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Inst. for Fish. Res.
F. F. Hooper

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

GERALD P. COOPER PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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RADIOISOTOPES IN CONSERVATION RESEARCH

By

Frank F. Hooper

Radioisotope technology has had its influence on nearly every phase of modern living. Benefits from the use of isotopes have appeared in industry, agriculture and medicine. Comparatively few applications of this new technology have been attempted in various fields of conservation. The purpose of this report is to pass along a few facts regarding the use of radioisotopes to other researchers within the Conservation Department. The report summarizes some of the author's experience gained during a 4-week course in radioisotopes technology at the Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee (April 29-May 24, 1957).

What is a radioisotope? A radioisotope is a particular variety of atom of a chemical element. It differs from ordinary atoms of the element in that it is continuously giving off some form of radiation. It is this property which makes isotopes useful in research. Radiation given off enables these atoms to be detected and counted wherever they may be. Radioactive atoms behave like ordinary atoms in most chemical reactions. As far as we can tell, living cells cannot discriminate between the radioactive and the non-radioactive atoms of a given element. For example, if plant cells are offered carbon dioxide consisting of a mixture of radioactive carbon (C^{14}) and ordinary carbon, they take up the radioactive carbon as readily as the non-radioactive. This gives us a method of studying photosynthesis and plant growth.

Radioactive isotopes have been made for nearly all chemical elements. This does not mean that one can secure a usable radioisotope for any element. Many isotopes are unsuitable for research because they disintegrate rapidly; that is, they turn into another chemical element in a few seconds or minutes.

Where can isotopes be secured? About 95 percent of all isotopes for civilian applications are prepared at the Oak Ridge National Laboratory. This laboratory supplies isotopes directly to licensed isotope users and also supplies commercial concerns who re-package and sell the isotopes under their own label. Most of the isotopes supplied by Oak Ridge are fission products taken from the atomic piles or they are materials produced by irradiating chemical compounds in the pile. A few isotopes are produced only by bombardment of elements in cyclotrons. An institute or individual licensed to use radioisotopes can obtain rapid delivery directly from Oak Ridge or from commercial suppliers. Isotopes are shipped through the mails, by air, and by railway express. Short-lived isotopes can be delivered within 24 hours of the time they are taken from the atomic piles at Oak Ridge.

Cost of radio isotopes. Costs of isotopes vary tremendously depending upon how they are prepared and purified. Isotopes that are fission products (wastes) from the atomic piles are inexpensive (e.g., iodine 131 at $0.12 per millicurie). Isotopes prepared by neutron bombardment in the pile are somewhat more expensive (e.g. carbon 14 at $36 per millicurie). The cost of isotopes is not a serious obstacle in most ecological studies since radiological safety and health considerations prohibit the use of large quantities.

Who can use radio isotopes? Regulations concerning licensing of persons to use isotopes are published in the Federal Register, Vol. 21, No. 6, January 11, 1956. Small quantities of certain radioisotopes are "generally licensed," that is, they are available without filing an application or receiving a license. The quantity of "generally licensed" isotopes that can be obtained is usually 10 microcuries or less. This quantity is sufficient for certain types of laboratory experiments. To obtain larger quantities, a "specific license" is required. Licenses are issued by the Isotope Extension Service of the Division of Civilian Applications of the Atomic Energy Commission. Licenses are granted only to individuals who are qualified by training and experience to use these materials and who have at their disposal the special equipment and facilities required for their usage. Ordinarily persons who have satisfactorily completed a course in radioisotope technique either at Oak Ridge or at a university would qualify provided they have laboratory facilities suitable for handling "hot" chemicals. Such a laboratory may be a part of a larger building but must not be accessible to unauthorized persons. Facilities for the disposal of "hot" waste and a fume hood must be provided and adequate radiation detection equipment is required. Elaborate equipment for remote handling of isotopes is required if large quantities of the more dangerous isotopes are to be used. At most university campuses, (e.g., University of Michigan and Michigan State University) permits are issued to a single person, the staff radiological safety officer, who is responsible for the use of all isotopes on the university campus. He supervises the purchase and use of isotopes, checks safety installations and gives advice to isotope users.

<u>How are radioisotopes disposed of after use?</u> The Atomic Energy Commission prescribes disposal methods. Safe quantities of radioisotopes can be put down the domestic sewer drain. Dangerous amounts must be

buried under rather precise conditions outlined by the Atomic Energy Commission. Most of the large commercial suppliers of radioisotopes also offer a waste disposal service. The "hot" wastes are simply returned to these companies for disposal.

Can isotopes be used in field experiments? Yes, if proper precautions are observed and the quantity of isotope used does not endanger public health. Whether or not a given quantity of an isotope is hazardous depends upon the type of radiation given off, the half-life of the isotope, and the intensity of the radiation produced by the isotope. Maximum permissible concentrations of isotopes in air and water are given in the Federal Register, Volume 22, No. 19, January 29, 1957. Permissible concentrations, particularly for isotopes of short half-life, are well within the range that can be measured by counting equipment. For example, the maximum permissible concentration of Phosphorous 32 in water is 0.2 microcuries per liter. By concentrating the water sample slightly, good detecting equipment can measure a concentration of approximately 0.0036 microcuries per liter. Thus there is a safe usable range for experimentation.

How can radioisotopes assist in research work? The useful property of radioisotopes as far as research is concerned is that minute quantities can be detected and measured. Most of the important uses of isotopes have been either (1) measuring the amount of a chemical or the number of organisms and (2) marking chemicals or organisms so that their movements can be followed during an experiment.

Counting Experiments

For population estimates animals can be marked with isotopes and the Peterson Index used to determine numbers. In addition to this type of counting, isotopes enable indirect estimates of the number of microscopic plant cells. The following example will illustrate this use.

We wish to know the number of living algal cells present on a large and irregular substrate such as a chunk of stream rubble. This number could be estimated rather rapidly by allowing the living cells of a substrate to absorb a small amount of Carbon 14 while they are undergoing photosynthesis. After the Carbon 14 is absorbed the radioactivity of a small sample of the cells in which the number of cells is accurately known is compared with the activity of all of the algae scraped from the rock. This ratio of activity is used to calculate the total number of living cells. Measuring the radioactivity of such samples is a rapid process. Such a test could be accomplished in a few hours whereas absolute counts of the material would probably require several days.

The Diffusion and Movement of a Chemical in a Lake or Waterway

Numerous studies have proven the value of isotopes in following the devious paths a chemical or some other water-borne material may take when released into a lake or waterway. For example, the movement of sediments carried to sea by the River Thames has been analyzed by introducing radioactive sand and silt. Using radioactive phosphorous, translocation of this substance within the food chain of a lake or stream can be followed. In many cases where ordinary chemical methods fail because they lack sensitivity, radioactive isotopes can be used quickly and effectively. For example, if one wished to make a detailed study of the fate of the arsenic used in an aquatic weed control treatment, this could be done much more accurately and with considerably less effort using isotopes than with routine chemical techniques. In such a test a small quantity of sodium arsenite labeled with radioactive arsenic (As 76) would be added to the sodium arsenite of the spray. Following treatment small samples collected from any part of the lake or waterway (mud, weeds, water, plankton) can be quickly counted to give the fraction of arsenic that has moved to these sites. Such an analysis would take a single day whereas several weeks might be required to do the same job with ordinary chemical methods. Isotopes are being used by the Sanitary Engineering Group at Oak Ridge National Laboratory to follow pollutants in streams.

Following the Movement of Animals By Radioactive Tags

The movement and migrations of representatives of practically every major group of animals (insects, bacteria, protozoa, birds, fish, mammals, amphibians) have been followed using radioisotopes. An excellent summary of these studies was recently published by Pendleton (Ecology, October, 1956). Animals may be marked with a tag containing a high energy gamma ray emitter so that the tagged animals can be detected at a considerable distance from the detecting device (up to 20 feet). However, the greater the detection distance the stronger the radioactive source required and the greater the hazard to the animal carrying the tag and to persons who might accidentally ingest the tag. A safer and perhaps more useful method is to feed the animal a radioactive food and follow movements by detecting the radiation in excreta or feces. Relatively safe short-lived isotopes can be used in this type of experiment.

INSTITUTE FOR FISHERIES RESEARCH

Frank F. Hooper

Approved by: G. P. Cooper

Typed by: J. M. Lederer