RADIOISOTOPES IN HYDRAULIC ENGINEERING RESEARCH --

A SUMMARY OF LITERATURE

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April 1960 CER60WWS28

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Since the end of World War II, radioisotope techniques have been successfully applied to an ever increasing number and variety of research problems. In particular, radioisotopes have found useful applications as tracers because:

1. They are readily detectable in extremely small concentrations (e.g. 10^{-7} parts per billion for Iodine-131, Parker (21) 1958),
2. Radioactive tracers can be prepared in a wide variety of chemical and physical forms,
3. The chemical and physical properties of radioisotopes are very nearly identical to those of the stable isotopes having the same atomic number.

Radioisotope tracer techniques have been applied most extensively in the fields of medicine, agriculture, biology, chemistry and industrial control. Hydraulic engineers have been somewhat slow to investigate and capitalize on the potentialities of radioisotopes as a research tool. Nevertheless there have been a number of interesting applications in the area of hydraulic research. Some of these are listed and briefly described under specific subheadings in the following paragraphs.

Sediment problems - Krone (18) 1959, (19) 1957 has applied radioactive tracer techniques to the solution of problems created by the continual deposition of sediment in the navigation channels of San Francisco Bay. More specifically, radioisotopes were used to locate and evaluate sources of shoaling material, to evaluate dredging practices, to provide guidance in remedial measures, and to provide knowledge of sedimentation under maximum development of the channel system. The associated research program has been concerned primarily with methods of labeling bay sediments, means of detecting and measuring the labeled sediments, and on application of these methods and means to sediment transport problems.

Putman et al (22) 1954, have described similar studies in which radioisotope-labeled sediments were used to investigate the movement of mud masses which interfered with the maintenance of shipping channels in the Thames estuary.

A number of investigations: Putman and Smith (23) 1956, Reid (25) 1958, Inose et al (15) 1956, and Arlman et al (2) 1958, have been concerned with tracing the movement of sand on off-shore bottoms by means of particles tagged with radionuclides.

Radioisotopes have also been used successfully in tracing the movement of bed materials in hydraulic model studies.

Additional applications of tagged sediments as tracers in rivers and oceans are reported by Hours and Jaffry (13) 1959, who also give an excellent account of techniques in the preparation and usage of tagged particles.

Fluid mechanics - One of the potentially most significant applications of radioisotope techniques in fluid mechanics is in the study of turbulent or eddy diffusion in pipe and open channel flow. Experiments of this type in natural streams, and pipelines have been reported by Simpson et al (27) 1959, Parker (21) 1958, Godfrey (10) 1960, and Thomas (30) 1956. Surprisingly, this technique does not seem to have been utilized as yet for the study of turbulent diffusion in laboratory flumes.

It has been suggested by Sayre, Guy and Chamberlain (26) 1959, that tracers offer a promising method for obtaining experimental data from which the scale and intensity of turbulence can be determined.

Salts, Glover (8) 1956, Glover and Daum (9) 1957, and other types of chemical tracers have been employed in studies of turbulent diffusion. However, radioisotopes have significant advantages in that by proper choice of the tracer element, such troublesome problems as density currents and undesirable adsorption and/or chemical reactions can usually be eliminated, Parker (21) 1958.

Actual and proposed uses of radioisotopes as tracers in studies of velocity distribution in laminar and turbulent flows near a solid boundary by the tracer-displacement technique have been described by Beatty et al (3) 1956.

In a different type of application, Kerr and Rosenberg (17) 1958, have used radioisotopes to investigate cavitation phenomena. By coating turbine runners with a radioactive paint and measuring the radioactivity of the discharge water at various turbine speeds, an index of cavitation erosion was obtained.

Sanitary engineering - Radioisotopes have been used for a number of purposes in sanitary engineering research. Straub and Hagee (29) 1957, have reported a number of these including the determination of flow time in streams, the testing of pilot plant facilities, and the testing of pasteurization equipment. Thomas (30) 1956, has discussed the advantages of radioisotopes over other more conventional types of tracers. Archibald (1) 1950, has described various tracer tests in pipelines, sewage treatment tanks, and hydraulic models of sanitary-engineering structures. Stanley (28) 1955, has determined the depth of penetration of floc into rapid sand filters by means of radiotracers. Other applications include the labelling of sewage sludge discharging into the ocean by Ellis and Gardner (6) 1958, and the use of tracers in sedimentation tank studies by Valentine and Bluhm (31) 1959.

Flow measurement - A number of applications of radioisotope techniques to problems of flow measurement in pipes and open channels have been made. These are divided mainly into two categories which may be considered as the radioisotope analogies of the salt-velocity method and the salt-addition method. Except for the substitution of radioisotopes for salt or other types of chemical tracers, there is nothing essentially new in these methods of flow measurement. The previously-cited advantages of radiotracers over salts and other types of chemical tracers apply here also. Flow measurement by radioisotope techniques has been reported in the literature by Putman and Jefferson (24) 1956, Haworth and Platt (12) 1953, Beatty et al (3) 1956, Moser and Neumaier (20) 1957, Hull and Macomber (14) 1958, and others.

Miscellaneous applications - Radiotracer techniques have also been used in related areas of research which are somewhat outside of the general hydraulics field. Among such applications are numerous studies of the movement of groundwater, e.g., Fox (7) 1952, Kaufman and Orlob (16) 1956, Halevy and Nir (11) 1959, von Buttlar and Wendt (5), 1959. In oceanography, radioisotopes have been used for the determination of ocean mixing rates, Broecker et al (4) 1959.

The fact that the limited number of applications described in the foregoing paragraphs have been notably successful appears to indicate that an important potential exists for the application of radioisotope techniques to the solution of problems in hydraulic research.

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