DEVELOPMENT OF GAMMA PROBE FOR RADIATION SURVEYS OF THE BOTTOMS OF SURFACE WATERS

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ABSTRACT

We have developed a practical method for mapping variations in gamma activity and electrical conductivity of submerged sediments. Prototype probes are being constructed and tested. The first prototype was essentially a background survey meter (Jones, 1979) packaged in a 53-cm-long by 5.4-cm-diameter waterproof vehicle. This tubular vehicle was towed by boat in contact with the bottom sediments of lakes and rivers. Originally, this vehicle was designed (and is still frequently used) for locating groundwater and contaminant entry areas in surface waters. By logging geographic position and sediment variables, it has been possible to produce contour maps in areas of interest. Thus it is possible to optimize environmental analysis and avoid the "hit or miss" approach of traditional bottom-sediment surveys.

INTRODUCTION

Contaminants present in surface-water discharges as a result of industrial effluents can accumulate in bottom sediments. Because of the overlying water, it has been difficult to determine the areal distribution of contaminants in these sediments. Consequently, environmental questions often cannot be addressed without great cost. Mobile methods for rapid detection and mapping of sediment contamination would greatly enhance the value of laboratory analyses required for monitoring. If areas of potential contamination were surveyed and the results shown on a map, it would be possible to verify the effectiveness of monitoring, reduce its cost or focus on corrective action.

Most instruments, presently used for underwater surveys, are designed to operate some distance above the bottom, not in contact with it, to avoid snagging, abrasion or damage. Although many contaminants are preferentially associated with sediments, they cannot be readily detected without direct sediment contact. Several devices have been designed to be lowered to the bottom to make point measurements, but they do not provide information between the points of measurement. A continuous line of data along the bottom can be decisive because contaminants are rarely distributed uniformly. Some large devices have been designed for towing behind oceanographic vessels. These devices are unsuited for surveys on the bottoms of lakes, estuaries or rivers, particularly near shore-based industrial areas.

Many radionuclides that may be present in industrial discharges become associated with bottom sediments. Shielding by water prevents detection unless the detector is within a few centimeters of the radioactivity. Consequently, most radiometric surveys of bottom sediments are done by sediment coring and subsequent laboratory analyses. However, coring is a point sampling approach. Without a measure of spatial heterogeneity, coring can not provide satisfactory coverage without enormous effort. Therefore, the detailed, quantitative information from sediment cores can rarely be used fully.

The project outlined here was designed to provide continuous line data that could be used to generate contour maps of gamma activity distributions. Such a map could be used to select coring locations and to reduce the numbers of cores required. Quantitative information from these cores can be used to calibrate the mapped distributions. A map of sediment radioactivity could also help form conceptual models for aquatic transport, dispersion and deposition. Information on the lateral distributions of gamma activity of bottom sediments could also help to verify the results of effluent monitoring programs, improve the information quality of bottom samples that are taken to answer allegations regarding release of contaminants, and to establish representative monitoring points. Where there are valid concerns that sediments may be contaminating invertebrates or fish, a contour map of gamma activity can help target areas for definitive study.

BOTTOM-CONTACT SEDIMENT SURVEY PROBE

The probe serves as an underwater gamma radiation survey vehicle that can be towed along the bottom of a body of water with minimal snagging. Another requirement was that the vehicle remain oriented so that detectors in the probe would "look" toward the bottom, or upward toward the overlying water.

The initial prototype was a 53-cm-long x 5.4-cm-diameter tube, closed at both ends and containing a Geiger-Muller tube. Lead was added inside of the 5.4-cm-diameter tube to keep the probe on the bottom during normal towing speeds of 1 meter per second. Mass within the tube was distributed to maintain the orientation of the probe. Orientation also ensured that contact with the bottom could be ascertained while the probe was underway, by monitoring electrical conductance with electrodes located along the lower side of the probe. During towing, the probe did not roll or twist along its longitudinal axis by more than 10 degrees, so that the sensors, which had been fixed within the vehicle, were oriented to "look" up, down, or sideways (Jones, 1979; Lee and Beattie, 1991).

A stretched version of the probe was built to allow adjustment of the probe mass by the addition or removal of lead weights, while at the same time preserving the self-orienting feature of the probe. Where sediments were very soft, it was advantageous to increase or decrease the overall mass for selected runs. Also, in the stretched version, the lead shielding over the upper and lateral sides of the detector was removed so that radiation could be detected from all around.

Because of their robustness, the two detectors used to date have been Geiger-Muller tubes. The two Geiger-Muller tubes used have outer dimensions of 26.7-cm long x 2.25-cm diameter and 99.3-cm long x 5.075-cm diameter. In laboratory tests, the larger tube has been shown to be 16 times more sensitive than the smaller tube. Currently, the larger tube is being incorporated into a second probe and a third device, which will have a NaI detector, is being designed.

FIELD-PORTABLE DATA ACQUISITION

A geographic positioning system has been interfaced to a computer for logging the position of the probe while it is underway. The positioning system is portable, semi-automatic and laser-based. Tests have shown that records of sediment variables and geographic location (to plus or minus one meter) can be logged under field conditions.

A portable computer has been modified and software has been written to convert analog signals to digital data, to store these data and display concurrent, real-time records of gamma activity and sediment conductivity. Having a real-time graphical display, the operators are able to identify key sampling locations, and to form a mental image of the underlying spatial variations of the sediment. Therefore, the density of coverage and the sampling for ground truth was adjusted at early stages of the current investigation of the Chalk River waterfront on the Ottawa River.

With geographic positioning, the system has allowed us to collect data for creating coloured contour maps of the distributions of sediment radioactivity and conductivity. Results of work along the Chalk River waterfront have shown good agreement between laboratory analyses of river sediment and contour maps made with this data acquisition system. Good agreement has also been seen between point data and probe results in a study of a small pond near one of the waste management areas at Chalk River.

CONCLUSION

A new approach to underwater monitoring near industrial sites has been introduced for surveying areas of interest in aquatic environments. The approach has the potential to reduce the costs of monitoring and remediation by identifying specific areas for detailed study. Sediment monitoring or cleanup can be targeted on locations where maximum benefit can be obtained.

REFERENCES

Jones, A.R., 1979. Two survey meters for measuring low gamma-ray dose rates. AECL Research, AECL-6407.

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