

Table 1. Types of samples and ICP-MS Metals lab SOPs.

Sample Type	Analyte	Sample receiving and handling SOP	Sample preparation SOP	Sample Analysis, Data processing and QC SOP
Algal samples (filters)	Total P contained in filter	SIRFER sample handling	Clean Labs Milli-Q Weighting Ashing Pipetting Plastic Leaching	Total Phosphorous in Plant tissue
Surface water particulates (filters)	Total P contained in filter	SIRFER sample handling	Clean Labs Milli-Q Weighting Ashing Pipetting Plastic Leaching	Total Phosphorous in Plant tissue

ICP-MS LAB	
Clean Labs	
10/10/16	Christopher Anderson – version 0.2
REQUIRED READING: CHEMICAL HYGIENE PLAN	

OVERVIEW

Clean spaces in the ICP-MS labs are areas in which air has been pre-filtered before entering the space and are maintained at a higher level of cleanliness as opposed to the other labs and spaces. These are designed to minimize the amount of particulate contamination that can influence the trace metal analyses the lab participates in. There are two rooms in which MERV 14 filtered air is being delivered, and six (6) laminar flow benches, which are further filtered and used as clean areas for bench wet chemistry work.

SCOPE

Room 482 (positive pressure, filtered air MERV 14)

Room 479 (positive pressure, filtered air MERV 14)

Laminar flow hood (L1) in 476

Laminar flow hood (L2) in 476

Laminar flow hood (L3) in 482

Laminar flow hood (L4) in 482

Laminar flow hood (L5) in 479

Laminar flow hood (L6) in 479

TRAINING

Users should be able to demonstrate working in and keeping spaces tidy in order to prevent contamination as much as possible.

GENERAL RULES

1. Anything coming into the labs, including your clothes and shoes, must be free of any loose dust or dirt to the best of your ability. For example: if shoes are covered in mud you may not enter the labs.
2. Cardboard is not allowed inside of the labs.
3. Any rusty equipment is also prohibited.

4. Personal items are not allowed inside of 476 at all. This encompasses all bags, food and drinks. Items are allowed in the vestibules between rooms 482, 479 and the hallways, but not any further. Both rooms have cabinets for secure storage of personal items.
5. As with any lab, goggles or eye protection must be worn always while inside of the labs. Prescription glasses are okay, but use personal discretion and put on extra protection if needed. The lab provides goggles and face shields.
6. Long pants and close-toed shoes are required. Long sleeved shirts or sweaters are recommended.
7. Gloves are provided and must be used for all handling of objects in the lab.

USAGE PROTOCOLS

Entrance

The labs indicated (room 482 and 479) both prohibit outside shoes from being used in the lab. To enter, hypoallergenic shoes provided by the lab must be worn or shoe covers must be pulled over and cover most of the shoe. Once shoes have been changed or covered, use the sticky mats on the floor to clean off the bottom of the shoes. Room 482 has two mats, and must be walked on starting with the blue to white. You must not step over the mats, or use the shoes or shoe covers outside of those two labs.

Hypoallergenic lab frocks (Tyvek) are also provided by the lab, and are strongly recommended when entering and working with chemicals in the labs.

Laminar Flow Hoods

Laminar flow benches provide ULPA grade filtered air and are very clean spaces used for sample preparation and other wet-work where a dust free environment is important. Hypoallergenic clothing such as the Tyvek jacket or arm covers must always be worn when working inside of the hoods, so that skin or dust does not fall into the hoods.

Acid Grades

We use three different purity grades for HNO_3 , H_2SO_4 , HCl , NH_4OH , H_2O_2 and HF . They are in the following order, with 1 being the cleanest.

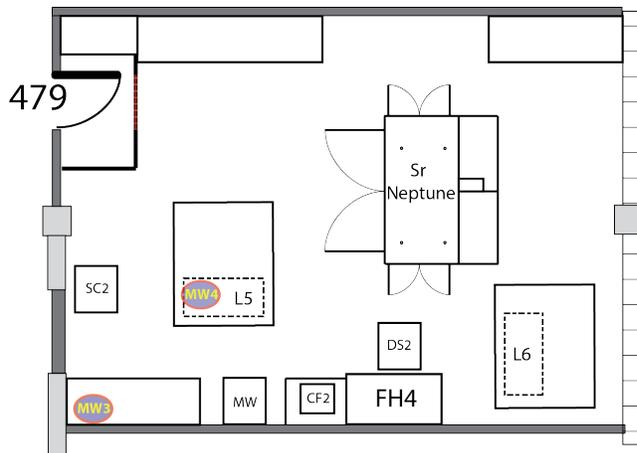
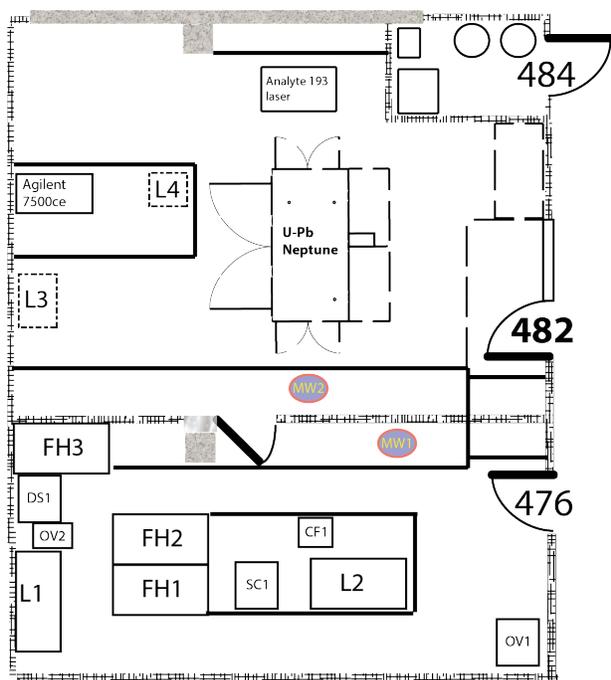
1. Optima, Aristar Ultra, PlasmaPure Plus, Omnitrace Ultra
2. Trace Metal Grade, Aristar Plus, PlasmaPure
3. Reagent Grade, ACS Grade
4. The cleanest grade has impurities in the ppt (part per trillion), with the rest gaining impurities by one order of magnitude each. Trace metal grade (TMG) is the most commonly

used in the lab, used for most sample preparations. Optima/Artistar Ultra (Clean) is used for small digestions and standard preparation, while ACS grade is used mainly for cleaning plastic and glassware.

Cleaning

When bringing something into the lab or into a laminar flow hood, it must first be wiped down with deionized water to remove any dirt or dust. Any cleaning of lab surfaces must only be done with deionized water as well, as cleaning supplies containing detergents or bleach contain ions that are considered contaminants in the lab.

Location of laminar flow benches



ICPMS LAB	
Milli-Q	
10/10/16	Diego Fernandez – version 0.2
REQUIRED READING: CHEMICAL HYGIENE PLAN, CLEAN LABS	

Overview

Two Milli-Q (double de-ionized H₂O) systems and four delivery points for Milli-Q water (**MQ-water**) exist in the ICPMS labs. The system in 479 FASB delivers low boron Milli-Q water. All three delivery points provide ppt level for most elements and ppb levels DOC water. Water contained in carboy in 476 residence time is 1-2 days, and then contains dissolved CO₂. Both Milli-Q systems are fed from building de-ionized (DI) water through a connector and pressure regulator located at the back of the Milli-Q systems.

Training

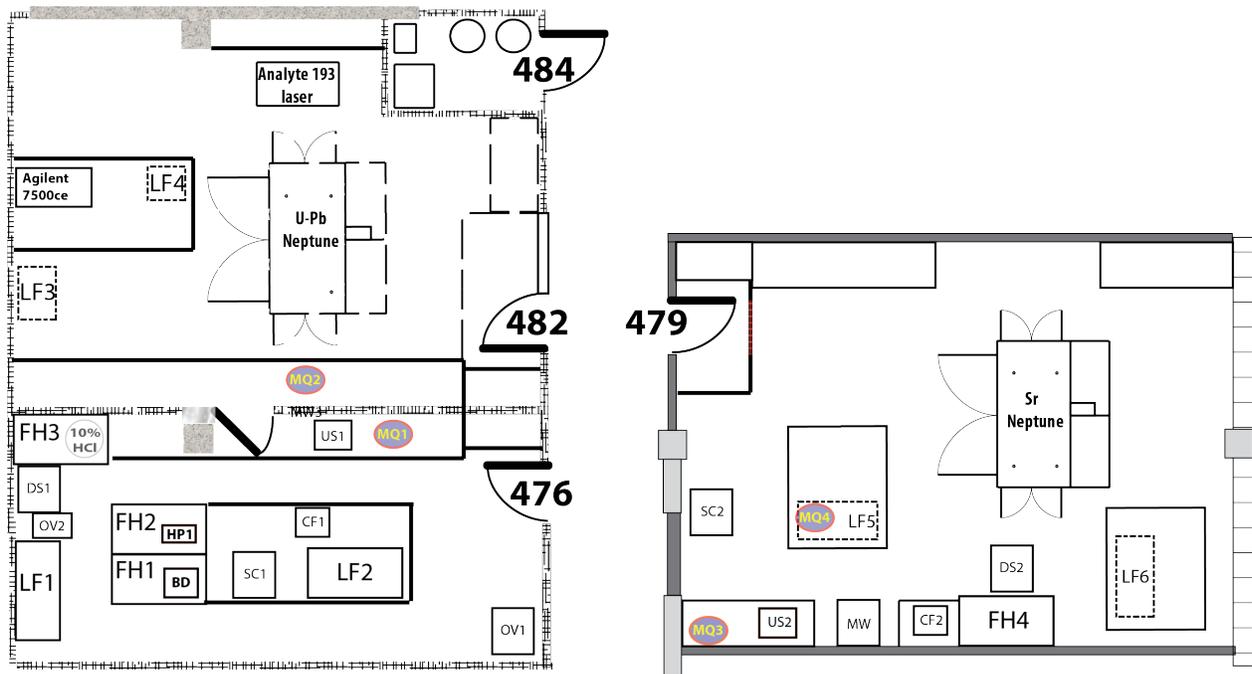
Users should be trained to use this method until they are proficient.

DI SHUT-OFFs

In case of leaks from the DI water feed shut off the DI main valve: under adjacent sink for Milli-Q system in 476 FASB (MAQ1) or under eastern sink in 475 FASB for Milli-Q system in 479 FASB.

STATIONS

- 476 Carboy station (MQ1)
- 482 Delivery arm on counter (MQ2)
- 479 Delivery arm (MQ3)
- 479 Delivery arm in in laminar flow bench (MQ4)



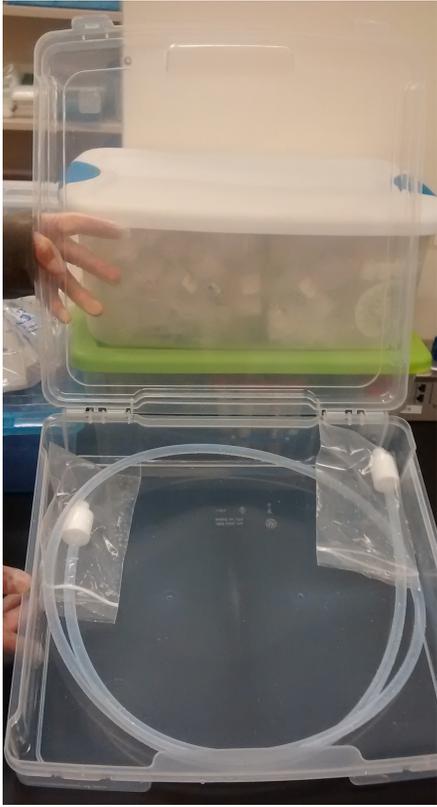
BASIC OPERATION

1. Standby and Pre-Operate modes. Push button to switch between modes.
2. Delivery valve: up position (closed) and down position (delivery)
3. Conductivity sensor on delivery arm: green solid LED means OK, blinking mean water is not ready
4. DOC sensor in display
5. End filter and air purge: screw open to release air above filter

FILLING CONTAINERS WITH MILLI-Q WATER

MW1 (476 Carboy station)

Make sure the system is in Pre-Operate mode. For containers < 2 L rinse the sink with DI water and place your container under carboy spigot on round stand in the sink. For containers > 2 L leave container on cart and connect filling tubing to spigots after removing flow control pieces; connect red labeled end in delivering carboy; use gloves to handle PTFE filling tube and do not touch the filling end; use bag to cover container mouth and place back tubing in ziplock bag after use; put red labeled end in red labeled bag.



MW3 (482 Delivery arm on counter)

Make sure the system in 476 is in Pre-Operate mode. Only containers < 2 L: place container in box and push down valve in arm, let water flow until green is solid to start filling the container.

MW3 (479 Delivery arm)

Make sure the system is in Pre-Operate mode. Only containers < 5 L: place container on sink border and push down valve in arm, let water flow until green is solid to start filling the container.

MW4 (479 Delivery arm in in laminar flow bench)

Make sure the system in 476 is in Pre-Operate mode. Only containers < 2 L: hold container and press pedal on floor.

ICP-MS LAB	
Weighing	
3/30/2017	Diego Fernandez – version 0.1
REQUIRED READING: CLEAN LABS; MILLIQ; PIPETTING	

Overview & Scope

To weight liquid and solid samples in closed plastic containers including PTFE vials, PP centrifuge tubes and LDPE bottles. To weight solid samples using metal weighting boats. Sample types include liquid standard solutions, natural waters or sludges; dry and wet tissue; soil, sediments, powdered rocks, mineral grains and engineered materials.

Mass range: 2 mg – 250 g. Precision: 0.1% or better for samples > 10 mg.

Training

Users should be trained to use this method until they are proficient.

Equipment

Balance: choose between the three available balances (1 mg up 600 g, 0.1 mg up to 220 g, or 0.01 mg to 60 g) depending on the masses and precision required.

Weighting boat and plastic spatula

Laminar flow area

Frock and vinyl gloves

Goggles

Anti-static fan

Forceps

Clean-room wipes

MQ-water

Clean plastic box 16" long, 8" wide, 6" tall

Compressed argon

Eppendorf pipettors and tips

2% trace metal grade HCl

Method 1: direct transfer of sample into plastic container

1. Work with plastic vials containers in designated laminar flow area.
2. Use an appropriate rack for PTFE vials or PP centrifuge tubes.
3. Tare the balance, either empty for flat-bottom containers or with a beaker of appropriate size to hold tubes.
4. Use forceps to hold the plastic container in front of the anti-static fan for 5 seconds.

5. Open balance sliding side or top door and place plastic container on dish or beaker. Use forceps to handle containers; do not touch plastic containers with gloved hands after static charges have been removed.
6. Close door and wait until reading stabilizes. If value drifts, hold container in front of anti-static fan for another 10 seconds and repeat until a stable reading is obtained.
7. Record reading.
8. Transfer solid or liquid sample into plastic container in designated laminar flow area. Solid samples should be transferred a plastic spatula. For finely ground light samples hold the plastic spatula in front of anti-static fan for 5 seconds. Liquid samples should be transferred using automatic pipettors with new acid-leached tips.
9. Close container tightly and repeat 3 to 7.
10. If another solution is required to mix in the same container, repeat 8 and 9.

Method 2: use of metal weighting boat to weight a solid sample into a plastic container.

1. If the mass of the empty plastic container is needed use Method 1 steps 3 to 7.
2. Regardless of step 1 use forceps to hold the plastic container in front of the anti-static fan for 5 seconds.
3. Hold your gloved hands in front on anti-static fan for 5 seconds.
4. Clean weighting boat with MQ-water in ultrasonic bath for 1 minute twice, then blow with argon and wipe with clean-room wipes. Pick weighting boat according to sample size: for samples <10 mg use small boats; for samples 10 mg – 1 g use large boat. Some samples may stick to boats producing losses during transfer; losses are typically minimal for samples > 10 mg, but can be large for smaller samples. Metal boats should never be used for wet samples.
11. Weight empty clean boat directly on balance dish and record **initial weight**.
12. Transfer solid sample into weighing boat. Perform this operation with boat, sample container, receiving plastic container, clean spatula and a clean-room wipe resting inside an open clean plastic box located in laminar flow area. For finely ground light samples hold the plastic spatula in front of anti-static fan for 5 seconds before using it. Never hold the loaded boat in front of anti-static fan. Pour sample from boat into plastic container carefully.
13. Weight and record empty boat after transfer.
14. Clean boat as in step 4 and check **initial weight**. If the value changes more than 0.1 mg, clean the boat as in 4 again before continuing with other samples.

ICPMS LAB	
<h1>Plastic leaching</h1>	
10/10/16	Diego Fernandez – version 0.1
REQUIRED READING: CHEMICAL HYGIENE PLAN, CLEAN LABS, DATA AND DOCUMENT MANAGEMENT, MILLI-Q	

OVERVIEW

Plastic bottles (LDPE bottles, PP centrifuge tubes, PS autosampler tubes and PTFE digestion Savillex vials, MW digestion vials, BD digestion vials, or PTFE autosampler tubes) are acid leached to reduce blank levels of trace elements. PS tubes are rinsed with water before use; LDPE and PP are leached with 10% HCl at 65C; while PTFE vials or tubes are leached with a multistep process.

PS polystyrene; **LDPE** low density polyethylene; **PP** polypropylene; **PTFE** Polytetrafluoroethylene

Training

Users should be trained to use this method until they are proficient. Use of personal protection equipment is crucial for these methods.

Multi-step PTFE cleaning

Do not mix screw cap vials of different sizes or with tubes; clean vials and caps together. Pour content of vials or tubes in acid waste container and remove sharpie labels using alcohol or acetone. Leave caps off and rinse all vials and lids, or tubes, with water in a clean plastic box thoroughly. Save this box for the following steps and use a box with a good lid that is big enough for all vials or tubes. Before use, rinse the box with Mili-Q water and check for leaks through the lid.

- 1. Triton-X detergent.** Add ~10 mL Triton-X detergent to the box filled with vials and water. Close box with lid, shake to disperse the detergent and put it in US for 30 min, shaking once in while. Rinse the detergent thoroughly and drain the water as much as possible by shaking the box with the lid slightly open.
- 2. Hot 50% HNO₃.** Transfer vials into large PTFE jars on hot plate in FH2 labeled 50% HNO₃; use PTFE spoons to drop the vials to avoid splashing. Close loosely PTFE jar and agitate to remove air trapped in and between vials and lids, and leave for at least a day with the hot plate set at 150C (agitate again when hot). Let the jar cool down off the hot plate. Fish the vials out using PTFE spoons and transfer into box. You can also use auxiliary 2L LDPE wide mouth bottle in FH2 to pour acid out from the jar to make the fishing easier. Rinse vials with water in box with Milli-Q water in MQ1, and finally drain the water as much as possible.

3. **Hot 50% HCl.** Repeat step 2 with jar labeled 50% HCl.
4. **Reflux.** In LF put 1-2 mL conc TMG HNO₃ and 1 drop of conc TMG HCl in each vial. Close vials tightly with screw cap and put them on DS1 at 220 C for 2-4 hours. Let vials cool down and transfer into box. Rinse closed vials with water in MW1 and drain the water out. Take the box back to DS1 and open each vial, pour the acid out into a waste container and close again. Make sure there are no drops inside the vial or inner cap. Put closed vials back in box and take the lidded box with vials to LF (for large batches rinse the closed vials again in MW1 and drain). Open box in LF and take the vials out. Open each vial, rinse the inside of vial and the caps with water wash bottle and place to dry in plastic shelves. Close vials and place in dated and initialized ziplock bag to store when dry.

A. PS autosampler tubes cleaning

Use Milli-Q wash bottle in LF to rinse the tubes before use; rinse the inside of tube thoroughly and pour in waste container.

B. LDPE sample bottles and PP centrifuge tubes > 10 mL

Use acid in carboy with 10% HCl in FH3 to fill bottles or tubes (new unused) leaving a small headspace. Fill ziplock bag with one or two full layers of bottles or tubes. Place in OV2 at 65 C in Pyrex tray, stacking bags flat on top of each other. Leave for one day, then turn over the bags and leave them for a second day. Remove from OV2 and let them cool to room temperature, then pour the acid contained in bottles or tubes in the 10% HCl carboy in FH3. Rinse bottles or tubes individually and thoroughly (outside and inside) using water in MQ1. After each rinse, fill the bottle or tubes with water, cap them and put them in a clean plastic box. Take the box with full containers into LF1 or LF2, empty the water in waste container inside LF and let them is dry on racks. Cap and zipclock bag clean dry bottles or tubes and place in storage drawers.

C. PP centrifuge tubes < 2.5 mL

Use an acid leached LDPE wide mouth bottle >500 mL as leaching container. Fill the bottle with tubes (unused) leaving a headspace 20% of the total volume. Fill bottle with water to the brim, cap and take it to DS. Drain bottle to the level of vials and add TMG conc HCl leaving almost no headspace (1 cm below rim). Cap tightly, put bottle in ziplock bag and place in OV2 at 65 C in pyrex tray. Leave for at least three days; shake at least once a day.

D. Teflonware cleaning

D1. Savillex digestion vials. Step 1-4.

D2. MW Milestone Ethos 6 mL digestion vials. Step 1-4, with step 4 done in MQ.

D3. Block digester 50 mL digestion vials. Step 1-4, with 4 done in block digester; reflux using 4-5 mL TMG conc HNO₃ and 1 mL TMG conc HCl in each vial.

D4. ESI autosampler tubes. Step 1-3. Add a step PP centrifuge tubes <2.5 mL

ICP-MS LAB	
Pipetting	
3/30/2017	Diego Fernandez – version 0.1
REQUIRED READING: CLEAN LABS; MILLIQ; WEIGHTING	

Overview & Scope

Measure volume of liquids precisely within the range of 0.020mL to 10.00mL.

Volume range: 0.002mL to 10.00mL. Precision: 0.3% or better for samples > 0.100mL; up to 1 % for samples < 0.100mL.

Accuracies and precision quoted are applicable only to relatively diluted aqueous solutions and do not apply to liquid possessing high-viscosity, low surface tension, or volatile solutes. In the latter cases volumes cannot be trusted and weighing is used for dilutions.

Training

Users should be trained to use this method until they are proficient. Calibration by weighing is performed until operator obtains the quoted precision.

Equipment

Eppendorf pipettors and tips
Balance (0.1mg up to 220g)
Weighting lidded glass container
Laminar flow area
Frock and vinyl gloves
Goggles
Anti-static fan
Forceps
Clean-room wipes
MQ-water
5% HCl (trace metal grade)

Method 1: Calibration

1. Use appropriate protective wear such as goggles, gloves, and smock.
2. Work in designated laminar flow area.

3. Choose appropriate volume of pipette for the task at hand. The available volumes and color codes are as follows: 1000-10000 μ L (Turquoise); 500-5000 μ L (Purple); 100-1000 μ L (Blue); 20-200 μ L (Yellow); 2-20 μ L (Yellow).
4. Attach the correct sized tip to the volumetric pipette by pressing the pipette firmly into the tip.
5. Close pipette tip box before continuing to prevent accidental contamination of clean tips.
6. Twist the plunger to adjust volume to the desired amount (set volume). You may need to simultaneously hold down two adjacent buttons to unlock the twisting mechanism. **STAY WITHIN THE VOLUME RANGE DESIGNATED ON THE PIPETTE.** Failure to do so will damage the volumetric pipette.
7. Press plunger down to the first stop.
8. Insert pipette tip vertically into 5% HCl before slowly releasing plunger to draw up liquid; ensure that the tip remains submerged during this process to prevent air bubbles being drawn into tip.
9. Evacuate the pipette tip of liquid by holding pipette vertically over the desired location and slowly pressing the plunger down to first stop, and then continue pressing until you hit the second stop. Dispose this liquid in the waste container.
10. Repeat step 9 with MQ-water, twice.
11. Tare weighting lidded glass container in balance.
12. Load pipette tip with MQ-water and transfer its content into weighting container.
13. Weight glass container with water from tip and record mass.
14. Repeat steps 11-13 at least five more times.
15. Calculate the masses of the six water aliquots delivered with the pipettor.
16. Calculate the average and standard deviation (SD) of the six masses, and convert to volumes using a density of water equal to 0.9978 g/mL (22 C). The average should be within 0.3 % of set volume and the relative SD should be smaller than 0.3 % for volumes > 0.100mL. The average should be within 0.5 % of set volume and the relative SD should be smaller than 0.5 % for volumes < 0.100 mL and > 0.020mL. The average should be within 1 % of set volume and the relative SD should be smaller than 1 % for volumes < 0.020mL.

Method 2: Volume delivering

1. Use appropriate protective wear such as goggles, gloves, and smock.
2. Work in designated laminar flow area.
3. Choose appropriate volume of pipette for the task at hand. The available volumes and color codes are as follows: 1000-10000 μ L (Turquoise); 500-5000 μ L (Purple); 100-1000 μ L (Blue); 20-200 μ L (Yellow); 2-20 μ L (Yellow).
4. Attach the correct sized tip to the volumetric pipette by pressing the pipette firmly into the tip.
5. Close pipette tip box before continuing to prevent accidental contamination of clean tips.
6. Twist the plunger to adjust volume to the desired amount (set volume). You may need to simultaneously hold down two adjacent buttons to unlock the twisting mechanism. **STAY WITHIN THE VOLUME RANGE DESIGNATED ON THE PIPETTE.** Failure to do so will damage the volumetric pipette.
7. Press plunger down to the first stop.
8. Insert pipette tip vertically into 5% HCl before slowly releasing plunger to draw up liquid; ensure that the tip remains submerged during this process to prevent air bubbles being drawn into tip.
9. Evacuate the pipette tip of liquid by holding pipette vertically over the desired location and slowly pressing the plunger down to first stop, and then continue pressing until you hit the second stop. Dispose this liquid in the waste container.
10. Repeat step 9 with MQ-water, twice.
11. Load pipette tip with desired liquid and transfer its content into recipient tube or bottle.
12. Discard tip.

Contamination Prevention Measures

1. Keep the pipette tip housing closed when not in use.
2. Never pipette directly from primary standard bottles
3. If moving a volumetric pipette from one laminar flow bench to another, place the pipette within a clean plastic bag or box before transferring.
4. Wear clean gloves when refilling the pipette tip storage housings.
5. Discard used pipette tips between pipetting different samples/liquids.

ICP-MS LAB	
<h1>Ashing</h1>	
3/30/2017	Diego Fernandez – version 0.1
REQUIRED READING: CLEAN LABS; MILLIQ; WEIGHING; PIPETTING	

Overview & Scope

Ground plant material is heated and combusted to remove all organic carbon. Crucible selection depends on the trace elements required. Platinum, nickel and ceramic has to be tested in order to minimize chemical blanks.

Training

Users should be trained to use this step-wise method until they are proficient

Equipment

10mL lidded crucibles
 Numbered rack for crucibles and transporting box
 Clean-room wipes
 Balance (0.1mg), weighting boat and plastic spatula
 Laminar flow area
 Frock and vinyl gloves
 10 mL lidded crucibles
 MQ-water
 Clean plastic box 16" long, 8" wide, 6" tall
 Compressed argon

Method

1. Remove clean crucibles from storage box and place in designated laminar flow area. Handle crucibles with gloved hands always inside designated laminar flow area.
2. Transfer crucibles from storing box in numbered rack.
3. Record sample names in **rack template**.
4. Clean weighting boat with MQ-water in ultrasonic bath for 1 min twice, then blow with argon and wipe with clean-room wipes.
5. Weight empty clean boat and record **initial weight**.
6. Transfer 20-30mg of sample into weighing boat. Perform this operation with boat, sample container, spatula and a clean-room wipe resting inside an open clean plastic box located in laminar flow area
7. Pour sample carefully into designated crucible.
8. Weight and record empty boat after transfer.
9. Clean and weight boat to check **initial weight**.
10. Continue with all samples.
11. Transfer rack into transporting box and take box to furnace area.

12. Place crucibles in furnace and record positions in **furnace template**.
13. Set heating program 1: 90 min at 120°C + 120 min at 350°C + 120 min at 550°C.
14. Once furnace cools down remove crucibles into racks and transport into designated laminar flow area.
15. Proceed with specific method for acid digestion of ashes.

ICP-MS LAB

Total Phosphorous in Plant Tissue

Revised 7/8/2019

Christopher Anderson – v. 2.0

REQUIRED READING: CLEAN LABS, MILLI-Q, WEIGHTING, PIPETTING, ASHING; PLASTIC LEACHING

Overview & Scope

Total phosphorous is measured in dry, homogenized plant tissue ashing using ICP-MS and an external calibration/internal standard method. Phosphorous content within the range 0.01-1 % (g of P in 100 grams of dry plant tissue) can be determined with an estimated 5% precision ($P > 0.05\%$) or 10% precision ($P < 0.05\%$). Standard reference material SRM1573a (Tomato Leaves, National Institute of Standards and Technology) containing $(0.216 \pm 0.004) \% P$ is used as primary standard. This method can also be used for total P contained in fiberglass filters containing seston.

Training

Operators should be trained and proficient with daily maintenance procedures (i.e. tuning, front end checking, cones cleaning, etc) and the Agilent 8900 software. Operators should be trained to use this step-wise method until they are proficient. A checklist is provided in an appendix to this method as a guide for trained users, however other issues not listed may have to be assessed.

Materials and Instrumentation

Hydrochloric acid **5% HCl** (trace metal grade or better) contained in FEP bottles is used to digest the ashed samples and to prepare dilutions and calibration curve

Calibrated Eppendorf pipettors with acid leached tips

Agilent 8900 #100 triple quadrupole ICP-MS

ESI SC2-DX auto-sampler with syringe pump loading and FAST introduction system set to 2x60 position racks.

Laminar flow bench

Acid leached **1 mL PP centrifuge tubes**

14mL PS tubes with 60 position (12x5) racks

P single-element ca. 1,000 ppm standard (Inorganic Ventures)

Agilent 1 ppb Li, Co, Y, Ce and Tl tuning solution and **P 1ppm** tuning solution prepared volumetrically from phosphorous single-element 1,000 ppm standard (Inorganic Ventures)

In 1ppm internal standard prepared volumetrically from indium single-element 1,000 ppm standard (Inorganic Ventures)

Standard reference material SRM1573a (**SRM**)

Method

Ash digestion

1. Plant material or folded fiberglass filters containing seston are ashed following Ashing SOP. For plant material or SRM, the mass weighted into the crucible (**MS**) is used for the calculation of % P (g of P per 100 grams of dry plant material). For filters containing seston, masses of filters are not needed for calculation of total P (micrograms of P in filter).
2. Perform all digestion and further dilutions for samples, chemical blanks and SRM in designated laminar flow area
3. Write label into as many acid leached 15 mL PP centrifuge tubes as crucibles containing samples, SRM or chemical blanks. Use crucible rack template to obtain labels.
4. Weight and record the masses for all empty 15 mL PP centrifuge tubes.
5. For ashed plant material (SRM and chemical blanks) and using FEP wash bottle with 5% HCl add about 1 mL of 5% HCl into first crucible.
6. Stir and use a pipettor with a 1 mL acid leached tip to transfer the liquid into the corresponding 15 mL PP centrifuge tube.
7. Repeat steps 3 - 4 four additional times to get a total of about 5 mL in the 15 mL PP centrifuge tube.
8. Continue with next SRM or chemical blank. Use a new acid leached tip each time.
9. For ashed folded filters transfer filter using a new plastic spatula into the corresponding 15 mL PP centrifuge tube.
10. Using FEP wash bottle with 5% HCl add about 1mL of 5% HCl into crucible.
11. Stir and use a pipettor with a 1mL acid leached tip to transfer the liquid into the corresponding 15 mL PP centrifuge tube.
12. Repeat steps 8 - 9 four additional times to get a total of about 5 mL in the 15 mL PP centrifuge tube.
13. Weight and record the masses for all 15 mL PP centrifuge tubes containing samples, SRM or chemical blanks digests.
14. Calculate the mass of each digest (**MD**) by subtracting values of empty tube (step 2) from value of tube with digest (step 12).
15. Vortex all tubes for at least 10 seconds a piece or place in an ultrasonic bath for 5 minutes and leave digest resting for at **least** 12 hours.

Secondary dilution and calibration curve

16. Use 60 position (12x5) racks to hold as many PS auto-sampler tubes as needed for samples, SRM and chemical blanks. Use rack template to record sample position. Save the right section of rack 1 for calibration curve. Rack 1 and Rack 3 will be positioned later in position 1 and 3 in auto-sampler. An example is provided below. The maximum number of tubes (including samples, chemical blanks, SRM and calibration curve) that can be run in one sequence is 120.

Rack 1

	smp57	smp49	smp41	smp33
	smp58	chem blk	smp42	chem blk
	smp59	smp50	smp43	smp34
	SRM15	SRM13	SRM11	SRM9
	smp60	smp51	smp44	smp35
	smp61	chem blk	smp45	chem blk
	smp62	smp52	smp46	smp36
	chem blk	smp53	chem blk	smp37
	smp63	smp54	smp47	smp38
	SRM16	SRM14	SRM12	SRM10
	smp64	smp55	smp48	smp39
	chem blk	smp56	chem blk	smp40

Rack 3

smp25	smp17	smp09	smp01	blk
smp26	chem blk	smp10	chem blk	blk
smp27	smp18	smp11	smp02	blk
SRM7	SRM5	SRM3	SRM1	blk
smp28	smp19	smp12	smp03	lolo
smp29	chem blk	smp13	chem blk	lo
smp30	smp20	smp14	smp04	mid
chem blk	smp21	chem blk	smp05	hi
smp31	smp22	smp15	smp06	hihi
SRM8	SRM6	SRM4	SRM2	hihihi
smp32	smp23	smp16	smp07	
chem blk	smp24	chem blk	smp08	

17. Using calibrated pipettors and new acid leached tips for each tube, follow the recipe below to dilute samples, SRM and chemical blanks and to prepare the calibration curve. Prepare at least two **cal blk** tubes for 25 samples. Add one extra **cal blk** tube per extra 20 samples.

NEON	2o P	cal blk	lolo	lo	mid	hi	hihi	hihihi	smp or chem blk	srm
		mL	mL	mL	mL	mL	mL	mL		
1o P	0.200							0.100		
2o P			0.012	0.050	0.125	0.500	1.250			
srm										0.100
smp or blk									2.000	
1 ppm In IS		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.050	0.050
5% HCl TMG	9.800	9.900	9.888	9.850	9.775	9.400	8.650	9.800	2.960	4.850

ICP-MS set-up

18. Check stand-by parameters of Agilent 8900, making sure that they are within normal operating parameters
19. Turn plasma on and leave "Execute plasma on parameters" checked.
20. Leave instrument to run automated warm up routine which takes 30 minutes.
21. Make sure the 1ppb tune solution is open and placed in tune rack position 1
22. Let the instrument run torch axis, lens tune, resolution/axis tuning and performance report. Add any to queue that were not initially checked.
23. Load batch from template and check 1ppm P calibration point at mass $^{31}\text{P} \rightarrow 47$ and try to tune for an intensity of more than 400 kcps.
24. Rinse for 1 minute with 5% HCl and check background intensity for mass $^{31}\text{P} \rightarrow 47$ to be no larger than 500 cps.

ICP-MS run

25. Make sure the acquisition method within the batch has the right parameters: 0.1 sec dwelling time on $^{31}\text{P} \rightarrow 47$ and 0.1 sec dwelling time on $^{115}\text{In} \rightarrow ^{115}\text{In}$, 48 replicates, and automatic detector mode and auto P/A factor adjustment; take-up time is 100 seconds with an 80 second rinse in the peri-pump program; and only one tune step being named O2 with the cell gas on and the 4th gas set to 40%.
26. Make sure that the correct auto-sampler program is loaded in the FAST portion of the ESI-SC software, which is "microfast-peri-500uL.txt".
27. Load Rack 1 and Rack 3 in rack positions 1 and 3 in auto-sampler.
28. Fill carrier bottle with 5% HCl.
29. Fill rinse port bottle with water.
30. Empty waste containers.
31. Write a sequence to run calibration curve, chemical blanks, samples and SRM following the previous example for 63 samples:

position	sample ID	position cont 1	sample ID cont 1	position cont 2	sample ID cont 2
3101	blk	3402	chem blk	1203	smp43
3102	blk	3403	smp18	1204	SRM11
3103	blk	3404	SRM5	3101	blk
3104	blk	3103	blk	3102	blk
3101	blk	3104	blk	1205	smp44
3102	calblk	3405	smp19	1206	smp45
3105	lolo P	3406	chem blk	1207	smp46
3106	lo	3407	smp20	1208	chem blk
3107	mid	3408	smp21	3103	blk
3108	hi	3101	blk	3104	blk
3109	hihi	3102	blk	1209	smp47
3110	hihihi	3409	smp22	1210	SRM12
3101	blk	3410	SRM6	1211	smp48
3102	blk	3411	smp23	1212	chem blk
3103	blk	3412	smp24	3101	blk
3104	blk	3103	blk	3102	blk
3101	blk	3104	blk	1301	smp49
3102	blk	3501	smp25	1302	chem blk
3201	smp01	3502	smp26	1303	smp50
3202	chem blk	3503	smp27	1304	SRM13
3203	smp02	3504	SRM7	3103	blk
3204	SRM1	3101	blk	3104	blk
3103	blk	3102	blk	1305	smp51
3104	blk	3505	smp28	1306	chem blk
3205	smp03	3506	smp29	1307	smp52
3206	chem blk	3507	smp30	1308	smp53
3207	smp04	3508	chem blk	3101	blk
3208	smp05	3103	blk	3102	blk
3101	blk	3104	blk	1309	smp54
3102	blk	3509	smp31	1310	SRM14
3209	smp06	3510	SRM8	1311	smp55
3210	SRM2	3511	smp32	1312	smp56
3211	smp07	3512	chem blk	3103	blk
3212	smp08	3101	blk	3104	blk
3103	blk	3102	blk	1401	smp57
3104	blk	1101	smp33	1402	smp58
3301	smp09	1102	chem blk	1403	smp59
3302	smp10	1103	smp34	1404	SRM15
3303	smp11	1104	SRM9	3101	blk
3304	SRM3	3103	blk	3102	blk
3101	blk	3104	blk	1405	smp60
3102	blk	1105	smp35	1406	smp61
3305	smp12	1106	chem blk	1407	smp62
3306	smp13	1107	smp36	1408	chem blk
3307	smp14	1108	smp37	3103	blk
3308	chem blk	3101	blk	3104	blk
3103	blk	3102	blk	1409	smp63
3104	blk	1109	smp38	1410	SRM16
3309	smp15	1110	SRM10	1411	smp64
3310	SRM4	1111	smp39	1412	chem blk
3311	smp16	1112	smp40	1203	smp43
3312	chem blk	3103	blk	1204	SRM11
3101	blk	3104	blk	3101	blk
3102	blk	1201	smp41	3102	blk
3401	smp17	1202	smp42	1205	smp44

32. "Add to Queue", and when the software is done setting itself up for analysis make sure the "Turn Plasma Off at End" button is selected in the "Queue" context.

Data treatment and reporting

A linear equation is used to fit the intensity ratio (intensity of P/intensity of In) to the concentration of phosphorous in the calibration solutions. The concentration of phosphorous ($[P, \mu\text{g/g}]$) in the samples, chemical blank and SRM in the secondary dilutions can be calculated using the equation of the linear regression.

$$[P, \mu\text{g/g}]_{tube} = m \left(\frac{cps_P}{cps_{In}} \right) + b$$

Where cps_P is the phosphorous signal for the sample, cps_{In} is the signal of the indium internal standard added, m and b are the slope and intercept of the calibration line. To determine the concentration of total phosphorous $C_{total P, \mu\text{g/g}}$ (in micrograms of P per gram of plant material) in plant material SRM it is necessary to take into account all the dilution steps during sample preparation. This can be determined using the following equation for SRM:

$$C_{total P}[P, \mu\text{g/g}] = [P, \mu\text{g/g}]_{tube} \frac{MD}{MS} 25$$

Where MD is the mass of digest, MS is the mass of sample and the factor 25 corresponds to the dilution factor used to prepare the secondary dilution for SRM. Total content of phosphorous $C_{total P, \mu\text{g}}$ (in micrograms of P per filter) in fiberglass filters containing seston or empty crucibles (chemical blank) can be determined using the following equation:

$$C_{total P}[P, \mu\text{g}] = [P, \mu\text{g/g}]_{tube} MD 2$$

Where MD is the mass of digest and the factor 2 corresponds to the dilution factor used to prepare the secondary dilution for filters containing seston or chemical blanks.

Average values for chemical blanks are averaged and subtracted to sample values.

Detection limit (DL) is defined as:

$$Detection\ Limit[P, ppm] = m \left(3 \times SD \left(\frac{I_{P,blank}[cps]}{I_{In,blank}[cps]} \right) \right) + b$$

Where SD is the standard deviation of all intensity ratios for the calibration blanks run through the sequence. Sample specific limit of determination (LoD) is defined as the product of the DL and the sample specific dilution factor. Sample specific limit of quantitation (LoQ) is defined as 3.3 times the LoD.

QA/QC

The following three criteria are used to warrant the accuracy of the method:

1. Detection limit < 5 ng P/mL
2. Linearity of calibration curve > 0.999
3. Measured value (average of 9 replicates) for SRM1573 within 5% of certified value.

Appendix

Daily sensitivity and measuring parameters are recorded in **ICP-MS Masshunter Instrument Control Performance Report**.

Version #	Date	Created or modified by	Changes implemented
0.1	8/15/17	Diego Fernandez	Creation of initial method for P in plant material by microwave digestion and ICPMS detection
1.0	1/15/18	Diego Fernandez	Creation of method for P in plant material by ashing and ICPMS detection
1.1	5/9/18	Christopher Anderson	Change in calibration and ICPMS set up
2.0	7/8/19	Christopher Anderson	Changed the major components being used for calibrating and set-up of new instrument as the 7500ce was retired as well as some changes to formatting