any associated health risk. We tested 47 bottled waters (45 brands), which included 12 carbonated and 35 noncarbonated products. We selected the brands and products based on marketing data and data from a shopper survey of stores in the New York metropolitan area. We purchased the samples between January and March 2020 from stores in the New York and New Jersey area, from stores in other regions of the U.S., and from online retailers. We included nationally available products and obtained unique samples or lots of each product.

Sample Preparation

The unopened samples were masked, blind-coded to preserve their identities, and shipped overnight to an independent, accredited laboratory. At the lab, sample preparation was performed in fume hoods verified to be free from trace metals and PFAS contamination. Water, sample containers, and other materials used for the analyses were monitored for contamination to account for any biases in sample results.

Testing

All samples were prepared and analyzed in accordance with the following Environmental Protection Agency methods:

- Analysis for total arsenic, cadmium, and lead by inductively coupled plasma mass spectrometry (ICP-MS) following EPA Method 200.8.
- Analysis for total mercury by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (CV-AFS) following EPA Method 1631E.
- Analysis for 30 PFAS by isotope dilution solid phase extraction and liquid chromatography tandem mass spectrometry (LC-MS/MS) following a modified EPA Method 537.1.

All arsenic-positive samples were prepared and analyzed for inorganic arsenic III and V, and three organic arsenic species—monomethyl arsonic acid (MMA), dimethyl arsinic acid (DMA), and trimethyl arsine oxide (TMAO) by ion chromatography-inductively coupled plasma-collision reaction cell-mass spectrometry (IC-ICP-CRC-MS). Carbonated samples were purged in ultrapure-grade nitrogen for 15 minutes and sonicated to remove the carbonation before analysis. A method blank and a blank spike were purged as well, to show that there was no contamination or species conversion.

Sample analysis was precluded by a multipoint calibration curve spanning the entire concentration range of interest. Calibration curves were performed at the beginning of each day of analysis and verified during analysis. The testing conformed to the quality control criteria and performance requirements set in the cited official methods, as well as to those in ISO 17025.

Data Analysis and Risk Assessment

We reported the average of two to four samples tested of each product. The results of individual PFAS in many products were above the method detection limit (MDL) but below the method reporting limit (MRL). We defined total PFAS as the sum of average concentrations of all PFAS detected in the samples tested of a product. To estimate the exposures and assess potential risks posed by the measured contaminants, we applied a method used by many risk assessors[1], including the EPA[2], to calculate the average concentration of a metal or an individual PFAS chemical in a product. If the metal or PFAS chemical was detected in any of the samples of the product, the samples that had test results below the MDL were assumed to have a concentration of half the MDL for that metal or PFAS chemical. If the metal or PFAS chemical was not detected in any of the samples tested of the product, we assumed a concentration of zero for all the samples of that product for that metal or PFAS chemical. This approach to risk assessment appropriately took into account important uncertainties about potential levels of undetected risk in samples with test results below the MDL.

We compared the average levels of contaminants in a product to the Food and Drug Administration limits for heavy metals in bottled water, the EPA Health Advisory for PFAS, and the International Bottled Water Association operation control limits for PFAS, as well as to health-based exposure limits that are more stringent and protective of health.

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[1] Xue J, Zartarian V, Wang S, et al. (2010). “Probabilistic Modeling of Dietary Arsenic Exposure and Dose and Evaluation with 2003-2004 NHANES Data.” Environmental Health Perspectives, 118(3): 345-35.

[2] Environmental Protection Agency. “Regional Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments.” Available at: https://www.epa.gov/risk/regional-guidance-handling-chemical-concentration-data-near-detection-limit-risk-assessments.