U.S. Department of Health & Human Services

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Elemental Analysis Manual

for Food and Related Products

The following is a section of the Elemental Analysis Manual for Food and Related Products.

For additional information and to view other sections of the manual, visit the Elemental Analysis Manual for Food and Related Products web page at https://www.fda.gov/food/laboratory-methods-food/elemental-analysis-manual-eam-food-and-related-products

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2.4 Contamination Control

Version 3.0 (September, 2021)

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GLOSSARY and ACRONYMS

Contamination control is a part of elemental analysis. It prevents false positives in regulatory investigations, enables detection limits to be increasingly low, and is, quite simply, an aspect of good quality work. Efforts are made throughout the analytical procedures to minimize the potential of contamination which can come from the laboratory environment, the analyst, reagents, and various laboratory items (ware, apparatus, instrumentation, etc.).

Method blanks are used as the primary means of monitoring for contamination. Advice on controlling contamination is available in the literature. [1] [2] [3]

2.4.1. LABORATORY ENVIRONMENT

Laboratories have aerosols floating around (solid particulates, liquid droplets, colloidal suspension material, etc.) that can settle or otherwise enter into samples and/or the various solutions. There are also work surfaces, floors, walls, and various items from which debris can get into suspension and contribute to the airborne load and/or contaminate via surface contact with hands, utensils, etc., and ultimately end up in samples or solutions. Therefore, it is important to minimize contamination throughout the laboratory with particular attention being paid to the laboratory's airborne environment.

Good practices to minimize laboratory aerosols include, for example:

- Process samples in labs where particulates are controlled as much as reasonably possible. Relative to the ISO 14664-1 standard [4], the most common compromise (between low particulate count and effort/cost) is to use class 5 workbenches or laminar flow hoods in class 7 work areas.
- Reduce clutter.
- Limit the storage of materials (particularly of cardboard and paper products).
- Wipe down work surfaces with Type I water (before sample processing).
- Routinely perform a general cleaning of the laboratory.
- Process analytical portions in an area that is separate from where laboratory samples are homogenized, instrumental analyses occur, and high-concentration stock standards are stored and used.

HEPA filtered enclosures for autosamplers are commercially available and encouraged. Additional advice on preparing and maintaining a clean laboratory is available in the literature[4-5]. [5] [6]

2.4.2. ANALYST

Hair, skin, and clothing (including any materials these may have such as cosmetics and any general soiling material), plus sweat and respiration droplets in breath can all contribute to trace elemental contamination - especially via the airborne aerosol mechanisms.

The use of appropriate personal protective equipment (PPE) not only protects the analyst from unnecessary exposure, but if the appropriate "clean room" types are used it also minimizes the potential for contamination of the sample by the analyst. Most laboratory coats and chemically resistant gloves are generally sufficient for routine food (and pharmaceutical) trace element applications. Additional shoe, hair and face coverings may have to be considered for ultra-trace element applications.

Samples, standards, reagents and labware that will come into contact with samples or standards should not be handled with ungloved hands. Colorless, powder-free, vinyl, nitrile or polyethylene gloves are preferable. Analysts should be aware that prolonged contact of gloves, especially colored gloves, with acid solutions can result in leaching of elements into the solution. Gloves should be changed frequently, especially if known to have come into contact with high concentration samples or standards. In some cases, the use of polyethylene disposable gloves over chemically resistant nitrile gloves may be economically advantageous.

Select laboratory coats (and/or shoe, head or face covers) made from low-lint materials. Single-use disposable polypropylene laboratory coats help to reduce the risk of cross-contamination.

Analysts should be cognizant of, and limit to the extent possible, contact with all solution contact surfaces. For example, analysts should avoid touching the underside/inside surface of weigh boats, microwave digestion vessel lids, container lids, pipette tips and autosampler tubes.

2.4.3. LABORATORY WARE

Any laboratory ware which comes into contact with samples, standards or reagents can contribute to trace metal contamination.

- Use plastic polymer utensils and containers when feasible instead of glass, ceramic, or metallic materials. Synthetic quartz is recommended over borosilicate glass, particularly for strongly acidic or high heat applications.

Low-density polyethylene bottles are recommended for storage of standard and analytical solutions because of low cost and low trace metals contamination but other types of plastic bottles can be used such as high-density polyethylene, polypropylene, polystyrene, Teflon® etc. The relatively high cost of Teflon® FEP bottles (preferred from a contamination standpoint) may limit their use to storage of intermediate and standard solutions.

- Reusable laboratory ware should be cleaned before and between uses. If it is non-metallic, wash in clean-rinsing laboratory detergent, rinse with reagent water, soak ≥4 hrs in 10% nitric acid, and rinse again with reagent water. Then, immediately before use, it can be rinsed again if desired with 1% nitric acid. If it is metallic, wash in clean-rinsing laboratory detergent then rinse with reagent water (do not soak in acid solution). Air dry (in clean area, e.g.. ISO 14644-1 Class 5). Do not dry with cloth or paper towels.
- Disposable laboratory ware, such as autosampler cups and bottles/tubes should be rinsed with 1% nitric acid immediately before use. This type of ware should be purchased in relatively large supplies and tested (for contamination) before use. Pre-cleaning, using the non-metallic reusable ware procedure, may be warranted.
- Air displacement micropipette tips are not likely to need cleaning unless they are used for ultra-low level work. They should be colorless.
- Avoid use of paper products unless they are low-lint products specifically designed for laboratory and even then use caution because they may leach elements (e.g., nickel and copper).

2.4.4. LABORATORY APPARATUS

Sample processing and analysis involves the use of laboratory apparatus that can introduce contamination.

- Clean sample homogenization equipment such as food processors, blenders, mills, etc., prior to and between uses. Consider the material composition of the equipment's components/implements (cutting blades, mixing paddles, containers, etc.) and avoid materials that could introduce any of the elements of interest.
- Micropipette tips can be pre-rinsed with the solution to be dispensed (to minimize the risk of contamination from residual manufacturing residues).

- Keep balances clean between uses and when possible place them in HEPA filtered areas - ideally ISO 14644-1 Class 5 [4]. Static reduction techniques reduce the risk of particulate cross-contamination between samples.
- Routinely clean or change autosampler bottles, probes, and transfer tubing and use of fresh rinse solutions for each analytical batch. This is especially important after highly concentrated samples have been run. Programming of rinse and uptake times should be evaluated and managed to minimize the risk of sample-to-sample carry-over contamination.
- Routinely clean or change spectrometer sample introduction system components (probe, uptake tubing, spray chamber, torch, and cone).

2.4.5. REAGENTS

Reagents, whether purchased or prepared in-house and whether newly acquired, taken out of storage, or even in day-to-day routine use, may have contamination.

The following are examples of good practices, some “when available” preferences, and basic general information for acquiring and using reagents for elemental analysis:

- Preferentially use reagents that have some sort of high-purity claims and ideally which have been tested for elemental impurities and come with certificates of analysis. (Be sure to check the certificates to verify that the elements of interest are at acceptably low levels.)
- Maintain traceability records that accompany reagents and show the information that uniquely identifies them (manufacturer, type, lot or batch number, date acquired and/or prepared, etc.).
- Acids are typically offered in different grades and/or designations and they may even be specifically marketed for trace elemental applications.
- Acids may be refined by double distillation or sub-boiling distillation. The latter may be designated as “ultra-pure” grade and will likely be substantially more expensive - but these may be necessary when measuring analytical solution concentrations near or below 1 ng/g.
- Commercial reagents such as standard solutions may contain unlisted elemental impurities. For example, elemental standard solutions marketed for use with FAAS or EDXRF may not be suitable for use with ICP-MS.
- Always be critical of reagent quality and maintain awareness that reagents can not only become contaminated in the laboratory but may even arrive with contaminants.

2.4.6. BLANKS

Blanks are generally used to monitor for contamination. Blanks can be evaluated for a specific analytical batch, as well as tracked over many analytical batches to reveal trends or measurable deviations from typical laboratory or method performance. Collectively with other laboratory blank data, blanks are used to reflect some aspects of method performance.

Matrix Blanks would ideally be prepared from analyte-free sample material which would provide the most rigorous evaluations of potential contamination, but such material is seldom available. Surrogate material can also be used but more commonly EAM methods direct the use of Method Blanks (an aliquot of reagent water corresponding to the selection of an analytical portion).

Within the context of the EAM, Method Blanks are intended to cover those aspects of the Method directed by the specific Method instructions. For example, microwave digestion, analytical solution dilution and instrumental analysis. Aspects related to isolation of edible portion, sample selection and homogenization/compositing processes are generally not included.

Similarly to the Matrix or Method Blank, a *Sampling* Blank taken through each of the sample manipulations preceding the Method instructions can be used to evaluate the risk for contamination arising from these processes. If contamination is identified, it may need to be subtracted from the analytical results in similar manner as the Method Blank. However, it is preferable to modify the sampling procedure to minimize the contamination risk if possible.

If sample preparation involves liquids (e.g., blending), reagent water alone may be an adequate blank. Reagent water would, however, not be ideal for solid phase preparation (e.g., grinding). It would not invoke as much mechanical grinding effects as solid phase material (i.e., result in under-estimating contamination). In contrast, water could also result in increased solubility relative to actual sample material (i.e., result in over-estimating contamination). For solid phase processes of plant materials, ashless filter paper and microcrystalline cellulose have been used as suitable blank material and it is feasible for these to be cleaned/washed in water or dilute acid.

An alternative blank approach for studying sample processing effects, but one that is probably more suited to method development than for routine analyses, is to use some combination of reference material(s). Certified Reference Material (CRM) and/or Laboratory Fortified Matrix (LFM) can be used independently or combined in specific proportions to achieve a reasonable matrix with desired analyte levels.

2.4.7. HISTORY

EAM 2.4 Table 1. History

Version	Revisions Made	Effective Date
1.0	Not applicable; content of 2.4 was formerly section 3.1	n/a
2.0	Contamination Control; formerly section 3.1 moved to this location in the EAM; converted to PDF for web posting.	September 2014
3.0	Expanded scope by adding subsections and more detailed discussion; added *History* section.	September 2021

References

[1] G. a. S. P. Knapp, "Sources of Analyte Contamination and Loss During the Analytical Process, in Sample Preparation for Trace Element Analysis," in *Wilson and Wilson's Comprehensive Analytical Chemistry*, vol. 41, Z. a. S. R. Mester, Ed., Amsterdam, Elsevier, 2003, pp. 23-45.

[2] C. J. Rhoades, "Clean Laboratory Chemistry for the Microwave Assisted Digestion of Botanical Samples," *J. Anal. At. Spectrom.,* vol. 11, pp. 751-757, 1996.

[3] S. Morton, "Contamination Control in the Trace Metal Laboratory," *A . Lab. News,* vol. 33, pp. 20-22, 2001.

[4] International Organization for Standardization, "ISO 14644-1:2015 Cleanrooms and associated controlled environments - Part 1: Classification of air cleanliness by particle concentration," [Online]. Available: https://www.iso.org/standard/53394.html. [Accessed September 2021].

[5] Environmental Protection Agency, "EPA 821-B-96-001 Guidance on Establishing Trace Metal Clean Rooms in Existing Facilities," 1996. [Online]. Available: https://archive.epa.gov/epa/cwa-methods/guidance-establishing-trace-metal-clean-rooms-existing-facilities-draft.html. [Accessed September 2021].

[6] International Atomic Energy Agency, "IAEA TECDOC 1339 Clean Laboratories and Clean Rooms for Analysis of Radionuclides and Trace Elements," 2003. [Online]. Available: https://www.iaea.org/publications/6594/clean-laboratories-and-clean-rooms-for-analysis-of-radionuclides-and-trace-elements. [Accessed September 2021].