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A Battery-Operated Air Sampler for Remote Areas

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A BATTERY-OPERATED AIR SAMPLER FOR REMOTE AREAS

by

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FOREWORD

Protection of the environment requires effective regulatory actions that are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach that transcends the media of air, water, and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound monitoring data base for exposure assessment through programs designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment

- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs

This report presents an approach in solving some of the problems associated with the development of a remote air monitoring system. To date, many proposals have focused only on the selection of remote monitoring sites pollutants to monitor, etc.; the real-world problems of how to monitor and what equipment will best serve the objectives have not been considered. The utilization and application of the equipment as described in this report will be of value to those concerned with monitoring air in remote areas. For further information on this equipment, contact the Pollutant Pathways Branch of the Monitoring Systems Research and Development Division.

George B. Morgan
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SUMMARY

An air sampling system developed to evaluate air quality in biosphere reserves or in other remote areas is described. The equipment consists of a Dupont P-4000A pump and a specially designed battery pack containing Gates batteries.

This air sampling system was tested in southern Utah and at 10 remote sampling sites in the Great Smoky Mountains National Park. The equipment was backpacked to the remote sampling sites, and was operated continuously at full capacity for a maximum 8-day period. Except for tampering by curious hikers at one site, the equipment operated satisfactorily.

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ACKNOWLEDGMENT

We appreciate the assistance of Mr. Gloyd Green of the U.S. Environmental Protection Agency, Environmental Monitoring Support Laboratory-Las Vegas, in selecting and constructing the power supply.

INTRODUCTION

Most air sampling equipment requires conventional electrical sources. The majority of the techniques employed and the equipment presently in operation are only satisfactory in suburban, rural, and/or industrialized areas where a suitable power supply is available.

Sampling air in primitive and wilderness areas that are accessible only by foot and pack animals has necessitated the need to design equipment that is suitable for use in these remote locations. Transportation of equipment by air in many remote regions is prevented by regulations prohibiting low-altitude flying. Low-flying aircraft such as helicopters would also tend to pollute the very areas being sampled.

Remoteness also compounds problems encountered with equipment calibration and repair. Problems of this nature, especially for remote long-term air sampling studies, can seriously affect the outcome of the monitoring program.

A cooperative pollutant monitoring study between the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Support Laboratory-Las Vegas (EMSL-LV) and the U.S. Park Service in the Great Smoky Mountains National Park required sampling air in remote regions of this biosphere reserve (UNESCO, 1971). Data collected from previous studies in this area (Wiersma et al., 1978) showed that particular emphasis should be given to the sampling and characterization of airborne particulates. The sampling scheme described in this article details the equipment used to complete this task.

CONCLUSIONS

1. The construction of a low-cost and accurate air pollutant monitoring system is a critical need in the overall development of a remote air monitoring system.

2. The use of this air monitoring system in remote areas has shown it to be an extremely efficient and dependable air sampling device.

3. Air sampling studies conducted in remote areas and/or on biosphere reserve sites will enhance the development of a uniform, efficient, and cost-effective pollutant monitoring program.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. The development of monitoring equipment and methodology for assessing pollutant levels in remote areas should be pursued.

2. A remote monitoring program should be initiated with intermediate results being disseminated as soon as possible.

3. Developed equipment should be used and tested under a variety of remote environmental conditions.

MATERIALS AND METHODS

Prime considerations of design were weight, durability, no required maintenance, and a need to operate at full-capacity for a minimum of 8 days. The pump selected for this air sampling system was the Dupont constant Flow Air Sampler P-4000A. It is a 4-cylinder diaphragm-type pump weighing 840 grams (g). The pump is capable of flow rates from 500 to 4,000 cubic centimeters per minute (cm^3/min) and is guaranteed to run within $\pm$5% of the selected flow rate. This is accomplished by electronic control circuits which automatically adjust the motor speed to pump at a constant flow rate regardless of changes in pressure and temperature during the sampling period (Dupont, 1978).

The pump comes equipped with two internal rechargeable nickel-cadmium (Ni-Cd) batteries. These batteries were removed prior to the pump's use because they do not provide sufficient power for operating the pump over extended periods of time as required for remote air sampling. Also the remoteness of the sampling sites prevented the possibility of recharging the Ni-Cd batteries on a daily basis as intended by the manufacturer.

The pump draws a minimum of 125 milliamperes (mA) during free-flow conditions, and a maximum of 400 mA during restricted flow. Because of the current required and the length of operating time, a power supply that provided an average of 200 mA current over a 2-week period was needed. At this level a power supply of 67.2 ampere-hours (Ah) was necessary. As the environmental conditions under which the equipment would be required to operate might be adverse, it was decided to add a power reserve of 12.8 Ah.

The power supply consisted of Gates rechargeable sealed acid batteries. Packs of six individual cells are rated at 6 volts and 10 Ah. Their relatively small size (13.7 cm x 9.1 cm x 8.0 cm) and weight (2445 g per pack) were important in their selection.

To provide the required 80 Ah rating, eight battery packs were needed. However, due to the total bulk and weight of eight packs, only four were connected together. Four packs were placed in individual carrying cases for transporting. Each case weighed 2010 g and was constructed from 1.2-cm thick Plexiglas® measuring 30.0 cm x 20.8 cm x 11.3 cm. The four-pack power supply units were constructed to enable parallel connection. Two power units were used per site to satisfy the necessary 80 Ah requirement. Additional power supply units could be paralleled to provide longer equipment operation if required.

Figure 1 shows the discharge voltage as a function of time under laboratory operating conditions for one power supply unit of 40 Ah. The discharge was fairly constant for 6 days. However, on the seventh day a sharp decrease was noted. During the seventh and ninth days, even though the voltage was decreasing, the pump maintained a 4000 cm^3/min flow rate. In most battery-powered systems, the capacity per cycle increases as the temperature increases; therefore, precautions in calculating the operating time should be taken in adverse temperature conditions.

The air flow through the filters was controlled by Visi-Float® flowmeters. Latex laboratory tubing, with an inside diameter of 5.0 millimeters and a wall thickness of 2.0 millimeters, was used for all inlet and discharge piping from the pump and filter holders to the flowmeters. The pump was placed 2 m from the filter holder which was a 37-millimeter-diameter Millipore ® aerosol monitor. The aerosol monitor included an aerosol filter membrane with a pore size of 0.45 micrometer (μm). The monitors were convenient to use under field conditions because of their ease in changing and because contamination of the membrane was easily avoided.

RESULTS AND DISCUSSION

Installation of the sampling equipment in the field took approximately 20 minutes per site. The power supply units, pump, and flowmeters were placed on the ground. The pump and flowmeters were put in a plastic bag to protect them from the frequent rain storms. At eight sites, the aerosol monitors were placed approximately 1.7 m above the ground, attached by wire ties to the trunks of suitable trees. At the remaining two sites they were attached to the top of a barbed wire enclosure. The enclosure as shown on Figure 2 was constructed from one-half-inch conduit pipe measuring 2.0 x 2.0 meters square at the base. It resembled a pyramid in design having a peak height of 2.6 m. Barbed wire was strung around the base to a height of 1.2 m to prevent bears from damaging the sampling equipment.

Four aerosol monitors were used per pump due to the analytical requirements. One filter was analyzed by scanning electron microscopy, another by atomic absorption, and a third by x-ray fluorescence spectrometry. The fourth filter was kept as a replacement in case of damage or loss to one of the

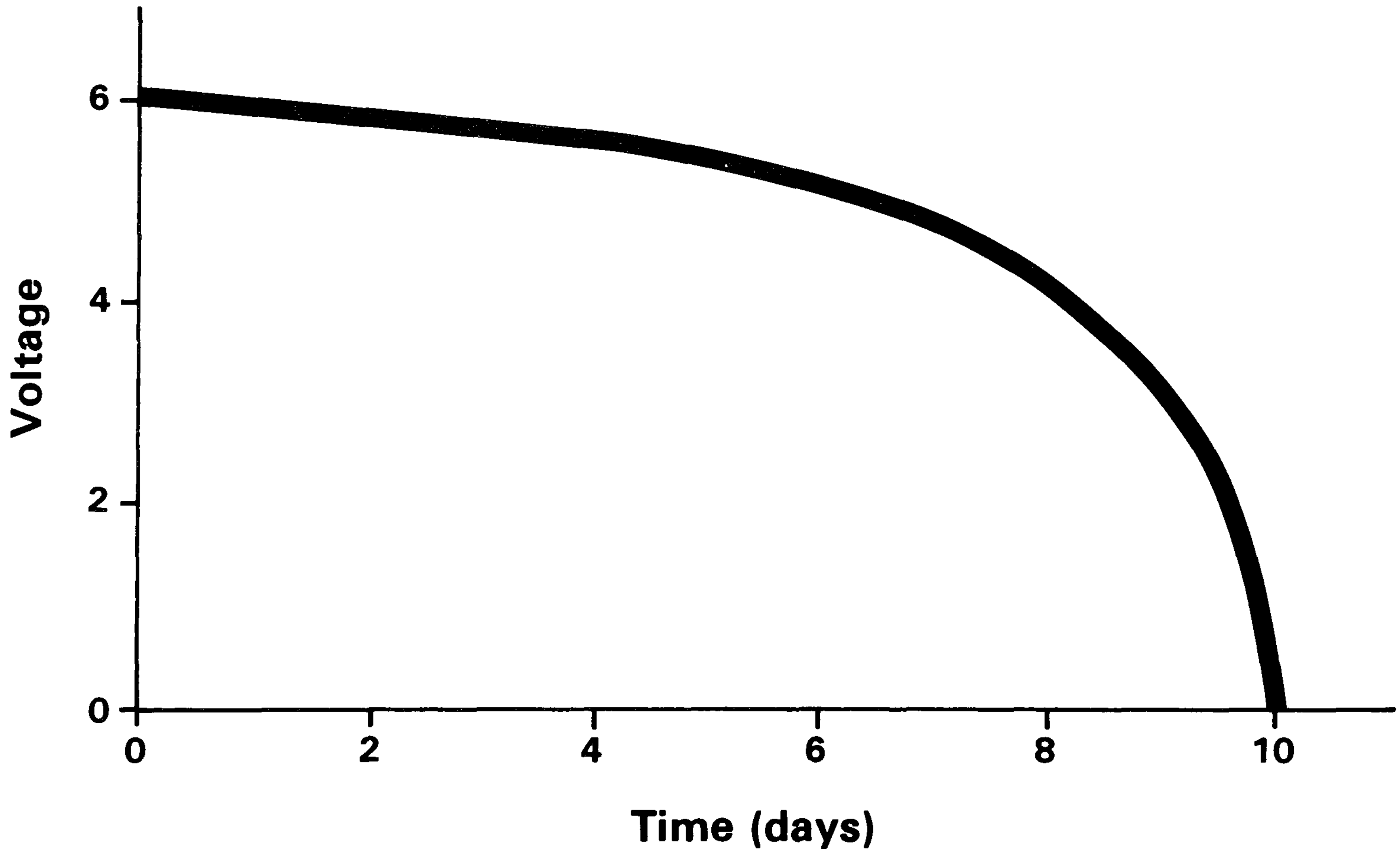

Figure 1. Change of discharge voltage as a function of time for one 40 Ah power supply unit.

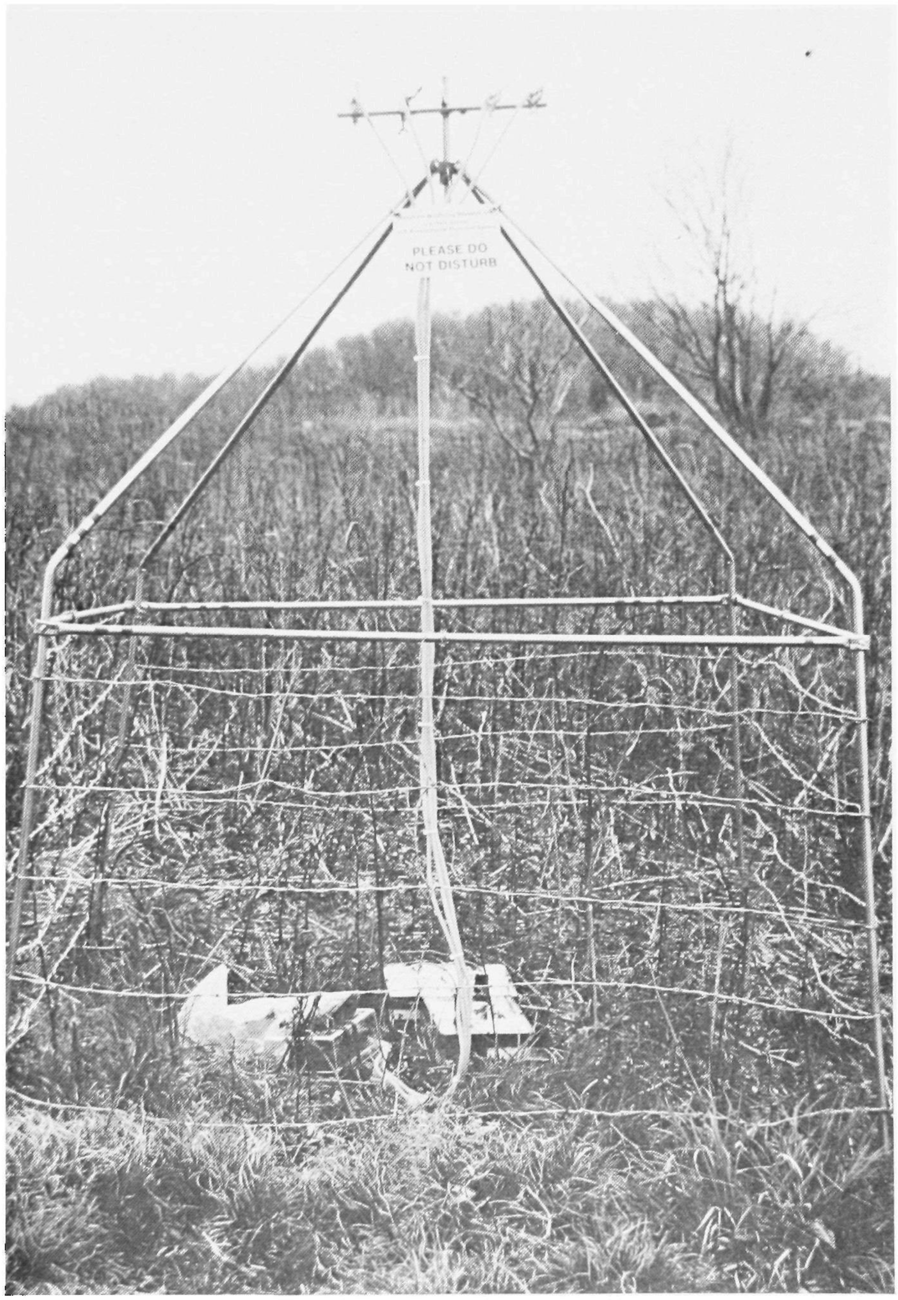

Figure 2. Barbed wire enclosure constructed to prevent people and animals from tampering with air sampling equipment.

other three, or in case a more extensive analytical examination was required.

The operational time at each sampling site varied from 4 to 8 days. The flow rate through each filter at all of the sites was 1,000 cm^3/min. None of the air monitoring sites were visited after the initial installation until they were dismantled.

At the end of the sampling period, the flow rates were noted and recorded. At 8 of the 10 sites the monitoring equipment was operating normally. At one site the flow rate through each filter had dropped to 800 cm^3/min. As far as could be determined, this pump and the other associated equipment were operating properly. The reason for the drop in flow rate is not known. At the remaining site, the equipment was not operating. It was obvious that the gear had been tampered with, probably by local hikers. Also, at one of the enclosed sites, a bear cub had gotten through the barbed wire and overturned the batteries and pump. However, the equipment at this site, even though subjected to this abuse, continued to operate properly.

The use of this air sampling equipment has also been tested and operated at five sites in southern Utah. The length of operation at each site was for a 40-hour period. During these operations, no malfunctions or drop in flow rates occurred at any of the sampling sites.

This air sampling system has proved to be an effective and efficient field instrument for sampling air in remote areas especially where back or horse packing are the only means of access. It also provides dependable air monitoring capabilities in areas without conventional power sources.

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