



Standard Practice for Total Digestion of Sediment Samples for Chemical Analysis of Various Metals¹

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1. Scope

1.1 This practice covers two procedures for the total digestion of sediments for subsequent determination of metals by such techniques as flame atomic absorption spectrophotometry, graphite-furnace atomic absorption spectrophotometry, atomic emission spectroscopy, etc.

1.2 This practice is applicable in the subsequent determination of volatile, semivolatile, and nonvolatile metals of sediments.

1.3 Actual metal quantitation can be accomplished by following the various test methods outlined under other appropriate ASTM standards for the metal(s) of interest. Before selecting either of the digestion techniques outlined in this practice, the user should consult the appropriate quantitation standard(s) for any special analytical considerations, and Practice D 3976 for any special preparatory considerations.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see Note 7.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 ASTM Standards:

D 1129 Terminology Relating to Water²

D 1192 Specification for Equipment for Sampling Water and Steam in Closed Conduits²

D 1193 Specification for Reagent Water²

D 3976 Practice for Preparation of Sediment Samples for Chemical Analysis³

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology D 1129.

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3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *total digestion*—the dissolution of a sediment matrix such that quantitation will produce a measurement which is more than 95% of the constituent present in the sample.

3.2.2 *partial digestion*—the dissolution of a sediment matrix such that quantitation will produce a measurement of less than 95% of the constituent present in the sample. In such cases, recovery is operationally defined by the digestion procedure.

4. Summary of Practices

4.1 Many procedures are available for the total digestion of sediments prior to metal analysis, but almost all the methods fall into one of two main classes: fusion and subsequent dissolution of the bead, and wet digestion which directly dissolves the sample with mineral acids. Each of the classes has advantages and disadvantages, as do the individual procedures which fall under them. The two procedures outlined in this practice were selected because they are the least restricted, in terms of utility, for dealing with a wide variety of matrices. Before choosing a particular method, the user should consult the pertinent literature to determine the utility and applicability of either method, prior to final selection; or if a less rigorous digestion could be employed.^{4,5,6,7} Even then, experience with a particular sample type or digestion test method, or both, may have to be the final arbiter in test method selection.

4.2 Field collected samples should be treated according to the procedures outlined in Practice D 3976.

4.3 Dried samples are ground to finer than 100 mesh (150 μm) using an appropriate grinding device or system.

4.4 *Procedure A*—Fusion with lithium metaborate/tetraborate.

4.5 *Procedure B*—Wet digestion using a combination of hydrofluoric, perchloric, and nitric acids.

¹ This practice is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D 19.07 on Sediments, Geomorphology, and Open-Channel Flow.

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² *Annual Book of ASTM Standards*, Vol 11.01.

³ *Annual Book of ASTM Standards*, Vol 11.02.

⁴ Johnson, W., and Maxwell, J., *Rock and Mineral Analysis*, 2nd Edition, John Wiley & Sons, New York, 1981, p. 489.

⁵ Pinta, M., *Modern Methods for Trace Element Analysis*, Ann Arbor Science Publishers, Ann Arbor, 1982, pp. 133–264.

⁶ Dolezal, J., Povondra, C., and Sulcek, Z., *Decomposition Techniques in Inorganic Analysis*, Elsevier Publishing Co., New York, 1968, pp. 11–157.

⁷ Shapiro, L., "Rapid Analysis of Silicate, Carbonate, and Phosphate Rocks," Revised Edition, *U.S. Geological Survey Bulletin*, 1401, 1975, p. 76.

5. Significance and Use

5.1 The chemical analysis of sediments, collected from such locations as streams, rivers, lakes, and oceans can provide information of environmental significance.

5.2 These practices can be used with either suspended sediment (material actively transported by water) or bed sediment (material temporarily at rest on the bed of a water body).

5.3 Standardized practices for digesting sediments, for subsequent chemical analysis, will facilitate inter- and intra-areal comparisons as well as comparison of data generated by different groups. The use of total digestions also eliminates the ambiguities and interpretational difficulties associated with partial digestions and the operational definitions that accompany them.

PROCEDURE A—FUSION

6. Scope

6.1 This procedure is effective for the total digestion of suspended and bottom sediments for the subsequent determination of aluminum, calcium, iron, magnesium, potassium, manganese, silicon, sodium, and titanium.

6.2 This practice may be appropriate for the subsequent determination of other metals provided the concentrations are high enough or if the instrumental sensitivity is sufficient.

7. Interferences

7.1 Numerous inter-element interferences, both positive and negative, exist for this procedure and have been amply documented elsewhere.^{4,5}

7.2 Interferences are eliminated or compensated for, or both, through the use of cesium chloride (CsCl), orthoboric acid (H₃BO₃), lithium metaborate (LiBO₂), lithium tetraborate (Li₂B₄O₇), and the use of mixed salt standards during quantitation by flame atomic absorption spectrophotometry.

8. Apparatus

8.1 *Graphite Crucibles*, drill point, with a 7.5-mL capacity and a 1-in. (25.4 mm) outside diameter, 3/4-in. (19.05 mm) inside diameter, and total depth of 1 3/8 in. (34.925 mm).

8.2 *Magnetic Stirrer*.

8.3 *Muffle Furnace*, capable of reaching a temperature of at least 1000°C.

9. Reagents

9.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all digestions. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.⁸ Other grades may be used, provided it is first ascertained that the reagent is of

sufficiently high purity to permit its use without lessening the accuracy of the subsequent quantitation.

9.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type II of Specification D 1193.

9.3 *Mixed Salt Standards*—The mixed salt standards are provided as a guide to the user for use with atomic absorption analyses to reduce matrix and interelement interferences. They have been found effective for the constituents listed in 6.1. They may have to be modified to accommodate others.

9.4 *Cesium Chloride, Solution* (4 g/L)—Dissolve 4 g of CsCl in water and dilute to 1 L.

9.5 *Diluent Solution*—Dissolve 6 g of flux mixture in 500 mL of water. Add 12.5 mL concentrated nitric acid (sp gr 1.41), and dilute to 1 L with water.

9.6 *Flux Mixture*—Thoroughly mix 1 part powdered anhydrous lithium metaborate, LiBO₂, and 2 parts anhydrous lithium tetraborate, Li₂B₄O₇. Store in a tightly closed bottle.

NOTE 1—It is possible to purchase pre-mixed fusion fluxes from several suppliers, and provided they are of sufficient purity, have been found quite satisfactory.

9.7 *Mixed Metals Solution, Stock*—Dissolve by appropriate means, the following compounds, elements, or both: aluminum metal (1.500 g), calcium carbonate (1.249 g), iron metal (1.000 g), magnesium metal (0.200 g), manganese metal (0.040 g), KCl (0.668 g), ammonium hexafluorosilicate (18.987 g), NaCl (0.636 g), and ammonium titanyle oxalate (1.227 g), and dilute to 1000 mL with diluent solution (9.5). This solution will contain the following concentrations: aluminum (1500 mg/L), calcium (500 mg/L), iron (1000 mg/L), magnesium (200 mg/L), manganese (40 mg/L), potassium (350 mg/L), silica (3000 mg/L), sodium (250 mg/L), and titanium (200 mg/L). Store in a plastic or TFE-fluorocarbon bottle.

9.8 *Mixed Metals Solutions, Standards 1, 2, and 3*—Take respectively, a 10-, 6-, and 2-mL aliquot of the mixed metals stock solution (9.7), and dilute to 100 mL in volumetric glassware with standard diluent solution (9.5). Concentrations are given in Table 1.

9.9 *Nitric Acid*, concentrated (sp gr 1.41).

9.10 *Nitric Acid* (1 + 1)—Add 250 mL of concentrated nitric acid (sp gr 1.41) to 250 mL water. Store in a plastic bottle.

9.11 *Orthoboric Acid Solution* (50 g/L)—Dissolve 50 g of H₃BO₃ in water and dilute to 1 L. Heat may be required to complete dissolution. Prepare fresh daily because orthoboric acid may precipitate within 12 to 18 h.

TABLE 1 Concentrations of Mixed Metals Solutions 1, 2, and 3

	Standard 1, mg/L	Standard 2, mg/L	Standard 3, mg/L
Volume (mL)	10	6	2
Iron	100	60	20
Magnesium	20	12	4
Silicon	300	180	60
Aluminum	150	90	30
Titanium	20	12	4
Calcium	50	30	10
Sodium	25	15	5
Potassium	35	21	7
Manganese	4	2	1

⁸ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.