Isotope Techniques for Hydrology. Technical Reports Series No. 23. Published by International Atomic Energy Agency, Vienna, Austria, 1964. Distributed by International Publications, Inc., 317 East 34th Street, New York, N. Y. 10016. 38 pages. $1.00

The titled document is the report of a panel on isotope applications in hydrology, convened under the auspices of the International Atomic Energy Agency. The document covers, in some detail, the isotopes that have been used in in hydrology, and then specifically discusses some aspects of surface- and ground-water applications. Mention of activation analysis is made, although essentially no space is spent in indicating its real potentialities. This is unfortunate since herein probably lies one of the major contributions of the nuclear discipline to water supply and quality analysis.

The discussion of experience with isotopes and those isotopes with desirable characteristics is well presented in the space provided. In most cases the isotopes are discussed in connection with a ground-water dating or tracing application. Such discussion of isotope characteristics is easily related to the later consideration of use in surface-water studies.

The emphasis on water dating tends to be overdone in the amount of discussion presented, particularly in view of its relative minor importance to the overall field of ground-water hydrology. The issue of how important dating is to hydrology apparently is disposed of in one statement on page 9: "Dating of ground water is a technique which *can give information* on recharge rates . . ." The discussion then turns directly to dating, with no further consideration of the applicability to ground-water hydrology. As is the case with so many dating proponents, the way to calculate a recharge rate (a volume of fluid per time) from a dating (just time) without a myriad of unrealistic assumptions is not given. Further, the carefully thought out and published paper by Skibitzke[1] in 1958 was not considered. In that paper the fallacies are explicitly pointed out for the extensive use of dating and tracers in hydrology for the usual proposed applications.

The reviewed document gives helpful information on the behavior and interactions of tracers in soils. Such information can be expected to contribute to better use of tracers in the future for studying the advanced phases of ground-water research—such as hydrodynamic dispersion characteristics and porosity distributions in heterogeneous porous media. The present types of uses as reported can not, in general, be expected to quantitatively contribute such knowledge for the reasons pointed out by Skibitzke as early as 1958.

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[1]HERBERT E. SKIBITZKE, "The use of Radioactive Tracers in Hydrologic Field Studies of Ground Water Motion," *Extrait des Comptes Rendus et Raports—Assemblée Générale de Toronto 1957.* **Tome II,** 243.

Radioisotopes in Hydrology. Published by International Atomic Energy Agency, Vienna, Austria, 1963. Distributed by International Publications, Inc., 317 East 34th Street, New York, N. Y. 10016. 459 pages. $9.00.

This book contains the proceedings of the International Symposium on Radioisotopes in Hydrology, held in Tokyo, Japan, 5-9 March 1963, under the sponsorship of the International Atomic Energy Agency in cooperation with the Japanese Government. Twenty-seven papers (21 in English and 6 in French) are included in the volume; each is followed by an abbreviated discussion which occurred at the Conference. Each paper is preceded by an abstract in the four languages of the conference: English, French, Russian, and Spanish.

The purpose of the conference was to present and discuss investigative methods and uses of radioactive tracers in hydrologic studies. Papers presented fitted well into the conference theme. The technical and semitechnical reports are grouped into five areas of isotope applications: mixing process and discharge measurement in rivers and lakes; sediment and bed load transport; speed and direction of ground-water flow; in-well ground-water-velocity measurement devices; and characteristics of specific isotopes for ground-water tracing.

The conference was quite effective in bringing together people in varied disciplines from many countries to let them become aware of the results, types of investigations and, most importantly, the problems being encountered in using radioactive tracers in hydrology. Although no formal conclusions are presented, several general conclusions and trends are evident from the papers and from the ensuing discussion:

1. The major limitation of using isotopes for measuring discharge in large rivers or canals is the uncertainty of complete mixing. This limitation can be minimized only through injecting tracers across the entire flow, as contrasted to point injection, and by using a spatial concentration integration to determine the true diluted tracer concentration downstream.

2. The use of radioactive tracing for studying sediment transport seems to have potential. The major detail work reported is that in the United Kingdom, using reactor-irridiated sand in flume studies of transport. Rather high activities, which are needed to detect longer time and distance particle transport, may be a limitation in long-range studies.

3. The utilization of radioactive tracers in ground-water hydrology is moving into a new stage of development on the way toward assuming a mature position among ground-water investigative methods. This change is evident, particularly as noted in pages 175-237, by the absence of the more glamorous claims of the past, and the presentation of careful evaluations of those useful hydrologic tracer methods.

A number of papers in the publication emphasize what is slowly coming to light, that tracers at this time have limited application in quantitatively describing in detail a ground-water flow system. Although tracer tests may provide useful information on water (or waste) movement rates and approximate paths between injection and sampling points for an existing flow system, they provide limited information on the details of the system (hydrologic parameters, such as permeability and potential distributions) which are needed for a complete analysis of flow. There are few instances where flow analysis is desired for a system that is not to be exploited in some manner, recharge or pumping, by man. Data from tracer tests conducted prior to the fact may be of little value in the case where the system is subsequently altered appreciably through human efforts or natural phenomena. On the other hand, if such techniques can be employed to yield accurate

data on independent variables, e.g., permeability or porosity distributions, then a major step will have been taken towards getting the types of information sorely needed by the scientific hydrologist.

The book presents a number of articles dealing with test methods for obtaining and, perhaps more importantly, interpreting results to get information on some of the above-mentioned soil parameters; more work of this type is needed. Also, worthwhile presentations are included on the application of specific radioisotopes and desirable characteristics for tracing. There is, however, a general lack of supporting analysis needed for rational interpretation of tracer results and the setting of error bounds in the cases of measuring large discharges of water.

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About the Reviewer: Mr. Nelson is presently a senior research scientist with the Pacific Northwest Laboratories of the Battelle Memorial Institute with particular interest in the mathematical description of flow in heterogeneous porous media and its application to the solution of natural flow systems involved in ground-water management, petroleum engineering, and nuclear waste disposal. Prior to his association with BMI, he was with the General Electric Company at Hanford and, earlier, with the U. S. Department of Agriculture. His academic training was at Colorado State University and at the University of Idaho.

Plutonium. By M. Taube, translated by E. Lepa and Z. Nanowski. The MacMillan Company, New York (1964), 258 pages. $8.50.

This is a recent translation of a Polish book originally published in 1964. The blurb inside the jacket of the book states, "This book deals comprehensively with the properties of plutonium, its technical background and its application to nuclear research and practical use." I disagree with the term "comprehensive" since, with the exception of aqueous chemistry and processing technology, the various topics are treated in a rather superficial manner. The reader who is engaged in the plutonium field will not find this book especially useful. However, for someone interested in a broad descriptive review of separation techniques, processing procedures, and ways in which plutonium may be utilized in reactors, the book will provide ample return for the time spent in its perusal. The book, which contains several hundred references and reads like a novel, can be finished in a few hours.

The work is divided into six chapters. The first chapter begins with a brief history of plutonium discovery and production methods. The nuclear chemistry of plutonium is then treated in an elementary manner but adequately enough to familiarize the reader with the subject. The section is concluded with a treatment of the fission process and fission product yield from both fast and thermal neutron spectra.

Chapter 3 deals with the chemical properties of plutonium and plutonium compounds. There is little discussion (other than acknowledging their existence) of metallic plutonium, alloy systems, or refractory compounds such as PuO_2 or PuC. On the other hand, considerable treatment is given to the aqueous chemistry of plutonium. Some of the subjects discussed are plutonium compounds in aqueous solution, oxidizing-reducing reactions, complex compounds in aqueous medium, hydrolysis, ion-exchange, etc. The part of this chapter on aqueous chemistry is the most detailed of the book.

Chapter 2 is devoted to the physiological effects and health physics aspects of plutonium. The author discusses plutonium and its alloys as sources of alpha, gamma, and neutron radiations, and then describes the effects of these radiations on the human body. The chapter is concluded with sections on prophylaxis, therapy, and general work rules for use in plutonium laboratories.

The longest chapter, Chapter 4, is entitled "Plutonium Technology." The author has defined "plutonium technology" as being that segment of engineering associated with processing plutonium from its formation into forms suitable for use as nuclear reactor fuel. A title more meaningful to Western readers would be "Plutonium Processing Technology." As in Chapter 2, rather detailed descriptions are given techniques involving aqueous chemistry. This chapter has a rather large number of flow charts and covers nearly every processing technique in use today.

Chapter 5 deals with plutonium as a nuclear fuel in both fast and thermal reactor systems. This chapter contains much that is elementary, such as sections on neutron capture, moderation, and the definition of breeding ratio. The important subject of irradiation performance is given only one-half page. Next, the reasons why plutonium is favored for fast reactor systems, rather than for thermal systems, are discussed and the chapter is concluded by predicting that plutonium will be the principle fuel of the future.

The author ends his book with Chapter 6 in which he tries to predict the future role of plutonium in the timetable of nuclear power development. The worth of this chapter is severely reduced in that the economic aspects of his arguments are based on pre-1962 cost analyses. Since that time, the economics of nuclear power plants have changed drastically, and consequently, this treatment is of interest only for its historical value.

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