AN INSTRUMENT TO AUTOMATICALLY MEASURE AND RECORD THE MAGNITUDE, CONDUCTIVITY, pH, AND TEMPERATURE OF PRECIPITATION DURING STORMS

Alex M. Sturrock, Jr., and James C. Jelinski

U.S. Geological Survey
Hydrologic Instrumentation Facility
NSTL, Mississippi 39529

ABSTRACT

A Leonard Mold and Die (LM&D) atmospheric precipitation collector[1/] has been adapted to monitor pH, conductivity, temperature and magnitude of precipitation during storms on a continuous basis. The collector, which functions as a flow-through monitor for precipitation, is interfaced to a battery powered microcomputer based controller and recorder with a hard-copy printer to record data at user-selected time intervals during storms. At midnight of each day the recorder is programmed to output the Julian day, time of day and values of the four parameters on the hard-copy printer.

INTRODUCTION

A study to determine changes in pH and conductivity during storms was started at the U.S. Geological Survey Hydrologic Instrumentation Facility near Bay St. Louis, Mississippi in October 1982. An LM&D atmospheric precipitation collector, adapted to function as a flow-through monitor for precipitation, monitors pH, conductivity, temperature, and magnitude of precipitation on a continuous basis. The collector is interfaced to a battery-powered microcomputer-based controller/recorder with a hard-copy printer to record data at 2-minute time intervals during storms. The recorder is programmed to output the Julian day, time of day, and values of the four parameters on the hard-copy printer at midnight of each day.

To determine if the collector would function well in a colder environment a second unit was fabricated and put into operation at a site near Hartford, Connecticut in January 1983. Preliminary results indicate the neoprene boot covers, that protect the arms that actuate the lid lever, freeze causing the drive unit to strip the drive gear preventing the lid cover from moving to the dry collector bucket during a precipitation event.

FABRICATION

The wet collection bucket was modified to serve as a flow-through monitor by cutting a 1¼-inch (31.75 mm) diameter hole in the center of the bottom. An eleven-inch (279.40 mm)

[1/] The use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Proceedings, Eastern Snow Conference, V. 28, 40th Annual Meeting, Toronto, Ontario, June 2-3, 1983

diameter polyethelene funnel was then fitted into the collector bucket and the funnel rim was sealed to the inside of the bucket using a silicone-base caulking. A one-inch (25.4 mm) diameter hole was cut in the center of the bottom of the bucket holder to allow passage of the inlet tube from the bucket to the sample chamber. The inlet tube uses a number 2 rubber laboratory stopper inserted near the bottom of the funnel and fitted with a tubing adaptor to transmit the flow of precipitation from the funnel to a 3/16-inch (4.76 mm) diameter outlet nozzle into the sample chamber.

The sample chamber is composed of 2 parts -- the conductivity cell and the sensor block. The conductivity cell is a Beckman model VKY ICY 200 dip-type cell which normally features 2 carbon contact rings to contact the water for measurement and has a cell constant of 1.0. The cell was modified by machining an inlet funnel to house the pH probe and an overflow slot near the end of the cell. The cell is mounted in the inverted position and functions as a cup type cell to insure constant wetting of the pH probe mounted in the center of the cell. As water enters the conductivity cell it is routed to the sensor block via the overflow slot. The sensor block serves as the second half of a U-tube which holds water in the conductivity cell to prevent drying of the pH probe. The first half of the U-tube is formed by the conductivity cell. The sensor block is machined from clear acrylic plastic and contains the routing channels for discharge and overflow of precipitation. The sensor block also provides mountings for the temperature probes, used for sensing the precipitation temperature, and temperature compensation for the pH and conductivity probes. A sample chamber holder, fabricated from aluminum U-channel and aluminum sheet, serves to secure the conductivity cell to the sensor block and to position both inside the shelter.

Further modifications to the collector consisted of a shelter constructed from aluminum sheet to house the instruments, and a fabricated frame mount for the tipping-bucket rain gage. A small diameter hole was cut in the bottom of the shelter to route water to discharge.

OPERATION

The LM&D atmospheric precipitation collector can be operated on either 110V AC or a DC power source capable of supplying 12 volts at 5 watts. The greatest portion of the power is required by the rainfall detector heater, incorporating a grid and electrically heated plate, to evaporate water from the detector plate after precipitation has stopped.

As rainwater bridges the gap between the grid and the plate of the detector a sensing circuit triggers the collector drive unit to move the cover from the wet precipitation collection bucket to the dry collector bucket. As the cover moves, a switch in the collector drive unit is activated and power is supplied to the detector heater in the underside of the plate. When rainwater no longer bridges the gap between the grid and the plate the drive unit will return the cover to the wet collection bucket.

Changes in pH, conductivity, and temperature of precipitation are monitored during a storm by a battery-powered CR21 Campbell Scientific micrologger and printer, which serves as a microprocessor controlled timer, sampler controller and recorder. The CR21 is interfaced to a U.S. Geological Survey (USGS) minimonitor which supplies the necessary signal conditioning between the probes and the CR21. The probes used -- in addition to the already described Beckman conductivity probe -- were a Corning model 476223 pH electrode, and a platinum type thermistor Rosemount model RNT 78-55-3 for temperature.

A signal supplied by the LM&D drive unit activates the CR21 during a precipitation event. The CR21 in turn activates the minimonitor to turn on and off at two-minute intervals, and records data from the three probes.

During the precipitation event the CR21 instructs the printer to print the following information at 2-minute time intervals -- the active state code, the time of day (hours and minutes), the temperature of precipitation (degrees C), the conductivity (micromhos) and pH (pH units). The volumetric measure of the precipitation is by a tipping bucket rain gage, Weathermeasure model P-501-I, which records each 0.01 inch (0.245 mm) of rainfall. This unit, mounted at the same height as the wet collector bucket, is connected directly to a CR21 pulse-counting circuit. The data output of the printer, for this volumetric measure, is as follows: the precipitation event counter code, the time of day (hours and minutes), and the number of bucket tips during the one-minute interval.

The CR21 is also programmed to output the following information at midnight of each day: the output table identification code, the Julian day, the time of day (24-hour basis), a baseline code, the current instantaneous values of temperature of precipitation, conductivity, and pH.

Calibration checks for the three probes were conducted at approximately monthly intervals using standard solutions and a calibrated thermometer. Results indicated that the calibration remains constant and that no recalibration has been necessary.

FIELD TEST AND EVALUATION

Two of the described instrument systems are currently undergoing field testing at sites located in Mississippi and Connecticut. At the Mississippi site, located at the National Space Technology Laboratories near Bay St. Louis, Mississippi, initial testing started in early October 1982. The work is being conducted as a cooperative endeavor between the USGS District Office in Jackson, Mississippi and with a local power company. It affords an opportunity to compare directly the results of composite weekly samples of acid precipitation with the continuous-event-oriented unit developed at the USGS Hydrologic Instrumentation Facility.

The cooperative program requires that the weekly composite sample be collected at 9:00AM every Tuesday morning, and values of pH, conductivity, and temperature measured and recorded before sample transmittal to the USGS Quality of Water Laboratory in Atlanta, Georgia for additional analysis. The results of the field and laboratory measurements of pH and conductivity are presented in table 1 for three separate sample-week events. For the first sample week of November 16-23, 1982, six precipitation events occurred. The modified unit showed a range from 4.0 to 4.7 in pH and 4 to 26 units in conductivity. In the second sample week of March 22-29, 1983, three events occurred, and the values of pH and conductivity in the prototype unit ranged from 4.2 to 5.4 and 2 to 42 respectively. In the third sample week -- April 12-19, 1983 -- only two events occurred, and the ranges were from 4.0 to 5.1 in pH and 6 to 30 units in conductivity.

Table 1. -- Average weekly values of pH, conductivity, and total precipitation collected at the Mississippi site.

Period	pH (pH units)	Conductivity (micromohs)	Total Precipitation (inches)
Nov 16 - Nov 23, 1982	4.6 (4.5)	13 (15)	1.67
Mar 22 - Mar 29, 1983	4.5 (4.4)	18 (17)	2.49
Apr 12 - Apr 19, 1983	4.7 (4.9)	14 (13)	2.05

( ) Atlanta Laboratory analysis

Data collection at the Connecticut site, located approximately 20 miles northeast of Hartford, Connecticut, began in early January 1983. The purpose was to determine the effect of a colder environment on the operation of the modified collector. At this site the precipitation collector was mounted over a well house and the remaining instrumentation was placed inside the house to insure protection from the weather. A second collector, installed to composite event-type sampling was concurrently operated.

For the modification to the cold weather environment the wet collector bucket was replaced by a Coleman ice chest, fitted with a funnel in the cover and a 60 watt lamp inside to heat the funnel. To reduce freezing between the funnel and the well house, in late January the collector legs were shortened to 12 inches (304.80 mm) to decrease the length of inflow tubing between the collector and one sample chamber.

Problems arose during the cold-weather period from ice accumulation and hardening of the neoprene boot covers that protect the arms that actuate the lid lever. This caused the drive unit to strip the drive gear, and prevented the wet collector cover from moving to the dry bucket, during a precipitation event.

SUMMARY

Results of the field test evaluation show that for a non-freezing environment the modified unit will function satisfactorily, and will measure -- with acceptable accuracy -- the variations in temperature and amount of the composite sample collected over a weekly-sampling interval. The modified unit will also measure the variation in the pH and conductivity that occurred during the sampling period.

Additional improvements are needed by the manufacturer to improve operation for a freezing environment, to insure continuous operation of the unit.