



Authors: David Price, Bo Wullenwaber, Chris Pegg

TRAXStation 221

Safe, Accurate, and Precise Dilution of High-Acid-Strength Soil Digests Using **TRAXStation**

Introduction

Drinking water and wastewater services are essential to public health and require rigorous testing to meet regulatory standards. Anglian Water – the UK's largest water and water recycling company by geographic area – serves nearly seven million people. Accordingly, they routinely digest agricultural soil and sewage sludge samples in high-strength acids for ICPOES and ICPMS analysis.

Similar high-acid digestion workflows are widely used for solid matrices such as sediment, contaminated land, ash, compost, and forage, including U.S. EPA methods (e.g., 3015A, 3052, 3050B, 3050C). However, manual preparation is time-consuming and hazardous due to

the large volumes of corrosive acids (typically ~20% aqua regia), increasing the risk of exposure and injury.

TRAXStation automates this procedure vortex mixing, barcode reading, uncapping, precisely aliquoting, and adding diluent, thereby reducing manual handling, improving safety, and freeing staff for higher-value tasks.



TRAXStation Workflow

TRAXLink

Automates key sample-handling steps (uncapping, barcode reading, and recapping) into one automated module.

Dual Rinse Station

Ensures ultra-low cross-contamination through internal and external probe rinsing between samples, minimizing cross-contamination and ensuring precise dilution of challenging soil digests.

StationPump

An intelligent, high-pressure syringe module delivers precise liquid handling, including dispensing aliquots down to 10 μL .

Metal-free Construction

Provides a metal-free, acid-resistant sample flowpath within a clean, protected environment fitted with ultra-low-particulate air filters.

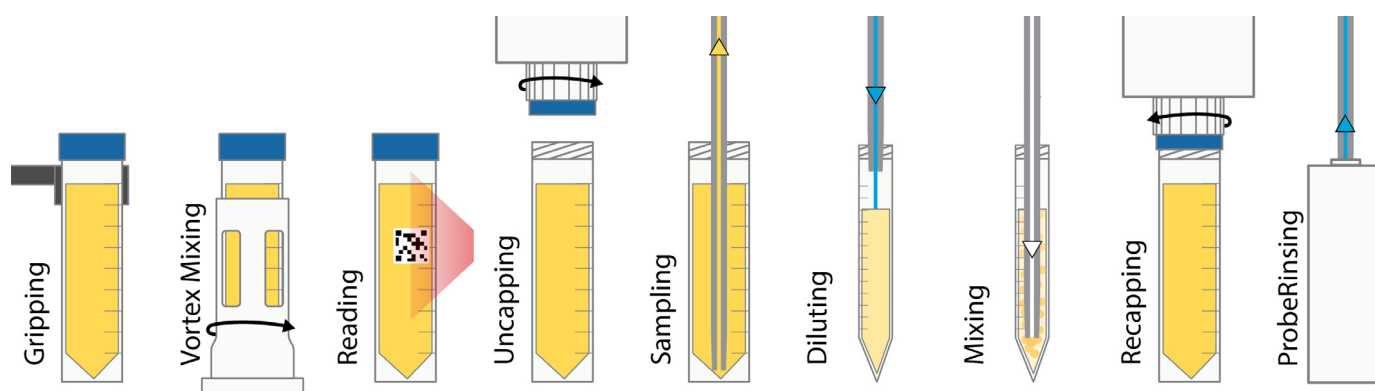


Figure 1. TRAXStation automatically grips samples, vortex mixes, reads barcodes, uncaps, and dilutes.

TRAXStation 221 Layout

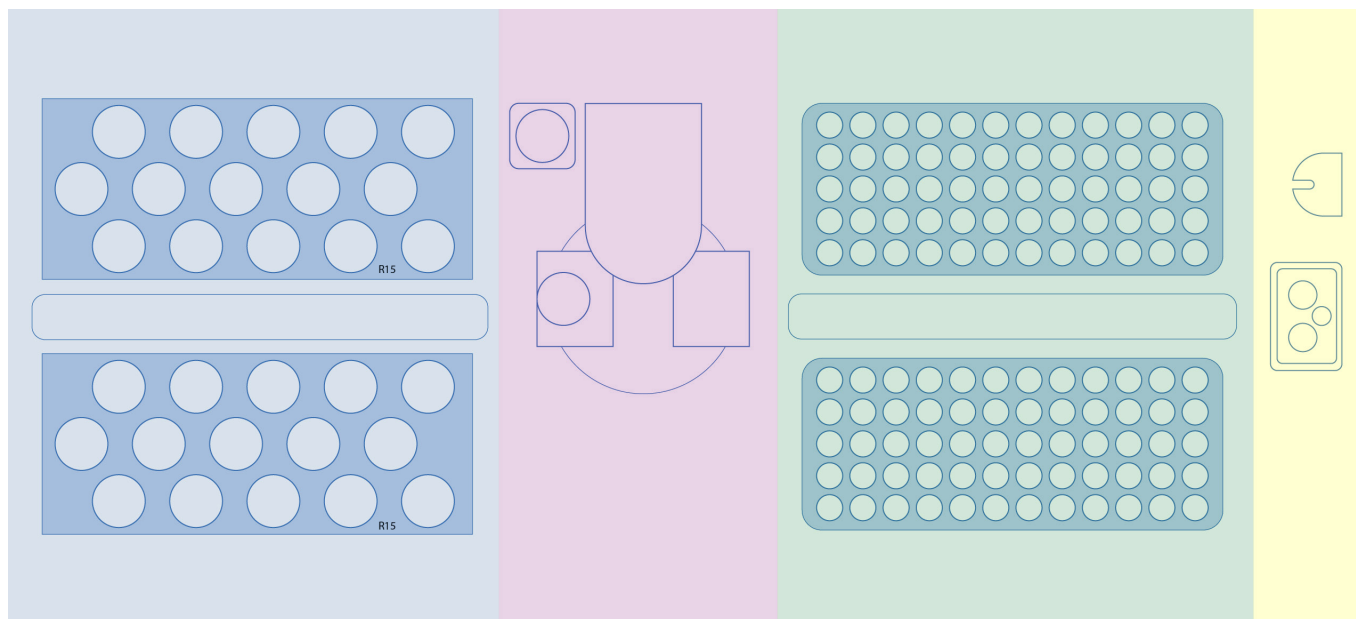


Figure 2. TRAXStation 221 layout: 50 mL source tubes (15 per rack) and 15 mL destination tubes (60 per rack). TRAXStation automatically grips each source vial, vortex mixes, reads the barcode, uncaps, dilutes, samples, gas mixes, rinses the probe, and transfers it to the destination side.

Experimental

Two experiments were conducted to assess the accuracy and precision of **TRAXStation** for safely diluting high-acid-strength digests. Key experimental parameters are summarized in the following table.

Table 1. Instrumental parameters used in this experiment.

Instrument Parameter	Value
Instrument	Thermo TQs
Autosampler	TRAXStation 221
Syringe Configuration	2 x 24 mL
Nebulizer	PFA
Torch/Injector	2.5 mm ID
Probe	FilterProbe
Source Vial	50 mL Falcon
Prepare Vial	15 mL Sarstedt
Sample Uptake	0.28 mL/min
RF Power	1550 W
Nebulizer Gas Flow	0.93 L/min
Auxiliary Gas Flow	0.8 L/min
Plasma Gas Flow	14 L/min
Sample Uptake Tubing	Black-Black
Internal Standard Tubing	Orange-Green
Drain Tubing	Gray-Gray
Replicates	3



Figure 3. TRAXStation integrates seamlessly into existing ICPMS workflows while reducing labor, consumables costs, and operator exposure.

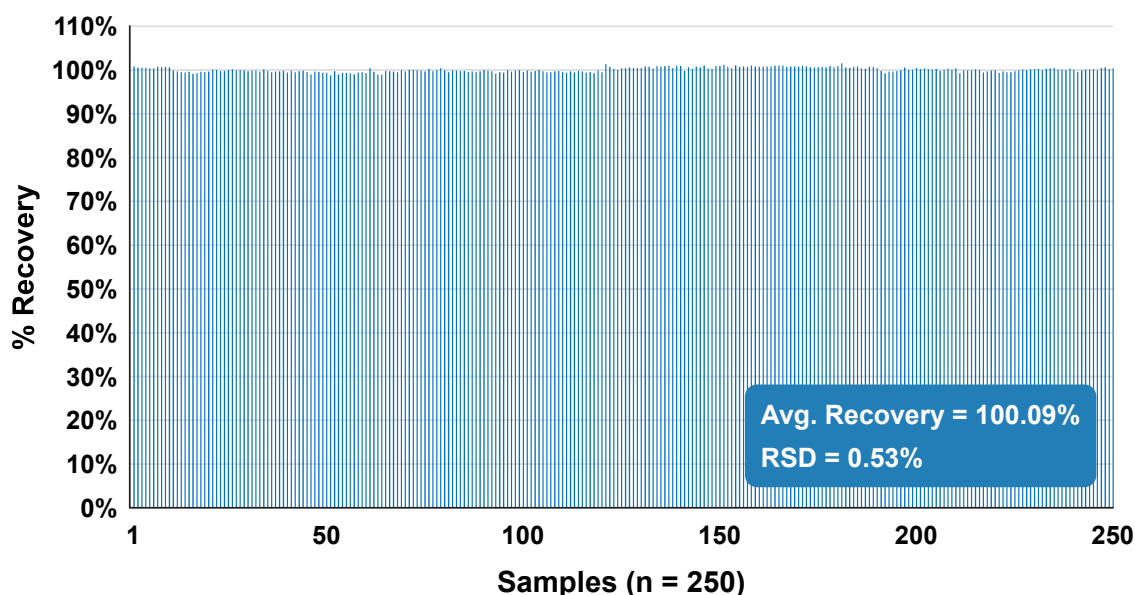
Gravimetric Validation

A gravimetric validation was performed using deionized water as a proxy for acid digests. Mass differences were measured before and after the automated **TRAXStation** workflow across 250 samples over multiple days, with variable batch sizes. Mass loss from 50 mL tubes was verified using a four-figure analytical balance, targeting 1 mL (1 g). Mass increase in a 15 mL tube after transferring

and diluting to 10 mL (1 mL sample + 9 mL diluent) was also recorded.

Results show excellent accuracy: 100.09% recovery for the 1 mL aliquot and 99.96% for the 10 mL final volume. Precision was strong, with RSDs of 0.53% (1 mL) and 0.19% (10 mL).

TRAXStation Recovery of 1 mL from 50 mL Digest Tubes



TRAXStation Recovery of 1 mL from 50 mL Digest Tubes Diluted to 10 mL Tubes

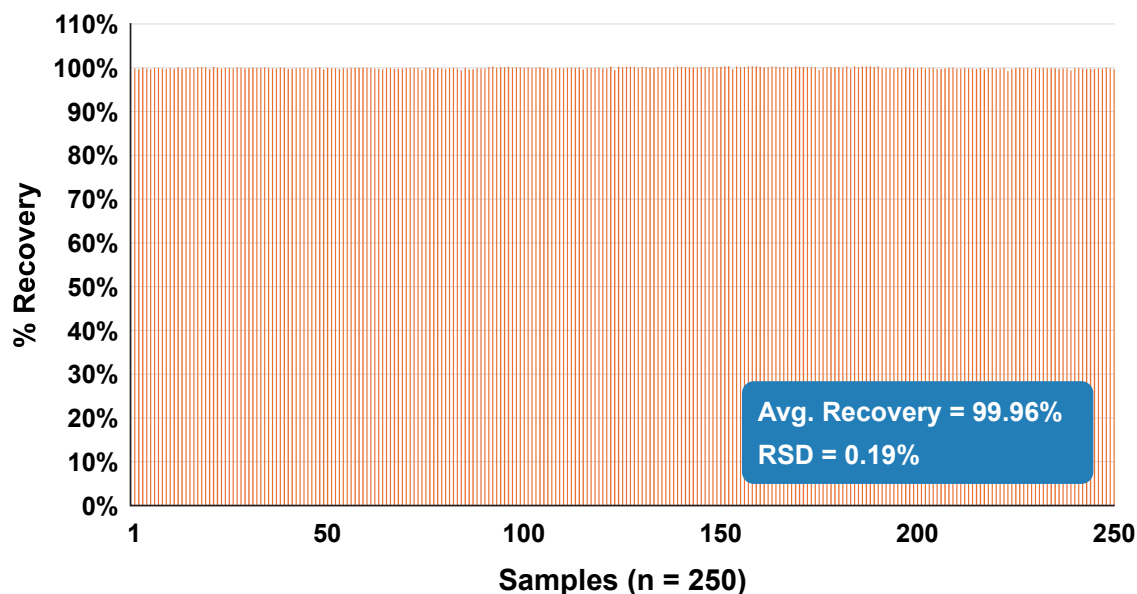


Figure 4. Gravimetric validation of deionized water measuring mass difference.

ICPMS Analysis of 20% Aqua Regia Soil Digests Prepared by TRAXStation

A second experiment used 27 concentrated (20%) aqua regia soil digests, donated by Anglian Water, plus a blank and two fortified QC samples. **TRAXStation** automatically picked up each 50 mL tube, vortex mixed, uncapped, transferred 1 mL to a 15 mL tube, added 9 mL of diluent, mixed, recapped, and returned the source tube.

The diluent was spiked with thallium (Tl), an element absent from the samples, to validate dilution accuracy (target = 10 ppb after 10x dilution). Diluted digests were analyzed by ICPMS (prepFAST 3 and Thermo TQs) across 10 cycles on different days. Mean Tl concentration was 10.04 ppb with a 3.08% RSD, demonstrating high accuracy and excellent precision.

Recovery of Tl-205 Added to Diluent

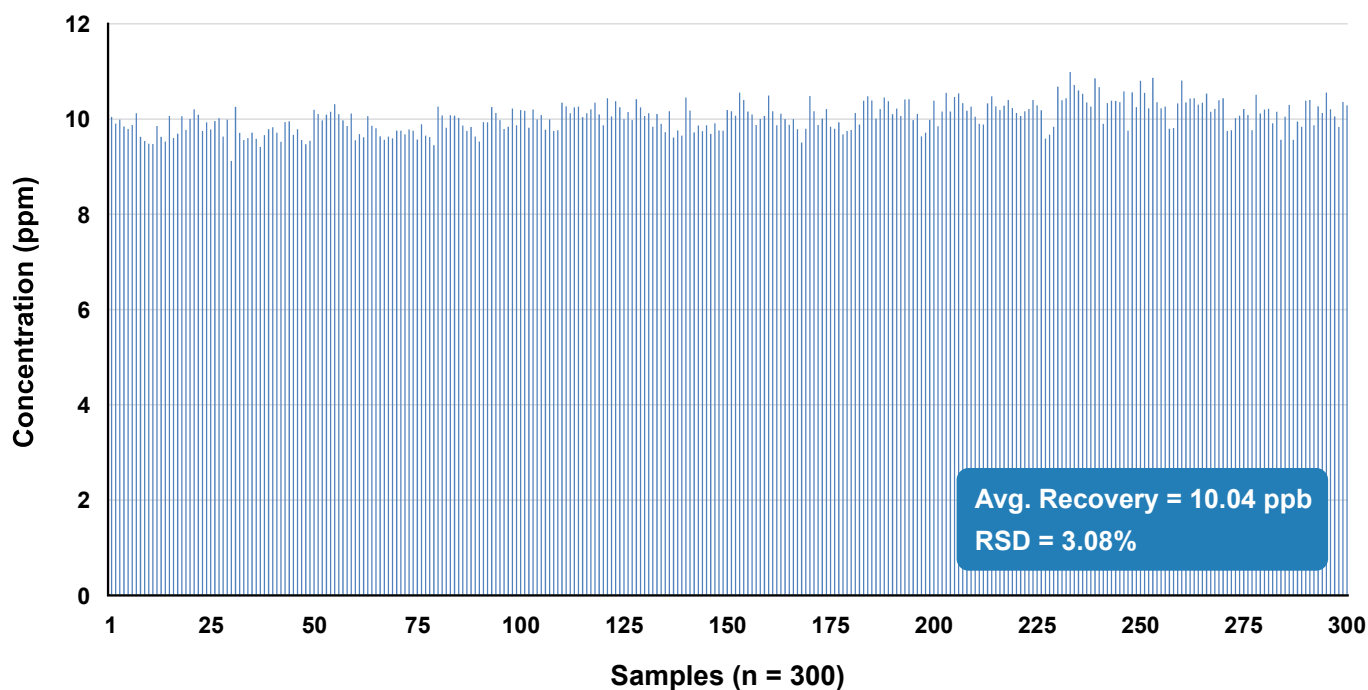


Figure 5. Recovery of diluted digests of concentrated aqua regia (20%) soil samples.

Comparison of Automated and Manual Sample Preparation

Concentration for 27 soil digests (mg/kg dry soil) was compared with Anglian Water's manually prepared results. This method involved microwave digestion of ~0.5 g of soil with 2.5 mL of HNO₃ and 7.5 mL of HCl. Following digestion, solutions were filtered into 50 mL volumetric flasks.

On the day of analysis, a 1 mL sample of each digest was transferred to 15 mL tubes and diluted with 9 mL of deionized water. These 10x-diluted samples were analyzed by ICPMS, with results corrected for dilution, sample mass, and volume.

Each digest was processed and analyzed 10 times, yielding the following calibration curves comparing this automated workflow (x-axis) with Anglian Water's manually prepared samples (y-axis). Results show excellent agreement between the two soil digest samples, with $R^2 > 0.9925$ across nine elements.

The strong correlation and consistent slopes confirm **TRAXStation** delivers accuracy and precision comparable to manual preparation, with reliable and reproducible performance.

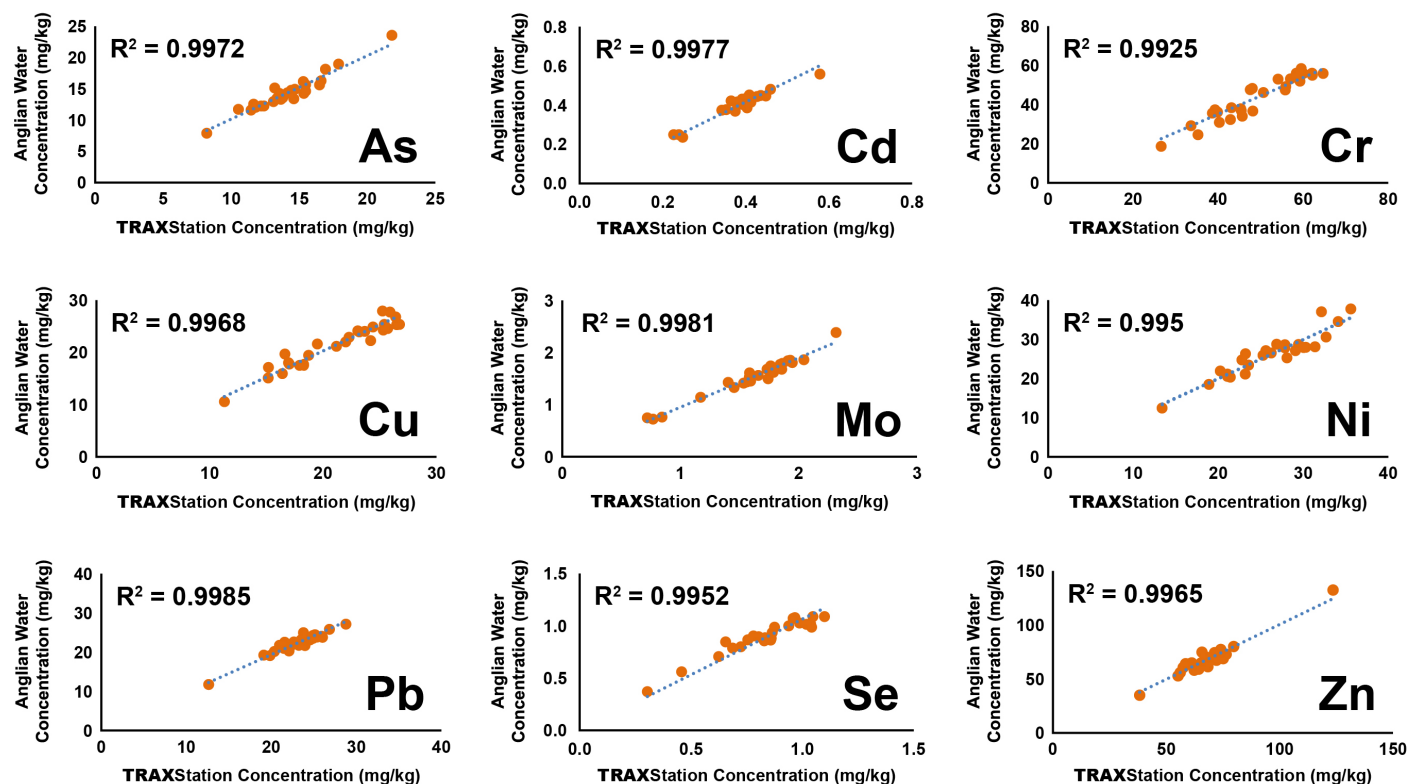


Figure 6. Calibration curves for nine elements across 27 soil digest samples. Concentrations from ESI's **TRAXStation** were compared to results from Anglian Water.

Comparison of QC Results – TRAXStation vs. Manual Preparation

QC results from the two soil digests were also compared to further validate **TRAXStation** performance and verify consistency. Concentrations of nine elements in automatically prepared samples were evaluated against manually prepared results, across two labs using different ICPMS systems and calibration ranges.

The 20 **TRAXStation** QC results (blue) closely matched the two manual results (red). This agreement demonstrates the system's ability to automate a slow, laborious procedure with precision and accuracy equal to or better than manual preparation, supporting its reliability for soil digest workflows.

Comparison of QC Results

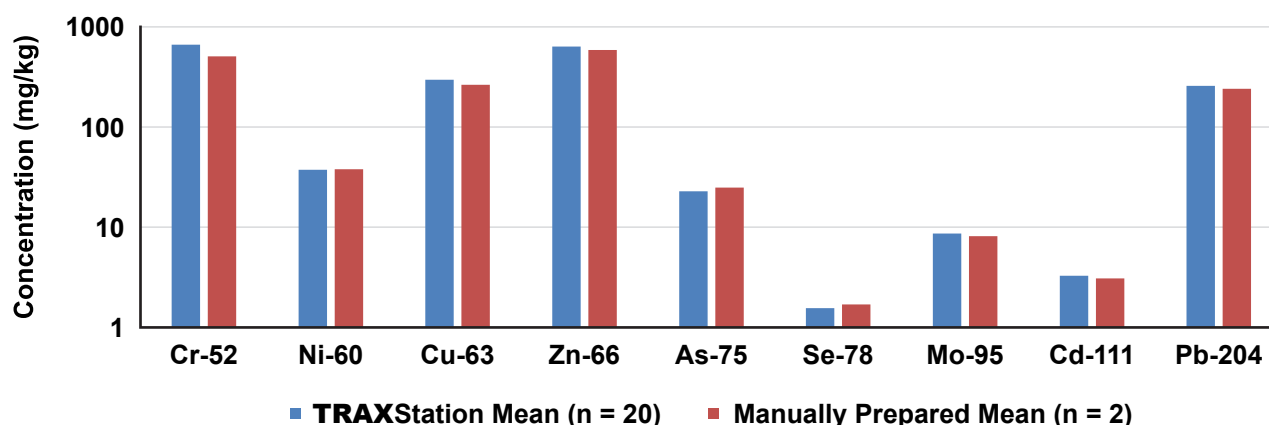


Figure 7. Comparison of QC results from **TRAXStation** vs. Anglian Water's manually prepared samples.

Conclusion

TRAXStation delivers excellent accuracy and precision, exceeding typical analytical targets. It also ensures data quality by reducing variability from manual handling and minimizing operator exposure to hazardous acids.

For labs performing regulated methods (e.g., EPA), like Anglian Water, automated barcode reading provides a complete audit trail, confirming each digest, QC, or

blank was processed correctly according to a specific method. The system also generates run lists, which can be uploaded directly to the ICPMS, eliminating transcription errors.

By automating these workflows, **TRAXStation** improves overall efficiency and frees scientists to focus on higher-value tasks.



© Elemental Scientific | 7277 World Communications Drive | Omaha, NE 68122
Tel: 1-402-991-7800 | sales@icpms.com | www.icpms.com

A-26101