BOOK REVIEWS

Selection of books for review is based on the editors' opinions regarding possible reader interest and on the availability of the book to the editors. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

VALUABLE THOUGH IMPERFECT

Title Tritium and Other Environmental Isotopes in the Hydrological Cycle (Technical Report Series No. 73)

Publisher International Atomic Energy Agency, 1967

Pages 83

Price $2.00

Reviewer Wallace de Laguna

This report is one of a series on timely, but otherwise unrelated, topics prepared by the IAEA in the following fashion. A panel of experts on the topic in question is convened, usually in Vienna, and under the guidance of a chairman holds somewhat informal discussions for several days. Working papers may be sent to the panel members prior to the meeting, and some of the participants will bring prepared papers with them. These, and such records as may be kept of the discussions, are used by the Scientific Secretary to prepare the report. This can be quite a task because of the diverse nationalities, backgrounds, and viewpoints of the participants, and, as happened in the case of this report, the Secretary may get help from other members of the panel or from nonparticipants who are familiar with some phase of the subject. Because the reports make an attempt to present the viewpoints of the entire panel, they may not be as concise or organized as compactly as though they had been prepared independently by one man. This makes them a little uneven in their presentation, and a close study rather than a rapid reading may be required. This is not a serious disadvantage for the truly interested reader.

The subject report covers the deliberations of a panel of 20 men from 9 countries who met in Vienna from October 12-16, 1964. The topic proposed was "Worldwide Survey of Hydrogen and Oxygen Isotopes in Precipitation," but the title of the report was changed, because the panel chose to consider applications to oceanography and meteorology as well as hydrology. By "environmental isotopes" is meant tritium, particularly by the tritium released to the atmosphere by the explosion of thermonuclear devices, and the two stable isotopes, deuterium and oxygen-18. The concentration of the stable isotopes in water or water vapor is altered slightly when water is evaporated or condensed, and the amount of variation from Standard Mean Ocean Water is, among other things, an indication of the temperature at which the water evaporated or condensed.

At the close of the meeting the panel decided the preparation of the report should be postponed for at least a year so it might include the data on tritium fallout through 1965, as the tritium concentrations passed through a crest in the Summer of 1963 due to tests by the Russians in late October 1961. This is one reason the report did not appear until 1967.

The first section of the report describes the distribution of tritium in precipitation for a worldwide network of sampling stations and illustrates the variation of tritium concentration with time of year, latitude, altitude, and the relation of the sampling point to the major movement of air masses over the continents and oceans. There is a brief, perhaps too brief, discussion of the general conclusions that may be derived from the data. For example, no explanation is advanced for the high values of tritium in precipitation in the northern hemisphere in late spring and early summer, nor for the distribution with latitude, which shows a peak at latitude 50° N. The reader should be able to deduce the reasons for himself but probably would welcome the ideas of the panel.

The second section of the report considers the physical factors that control the distribution of deuterium and oxygen-18 between water vapor and water under equilibrium and nonequilibrium conditions. These factors are then used to show how distance from the oceanic source, temperature, exchange, and evaporation produce variations in the concentration of the two isotopes in rainfall under natural conditions. The explanations are too brief and, in a very few places, too ambiguous to be entirely satisfying. For example, in discussing the "kinetic effect" the statement is made (p. 17) that $H_2{}^{18}O$ is preferentially enriched in the liquid or the vapor phase. The reader can work this out for himself, but here, as in many parts of the report, the reader must work over the report, not glance through it. Unfortunately, one of the few errors in the report is made in Fig. 10 (p. 19); the labels on the ordinate and abscissa are reversed. This figure is central to an understanding of the distribution of the stable isotopes.

The next section is concerned with the possible use of tritium or other isotopes in the study of problems in meterorology. All that is done is to suggest how tritium might be used to study turbulent mixing and convection in the atmosphere, the transport of water by air masses, the inflow of tritium from the stratosphere, and the structure of hurricanes. Only in the case of the last topic has any work actually been attempted. Very much the same situation is found in the use of the environmental isotopes to study problems in oceanography; possible lines of investigation are pointed out, but, so far, little work has been done.

In the use of tritium and the stable isotopes to study problems in hydrology, some progress has been made. The IAEA has supported such studies in several areas of the world, in addition to having supported much of the sampling and analysis of precipitation for the environmental isotopes. The first problem considered is the relation of the concentration of the isotopes in the rainfall in a given area to their concentration in the recharge to the groundwater. Unfortunately, the topic must be discussed on the basis of the application of general principles; little actual work has been done so far.

Studies in the Antalya region of Turkey, in Kenya, in the Vienna Basin, and of the Neusiedlersee in Austria, which were based largely on the use of the environmental isotopes, permittted the investigators to make certain generalizations about the relation of groundwater flow to surface recharge areas, but few of the studies gave definitive answers. Some of the results, such as the determination of the direction of groundwater flow, could have been obtained more easily by classical methods. Some of the results obtained, such as a variation in the rate of movement of groundwater with depth, are open to other interpretations. Studies of evapotranspiration in Germany, if correctly reported, are based on some mistaken assumptions about the movement of groundwater in the unsaturated zone above the water table. It is not strictly true that "the tracer can progress beyond the root zone only when the field capacity is satisifed at this level and all levels above."

Some of the writing in this general section is hard to follow. Such statements as "Plotting the concentration map of deuterium for rivers of the United States of America reveals that the iso-concentration lines follow the contours of mean annual snow to mean annual total precipitation plotted against relative deuterium concentration" must be deciphered rather than read. In general, however, the presentation is reasonably intelligible.

The final section of the report is titled "Advances in Techniques for the Collection and Analysis of Isotopic Samples." Some of the generalizations about methods of sampling are only partly true. It is not commonly true that "the deeper of two aquifers or the deeper layers within a single aquifer are more likely to have a higher head than the shallower ones." However, the general thesis of this section, that groundwater sampling can contribute to serious errors unless carefully done, is undoubtedly correct.

All details of the methods of analysis are omitted, probably a wise decision, but a hydrologist wishing to use the environmental isotopes will probably find that analyzing the samples is one of the most difficult aspects of the work.

The report is a valuable, if not a perfect, introduction to the subject. The reader should be grateful to the panel that the report was prepared, and forgive its minor shortcomings.

Wallace de Laguna, a geologist, is a product of Harvard University (PhD, 1938) and the Groundwater Branch of the U.S. Geological Survey (1940 to 1955). He has worked at Brookhaven National Laboratory for the USGS (Bulletin 1156) and, as a member of the Health Physics Division of the Oak Ridge National Laboratory since 1955, he has been concerned with the safe disposal of radioactive wastes. He has done a little work with tracers, some of it quite successful, but he admits to being somewhat prejudiced against the use of environmental isotopes as working tools in hydrology.