United States Geological Survey

Reston Stable Isotope Laboratory

Report of Stable Isotopic Composition

Reference Material USGS50

Lake Kyoga Water

(Hydrogen and Oxygen Isotopes in Water)

This reference material (RM) is intended for daily normalization of stable hydrogen-isotope (δ^2H) and oxygen-isotope (δ^{18}O) measurements of unknown waters with an isotope-ratio mass spectrometer or a laser absorption spectrometer. A unit of this RM consists of 144 autoclaved glass ampules of Lake Kyoga water, Uganda. Glass ampules containing 5 mL of water are available.

Recommended Values: Stable hydrogen and oxygen isotopic compositions are expressed herein as delta values [1] relative to VSMOW (Vienna Standard Mean Ocean Water) on scales normalized such that the δ^2H and δ^{18}O values of SLAP (Standard Light Antarctic Precipitation) are –428 ‰ and –55.5 ‰, respectively [2,3]. Each stable isotopic composition is given as a reference isotope-delta value with an estimated expanded uncertainty ($U = 2u_c$) about the reference value that provides an interval that has about a 95-percent probability of encompassing the true value. [4]

Stable hydrogen isotopic composition: $\delta^2H_{VSMOW\text{-}SLAP} = +32.8 \pm 0.4$ ‰

Stable oxygen isotopic composition: $\delta^{18}O_{VSMOW\text{-}SLAP} = +4.95 \pm 0.02$ ‰

Technical coordination for this RM was provided by Haiping Qi of the Reston Stable Isotope Laboratory (RSIL).

Reston, Virginia 20192
August 21, 2026

Tyler B. Coplen, Director
Reston Stable Isotope Laboratory

Expiration of Reference Value: The reference values for the isotopic composition of USGS50 are valid until December 31, 2036, provided the RM is handled in accordance with the instructions given in this Report of Stable Isotopic Composition (see "Instructions for Use"). A reference value is nullified if the glass ampule containing the RM is inadvertently broken.

Source of the RM: Water was collected from Lake Kyoga, Uganda by Ms. Christine Mukwaya (Directorate of Water Resources Management, Entebbe, Uganda). This water was filtered at the RSIL with a 0.2-µm filter, homogenized, loaded into 5-mL glass ampules, and sealed with a torch. Each ampule was inverted and autoclaved at about 120 °C for a minimum of 20 minutes to terminate biological activity. Each ampule was weighed to identify and eliminate any leaking ampules. This water is low in total dissolved solids, and typical selected anion concentrations are: dissolved chloride is ~ 10 mg/L; dissolved nitrate is ~4 mg/L; dissolved sulfate is ~0.5 mg/L; dissolved fluoride is ~0.4 mg/L; dissolved bicarbonate is ~120 mg/L.

Stability: USGS50 is stable at normal room temperatures. The reference values in this Report of Stable Isotopic Composition apply only to freshly opened ampules.

Instructions for Use: This RM is intended for daily calibration of instrumentation and for calibrating unknown waters by interspersing aliquots of the RM among water sample unknowns. The unused fraction of this RM should be discarded after opening an ampule due to the strong possibility of evaporative losses causing significant isotopic fractionation. It is envisioned that laboratory personnel will open an aliquot of USGS50 daily and they analyze their unknown waters. Laboratory personnel can use two different water RMs (others include USGS45, USGS46, USGS47, USGS48, USGS49, and USGS53) and then normalize isotopic measurement results to the VSMOW-SLAP scale [5]. Many users employ LIMS for Light Stable Isotopes for their normalization [6].

Reporting of Stable-isotope-delta Values: The following recommendations are provided for reporting stable hydrogen and oxygen isotope-delta values [3]. It is recommended that:

- The δ^2H values of all hydrogen-bearing substances be expressed relative to VSMOW-SLAP on a scale where the δ^2H of SLAP = –428 ‰ exactly.
- The δ^{18}O values of all oxygen-bearing substances be expressed relative to VSMOW-SLAP or relative to Vienna Peedee belemnite (VPDB; for carbonates) on a scale such that the δ^{18}O of SLAP = –55.5 ‰ relative to VSMOW, and for carbonates, such that δ^{18}O of NBS 19 calcium carbonate = –2.2 ‰.
- Authors report delta values of international distributed (secondary) isotopic reference materials as though they had been interspersed among and used for normalization of unknowns, as appropriate, for the measurement method. In this manner, measurement results can be adjusted in the future as analytical methods improve and consensus values of internationally distributed isotopic reference materials change.
- Reporting of delta values relative to SMOW and PDB (Peedee belemnite) be discontinued [7].

REFERENCES

[1] Coplen, T. B., 2011, Guidelines and recommended terms for expression of stable-isotope-ratio and gas-ratio measurement results: Rapid Communications in Mass Spectrometry, v. 25(17), p. 2538–2560. https://doi.org/10.1002/rcm.5129

[2] Gonfiantini, R., 1978, Standards for stable isotope measurements in natural compounds: Nature, v. 271, p. 534–536. https://doi.org/10.1038/271534a0

[3] Coplen, T. B., 1994, Reporting of stable hydrogen, carbon, and oxygen isotopic abundances: Pure and Applied Chemistry, v. 66(2), p. 273–276. https://doi.org/10.1351/pac199466020273

[4] Coplen, T. B., Wassenaar, L. I., Mukwaya, C., Qi, H., Lorenz, J., 2015, A new isotopic reference material for stable hydrogen and oxygen isotope-ratio measurements of water – USGS50 Lake Kyoga Water: Rapid Communications in Mass Spectrometry, v. 29(21), p. 2078–2082. https://doi.org/10.1002/rcm.7369

[5] Coplen, T. B., 1988, Normalization of oxygen and hydrogen isotope data: Chemical Geology (Isotope Geosciences Section), v. 72(4), p. 293–297. https://doi.org/10.1016/0168-9622(88)90042-5

[6] USGS, Reston Stable Isotope Lab Laboratory Information Management System (LIMS) for Lasers & Light Stable Isotopes. https://www.usgs.gov/software/reston-stable-isotope-lab-laboratory-information-management-system-lims-lasers-light

[7] Coplen, T. B., 1995, Discontinuance of SMOW and PDB: Nature, v. 375, p. 285. https://doi.org/10.1038/375285a0