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A HOMEMADE INSTRUMENT FOR COLLECTING SOIL WATER FROM POROUS CERAMIC CUPS

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ABSTRACT.—An efficient Ceramic-Cup Water Collection Instrument (CCWCI, "quickie") is described. Soil water collection from ceramic-cup samplers may require compositing by equal volume from distantly spaced samplers, or simultaneous water collection from closely spaced samplers without compositing. All collection must be done with minimal opportunity for sample contamination. The CCWCI combines these and other soil water collection needs into a streamlined system that may be adapted to a variety of experimental designs and field conditions.

KEY WORDS: porous cups, soil solution, soil leachate, ceramic-cup lysimeters, nutrients.

Porous ceramic-cup samplers are widely used in soil nutrient studies to extract soil water from various soil depths. Under vacuum, these samplers draw water from the soil and temporarily store it. Then, the stored water must be collected and transported to a laboratory for chemical analysis. Unfortunately, there are no collection instruments commercially available for this time-consuming and repetitive procedure. To fill that gap, we have developed a Ceramic-Cup Water Collection Instrument (CCWCI, pronounced "quickie"). The CCWCI is well suited to studies with many ceramic-cup samplers that require sample collection at frequent intervals or require sample compositing in the manner suggested by Hansen and Harris (1975).

The basic features of CCWCI are:

1. It permits compositing by equal volumes from widely spaced samplers.
2. It permits simultaneous sample collection from several samplers located adjacent to each other.
3. It retains a vacuum while being moved from one subsampling point to the next, thereby minimizing the vacuum pumping operation.
4. It permits the reapplication of a vacuum to the samplers in one continuous operation with sample collection.
5. It minimizes sample contamination from outside sources.
6. It permits splitting of composited samples into two or more sample storage containers.
7. It has space for carrying sample storage pacs and sampler repair materials.
8. It is fabricated from lightweight commonly available materials using conventional shop tools.
9. It may be modified to meet the needs of different sampling schemes.
10. It is intended for use with two-line porous ceramic-cup samplers similar to those described by Linden (1977), and Knighton and Streblow (1981).

MATERIALS

The CCWCI system described here (fig. 1) is designed to collect subsamples at two soil depths at each of two widely spaced subsampling points. The materials required are:

Material	Quantity	Cost
Available through Curtin Matheson:[1]		
Tubing, latex 5 mm (3/16 in.) I.D. Cat. No. 244-491	203 cm (80 in.)	$ 1.75
Tubing, latex, 6 mm I.D. × 16 mm O.D. (¼ in. × ⅝ in.) Cat. No. 203-471	30.5 cm (12 in.)	.90
Tubing, polyethylene 3 mm (⅛ in.) I.D. Cat. No. 204-875	203 cm (80 in.)	1.75
Available through Plasticware catalog:[2]		
Desiccator, vacuum 171 mm (6 in.) Cat. No. 6514-10	1 each	27.00
Available through Chemical Lab:		
Clamps, pinchcock	10 each	6.00
Flask, Erlenmeyer 500 ml heavy wall	4 each	7.04
Stoppers, rubber #00 1-hole	2 each	.20
Stoppers, rubber #7 3-hole	4 each	1.68
Y-connector, polypropylene 6 mm (¼ in.)	2 each	.36
Available through most local hardware stores:		
Aluminum sheet 24 gauge	16.5 cm × 28 cm (6-½ in. × 11 in.)	1.25
Angle aluminum 19 mm × 2 mm (¾ in. × 1/16 in.)	5.34 m (17 ft 6 in.)	8.40
Bolts, flat or round head, 5 mm × 19 mm (3/16 in. × ¾ in.)	4 each	.25
Aluminum Rivet Back-up Plates 3 mm (⅛ in.)	30 each	1.00
Door pull handle 15 cm (6 in.)	1 each	1.50
Hasp, draw pull 16 mm × 41 mm (⅝ in. × 1-⅝ in.)	1 each	1.10
Hinge 2.5 cm × 2.5 cm (1 in. × 1 in.)	7 each	3.25
Hinge 3.8 cm × 3.8 cm (1-½ in. × 1-½ in.)	2 each	1.10
Lid support	1 each	2.00
Masonite, tempered 5 mm (⅛ in.)	122 cm × 52 cm (48 in. × 20-¼ in.)	1.50
Nuts, 5 mm (3/16 in.) thread	4 each	.15
Plexiglass, clear, 3 mm (⅛ in.)	23 cm × 51 cm (9 in. × 20-⅛ in.)	4.00
Plexiglass, clear, 6 mm (¼ in.)	25 cm × 25 cm (9-¾ in. × 9-¾ in.)	2.75
Pop-rivets, aluminum 3 mm × 6 mm (⅛ in. × ¼ in.), 3 mm × 9 mm (⅛ in. × 3/16 in.), 3 mm × 12 mm (⅛ in. × ½ in.)	125 total	5.00
Rubber band 3 mm × 15 cm (¼ in. × 6 in.)	1 each	.15
S-hooks, 25 mm (1 in.)	2 each	.34
Strap aluminum, 13 mm × 3 mm (½ in. × ⅛ in.)	35.5 cm (14 in.)	.66
Tape		
Velcro, 19 mm × 3 mm (¾ in. × ⅛ in.)	61 cm (24 in.)	4.00
	TOTAL	$ 95.08

[1]*Curtin Matheson Scientific, Inc., P.O. Box 1546, Houston, Texas 77001.*

[2]*Plasticware catalog, Cole-Parmer Instrument Co., 7425 North Oak Park Ave., Chicago, Illinois 60648.*

An experienced craftsman can fabricate one CCWCI in 30 working hours.

FABRICATION

Construct a box (fig. 1) to contain the CCWCI sample collection equipment. Use angle-aluminum for the frame; use masonite for the bottom, flask-support, sides, and back panels; and use plexiglass for the front and top panels. Use pop rivets with backup plates as fasteners. Details and dimensions are illustrated in figures 2 and 3.

Assemble the outside angle-aluminum frame first. The inside flask-support frame should not be cut or installed until the side panels have been placed in the frame. Cut the bottom, front, side and back panels to inside frame dimensions. Use two layers of masonite for the bottom panel and cut a hole 10.3 cm in diameter in the upper layer to hold the bottom of the overflow reservoir when it is in place. Cut access doors 17 cm^2 in each masonite side panel as indicated (fig. 3). The doors should be located so that they close against the angle-aluminum frame of the flask-support. Glue strips of Velcro to the leading edge of each door and to the aluminum doorstop to hold the doors closed. Cut an access door in the back panel just above the lower angle-aluminum frame 19 cm wide and at least 24 cm long. An aluminum bar must be installed inside the upper edge of the door opening to serve as a doorstop. Use Velcro strips to hold the door closed. Fingerholes, 2 cm in diameter, should be drilled near the leading edge of each door for easy opening. Drill two holes 6 mm in diameter in each side panel as indicated for sample collection lines. Storage pockets may be attached inside each side panel beneath the access doors using sheet-aluminum folded to desired dimensions. We use the pockets to hold whirl-pac sample storage bags that are prelabeled and may have sample preservative added in advance. Drill one hole in the front panel for a vacuum line. After the panels are secured in the aluminum frame, the flask-support frame and panel may be cut to inside dimension of the box and assembled. Cut a hole 7.8 cm in diameter in the center of each quadrant of the flask-support panel to hold inverted Erlenmeyer flasks. Cut the CCWCI plexiglass lid and fasten a strip of angle-aluminum along the leading edge (fig. 3) and attach the clasp loop to the aluminum. Also, attach a carrying handle and a support bracket to the lid.

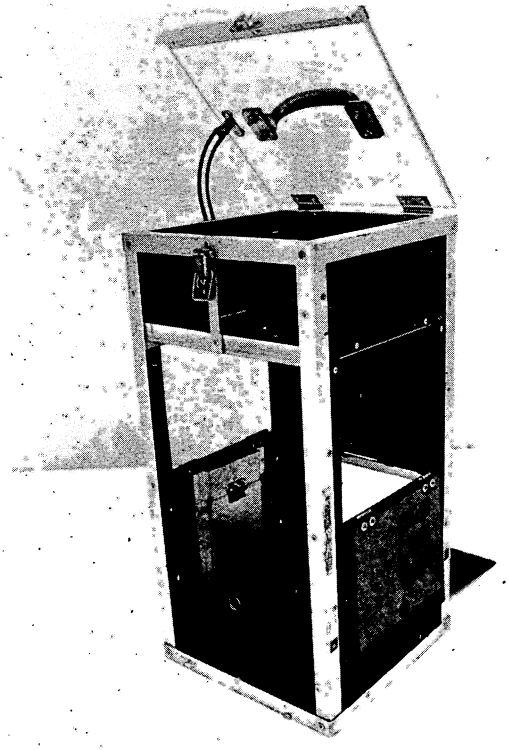

Figure 1.—*Front view of the empty CCWCI box.*

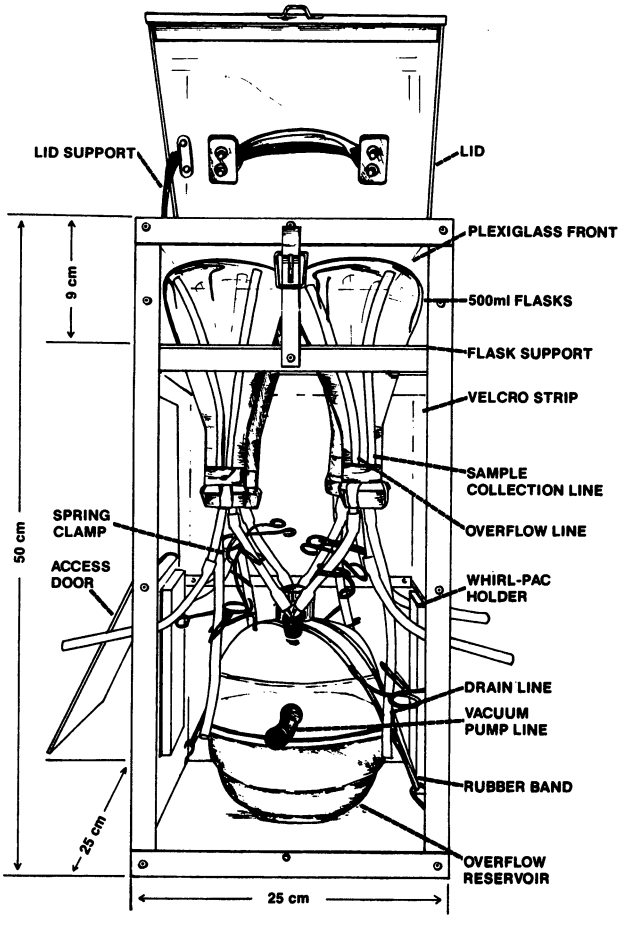

Figure 2.—*Front view of the completed CCWCI.*

Modify the desiccator to serve as a vacuum and water overflow reservoir. Drill two holes, 1.2 cm in diameter, in opposite sides of the lid. Center them 2 cm from the knob. Place the desiccator base in the hole provided in the bottom panel of the CCWCI. Attach tubing compatible with the vacuum pump to the existing vacuum port on the side of the desiccator lid. Position the lid on the desiccator base and extend the tubing about 5 cm to 6 cm out of the hole in the plexiglass front. Secure the desiccator to the CCWCI by stretching a large rubber band from the side panel hooks across the desiccator lid. Insert the "Y's" into No. 00 1-hole rubber stoppers and set the stoppers in the drilled holes in the desiccator lid.

Invert four Erlenmeyer flasks in the flask support, and attach tubing to each housing using a 3-hole No. 7 rubber stopper as follows:

1. Sample collection line—use polyethylene tubing from 18 cm beyond the inside stopper surface through the stopper to just inside the closest CCWCI side panel sample collection line hole which is 1 cm in diameter. Use 10 cm of latex tubing to extend this line through the hole.
2. Vacuum-overflow line—use polyethylene tubing from 16 cm beyond the inside stopper surface to 2 cm beyond the outside stopper surface. Use latex tubing to extend this line to a "Y" on the overflow reservoir (desiccator) lid.
3. Drain line—use polyethylene tubing from flush with the inside of the stopper to 2 cm outside. Use 20 cm of latex tubing beyond this and dangle it from the stopper.

Once the lines are installed securely, tape the stoppers to the flask. Attach pinchcock clamps to each drain line and to each overflow line. The completed CCWCI is illustrated in figure 4 with two models of ceramic-cup samplers and a small hand-held vacuum pump.

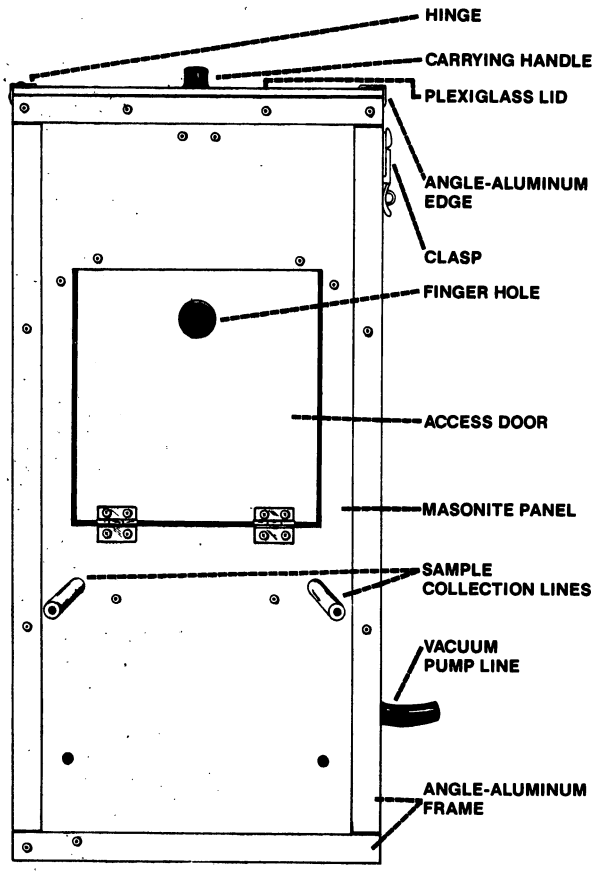

Figure 3.—*Side view of the completed CCWCI.*

OPERATION

Many variations exist for collecting individual or composite samples. The following steps describe the procedure for field operation of the CCWCI when

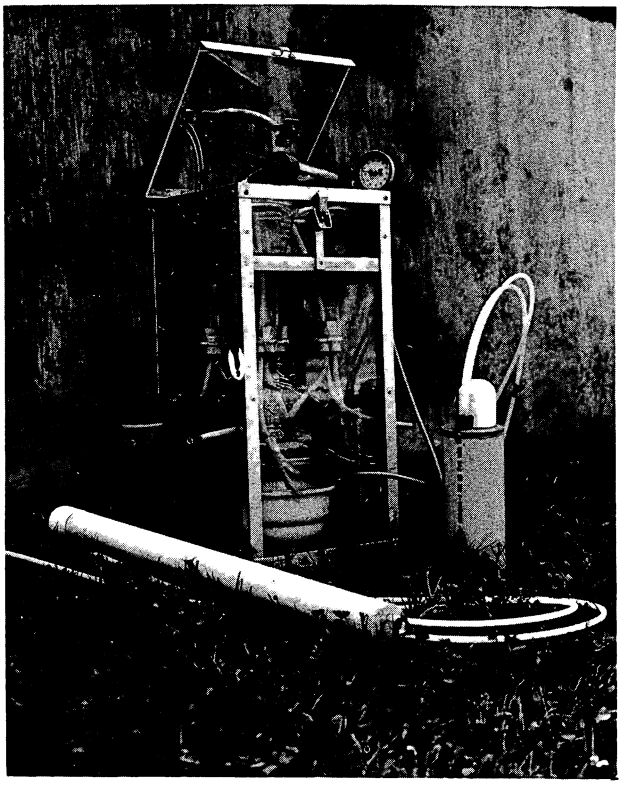

Figure 4.—*Completed CCWCI with ceramic soil water samplers and small hand-held vacuum pump.*

there are four ceramic-cup samplers per plot with one deep and one shallow sampler at each of two widely spaced subsampling points. It is assumed the samples collected from the two shallow samplers are to be composited, as are the samples from the two deep samplers.

1. At one pair of samplers, attach the shallow sampler collection line to the right front CCWCI sample collection line and similarly attach the deep sampler to the left front CCWCI sample collection line.
2. Release the clamps on the two front vacuum-overflow lines attached to the samplers.
3. Attach a vacuum pump to the vacuum line on the overflow reservoir.[3]
4. Release the clamp on the vacuum line and draw a vacuum. Water will be drawn from the samplers into the flasks. The flask will retain approximately 400 ml and the excess will be drawn into the overflow reservoir.
5. Be prepared to place a clamp on each air inlet line of the ceramic samplers immediately when it is visibly, or audibly evident air is being drawn into the attached flask which indicates the sampler is empty.
6. After both samplers are empty, continue to draw a vacuum until the entire system is recharged to the desired vacuum.
7. Place clamps on the ceramic sampler lines, on the vacuum-overflow lines, and on the vacuum pump line.
8. Disconnect the samplers, attach the sampler line ends together, and remove the two clamps. The vacuum will be lost in the flasks but not in the overflow reservoir.
9. Disconnect the pump, move to the next pair of samplers, and repeat steps 1 to 8 using the back flasks and matching the shallow and deep samplers on the same sides of the CCWCI used at the previous subsampling point.
10. Composite the two deep samples and the two shallow samples. Do this by drawing the two drain lines out through the CCWCI side access door and draining an equal sample volume from each flask into a sample container. If the composited sample must be split into different containers to meet analytical requirements, do this by draining visually estimated equal volumes into each container.[4]
11. Drain excess sample water out of the flasks. It is not normally necessary to flush the CCWCI between samples because the dilution effect is overwhelming. However, flushing with distilled water may be necessary if extreme differences in element concentrations are expected.
12. Remove the bottom of the overflow reservoir and discard overflow water only when necessary because this destroys the vacuum in the CCWCI.
13. Move to the next plot and repeat the procedure.

LITERATURE CITED

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Linden, D. R. 1977. Design, installation and use of porous ceramic samplers for monitoring soil-water quality. Agricultural Research Service, U.S. Department of Agriculture Technical Bulletin 1562, 16 p.

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[3]*Either a large-volume pump equivalent to the Boekel 2043 (Curtin Matheson Scientific, Inc., Cat. No. 196-758) equipped with a vacuum gauge or a smaller pump equivalent to the Pressure-Vacuum Hand Pump (Cat. No. 2001) from Soilmoisture Equipment Corp., P.O. Box 30025, Santa Barbara, California 93105.*

[4]*Plastic 6-oz. Whirl-pac bags (Curtin Matheson Scientific, Inc., Cat. No. 205-070) are convenient for sample collection and storage.*

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